A comparison between the operation of the engineering profession in the United Kingdom and other countries

engineering council

THE Engineering Profession

by Sir James Hamilton KCB MBE

Acknowledgements

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The Author

Sir James Hamilton was born in Penicuik, Midlothian. He was educated in various state schools and at the University of Edinburgh: he graduated in 1943 with a degree in civil engineering. He holds honorary doctorates from the Heriot Watt University and from the Council for National Academic Awards. Sir James is a Fellow of the Royal Society of Edinburgh, of the Royal Academy of Engineering, of the Royal Aeronautical Society and an Honorary Fellow of the Institution of Mechanical Engineers.

His principal appointments include:

1943-45	Development of anti-submarine weapons for the Royal Air Force.
1945-52	Head of Flight Research at the Marine Aircraft Experimental Establishment, Felixstowe.
1952-64	Research into the aerodynamics of high-speed flight at the Royal Aircraft Establishment, Farnborough.
1964-65	Head of Project Assessment, RAE.
1965-66	Project Director, Anglo-French Combat Aircraft.
1966-71	Director-General, Concorde.
1971-73	Deputy Secretary, Aerospace Industry: Department of Trade and Industry.
1973-76	Deputy Secretary to the Cabinet.
1976-83	Permanent Under Secretary of State, Department of Education and Science.

Sir James was a Director of the Hawker-Siddeley Group from 1983-91: of Smiths Industries from 1984-94 and of Devonport Royal Dockyard from 1987-97. From 1997-2000 he was Chairman of Brown and Root Ltd. He was Vice-chairman of the Council of University College, London from 1985-1999, President of the Foundation for Educational Research 1983-1999, a Trustee of the Natural History Museum from 1984 until 1988, Vice-president of Reading University Council 1983-95 and President of the Association for Science Education 1985-86. He is currently a member of the Advisory Board of the Royal College of Defence Studies.

Sir James was executive member of the steering group studying the organisation of the engineering profession in the UK (1992-1993, The Fairclough Study); the findings of the group were published in April 1993 - *Engineering into the Millennium.*

Foreword

Sir James Hamilton undertook a survey of the Engineering Profession in the UK and overseas during the latter part of 1999 and beginning of 2000. The survey was commissioned by a major charity, but much of the statistical work was undertaken by the Engineering Council.

The resulting report has been generously provided to the Engineering Council for publication. It represents a significant overview by an industrialist and engineer much associated with the profession over many years.

It is important to realise that much of the content of this report is necessarily ephemeral. Procedures, laws and educational structures change. Nevertheless it provides an excellent overview of the state of the profession in the early months of the Millennium and provides a seasoned commentator's view of the challenges and opportunities it faces.

Malcolm Shirley CEng

Director General
Engineering Council

Executive Summary

This report presents the outcome of a desk study, which compares the operation of the Engineering Profession in the United Kingdom with that in other 'similar' countries. Being a desk study it is based largely on existing information reinforced by more detailed investigations undertaken on my behalf by British Embassies and High Commissions.

Much of the published information has come from widely scattered sources with varying degrees of reliability and detail. This may lead on occasion to minor inconsistencies, for example in relation to the definition of the term 'engineer' and to the distinction between sub-degree, bachelor and masters qualifications. I do not believe that the distinctions in any way invalidate my general analysis and the conclusions that I have drawn.

In the main report, I have examined the question under a number of headings:

- organisation;
- education and training;
- accreditation;
- regulation and protection of professional titles;
- numbers;
- the technician problem;
- status and rewards;
- outputs;
- Academies;
- international collaboration.

Organisation

As might be expected, there are almost as many patterns of organisation for the profession as there are countries: the differences in organisation reflecting wider differences in culture, history and social structure (annexes 1 and 2).

At one end of the spectrum lie those countries having a powerful central body, appointed by act of parliament (Italy, Greece, Portugal) with – in theory at least – tight control over education, regulation, licensing and so on. At the other end are countries having a number of engineering Institutions covering specific engineering disciplines but no central co-ordinating body. A common pattern is the 'umbrella' concept where one or two Institutions in addition to their learned-society activities have become, by custom and practice, co-ordinating bodies. A good example is Germany where the Verein Deutscher Ingenieure (VDI) has assumed this role. Some of the Commonwealth countries, Malaysia, Hong Kong, Australia, South Africa have a distinctive pattern involving one Institution overseeing the whole profession with some kind of sectoral arrangement to look after specific disciplines.

The UK pattern, with a non-Governmental central body, the Engineering Council (EC), and 34-40 powerful Institutions, falls somewhere about the middle of the spectrum. Its strength is that the EC has a clear remit to act as the voice of the profession, in face of Government: its weakness is the difficulty of achieving any kind of consistency of practice and opinion amongst 40 or so separate Institutions, and the continuing tension between the EC and the Institutions over who does what.

It is tempting to suggest that the UK profession might benefit from a system with fewer Institutions and a more powerful central body, but the corresponding upheaval would be widespread and potentially damaging to the profession. Although it can be no more than a qualitative judgement, I have to say that this study has not revealed any obvious connection between the well-being of the engineering profession and the kind of governing organisation: we have to look elsewhere for improvement.

Education and training

There is a good deal of mythology surrounding the comparison between the British approach to the education and training of engineers and the practice in other ‘similar’ countries. Comparisons tend to be based on the relatively short undergraduate course in the UK – 3 years – as against 5, 6 or 7 years in other countries: the longer the better goes the argument.

In practice the nominal period in many countries is appreciably less than that actually taken by most students and the equation more equals better has to be treated with some care. In comparing future policies, two factors have to be borne in mind: first there is a good deal of concern in a number of other countries about the long courses, partly because they are expensive and partly because graduates are 26 or 27 before they enter the world of work and then with relatively little practical experience: the German move towards BSc and MSc courses is significant.

The second factor is revision of the British system as defined in SARTOR 3rd Edition (published 1997). One of the principal aims of SARTOR is to define a British system that, in terms of breadth, depth and quality, will stand comparison with the best practice in any other country. One of the principal criticisms of SARTOR is that, particularly for Chartered status, the requirements are too demanding. But, in a sense this is more a commentary on the standing of the C. Eng qualification than a criticism of what SARTOR is trying to achieve. Although the engineering Institutions have signed up to SARTOR the manifest risk to its acceptance lies in the Institutions’ concern that it will reduce their intake of members: if this should lead to a separation between the requirement for C.Eng and that for Institution membership, the credibility of SARTOR could be significantly eroded.

Accreditation of further and higher education

Although ‘accreditation’ and ‘quality assurance’ are subtly different, I choose the former as a measure of ‘quality’ simply because there was more information readily available.

Here again there are as many systems as there are countries; the approach varies from control by central government to a virtual ‘free for all’ with control at individual university level.

The UK has a comprehensive, but rather convoluted approach. In theory, the body responsible for accrediting courses is the Engineering Council: in practice the Council delegates authority to individual ‘nominated’ Institutions each of which has its own arrangements for accreditation. There are – limited – arrangements for exchanges of views between Institutions but by and large each makes its own judgements. The situation is further complicated by the recent formation of the Quality Assurance Agency for Higher Education (QAA), a Government-funded body with the responsibility of assessing the quality of all UK degrees.

Although the desire of individual Institutions to retain a foothold in this area is understandable, one cannot help feeling that the present arrangements are unnecessarily complex, burdensome for the universities and subject to inconsistencies.

Here is a topic worth probing further.

Regulation and protection of titles

As in other aspects of the structure of the profession, there is a wide variation between countries in this area. At one extreme are those countries which have, in theory at least, legislative backing for the right to practice and protection of title; others like Japan have licensing applied only to some disciplines – usually building and construction; others again, like the United States, have State-controlled protection of title and licensing for certain activities – approval of design drawings for example.

The UK has protection of the titles C.Eng, I. Eng and Eng. Tech. plus a register but, apart from some very limited activities, no system of licensing. The question here is whether an extended list of licensed disciplines would enhance the profession: ‘enhance’ in this context I take to include service to the public as well as status.

The usual argument is that the only effective way to improve the standing of the profession in this country is through a system of licensing with protection of the term ‘engineer’. I have to say that I do not find this line of reasoning persuasive. The analogy drawn with other ‘licensed’ professions such as the medical and veterinary professions seem to me invalid – their status does not depend on licensing. Nor do I believe that the status of the engineering profession would be enhanced by such a move. Indeed, the legislative complication could well make things worse. There is certainly no significant pressure from employers and, interestingly, the Finniston Report, generally labelled, unfairly, 'dirigiste' came out against overall legislative control of the profession.

All this leaves open the question of whether a limited extension of licensing would be worthwhile.

Numbers

Although not strictly within the compass of 'operation', I thought it wise to include a few statistics to give some background.

In terms of the annual output of first degrees in engineering and science, the situation is dominated by the three giants, USA, China and Japan but within the European Union the UK is second only to Germany in numbers of engineering graduates and we lead the field in numbers of science graduates. In terms of engineers and science degrees as a percentage of all degrees, we do less well. Over the past decade the percentage of engineering degree acceptances of home students in the UK has fallen from 11 to 6 but the number of acceptances has increased by nearly 20% to 16,298 over the last ten years. This figure though undercounts the actual numbers on Engineering and Technology degree courses.

The relative drop in the popularity of engineering degree courses is not confined to the UK: it is a problem shared by many Western countries including Germany and the USA. By contrast, in the Pacific-Rim countries, entries into undergraduate courses are booming.

The technician problem

Most of this report deals with Chartered Engineers: many would argue – and certainly many companies – that the real problem lies in the supply of well qualified technologists – including some at Incorporated-Engineer level.

All the indications are that in terms of numbers we still lag behind Germany in this respect with roughly 60% of the German industrial workforce having intermediate qualifications and only 30-35% of the British.

However, these numbers have to be treated with some care. First, we have the edge on Germany in terms of the percentage of graduate engineers in the work force; second the USA has an even smaller percentage of qualified people at sub-degree level – but a higher percentage of graduates; thirdly anecdotal evidence suggests that the German scene is not as rosy as the figures would suggest.

Outputs

These last arguments are reinforced by my attempt to assess relative performance in terms of outputs rather than the inputs upon which most of this report's analysis is based.

I have used a study by the NIESR into productivity comparison between the UK and 'similar' countries. The detailed comparison is described in the body of the report. The NIESR analysis is complex and by no means definitive but it does suggest that, although there are major differences in productivity between the UK and the USA and Germany, only a small proportion of the difference can be attributed to differences in the mix of skills between the three.

Interesting, but not a result to diminish our attempts to produce a larger and more highly qualified body of technicians.

Conclusions

In this section I make a number of suggestions about initiatives that might be taken in regard to the advancement of the engineering profession in the UK.

Introduction

This report gives my findings as a result of a desk study with the aim of investigating

> *'how the operation of the engineering profession in the UK compares with that in other countries.'*

The report is limited in the sense that as a desk study it relies perforce upon information which was either readily available or could be obtained by correspondence. An approach of this kind is fine for acquiring data on how the profession operates in each country in principle: its weakness is that it gives little idea of how the system works in practice – what are its strengths and failings.

Even the collection of the raw data was far from straightforward: the last essay into this area was conducted by the Finniston Committee 20 years ago. Since then there have been a number of studies of individual aspects but no one study that, to my knowledge, brought all the strings together.

In the early part of the report I give a brief history of how the engineering profession in the United Kingdom developed – necessary if one is to understand why it operates as it does today. This is followed by what is, in effect, the heart of the report: a description of how the profession operates in a number of 'similar' countries with a brief overall analysis and comparison with how affairs are managed in the UK.

Predictably, there are almost as many approaches to the operation of the profession as there are countries and since the organisation of the engineering profession is influenced by the overall social structure and mores of the country concerned, extrapolation to British custom and habit tends to be a hazardous business.

I have therefore taken a rather catholic view of 'operation' and extended my analysis to look at international comparisons in terms of numbers (degrees, entrants etc), sub-degree qualifications, status and rewards, outputs – here, as determined by productivity - and the current scene on international collaboration.

Lastly, I draw some conclusions centred around what initiatives might be taken to improve the operation of the engineering profession in the UK.

The Engineering profession in the UK

In this chapter, I give a brief history of how the engineering profession has developed in the United Kingdom. In annex 1 I give an account of its current organisation and summarise the corresponding arrangements in other countries.

The current system for organising and regulating the engineering profession in the UK reflects the strengths and weaknesses that one would expect from a system that has developed in a relatively unstructured way over the past 170 years.

Emergence of the engineering Institutions

Reflecting its primacy in the development of the Industrial Revolution, the UK was a pioneer in the creation of Institutions aimed at advancing the status and quality of the engineering profession. In 1818 the foundation stone was laid for the first engineering Institution, the Institution of Civil Engineers, set up for the benefit of all those engaged in all kinds of civil, as opposed to military, engineering. It remained the only Institution until the creation of the Institution of Mechanical Engineers in 1847, impelled by the rapid development of powered machinery and vehicles.

Concentration on shipbuilding led to the launching of the Royal Institution of Naval Architects in 1860: the widespread use of coal gas resulted in the Institution of Gas Engineers in 1863: and the Institution of Electrical Engineers was founded in 1871 to signal the development of telegraphy and the spreading use of electrical power.
After this the tendency grew to form a new Institution as each new discipline of engineering emerged: at the same time the larger Institutions have themselves adapted to new disciplines with resulting overlaps in activity.

The early history of the Institutions was that of learned societies of engineers with a common interest in the presentation and discussion of engineering work. Only later in their development did they acquire a regulatory role, determining standards for engineers and conducting their own examination for admission of individuals to corporate membership. Some twentieth century Institutions - the Institution of Chemical Engineers for example - were primarily concerned from the outset with training and qualifications.

The Council of Engineering Institutions

By around 1960 there were over 50 recognised engineering Institutions, acting virtually independently of one another. A first attempt at co-operation was the formation of the Engineering Institutions Joint Council. This was an informal grouping of the Chartered Institutions: the non-chartered or incorporated Institutions being excluded.

This, in turn, led to the setting up of the Council of Engineering Institutions (CEI) which was incorporated by Royal Charter in 1965.

The object of the CEI was to promote and co-ordinate in the public interest the development of the science, art and practice of engineering. At first it covered only Chartered Engineers. Incorporated Engineers - then known as Technician Engineers - and Engineering Technicians were later brought into its Engineering Registration Board but the Incorporated Institutions were not included on its governing body. This was controlled by Chartered Institutions and Chartered Engineers.

All Institutions were required to register all their corporate members in the appropriate section of a CEI register: Institution membership was a pre-requisite for registration.
The Institutions paid fees to the CEI on a per capita basis so that its income was almost entirely dependent on the number of registrants.

In its 18-year existence the CEI achieved much in drawing the profession together, in establishing a common examination and eventually in recognising the non-chartered grades of engineer.

But it failed to promote the engineering profession to the public and the Government. It also failed to harness the strengths of the major Institutions, while depending too much on securing the consensus of many Institutions. As the Finniston Inquiry put it:

“Without doubting the value of these activities, it must be said that the CEI has not made a significant impact upon the fundamental problems of establishing greater understanding of the nature and role of engineering and in promoting the engineering dimension in national economic affairs. Moreover it does not appear to visualise a role for itself in this respect .... Individual Institutions have from time to time expressed their frustration with the cumbersome procedures of seeking changes through unanimous consent from all sixteen members, and some have threatened withdrawal.”

