Värmeforsk's Basic Program 2008-2011

1. Background

Värmeforsk (the Thermal Engineering Research Association) is a non-profit organisation for research and development in the energy industry, with an emphasis on fuel-based power and heat production. Värmeforsk's members include energy producers as well as the forestry and manufacturing industries and energy consulting firms. The aim of its operations is to conduct competition-neutral research focusing on coordination between research, technical development and application.

The research programs designed to address the energy industry's most urgent needs, which are largely determined by external factors such as environmental objectives. Environmental issues generally play a central role in Värmeforsk's research programs, where R&D related to biofuel-based power and heat production has been a top priority for the past 20 years.

Through Värmeforsk the industry cooperates with the Government, via the Swedish Energy Agency, by actively promoting development of a sustainable energy system that meets the established environmental targets and climate policies.

Värmeforsk's organisation is divided into two program areas, the *Basic Program* and *Applied Program*. The Basic Program is Värmeforsk's traditional core area, where stakeholders collaborate in joint research initiatives that are established for one period at a time, normally three years. Research activities in the Basic Program have been underway since 1968, although the program *focus* has been continuously adapted to changes in external conditions. The applied programs are set up in response to an anticipated demand or expressed need in a specific area, and are funded by companies with a special interest in the different program topics. Research projects in the Basic Program have a high theoretical content and Värmeforsk often functions as a link between academic and institutional research agencies and applied studies at plants and other heat/power facilities. The following description provides a general outline of the Basic Program for the period 2008-2011.

The Basic Program is organised in four research areas:

- Plant & Combustion Technology
- Materials & Chemical Technology
- Process Control
- System Technology

For each research area, Värmeforsk's Board of Directors appoints a research team of around 20 qualified representatives from the funding-provider organisations, including the Swedish Energy Agency. The research teams are responsible for decision-making in the research projects, follow-up of ongoing projects and quality assessment of research reports.

Another important function for Värmeforsk is network building, both within the industry and with other stakeholders.

2. Objectives and purpose of the Basic Program

2. 1 Overall objectives of the program

The objective of Värmeforsk's Basic Program is to develop more efficient and environmentally friendly heat and power production plants and forestry industry lignin- and biofuel boilers. The program is focused mainly on production of electricity and/or heat and other alternatives for combined production, such as cooling, vehicle fuels and other products.

The primary purpose of these activities is to contribute towards greater profitability and knowledge among players in the industry. This is particularly important in view of changing conditions for fuel supply and fuel prices, competition for fuel raw materials or the need for increased domestic biomass-based power production.

Concrete goals for the Basic Program for the program period 2008-2011 are to draft recommendations for:

- Adaptation of fuel preparation processes, combustion equipment and combustion technology to utilise at least three fuels that are not currently in wide use and that are expected to give rise to problems in the plants.

- For at least three fuels or fuel mixes that are not currently in wide use, to develop fuel gas cleaning systems that cost-effectively minimise emissions of particles, halogens, dioxins and hydrocarbons.

- Process design and material selection to boost the heat-to-power ratio in a CHP plant for a steam process with high steam temperatures of up to 600ºC

- Process selection for CHP plants with a heat capacity of 2–10 MW and a maximum power production cost of SEK 600/MWh.

- Energy-efficient system solutions for profitable production of more than one of the energy-bearers electricity, cooling and fuels i combination with heat production.

- Within a five-year period, develop at least three new viable concepts for energy combine solutions in which synergies lead to efficient energy systems and good resource conservation.

- Process design and cleaning technology to cost-effectively reduce and eventually eliminate emissions of prioritised and hazardous substances covered by the EU Water Framework Directive[1].

- Solutions for existing plants that can lead to a reduction in operating and maintenance costs of at least 20% at the component level and 5 % at the system level.

[1] Framework Directive 2000/60/EG

- Development of technical solutions to cost-effectively reduce emissions in order to meet national environmental objectives

The intention is to allocate around 70 % of the budget to projects that contribute to attainment of the above goals.

The research should also contribute to providing a platform of general relevance for ongoing efforts by companies in the industry to optimise production efficiency and reduce environmental impact. The ambition is for 80% of all research project conclusions and results to be applied or commercialised within a five-year time horizon. This goal is measured successively in connection with publication of reports through certification by at least three industry companies that the application/commercialisation has been made possible by the conclusions of a specific report.

The concrete overall goals for activities in the Basic Program are:

- *Plant & Combustion Technology*
  To recommend cost-effective modifications in existing plants that can lead to significant reduction in operating and maintenance costs and/or environmentally damaging emissions.

- *Materials & Chemical Technology*
  To recommend solutions for existing plants that lead to a reduction of at least 20% in the total lifetime cost of components or systems.

