EXECUTIVE SUMMARY
of the evaluation committee for Chemical Processes (18/7/2005 – 22/7/2005)
Chemical Process Engineering Research Institute (CPERI)

The Chemical Process Engineering Research Institute (CPERI) is organized to carry out research and development in the chemical engineering sciences. The thrust of the fundamental and applied research has very strong links to the technological needs of the Greek, European and worldwide chemical, polymer, energy, and materials-based industries.

The overall scope of activities in the Institute can be grouped around three larger areas, i.e., "Advanced Production Systems", "Energy and Environmental Technologies" and "Particle and Advanced Material Technologies". These areas cover the production and transformation of materials including energy-production systems, the elucidation and use of chemical engineering principles to optimize reaction conditions and minimize energy consumption (including the development of advanced software packages for process simulation, design, optimization and control) as well as the synthesis and characterization of materials. To achieve these broad goals, the Institute brings together academic researchers (primarily from the Department of Chemical Engineering at the University of Thessaloniki) from northern Greece with permanent research staff.

Overall, the Institute has delivered an excellent performance over the last five years. Over the last five years the Institute has been very successful in integrating new laboratories such as the "Laboratory of Inorganic materials" and has reorganized by strengthening its efforts in supporting successful initiatives. This has led, e.g., to an assembly of outstanding pilot plant equipment in the area of petroleum processing.

Some of these approaches are seen outstanding on a world-class level. Overall, the strongest contributions were observed in the "Laboratory of Environmental Fuels and Hydrocarbons" (Catalyst activity evaluation protocols for use in hydrocarbon refining processes), "Laboratory of Polymer Reaction Engineering"(Development of advanced software tools for the design, optimization and control or polymer production processes), "Aerosol and Particle Technology Laboratory" (Catalytic emission control technologies for mobile and stationary sources) and "Laboratory of Inorganic Material"(Development superparamagnetic nanoparticles for NMR diagnostic purposes).

It is impressive how the international recognition covers large fractions of the output of the Institute. This is seen by the unique position the individual groups have in their interaction with Industry (such as the interaction of the "Laboratory of Environmental Fuels and Hydrocarbons" with BP-Amoco and the interaction of the "Aerosol and Particle Technology Laboratory" with the automobile industry. In this context we would also like to mention the awarding of the SAE fellowship to Dr. Konstandopoulos in 2005.

The output in terms of industrial reports and practical evaluation of catalysts is world-class. Also the filter and particle techniques have received highest recognition by all major players in the automobile industry.

The success in attracting external funds in particular reflects the extremely high technological expertise, demonstrated in particular by the Laboratory of "Environmental Fuels and Hydrocarbons", "Laboratory of Polymer Reaction Engineering", "Aerosol and Particle Technology Laboratory" and "Laboratory of Inorganic Material" all supported by the "Laboratory of Analysis and Characterization of Solids"

We would like to point out that low level of direct funding from the Greek Government (i.e., the regular annual budget of GSRT) constrains the ability to set long-term strategic goals and to implement the necessary policy. In comparison to the funding of other comparable institutions in the European Union the current level is seen inadequate in absolute terms to provide the necessary means to respond in an optimal way to upcoming opportunities. This has to bee seen in contrast to the remarkable success in attracting external funds across the Institute. The evaluating team is convinced that the bettering of the GSTRT funding would provide an enormous leverage for the researchers.

In light of the above, the committee strongly recommends the following specific actions,

- Increase of the annual budget from the GSRT by at least 50% from the existing level in order allow the institute to make the development of the Institute much stronger and more sharply focused
- The committee supports the plans for the reorganization of the institute. At the same time it strongly recommends to maintain the clear focus shown so far. Thus, new laboratories should be the installed only step by step under the constraint that existing successful activities maintain their room to grow. In direct respect to the plans, which have been discussed during the evaluation, especially the planned activities in "Thin films and Nanotechnology" and "Biomaterials" imply special external financial support. Establishing new laboratories should require the consensus of the "Laboratory Directors".
- First priority should be given to funding in the areas that are documented in 1.2.2 to have achieved excellent and/or promising results. In addition, the committee strongly recommends to enhance the capabilities of transmission electron microscope by purchasing a CCD camera and sample holder with a wider tilt angle
- In order to intensify the interaction between the University groups and researchers of the Institute integration of more groups of the University of Thessaloniki should be undertaken. The director should develop a strategy to integrate individual permanent researchers into teaching and into supervision of PhD students at the University of Thessaloniki.
- Strong success coupled incentives with respect to promotion and financial remuneration should be given to the researchers.
- It is recommended to involve researchers formally in the policy making procedures of CPERI.

