Translation of original Swedish version

Programme description for the Cooperation Programme

Materials technology for thermal energy processes

2014-2018

Contents

STEM143 ver.W-2.0, 3 March 2005

1 Summary

The aim of the Cooperation Programme Materials technology for thermal energy processes programme is to use materials technology and process technology development to promote the efficient use of renewable fuels and waste in the production of power and heat in thermal processes involving high fuel flexibility, good part-load characteristics and minimal impact on the environment. The programme aims to build up knowledge and expertise for the design of thermal processes in terms of both process technology and materials technology. It should be possible to implement the results of the programme in five to ten years' time.

This programme's initiatives should help to provide the following in terms of the thermal energy processes:

- Increased power production through increased electrical efficiency, improved availability and more effective production of power and heat from renewable fuels and waste in thermal energy conversion processes.
- Improved fuel flexibility thanks to greater opportunities to use waste fuels which are technically complicated in terms of combustion while maintaining electrical efficiency in steam turbine processes and the option of using renewable fuels in gas turbine processes.
- Improved operating flexibility, and the option of cyclic operation of thermal energy processes.

The materials in a plant are often the dimensioning factor determining what the plant is capable of handling. To meet the above objective, research into materials technology is required in order to achieve materials which are sustainable, resistant to erosion and corrosion and weldable in different environments.

Research institutions (universities, colleges and research institutes) will work within the programme in cooperation with the industry in order to formulate and perform research tasks which match the problems faced by the industry and at the same time lead to education of research students and senior researchers at colleges/universities. Programme projects should have a high degree of industrial relevance and at least 60 per cent industrial cofinancing. The programme involves a total research budget of SEK 115 000 000. The Swedish Energy Agency's share of the programme is SEK 46 000 000, which is equivalent to 40 per cent of the scope of the programme.

The beneficiaries for the activities within the programme are energy companies, boiler manufacturers, gas and steam turbine manufacturers, material producers, contractors, consultants, researchers, etc.

STEM143 ver.W-2.0, 3 March 2005

2 Focus of the programme

2.1 Vision

Using materials technology development as a basis, the programme is intended to contribute to achieving the following:

- transform Sweden and the EU into a society which is sustainable in the long-term as regards energy, for the benefit of the global environment, as well as ensuring Swedish industry is internationally competitive, via the development of more efficient and flexible thermal energy conversion processes using renewable fuels and waste fuels.
- Enable the production of power from renewable fuels and waste fractions at an electrical efficiency which is 3-4 percentage units higher than is the case for present day commercially available plants[1].

2.2 Purpose

The purpose of the *Materials technology for thermal energy processes* programme is to use materials technology development to promote the efficient use of renewable fuels and waste fractions in the production of power and heat in thermal processes involving high fuel flexibility, good part-load characteristics and minimal impact on the environment. Solid fuel boilers with either steam or gas turbines are suitable candidates for this.

The programme is intended to contribute to advances in knowledge with a view to facilitating the design of thermal processes for various energy applications, both in terms of process technology and the choice of materials involved, based on competence enhancement, refinement of methods and new tools. The programme will focus on combustion using an efficient steam turbine process, but will also include gas turbine processes.

The programme will also help to strengthen networks between research institutions (colleges, universities and research institutions) and industry, and develop Swedish trade and industry with enhanced competitiveness, while also contributing to the transition to an energy system which is sustainable in the long term.

[1] The reference level (2010) for present day plants is steam data 140 bar/540 °C with two high pressure pre-heaters, plant capacity 50 $MW_{electricity}$ and using 'clean' biofuels (forest residues).

2.3 Scope

The programme will continue over four years, from 16 April 2014 to 15 April 2018. Administration of the programme will continue until 15 July 2018 so that completed projects can be described jointly in a final report and in order to submit a final financial report to the Swedish Energy Agency and participating industrial stakeholders. The programme's total allocation for research amounts to SEK 115 000 000 between 16 April 2014 and 15 April 2018, of which the Swedish Energy Agency's share is 40 % (SEK 46 000 000) and trade and industry's share is 60 %. The costs for coordination and dissemination of results are handled in a separate partnership agreement between Elforsk, which is the coordinator for the programme, and the Swedish Energy Agency.

