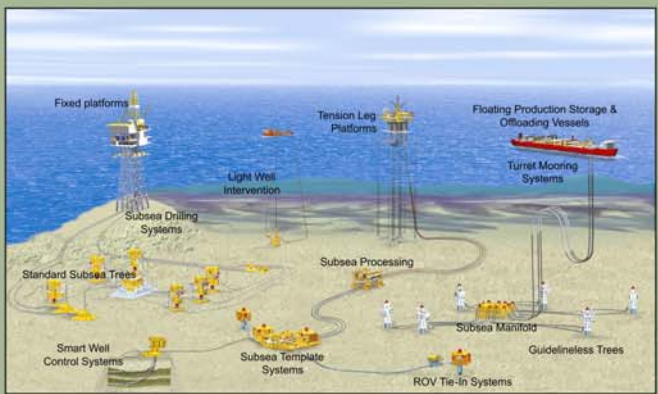
Earth Sciences and Petroleum Engineering (ESPE)
Faculty of Engineering Science & Technology

Report self evaluation ESPE

"What makes candidates from this programme different from those graduating from other technology programmes at NTNU is the strong basis of geology and geophysics and the integration of this knowledge in the various fields of specialization.
This makes the candidates qualified for many jobs in some of modern society's most challenging fields, especially those related to energy, to the exploration and exploitation of non-renewable mineral resources, to the environment and to climate"

ESPE students studying North Sea-equivalent sedimentary rocks in North-East Yorkshire, England



Offshore field developement

NTNU
Innovation and Creativity

1 Ingress

The Earth Sciences and Petroleum Engineering (ESPE) programme represents the direct continuation of the Royal ***Bergseminar****, which was founded at Kongsberg in 1757. It was the first institution of higher civil education in Norway and is the "forefather" of both the University of Oslo (founded 1811) and of NTNU (opened 1910 as NTH). The 250-year anniversary was celebrated last month (September & October 2007) both at Kongsberg and in Trondheim, and the two departments*

- ***Department of Geology and Mineral Resources Engineering,*** *and*
- ***Department of Petroleum Engineering and Applied Geophysics***

which are responsible for the ESPE were natural highlights in the celebration in Trondheim.
What makes candidates from this programme different from those graduating from other technology programmes at NTNU is the strong basis of geology and geophysics and the integration of this knowledge in the various fields of specialization. This makes the candidates qualified for many jobs in some of modern society's most challenging fields, especially those related to energy, to the exploration and exploitation of non-renewable mineral resources, to the environment and to climate.

2 Introduction

After it was decided that all the integrated 5-year Master programmes in technology at NTNU should be evaluated by an international specialist group (spring 2007) and that so-called self evaluation should be an important part of this, the programme council for the Earth Sciences and Petroleum Engineering (ESPE) established a working group consisting of

- Professor Tore Prestvik (programme leader)
- Professor Kai Nielsen (technical geology and environmental and natural resources engineering)
- Associate professor Sverre Ola Johnsen (petroleum geoscience and resource geology)
- Professor Sigbjørn Sangesland (petroleum engineering)
- Student Øyvind Solberg (5^{th} year petroleum geoscience)
- Student Silje Wiik (4^{th} year technical geology)
- Student Anne Marie Busch Iversen (5^{th} year petroleum engineering)
- Senior Executive Officer Marit Snilsberg (secretary)

The group was asked to collect and discuss data of the various kinds that were supposed to be included in the material that should be available for the NTNU bodies and the international panel in the form of a final report. As we understood it, to describe learning objectives according to a Dutch recipe was the most central task.

The work has been difficult for several reasons. Especially, it has been difficult to set aside time to do this in a period and in an atmosphere which has been characterized by the hard work within the programme board and at the two affiliated departments (*Department of Geology and Mineral Resources Engineering* and *Department of Petroleum Engineering and Applied Geophysics*) in trying to split the programme in two: one programme for *Petroleum science* and one for *Geotechnology* (mostly "land-based"). Actually, this split was finally determined by the NTNU's board in a meeting November 14th 2007. Thus, this report deals with a study programme which no longer exists (see more details on this below).

We hope that this new situation will make it possible to recruit students that from "day one" are fully devoted to specialize in (land based) technical geosciences. However, to succeed in this recruiting process is a major challenge that we face. Since the new programmes will have a 100% common curriculum during the first two years of study, the split does not represent an introduction of anything new with regard to studies specializations.

Thus, evaluation of the now non-existing programme still makes sense, and what is learned from this process should be easily transferred to the new programmes. The rest of this report is based on the experience we have gathered over the last 20 + years in the programme for ***Earth Sciences and Petroleum Engineering*** (ESPE).

