

Estonian Higher Education Accreditation Centre

Evaluation of Research in Chemical Engineering and Environmental Technology in Estonia

Institutes evaluated

**Tallinn Technical University
Department of Chemical Engineering,
Department of Environmental Engineering**

**Institute of Chemistry at Tallinn Technical University
Department of Environmental Chemistry and Technology**

Institute of Oil Shale Research at Tallinn Technical University

Evaluation dates

April 2nd to 7th 2002

Expert team

Professor Jan Mewis (Chairman)
Department of Chemical Engineering
K.U.Leuven
de Croylaan 46
B-3001 Leuven, Belgium
E-mail: Jan.Mewis@cit.kuleuven.ac.be

Professor James Frederick
Chalmers University of Technology
School of Chemical Engineering
Department of Forest Products and
Chemical Engineering
Kemivägen 10
SE-41296 Gothenburg, Sweden
E-mail: jimfred@sikt.chalmers.se

Professor Mara Jure
Faculty of Material Science and Applied Chemistry
Riga Technical University
Azenes 14/24
Riga, LV-1048, Latvia
E-mail: mara@ktf.rtu.lv

EVALUATION OF RESEARCH INSTITUTES IN CHEMICAL ENGINEERING AND ENVIRONMENTAL TECHNOLOGY IN ESTONIA

Report to the Estonian Higher Education Accreditation Centre (EHEAC)

April 2-6, 2001

I. Introduction

At the request of the Estonian Higher Education Accreditation Centre, Tallinn (EHEAC), an evaluation team (hereafter named the “**Evaluators**”) visited institutes in Estonia carrying out research activities in chemical engineering and environmental technology. The evaluating team consisted of Prof. Jan Mewis (Katholieke Universiteit Leuven, Belgium), Prof. James Frederick (Chalmers University of Technology, Sweden) and Prof. Mara Jure (Riga Technical University, Latvia).

The institutions to be evaluated were:

- a) Department of Chemical Engineering of Tallinn Technical University (chair of Chemical Engineering, Prof. V.Oja, and chair of Chemical and Environmental Technology, Prof. R. Munter) and Department of Environmental Chemistry and Technology of the Institute of Chemistry at Tallinn Technical University (head: Prof. R. Munter);
- b) Department of Environmental Engineering of Tallinn Technical University (head of department: Prof. K. Hääl);
- c) Institute of Oil Shale Research of Tallinn Technical University (director: Prof. J. Soone).

The evaluators were provided in advance with self-assessment reports from each of these three groups, prepared by members of these groups.

After a brief orientation meeting at EHEAC, the evaluators visited the different departments and institutes in Tallinn and Kohtla-Järve, the latter for a visit to part of the Institute of Oil Shale research and an industrial oil shale processing unit. At these occasions staff members of the various laboratories presented their work. During these presentations as well as during the subsequent discussions additional information about the research activities was provided. This included additional documents such as copies of published papers.

In their work the evaluators followed the guidelines established by the EHEAC for research evaluation. This means that separate ratings are given for *quality of research* and for *overall capability* of the research groups. The ratings are based on the rating system provided in the said guidelines. For the Department of Environmental Engineering at TTU (consisting of 3 sub-units) and for the Institute of Oil Shale Research at TTU (consisting of 3 sub-units) only global evaluations are given. It turned out that the performance of the sub-units of these institutions could not be separate to the extent that evaluation of each sub-unit was meaningful. In the discussion, however, separate comments are made for the various sub-units whenever deemed suitable.

II. General Comments

Based on the information collected from the various institutions some general comments can be formulated.

The evaluators observed that in all the institutions research is seriously hampered by the poor conditions of the available facilities. There were clear differences between the institutions but in most cases the general laboratory infrastructure is old to very old. The same is often the case for library facilities. Computing facilities are gradually improving, they are of very variable level, depending on the institution. Also, part or sometimes most of the research equipment is outdated, which seriously affects the quality of the work and also the kind of work that can be performed. A substantial part of the work is characterization and analysis that can be done with the available analytical tools. This situation, in combination with the fact that ratings are to be made with respect to international standards, should be taken into account when judging the research groups. **The evaluators recommend that the basic infrastructure and the research equipment of the laboratories be upgraded to present international standards. It is recognized that funds are limited. Consequently, it is recommended that upgrading will be done in a selective manner, based on priorities and on performance of the laboratories.**

Considering the limited resources it is imperative that too much overlap in areas of expertise should be avoided. **Hence, the evaluators recommend that specialized equipment should be allocated selectively between laboratories, according to their expertise.**

The evaluators are concerned about the age distribution among researchers. Because of structural difficulties of a general nature, it has been difficult to attract good young researchers and young people apparently have been leaving the laboratories. This causes a serious gap in the age structure for the age below 40 years. Such a situation is problematic for the future of a research laboratory and even for the research infrastructure of the country. Very recently the situation seems to improve slightly. Especially those laboratories that are a direct part of TTU have been able to attract some PhD students.