2.4 Goals

The programme's overall goal is to help to make a transition to an energy system which is sustainable in the long term thank to materials and process technology development for thermal energy processes based on renewable fuels and waste. This includes the steam turbine process (boiler system and steam turbine) and the gas turbine process. The research should contribute the following to these processes:

- Increased power production through greater electrical efficiency, improved availability and streamlined production of power and heat from renewable fuels and waste in thermal energy conversion processes.
- Improved fuel flexibility thanks to greater opportunities to use waste fuels which are technically complicated in terms of combustion while maintaining electrical efficiency in steam turbine processes and the option of using renewable fuels in gas turbine processes.
- Improved operating flexibility, and the option of cyclic operation of thermal energy processes.

To meet the above objective, research into process solutions relating to materials technology is required in order to achieve materials which are sustainable, resistant to erosion and corrosion and weldable in different environments. The goals of the programme are as follows:

1. To examine opportunities and obstacles with regard to how plants in Sweden can achieve greater steam data corresponding to the long-term ambition of electrical efficiency which is 3-4 percentage units higher than the best technology for a given fuel at present (see section 2.2 for reference values).

2. To further develop tools and techniques to facilitate the application of new material solutions in plants.
3. To evaluate exposures and application tests of various solid and composite materials and/or coated materials with the aim to develop improved material solutions which help to bring about greater fuel flexibility and increased electricity production.
4. To evaluate the mechanical properties and service life of various materials in relation to new material requirements for more efficient electricity production (elevated pressures and temperatures).
5. Suggestions for measures and solutions in order to reduce superheater and furnace corrosion, erosion-related problems and low temperature corrosion should have been developed.
6. Suggestions for new design solutions, operating parameters and tools for assessing what technical demands a specific fuel places on the plant should have been developed for CHP plants with the aim to help achieve enhanced fuel flexibility and availability.
7. Suggestions for materials technology or design solutions for steam turbines should be produced with a view to helping facilitate turbine stage efficiency increased by two per cent.
8. To test and validate new materials and surface coatings for future industrial gas turbines in order to permit high fuel flexibility, availability and efficiency, as well as cyclic operation.
9. To develop methods for quantifying processability[2] for new materials, as well as creating an understanding of microstructure development and mechanical properties for more efficient energy plants.

Academic/industrial goals:

- At least six licentiates and six doctors should graduate during the programme period.
- At least 50 articles in scientific journals and conference contributions reviewed by peers.
- At least four projects during the phase, leading to commercial products and patents.

[2] Processability refers to welding and moulding, for example.

2.5 Success criteria

For the programme to be successful, the following criteria must be met:

- Participating industrial companies will play an active part in the projects, where various experts together with academia will work together to complete research tasks of relevance to the industry and the objective of the programme.
- Mutual mobility of staff between industry and academia by allowing researchers periodically to carry out their work within the industries and industrial staff to take part in academic work or through recruitment of industrial doctoral students.
- This research will achieve results which the industry can utilise and which will lead at the same time to scientific qualifications (doctorates/licentiate degrees) and long-term expertise building within the universities.
- The programme will interact and make exchanges, where appropriate, with other research programmes such as HTC (Competence centre High temperature corrosion) and SEBRA (Interaction programme in the field of fuel-based production of power and heat).

2.6 Research, development and technology areas

The programme is divided into two business areas, *development of process and plant technology* and *development of materials technology.* The starting point shared by both areas is the fact that materials technology process development should help to ensure that renewable fuels and waste can be used efficiently in order to produce electricity and heat within thermal energy processes. This involves high fuel flexibility, good part-load characteristics and minimal impact on the environment. In the process technology element, the knowledge developed during the materials technology element should constitute a knowledge base for the demonstration and implementation of new solutions. The results from the projects should be applicable within five to ten years.