First, we will mention some problems resulting from the very rigid scheme – as we see it - for the curricula of the Master of technology degree at NTNU. To be more precise, we think of decisions on how much mathematics all master students must have (irrespective of field), how much mechanics, physics, chemistry etc., and how many courses of "non-technical" themes have to be included. Especially problematic are the strict requirements of ***where*** (semester/year) in the curriculum these classes can be placed. As a theoretical example, we are not free to place Math 3 in the third year, even though the students may not need this background until the 4th year. There are also strict regulations on how project work and related topics should be practised. Because our programme in total probably requires more general science (physics, chemistry, mechanics) in addition to math than most other engineering programmes (see Table 5), the rigid scheme is especially problematic, because all these regulations put restrictions on our possibility to make an optimal educational set-up for the specializations we are experts in. Because of this "system", the general tendency over the past 30 years is that the students more and more end up as generalists rather than specialists. ***We hope these aspects will be considered in the evaluation panel's work.***

Petroleum engineering and petroleum geosciences are also taught at other universities in Norway. In spite of this, NTNU has been successful in recruiting students to these fields. We think this success is related to the good and long-lasting reputation that engineering education at NTNU has, both in industry and generally in the society. On the other hand, NTNU is the only university in Norway teaching "land-based" technical geosciences and mining on the MSc level, i.e. NTNU has so-called "national responsibility" for these fields. Through more than 20 years, the study programme *Earth Sciences and Petroleum Engineering* has been the common "port of entry" both to these "land-based" fields and to the petroleum-related fields. As mentioned above, in recent years the petroleum-related fields have attracted so many students that it has become a serious problem to recruit students to the "land-based" field of study, with the result that over many years now, very few students have graduated in these fields. The council of the ESPE study programme therefore proposed (May & September 2007) that the programme should be split in two parts, one program for petroleum-related education and one for the (land-based) technical geosciences. The NTNU board approves this view and made the final decision on this issue in its November 14th 2007 meeting. It is worth repeating here that the splitting will not result in implementation of any new studies at NTNU, it is only a formal/technical way to improve recruitment of students to a field that desperately needs highly qualified engineers. It is believed that the separate petroleum-related study program will not have problems recruiting enough students.

3 Learning objectives of the ESPE

The principal objectives for the MSc programme in Earth Sciences and Petroleum Engineering (ESPE) are to educate engineers who can contribute to an efficient and sustainable and environmentally safe exploration and exploitation of all kinds of non-renewable mineral resources. The academic level of a good candidate corresponds to that of the entry qualifications for doctoral studies.
The ESPE is based on basic knowledge of geology and geophysics in addition to the more general fields of science, such as mathematics, physics, mechanics, chemistry and computer science. This gives a strong and directed background before choosing field of specialization after two years of study. The broad science background is meant to be a tool for the candidates to meet future challenges within their field of specialization. The programme, which is concluded by a one semester research project (master thesis) in a chosen, focused field, represents high-level professional education. The programme has four fields of study:

- *Technical geology (TG)*
- *Environmental and natural resources engineering (ERE)*
- *Petroleum geosciences and resource geology (PG)*
- *Petroleum engineering (PE).*

A further description of these follows below. Each discipline is mastered on different levels, from laboratory and field work to basic theory, including a reflective understanding of its structure and relations to other fields. In some selected areas, this knowledge has reached the forefront of scientific research, or to relevant industrial research.

3.1 Common to all fields of study is broad knowledge of geoscience, such as:

- **3.1.1 Geology and geophysics:** The structure of the Earth, rocks and minerals, plate tectonics and structural geology, the Earth's development and evolution through time, geological resources such as oil and gas, metals and industrial minerals, building materials, and water. In geophysics, refraction and reflection seismics, gravimetry and magnetometry, electrical and electromagnetic methods, radiometry are central.
- **3.1.2 Geomechanics and porous media:** Geomechanics: stress and pore pressure in the Earth's crust, tectonic stress. Stress in boreholes, rock mechanics in reservoir control etc. Porous media: porosity, permeability, equations of one- and two-phase flow etc.

3.2 Description of the various fields of study and their main profiles:

3.2A Technical geology (TG):
Broad and in-depth knowledge of the technology-related geoscience disciplines with the capability to utilize this knowledge for applied tasks. The level of knowledge forms a good base for innovative contributions to new knowledge in technical geology. The specialized education is based on additional knowledge of general geology, namely description, classification and interpretation of geological structures such as faults, folds and foliation, and the relations between such structures and the formation of large scale features such as orogenic belts and sedimentary basins. Furthermore, understanding the formation and geological settings of economic and strategically important non-metallic and metallic ores and minerals is emphasized.

TG 3.2A.1 Engineering geology/rock mechanics: Engineering geology methods for planning and building subsurface and surface structures on rock. Mechanical properties of rocks, rock masses and unconsolidated geological materials. Tunnels with rock mechanics problems, pre-investigation for sub-sea tunnels, stability and ground support in tunnels, water inflow and methods for water control, deposition of waste in underground excavations, numerical modelling of structures in rocks and unconsolidated materials. Groundwater in rocks and in unconsolidated ground.