The evaluators recommend that urgent actions should be taken that make it possible to attract young researchers. Most of these actions have to be taken on a higher level than that of the institutions that are being evaluated. Association of the laboratories with an educational institution such as TTU is very important in this respect, as are up-to-date facilities.

The various laboratories have different publication strategies and also the number of papers per researcher is variable. There is, however, in general a tendency to publish in a limited number of international journals, in particular in very specialized journals with a limited circulation. While such journals are very useful to reach experts in the field, it is also important that researchers publish regularly in prestigious and more general scientific journals, which also have a higher impact factor (IF). In this manner international visibility of the research work can be improved. This might reduce the number of papers published but should be proof of a higher level of work. Such a publication policy becomes important once the research groups start to compete for foreign and international research funds. **The Evaluators strongly advise the usage of an internationally recognized evaluation system in future self-evaluation reports - the impact factors (IF) of journals and the number of citations in SCI databases should be taken into account. An effort should also be made to publish more frequently in archival journals with higher impact factors, even if this should reduce publication frequency.** This will only be possible if this policy is accepted in Estonia as well.

The Evaluators strongly advise the usage of an internationally recognized evaluation system in future self-evaluation reports - the impact factors (IF) of journals and the number of citations in SCI databases should be taken into account.

The efficiency of the research budgets that are made available through the national funding bodies could be improved if a larger degree of flexibility were allowed in their usage, e.g. with respect to the period they have to be spent.

The institutions that have been evaluated deal with research related to the environment and/or oil shale. Both of these topics are of the utmost importance to Estonia, especially in the light of closer relations with the EU. **The evaluators want to emphasize the particular relevance for Estonia of the research work under consideration.**

III. The Department of Chemical Engineering (TTU) and the Department of Environmental Chemistry and Technology at the Institute of Chemistry (TTU)

Environmental research at the Department of Chemical Engineering at TTU and the Department of Environmental Chemistry and Technology at the Institute of Chemistry are both under the direction of Prof. Rein Munter. The activities of these two departments

are closely coordinated, and there is strong collaboration between them. However, each department reported its research activities, publications, and funding separately. The Evaluators have therefore provided independent evaluations for each of the two departments.

The Department of Chemical Engineering (TTU)

General Overview

Environmental research at the Department of Chemical Engineering is under the direction of Prof. Rein Munter who holds the Chair of Chemical and Environmental Technology. Prof. Munter also heads the Department of Environmental Chemistry and Technology at the Institute of Chemistry. The Department of Chemical and Environmental Technology currently has 12 staff members, including six faculty members and senior researchers, all of whom hold PhD degrees; three technical staff; an administrative assistant; and a secretary. During the evaluation, the Evaluators met with five of the six faculty members and senior researchers, and visited the department's laboratories on the TTU campus.

The environmental research at the Department of Chemical Engineering is fundamental in nature, but yet with clear applications to Estonian society: treatment of water for municipalities, treatment of contaminated water from the shale oil industry and groundwater from former Soviet military installations, and sustainable water management in the shale oil and pulp and paper industries.

The Evaluators consider the **research activities** in Chemical and Environmental Technology to be '**good to satisfactory**'. During the evaluation period, the group published nine papers in peer-reviewed journals, thirteen other papers, and two monographs. About half of the peer-reviewed papers were published in international journals with reasonable impact factors (from 0.5 to 1.3), and half in the Proceedings of the Estonian Academy of Science – Chemistry. Fourteen of the papers were listed in the SCI Databases. These papers had been cited 27 times (1.9 citations per paper), which indicates that the work is recognized as important by other researchers. The department's researchers recognize the importance of publishing their results in highly regarded journals to increasing international recognition, and they are doing so. **The Evaluators commends their efforts in this area, and encourages them to seek additional opportunities to do so.** The work by this group is recognized in Estonia as being of high quality. In 2001, The Estonian Science Foundation recognized the contributions of Professor Munter, Associate Professor Preis, and Dr. Trapido in the area of advanced oxidation processes in water treatment, by presenting them with the Estonian National Science Award that year.

Collaboration with other research groups, both internationally and nationally is important for professional growth of the researchers and for sharing of expensive research facilities. Researchers from the department have established collaboration with other universities in the Baltic region, elsewhere in Europe, and in North America. During the evaluation

period, Professor Munter, Dr. Sergei Preis and Professor Juha Kallas has collaborated extensively with their counterparts at Lappeenranta University of Technology (Finland). Professor Munter has also collaborated with universities in Austria, Germany, and Norway during the evaluation period, and previously with several universities in the United States and Canada, England, and Finland.