2.6.1 Process and plant technology developments

The emphasis in this field is on being able to demonstrate and implement more efficient and profitable thermal processes for the production of power and heat at both existing and new plants. This field includes process technology solutions, plant technology and economic analyses, and may involve:

- Working via the model and reference plant concept to show how the programme's results may be of use and relevance for plants, as well as identifying further research and development needs for issues such as fuel flexibility and operating flexibility.

- Suggesting and verifying cost-effective solutions in terms of operation and material choices to reduce corrosion and erosion.
- Verifying that steam temperatures can be increased by at least 40°C, from approximately 540 to 580°C using clean biofuels (forest residue), and from approximately 450 to 500°C using waste fractions (RDF) as fuel, by means of pilot-scale material tests with conventional superheater materials in existing boilers.
- Compiling work processes and guidelines to facilitate the use of new materials in plants, including control checking and follow-up systems.
- Presenting a road map showing how plants in Sweden can achieve higher steam data in line with the long-term vision of electrical efficiency which is 3-4 percentage units higher than the best technology for a given fuel today.
- Supporting projects for the demonstration of CHP plants, or subsystems in existing plants, with enhanced steam data.

2.6.2 Materials technology development

In the field of materials technology development, efforts will concentrate on developing materials technology solutions for boilers and performance-enhancing material issues for gas turbines and steam turbines. This field will involve the development of more fundamental knowledge of materials which can be applied and demonstrated in advanced new processes and applications for energy conversion.

Initiatives in the field of *materials technology solutions for boilers* may involve:

- Solutions to minimise problems with high temperature corrosion and erosion in boiler plants and a greater understanding of the conditions under which these problems occur.
- Measures to prevent problems with low temperature corrosion in economisers and air preheaters, for example, and enhanced knowledge of the conditions under which these problems occur.
- Testing and evaluating different groups of materials (alloys forming aluminium oxide, NiCrFe materials, et al.) for solid components, composite materials and/or surface coatings in various environments, operating conditions and temperature ranges with a view to developing materials with improved properties.

- Application testes of steam coil in superheater with a view to examining criteria for higher steam data (600°C steam temperature for pure biofuels).
- Conducting laboratory studies in order to evaluate mechanisms that have most effect on the mechanical service life of materials in relation to new demands on materials at higher steam pressures and temperatures.
- Furthering our knowledge of the technical problems and risks associated with increased fuel flexibility. Understanding the conditions under which problems occur, analysing dynamic corrosion processes (such as corrosion memory effects[3]) and possible measures for preventing problems, e.g. through additives and choice of materials.
- Materials technology development for conversion of boilers from fossil-fired to biofuel-fired plants, including admixture of renewable fuels.
- Development in materials technology for gasification processes

Initiatives in the field of *material issues for gas turbines and steam turbines* may involve:

- Testing and evaluating materials and surface coatings for efficient gas turbines optimised for cyclic operation in order to balance electricity production from solar and wind power.
- Developing improved blade profiles and advanced technology for industrial steam turbines with a view to improving turbine efficiency.
- Developing methods for quantifying weldability and moulding, i.e. how advanced new materials are joined to more conventional materials in order to achieve cost-effective solutions for more efficient energy plants.
- Mapping and creating an understanding of how the microstructure of materials develops over time and at temperature for nickel base alloys and the conditions under which ductility problems[4] occur and possible measures for preventing problems.
- Evaluating the effect of long-term exposure for mechanical properties of nickel base alloys, and evaluating the applicability of particle growth laws in order to predict the microstructure during exposure.
- Operating flexibility, as well as utilisation of renewable fuels (biogas, hydrogen gas and liquid biofuels) and fuel flexibility in gas turbines

[3] Corrosion means that historical operation affects corrosion products and deposits in boilers
[4]Ductility is a measure of the ability of a material to undergo deformation without cracking.

2.7 Energy relevance

Increased use of renewable fuels forms an important part of the EU energy and climate policy objectives. The programme is oriented towards increasing our knowledge of the design of energy plants to enable better and less problematic use of renewable fuels and waste with greater electrical efficiency and availability.