TG 3.2A.2 Mineral production: Methods and equipment for excavation and processing of all types of mineral raw materials, including methods in connection with the start-up and closure of production. Satisfactory social, environmental and economic management of non-renewable natural resources in a sustainable development perspective.

3.2B Environmental and natural resources engineering (ERE)

Broad and in-depth knowledge of the technology-related natural resources, their engineering and management as well as their environmental challenges, with the capability to utilize this knowledge for applied tasks. The level of knowledge forms a good base for innovative contributions to new knowledge in environmental and natural resources engineering. It is necessary to understand the processes that lead to groundwater formation in rocks and unconsolidated geological formations, as well as groundwater flow and groundwater chemistry. Understand and prevent the dispersion of contaminants in ground and in water.

ERE 3.2B.1 Environmental issues: Satisfactory social and economic management of the environment and natural resources in a sustainable development perspective. Health, environment and safety in industry, trade and public management.

ERE 3.2B.2 Environmental technology: Methods and equipment for both prevention of pollution and rehabilitation after pollution has occurred. Methods and equipment for waste handling and recovery of materials. This includes processes for fragmentation, sorting, and cleaning of recovered materials and waste.

3.2C Petroleum geosciences and resource geology (PG):

The main profiles of this field of study are based on broad and in-depth knowledge of geology and ability to transfer this knowledge into practical work. The level of knowledge is a good basis for innovative contributions to new knowledge within geosciences.

PG 3.2C.1 Petroleum and resource geology*:* Resource geology deals with the geological processes leading to the formation and accumulation of hydrocarbons as well as of metallic and non-metallic ores and minerals in the Earth's crust. Description, classification, and interpretation of geological structures such as faults, folds, foliations etc., as well as the relationship between such structures and the formation of orogenic belts and sedimentary basins, are important. The emphasis in petroleum geology is on understanding of processes leading to the formation of sediments and sedimentary rocks, and ability to describe and interpret sedimentary successions. Resource geology directed towards metallic and non-metallic ore formation processes is based on mineralogy, general petrology and geochemistry.

PG 3.2C.2 Petroleum geophysics (seismics and petrophysics): Detailed knowledge of P and S waves, seismic wave propagation, acoustic impedance, acquisition and processing of seismic data. Furthermore, interpretation of 2D and 3D seismic data, production of time-contour maps, depth conversion, inversion of seismic data after stack, repeated seismics (4D-seismics), poly-component measurements (4C-seismics), and seismic modelling. Seabed logging with electromagnetic methods are also important. Petrophysical methods comprise practical interpretation of measurements from boreholes, resistivity, gamma radiation, neutron porosity, density, and sonic velocity as well as the physical and chemical environment, and geometrical relationships in the borehole-corrections for such factors.

3.2D Petroleum engineering (PE):
The main profiles of this field of study are based on a broad and in-depth scientific and technical knowledge within the petroleum technology disciplines and the skills to use this knowledge for practical tasks. The knowledge is a good basis for innovative contributions to new knowledge within the petroleum industry, including contributions in the form of new processes and methods for effective and profitable exploration and production of oil and gas.

PE 3.2D.1 Petroleum Production: In this main profile, emphasis is on procedures for selection, planning and development of oil and gas fields onshore and offshore, well construction, multiphase flow, inflow in vertical and horizontal wells, formation damage, well productivity and integrated operations (IO).

PE 3.2D.2 Drilling Engineering concentrates on equipment, systems and methods for drilling, including high deviated and horizontal drilling, directional control, well trajectory planning and analysis of forces in drill string and casing, and furthermore, on borehole stability, borehole hydraulics and methods and procedures for pressure control.

PE 3.2D.3 Reservoir Engineering deals with methods and procedures for calculation of hydrocarbon volume and for optimal hydrocarbon recovery. This includes laboratory measurements of flow of oil, gas and water in reservoir core samples, analysis for determination of phase behaviour of hydrocarbon systems and injection fluids, analysis of pressure tests in wells and modelling, including numerical simulation of fluid flow in the pore system (micro scale) and in the reservoir (macro scale).

PE 3.2D.4 Formation evaluation Central in this profile is the use of petrophysical methods for collecting data from reservoirs based on borehole measurements (borehole logging), analysis of formation core data and data from the drilling process, including analysis of these. Types of formation and fluids, pressure, porosity, saturation, permeability, velocities, shale content and layer thickness, recovery factor, density, salt contents and mineralogy, etc. can be decided. Common methods are resistivity, acoustics, and radioactive measurements, magnetic resonance (NMR), thickness measurements, etc. The subject includes measurements during drilling (LWD) for controlling the borehole trajectory (geo-steering) and wire line logging.

3.3 Detailed knowledge of systems, methods and tools as well as capability to apply the knowledge for analysis, modeling, simulation, planning and accomplishment of research tasks.