- *Process Control*
  To recommend cost-effective solutions that can lead to significant improvements in a plant’s electric efficiency or energy availability and/or reduction of environmentally harmful emissions.

- *System Technology*
  To examine possible fuel raw materials with respect to logistics, system design, total environmental impact, economy, competing usage and risks.

2.2 New features in the program for 2008-2011

2.2.1 Program period

Although Värmeforsk's Basic Program has traditionally run for a period of three years, the upcoming program period has been extended to four years. The motive for the change is to achieve better continuity in the research programs and provide more time for completion of research projects.

An assessment of the program will be carried out after two years.

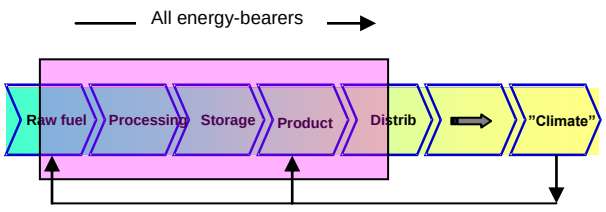
2.2.2 Efficient resource utilisation

The top priorities for the upcoming program period are *resource conservation* and *energy optimisation*, which partly reflect a growing awareness of climate change and the establishment of national and international climate objectives. The EU's proposed energy policy calls for a 20% reduction in greenhouse gas emissions, a 20% share of power production from renewable energy sources and a 10% share of biofuel in vehicle fuels by the year 2020. At the same time, the EU has adopted a new Energy Services Director requiring the industrial, transport and property sectors to achieve energy savings of 9% over the next nine years. The ability to tackle these challenges will rely on the development of solutions that make it possible to utilise the available resources as efficiently as possible.

Biofuel will play a very important role in meeting these environmental targets. Biofuel usage currently accounts for 2/3 of all renewable energy production in the EU, and will increase significantly at the global level in the years ahead. Finding new alternative biofuels for energy production, while at the same time preventing competition for fuel between industries, will be a key challenge for the near future.

With 20 years of experience in combustion of biofuels, Värmeforsk has in-depth insight into the possibilities and problems associated with combustion of a varied range of fuels and fuel mixes. In earlier program periods, efficient utilisation of bio raw materials has focused on different combined processes for cogeneration of power, heat and cooling, or processing of biofuel. In the upcoming program period for 2008-2011, a further step towards improved resource utilisation is being taken through system integration with other industrial processes and use of a wider fuel mix. This has created an interesting new dimension, as previously separate operations are integrated and wide-front cooperation is started.

In the new program, the focus is on energy processes along the *entire* energy conversion chain for a varied fuel range.



This includes examination of new fuel raw materials with respect to logistics, processing, system design, environment, economy, steering instruments and risks. In order to carry out system design in planning of a new plant or optimisation of an existing one, all production parameters must be taken into account. This means that factors that are normally outside Värmeforsk's field of interest, such as transports and storage or distribution networks and district heating centre, will be included as components of system-related research projects.

2.2.3 System Technology

Ahead of the program period 2008-2011, the area of Transverse Technology has changed name to System Technology and been given a partly new focus. In the Transverse Technology research program, the focus has been on developing the *entire* production facility, in contrast to the other research teams which concentrate on specific technical areas. The new System Technology research program retains the original intentions of the Transverse Technology program, but has an emphasis on more long-term development of energy system solutions. The research program is aimed at developing flexible plants for fuel optimisation in power and heat production. This can also involve cooperation with local and regional industries to build energy combines for optimised production of electricity, heat and other products (cooling, pellets, vehicle fuel, biogas, etc.) as a means for further improving efficiency in raw material utilisation.

3. Prioritised research in each technical area

3.1 Plant & Combustion Technology

The overall objective in the Plant & Combustion Technology area is to optimise efficiency and improve power and heat production from an environmental, technical and economic standpoint. Technological development is aimed at enabling combustion of various fuel types with optimal operating economy, high availability and minimum environmental impact.

The program's main areas are:

- Plant concepts, technical solutions for efficiency optimisation in production.

  The plant concept area is focused on the development of plant technology solutions at the sub-system and component level and thus differs from the System Technology program area, which covers the entire production system. Technical solutions developed in the Plant Technology program may serve as a platform for development of efficient energy systems in the System Technology program.

  In the plant concept area, new and flexible technology will be developed for optimised energy production. This can include development of plant components or more efficient sub-systems, for example by minimising internal electricity consumption for fans, pumps, etc.

- Fuel-related issues

  Anticipated competition for biofuels will lead to the introduction of new types of fuel on the market, of which a few examples are energy crops and waste products from industrial processes, alongside increase usage of gaseous (natural gas, biogas) and liquid fuels. This trend is accentuating the need to be able to use a wide range of fuels in the production plants. By actively choosing fuels according to their suitability for a specific a plant and fuel mix, it is possible to reduce operating problems, particularly in combination with the use of additives for fuels with a high alkali content. The research program for 2008-2011 will be focused on addressing problems that arise in fuel-related areas such as preparation, handling and corrosion, but also on increasing knowledge about different fuels through characterisation and evaluation from a life cycle perspective.