Within TTU, there is very close collaboration between the Department of Chemical and Environmental Technology and the Department of Environmental Chemistry and Technology of the Institute of Chemistry. These departments have shared two Basic Research Grants provided by the Estonian Ministry of Education, and Dr. Marina Trapido of the latter department has been a co-investigator on both of the Department of Chemical and Environmental Technology's Basic Research Grants during the evaluation period. One measure of the success of this collaboration is that Professor Munter, Dr. Trapido, and Associate Professor Preis received jointly the Estonian National Science Award in 2001 for their work in advanced oxidation processes in water treatment. Another measure of the extent of collaboration is co-authorship of publications: eleven of the twenty-five peer-reviewed papers listed in the department's Self-Assessment Report were co-authored by at least one researcher from each department.

During the five-year review period, the total funding for research in Chemical and Environmental Technology within the Department of Chemical Engineering was 3.79 million EEK. 64% of this funding came from two Basic Research grants from the Estonian Ministry of Education. The department also received five grants from the Estonian Science Foundation (32% of total funding), and one from the Maj and Tor Nessling Foundation, Finland (4% of total funding). Overall, the financial support for Chemical and Environmental Technology increased by 31% from 1997 to 1998, and then has been rather stable, increasing or decreasing by 6%/year over the next three years. Support from Basic Research grants dropped by about half from 2000 to 2001. This decrease was offset mainly by an increase in research funding from the Estonian Science Foundation and the Nessling Foundation grant. **However, the Evaluators recognize the large decrease in Basic Research support and its implications to stability of support for research in Chemical and Environmental Technology is a cause for concern.**

No research contracts for Chemical and Environmental Technology were listed in the Self-Assessment Report. Obtaining external contracts would provide additional funding for researchers in Chemical and Environmental Technology during a period when state support may be declining.

The age distribution of the department's researchers raises an important concern. All of the faculty and senior researchers except Assoc. Prof. Preis are over 60 years old and there are no younger researchers within Chemical and Environmental Technology who will become the future faculty and senior researchers. **New young researchers need to be recruited so that research in this critical area will continue, and at the current level of quality.**

The Department's facilities and research equipment seems to be adequate, but in many cases will need replacement or upgrading in the near future. **Funding needs to be provided for these improvements.**

The Evaluators rate the **overall capability** for research in Chemical and Environmental Technology by the department as **'excellent to good'**.

Recommendations

- The Evaluators noted that the Department of Chemical Engineering has focused no effort on minimizing waste generation as a means of improving water quality, nor on control of air pollution or solid waste discharges. As Estonian industries develop and grow, there will be more pressure on the environment from their discharges of air emissions, aqueous effluent, and solid waste. The cost of end-of-pipe treatment to meet today's environmental standards can be excessively high; in-process reduction of waste generation is often a viable, cost-saving alternative. The Department of Chemical Engineering should begin to develop expertise in green chemical engineering so that they can take a lead role in in-process reduction of wastes as demand for this expertise by the Estonian industry increases.
- Given the age of the researchers in the area of Chemical and Environmental Technology, young researchers need to be recruited so that research in this critical area will continue, and at the current level of quality. Financial support needs to be provided to attract younger researchers to the department, and to retain them. Funding for travel to international conferences needs to be provided for these younger researchers.
- The salary levels in the department need to be increased so that the Department can retain the current research staff.
- There was no evidence of collaboration between the Department of Chemical Engineering and the Department of Environmental Engineering at TTU. Water and wastewater treatment is an area of common interest to these departments. This would seem a natural area for collaboration, with potential for synergism between the more basic research at the Department of Chemical Engineering and the more applied studies at the Department of Environmental Engineering. **The Evaluators encourages these two departments to explore possibilities to develop collaboration between them.**
- There is a great need to increase and stabilize funding for Chemical and Environmental Technology research, to increase salaries, support young researchers, and provide needed equipment. At least part of this responsibility belongs to the Estonian Ministry of Education. However, the department also needs to pursue external contracts to stabilize or improve their financial support.

The Department of Environmental Chemistry and Technology at the Institute of Chemistry, TTU

General Overview

The department was created in 1992, and has been headed by Prof. Rein Munter since its inception. Prof. Munter also heads the Department of Chemical and Environmental Technology at TTU. The Department of Environmental Chemistry and Technology currently has 8 staff members, including three faculty members and senior researchers, all of whom hold PhD degrees; three junior researchers who hold M.Sc. degrees, and two engineers. During the evaluation, the Evaluators met with five of the six senior and junior researchers, and visited the department's laboratories at the Institute of Chemistry building.

The department has focused on oxidative treatment of water, purification of industrial wastewaters, and the distribution of PAHs in the environment. The research is fundamental in nature, but yet with clear applications to the needs of Estonian society.