The programme's objective of contributing to more electricity being produced via higher or equal electrical efficiency, but using more problematic and varying fuel fractions, as well as better availability, is considered to have a high degree of energy relevance.

Issues relating to materials arise in all processes and products. Construction material performance and durability are often the dimensioning factor and basis for the efficiency of thermal energy processes. Higher temperatures and more complex environments due to more problematic fuel types, as well as the high environmental requirements involved in these processes , impose new and not inconsiderable demands on the choice of materials. Plant-related adaptation and process development are required to facilitate the construction of cost-efficient plants with high fuel flexibility; they are also considered highly energy-relevant, given that new high-efficiency thermal processes are nearing the commercialisation stage.

In an international context, and, indeed, in the long term in Sweden as well, increased load flexibility to support electricity production from solar and wind sources is becoming increasingly important. For this reason there is a need to research and develop materials and processes addressing the requirements of cyclic operation. This will enhance the improve the potential for electricity production from other renewables, such as solar power and wind.

2.8 Relevance to society and industry

The results from this and other associated research programmes within the field can be applied and utilised in successive demonstrations and tests of various design solutions. The results may also be applied and utilised via their implementation in a demonstration plant and in subsequent stages of development in commercial products and services. The results will benefit the programme's interested parties (e.g. equipment and material suppliers) allowing them to implement competitive solutions with their own concepts that can be sold both in Sweden and abroad.

Thanks to the long-term nature of the programme's research, senior and newly qualified doctoral researchers will acquire ever greater levels of competence, as well as knowledge in the field, from which industrial companies stand to benefit.

The programme will thus contribute to long-term creation of competence within the fields of process, combustion, and materials technology linked to energy applications.

Materials research is very relevant for industry. Issues relating to materials are always pertinent in all thermal processes, i.e. everything from large biofuel boilers and high-output gas turbines to vehicle combustion engines and small-scale applications. The programme's corporate stakeholders count national and multinational manufacturing companies among their ranks: companies which are important to Sweden with a significant proportion of their production earmarked for export. The companies’ operations in Sweden have a significant impact on employment in the country. The companies also have a sizeable amount of research and development based in Sweden. To have a strong and competitive research base within Sweden is therefore of strategic importance for the Swedish economy. The competitive edge of these companies will be enhanced by Swedish research prominence in materials, and research at Swedish research institutions can continue to be top class internationally.

Materials research is also extremely relevant for society. The development of new materials for new, more efficient and more environmentally friendly thermal processes is an important factor in the successful transformation of the energy system.

2.9 Environmental aspects

Biofuels are an important resource for work on meeting the environmental quality objective of *limited climate impact*. Increased demand for renewable fuels has resulted in an increase in competition and higher prices. There has therefore been a growth in demand for cheaper and more complex fuels. What is common to these fuels is that they result in problems of a materials technology nature in plants, and these problems need to be solved if there is to be efficient electricity production. The programme is developing new materials for the newly developed thermal processes of the future, which include gasification of biomass, gas turbines for synthetic gas, etc. Increased electricity production from biofuels may replace the use of fossil fuels.

The other environmental quality objectives concerned by the programme are *fresh air*, *no eutrophication* and *natural acidification only*. It is mainly in densely populated areas that high levels of air pollution can occur, which can be detrimental to health and the environment. Centralised production of electricity and heating at CHPs with good exhaust gas treatment can replace smaller plants with poorer treatment of the gases.

2.10 Project implementers/project participants

Project implementers may include researchers at research institutions (universities, colleges and research institutes) and relevant industrial companies.

It is particularly important to ensure that the results are applied, and that the research and development carried out at research institutes meets needs and requirements formulated together with beneficiaries or the industry in question. Active participation from trade and industry is vital, both for these reasons and in order to assist with available resources in order to implement the programme.

2.11 Beneficiaries/stakeholders

Beneficiaries of the results of the programme are energy companies, boiler manufacturers, gas and steam turbine manufacturers, material manufacturers, consultants and researchers.