The Finniston Report

Recognising the growing disenchantment with the CEI, the then Labour Government announced in 1977 the appointment of a Committee of Inquiry into the Engineering Profession to be led by Sir Monty Finniston. The terms of reference make interesting reading in relation to the subsequent history. They were:

"To review for manufacturing industry and in the light of national economic needs: -

i) the requirements of British Industry for professional and technician engineers, the extent to which their needs are being met and the use made of engineers by industry;

ii) the role of the engineering Institutions in relation to the education and qualification of engineers at professional and technician level;

iii) the advantages and disadvantages of statutory registration and licensing of engineers in the UK;

iv) the arrangements in other major industrial countries, particularly in the EEC, for handling their problems, having regard to relevant comparative studies and to make recommendations."

Finniston reported in January 1980. He proposed the establishment of a statutory Engineering Authority with three new grades of registration based educationally on the master's degree, the bachelor's degree and the Higher National Certificate respectively. There was no recommendation for an Engineering Technician grade. Numerous other recommendations covered engineering in the economy, the supply and employment of engineers, engineers' formation and actions required of employers.

The Government of the day decided against legislation to create a statutory body. For their part the Institutions strongly opposed steps which they saw as threatening their independence and the self-regulation of the profession.

The outcome was the Engineering Council, a compromise reasonably acceptable to the Institutions and the Government but opposed by Monty Finniston.

The Engineering Council

The Engineering Council (EC) was established by Royal Charter in November 1981 "for the advancement of education, and the promotion of the science and practice of engineering, including relevant technology, to the public benefit and thereby to promote industry and commerce in the UK."

There is no need in this study to describe in detail the operation of the EC in its first decade. The Council and the Institutions together achieved a great deal. Common standards of competence were established, the Council put in place a national system for continuing professional development (CPD), launched a code of Professional Practice on Risk, persuaded the Government to provide additional undergraduate places for science, technology and engineering amongst other educational initiatives, and encouraged young people to consider an engineering career through schemes such as Neighbourhood Engineers, the Young Engineers for Britain competition and Women into Science and Engineering. Over the same period the initiatives were matched and complemented by equally noteworthy achievements by the Institutions not least by a closer collaboration between individual Institutions.

But some of the weaknesses noted by Finniston remained. Fragmentation into over 40 Institutions compounded the failure of successive central bodies to speak to the outside world with a single voice. A degree of mistrust developed between the Council and some Institutions; the mistrust made worse by the fact that neither Institutions nor individual engineers played any part in selecting Council members.

Overall it became clear that the Council and the Institutions between them did not have the desired impact in improving the standing and influence of the profession that had been expected.

The Fairclough Report

In 1991 the then Chairman of the Engineering Council, Sir John Fairclough, drew attention to the excessive fragmentation of the profession and its poor image compared with other professions. He argued that the profession needed a new single body "owned by the profession, empowered to set professional standards for the individual engineers, giving a focus on common issues and providing an operation within which the Institution would work."

The outcome of this demand was a year-long review

"To consider the formation role and organisation of a single body to act as a focal point for the engineering profession:

- to set professional standards of performance and conduct;
- to represent the profession on major issues;
- to provide an operating framework for engineering institutions, institutes and societies."

The review was conducted by a group of past-presidents of Engineering Institutions and the corresponding report was published in April 1993.*

The central recommendations of the report were that "the profession should embark on a programme of reforms .... to create a New Relationship between the Engineering Council and the Institutions. ...... and should by the end of 1995 establish a proposal, on which the whole profession would then be invited to decide, to move in a series of steps from the New Relationship to a Single Institution.

The Engineering Council should continue to act as the Central Body unless and until replaced by a Single Institution, but that the programme of reforms should include an independent review of

its operation and the necessary structure and staffing to fulfil the requirements of the new relationship ....."

Given the history of the Institutions' response to Finniston, it is hardly surprising that they were not greatly enamoured by these proposals, particularly the concept of a Single Institution. But there was agreement on the need for a 'New Relationship' and after many debates the current form of the Engineering Council emerged (annex 1a)

* *Engineering into the Millennium:*

Interim Report of the Council of Presidents Steering Group - April 1993.

Analysis

Basic Comparisons

The raw data relevant to the operation of the profession in individual countries is given in annexes 1 and 2. Broadly, the countries that I have studied fall into one of three groups:

- the G7 group – United Kingdom, United States, Canada, Japan, Germany, France and Italy; they are given the most detailed coverage;
- a selection of 'similar' countries – mostly European for which data were available: these form the remainder of annex 1:
- a group of countries – mostly Pacific Rim – for which limited information was readily available.

Collecting these data proved remarkably tiresome and time-consuming. Their date of application varies – though nearly all come from the 1990's; some of them may have been overtaken by more recent changes: Since rapporteurs will tend to fight shy of criticising their native systems, the information most likely falls short of 'warts and all'. Nevertheless, I believe that it is adequate for the kind of comparative study envisaged in my terms of reference.

Predictably, given the widely varying social structures in the countries concerned, no clear pattern emerges from annexes 1 and 2: but there are one or two interesting trends.

Organisation

Most countries have engineering Institutions of one kind or another. They tend to concentrate on learned-society activities but one or two – notably in Scandinavia – undertake trades-union tasks such as negotiation of salaries and terms and conditions of employment. As to central bodies, only a few – notably Italy, Greece and Portugal – have responsibilities specified by law and correspondingly powerful influence over registration and licence to practice. The most common pattern is that where an Institution acts as an 'umbrella' body for the profession with certain limited powers – the VDI in Germany is one example. Another pattern is provided by the USA and Canada - umbrella national Institutions with state/province control by law over licensing. The UK with a chartered central body sharing power with the Institutions falls into the middle ground.

Education and qualifications

Again, at first blush, there appear to be as many systems as there are countries; but, on closer examination, a pattern of a kind emerges, based on the concept of a binary approach: a short cycle of 2 – 4 years study which leads to a degree or a sub-degree qualification and long cycle based on 5 – 7 years study leading to what is claimed to be the equivalent of a masters degree. The short cycle equates to some kind of technologist qualification (Incorporated Engineer in UK terms) and the long cycle to a Diploma Engineer (Chartered Engineer in UK terms). Even those countries which, on paper, have a single-cycle pattern, do in practice tend towards the 2-cycle approach: the United States, for example, which has a sizeable proportion of masters degrees in engineering (25%). Traditionally, the UK has based the basic engineering education on the 3-year bachelor degree but the SARTOR approach moves firmly towards a 2-cycle system.

A continuing feature of engineering education in continental countries is the discrepancy between the nominal and actual lengths of degree courses: this can be as much as 2 or even 3 years. This has led to some soul searching amongst the authorities in a number of countries who are concerned that in today's world someone entering employment at 26 or 27 with relatively little work experience may be at a disadvantage compared with a younger graduate who has a year or two's experience of life in the real world under his belt. Germany, in particular, has set up a pattern of BSc and MSc degrees to meet this problem. How far it will compete with the long-standing and prestigious Diploma courses remains to be seen.

Regulation and protection of professional titles

A surprising number of countries do not require any experience beyond a degree to enter practice: though it is true that some degrees involve an element of practical experience. In general, those countries with a statutory centred body have the more demanding requirements – usually including a national examination and well-defined limits on title and license to practice. Some countries have a kind of half-way house with requirements for certain kinds of title, for example, Professional Engineer (PE) in the United States which requires 4 years of approved experience plus a State examination but is not a sine qua non to practise.

Traditionally, the UK has never had a structured post-degree route for engineers but the SARTOR document defines the requirements in precise terms. The problem here, and we shall return to this question, is not the wisdom of the SARTOR proposal, but the extent to which the benefits of Chartered status compensates for the effort required to be registered (in all countries employers pay little attention to status even with rigid licensing).

Accreditation

Here we have an unholy mixture of control by individual universities, by engineering Institutions, by non-government agencies and by Government agencies. One suspects that the situation is further complicated by differences in standard within any one system.

The UK approach manages to combine elements of most of these systems (annex 1a). I see some room for a simpler system here.

Registration

Rather fewer than half the countries studied have registers and most of these cover no more than part of the profession.

Legislation

There are two aspects to statutory definition of the profession: statutory control of the right to practice: statutory protection for titles. Relatively few countries exercise the first of these fully though there are several that have control over certain functions – usually construction – and some that have control over part of the profession – professional engineers in the United States and Canada for example.

Many more – including the UK – have legal protection of title, although again this applies only to a proportion of the total of those engaged.

Comments

It is perhaps unsurprising that no great truth leaps out of a straightforward comparison of engineering profession structures in what are very different societies.

This is particularly true of organisations where history, societal development and national characteristics all have their part to play. In an earlier chapter I have described how the current organisation of the UK engineering profession developed over the years. It is still evolving especially in terms of the relationships between the Engineering Council and the Institutions. It is tempting to envy those countries where there is a single Institution or a single dominating Institution but questionable whether this can be achieved in the UK within the foreseeable future without a major upheaval.

Under the headings of education, training, regulation and protection of titles much of the UK approach is embodied in the Engineering Council's Standards and Routes to Registration (SARTOR). This approach implicitly takes into account the experience of other countries. It has had a difficult birth and now needs a period of stability and support from the Institutions if it is to prosper.

As to accreditation: we have a soundly based system but one that appears to be over-complex. The Engineering Council is currently examining an output-based approach, which will also – hopefully – be less complex.

Does any of this suggest obvious areas worth investigating: I believe that there are one or two:

- remedial mathematics courses for students entering first-year engineering courses are now common place. Their quality is highly variable and needs examination;
- accreditation is another potential area but would need to take account of the current EC study on output-based systems;
- legislative control of the profession is a familiar war-horse: is there a case for 'creeping' licensing;
- and perhaps the most hoary chestnut of all – how to improve the status of engineers and engineering in the UK.

I expand on some of these issues in the sections that follow.

Numbers

Statistics as applied to the engineering profession are no less confusing than in any other context. Nevertheless some analysis is worthwhile if only to get a broad idea of how we rate with other countries.

Degrees

To get an overall sense of proportion, the simplest criterion is the number of engineering and science degrees per annum (Fig 1). The three giants China, USA and Japan with USA leading the total, but lying behind Japan and China in numbers of engineers, dominate the field. For the rest of the world, Germany leads the way although the UK produces more natural science degrees than Germany and is second only to Germany amongst all EU countries in terms of engineering degrees.

The UK picture is less bright in terms of the percentage share of all degrees when we lose our leading position in Europe (Fig 2). The Pacific Rim countries are interesting: South Korea leads us in terms of engineering degrees but has few science degrees, giving the UK a marginal lead overall. Singapore and Taiwan are huge in percentage terms but small in numbers.

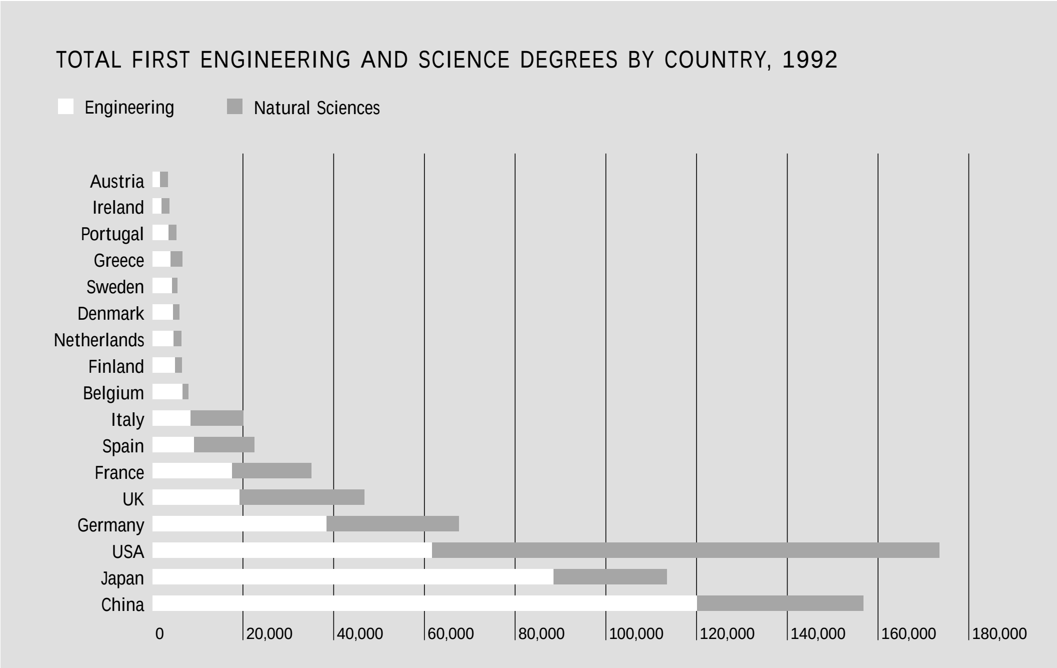
Related to the proportion of the labour force, (Fig 3) the UK again has a leading place but the figures include natural sciences and medical sciences as well as engineering. In line with the pattern displayed in Fig 2 the inclusion of science may account in part for the UK's good performance.

Input to the profession

The trend in acceptances of home students to engineering courses in the UK is shown in Fig 4. Within recent years the number has fallen but over the decade the number of entrants has increased by nearly 20% to 16,298 (1998). However, in large measure this simply reflects the great increase in the total number of young people entering university courses. Over the same period the percentage of engineering entrants fell from 11 to 6.

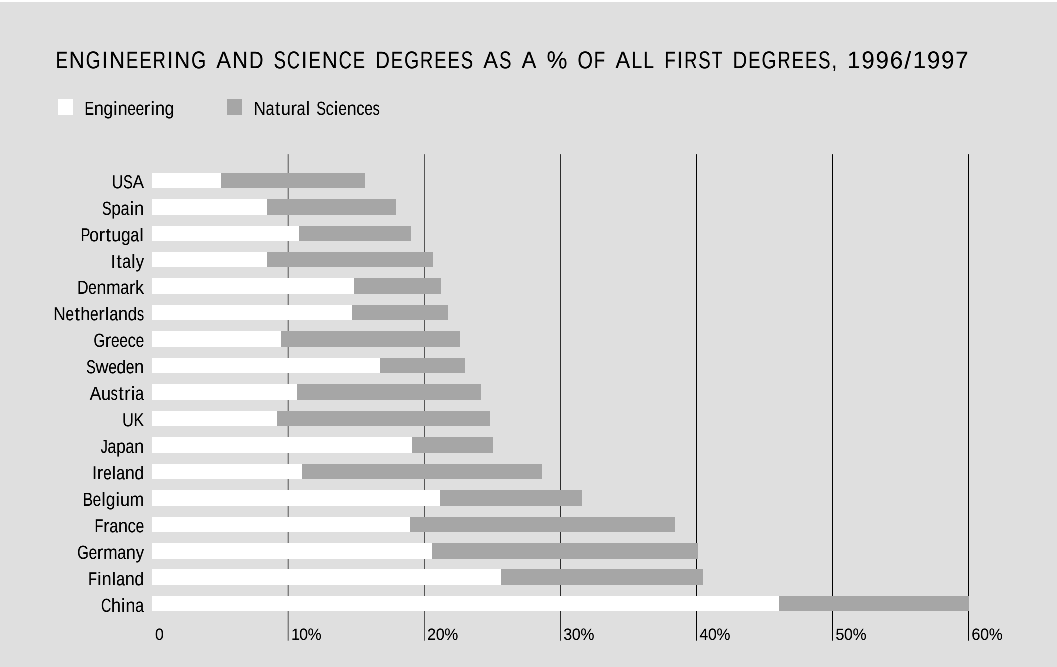
We are not alone in facing a potentially difficult supply problem. In Germany, over the period 1991 – 96 the number of students entering science and engineering dropped by a startling 50%. In the United States, entrants to engineering courses have dropped by 14.5% over the period 1985 – 1998.