The Evaluators consider the **research activities** in Department of Environmental Chemistry and Technology to be **'good'**. During the evaluation period, the group published twenty papers in peer-reviewed journals, thirteen other papers, and two monographs. Most of the peer-reviewed papers were published in international journals with reasonable impact factors (from 0.5 to 1.0). Sixteen of the papers published by the department's senior researchers were listed in the SCI Databases. These papers had been cited 38 times (2.4 citations per paper), which indicates that the work is recognized as important by other researchers. The department's researchers have clearly recognized the importance of publishing their results in highly regarded journals to increasing international recognition, and they are doing so. The work by this group is recognized in Estonia as being of high quality. In 2001, The Estonian Science Foundation recognized the contributions of Professor Munter, Dr. Trapido, and Associate Professor Preis in the area of advanced oxidation processes in water treatment, by presenting them with the Estonian National Science Award that year.

Collaboration with other research groups, both internationally and nationally is important for professional growth of the researchers and for sharing of expensive research facilities. Researchers from the department have established collaboration with other universities in the Baltic region, elsewhere in Europe, and in North America. During the evaluation period, Professor Munter has collaborated with researchers at Lappeenranta University of Technology (Finland), and with universities in Austria, Germany, and Norway. He has also previously with several universities in the United States and Canada, and England. Dr. Marina Trapido has collaborated with researchers at three universities in Finland. Two of the department's PhD candidates, Marina Krichevskaya and Anna Goi, have obtained research training or an academic degree from universities in Finland and Austria.

There is very close collaboration between researchers at the Department of Environmental Chemistry and Technology of the Institute of Chemistry and the

Department of Chemical Engineering at TTU. Over the past five years, these departments have shared two Basic Research grants provided by the Estonian Ministry of Education. One measure of the success of this collaboration is that Professor Munter, Dr. Trapido, and Associate Professor Preis received jointly the Estonian National Science Award in 2001 for their work in advanced oxidation processes in water treatment. Another measure of the extent of collaboration is co-authorship of publications: eleven of the twenty-five peer-reviewed papers listed in the department's Self-Assessment Report were co-authored by at least one researcher from each department.

There would seem to be an opportunity for collaboration between researchers at the Department of Environmental Chemistry and Technology of the Institute of Chemistry, and the Department of Environmental Engineering. The research at the Department of Environmental Chemistry and Technology is fundamental, while that at the Department of Environmental Engineering is more applied, and the efforts of each group could complement those of the other. The Laboratory of Water Quality at the Department of Environmental Engineering is badly in need of new chemical analysis equipment. **It might make sense to integrate that Laboratory into the Department of Environmental Chemistry and Technology, so that new equipment could serve the needs of both research groups.**

During the five-years review period, the total funding for research in Environmental Chemistry and Technology was 2.84 million EEK. 57% of this funding came from two Basic Research grants from the Estonian Ministry of Education. The department also received six grants from the Estonian Science Foundation (43% of total funding) during this period. Overall, the financial support for the department increased by 20% from 1997 to 1999, and has remained nearly constant since then. No research contracts for Chemical and Environmental Technology were listed in the Self-Assessment Report.

The age distribution of the department's researchers is a concern. Two of the three senior researchers, including Professor Munter, are over 60. Dr. Trapido will be the apparent successor when Professor Munter retires. The younger researchers of the department, Marina Krichevskaya and Anna Goi, show great promise and should advance to senior research positions in that department as their careers develop. In addition, the department needs to continue to attract excellent young scientists and engineers as its future researchers.

The Institute of Chemistry's building is currently being renovated. With these renovations, the department's facilities should be adequate. The currently available research equipment seems to be marginally adequate, but will need replacement or upgrading in the near future. **Funding needs to be provided for these improvements.** It is not clear to the Evaluators where this funding will come from, or when it will be available.

The Evaluators rate the **overall capability** for research by the Department of Environmental Chemistry and Technology as 'good'.

Recommendations

- Financial support needs to be provided to attract younger researchers to the department, and to retain them. Funding for travel to international conferences needs to be provided for these younger researchers.
- The salary levels in the department need to be increased so that the Department can retain the current research staff.
- Opportunities for collaboration between researchers at the Department of Environmental Chemistry and Technology of the Institute of Chemistry, and the Department of Environmental Engineering should be explored.
- Integration the Laboratory of Water Quality into the Department of Environmental Chemistry and Technology, so that new equipment could serve the needs of both research groups, should be evaluated.

IV. Department of Environmental Engineering (TTU)

General overview

The department lead by Prof. Kaido Hääl consists from 3 units: the Chair of Water Engineering (head - Assoc. prof. Valdu Suurkask, 7 researchers), the Chair of Heating and Ventilation (head – Prof. Kaido Hääl, 2 researchers) and the Chair of Environmental Protection (head – Prof. Enn Loigu, 12 researchers). Research is conducted in two locations – in the building of the Faculty of Civil Engineering at Mustamäe, and at Järvevana tee. During the evaluation period departmental researchers have worked on two main topics supported by target financing (‘The criteria for water quality estimation and improvement of purification technology for natural and waste waters’ (Prof. H.Mölder, 1996-1999) and ‘Advanced methods for improvement of natural and built environment quality’ (Prof. K.Hääl, 2000-2004)), 8 subtopics, 13 grants, 14 contracts related to the main topics (within this group international contracts brought 2.729.540 EEK) and 9 contracts outside the main topics (6 domestic contracts brought 985.000 EEK and 3 international contracts brought 1.806.000 EEK). One doctoral thesis and 8 Master’s theses have been defended during the review period. Researchers have participated in 260 scientific events, including 185 international (with 129 presentations) and 73 national (51 presentations), and the department has organized 16 conferences, symposia and workshops.