1.1 General description of the field

The Chemical Process Engineering Research Institute (CPERI) is organized to carry out research and development in the chemical engineering sciences. The thrust of the fundamental and applied research has very strong links to the technological needs of the Greek, European and worldwide chemical, polymer, energy, and materials-based industries.

The overall scope of activities in the Institute can be grouped around three larger areas, i.e., "Advanced Production Systems", "Energy and Environmental Technologies" and "Particle and Advanced Material Technologies". These areas cover the production and transformation of materials including energy-production systems, the elucidation and use of chemical engineering principles to optimize reaction conditions and minimize energy consumption (including the development of advanced software packages for process simulation, design, optimization and control) as well as the synthesis and characterization of materials. To achieve these broad goals, the Institute brings together academic researchers (primarily from the Department of Chemical Engineering at the University of Thessaloniki) from northern Greece with permanent research staff.

Fuel processing and substitution of existing fuels by renewable materials is one of the key problems to sustain the current level of mobility and energy distribution without damaging the environment to an intolerable degree. The field contributes critically to a cleaner environment by providing alternatives for a fossil based energy scheme based on renewables. In the field of polymer engineering, the areas of polymer reaction design, optimization and control and of novel micro- and nanotechnologies with applications in health, food, environment, and agriculture, are of particular significance. Sustainable development also motivates the need for water treatment and pollution abatement, energy conservation and utilization of renewable energy. The solution of many current environmental health, energy, and materials/process industries related issues, relies on understanding and exploiting the science of fine particles and their suspension in various media. Advanced inorganic materials will find applications in separations, as functional ceramics and even in medical diagnostics.

Progress in these areas requires strong analytic capabilities to characterize morphology and structure, as well as the chemical composition and the properties of the developed or applied materials.

1.2 State of the art in Greece compared to Europe and the rest of the world

Greece has a long and distinguished history in the development of modern chemical engineering. This is evidenced by the large number of important Greek researchers in this field (many of the expatriates) and by the two research institutes evaluated in this report, which are truly centres of excellence. It is important to note that ICE/HT and CPERI complement one another in their research activities. Certainly, both institutes are world class research centres. Overall, ICE/HT is more material and device oriented while CPERI is more process oriented. This statement is a generalization and certainly important examples of process oriented science are found with ICE/HT, while material and device oriented research is conducted at CPERI. These

complementary approaches represent an important opportunity for both institutes to leverage their mutual strength.

Indeed, a high percentage of the important research in the chemical engineering science and technology in Greece is being conducted within these two institutes. This demonstrates the high quality of the associated faculties and the permanent research staff. These two centres also have well designed research laboratories and are stocked with state-of-the-art equipment, which is not normally encountered in Greek universities. In both institutes, the research teams have managed to establish several important research facilities, such as pilot plants and modern state-of-the-art laboratory analysis systems, that may be considered not only excellent for Greece, but also for Europe and the rest of the world.

The existence of these two institutes is critical to the strong position in Greece in chemical engineering within Europe. The two institutes are seen to be superior to renowned Institutes in Europe such as VITO (Vlaamse Instelling voor Technologisch Onderzoek) or divisions of TNO (the Dutch Institute of Toegepast Natuurkundig Onderzeok) or the Fraunhofer Institute in Germany. Judging the quality of the individual researchers, we are confident that they can compete well with professors of the top European Universities in their respective field.

1.2.1 Human Capital

The Institute has successfully attracted a full time staff of first-rate scientists and engineers. The demographics of the staff are well distributed and every person is fully active. There is a very healthy and vigorous spirit in the Institute allowing younger scientists to develop their potential. As seen by the excellent output, this opportunity has been well used by all.