Figure 1



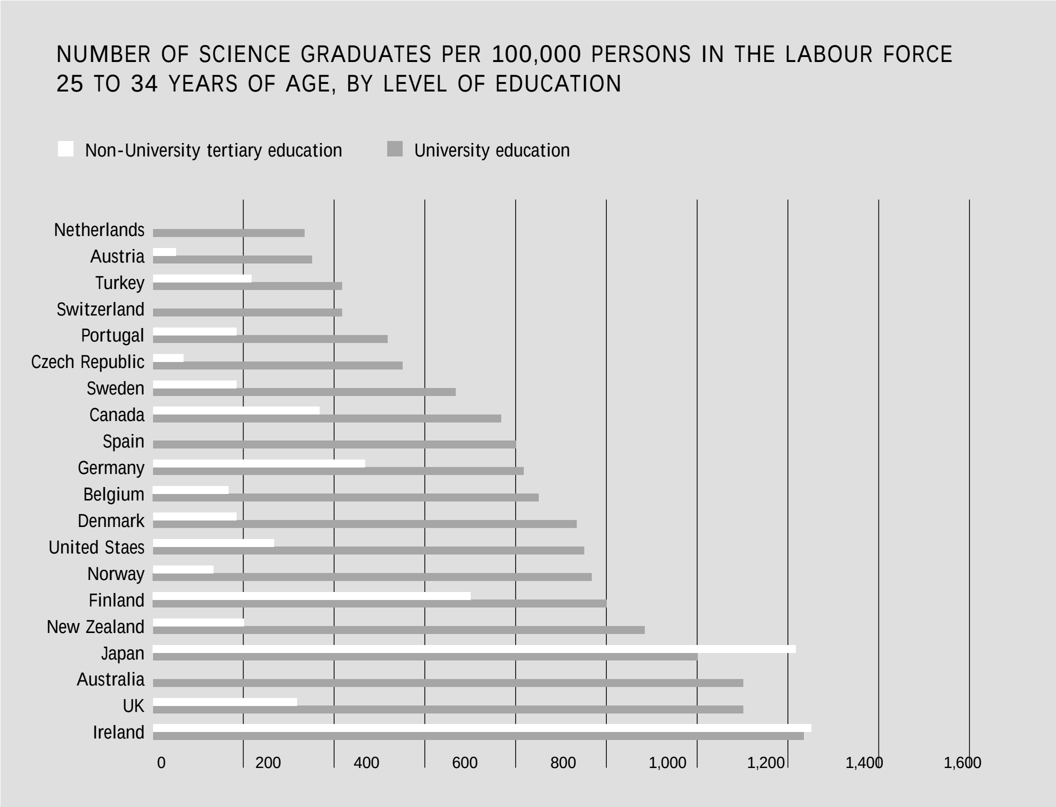
Source: US National Science Foundation

Figure 2



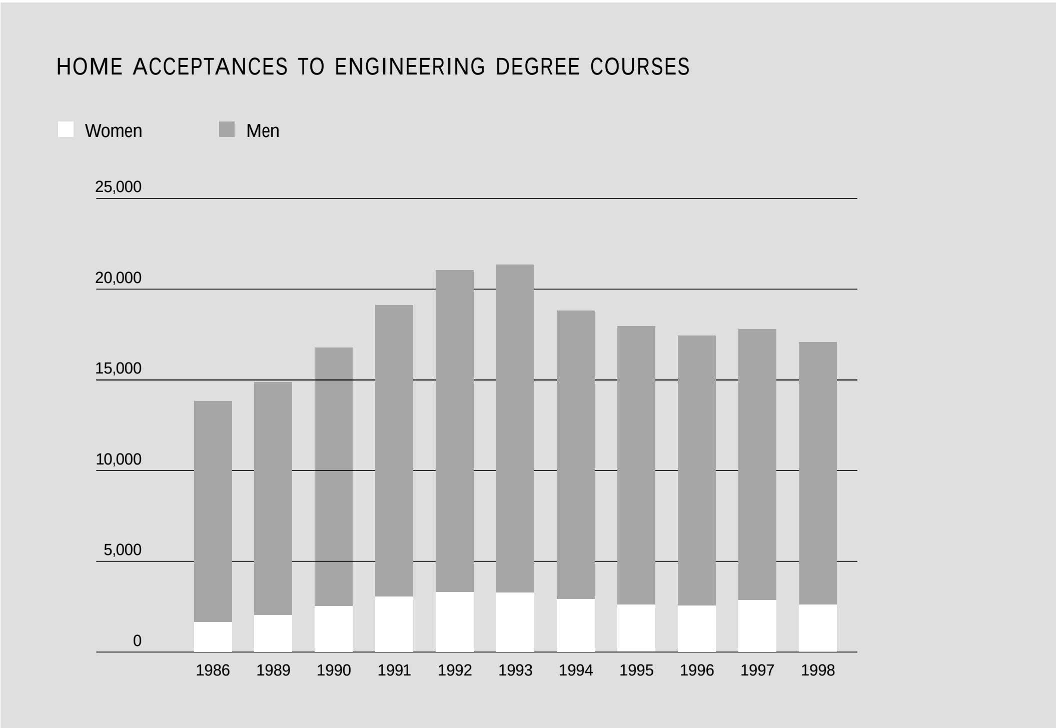
Source: US National Science Foundation

Figure 3



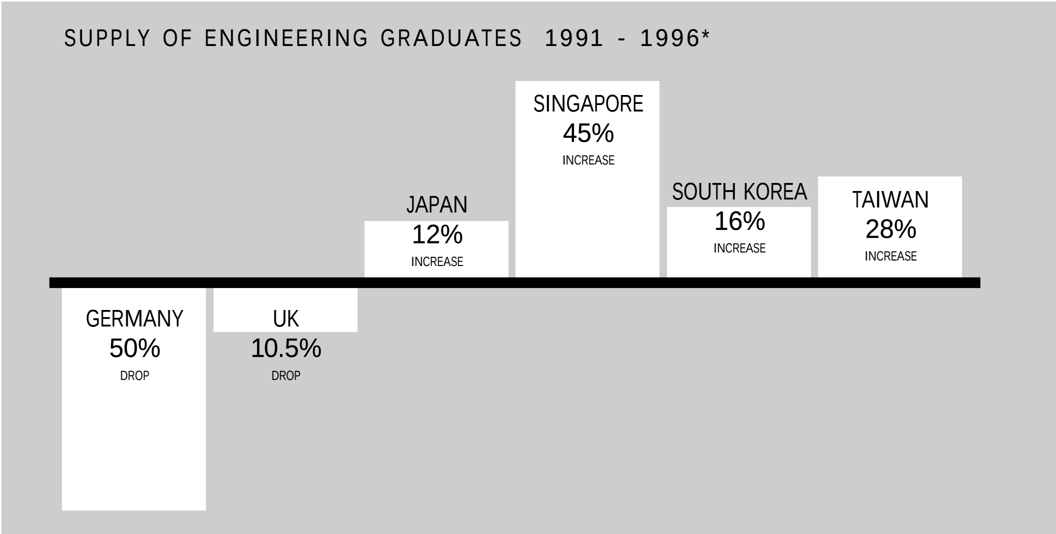
Source: OECD

Figure 4

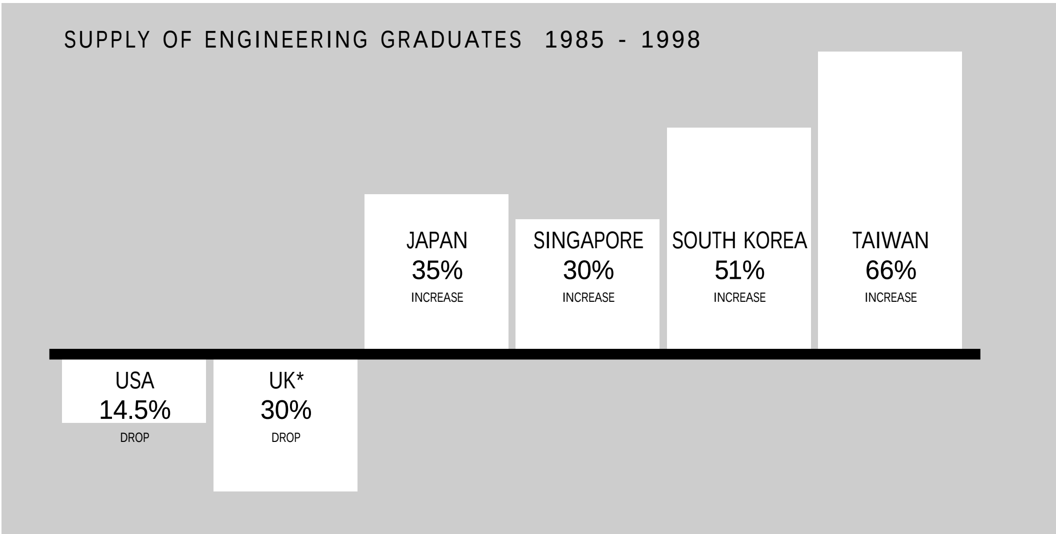


Source: UCAS / UCCA / ICAS Annual Reports

These figures make an interesting comparison with corresponding trends in Pacific Rim countries over the same period.



* *The figures for Germany and UK are entrants into university courses: for the Pacific Rim they apply to graduates. The comparison is valid provided the wastage rates do not vary significantly over the period.*



Nor is the problem confined to the UK, Germany and the USA: most Western countries report similar difficulties in persuading their young people into science and engineering undergraduate courses. The severity of the problem is not uniform across the higher-education system: the most prestigious schools are still able to recruit high-quality candidates – the difficulty is with the 'tail'. This in turn is reflected in the wide range of entry qualification specified by UK universities for entry into their engineering schools.

* *Note: UK 1988-1998*

The Technician Problem

In this report so far, I have concentrated largely on the engineering profession as it relates to chartered engineers. In part, this is because the most readily available information comparing one country with another concerns that level of the profession. But there are many who would argue that for the UK the most serious deficiency lies with the more ‘practical’ end of the professional spectrum – in Engineering Council terms with the Incorporated Engineer and the Engineering Technician – especially the latter.

This is a tricky area: little comparable information is available and even among similar nations there are wide variations in definition (annexes 1 and 2).

For many years the National Institute for Economic and Social Research (NIESR) has made a special study of this problem with particular emphasis on comparison between the UK and Germany. Their broad assessment is summarised in the tables below:

VOCATIONAL QUALIFICATIONS OF THE WORKFORCE
IN BRITAIN 1974-78 AND GERMANY 1978

	Manufacturing		Chemicals		Engineering	
	Britain	Germany	Britain	Germany	Britain	Germany
Higher and bachelor degree	3	4	9	8	4	4
Intermediate qualification	29	61	29	63	34	63
No vocational qualification	68	36	62	30	62	32
Total	100	100	100	100	100	100

VOCATIONAL QUALIFICATIONS OF THE WORKFORCE
IN BRITAIN 1990 AND GERMANY 1984

	Manufacturing		Chemicals		Engineering	
	Britain	Germany	Britain	Germany	Britain	Germany
Higher degrees[1]	1	3	3	8	1	4
First degrees Britain *Fachhochschule diplomes	7	3	12	4	8	6
Sub total	8	6	15	12	9	10
Intermediate qualifications[2]	35	68	27	67	42	68
No vocational qualifications	57	26	57	21	49	23
Total	100	100	100	100	100	100

1 British PhD and Masters; German PhD and Diplome (U)

2 British HNC, HND, City & Guilds, apprenticeships: German Techniker and Meister Qualifications, Berufsabschluss.

The overall pattern is clear: taking all graduates together there is little difference between the two countries – indeed over the 16 years of the study, the balance has moved in favour of the UK. For the lower levels of qualification, however, Germany has a marked preponderance of qualified over unqualified whereas the reverse is true of the UK.

Does it matter: the NIESR thinks so, to quote:

> *'Recent studies suggest that there is a positive, and statistically significant, association between Anglo-German difference in the proportions of the workplace qualified to intermediate level and relative performance in respect of labour productivity and export competitiveness.'*

I comment on this last claim later in the report. For the rest, it is only fair to point out that, since the NIESR study there has been a number of UK developments in the area of so-called 'intermediate' qualifications, notably:

- the advent of NVQ's and GNVQ's
- the creation of modern apprenticeships and national traineeships

Though introduced with the best of intentions, NVQ's and GNVQ's have had a shaky start in life: both have been the subject of major reviews and will, hopefully, prove more generally attractive and applicable as a result. That said, what evidence there is suggests that the number of those taking NVQ3 (Engineering Technician) and HNC/HND (Incorporated Engineers) are slipping. Moreover, many of those taking HNC/HND are being encouraged to go on to a degree qualification. This tends to inflate the number of HNC/HND completions while disguising the fall in HNC/HND diplomas available to industry.

The introduction of modern apprenticeships (MA) has been more of a success story: there are currently 24,000 young people in the MA scheme and the scheme gets good marks from trainees and employers. The aim is to increase the numbers to 36,000.
This target is at risk from three sources: the attitudes of potential recruits and their parents; the tendency already noted for school leavers to move either directly or through HNC/HND into higher education; and the complex system of funding the apprenticeship system of skills training. The Department for Education and Employment has recently published a White Paper* which, among other things, puts forward proposals for a single Learning and Skills Council to 'drive forward improvements in standards and bring greater coherence and responsiveness.' The Council will deliver all post-16 education and training – apart from HE.

* *Learning to Succeed - a New Framework*

These initiatives, if put into practice, will no doubt have some effect on the training and education of technicians: what remains to be seen is whether they can overcome the problem of attitude which still bedevils the British approach to the technician problem.

Some confirmation of these trends is given by the variation in the number of registrations for Incorporated Engineers and Engineering Technicians. For the past decade they have shown a downturn trend – 55,000 to 51,000 incorporated, 17,000 to under 16,000 technicians. But these figures have to be treated with caution: only a small proportion of those qualified actually register.

The problem of numbers is compounded by the diversity – some might say confusion – of provision in this area. There are 840 NVQs and 1,800 other vocational qualifications approved for Government funding; and more than 17,000 vocational qualifications outside the NVQ framework. Aside from their confusing nature, vocational qualifications are seen by many young people and their parents as closing down options rather than keeping them open: apprenticeship training is wrongly perceived as excluding the possibility of later going on to higher education.

These problems have been analysed recently by the National Skills Task Force** (NSTF): they have identified a number of shortcomings in the UK approach and suggested improvements.

** *Delivering Skills for all: second report of the NSTF 1999*

Status and Rewards

Of all the topics covered in this report, few are likely to cause more contentious debate than the status and rewards of British engineers compared with their opposite numbers in other countries.

Every year the Engineering Council (EC) produces a survey of Registrants' earnings within the British profession: the survey is invariably greeted with the criticism that it presents an over-optimistic picture of what engineers earn. Nevertheless, the EC figures are the most comprehensive available and I have used them in the analysis that follows.

Starting with the newly fledged graduate, the EC gives the following league table of median salaries:

MEDIAN SALARIES OF GRADUATES

	£
Auditing	16,500
Marketing	16,250
Computing	16,000
Engineering	16,000
Accounting	15,500
Personnel	15,250
Management	15,200

Source: Association of Graduate Recruiters (AGR).
These figures apply to 1998 and to mostly the larger companies, who pay above the market rate.