Research activities of the department in overall are evaluated as ‘**satisfactory**’ – 15 articles have been published in pre-reviewed journals (and 4 in other sources) during the period of evaluation. Nevertheless, significant differences between the three chairs should be pointed out> the Chair of Environmental Protection has 7 articles, the Chair of Water Engineering 5, and the Chair of Heating and Ventilation 3 articles that were reviewed in Current Comments (CC). Using these parameters, the papers published by the Chair of Environmental Protection have the greatest impact – there are 2 articles in journal ‘Hydrobiologia’ (IF=0.582) and three articles in journals, having IF’s of 0.462, 0.849 and

1.088, respectively. The Evaluators consider the **research activities** within this Chair to be ‘**good**’. By comparison, the Chair of Water Engineering has one article in the journal ‘Oil Shale’ (IF=0.308), and researchers of the Chair of Heating and Ventilation have been cited in SCI once. In addition, researchers of the Chair of Environmental Protection have published 4 monographs during years 1997-2001 and presented 27 papers at technical conferences. The corresponding numbers for the Chair of Water Engineering and the Chair of Heating and Ventilation are 15 and 9).

The **overall capability** of the departmental research groups is judged to be ‘**good**’. Several research activities are novel and innovative, but many are routine investigations. These more routine investigations have value to Estonia and the Baltic region. One example is the mapping of measured chemical concentrations in the environment done at the Chair of Environmental Protection (Water Quality Laboratory) which provides results that are very important not only for Estonia, but for the whole Baltic Sea region. A specific example is the Estonian-Swedish joint project (BEAROP) which will provide hydro-chemical monitoring data on agricultural areas for the Nordic-Baltic common data bank, from information on water quality collected from rivers in Estonia. Another example is the design of codes for water supply (the Chair of Water Engineering), which can not be treated as scientific problems, but it is, of course, necessary. Granular sludge treatment (the Chair of Water Engineering) is an example of original research. The department has a fairly clear strategy for further research. **The Evaluators suggest that more efficient use of facilities (equipment, money for infrastructure) is possible by moving the Water Quality Laboratory to the same building, where other departmental laboratories are situated.**

More effort could be made to encourage novel and original research that will have an impact both in Estonia and worldwide. The Evaluators would like to acknowledge one of the strengths of the Chair of Environmental Protection – a rather low average age (46.5) of the staff and a strong interest in increasing the number of students who participate in their research. **Unfortunately, the age structure of the two other chairs is not satisfactory.** Three of the eight graduates who defended their theses during the review period are already more than 45 years old; nowadays department has 23 researchers working on their theses and four of them are 42-50 years old. To maintain a healthy age structure within the scientific and academic community in Estonia, an increase in state financed positions for graduate students and, especially, postgraduates, is needed, special research grant programs could be provided for young researchers (post-docs), and additional funding (e.g., for 1-2 years for applicants under 35 years age) provided for young academic staff. The proportion of state financed engineering students in specialties of the department (10% for Chemistry and 13% for Civil Engineering, based on the total number of TTU students) in comparison with other fields seems inadequate (e.g., compared with 28% of students with Economics major). At this moment department has only three state-supported doctoral students; the studies of the other four PhD students are financed by companies. This means that after defending their theses, the four industrial-supported students will leave the university. Demand for top specialists in engineering, the ‘brain drain’ to abroad and to rich and stable companies (due to low salaries of researchers - the difference is up to 4 times - and instability in science

financing) has to be taken into account, too, when state-financed positions for engineering students are allocated. The potential of the department to supervise theses, according to the Self-Evaluation Report, is 3-4 times larger than the number of students.

The need to increase funding for participation in conferences was mentioned in the Self-Assessment Report: the Evaluators recommend that fees for attending international conferences could be provided to researchers on a competitive basis by the Estonian Science Foundation.