3.3.1 Knowledge of and experience with modern software being used in technical geology, environmental, resource and petroleum geology, as well as in natural resource and petroleum engineering.
3.3.2 Knowledge and experience with computational tasks within geosciences and petroleum engineering.
3.3.3 Knowledge of experimental techniques, experience in design and completion of experiments, interpretation of results, and evaluation of validity of the results.
3.3.4 Ability to describe a situation/condition/state and model it mathematically.

3.4 Capability to solve technological tasks in an independent and systematic manner by analyzing the problems, formulating subtasks and creating innovative solutions, also in new and unknown settings. This includes a professional attitude in identifying problems and to summon necessary expertise, to register and critically evaluate available knowledge, and to plan and perform research under changing conditions. Ability to integrate new knowledge and evaluate its limitations, ambiguity and incompleteness.

3.4.1 Systematic analysis of technical data in geo- and environmental science as well as of petroleum engineering, and interpretation of analytical results.
3.4.2 Propose methods for technical, economical and quality related improvements, e.g. of geological interpretations. Propose alternative and innovative solutions in development of certain fields using new or enhanced technology, new methods and materials for specific applications.
3.4.3 Propose alternative and innovative solutions in technical geology, petroleum and resource geology, and in environmental and resource related engineering
3.4.4 Perform investigations that can show whether proposed technological and economical methods and techniques are environmentally and socially-related acceptable.
3.4.5 Describe proposed methods and solutions in detail, so they can be implemented.

4 Course matrices

The table below contains (a) the compulsory courses for all our students during the first two years, and (b) the working group's rating of their importance for obtaining the learning objectives defined above. The courses "Experts in Team" and a so-called "perspective course", both taught in the 4th year, are also included in this table. The students and the teachers in the evaluation group made their own, independent rating (left and right columns, respectively).

Table 1. Compulsory courses in the first two years of study

Course	Course name / topics	Students' rating*	Teachers' rating*
TMA4100	Calculus 1	3	4
TMA4105	Calculus 2	2	4
TMA4110	Calculus 3	3	4
TMA4130	Calculus 4N	3	4
TMA4240	Statistics	3	4
TDT4105	Information Technology, Introduction	3	3
TDT4130	Procedure-Oriented Programming	2	3
TFY4102	Physics	3	4
TMT4100	Chemistry	3	4
TKT4126	Mechanics	3	4
TIØ4256	Technology Management 1	2	3
TEP4100	Fluid Mechanics	4	4
EXPH0001	Philosophy and Theory of Science	1	4
TGB4100	Geology, introduction	4	4
TGB4110	Resources of the Earth	4	4
TPG4100	Physics and Geophysics	3	4
TPG4112	Geomechanics and Flow in Porous Media	4	4
	Experts in Team	3	4
	Perspective course**	1	1

* Rating scale: 1, 2, 3, 4. Rating shows relevance and/or importance for the MSc in Earth Sciences and Petroleum Engineering. 1 shows little importance, 4 is high relevance etc.

** This is many different courses that students can choose among. Common to them is that they need to be given from a faculty or department (medicine, social science etc.) not related to natural science or technology.

Comments on the course ratings: It is worth noticing the low rates the students have given to *Philosophy and Theory of Science, Technology Management 1* and the *Perspective course.* This general view that non-technical courses are of low importance is also apparent from the teachers' rating. We will also focus on the low rating given to *TDT4130 Procedure-Oriented Programming*. This reflects disregard with the whole package of computer science courses (totally three), see rating of *TDT4105 Information Technology, Introduction* (table above) and *TPG4155 Applied Computer Methods in Petroleum Science* (attachment # 1). Apparently, this is something that should be considered closely when the curriculum for next year is discussed (November 2007). The low rating the students have given to *TMA4105 Calculus 2* is based on their impression that much of the content of this course has not been very relevant in later engineering courses. This may be a coincidence depending on the specialization the actual students have chosen, because Calculus 2 is one integral part of a package of courses in mathematics for all technology students.

Two attached tables (attachment # 1), one for each department, list all courses that are designed and taught for the 5-year MSc programme. The rating of courses taught for the various fields of specialization is mainly 4's (and some 3's), as expected.

5 Resources

Teaching resources can be either human or material. In our teaching, both laboratory and field courses are essential. While laboratory activities always have been covered as part of the running cost, we used to have special funding for field teaching, which is an important (and perhaps special) part of the geoscience education. In later years, field teaching has not been funded as a separate activity and has to be covered through the regular budget. In this respect, it is fortunate that industry understands the importance of field education in geology and geophysics and has sponsored our field courses at Svalbard (Statoil), in Oman (Shell), England (BP) and the Pyrenees (Norsk Hydro) for several years. Several other obligatory field courses in geology are covered by the department, without extra funding.