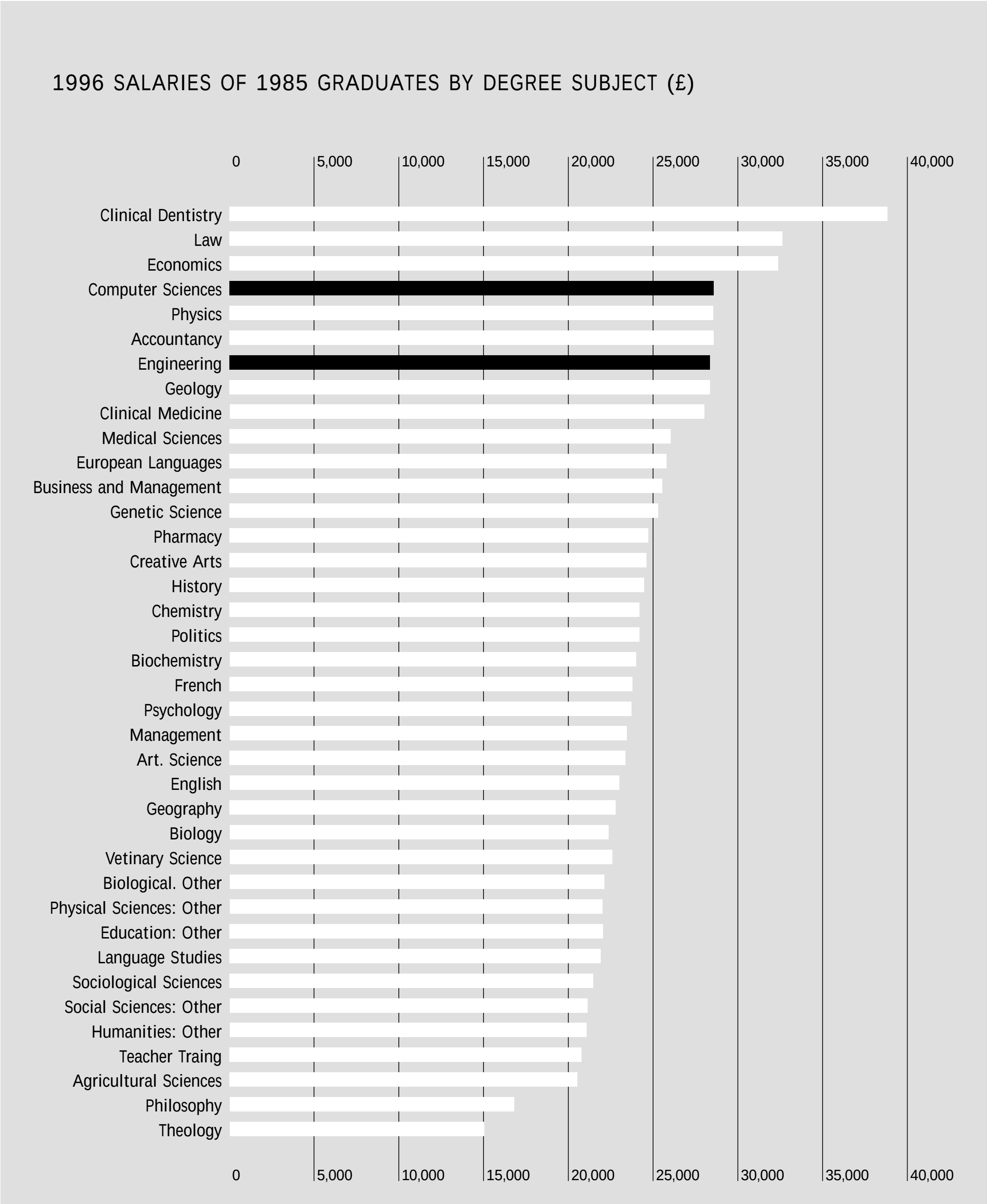
At a later career stage, a comparison of the 1996 salaries of 1985 graduates puts engineering in 7th place out of 38 university disciplines: surprisingly, engineering salaries rank above those for clinical medicine (Fig 5).

The median earnings of registered engineers and technicians are given as:

MEDIAN SALARIES OF REGISTERED ENGINEERS AND TECHNICIANS

	1995 £	1997 £	1998 £	1999 £
Chartered Engineer	31,000	34,000	35,800	37,994
Incorporated Engineer	25,980	26,850	28,000	28,980
Engineering Technician	21,000	23,500	24,100	25,000

Figure 5



Source: HEFCF. Mapping the Careers of Highly Qualified Workers

Comparison of earnings with other countries is fraught with obvious pitfalls. Taking the general scene first, a study of 1990* concluded that for experienced engineers' earnings in the UK lay 10th out of a league table of 11: the ratio Germany:UK was 2.2:1. A 1997 study quoted by FEANI gave a ratio of Frankfurt: London of 2.2:1 – but the agreement may be coincidental since the FEANI figures were adjusted for purchasing power.

As against that evidence, the latest evidence from Germany suggests an average salary of around £51,000 for a Dipl. Ing. in his mid 40's: this compared with the EC figure of £42,000 for the average earnings of a Chartered Engineer. As might be expected the UK runs a poor second to the USA in terms of starting salaries (Table 1).

The question of status is even more fraught: again the EC has produced some interesting numbers on career prospects and status within industry and commerce.

For the manufacturing sector the latest figures for the qualifications of top executives are as follows:

QUALIFICATIONS OF TOP EXECUTIVES

	%
Unqualified	62
Qualified in science/engineering/technician	24
Qualified in accountancy	6
Other graduates	7

and for companies in the FTSE 100, directorships fall-out like this:

DIRECTORSHIPS IN THE FTSE 100

	Engineers	Accountants	Others
Industry	28	19	53
Commerce	9	32	70
Finance	6	22	72
All sections	14	21	65

In terms of top executives in the FTSE 100:

TOP EXECUTIVE IN THE FTSE 100

	Engineers	Accountants	Others
Industry	40	9	51
Commerce	7	22	71
Finance	4	9	87

* *Training and employment of engineers in Europe – EGOR Group 1990*

None of this looks too depressing, but the low social status of engineer in Britain remains a problem. In terms of comparison with other countries and notably the G7 group – we lag in the status race, although curiously enough, although the status of engineers in these countries is still high they all – with the exception of Japan and the Pacific Rim – report reducing numbers entering engineering degree courses to the extent that, certainly in the USA and Germany there is concern about the match between supply and demand.

Associated with the overall status of the engineers in the UK is the particular issue of the standing of degree courses in terms of A-level scores for entry. I have not studied this aspect in detail but a cursory examination suggests a huge variation from a score of 30 (3 A's) for Cambridge to 6 or 8 (D and E) for some former polytechnics. In fairness, some of the latter were former HNC/HND courses in building rather than full-blown classic engineering courses. This wide variation in entry standards was addressed by SARTOR 3rd Edition (published 1997) in terms of relating accreditation to entry qualifications: thus for an MEng degree leading to CEng, the exemplifying requirement is 24 A-level points and for BEng (Hons) 18 points – both for 80% of the intake. Similarly the entry requirement for Incorporated Engineering degrees is 10 points – again for 80% of the cohort.

This approach has been criticised as being too demanding for MEng and based on inputs rather than outputs. But, in defence, it does recognise the need for one elite route and it offers – in face of an increasingly wide spectrum of entry ability – an approach to Incorporated status, which is not simply a degraded MEng.

TABLE 1

STARTING SALARIES - ENGINEERS AND SCIENTISTS IN THE USA AND UK
£1 = $1.6

	USA*	UK**
Chemical Engineering	36,400	
Civil Engineering	30,000	
Electrical Engineering	37,500	
Mechanical Engineering	32,500	
Life Sciences	20,000	
Maths and Computer Sciences	28,000	
Physical Sciences	23,800	
Social Sciences	23,800	
All		15,000 - 18,000

* *1998 figures from the National Science Foundation for PhD graduates*

** *from the EC for 1st degree graduates.*

Note: This table does not exactly compare like with like. Also it ignores relativities with other disciplines and national earnings. Exchange rates are used rather than a purchasing power parity (PPP) measure.

Outputs

So far, in my treatment of outputs I have concentrated on what might be termed intermediate outputs: measures which relate to the UK performance compared with like countries in terms of numbers of people and degrees. These give a general sense of where the UK engineering profession stands but they tell us little about our industrial performance which is one – but only one - significant measure of how well our engineering profession performs compared with that of other countries.

The problem is that any measure – productivity is the usual criterion – is hedged around with so many variables that the isolation of any one parameter becomes painfully difficult.

The most recent comprehensive study of the topic is a report by Mary O'Mahony of the NIESR.* In this analysis, O'Mahony makes a stab at estimating how the relative labour productivity performance of Britain, the United States and Germany is affected by differences in skill levels in the working population compared with other factors – I shall concentrate on this aspect of her work.

But to start with the overall picture: Table 2 summarises relative productivity between five major countries in terms of various measures and Table 3 the development of labour productivity

1950 – 1998. In what follows I use market output per hour as a measure of productivity: this differs from GDP per hour in excluding the contribution of government administration, education and health.

'Thus, according to one estimate the 1995 labour productivity levels for Britain and Germany are brought to near equality when allowance is made for skill differences, whereas the comparison between Britain and the US is little affected.'

A sectoral analysis reveals a rather more complex situation. In Table 5 O'Mahony gives labour productivity figures for a number of sectors. Without going into too much detail, the table illustrates that in some sectors – Financial & Business Services for example – the British performance is better than the aggregate figures, in others – manufacturing say – it is significantly worse.

If allowance is now made for extra factors – fixed capital investment for example – the relative British labour performance is improved; confirming the poor British resources of capital investment over the period. (Table 6).

* *Britain's Productivity Performance 1950 – 1996: An International Perspective: National Institute of Economic and Social Research (NIESR) 1999*

Table 2

BRITAIN'S RELATIVE LABOUR PRODUCTIVITY POSITION, 1996 (UK=100)

	UK	US	France	Germany	Japan
GDP per capita	100	137	105	113	113
GDP per person engaged	100	129	126	126	102
GDP per hour	100	121	132	129	90
Market output per hour	100	128	120	131	81

Table 3

LABOUR PRODUCTIVITY[a] IN THE AGGREGATE AND MARKET ECONOMIES

	UK	US	France	Germany[b]	Japan[c]
A Total Economy					
Growth rates (% per annum)					
1950-96	2.60	1.55	3.70	3.87	4.48
1950-79	2.99	2.34	4.62	5.18	6.11
1973-96	2.22	0.77	2.78	2.56	3.06
Levels (UK=100)					
1950	100	195	79	72	41
1960	100	197	95	96	47
1973	100	166	116	119	74
1979	100	154	130	131	79
1989	100	133	137	125	87
1996	100	121	132	129	90
B Market sectors[d]					
Growth rates (% per annum)					
1950-96	2.97	1.97	4.08	4.07	5.02
1950-73	3.38	2.74	5.25	5.44	7.20
1973-96	2.55	1.20	2.92	2.70	3.13
Levels (UK=100)					
1950	100	203	72	79	36
1960	100	208	90	102	44
1973	100	175	110	126	71
1979	100	160	123	140	74
1989	100	137	130	131	80
1999	100	128	120	131	81

Notes
a. Output per hour worked
b. Formerly West Germany
c. The data series for Japan starts in 1953
d. Excluding non-market services

Table 5

LABOUR PRODUCTIVITY LEVELS BY SECTOR (UK=100)

		US	France	Germany	Japan
Agriculture, forestry and fishing	1950	155	34	26	22
	1960	192	45	36	30
	1973	126	43	38	23
	1979	113	47	42	20
	1989	139	59	47	20
	1996	144	75	52	19
Mining and oil refining	1950	210	51	75	4
	1960	335	110	140	10
	1973	303	127	231	32
	1979	296	341	406	66
	1989	234	218	193	38
	1996	107	116	87	20
Electricity, gas and water	1950	425	64	109	151
	1969	492	83	137	193
	1973	370	143	134	228
	1979	301	166	158	232
	1989	219	179	122	200
	1996	163	120	84	143
Manufacturing	1950	290	77	74	47
	1960	86	111	48	
	1973	186	101	115	94
	1979	190	133	147	126
	1989	162	126	119	134
	1996	171	130	126	147
Construction	1950	226	76	62	80
	1960	318	86	99	82
	1973	183	102	120	136
	1979	158	119	137	138
	1989	112	124	107	123
	1996	84	96	84	96
Transport and communications	1950	189	88	65	30
	1960	177	92	83	50
	1973	174	113	92	73
	1979	181	133	109	70
	1989	146	137	102	56
	1996	113	117	100	55
Distributive trades	1950	152	126	76	15
	1960	164	146	92	18
	1973	146	139	106	56
	1979	147	159	122	72
	1989	143	149	109	83
	1996	155	143	111	96
Financial and businesss services	1950	194	92	55	30
	1960	189	125	77	33
	1973	187	169	134	59
	1979	151	141	137	51
	1989	118	141	145	51
	1996	115	112	169	56
Miscellaneous personal services	1950	200	141	40	44
	1960	177	163	61	47
	1973	172	163	104	87
	1979	480	175	119	83
	1989	175	176	151	34
	1996	133	132	145	67

Table 6

TOTAL FACTOR PRODUCTIVITY: RELATIVE LEVELS BY SECTOR (UK=100)

		US	France	Germany	Japan
Agriculture, forestry and fishing	1973	88	61	45	31
	1979	76	59	46	22
	1989	100	61	45	18
	1995	100	65	46	15
Mining and oil refining	1973	146	83	186	20
	1979	175	261	435	44
	1989	189	232	327	38
	1995	140	177	240	22
Electricity, gas and water	1973	219	88	119	213
	1979	170	92	119	165
	1989	126	95	91	120
	1995	115	87	79	100
Manufacturing	1973	159	89	102	86
	1979	168	118	133	116
	1989	143	103	108	115
	1995	142	103	106	116
Construction	1973	150	87	101	134
	1979	135	100	116	132
	1989	101	93	88	97
	1995	84	78	70	74
Transport and communications	1973	139	107	81	86
	1979	144	118	94	84
	1989	120	117	83	76
	1995	111	110	85	59
Distributive trades	1973	119	116	90	61
	1979	127	136	109	74
	1989	128	126	102	82
	1995	135	126	106	94
Financial and businesss services	1973	182	215	150	82
	1979	171	190	150	74
	1989	124	174	139	61
	1995	122	134	141	59
Miscellaneous personal services	1973	157	170	87	123
	1979	167	82	95	104
	1989	164	164	110	84
	1995	135	131	115	83

O'Mahony divides skill levels into high and intermediate and low (roughly HE, FE and none); and she summarises the effect on productivity as follows (Table 4):

Coming now to the issue that concerns us in this report – the effect of skill mix on productivity. Table 7 gives a breakdown of the skill mix between Britain, the USA and Germany. Here,

- Higher – degree or above;
- Intermediate – craft to sub-degree;
- Low – effectively no qualifications

The pattern varies from sector to sector but between Britain and Germany it is the now familiar one of Germany high in intermediate and low in higher, with the reverse trend in Britain. The place of the US is interesting; higher than either Britain or Germany in the higher qualification, lower than Britain and much lower than Germany in intermediate.