The department's cooperation with other institutions, both nationally and internationally deserves the highest grade. The researchers participate in many other projects besides target funded topics and ESF grants (funding of which in last 2 years decreases in country). Funding of contracts is increasing year by year and forms approximately 2/3 of finances of the department. Total financing of the department exceeded eleven million EEK during the evaluation period. Development of the department is hindered by inadequate financing from the state budget. The most urgent need is for updating of laboratories with appropriate modern analytical equipment (FTIR spectrophotometer, HPLC, electronic balances, etc.). Funding of international projects is used efficiently for equipment (e.g., modernization of the Heating and Ventilation laboratory was supported mainly by the EU TEMPUS-JEP project, with a total cost of unique equipment of approx. 1.5 million EEK; approximately 2.5 million EEK was spent on the modernization of Laboratory of the Training Center of the WWTP Maintenance Personnel). The department has international cooperation with similar laboratories in Latvia, Lithuania, Russia, the Netherlands, Sweden, Finland, Belgium, Ireland and Norway, the Ministry of the Environment of Schleswig-Holstein, the Finnish Ministry of Environment, the US EPA, the Danish company Carl Bro, the Finnish company AX Consulting/Axovaatio Oy, Chalmers University of Technology, the Swedish Institute of Agricultural Engineering, The Royal Institute of Technology, Espoo-Vanta Vocational Higher School, etc.

Implementation opportunities for the research results in water engineering and environmental protection **are very promising** as research done at department has applied sciences character and is essential for not only for Estonia, but for the whole Baltic region and its future.

Chair of Water Engineering

Research is closely linked to the practical tasks of damages caused by natural and industrial wastewater in Estonia. The main focus is on aerobic and anaerobic bioprocesses connected with joint phosphorous and nitrogen removal from small town waste water. Sustainable technologies and analysis of product cycle are a new trend (doctoral thesis of S. Talve, defended at Helsinki University). Research activities of this group should be improved considerably by publishing their results in journals having higher IF; as was already mentioned, there was only one article published during these years which has an IF of 0.308 (although 5 publications are reviewed by CC). It seems that the undesirable age structure in next years would be improved, because five Master's theses

were defended during the review period and nowadays seven young researchers are working on their theses.

Chair of Environmental Protection

A methodology of river monitoring has been developed, the rate and reasons for changes in water quality in rivers are being analyzed, a 3-dimensional hydrodynamic model of the coastal sea area has been created in cooperation with the Estonian Institute of Maritime Research, and a program dealing with the quality of water in small rivers of Estonia is under way. Investigation of diffuse pollution from agriculture, prevention of nutrients run-off from agriculture, activities to support sustainable agriculture. These complex investigations are aimed toward developing sustainable and environment friendly agricultural practices to decrease water pollution in small rivers in Estonia. Advances in surface water quality studies have placed this laboratory in the lead position in Estonia - senior researcher M. Hannus supervises the chemical analysis of surface water monitoring methodology, and promotes activities related to quality management, assurance and control. Much attention is devoted to attraction of new researchers and group has a good age structure. The new Master's program within Baltic network of studies (together with Latvia and Sweden) will be started in autumn of this year. The Evaluators assess the **research activities** of this group as '**good to satisfactory**'. Investigations done at this chair, deserve the **highest evaluation for attracting considerable funding** by contracts and implementation of results (wastewater treatment methods are introduced (or will be) in many WWTP - in Tartu, Tallinn, Pärnu, Naarva, Haapsalu).

Chair of Heating and Ventilation

Heat and technical-economical aspects of indoor climates: analysis of the indoor climates of different building types, creation of effective renovation schemes of engineering systems, in compliance with the requirements of healthy indoor climates. The **research activities** of this small group, consisting from only 2 researchers, are '**unsatisfactory**', as only one citation was found in the SCI Databases for their investigations. Hopefully, this situation will change in the near future, because there are 7 students working on their theses under the supervision of the group's researchers. Research done at this group is important for Estonian civil engineering. Implementation of results will be very valuable and will lead to energy audits of buildings and building service system renovation. **The highest evaluation** can be given for attracting of considerable **funding** as contracts. New trends (e.g., sustainability) in this field of research should be taken into account for a better research perspective.

Recommendations

- Research perspectives need to be revised, with emphasis on originality and novelty.
- More efficient use of facilities (moving of Järvevana tee laboratories to Mustamäe building closer to students) should be considered.
- Updating of equipment and instrumentation of laboratories is strongly advised.
- Improvement of the age structure is necessary for the two groups within the Chair of Heating and Ventilation and the Chair of Water Engineering .
- Currently, on-going investigations (air, water, soil, ground water) are dispersed between different researchers groups, and integration is insufficient. The development of cooperation between several research groups within TTU and in other universities related to the multi-criteria evaluation of the state of environment and processes concerning sources of nutrients, transport, cycling and their impacts on the environment is strategically important; more attention should be paid to the sustainability approach in the future.

V. Institute of Oil Shale Research (TTU)

General Overview

The Institute of Oil Shale Research at Tallinn Technical University, led by Prof. J. Soone, consists of three laboratories. Two of these, the Chemical Laboratory (head of laboratory: senior research associate Dr. E. Raidma) and the Analytical Laboratory of Fuels and Oils (head of laboratory: senior research associate Dr. R. Muoni) are located in Kohtla-Järve. The third one, the Laboratory of Oil Shales and Shale Oil (head of laboratory: senior research associate Dr. H. Luik) was part of the Institute of Chemistry until the beginning of 2001 and is still located in the building of that Institute at Tallinn.