- Minimised environmental impact

  Reduction of emissions is traditionally a highly prioritised area for Värmeforsk. The emergence of new fuels with a different fuel composition and the introduction of more stringent environmental requirements are creating new challenges for plant owners. Added to this are higher demands on reporting procedures and measurement technology. Within the program, technology for measurement and flue gas cleaning will be developed and/or evaluated for adaptation to emission requirements related to plant size and fuel, so that the optimal equipment is used and the applicable emission requirements are met.

The Plant & Combustion Technology program is focused on matters related to flue gas cleaning and measurement of emissions into the air, while emissions into water are handled within the Materials & Chemical Technology program.

3.2 Process Control

With today's computerised monitoring, control systems are the hub of a production facility and are of decisive importance for plant availability and safety. This places heavy demands control systems to be robust and reliable at the same time that they provide operators with easy-to-understand information. The goal of the research program for 2008-2011 is to develop control, optimisation and monitoring systems for different processes and fuels to enable safe and economical operation with minimum environmental impact.

The program's main areas are:

- Control systems and optimisation

  The operating economy of a heat production plant is strongly influenced by external factors such as fuel prices, electricity prices and the current weather situation. The interrelationships between these factors are often complex and impossible for an operator to keep track of at every moment. In this context, model-based control strategies and production planning methods are key instruments for plant optimisation and reduction of operating expenses. This program area will focus on new methods for control and production planning in different energy systems and processes.

- Interaction between user and process

  In today's complex processes, it can be difficult to create technology and methods that provide operating and maintenance personnel with reliable and clearly presented information to support their decisions in various operating and maintenance situations. MMI (Man–Machine–Interface) is a field of research area concerned with the way in which humans interact with "machines" in different situations. In the program for 2008-2011, the usability of MMI will be studied and developed for effective visualisation of production plants or as an interactive educational tool.

- Measurement technology

  The connection between measurement and control technology is decisive in enabling integration of all critical measurement data in the control system, which is needed to optimise control and monitoring of the combustion process to meet the established environmental requirements. The goal for the program period is to develop new and reliable measurement methods that can be integrated into the control strategy, but can also be used for quality assurance of the measurements used in reporting of environmental data to the authorities.

- Quality and security

  The hardware and software used in commercial control and monitoring systems are continuously replaced and therefore need to be updated. One important consideration in software upgrades is traceability from the original requirement to application software, and verification of this. This applies not least to remote-controlled plants, where communication with superior systems and protection from unauthorised computer access must be quality assured. The research program is focused on further development of methods for well structured and tested software and hardware in control systems.

3.3 Materials & Chemical Technology

The overall objective of the Materials & Chemical Technology program is to contribute to high availability and low production costs in power and heat production plants and forestry industry lignin- and biofuel boilers through research, development and demonstration. The goal is to gain knowledge and insight into how fuel choice and structural solutions affect the materials and how fuels in combination with improved performance, such as higher steam data in boilers or higher combustion temperatures in gas turbines, affect plant availability and lifetime.

The program's main areas are:

- Fuel-related material and chemical issues

  New types of biofuels and waste-classified fuels have a significant impact on plant availability through increased corrosion, erosion and surface coating problems on heat transfer surfaces or in flue gas condensing plants. In modern gas turbines with high combustion temperatures, the availability and useful life of components is a central issue, particularly in combustion of biogas. In the upcoming period, the program will evaluate materials and surface coatings that are adapted for new fuel types (solid, liquid and gaseous), and for enhanced plant performance.

  Development activities take place in close cooperation with research agencies such as HTC (Competence Centre for High Temperature Corrosion) and KME (Consortium for Materials Technology for Thermal Energy Processes).

- Environmentally-related material and chemical issues

  Material and chemical-related problems arise even with regard to water and steam in energy production plants. The use of new fuels and a more varied fuel mix also means that water emissions from the plants are increasingly polluted and demand more extensive and efficient cleaning. This applies to flue gas condensate as well as leachate, ash, washing and soot water. At the same time, plants are subject to increasingly stringent demands on treatment of water discharge arising from the EU Water Framework Directive and the introduction of new environmental quality norms for water emissions of particles, heavy metals and polyaromatic hydrocarbons (PAH). Among other things, the program for 2008-2011 will focus on development of new technology for treatment and cleaning of water from energy production plants

as well as processes for closed water systems, partly for environmental reasons and partly for reasons of economy due to rising water costs.