Beneficiaries for each individual project are dependent on its results and focus. Researchers can benefit mainly from general development work, while the interests of industry are more along the lines of solutions for more efficient processes and results which may provide decision data for investments. The general enhancement of expertise resulting from the research in industry, for consultants and suppliers and at universities and colleges will assure the long-term development of the operation. Thus a large proportion of the results are expected to provide industry-wide effects.

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3 Background

The Swedish Energy Agency's priority research and innovation initiatives for an energy system sustainable in the long term[5] include increased use of bioenergy. At the same time, it is indicated that a "third leg" should be developed for power supply, besides hydroelectric power and nuclear power, in order to reduce vulnerability and enhance the security of supply. To achieve this, combined heat and power and other renewable power production must together stand responsible for a significant proportion of electricity production. As a result, research and innovation for development of renewable electricity production are urgent matters. Supply of biomass which is sustainable in the long term is extremely important to the Swedish energy system and the Swedish economy.

In 2010, 12.5 TWh of combined heat and power was produced from the district heating system and 6.4 TWh from industrial back pressure production, and this expansion is continuing. This research has been of major importance to the conversion to renewable fuels and has contributed significantly to the fact that Swedish is an international leader in the field of biofuel-based production of power and heat. Emphasis in future will be on increasing electricity exchange through higher steam data, or maintaining efficiency for more complicated fuels. This will demand new materials and design solutions. If conventional biofuels are subject to higher prices, the need for greater fuel flexibility at the plants will increase. There is currently a certain element of conflict between electricity exchange and fuel flexibility, and one of the challenges involves being capable of incinerate more wastelike and ash-rich fuels while maintaining availability and high electrical efficiency and at the same time utilising the heat sink efficiently.[6]

Earlier research

Earlier research in the field has taken place at KME, Consortium for Materials technology for thermal energy processes, in four phases between 1997 and 2014 with assistance from the Swedish Energy Agency. The consortium companies have worked in cooperation with research institutions to carry out research relevant to industry. The programme will be open to all players during this programme phase.

KME was evaluated in 2013, and the overall conclusion of the evaluation group is that the programme was very successful, focusing on industry-relevant areas and involving scientific and academic work which was of the highest order. KME is described as contributing to integration between industry and universities/research

[5] Government proposal 2012/13:21 Research and innovation for an energy system sustainable in the long term
[6] UP report Fuel-based energy systems ER 2012:09

institutes in a positive manner. The programme has contributed to a significant knowledge and technological leap in materials technology, such as:

- Design of final superheater sited in the cyclone lock in CFB boilers.
- Making a contribution to Vattenfall's work with its patented product ChlorOut, an additive that is added to the exhaust gases to reduce corrosion and deposits in superheaters.
- Validation of correlations and models for prediction of corrosion rate, which has led to development of an advanced calculation model based on chemical equilibrium calculation for material choices in boilers.
- Reduction of furnace corrosion with surface coatings of new alloys.
- The effect of additives (additives such as digested sewage sludge) to biofuels in order to reduce corrosion.
- Demonstrating the possibilities and challenges involved in constructing biofuel-fired combined heat and power plants for 600°C steam.
- New corrosion-resistant 9-12 % Cr steel has been produced and is being designed into the Siemens supercritical steam turbine for 620°C steam data.

Development of boiler plants

Enhanced efficiency for a given fuel in energy plants involves increased resource efficiency. To facilitate this, the temperatures in the plants need to be increased, which in turn increases demands on the temperature resistance of the materials used.

Superheater maintenance, repair and replacement represent one of the largest items in a plant’s operation and maintenance costs. A decision on a given material for primary, secondary and tertiary superheaters in terms of its cost-effectiveness must therefore be well-supported by the facts. A better choice of material and improved process solutions also enhance plant availability. Requirements for fuel flexibility and the transition to more problematic types of fuel in order to achieve greater utilisation of resources will increase demands on the materials and result in new problems which will require solving. Greater efficiency in the production of electricity will also place higher demands on materials, as described above, in several parts of a boiler, in terms of corrosion resistance and other properties. Knowledge of mechanical properties such as creep strength is required for the approval of new materials for use in pressurised sections. Manufacture calls for knowledge of a material's welding characteristics.