In the following, we concentrate on the human resources. We attach two tables (attachments 2 & 3) with information on the complete teaching staff in permanent or allocated positions. Here is a summary extracted from these tables:

5.1 Teaching resources:

IGB = Department of Geology and Mineral Resources Engineering
IPT = Department of Petroleum Engineering and Applied Geophysics

The two departments have almost identical human teaching resources available (PhD students and other ad hoc teaching resources not included):

Table 2. Academic staff data

Dep.	Full professors	Associate Professors	Adjunct Professors	Years allocated to teaching, Fte	Average age of permanent staff	Year range
IGB	13	5	5	10.0	57	34-69
IPT	12	3	7	8.9	56.7	46-64

5.2 **Number of courses taught** (see attachments 4 & 5):

IGB: 30 regular courses + 6 courses taught for other programmes + special courses, project- and thesis supervision. One course is a "service course" for students from other specializations.

IPT: 30 regular courses + 6 courses taught for other programmes + special courses, project- and thesis supervision. Two courses are "service courses" for students from other programmes.

The average regular, annual course load per person (including adjunct professors) is in the 1.4 – 1.5 range. This might not seem very high, but the project courses, special/individual courses and thesis supervision are not included in this calculation. Thus, we consider this load reasonable, not least because both departments have considerable extra teaching responsibilities (see below) towards other programmes.

5.3 **Departments' relation to and responsibility for other programmes:**

IGB is fully responsible for the 3-year *Bachelor in Geology* (annual enrolment 20) and 2-year *Master in Geology* (enrolment 15) programmes, but most courses offered are common with those of the 5-years Master in Technology. **IGB** is also involved with two extra courses in the 2-year International Master programmes *Hydropower Development* and *Geotechnics and Geohazards*.

IPT is responsible for a 2-years International Master programme in *Petroleum Engineering and Petroleum Geosciences* (annual enrolment ca. 30), and gives four extra courses in addition to the courses offered for the "regular" 5-year Master in Petroleum Engineering. **IGB** is also partly involved in this international programme.

In addition to ordinary courses, both departments give special courses for the study programme *Engineering and ICT* (IGB=1 and IPT=2) in its main profile Earth Sciences and Petroleum Engineering.

6 Research

As opposed to schools and regional colleges, Universities are supposed to give what is called "research based education/teaching". This means that the university teachers (hereafter called professors) are active researchers and supposed to use half of their time performing and/or conducting research (the other half is devoted to teaching, as reflected by the column "fte edu %" in attachments 2 & 3). We want to stress the importance of these principles for high quality education, but since ***research*** is not a major topic of this evaluation (not mentioned in the guidelines we got from the administration until very late in the process, i.e. mid-September), and because we have been so busy working with the "programme splitting process", we will only make a few points here.

Research is as dependent of available resources as teaching, perhaps more. Since doctoral studies are of major importance for the research, funding (both of salaries and running costs) for PhD projects are of major importance. And apart from time, the professors also need extra funding in order to run laboratories and projects. Through the years, research funding to the activity at departments has gradually become a less important part of the University's budget and is increasingly more and more dependent on external sources (Science Foundation and especially the related industry). Thus, in order to finance research it is important to come up with interesting proposals and to have good contacts with industry. Because university teaching is so dependent on and integrated with research, **it is of utmost significance for the quality of teaching on the programme that the scientific staff has adequate time and economic resources available for their research.**

In the tables of personnel (attachments 2 & 3), there is a column showing each professor's field of specialization and/or research, and below is a table listing the number of PhD candidates graduating from the two departments during the last 5 years. The PhD "production" was quite similar for the two departments during the actual period, but IPT scored considerably higher on publication. Besides showing a better publication rate among the scientific staff, this pronounced difference probably reflects the much higher number of active (not yet finished) PhD students at IPT. Two IPT professors of applied geophysics have recently won recognized research and/or publication prizes. Both departments are involved in activities at national centers of excellence.

Table 3. Research volume represented by number of doctoral candidates (PhD) and "publication points"

	PhD - **IPT**	PhD - **IGB**	Publication points **IPT**	Publication points **IGB**
2002	7	1		
2003	4	6		
2004	3	3		
2005	8	3	21.7	12.4
2006	2	8	33.1	18.2
Average	4.8	4.2		

IPT = Department of Petroleum Engineering and Applied Geophysics
IGB = Department of Geology and Mineral Resources Engineering

Master's theses and research. Even though a majority of students are mostly located at NTNU during their diploma semester (Table 4), most of our students take their diploma thesis in close cooperation with industry or a research institution (on- or off-campus). Seen from a student's viewpoint, this is fine because it gives a good opportunity to get involved with "real life problems" and perhaps it easily paves the way for a job after completion. In this regime, there is a formal supervisor at NTNU and (hopefully) a co-supervisor in the company/institution. However, even though it also from the University's viewpoint is positive to have good relations with industry, this way of organizing the Master's theses work leads to considerable and perhaps arbitrary spread in field/subjects and does not contribute much to the research activities at the departments. The reason why so few thesis projects originate from the departments (or individual professor's) active research, is the almost complete lack of funding available to make this possible. This is very unfortunate and probably one of the reasons behind the difficulty we have in recruiting PhD students. A closer connection between the individual professor/supervisor's own research and the topics chosen for the thesis would hopefully have stimulated more students to continue towards an academic career. Another aspect of this is that especially in the petroleum sciences there is almost impossible to work on real data, unless it is done in cooperation with industry, and often it has to be done *on* the company's premises.