At the end of 2001 the Institute had a staff of 47 people, including 16 research associates. Over the years the number of people has been declining. This factor, together with some general structural factors discussed under General Comments, resulted in an unfortunate age structure for the researchers with a high average age and hardly any young researchers. Apparently, the situation is starting to improve slowly, at least at the Tallinn location where interaction with students from TTU is easier.

Oil shale is very important for Estonia and this country has a long tradition in oil shale technology. Oil shale is a locally available source of energy that is being used in power stations. It is also a raw material that can be used for the production of fuels, chemicals and, to a smaller extent, construction materials. The use of oil shale has been hampered by some technical constraints and increasingly by environmental problems. Interest worldwide in oil shale research is strongly related to the price of crude oil and therefore is very cyclic. The resulting strong fluctuations in budget make it very difficult for institutions such as the Institute of Oil Shale Research to do long range planning and to maintain up-to-date infrastructure. These problems are very visible in the Institute. Partly because of the recent rise in oil prices interest in oil shale is strongly increasing and so

are the financial means of the Institute. **The evaluators suggest that a long term strategy and investment should be decided upon if Estonia wants to pursue the exploitation of its oil shale reserves.** Otherwise investments in this area of research will never be efficient. The prospects, at least for the next few years, are very promising. The Institute has recently been able to attract substantial means from various sources abroad, especially from the EU and the US. This will make it possible to improve the infrastructure, an essential process that has started recently.

The Institute of Oil Shale Research is the leading institute in Estonia in its area of research. Below, the activities in Kohtla-Järve and in Tallinn will be commented on separately. It was, however, considered that the activities and the publications are mixed to such an extent that only a common evaluation should be given. With respect to the **quality of research** the evaluators rank the Institute as **'satisfactory'**. This means that it satisfies the definition of that ranking in the guidelines for evaluation, i.e. the majority of the work performed during the period 1997-2001 is considered to be of possible relevance for the international community and has been, or could be, published abroad or in well-known national journals. The researchers of the Institute produced approximately 35 papers in international, peer-reviewed journals. Most of these papers were published in Oil Shale (impact factor 0.31). This is a logical channel for exchanging information among experts in the field of oil shale research. Some of the work performed here could, however, also be of interest to researchers in related fields. These could be reached by publishing in more general journals related to energy, oil, chemical engineering or chemistry. It will of course be a challenge to publish in journals with higher impact factors. In this manner it will be possible to gain more visibility on the international scene. At the moment visibility of most of the researchers of the Institute is relatively low, as illustrated by the limited number of citations to their papers. **The evaluators strongly suggest that publication in other prestigious journals should be attempted more often.** As far as participation in congresses is concerned the Institute is performing well at this moment.

Based on the criteria suggested in the guidelines for research evaluation the **overall capability** of the research at the Institute is rated **'good'**. The work received high marks for national and international cooperation and for success in applying for funds and grants. A rather high mark was given for multidisciplinaryity, whereas strategy and competence got average marks. Originality/novelty was judged slightly below average. Some of these scores are affected by external parameters and the various aspects are not identical for the two locations. These elements are discussed separately for the two locations (see below) but first some general remarks are made.

The Institute has experience and know-how in oil shale and shale oil research which is quite unique in the world. This position should be taken advantage of, and actually the Institute is already doing this through various collaborations and research contracts abroad. Maintaining expertise and a leading position in research are never trivial. In the present case the systematic reduction in available means led to a systematic reduction in the number of researchers and, more importantly, to a decay of the infrastructure, a severe lack of updated research equipment, modern library and computing facilities. All

of this, not to mention the low salaries, made it also extremely difficult to attract good young researchers. As mentioned above a long range strategy of the authorities will be required for the Institute to maintain its international position. Obviously the deteriorating situation had a negative effect on the quality of the research work also.

Laboratories at Kohtla-Järve

There are no separate data for the Analytical Laboratory of Fuels and Oils. Therefore, it will be discussed together with the Chemical Laboratory which is located at the same site. The laboratories at this site are essentially responsible for research in the areas of oil shale processing and shale oil processing. Improvements to the industrial Kiviter process have been developed over the years and a new thermal process is being developed. Roads to further take advantage of this know-how have been considered. This include studies of oil shales from other places in the world in order to export Estonian technology. Attempts are also being made to apply the pyrolysis technology to other material than oil shale, more specifically scrap tires. This work is by definition more technological in scope and therefore less suitable for publication. The number of papers in refereed international journals is indeed rather limited: recently about 4 such papers per year, mainly in Oil Shale. On the other hand there is now a trend, which is appreciated by the evaluators, to exploit the technological results of the research also by applying for patents on the technological achievements.