- Availability and plant life

Availability and production costs are of critical importance for the operating economy of a plant. The potential remaining lifetime of existing production plants can be significantly longer than the lifetime originally designed and calculated for. Effective maintenance methods are needed to increase the technical lifetime of constructural materials. Within the program, methods will be developed for needs-based assessment of maintenance measures. This will include the development of improved methods for condition assessment of critical components and cost-effective repair methods, but also for increasing knowledge about the existing failure mechanisms.

3.4 System Technology

Uncertainty about future energy prices is placing new demands on plant flexibility in terms of the capacity to produce power, heat and other products. A wide range of fuels and products, together with more rigorous environmental requirements, is leading to increasingly complex and costly plants. This, in turn, is creating a greater need for high plant efficiency and availability, long plant lifetime, high safety, environmentally-friendly production and high profitability, i.e. new demands on efficient plants and effective system design. The System Technology program is focused on long-term development of efficient energy solutions and is aimed at developing flexible plants that can be adapted to future needs and requirements. Through integration with other operations or by developing new products within a company, it is possible to create energy systems that optimise usage of raw materials/fuel.

The program's main areas are:

- Sustainable fuel supply – new concepts and raw materials

  Anticipated competition for biomass fuels will affect the market for biofuel in Sweden. Many renewable fuels have alternative uses, for example as raw materials in the forestry industry, in production of alternative vehicle fuels or in animal feed and human food products. Finding new alternative fuels for energy production will be increasingly vital. The research program for 2008-2011 will focus on examining possible fuel raw materials with respect to logistics, system design, environment, economy, steering instruments and risks.

  However, in a fast-changing market situation a plant must have the flexibility to use different types of fuel. One problem in this context is the conflict between optimisation of a plant for a high electric efficiency and the demands on fuel flexibility. The objective for the System Technology program is to develop methods for optimisation of the total energy system with regard to fuels, plants and products.

- Resource conservation

  To offset the effects of rising raw material and fuel prices, plants must boost their efficiency and optimise utilisation of fuel inputs. This can be achieved by boosting

the total efficiency, using closed systems or increasing utilisation of waste heat, or alternatively, by reducing consumption of electricity, fuel raw materials, water and chemicals. The goal of this program is to develop concepts and technology for efficiency optimisation and resource conservation in production of electricity and heat, for example by optimising fuel utilisation seen in the context of a larger system. Other aims can be to increase the plants' electric- and total efficiency, to minimise consumption of input raw materials in the processes and to utilise waste products.

- Energy combines – local and regional energy solutions

  Another area for increased resource conservation is different types of energy combines. There are available synergies between energy companies and process industries, which either require energy in the form of steam or electricity or which produce heat and/or other by-products that can be utilised by the energy companies. Through collaboration with other sectors and connection of industries to the district heating network and/or CHP plants, there is good potential to create efficient energy systems. The total efficiency is higher than that in a plant which produces only process steam and the annual operating time can be extended compared to a plant for district heating. The main focus of this program is to study energy combine solutions in which the synergy effects result in efficient energy systems and good resource conservation. The system studies examine local and regional conditions where possible forms of collaboration between energy companies and other industries can be of interest.

4 Scope

4.1 Within the plant fence

Research projects in the framework of the Basic Program are generally limited to those dealing with operations "within the plant fence". However, exceptions from this rule can be made for system studies, combined heat and power or other areas where the energy sector collaborates with other industries and organisations that are deemed to be of value to Värmeforsk's stakeholders. The primary focus should be on development of energy production plants.

4.2 Production plants with a capacity of more than 2 MWth

Research projects that can be related to production plants are limited by the requirement that the results be covered by and applicable to facilities with a capacity of 2 MWth or more.

4.3 Applicability within five years

The main principle is that the projects conducted within the program should be applicable in the plants within a period of five years. Possible exceptions can be made in prioritised areas, but this practical applicability must lie within a reasonable timeframe. In order to secure long-term values and ensure the implementation of projects in prioritised areas, the timeframe for large-scale application is assessed on a case-by-base basis.

4.4 Other research organisations

Closely related research projects may be carried out by other research organisations. Overlapping of R&D activities with other organisations such as SGC (the Swedish Gas Centre), Avfall Sverige (Swedish Waste Management Association), Elforsk (the Swedish Electrical Utilities R&D Company), JTI (the Swedish Institute of Agricultural and Environmental Engineering, Svensk Fjärrvärme (the Swedish District Heating Association), etc., should be avoided. However, an effort should be made to ensure that projects in the program's prioritised areas are implemented. Information sharing and collaboration with related areas should be strived for, but should not limit the scope of activities.

5 Implementation

5.1 Timetable

The program will be carried out over a period of four years, from 1 January 2008 to 31 December 2011.

Budget

The program budget is estimated at approximately SEK 22 million per year, or SEK 88 million for the entire program period.