Table 4. Data on location of ESPE diploma students 2003-2007

Year	Number of diploma students	Located at NTNU during most of the thesis semester (1)		Located away from NTNU during most of the thesis semester (2)	
	#	#	%	#	%
2005-2007	134	84	63	50	37

(1) Most of these theses are also done in cooperation with industry/research institutions
(2) Many of these students have very little contact with the formal supervisor during the thesis work

7 International student exchange and international MSc programmes

7.1 Student exchange:

NTNU (and other Norwegian universities) encourages students to study one or two semesters (as an integral part of their education) at well-reputed universities abroad. In the 5-year Master of Technology programmes, exchange is recommended in the 4^{th} year. The quality of this exchange is controlled by the fact that individual students need to have pre-approval from NTNU, both of institution and courses that should be taken while away. Normally, the exchange students are among the best half of our students. We have reports (for example from the US) that many of our students do very well in comparison with the "home country students" during their stay abroad. Attached are tables (attachment 6) showing the number of our students studying abroad the last 6 years and at what institutions/countries. Another table shows data on incoming exchange students. From this we can see that we get more students coming than the number we send out. And there is no direct relation, neither between the number of incoming and outgoing students, nor where they come from or go to.

7.2 International MSc programmes

As mentioned elsewhere in this report (e.g. under **5 Resources** above), both departments responsible for the 5-year MSc programme in Earth Sciences and Petroleum Engineering are also heavily involved in programmes directed towards international students. However, most of the teaching (courses) on these programmes are common with that of the "Norwegian" programme. Since this report is supposed to concentrate on the "regular" 5-year MSc in Technology/Engineering, we will not elaborate on the international programmes here, except expressing that we think the national (5-year MSc) students benefit in several ways from studying in an international milieu together with the foreign students.

8 Student data/statistics

Below is a table showing the complete study structure of the ESPE. The two departments **IGB** and **IPT** teach only 4 courses (of 16) during the first two years. This is less than for most other technology programs and – with the compulsory *Non-technical course*, the *Interdisciplinary teamwork course* and the *Perspective course* - this makes it difficult to find space for all of our own special field courses during the three last years.

Table 5. Structure of the programme Earth Sciences and Petroleum Engineering (ESPE)

Sem	Subject 1	Subject 2	Subject 3	Subject 4
10	Master Thesis (30 ECTS)			
9	Nontech 4	Specialization (theory + project)		
8	Experts in team	ESPE	ESPE	Eng/Techbase
7	Nontech 3	ESPE	ESPE	ESPE
6	ESPE	ESPE	ESPE	ESPE
5	Math 4	ESPE	ESPE	ESPE
4	Techbase 2	Nat.Sci. 4	Nat.Sci. 5 ESPE	ESPE
3	Math 3	Nat.Sci. 3	Nontech 2	Statistics
2	Math 2	Nat.Sci. 2	Ex.Phil.	ESPE
1	Math 1	Nat.Sci. 1	Techbase 1	ESPE

Programme-specific courses, incl. geology (ESPE) = 56.25%
Mathematics = 12.5%
Natural science (ex. geology) = 11.25%
Others subjects = 20%

In Table 6 below, we show selected data on applicants, number of students admitted, drop-out rate, percentage of female students etc., etc. It is apparent that the number of primary applicants has increased considerably the two last years. Also, the minimum and average entry qualifications have improved and are now on a very acceptable level. The percentage of female students on our program is among the highest in technology programmes at NTNU. Through many years, our students have not done especially well in Math. Apparently, we recruit students that are not among the very best in math (and physics?) but still determined to be good engineers in their field.