Hybrid solutions may be a part of the solution. A less complex pressure-resistant material is used in combination with composite technology (compound) or surface coating (based on different manufacturing methods) with advanced materials that are both corrosion and erosion resistant.

Good part-load characteristics are a natural aspect of the work on streamlining plants. Without adequate part-load characteristics, the results can only find limited application.

Development of turbines

Materials used in gas turbines have traditionally been of a completely different type than for boiler plants, known as nickel base materials, which are capable of withstanding significantly higher combustion temperatures; in some instance above 900°C. Despite the higher price and substantial technological challenges involved in using nickel base materials, they are already being used in the most high-performing plants of this type. This is just the beginning of a long-term development which could dramatically improve efficiencies, at the same time as reducing the environmental impact of power production plants.

Very long operating times are normal for both gas and steam turbines. A gas turbine compressor has a service life expectancy of at least 120,000 hours and a steam turbine of at least 200,000 hours. Knowledge of steels, the effect of long periods at high temperatures on the micro-structure and the resulting mechanical characteristics such as creep, are necessary to ensure reliability and minimise the risk of breakdown. The materials, temperatures and loads are the same for both gas turbine compressors and steam turbines. It is therefore helpful to coordinate gas and steam turbine requirements in the development of new materials.

The most significant challenges for efficient fuel utilisation in the development of gas turbines are high efficiency levels, guaranteed reliability over long operating periods and low emissions. Moreover, in an energy supply system which presupposes a transition from fossil fuels to renewables, these demands will accompany a scenario where a more aggressive environment is introduced within the turbines, as well as a need to handle flexible fuels and flexible cyclic operation methods. Consequently, a prerequisite for the development of the technology is progress within the field of materials, both through the development of new materials with improved characteristics and an enhanced knowledge of how to best use them.

Nickel base materials are most commonly used in gas turbines, but continued development of biofuel steam processes has resulted in temperatures calling for nickel base materials in steam turbines also, with previously only steel being used. Surface coating in steam turbines will soon also be feasible, and the development process is nearing the commercialisation stage.

The operational conditions in steam and gas turbines are such that the materials are subjected to many cycles, often in combination with corrosive environments. Improvements in materials for gas and steam turbines demand increasingly detailed knowledge of the material and its degradation during cyclic operations at high temperatures. Knowledge of materials ranges from conventional steels and nickel base materials to metal and ceramic surface coatings.

4 Execution

4.1 Procedures

Prior to commencement of the programme a public announcement will be made involving all the areas of activity of the programme. After that, there are preliminary plants for a further round of applications during the first year of the programme. There will be no limit on the total number of announcements for the programme.

Programme initiatives are based on strong interaction between research institutions (universities, colleges and research institutes) and industry. Applications should clarify how interaction is to take place between different research institutions and with the relevant industry. Projects which will be implemented in active cooperation between one or more industrial companies with research institutions will be given priority. Funding from the Swedish Energy Agency will ideally be assigned to the research institutions. In exceptional cases where it is not possible/appropriate to use research institutions as implementers, consultants/industrial parties can be implementers and make use of Swedish Energy Agency funding. Cofinancing is demanded within the projects, with at least 60 % coming from industry. Industrial cofinancing for the projects will be provided through cash financing or financing in kind. Companies' financing in kind will be calculated in accordance with the guidelines of the Swedish Energy Agency.

Within the programme, a programme council will be appointed in order to review applications and submit recommendations to the Swedish Energy Agency for decisions on state cofinance. The programme council will work to ensure that the programme is implemented in accordance with the programme description and that its aims are achieved.

Elforsk will be coordinating the programme, coordinating operations and standing responsible for implementation of the programme, which includes programme management, follow-up and dissemination of results.