This strong position could be even further improved by a closer mutual integration with the University of Thessaloniki. In order to intensify the interaction between the University groups and researchers of the Institute, integration of more groups of the University of Thessaloniki should be undertaken. This is expected also to increase the number of PhD students. The director is encouraged to develop a strategy to integrate individual permanent researchers into teaching and supervision of PhD students at the University of Thessaloniki. Preferably such strategy should lead to a formal agreement between the Institute and the respective faculties of the University.

1.2.2 Research Accomplishments

The Institute is organized at present according to the following divisions

- Advanced Production Systems
- Energy and Environmental Technologies
- Particle and Advanced Material Technologies
- Analytical Facilities

In the period of the last five years, the Institute in total has made excellent progress, which is emphasized by the very good results in many projects including excellent ones. Examples of major developments/achievements are the following

1. ***Laboratory of Environmental Fuels and Hydrocarbons***
   - Unique infrastructure at European level in the area of Applied Catalysis including bench scale units, pilot plants and IT extranet facilities

2. ***Laboratory of Polymer Reaction Engineering***
   - Development of drug carriers down to the nanometer scale, uniform in size and distribution, non-aggregated in dispersion, with optimized delivery properties and manufacturable at industrial scale

3. ***Laboratory of Natural Resources and Renewable Energy/Laboratory of Environmental and Energy processes***
   - Method to assess scale formation in reverse osmosis and nanofiltration membranes

4. ***Aerosol and Particle Technology Laboratory***
   - Monolithic solar water cleavage reactors for hydrogen production

5. ***Laboratory of Inorganic Materials***
   - Red-ox spinel based materials for the catalytic decomposition of water

6. ***Laboratory of Inorganic Materials***
   - Implementation of a High Resolution Transmission Electron Microscope equipped with X-ray microanalysis

The evaluators want to emphasize the following excellent achievements:

- ***Environmental Fuels and Hydrocarbons***
  - Hydrocracking Process for maximum Diesel production from Biomass Fischer-Tropsch wax upgrading
- ***Laboratory of Polymer Reaction Engineering***
  - Development of powerful, flexible, adaptive design and predictive simulation tools that can follow and predict the molecular and morphological properties of polymers produced in different reactor configurations in an accurate, prompt and comprehensive way

- ***Aerosol and Particle Technology Laboratory***
  - Design and realization of a diesel particulate filter for DaimlerChrysler

In addition, we wish to point out one exceptionally promising development:

  - Development of superparamagnetic nanoparticles for NMR diagnostic purposes

1.2.3 Opportunities and threats in relation to the national regional economy

During the last five years, the already excellent integration of the Engineering Science and Development at CPERI into the local economy, the Balkan region and Europe has further progressed. In addition, we would like to emphasize that the Institute has an outstanding reputation and excellent business relation with major players in the oil and automobile industry. In this context, we would like to point especially to the interactions of the teams of "*Laboratory of Environmental Fuels and Hydrocarbons*" and the *"Aerosol and Particle Technology Laboratory"*.

Two spin-off companies are being launched (PolymerS Ltd., CPERI Solutions Ltd) which is a clear sign of a healthy interaction with the local and international market.

1.3 Recommendations and measures to be taken

In light of the above, the committee strongly recommends the following specific actions,

- Increase of the annual budget from the GSRT by at least 50% from the existing level in order allow the institute to make the development of the Institute much stronger and more sharply focussed
- The committee supports the plans for the reorganization of the institute. At the same time it strongly recommends to maintain the clear focus shown so far. Thus, new laboratories should be the installed only step by step under the constraint that existing successful activities maintain their room to grow. In direct respect to the plans, which have been discussed during the evaluation, especially the planned activities in "Thin films and Nanotechnology" and "Biomaterials" imply special external financial support. Establishing new laboratories should require the consensus of the "Laboratory Directors".
- First priority should be given to funding in the areas that are documented in 1.2.2 to have achieved excellent and/or promising results. In addition, the committee strongly recommends to enhance the capabilities of transmission electron microscope by purchasing a CCD camera and sample holder with a wider tilt angle
- In order to intensify the interaction between the University groups and researchers of the Institute integration of more groups of the University of Thessaloniki should be undertaken. The director should develop a strategy to integrate individual permanent researchers into teaching and into supervision of PhD students at the University of Thessaloniki.
- Strong success coupled incentives with respect to promotion and financial remuneration should be given to the researchers.
- It is recommended to involve researchers formally in the policy making procedures of CPERI.