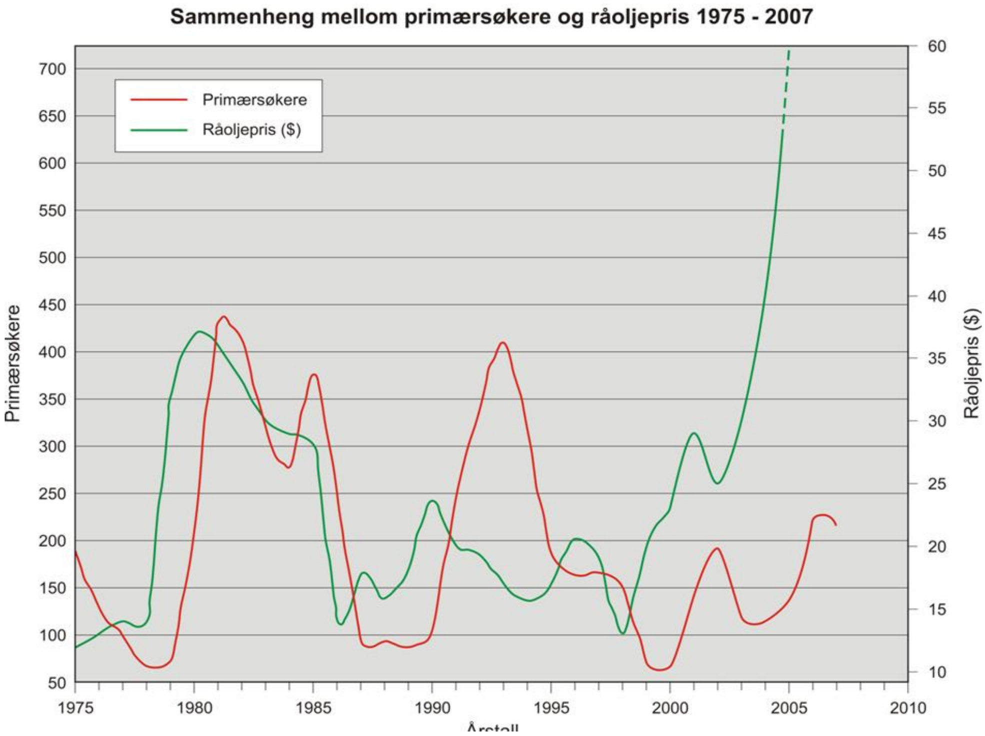
Through many years, we have noticed that the application to our program has been sensitive to the world's oil market, we get a drop in number of applicants during and after periods with low oil prices This is obviously the reason why we had few applicants and low entry qualifications 2003-2005 (see figure below), and it is likely that the improvement we see for 2006 & 2007 at least partly reflects a generally prosperous oil market.

Table 6. Detailed Student Data

Student-related issues	2003	2004	2005	2006	2007
Number of primary applicants – 5 year integrated Master programme	119	115	137	218	206
Ratio total number of applicants vs. primary applicants	8.5	7.1	7.4	6.5	6.9
Ratio primary applicants vs. allocated study places	1.5	1.4	1.7	2.4	2.0
Total number of students started	80	75	81	110	105
Number of students admitted to 2 year study	n.a	n.a	3	1	3
Total number of students in 2007 registered in each "class"	54	49	67	94	116
Percentage students still active 2007 Comparable data for all technological studies	67.5% n.a.	65.3% 71%	82.7% 74.6%	85.5% 82.5%	n.a.
Percentage female students	31.2	26.7	32.5	51.9	42.7
Minimum entry qualification for 5 year programme	49.3	46.3	51.2	55.5	55.8
Average entry qualification Standard deviation	n.a	53.0 4.7	54.7 3.6	59.9 3.8	n.a
Average entry qualification all Technological studies Standard deviation	n.a	56.5 5.3	57.2 4.7	59.2 4.6	n.a
TMA4100, Calculus 1 Average grade for ESPE students 1) Average grade for all Technological students	n.a n.a	2.11 2.42	1.16 2.07	2.13 2.30	n.a n.a

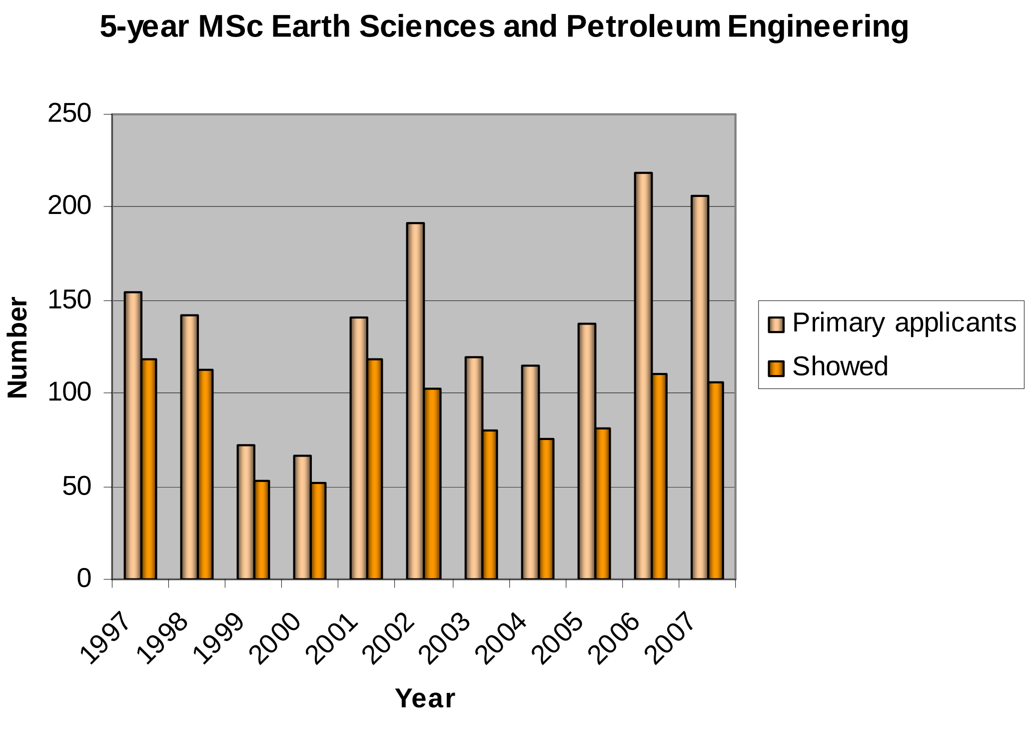
Primary applicants: Applicants for university education having Earth Sciences and Petroleum Engineering as their first priority
Entry qualification: Calculated level for students admitted, including added points according to preset rules.
n.a: Figures not available
1) Average grade calculated from: A=5, B=4, C=3, D=2, E=1, F=0.