What is to be made of all this? O'Mahony makes a brave attempt to boil it all down by estimating and isolating potential influences on labour productivity:

- skills
- capital investment
- the residuals – product and process innovation, organisational change

Her analysis is shown in Table 8. In brief, this demonstrates that the contribution of skills to labour productivity is small: 1 percentage point out of 27 for the UK/USA comparison and 4 percentage points out of 29 for the UK/Germany comparison. Given that from 1995 – 1999 the relative British performance in terms of Higher has almost certainly improved, the skills contribution is likely to be correspondingly smaller.

Taking a common sense view this analysis of output suggests two conclusions in relation to the structure of the engineering profession in the UK:

- it would be foolish to assume that an increase in the proportion of intermediate-level qualifications will of itself produce significant increases in productivity;
- it would be equally foolish not to continue our attempts to improve, rationalise and increase our involvement in this area of education and training

However, O'Mahony herself does point out that the growth accounting method used and its underlying assumptions may well underestimate the contribution of labour force skills in explaining different levels of productivity.

Table 4

LABOUR FORCE SKILLS AND PRODUCTIVITY, 1995

	UK	US	Germany
Skills proportions (higher), 1993	10.6	17.1	7.6
Skill proportions (intermediate), 1993	30.3	16.8	62.9
Market TFP, 1995	100	119	115
Market TFP with skill adjustment (1), 1995	100	118	111
Market TFP with skill adjustment (2), 1995	100	116	104

Table 7

SKILL PROPORTIONS OF THE WORKFORCE: MANUFACTURING

			UK	US	Germany
Chemicals and allied industries	1978/79	Higher	8.0	12.6	6.1
		Intermediate	31.5	6.5	59.3
		Low	70.5	76.9	34.6
	1993	Higher	14.9	27.1	10.2
		Intermediate	28.2	15.2	59.1
		Low	56.9	57.7	30.7
Metals	1978/79	Higher	3.3	7.9	2.1
		Intermediate	23.2	8.1	61.3
		Low	73.5	84.1	36.6
	1993	Higher	5.1	8.8	3.8
		Intermediate	38.0	15.4	63.7
		Low	56.8	75.8	32.5
Engineering	1978/79	Higher	5.1	10.9	4.2
		Intermediate	30.9	11.5	54.0
		Low	64.0	77.6	41.8
	1993	Higher	10.9	21.6	10.5
		Intermediate	45.3	18.0	63.6
		Low	43.8	60.4	25.9
Textiles, clothing and leather	1978/79	Higher	1.8	1.9	1.2
		Intermediate	8.9	4.8	48.7
		Low	89.3	93.3	50.1
	1993	Higher	3.6	7.7	2.6
		Intermediate	20.3	6.5	58.1
		Low	76.1	85.9	39.0
Food, drink and tobacco	1978/79	Higher	2.9	4.9	1.4
		Intermediate	12.3	6.2	61.2
		Low	84.8	88.9	37.4
	1993	Higher	6.7	12.6	2.7
		Intermediate	25.4	11.3	65.7
		Low	67.9	76.2	31.6
Other manufacturing	1978/79	Higher	3.7	9.6	2.0
		Intermediate	22.5	8.1	60.9
		Low	73.6	62.3	37.1
	1993	Higher	8.9	17.7	4.5
		Intermediate	33.9	14.5	65.1
		Low	57.2	67.8	30.4

Table 8

RELATIVE SKILLS AND DIVISION OF LABOUR PRODUCTIVITY LEVELS, 1995

	Relative skills		Contribution of		
	UK=100	Skills	Capital	Residual	Total
A. US					
Agriculture, forestry and fishing	103.3	1.8	30.0	-2.4	29.4
Mining and oil refining	97.6	-0.8	-37.1	26.0	-11.8
Electricity, gas and water	95.7	-1.4	35.7	22.4	56.7
Manufacturing	101.5	1.0	15.9	47.3	64.1
Construction	96.3	-3.0	4.0	-13.3	-12.3
Transport and communication	103.7	2.4	6.8	9.5	18.6
Distributive trades	104.1	2.8	13.9	36.7	53.3
Financial and business services	101.0	0.6	-5.6	20.6	15.5
Miscellaneous personal services	100.6	0.6	2.0	35.5	38.1
Total all sectors	102.3	1.6	7.4	11.5	20.6
Total market sectors	101.4	0.9	6.2	19.6	26.7
B. Germany					
Agriculture, forestry and fishing	106.7	4.1	11.3	-64.2	-48.9
Mining and oil refining	100.9	0.2	-71.0	40.2	-30.5
Electricity, gas and water	103.0	1.2	2.3	-22.2	-18.8
Manufacturing	106.1	-1.5	12.0	4.1	20.6
Construction	105.5	4.0	22.5	-40.4	-14.0
Transport and communication	110.7	6.9	16.3	-24.6	-1.6
Distributive trades	110.6	3.2	7.7	-1.6	14.3
Financial and business services	102.4	1.1	19.5	44.2	54.8
Miscellaneous personal services	105.3	3.9	29.9	16.0	49.8
Total all sectors	106.5	4.6	16.7	5.7	27.0
Total market sectors	106.3	4.1	12.2	12.9	29.2

Notes: The total contribution is calculated as the labour productivity levels with UK set equal to 100 minus 100. Skills contribution is measured as $\exp(\alpha^{J,UK}\ln(H_{J,UK}))-1).100$*, capital's contribution by* $(\exp((1-\alpha^{J,UK})\ln(K_{J,UK}))-1).100$ *and the residual as the total difference in labour productivity levels minus the sum of the contributions of physical and human capital.*

The Royal Academy of Engineering

I have not dealt in detail with the role of the Academy partly because the main responsibility for structural development of the profession lies with the Engineering Council and the engineering Institutions.

Nevertheless, the Academy has a key role to play in the advance of the engineering profession both as an advisor and as an originator of strategic thinking. Its international influence is greatly enhanced by the leading part that it plays in the Council of Academies of Engineering and Technological Sciences (CAETS). The Council is an independent non-political and non- governmental international organisation of like academies: at present there are 18 country members.

The stated objectives of CAETS are:

- to provide an international forum for discussion and communication of engineering and technological issues of common concern;
- to foster co-operative international engineering and technological efforts through meaningful contacts for development of programmes of bilateral and multilateral interest;
- to encourage the improvement of engineering science internationally;
- to foster the establishment of national engineering academies where none exists; and
- to contribute to the strengthening of engineering and technological activities in order to promote sustainable economic growth and social welfare throughout the world.

International Collaboration

In this report, I have concentrated on comparing and contrasting the operation of the engineering profession in a number of 'similar' countries to see if there are lessons to be learnt for the profession in the UK. A parallel movement is the growing activity concerned with improving international collaboration between nations that have an interest in the advancement of engineers and the engineering profession. I have already described the role of CAETS: in addition a number of the engineering Institutions have close links with sister Institutions in other countries. But the main focus of country to country negotiations lies in the Engineering Council.

There are currently three bodies mainly involved: the European Federation of National Engineering Associations (FEANI); the so-called Washington Accord and the World Federation of Engineering Organisations (WFEO).

FEANI

FEANI has around 27 members covering more than 1.5 million engineers. Its aims are:

- to affirm the professional identity of the engineers of Europe, and to promote the mobility and employability of engineers;
- to strive for a single voice for the engineering professions of Europe, whilst acknowledging their diversity;

Broadly, its activities cover all the aspects of the profession that have been covered in this report. Probably its most important and best known activity is the register of engineers, which awards the title Eur. Ing.

The Washington Accord

The Washington Accord dates from 1989. It is an agreement between eight English-speaking countries, having similar procedures for registration of professional engineers: USA, Canada, South Africa, Australia, New Zealand, Ireland, Hong Kong and the United Kingdom.

The original agreement concerned simply the acceptability of engineering degree courses, which had been accredited by one of the national bodies. While enabling the academic hurdles to registration to be cleared, it still allowed each country to apply its own requirements for assessment of professional development and training.

Under the chairmanship of Dr John Webster, former Director-General of the Institution of Engineers of Australia, considerable efforts have been made in the last two years to widen the agreement. The Engineers' Mobility Forum was set up with the specific intention of identifying the basis for mutual recognition of registered engineers from the countries concerned. A draft agreement is now in place, which envisages that engineers with seven years' professional experience after graduation would, in principle, be recognised. There are also provisions for 'fast track' engineers four years after graduation. The main stumbling block appears to be the difficulty federal agencies have in delivering agreement from state registration authorities in the United States.

There are implications for the Engineering Council and the Nominated Bodies as well. Adoption of the EMF agreement would require changes to Nominated Body procedures designed for applicants from EMF member countries outside the UK.

The other important area of development has been creation of a Forum to discuss mutual recognition of Incorporated Engineers/Technologists. (six of the eight national bodies call their Incorporated Engineers 'Technologists'). Several meetings have taken place, with considerable progress made on identifying characteristics of this important and growing section of the professional engineer population.

The World Federation of Engineering Organisations (WFEO)

The WFEO was established with the support of UNESCO in 1968. It is 'committed to the advancement of the world engineering profession for the benefit of mankind.' It works particularly to assist engineering development in the developing countries, and in the transfer of technology from one country to another. It works to improve the community understanding of engineering, the quality of engineering education and training, and the standards of engineering practice.'

In spite of this resounding remit, the effectiveness or the WFEO has been called into question by the Engineering Council and the Council has now withdrawn support for all WFEO activities other than those directly related to international recognition of engineering qualifications.

Conclusions

Taking my main headings:

Organisation

The Engineering Council has recently put forward a comprehensive review of its modus operandi* and, in particular, its relationship with the Institutions. It is manifestly too early to have yet another major review and the intrusion of a third party into the existing dialogue would simply add confusion.

Education and Qualifications

The higher education of engineers and, to an extent their professional development, is covered by SARTOR 3rd Edition (published in 1997). Given the long and sometimes acrimonious debate over the SARTOR 3rd Edition (published in 1997) concept, the sensible course now is to see how it develops in practice. In addition there is a continuing debate on the content of engineering degree courses+ with the associated question of remedial maths courses for undergraduate entry. Standards are highly variable.

That leaves open the conundrum of what I have called the ‘technician problem’. But this is in a sense only a part of the wider question of sub-degree education, which is suffering from a multiplicity of initiatives – actual and proposed.

One part of this activity is the status of the so-called over-arching certificate: but we have been round that buoy too often already.

Aside from that particular issue there is, in the context of achieving a first-class engineering profession in the UK, still much concern about the output standard of schools.

* *Building on the lasting new relationship. Report of the Engineering Council Activity Review Group. January 1999*

+*Engineering Higher Education. The Royal Academy of Engineering 1996*

Accreditation

The UK system is clearly one of the most comprehensive around but also – on paper at least – one of the most complex. There is work to be done here but developments must have regard to the EC initiatives on output-based systems.

Legislation

Still one of the most argued over issues. I believe that the connection between status and licensing is a chimera: in any case the question was specifically targeted and expounded in the Fairclough report.

Status

Apart from licensing, there is the more general question of the debate on status. I would suggest that there are bodies directly and indirectly involved who might contribute to this: the successor to the year of Engineering Success rumbles on: the EC has in mind a publicity programme which, among other things, would aim to 'market' C.Eng, I.Eng and Eng. Tech. The great lacuna here is the continuing misapprehension in the media about the nature and status of engineering.

Annex 1

1A United Kingdom

Organisation
The organisation of the engineering profession in the United Kingdom is founded on a central body – the Engineering Council (EC) – and forty or so engineering Institutions (EI's) covering individual engineering disciplines.

The mission of the EC is to enhance the standing and contribution of the engineering profession in the national interest and to the benefit of society.

The Council has a senate of 54 members

24 elected by voting registrants (i.e. members of EI's)
24 elected by the governing body of nominated bodies (i.e. EI's)
6 appointed by the Privy Council.

There are two subsidiary boards:

The Board for Engineers' Regulation (BER)
Which defines, monitors and reviews the education and training standards and the continuing professional development of engineers and technicians registered with the Council.

The Board for the Engineering Profession (BEP)
Which implements activities that provide a focus in the United Kingdom on matters that affect the whole engineering profession.

The EC maintains a National Register of qualified engineers and technicians. Currently there are 290,000 Chartered Engineers (CEng), Incorporated Engineers (IEng) and Engineering Technicians on the Register.

There are about 40 'Nominated' EI's: this status allows the EI to nominate individuals who have satisfied registration criteria for entry into the Engineering Council's Register. In addition nominated EI's may accredit education courses and arrangements for initial profession development (IPD). They may also assess individual candidates with non-standard backgrounds. The BER performs audits of nominated EI's.

As well as this regulatory role, EI's have a major function as Learned Societies. In partnership with the Engineering Council they accept an overall responsibility for advancing the interests of the profession as a whole.

Education and Qualifications

The traditional qualification taken in the UK universities is the three-year bachelor degree. Most of the qualifications are 'Honours' degrees divided into first, second or third class honours. About 10 – 15% of those graduating will achieve first-class degrees. In addition there are 'Pass' degrees: these have less prestige than Honours degrees.

Many engineering departments now run four year Masters degrees. The use made of the extra year varies: the student may take technical courses, which are more advanced than those at Bachelor level; or he may take courses in business, management or languages.

In addition to this system of Higher Education there is a wide range of colleges offering qualifications at sub-degree level.

Individual engineering Institutions offer membership at various levels depending on their experience and academic qualifications. This system is co-ordinated with the Engineering Council's definition of requirements for entry into the EC register – Standards and Routes to Registration (SARTOR).

There are three grades of engineer on the EC register:

Chartered Engineers (CEng)
Incorporated Engineers (IEng)
Engineering Technician (Eng. Tech)

CEng

For CEng the basic requirement is either a 4-year accredited MEng degree or a 3-year accredited BEng Hons degree plus a 'matching section'. After academic studies the CEng candidate must show evidence of Initial Profession Development (IPD) i.e. the acquisition of skills relevant to practice in a specific area of engineering.

The final step before registration is a stringent professional review of the competence achieved through IPD.

IEng

For IEng the educational requirement is an accredited 3-year Incorporated Engineer degree course or an accredited HND course followed by a period of further learning in a 'matching section'.

As for the CEng the academic courses are followed by a period of approved and assessed IPD.

Eng.Tech

For Eng. Tech the educational base is roughly at Baccalaureate level followed by an approved and assessed period of IPD.

Candidates for the register must be members of an Institution and they are ‘presented’ to the EC by their ‘parent’ Institution.

The latest figures give the following split of numbers on the EC register:

CEng	200,000
IEng	50,000
Eng. Tech	16,000
	266,000

This figure could be compared with the total membership of the Institutions, which is about 620,000 but in any case is larger than the number of registrants because they include students and graduates. However there are clearly many academically qualified engineers who choose not to join the Register.

Accreditation

The Quality Assurance Agency (QAA) assesses the quality of all UK degrees, including engineering degrees, for Higher Education. Accreditation is seen as something related, but different to quality in the UK: it is a judgement as to whether the graduate is adequately prepared to start on a career as a professional engineer. The accreditation process is therefore the responsibility of the Engineering Council.

In practice the business of accrediting individual degrees is sub-contracted by the Engineering Council to individual engineering Institutions. In order to be admitted to the C.Eng qualification two elements are required:

- an accredited engineering degree;
- a few years of approved engineering experience after obtaining the degree.

It is therefore important to the engineering student that the degree, which he/she obtains, is accredited. In order to obtain accreditation for a degree, it is first necessary for the university concerned to send a large amount of information to the appropriate engineering Institution. This information will include, for instance:

- entry requirements for students;
- the structure of the course;
- syllabuses;
- samples of examination papers;
- external examiners' reports;
- teaching timetables;
- pass lists and failure rates;
- information on qualifications of teaching and technical staff in the department;
- information on the management structure of the department;
- a statement on the aims and objectives of the course being taught;
- information on the research in the department.