4.2 Results and dissemination of results

Programme information will be provided on the external websites of the Swedish Energy Agency and Elforsk, www.energimyndigheten.se and www.elforsk.se respectively. Information on the programme's approved projects will be provided in the Swedish Energy Agency's project database on the website.

A communication plan is to be produced for the programme, and this is also to indicate how results are to be disseminated.

4.3 Evaluation

The programme will be evaluated towards the end of the programme period. This evaluation will take place against the programme description and primarily evaluate whether the aims and objectives of the programme have been achieved and how interaction between the Swedish Energy Agency and Elforsk has worked in terms of organisation and results. The evaluation will take place on the initiative of the Swedish Energy Agency and will be funded outside the programme budget.

5 Delimitations

5.1 Research, development and technology areas

Material research for thermal processes is taking place within three different programmes, with financial support from the Swedish Energy Agency. Besides the interaction programme *Materials technology for thermal energy processes*, this also includes *HTC* (Competence centre High temperature corrosion) and *SEBRA* (Interaction programme in the field of fuel-based production of power and heat).

Within HTC, basic knowledge will be produced to provide an understanding of the mechanisms for high temperature corrosion. This research will constitute a knowledge base which can be used by the Materials technology for thermal energy processes programme, which involves problem-oriented research project with applicability in five to ten years.

SEBRA is financing problem-oriented research focusing on production plants with short-term application, i.e. within five years.

The various programmes will keep an ongoing reciprocal check on the research being carried out within their respective programmes, both to avoid overlap and to seek to identify synergies and coordination opportunities.

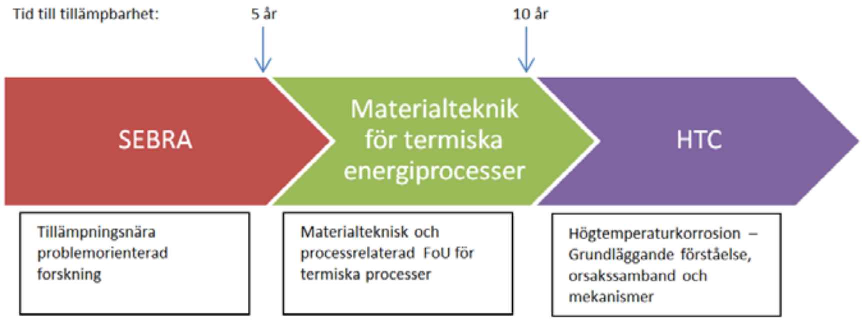
Research included in *Materials technology for thermal energy processes* can be summarised as follows:

- Research with applicability between five and ten years
- Materials technology and process-related applied R&D for thermal processes.

Research which is *not* included in *Materials technology for thermal energy processes* can be summarised as follows:

- short-term research for application within five years
- Basic research (understanding, causal relationships, mechanism) relating to corrosion and erosion corrosion at high temperatures.

The research programmes relate to one another with regard to research fields and timeframes as shown in the figure below.



5.2 Other related programmes within the Swedish Energy Agency

The Swedish Energy Agency has the following programmes which are linked to the Interaction programme Materials technology for thermal energy processes:

- Interaction programme for fuel-based production of power and heat (SEBRA)
- Competence centre for high temperature corrosion (HTC)
- Turbo power – development of process and turbo machine technology
- CECOST (Centre for Combustion Science and Technology)

5.3 International cooperation

The programme does not have the overall task of interacting on an international level, but attempts are being made to interact with international companies on the projects.

International interaction and influence are included in the devising of the content of the programme as combined power and heat based on biofuels and waste are areas of major Swedish interest and positions of strength. The content of the programme reflects the Swedish climate and energy policy which is part of the EU policy.

The involvement of suppliers and energy companies working in international markets will allow us to maintain an international customer perspective. Efforts will be made to obtain synergies from company involvement in and experiences of other international development projects.

6 Further information

Information on the programme is available from the Swedish Energy Agency and Elforsk websites:

- http://www.energimyndigheten.se
- http://www.elforsk.se/

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