5=EXCELLENT 4=VERY GOOD 3=GOOD 2=SATISFACTORY 1=UNSATISFACTORY

TABLE 1

How do you evaluate the Centre with respect to	5	4	3	2	1
1. Leadership					
2. Mission and goals					
3. Strategy and policy					
4. Adequacy of the resources					
5. Funding policies					
6. Facilities					
7. Academic reputation					
8. Societal relevance					
9. Balance of the strengths and weaknesses					
OVERALL ASSESSMENT	**5**				

REMARKS

Overall the Center is ranked excellent. The only major point to take care is related to the unbalance in the funding. We would like to note that the financial resources supplied by GSRT to the individual Institutes has to be increased by about 50 % from the current level in order to allow for a stable long term planning of these excellent initiatives. We, further, see a possibility in improving the visibility of the Center by increasing the publication activities.

TABLE 2

How do you evaluate the Institute with respect to	5	4	3	2	1
1. Leadership					
2. Mission and goals					
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6. Facilities					
7. Academic reputation					
8. Societal relevance					
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OVERALL ASSESSMENT	**5**				

REMARKS

CPERI as a member of the CERTH Center has unique structure consisting of 14 permanent researchers and 7 collaborating University professors. The Institute is grouped into three clusters plus an independent analytical group, which assists all the other groups in their tasks. The three clusters are "Advanced Production Systems", "Energy and Environmental Technologies" and "Particle and Advanced Material Technologies". This is a very appropriate structure, which is planned to be focused even further into two clusters by integrating the activities of the "Energy and Environmental Technologies" clusters into "Advanced Production Systems". The merger of the two groups in the former cluster into the "Laboratory of Environmental and Energy Technologies" is a very good initiative to maintain and create critical masses of the research groups.

While we note a strong leadership in the Institute, we would also indicate that the communication between the researchers and the Institute directorate might be an issue to be addressed.

In order to intensify the interaction between the University groups and researchers of the Institute, integration of more groups of the University of Thessaloniki should be undertaken. This is expected also to increase the number of PhD students. The director is encouraged to develop a strategy to integrate individual permanent researchers into teaching and supervision of PhD students at the University of Thessaloniki. Preferably, such strategy should lead to a formal agreement between the Institute and the respective faculties of the University.

We would like to point out that the low level of direct funding from the Greek Government (i.e., the regular annual budget of GSRT) constrains the ability to set long-term strategic goals and to implement the necessary policy. In comparison to the funding of other comparable institutions in the European Union, the current level is seen inadequate in absolute terms to provide the necessary means to respond in an optimal way to upcoming opportunities. This has to be seen in contrast to the remarkable success in attracting external funds across the Institute. The evaluating team is convinced that the increase of the GSRT funding would provide an enormous leverage for the researchers.

The success in attracting external funds in particular reflects the extremely high technological expertise, demonstrated in particular by the Laboratory of "Environmental Fuels and Hydrocarbons", "Laboratory of Polymer Reaction Engineering", "Aerosol and Particle Technology Laboratory" and "Laboratory of Inorganic Material" all supported by the "Laboratory of Analysis and Characterization of Solids"

While being very good, the academic visibility of the CPERI could be further improved by increasing the publication activities in higher impact journals.

With respect to the direct societal impact, the strong efforts to integrate into the Greek and local Macedonian economy should be positively mentioned. It should be noted that the work done at the Institute has a high global impact.

TABLE 3

How do you evaluate **quality** of the Institute with respect to	5	4	3	2	1
1.Originality of the approach and ideas					
2. Significance of the contribution to the field					
3. Coherence of the Institute[1]					
4. Prominence of the Institute head					
5. Prominence of the other research staff					
6. Quality of scientific publications (scientific impact)					
7. Quality of other results					
OVERALL ASSESSMENT OF QUALITY	**5**				

REMARKS

Overall, the Institute has delivered an excellent performance over the last five years. Over the last five years, the Institute has been very successful in integrating new laboratories, such as the "Laboratory of Inorganic materials" and has reorganized by strengthening its capabilities supporting successful initiatives. This has led, e.g., to an assembly of outstanding pilot plant equipment in the area of petroleum processing.