The Institution then appoints a panel to study this documentation and to visit the university department for one or two days. During the visit, they interview staff to clarify issues which they have identified from the documentation and inspect the facilities in the department, such as laboratories and lecture rooms. They also meet technical staff and representatives of the student body. Judgements are made by the panel of the academic standard and of the relevance of what is being taught. At the end of the visit, there is a meeting with the staff of the department, during which the Chair of the panel outlines those things, which the panel liked, and those, which it did not. The Chair then tells the department whether or not the panel will recommend accreditation for the course in question. Normally accreditation, if given, is for a period of between three and five years, at the end of which a further visit will be required if the course is to retain its accredited status.

Continuing Professional Development

Most of the engineering Institutions offer courses in CPD and indeed require such studies for their own qualifications. SARTOR specifies defined periods of Initial Professional Development as a prerequisite to registration. Although it is patchy, a growing number of companies offer CPD courses to their engineering staff.

Regulation and Protection of Professional Titles

The titles CEng, IEng, and Eng Tech are protected by law but the generic term engineer is not. Apart from a few highly specialised activities there is no system of licensing within the UK and hence no legal limitation on whom can claim to practice as an engineer.

Commentary

The engineering profession in the UK is faced with a falling share of the total entry to undergraduate courses. In 1988 the figure was 11%: in 1998 it had fallen to 6%, but over the same period the total number of acceptances of home students entering engineering degree courses increased from 13,641 to 16,298. Within the European Union the UK is second only to Germany in terms of annual intake to engineering undergraduate courses.

1B Canada

Organisation

There is no body equivalent to the Engineering Council in Canada. There are a number of engineering Institutions, mostly of the learned-society kind but one or two that have some responsibility for oversight of the profession. Among these are the Engineering Institute of Canada (EIC) and the Canadian Council of Professional Engineers (CCPE) which has specific responsibility for co-ordinating the activities of the 12 provincial and territorial associations of professional engineers in Canada. The Canadian Engineering Accreditation Board, CEAB, a constituent board of the CCPE, is responsible for the creation and administration of accreditation policies.

Education and Qualifications

With the exception of Quebec, university-level, engineering courses take 4 to 5 years: there is no formal requirement for practical experience during this period but there are arrangements for summer placements and a professional experience year. Taking Bachelor and Masters degrees together, about 17% are Masters.

There is no central control of university programmes but the CEAB has significant indirect influence through the accreditation programme.

Accreditation

Accreditation is exercised by the CEAB - a body controlled by the profession. Since graduation from an accredited engineering programme is the principal way of meeting the educational requirements for a registered professional engineer and the legal right to engineering practice, the CEAB can strongly influence the content and quality of practice in the Canadian engineering education system.

Regulation and Protection of Engineering Title

To become a registered professional engineer and gain the right to practise, a candidate for the title of Professional Engineer (PEng) must have a Bachelor's degree from an accredited engineering programme and at least two years of acceptable experience in industry. Engineering experience is acceptable only if it provides exposure to or experience in the following broad areas: practical experience; application of theory; management; communication and social implications of engineering.

Senior engineers in companies provide supervision: as in other countries many companies, especially smaller ones are finding it increasingly difficult to provide comprehensive training.

Continuing Professional Development

To some extent, CPD in the initial years is driven by the requirement for gaining a licence to practise. The provision of CPD and continuing education beyond the PE level is patchy: as in many other countries, good in large public and private corporations, less so in smaller companies.

1C France

Organisation

France has a number of learned societies connected with engineering and two umbrella bodies, the Commission des Titres d'Ingenieur (CTI) and the Conseil National des Ingenierus et Scientifiques de France (CNISF).

Of these the CTI is a Government-sponsored body formed in 1936 with a triple mission:-

- to accredit all new engineering programmes:
- to assess the quality of existing engineering curricula by means of a 6-year cycle of renewable accreditation:
- to take part in any study related to the strategy and/or development of engineering.

The commission is made up of two colleges each of 16 members. The first college represents employers, professional bodies (including CNISF) and trade unions, while the second represents the 240 schools and universities which award the Diplome d'Ingenieur (there are also 600 NFI schools accredited by CTI). Two thirds of the schools/universities fall under the Ministry of Education, and the others are split under the Ministries of Defence, Industry, Agriculture etc. They may be public or private schools; independent or departments of universities.

The CNISF is a non-governmental organisation recognised as a 'public utility' since 1860. It represents a community of engineers and scientists (450,000 in all): it interfaces with the Administration and has a monopoly to do so. Its direct and indirect membership is about 150,000. Perhaps the most significant recent activity of the CNISF is the initiative it has taken to create a French register of engineers (Repertoire) - see below.

Education and Qualifications

Until the early 1970's engineering education in France fell into two main streams: two-year training of high-level technicians provided in a number of technical secondary schools (Lycees Techniques) leading to the Brevet de Technician Superieur (BTS) and the five-year post-secondary courses leading to the prestigious Diplome d'Ingenieur. What follows is a brief outline of the current evolving system, described as 'an offering that is much richer and more complex than its predecessor'.

Perhaps the simplest route through the maze of French engineering courses is to consider them in terms of duration:

a) Two-year courses

i) at technical secondary schools leading to the BTS (Brevet de Technicians Superieur)

ii) at Instituts Universitaires de Technologie (IUT) created in 1966 and integrated into the universities. They offer a programme leading to the Diploma Universitaire (DUT). There are 150 IUTs with 14 specialist technician courses;

iii) Some universities offer Diplomes et Etudes Universitaire Scientifiques et Techniques (DEUST). The number involved is relatively small and geared towards local needs.

b) Three-year programmes

These comprise one year of post-BTS or post-DUT specialisation leading to a Diplome National de Technologie Specialise (DNTS).

c) Four-year programmes

There are various Masters degrees - Maitrises Technologiques, Maitrises de Sciences, Ingenieur-maitre, offered by universities and and Professional University Institutes - Instituts Universitaire Professionalises (IUP) for students who have already gained the Diplome d'Etudes Universitaires Generales (DEUG).

d) Five-year programmes

There are over 200 five-year programmes leading to the most prestigious French engineering qualification, the Diplome d'Ingenieur. The Diplome may be awarded by the universities or by the more elitist Grandes Ecoles (160) and 72 universities.

In spite of many attempts to modify the courses they provide, the Grandes Ecoles and, to a somewhat lesser extent, the universities, concentrate on developing general skills of analysis, mathematics and engineering science on the premise that the function of an engineering school is to provide their graduates with the conceptual foundation and tools which they can then learn to apply in particular tasks related to their employment - rather than produce finished engineers.
The eventual aim is primarily to produce technical administrators capable of managing a wide range of activities in industry and Government. That said, most Diplomes would be given the opportunity to learn practical skills and people management on the job.

One other category of French engineer is worth mentioning. This is the so-called New Engineering Formation (Nouvelles Formation d'Ingenieurs - NFI), created in 1990. The aim is to allow high-level technicians to become graduates by means of continuing education. Academic courses alternate with extended work experience. NFI's have shorter and light academic courses and longer periods with companies than the traditional Diplome course. The NFI is now evolving into a somewhat different animal - the Ingenieur Technique - based on a full-time course of higher education. A similar approach is available for apprentices: there are upwards of 1,000 apprentices studying for a Diplome.

Accreditation

See under CTI above.

Continuing Professional Development

There is a legislative requirement that French companies spend 2 per cent of their annual payroll on staff training: this appears to have encouraged widespread updating and retraining programmes. There is also a widespread system of continuing education covering all levels of education and allowing progression in the rank of formal qualifications.

Regulation and Protection of Professional Titles

As already explained there is a French register of engineers (the Repertoire) initiated by the CNISF. It is now administered by a Comite d'habilitation with members from CNISF, employers bodies and academic organisations.

There are currently three routes to registration on the Repertoire:

- Ingeneiur Diplome - graduate of a CTI Diploma course: registered automatically
- Ingenieur Reconnu Scientifique - holds another engineering qualification e.g. Maitrise plus five years experience
- Ingenieur Reconnu - holds a BTS or DTU (2 years) qualification, or even no higher education but has 10 - 15 years experience and holds an engineering position of high status within his company

Membership of the Repertoire is about 270,000 (nearly all Diplomes).
The Repertoire has no legislative backing: the only legally protected title in France is the Ingenieur Diplome.

Commentary

The complexity of the profession in France arises mainly from the corresponding complexity of the education and training. This in turn reflects the desire on the part of the Administration to provide formal qualifications for all levels of engineering activities from apprentices to the Diplome of the Grande Ecoles. Pride in the sheer quality of their graduates is mixed with concern that many are too fixed in their ways to meet the rapid and fundamental changes in the world of work.

1D Germany

Organisation

There are upwards of 100 engineering Institutions in Germany. Most of them have the dual function of learned societies and the promotion of their particular specialism. The German profession does not have a central body akin to the British Engineering Council, but there are two umbrella organisations that fulfil some of the EC functions: they are the Deutscher Verband Technisch-Wissenschaftlicher Vereine (DVT) and the Zentralverband der Ingenieurvereine (ZBI). The DVT is an association of 95 societies in the field of engineering and science. Its aim is to promote engineering sciences and the creation of a standardised technological framework. Individual scientific/engineering organisations get involved in the development of the legal framework associated with the administration of the engineering profession through the DVT. By far the largest and most renowned member of the DVT is the Verein Deutscher Ingenieure (VDI).

The VDI has some 130,000 members and 45 regional branches. In 1999, it opened a liaison office in Brussels, which will be responsible for giving advice to policy makers in the Community on engineering aspects.

Its principal aims are:

- to support continued training of engineers in all areas of the profession:
- to offer competent, balanced advice to the Government on all fields of technology and engineering:
- to act as a competent partner in preparing the ground for political decisions involving technological disciplines.

The organisation has 10 Divisions specialising in issues such as: higher education and training; legal affairs; women in engineering; and so on. It also has 18 technical divisions and inter-disciplinary committees specialising in such areas as construction; power engineering; production engineering; micro-electronics and precision engineering.

Two recent examples of the influence of the DVT and the VDI are worth quoting: the new laws relating to the governance of the engineering professional in the Lander (states) (Ingenieurgesetze der Lander) were drafted jointly by the VDI and DVT. The VDI is also deeply involved in the accreditation of Bachelors and Masters degree courses in the engineering sciences - more of this later.

The ZBI comprises 20 engineering organisations with a total of 100,000 members.

Education and Qualifications

Until recently there have been mainly two different grades of engineers depending on whether they have graduated from a university (Universitat, Technische Hochschule-Technische Universitat) or a university of applied science (Fachhochschule).

Diplom-Ingenieur (Univ/TU/TH)

In order to be awarded this degree, graduates need to have completed 4 - 6 years of study and submitted a diploma thesis. Large numbers of engineering graduates do research for their diploma thesis in companies or applied research facilities.

Diplom-Ingenieur (FH)

The Fachhochschulen (FH) developed from the former Ingenieurschulen, which were highly esteemed training centres for industrial engineers: the Fachhochschulen were raised to the status of academic institutions in the 1970's.

To graduate as a Diplom-Ingenieur (FH) the student must successfully complete a 4-year course which includes vocational training and institutionally guided work experience.
At the risk of over simplification, the main difference between FH and TH/TU lies in the treatment of the basic subjects such as mathematics, physics and mechanics: FH is aimed at the professional practice of engineers: TU/TH at the R & D end of the engineering spectrum.

The FH Diplom can also be obtained from one of the so-called comprehensive universities. (Gesamthochschulen).

There is some concern within Germany, that, compared with other European countries, the Diplom approach is too long and too rigid. There is some movement towards the more familiar concept of a 3-year Bachelors degree combined with a 2-year Masters degree. The Technische Universtat Hamburg has a programme of this kind in place (see also under 'accreditation').

Accreditation

Germany's 16 Federal states (Länder) have responsibilities for higher-education policies within the Higher-Education Framework Law. (Rahmen prufungsordnungen). The German institutes of higher education are autonomous self-governing bodies with their own courses and study regulations. But these regulations have to be compatible with the Land laws and have to be approved by the appropriate minister. Against this background, the German authorities argue that there is no need for a formal process of accreditation.

However, as against this, the VDI has recently founded an agency, which will be responsible for accrediting Bachelor and Masters degree courses in engineering. This will involve the participation of a number of engineering and industry associations, which will also provide funding. The agency will be supported by joint bodies of the Federal and State Governments and the engineering faculties of higher education institutions. The agency will apply Quality Management techniques for the accreditation of degree courses.

For these new Masters and Bachelor degree courses there will be no distinction between FH and TU/TH graduates. However, the universities will tend to offer BSc/MSc courses with a bias towards the theoretical approach and the Fachhochschulen BEng/MEng courses with a focus on applied engineering science.

Continuing Professional Development

Almost all German engineering education institutions offer a large number of different courses and seminars for continuing education. Most of them offer seminars or workshops dealing with the latest results of their R&D for participants from related national and international companies at least once a year.

Regulation and Protection of Professional Titles

Germany's 16 Länder passed engineering laws in 1970 - 71 that regulate who are allowed to use the title Ingenieur. This title may be used by science and engineering graduates from German universities, universities of applied science (Fachhochschulen), or an equivalent private engineering college. The title may also be used by those who acquired the title of Ing. grad which was common before the 1970 - 71 laws. The unlawful use of the expression Ingenieur is an offence.

Apart from certain specialist activities mostly in construction there is no requirement for postgraduate experience and no register of qualified engineers.

Commentary

The German profession has no central body directly comparable with the Engineering Council. But the DVT and the VDI combined appear to be fulfilling some of the EC role. Perhaps the most interesting current development is the move towards 'new' Bachelor and Masters degrees and the part that DVT/VDI will play in their evolution.

1E Italy

Organisation

There are two major organisations concerned with engineering policy. At the national level the Consiglio Nazionale deli Ingegneri (CNI) and at the provincial level the Ordine Provinciale degli Ingegneri (OPI).

Consiglio Nazionale deli Ingegneri

The CNI is a body set up by public law for the purpose of overseeing the organisation of the engineering sector at national level. It operates under the jurisdiction of the Ministry of Justice. The Consiglio Provinciale of the Ordine elects its Board every three years in a secret ballot.

The principal functions of the CNI are:

- to safeguard the title and practice of engineers at the national level:
- to give uniformity to activities carried on throughout Italy by means of recommendations and directives:
- to act as a judge of appeals by Italian citizens:
- to advise Parliament and Government on matters concerning the engineering profession: if necessary by drawing up draft bills:

CNI and OPI are involved in learned-society activities and in the development of continuing education for engineers.

The Ordine Provinciale

Each Ordine has its seat in the provincial capital. The OPI is the juridical body responsible for accepting applications for enrolment in the ALBO - register of engineers - and for the maintenance of the ALBO itself. All OPI have the same structure and are self-financed through the annual contributions of their members who elect the Consiglio de l'Ordine (Board) every two years.

In accordance with the Royal Decree no. 2357 (1925) the OPI has the following additional tasks:

- to manage the Ordine:
- to ensure that members who practise do so with integrity and care. The Boards of the Ordine can, if necessary, take disciplinary measures ranging from official reprimand to expulsion:
- to safeguard the title of Engineer: the Ordine's Boards can report abuse to the relevant authorities:
- to advise the public administration when so required.