Comments: Traditionally, ESPE students have scored low in mathematics compared to students of most other technology programmes, and it was especially low in 2005. But apparently, this has not been critical for their ability to complete the programme-related subjects satisfactorily



The graph above shows the connection between number of primary applicants and the price of oil since 1975. The general trend is a drop in number of primary applicants to the study programme 1-2 years after the fall in the oil price and a corresponding increase when the oil price is high. It is possible that the reorganization of oil companies in Norway also contributed to the drop in applicants in the late 1990s, resulting in almost "free entry" to the program in 1999 and 2000.

The figure below shows the relation between primary applicants and enrolment (showed) in the period 1997-2007. The almost "free entry" to the programme in 1999 and 2000 and many students with low entry qualifications are reflected in high drop out rate and low candidate production (not included in table) 5-6 years later. Also, the very large increase in number of primary applicants in 2006 and 2007 and the high ratio between applicants and actual enrolment is apparent.



9 SWOT analysis

Below is a summary of selected points from the SWOT analysis. The full list of points is attached (attachment # 7).

Strength

- Well-reputed institution with high status (NTH from 1910, NTNU since 1995), and Trondheim has good reputation as university city. This is characterized by very good student milieu and active student societies
- Good contact and interaction with the relevant industries on several levels, such as through industry-sponsored field excursions and with project- and thesis work
- The Norwegian continental shelf has a leading position internationally on field development under rough conditions
- NTNU is the only University in Norway with a programme in mining and related fields

Weaknesses

- The imposed scheme with many compulsory courses makes it difficult to design an optimal curriculum
- Studies of technical geology and natural resources engineering are not visible enough in the information materials. This has made recruiting difficult
- Too much overlap between contents in computer science courses
- Reduction in public funding for universities and lack of funding for maintaining and up-grading of laboratories

Opportunities

- Splitting the programme in two parts with separate enrolment in petroleum-related and "land-based geoscience" parts will hopefully give better recruitment to the technical geosciences
- Increased involvement from industry and the public
- Continued and increased help from industry in recruiting and financing PhD students and post-doc positions
- Increased demand for non-renewable resources in society is a positive challenge for departments studying such resources

Threats

- Increasing competition from other universities (UiS, UiB) in student recruitment

- Reduction in public funding. Too few resources from the government over the NTNU budget, especially if the internal model for funding will not been changed
- Problematic to stand out as a specific programme and attract students in the competition with other NTNU programmes
- Academic staff recruitment. High average age among the scientific staff at both departments, and small range in age indicates that a high proportion of the professors need to be replaced during a short time period.

10 Summary and Conclusions

The principal objectives for the MSc programme in Earth Sciences and Petroleum Engineering (ESPE) are to educate engineers who can contribute to an efficient and sustainable and environmentally safe exploration and exploitation of all kinds of non-renewable mineral resources.

The main findings from this self evaluation with regard to the above mentioned objectives are as follows:

- The study programme is well established and the best possible compromise under the strict imposed curriculum scheme.
- It is necessary to increase the students'awareness concerning the objectives of the programme
- Most basic science and special field courses have good or at least adequate relevance to the learning objectives, but there are too many non-technical courses
- It is a problem that necessary and compulsory teaching such as field work needs external financing
- The high average age among the teaching staff may soon become a problem, especially because the age range is small
- It is increasingly difficult to recruit Norwegians to the PhD studies. In the next round this may lead to problems in teacher recruitment
- Overall, we have an acceptable volume of student exchange, but there are conspicuously few students coming *from* USA *to* NTNU
- We have promising quantity and quality of applicants to the programme the last two years
- A good (high) percentage of female applicants, among the highest in technology at NTNU.

List of attachments:

1. Course matrices – both departments
2. Scientific Staff: Department of Geology and Mineral Resources Engineering
3. Scientific staff: Department of Petroleum Engineering and Applied Geophysics
4. Course and teaching matrix, IPT
5. Course and teaching matrix, IGB
6. Student exchange
7. SWOT-analysis