Some of these approaches are seen outstanding on a world-class level. Overall, the strongest contributions are observed in the "Laboratory of Environmental Fuels and Hydrocarbons" (Catalyst activity evaluation protocols for use in hydrocarbon refining processes), "Laboratory of Polymer Reaction Engineering"(Development of advanced software tools for the design, optimization and control or polymer production processes), "Aerosol and Particle Technology Laboratory" (Catalytic emission control technologies for mobile and stationary sources) and "Laboratory of Inorganic Material"(Development of superparamagnetic nanoparticles for NMR diagnostic purposes).

It is impressive how the international recognition covers large fractions of the output of the Institute. This is seen by the unique position that the individual groups have in their interaction with Industry (such as the interaction of the "Laboratory of Environmental Fuels and Hydrocarbons" with BP-Amoco and the interaction of the "Aerosol and Particle Technology Laboratory" with the automobile industry). In this context, we would also like to mention the awarding of the SAE fellowship to Dr. Konstandopoulos in 2005.

TABLE 4

Considering the number of staff. how do you evaluate the **productivity** of the Institute with respect to	5	4	3	2	1
1. Number of Ph.D theses					
2. Number of scientific publications					
3. Number of professional publications					
4. Other results					
5. Distribution of published output within the Institute					
OVERALL ASSESSMENT OF PRODUCTIVITY	**5**				

REMARKS

The Institute has graduated an acceptable number of PhD students over the last five years and has at present a good number of 36 PhD students working in the Institute. The publication output in international reviewed journals is very good (average of 53 publications per year). The number of publications per year is in line with excellent groups in the field worldwide.

The output in terms of industrial reports and practical evaluation of catalysts is world-class. Also the filter and particle techniques have received highest recognition by all major players in the automobile industry.

The overall communication of the research results within the Institute, and especially the workshops organized within the Institute, contribute to the excellent exchange of information as noted by the team of evaluators during their visit.

TABLE 5

Considering the objectives of the Institute, how do you evaluate the **relevance of its research activities** with respect to	5	4	3	2	1
1. The advancement of knowledge					
2. The dissemination of knowledge					
3. The implementation of knowledge					
OVERALL ASSESSMENT OF RESEARCH RELEVANCE	**5**				

REMARKS

The Institute has been exceptionally successful in the advancement of chemical Engineering Science and Technology and has emerged as one of the worldwide leading Centers in this field. The implementation of this knowledge through the direct channels of its industrial partners and through presentations at conferences has been outstanding. This is the more remarkable if one considers the highly confidential nature of much of the contract work of the group.

TABLE 6

Considering the present status and future developments of staff and facilities, how do you evaluate the long-term **vitality** of the Institute with respect to	5	4	3	2	1
1.Its past scientific performance					
2.Its future plans and ideas					
3.The staff age and mobility					
OVERALL ASSESSMENT OF VITALITY	**5**				

REMARKS

The Institute has shown an excellent performance over the last five years and this development is seen sustainable for the future. By careful restructuring (merging groups of sub-critical strength), the Institute has created teams that are able to successfully compete with other high profile institutions worldwide.

Efforts made for the "Laboratory of analysis and characterization of solids" have been very successful in establishing high quality analytical platform for all the laboratories, including the High Resolution Transmission Electron Microscope as well as the atomic force microscope (as recommended by the last evaluation commission).

Given the success and the clearly focused research organization in its present state, the team of reviewers supports the plans for the reorganization of the institute. At the same time, it strongly recommends to maintain the clear focus shown so far. Thus, new laboratories should be the installed step-by-step under the constraint that existing successful activities maintain their room to grow. In direct respect to the plans, which have been discussed during the evaluation, especially the planned activities in "Thin films and Nanotechnology" and "Biomaterials", special external financial support is needed. In the opinion of the evaluators establishing new laboratories should require the consensus of the "Laboratory Directors".

Prof. R. Jérôme

Prof. G.B. Marin

Prof. J.A. Lercher