Education and Qualifications

Engineering education in Italy is supplied by the engineering faculties of the universities and by the polytechnics of Milan, Turin and Bari.

There are two principal paths:

a) the Corso di Laurea (CDL) - 5 years full time:

b) the Corso di Diploma Universitario (CDU) - 3 years full time.

Corso di Laurea

The CDL course has a highly scientific orientation: there is no formal requirement for practical experience though the student has to develop and discuss a degree thesis which takes between six months and one year to prepare. In summary terms the Ingegnera Leureato must have 'good technical skills and must be qualified to carry out all the activities associated with 'design' and 'applied research' and to improve and to develop 'technological innovation.'

Corso di Diploma Universitario

The CDU is relatively new: its aim is to produce engineers who are well qualified to deal with 'short-term technical and industrial problems'. The CDU 'must not produce technicians with knowledge in a narrow sector or generic engineers without any professional skill.' There is a modular system of course structure and a required period of training in industry or a laboratory, usually lasting about three months.

Accreditation

There is no formal accreditation system. In Italy university curricula are defined by law within strict limits and all university degrees have legal status. The Italian authorities regard this system as negating the need for accreditation.

Continuing Professional Development (CPD)

CPD appears to be left to the initiative of individual companies but the CNI considers the development of a more structured CPD system as one of its major priorities.

Regulation and Protection of Professional Titles

By law, any academic title can only be awarded by a university or an Institutis Superiore and abuse of title is a punishable offence. In theory, professional engineers must be members of their Ordine degli Ingegnere: this requires them to pass a State Professional Examination which can be taken soon after the Laurea and is very often a formality. This compulsory membership is often circumvented by engineers employed in industry who do not have to 'sign' any professional document.

The legal status of the Ingegneri Diplomati is at the time of writing still unclear. They cannot be put on the register of their Ordine and their fields of work are correspondingly limited. Legal moves are in hand to try and remove this anomaly.

Comments

Italy has one of the most centrally regulated of all engineering professions and one of the longest degree courses (5 years, sometimes rising to 7). The introduction of the Diploma recognised the need for more flexibility and the demand for a shorter period of academic study.

1F Japan

Organisation

There is no central body in Japan having powers similar to those of the Engineering Council. Instead, the engineering profession in Japan is divided into four systems. The first of these is a corps of registered engineers known as Gijutsushi under the jurisdiction of the Science and Technology Agency (STA). The STA has designated the Japan Consulting Engineers Association (JCEA), a non-governmental institution, as the official body responsible for managing examinations and registering professional engineers (Gijutsushi). The JCEA is effectively an ‘administrative organisation’ which in addition to its formal duties relating to the Gijutsushi, interfaces with Government, organises continuing education, monitors rates of professional fees etc.

There are 19 technical disciplines covered by the Gijutsushi, most including conventional engineering activities, aerospace, mining, civil and so on, but also including agriculture, forestry and fisheries.

The second system, Kenchikushi, is under the Ministry of Construction and covers the field of architectural/civil engineering. In a country so prone to earthquakes, the qualifications of those involved in civil engineering and building work is strictly controlled. Put simply, the design of buildings and the supervision of buildings construction can only be undertaken by Kenchikushi. The Ministry of Construction also supports two other systems: these include building, mechanical and electrical engineers (BMEE) and interior planners.

As of March 1999, the Gijutsushi comprised about 40,000 registered members and the Kenchikushi about 80,000 registered members.

Education and Qualifications

The basic qualification for professional engineers is a 4-year University course. The first two years provide a general education biased towards Engineering Science but including humanities and foreign languages.

In the final two years, the student concentrates on specific engineering disciplines - the so-called ‘professional education’. Emphasis is on theory and principles but in the final year there is usually a project to provide some experience of ‘practical’ problems.

But the most striking feature of Japanese engineering education is the wealth of provision for sub-degree education and training: this is covered by Junior Colleges, Technical Colleges and Special Training Schools.

Of these, the Junior Colleges provide 2 and 3-year courses on the American model. The emphasis is on the liberal arts: about 7% of enrolments are in engineering courses. Entrants are graduates of the Senior High Schools.

The first Technical Colleges were established in 1967 in response to industrial demand for technicians; they provide courses in all the main engineering disciplines. Students enter from the Junior High School and follow a 5-year course.

There are over 2000 Special Training Schools (STS), nearly all of them private establishments run for profit. Pupils from the Junior High School are accepted but the current emphasis is very much on the further training of Senior High School graduates; for them the typical STS course takes 2 years.

Accreditation

There is no central system of accreditation in Japan. There is an all-too-clear pecking order of schools, colleges and universities and intense pressure on students of all ages to win a place at the more prestigious universities. A place at a top university is an automatic passport to a job at a top company. Competition is severe all round and no less so for places in university engineering departments.

Registration and Protection of Professional Titles

As described above, there are 4 systems of engineering, only 2 - Gijutsushi and Kenchikushi need concern us here.

Under the Gijutsushi system there are two grades of engineer - Registered Associate Engineer (RAE) - roughly Incorporated Engineer in UK Terms - and Registered Engineer (RE) - C. Eng.

Under the ‘Registered Engineer Law’ applicants for RAE need to pass the ‘first step examination’ administered by the JCEA. There are no limitations, such as educational background, concerning eligibility for these examinations but applicants must have practical experience of more than 4 years duration.

To be licensed as a Registered Engineer, applicants must have 7 years of practical experience to qualify for the ‘second step examination’. Again, there are no limitations on educational background as a prerequisite for taking these examinations.

Registration as a Gijutsushi is mandatory for only a limited number of engineering activities: most of them concerned engineering projects implemented by Japanese governmental authorities and by local government. Perhaps, not surprisingly, the biggest number of Gijutsushi is engaged in Civil Engineering.

In the Kenchikushi system there are 2 grades of registrant: second class and first class. To be eligible for the second-class examination, a candidate must have one of a number of qualifications.

- University/college (including Junior College) or Technical College degree in architecture - no practical experiences in civil engineering - at least 1 year of practical experience;

- Senior High School education with at least 3 years practical experience in architecture or civil engineering;
- Candidates with 7 years work experience do not require a formal educational background in architecture/civil engineering.

To be eligible for the first-class examination, the requirements are:

- University degree in architecture/civil engineering plus at least 2 years practical experience;
- 3-year junior college course in architecture/civil engineering plus at least 3 years practical experience;
- 2-year junior college/technical college course plus at least 4 years practical experience;
- a second class Kenchikushi plus at least 4 years practical experience.

The Gijutsushi and Kenchikushi titles are protected by law with penalties for abuse.

Commentary

In spite of the recent travails of the Japanese economy there is no shortage of good candidates for the engineering profession and entry into the profession remains as competitive as ever. As to status, if anything, the status of the profession in Japan has risen over the past few years.

1G United States

Organisation

There are some 60 to 70 institutions and societies in the United States covering individual engineering disciplines: for the most part their activities are concentrated on the learned-society function.

There is no central body equivalent to the Engineering Council but the activities of the institutions and societies are co-ordinated through the American Association of Engineering Societies (AAES). The AAES has over 800,000 members and some 28 member and associate societies. It is essentially a lobby organisation dedicated to advancing the knowledge, understanding and practice of engineering in the public interest. It is also responsible for conducting forums for leaders in the engineering industry and government to discuss issues affecting engineering and the public interest.

Education and Qualifications

The basic qualification for engineers is a four-year college or university course leading to a Bachelor degree. There is no central control over the content of the curricula but there is a powerful accreditation system run by the Accreditation Board for Engineering and Technology (ABET). One feature that distinguishes the American profession from the European is the high proportion of Masters graduates in engineering. Taking Bachelor and Masters graduates together, rather more than 25% are Masters.

Accreditation

Accreditation throughout the United States is the responsibility of the Accreditation Board for Engineering and Technology. The ABET process is a voluntary system that:

- assures that graduates of an accredited programme are prepared adequately;
- to enter and continue the practice of engineering;
- stimulates the improvement of engineering education;
- encourages new and innovative approaches to engineering education;
- identifies these programmes to the public.

The Board makes its assessments under a number of headings:

- student performance;
- programme educational objectives;
- programme outcomes and assessment;
- professional component;
- faculty;
- facilities;
- institutional support and financial resource;
- programme criteria.

Continuing Professional Development

The general approach of employers is that the Bachelor's degree provides a foundation and that it is in employment that the engineer develops his vocational skills and abilities. Employers appear to recognise this responsibility as a matter of course: it takes place through structured experience and monitored progress in-house and encouragement to take further formal outside qualifications. There appears to be much less concern about 'poaching' than in the UK.

Regulation and Protection of Professional Titles

There is no protection of title in the US: nor is there any national register. There is, however, a system of licensed engineers run by individual states. Of the 2 million or so graduate engineers only about 400,000 are licensed. A licence is required only for a restricted number of activities: signing off certain design drawings for example.

To obtain a licence an engineer needs to fulfil the following requirements:

- graduate from an accredited programme at a US university;
- pass an eight-hour examination looking at the fundamentals of engineering in the final year at university; the examination is nationally normed;
- four years of acceptable engineering experience;
- pass a second examination on the principles and practice of engineering: this second examination is discipline specific.

The licence then acquired is valid for only one state: licensing in another state requires a repeat of the process. In addition, 20 states now require that engineers continue their education following qualification, in order to retain their licence.

Commentary

The US organisation of engineering is an interesting example of a highly devolved profession virtually free from any central control but with a degree of co-ordination provided by AAES and quality control provided by ABET: both financed and supported by the profession as a whole.

As to status: engineering has always had a high standing in the US: that situation remains. There is a concerted effort to promote the role that engineers play in society and the importance of engineering in improving the quality of life.

The main area of concern is the decline in the number of young people going into the engineering profession: since 1985 undergraduate engineering enrolments have dropped by 14.5%. The concern is highlighted by the fact that a number of those currently studying engineering in the US are not US citizens and many of them will return to their home countries on graduation. The US Department of State has responded by increasing the number of Green Cards given to engineers who are non-US citizens.

1H Austria

Organisation

There is no official central body: most of the engineering Institutions are learned-society bodies but two have a more general remit. They are:

- Osterreichischer Ingenieur-und Architekten-Verein (OIAV)
- General promotion of the profession for graduates
- Verband Osterreichischer Ingenieure (VOI)
  For engineers from the Austrian equivalent of the German Fachhochschulen.

Education and Qualifications

A binary system based on Universities and Fachhochschulen. For a Diplom Ingenieur (Dipl-Ing), the duration of the course is about 5 years: for a Dipl-Ing (FH)) duration is about 3 years.

Accreditation

Austrian universities are state institutions. Austrian federal law establishes general regulations on university studies. The University Study Acts regulate the requirements of degree programmes. The Ministry of Science Research and the Arts must submit a university report to the National Assembly every three years, describing the achievements and problems of the universities.

Registration and Protection of Titles

There is no register: engineers can practise as soon as they graduate. The title Dipl-Ing is protected by law.

1I Belgium

Organisation

Belgium has a number of engineering Institutions: mainly learned societies but some with responsibility for advancing the interests of their members in legislation, remuneration and so on. There is no central body.

Education and Qualifications

In Belgium, a distinction is made between two kinds of engineering degrees:

- an academic engineering degree - the Burgerlijk Inginieur which is offered by the university engineering faculties (Ir)
- an engineering degree offered by institutes for higher education in engineering, called Industrieel Inginieur (Ing)

The university degree programme involves a five-year plus period of study (average 5.5 years) and the Ing degree a four-year plus period (average 4.5 years).

Accreditation

The kind of curriculum that may be offered is determined by law. Individual curricula are defined by the academic institution itself. There is a quality assessment procedure supervised by an interuniversity or interschool council. Every five years a nation-wide visiting committee (academics and industrialists) evaluates a particular discipline.

Regulation and Protection of Titles

There is no register in Belgium: engineers are free to practice as soon as they graduate. The titles Ir. and Ing. are protected by law.

1K Denmark

Organisation

Denmark has a number of 'learned-society' institutions and one umbrella body, the Society of Danish Engineers - Ingeniorforening in Danmark (IDA). The objectives of the IDA are:

- to look after the interests of the engineering profession;
- to influence technological development for the benefit of society;
- to stress the importance of scientific and technical education and research for society;
- to urge members to maintain and develop their professional education.

In addition to these objectives, the IDA has two other functions:

- negotiation of salaries for public employment;
- issue of evidence of formal qualifications.

Education and Qualifications

Post-secondary education is offered at eight engineering colleges (EC), at the Technical University of Denmark (DTU) and at Aalborg University (AUC). There are basically three degrees:

- Diplomingenior (Diploma engineer) 3 1/2 years minimum
- Civilingenior (Graduate engineer) 5 years minimum
- Eksportingenior (Export engineer) 4 1/2 years minimum

The Diplomingenior course is intended to provide students with the theoretical and practical knowledge required to practise as professional engineers in design, development, consulting and supervisory activities. The course includes 6 months of practical engineering training in industry.

The Civilingenior degree encompasses the main branches of engineering civil, mechanical, electrical, chemical. It is claimed to be the equivalent of a Masters degree. A Diplomingenior graduate may continue his studies for two more years to qualify for the higher degree.

Accreditation

The engineering degree courses are monitored by a common set of regulations produced by the Danish Ministry of Education. In practice the same external examiners cover the whole country for each topic. After each examination the external examiners submit a report to their chairman. On the basis of all reports from the colleges and universities the chairman will monitor quality within the institution and compare the development among institutions.

More recently the Danish Ministry of Education has established the Evaluation Centre (EC) which acts as the Danish centre for higher education and quality development. Formally it is an advisory board established on a trial basis until 1999: in practice it seems likely to become a permanent institution.

Regulation and Protection of Professional Titles

There is no register of engineers in Denmark: nor is the use of the term ingenior protected by law. With one or two exceptions, engineers may practice as soon as they graduate. However, the use of the titles Diplomingenior, Civilingenior and Eksport ingenior is restricted to graduates of the relevant engineering schools.

1K Finland

Organisation

There is no central body in the Finnish system. Four of the separate Institutions act as umbrella bodies. Their function is twofold:

- to act as advisory bodies to government and to further the interests of engineers and engineering;
- to act as trades unions: taking care of negotiations on salaries, working conditions and other employment matters for their members in the private and public sectors.

Education and Qualifications

There are three levels of engineering qualifications:

- the highest level is the diploma-Insinoori - MSc equivalent - which may be taken at one of five universities. In principle the course lasts for five years with 3 - 6 months of practical training: in practice they last seven years on average;
- in the non-university sector there are institutes of technology and polytechnics which offer the equivalent of a BSc after a nominal four years of study including 20 weeks of 'practical training';
- at the lowest level, Technician courses are also available at the polytechnics: they take four years with 20 - 40 weeks of practical training.

Accreditation

There is no formal system of accreditation in Finland. The universities are supervised by the Ministry of Education: the contents of degrees are defined by the ministry. There is, however, an agency set up by the Ministry of Education whose task is to support the universities in establishing their own assessment systems.

Regulation and Protection of Title

There is no register of engineers, nor is there any protection of title. Professional engineers may start to practice as soon as they graduate.

1L Greece

Organisation

There are a number of engineering institutions in Greece mainly concerned with learned-society activities. But there is also one influential central body - the Technical Chamber of Greece (TEE).

The TEE functions under public law: it is by law the official technical adviser to the state; it keeps the Register of all qualified engineers and registration is a prerequisite for practice in the engineering profession in Greece. The members of its constituent elements - there are sections in several regions of the country - and its President are elected every three years by all the qualified engineers in all the branches.