When considering strengths and weaknesses the technological experience in oil shale and shale oil, accumulated over the years in the Institute, is considered a real asset. It cannot only be applied to oil shale but to a number of related problems, e.g. in using other organic waste material. Contacts with industry locally and abroad are important for the technological research. These seem to be good in this case. The industrial experience of the director of the Institute is very important in this respect. The aging facilities constitute a serious limitation to the quality of the research and its exploitation now and in the future. The same holds for the age structure of the scientific staff, this is particularly so for the laboratories in Kohtla-Järve.

The basic strategy of the Institute is a sound one: i) development of oil shale technology and considering other applications of this technology, ii) valorization of shale oil. With respect to the first one **it is suggested to put more emphasis on the introduction of modern chemical engineering techniques**. This has already been done to a certain extent, viz. the use of supercritical solvents. Further work in this direction will only be possible when sufficient funds are available. Several initiatives have been taken to make additional use of shale oil products, e.g. as additives to fuels and polymers and as biocidal products. Penetrating suitable markets is an important problem in such work, this is recognized here and collaborations have been set up to overcome the problem. **Even more emphasis on collaboration with specialized laboratories and interested companies might be necessary to make progress in this area.**

The Laboratory of Oil Shale and Shale Oil (Tallinn)

This laboratory (head Dr. H. Luik) occupies a very small area in the building of the Institute of Chemistry at Tallinn, it consists of three laboratories and two offices (for 12 researchers and a variable number of students). The laboratory is divided in four research groups:

- geochemistry,
- thermal degradation of oil shale;
- upgrading of shale oil;
- phenols.

These are important aspects of oil shale and shale oil research. Useful results have been obtained in improving oil shale processing, including the reduction of polluting elements and waste products. Progress has also been made in processing shale oil and in finding new applications for shale oil derivatives. The emphasis of the work has been on characterization and data collecting. This is obviously important but the work should go beyond these topics. The available infrastructure is however a serious limiting factor, which explains in part the nature of the present research. The project on the use of supercritical solvents is a nice example of a new trend in the work. This also turns out the only area in which there is a PhD student associated with the Institute. Nevertheless the age structure of the researchers is still unsatisfactory.

Being close to the main campus of the TTU has made it easier to attract students for making their dissertation in this laboratory. This is important as there is a desperate need for young researchers in the whole Institute. In addition collaboration with other laboratories of the TTU is easier because they are close by. The poor condition of the facilities, also the Tallinn ones, is also a limiting factor in attracting young researchers.

The Tallinn laboratory has been quite prolific in producing papers: over 30 in international journals. The majority is in Oil Shale, as was the case for the Kohtla-Järve laboratories. Several of the researchers of the laboratory in Tallinn also publish elsewhere and have a good visibility in the international scientific community. **Yet, the evaluators would like to encourage the researchers in Tallinn to submit more of their papers to other international, peer-reviewed journals.**

Recommendations

- Estonia has a unique position in oil shale/shale oil research. If the country wants to utilize its oil shale reserves a long term strategy and ditto investment budget is essential. This would also make it possible to bring in foreign research funds and to export Estonian oil shale technology. The Institute is already involved in such international cooperation and this could be extended.
- If oil shale/shale oil research is to be continued on an international level, an upgrading to present standards of the research infrastructure, including scientific equipment, library and computers, is absolutely essential.

- The Institute of Oil Shale Research of the TTU is well aware of the direction in which the research should move. Considering the limited resources some focussing and prioritizing of the research work should be desirable. The use of modern chemical engineering techniques to increase the efficiency of the processes and to reduce the serious environmental impact should be given a high priority. For the same reasons it is important that the activities of the various laboratories of the Institute are properly coordinated as well as the collaboration with other laboratories in Estonia (e.g. for environmental protection and for finding new applications for shale oil derivatives). The overriding importance of the environmental aspects of the technology should be recognized.
- The Institute has initiated applying its technology to other areas (e.g. treatment of scrap tires and plastic, utilization of wood and peat). This attempt to diversification should be encouraged.
- The age structure of the researchers is of serious concern. Attracting good young researchers should be a top priority, which is of course hampered mainly by structural factors outside the control of the Institute. A closer interaction with the TTU should be useful in this respect. The laboratory at the Tallinn location could play an important role here, they are actually already attracting students for the dissertation work, including one Ph.D. student. The Kohtla-Järve laboratories should be included in this effort.
- The researchers of the Institute, especially those at Tallinn, have a good track record in publishing their results in international journals. Too much of the papers are in a single journal (Oil Shale) with a rather limited impact factor. The researchers are encouraged to submit more frequently papers to more general scientific journals with higher impact factors to improve their visibility. This would help in the long run to compete for international sources of funding.

VI. Acknowledgements

We thank the Estonian Higher Education Accreditation Centre and the staff of the visited institutions who were most hospitable to us and went to great lengths to show us all of their facilities and to make our stay a most enjoyable one.

Tallinn, April 6, 2002

The Evaluators Team:

Professor JAN MEWIS

Professor JAMES FREDERICK

Professor MARA JURE