Education and Qualifications

Greece has a binary system with University Educational Institutions (UEI) offering five-year degrees in engineering and Technical Education Institutions (TEI) offering three-year courses. The UEI courses are focused on a high standard of knowledge and research: the TEI on applied knowledge and practice.

Accreditation

There is no formal accreditation of courses or institutions: indirectly the TEE can 'keep an eye' on standards by way of its procedures for accepting engineers on to the register

Regulation and Protection of Professional Titles

The basic engineering title in Greece is the Diplomatouchos Michanicos (the five-year course) and it is protected by law.

It is the TEE that has the 'right and duty' to evaluate the adequacy of the graduate's preparation to embark on a professional career. There are two elements to be satisfied for registration:

- a graduate diploma
- an examination set and run by the TEE

Note that there is currently no similar procedure for three-year graduates who therefore lack the 'professional rights' of their five-year brethren.

1M Republic of Ireland

Organisation

The Institution of Engineers of Ireland (IEI) is the recognised qualifying body for the profession in Ireland: it is a chartered body set up by acts of the Irish Parliament in 1969.

Its purposes include:

- promoting knowledge related to the engineering profession and furthering the interest of the profession and its members;
- setting up and maintaining proper standards of education and training for admission to membership with power to provide and prescribe instruction and courses of study and to conduct examinations;
- safeguarding the use of initials and letters appropriate to all levels of qualification.

The Institution holds its own examinations for the qualification of MIEI (member) which is recognised as being the equivalent of a degree.

The IEI also acts as a learned society catering for the professional interests of some 14,000 members. The Institution's governing body is the Council whose members are either directly elected for a three-year term or represent individual Regions and Divisions. Its President is also directly elected and serves for one year.

A certain amount of Continuing Professional Development (CPD) takes place under the aegis of the Institution.

Education and Qualifications

Engineering education in Ireland is at two levels:

a) Universities and

b) the Regional Technical Colleges (RTC) and Vocational Education Committee Colleges (VECC).

Most of the engineering degree courses are based at the universities. The RTC's and VECC's do a certain amount of degree work, but their main focus is on sub-degree courses - National Certificate and National Diploma. Four years of study are required for a degree: the average time to completion is only slightly greater than this. National Certificate courses take four years and National Diploma courses three years.

The IEI has several grades of membership:

- Technician (Eng. Tech IEI): certificate plus two years experience
- Affiliate (A Eng. IEI): diploma plus three years experience
- Chartered (C. Eng. IEI): degree plus 8 years education and experience

Accreditation

All engineering degrees are awarded either by the universities or the National Council for Academic Awards (NCEA). Each of those awarding bodies has its own procedures for academic recognition and accreditation of courses. In addition, external examiners appointed to all engineering examinations are obliged to ensure adequacy of standard in examinations.

The statutory body for the accreditation of engineering degrees is the IEI. By law only the IEI may award the title of Chartered Engineer (C. Eng). All engineering degrees considered eligible for C. Eng status are subject to the accreditation of IEI: assessment generally takes place every five years.

Regulation and Protection of Professional Titles

There is no register of engineers in Ireland and the only title protected by law is that of Chartered Engineer: legal action may be taken by the IEI against any individual who fraudulently represents himself as a C. Eng.

1N The Netherlands

Organisation

There is no equivalent of the Engineering Council in the Netherlands. Three umbrella institutions speak for the engineering profession as a whole:

- Koninklijk Instituut van Ingenieurs (KIV1) represents graduates from the Universities of Technology;
- Nederlandse Ingenieurs Vereniging (NIRIA) represents engineers from the Polytechnics;
- Koninklijke Landbouwkundig Vereniging (KLV) represents graduates of the agricultural university

These three are involved with the Administration on all aspects of the engineering profession: however they have no formal legal status in this respect.

Education and Qualifications

There is a binary system for engineering education: engineering programmes leading to the equivalent of a Masters degree are given at three Universities of Technology; higher vocational training courses are given at the Hoger Berbebs Onderwijs (HBO) institutions.

The university course has a nominal length of 5 years: in practice students take an average of 5.5 - 6 years. This period includes a compulsory spell of practical training in industry and a masters project. Those who graduate are entitled to the title Ingenieur (ir).

For the HBO courses the nominal period is four years: actual length probably somewhat more. A major part of the third year is occupied by an industrial training period: part of the final year is devoted to the preparation of a thesis. Those who graduate have the title of Ingenieur (ing).

Accreditation

Accreditation is largely self-monitored. For the universities there is an Association of Co-operating Universities: the focus of the Association's procedures is a number of visiting committees which review all university studies in a given area of knowledge in the country on a six-year cycle. The corresponding body for the HBO's is the HBO Council.

Regulation and Protection of Professional Titles

There is no register of engineers. Those with the qualification ir or ing may practice as soon as they graduate: there is no protection of title.

10 Norway

Organisation

Two of the Norwegian Institutions act as umbrella bodies for the profession:

- Norske Sivilingeniorers Forening (NIF)
- Norges Ingenior Organisasjon (NITO)

Both are recognised by the national authorities and have dual functions:

- trades union activities including negotiations on salaries and working conditions in the public and private sectors;
- professional activities covering education, CPD and learned-society functions.

Education and Qualifications

Norway has a binary system of engineering education: engineering courses are available at university and non-university institutions.

The major university degree is called sivilingenior: the course lasts a nominal 4 1/2 years (nearer five in practice) and is reputed to be of MSc level. The major institution awarding their degree is the Norwegian Institute of Technology: the degree is also available in a limited number of fields at five other universities.

The non-university education in engineering leads to the ingenior degree and takes a nominal three years.

Accreditation

No information.

Regulation and Protection of Professional Titles

There is no register of engineers: sivilingeniors and ingeniors are able to practice as soon as they graduate.

However, in 1989 the NIF established the so-called Professional Development Certificate (PDC) programme. Its aim is to document the professional competence of chartered engineers. Admission is granted to engineers with a 'sound' graduate education and at least five years of practical experience: there are several routes to admission: all of them require a 2500 - 4000 certificate lecture. There is no legal protection of engineering title.

1P Portugal

Organisation

The Ordem dos Engenheiros is by law the recognised qualifying body for the profession. It has the power to set national standards for the registration of individual engineers by examination or by accreditation of courses. It is the 'competent authority' for the application of the appropriate laws to university level engineers and it confers the title of Engenheiro.
The Ordem is organised in eleven colleges (civil, mechanical, chemical etc).

Non-university engineers are represented by the Association Portuguesa de Engenheiros Tecnicos: but at the time of writing this institution does not have the legal standing of the Ordem.

Education and Qualifications

There are two levels of qualification in Portugal. The upper level is taken at one of seven universities and given the title Licenciatura. The lower level is taken at a polytechnic (LSE) and gives the title Baccharelato.

At University the course requires a minimum of five years - in practice six to seven years. It is aimed at giving competence in engineering science followed by an education in an engineering specialisation.

Polytechnic courses are geared to the development of technical skills to be applied in specific situations. The course curriculum is intensive: the average student takes about five years to obtain the degree.

Accreditation

Accreditation of university courses is the responsibility of the Ordem. Accreditation is granted to individual courses in the different major branches of engineering and is valid for periods not exceeding six years.

As a first step in the process, the academic institution submits an information package. This is followed by a visit to the institution undertaken by an Ordem-appointed 'jury' who can take evidence from staff and students concerned. At a more general level, the Government has set up the Funuacao das Universidades Portugujesas (FUP) to implement the quality assessment process over the whole higher-education system.

Regulation and Protection of Title

The Ordem is by law the recognised qualifying body for the profession. Registration is obligatory to be recognised as a professional.

Before registration in the Ordem, candidates for the title of Engenheiro have a tutorial training of six months or practical training for a period of two years: the title is protected by law.

Commentary

The Portuguese authorities are concerned at the low demand for engineering courses: there is a shortage of baccharelato grades.

1Q Spain

Organisation

Spain has a number of learned-society engineering Institutions: there is no single central body but two Institutions act as umbrella organisations:

- Instituto de la Ingeneria de Espana (IIE): members are 'superior', i.e. chartered engineers with titles recognised by the government;
- Instituto de Ingenieros Tecnicos de Espana (INITE): members are technical engineers

Both Institutions have continuous relations with Spanish Ministries on matters connected with the engineering profession.

Education and Qualifications

Engineering education in Spain has been in a state of flux for some time: these notes are the latest currently available. The Spanish system is divided into two cycles:

- First cycle is taken at a university and lasts nominally three years: in practice most students take longer. It leads to the degree of Ingeniero Tecnico. The courses are technically orientated and do not assume progression to the second cycle.

- Second cycle is also taken at a university. Entry is dependent on the subjects taken in the first cycle. If highly compatible with the second, then direct entry is allowed. If not, a number of 'bridging' modules have to be taken. Nominally, the second year takes two years - again the average student will take longer.

Accreditation

Spain has a formal 'Evaluation System' for higher education. The system operates on a voluntary basis. A Royal Decree of 1995 established the 'National University Quality Assessment Plan'. The Plan covers a five-year term: the normal period of assessment is one year divided as follows:

- Self-assessment: 5 months
- External assessment: 2 months
- Report writing: 2 months
- Release of results: 2 months

Spain is also involved in a Europe-wide system of evaluation - SECAI. The expertise for this development comes from the Universidad Poltecnica de Madrid (UPM). SECAI is designed to be a diagnostic evaluation system aimed at improving the quality of engineering education. It evaluates the institution rather than the curriculum: it is currently being applied at 14 centres.

Regulation and Protection of Title

The title conferred by both education cycles is protected by law.

1R Sweden

Organisation

There is no central qualifying body in Sweden. There are two umbrella Institutions:

- Sveriges Civilingenjors forbundet (CF): a service and professional organisation for graduate and student engineers;
- Ingeniors forbundet (Ing): a service and professional organisation for engineers and students

Both have broadly the same remit;

- to negotiate members salaries and conditions of employment;
- to advance technology and uphold the interests of graduate/professional engineers;
- to work towards higher quality in engineering education.

Education and Qualifications

There are two main kinds of engineering education programme: one leading to the degree of civilingenjor, a course lasting nominally 4 /12 years and one leading to the title of hogskoleingenjor which can take anything from 2 to 4 1/2 years depending on the course. In addition, some universities offer the degrees of Teknologie Kandidat and Tecknologie Magister.

The degree of civilingenjor can be awarded by four universities and three specialised Institutions. Nominally the duration is 4 1/2 years, in practice nearer 5. In addition to the academic course a period of industrial experience - usually 17 weeks - is required. The course carries high prestige and entry is competitive.

The qualification of Hogskoleingjenjor is offered by four universities, four specialised institutions and 14 university colleges. The wide range in length of their courses - 2 to 4 1/2 years reflects the variety of content and level they bring. Even the 4 1/2 year courses are much less orientated to basic theory and research than the corresponding civilingjenjor curriculum.

Accreditation

Neither of the engineering titles is legally protected and partly as a result there is no real system for accreditation.

There is a government agency - Hogskoleverket (HSV) - which supervises the universities and the quality of their education. It has granted the four comprehensive universities and the three specialised institutions the right to grant the degree of a civil ingenjor. It has granted to these seven and the 14 university colleges the right to grant the title of hogskoleingenjor. In theory HSV could withdraw these rights if the agency was dissatisfied with the quality of the courses offered.

Regulation and Protection of Title

The title civilingenjor and ingenjor have no legal status: there is no register of engineers.

Annex 2

KEY TO THE SUMMARY OF NATIONAL ENGINEERING ORGANISATIONS

Central body / registering body

EC	Engineering Council
G	Government appointed central body
G + LG	Central bodies appointed by government and local government
NG	Non-governmental central body
I	Single engineering Institutions
P	Province (Canada)
PE	Professional engineer
S	State (USA)
Um	Umbrella body: one institution of several acting as a de facto central body

Accreditation

G	Government agency
NG	Non-government agency
NGP	Non government agency controlled by profession
U	University control

Cycles

B	Baccalaureate or equivalent
C	College
E	Years of approved professional experience
F	Fachhochschule
U	University or equivalent
B: 5 + U	Bac, plus over 5 years of university education

Legislation

T	Title protected by law
T & P	Title protected: license to practice

SUMMARY OF NATIONAL ENGINEERING ORGANISATIONS

Country	Central Body	Short Cycle	Long Cycle	Requirements for Title	Accreditation	Register	Registering Body	Professional Title	Legislation
UK	NG/EC	B: 3U or B:2U + + matching section	B: 4U or B: 3U + matching section	deg + 4E + professional review	EC + Institutions	Yes	NG/EC	C Eng (long) I Eng (short)	T
Canada	Um + P	B: 4 + U	B: 4 + U	deg + professional exam	NGP	PE only	P	Professional Engineer (PEng)	PE only
France	Um	B: 2-4 U or C	B: 5 + U	deg	G + NG	Diploma only	NG	Diploma (long)	T
Germany	Um	B: 4 + F	B: 5 + U	deg	U	None	-	Dipl. Ing (U) (long) Dipl. Ing (FH) (short)	T
Italy	G + LG	B: 3U	B: 5 + U	deg + national exam	U	Yes	G + LG	Dutture (long) Diplomato (short)	T + P
Japan	Um	B: 2-4 C	B: 4 + U	deg + 2E - 7E + national exam	U	Yes	G/NG	Gijutsushi Kenchikushi	T + P
USA	Um + S	B: 4U	B: 4U	deg + 4E + state exam	NGP	PE only	State	Professional Engineer (PE)	PE only
Australia	I	B: 2U	B: 3 - 4U	3 - 4E	NGP	Yes	I	CP Eng (long) Eng Tech (short)	T
Austria	Um	B: 3 + U (FH)	B: 5 + U	deg	U	No	-	Dipl. Ing (U) (long) Dipl. Ing (FH) (short)	T
Belgium	I	B: 4 + U	B: 5 + U	deg	U	No	-	Ir (long) Ing (short)	T

SUMMARY OF NATIONAL ENGINEERING ORGANISATIONS

Country	Central Body	Short Cycle	Long Cycle	Requirements for Title	Accreditation	Register	Registering Body	Professional Title	Legislation
Denmark	Um	B: 3 1/2 = U	B: 5 + U	deg	U	No	-	Civil ingenior (long) Diplom ingenior (short)	T
Finland	Um	B: 4 + C	B: 6 + U	deg	G	No	-	Insinoori (long) Diplominsinoori (short)	None
Greece	G	B: 3 + C	B: 5 + U	deg + national exam	U	For long cycle only	G	Diplomatouchos (long) Michanicos (short)	T & P
Ireland	I	B: 2 - 4C	B: 4 + U	deg + 4E	I	No	-	Ceng (long) Assoc Eng (short)	C Eng only
Netherlands	Um	B: 4 + C	B: 5 + U	deg	U	No	-	Ir (long) Ing (short)	None
Norway	Um	B: 3 + C	B: 4 + U	deg	U	No	-	Sivilingenior (long) Ingenior (short)	None
Portugal	G	B: 4 + C	B: 6 + U	deg + 2E	G	Yes	G	Engenheiro (long)	T + P
Spain	Um	B: 3 + U	B: 5 + U	deg	G	No	I	Ingenerio (long) Ingenerio Technico Ingenerio (short)	T + some elements of P
Sweden	Um	B: 2 - 4 1/2 U & C	B: 4 1/2 U	deg	U	No	-	Civilingenjor (long) Hogskolingenjor (short)	None

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