MANAGEMENT SYSTEM AND POTENTIAL MARKETS FOR A HTR-GT PLANT

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Abstract

This article will discuss some aspects which could be helpful to execute a HTR-GT study successfully:

1. The preferred type of organisation for such a study; in order to achieve a maximum of support in society and industry, a minimum of through life costing and a maximum of through life support.

2. The lead time needed for such studies i.e. the design, component testing, prototype testing, the required efficiency, the type of energy in quantity and quality, financial targets, controlability, maintainability and reliability.

3. The potential markets for the nuclear gasturbine driven energy plants in the low power range. Analyses of the markets will be explained from the user's point of view on why, when and how, for what purpose, in which power range, as well as how many units per application would be required.

Introduction.

From time to time examples are published of products that are carefully designed, tested and produced with the involvement of scientists, designers and engineers and which turn out to be unmarketable and become a complete loss. One way to prevent this from happening is to invite potential users, producers and maintainers and inform them about your ideas and thoughts on design, marketing potential, production matters, financial targets and why you think it is needed. The next step is a difficult one for scientists, designers and engineers, but listen to these potential users, producers and maintainers, i.o.w listen to the market. This well-proven managementsystem is the only way to prevent disappointment and to create a maximum of support in society, a minimum of through life costing and a maximum of through life support i.o.w. the market for your product.

In the Netherlands the support for nuclear energy generation is rather slim, so to start a study for a new nuclear product is a very tense action. We followed this cautious procedure carefully, although it is certainly a new and uneasy approach for many of us.

The installation we have in mind.

What did we have in mind? In short a suitable replacement for certain diesel-driven or gasturbine-driven applications. An installation consisting of an inherently safe helium cooled pebble-bed reactor with a thermal power of less than 100 MW, directly coupled to a gasturbine in a closed cycle system, only using well-proven technologies and management systems. See Appendix 0.

Available for the replacement market around 2010.

Available at a comparable price, based on through life costing and through life support.

Suitable for the markets of:
- Combined heat and power applications
- Stand-alone heat generation
- Stand-alone electricity generation
- Ship propulsion
Driving reasons were not so much the limitation of the amounts of fossil fuels, but the CO2 problem (a major political subject in the Netherlands), the availability of well-proven technologies and management systems, the integration process of Europe with its free-market aspect and the ever increasing price of energy production. In addition the time has come to find new challenges for our youth and to set the next step in the history of energy generation.

For a market analysis it is important to consider:
1. The kind of user of your installation
2. The type of installation, i.o.w. Combined Heat and power, stand-alone electricity, stand-alone heat applications or ship propulsion
3. The required power range.

1. The kind of user is very important. The main division is:

1.a. The professional user - in other words the utilities. The characteristics of these installations are customer-built, high level power ranges stand-alone electricity generating plants with an efficiency of 35% or Steam turbine and Gasturbine combination plants (STEG) with an efficiency of 55%.

1.b. The non-professional user - this user needs energy for his industrial process like paper mills, dairies, breweries and ship propulsion, in most cases low temperature slightly superheated steam for processes like drying, brewing and pasteurizing. This kind of process is their speciality and they hate to be bothered with the when, where and how of their power as long it is reliable, available and as cheap as possible. These installations are standardised to a very high degree and are factory designed, constructed, assembled and tested.

The installation we have in mind is meant for the second kind of user. So we started to talk to them and to listen to them to fit their usage patterns, procedures, worries, wishes, maintenance schedules, etc. into our study.

A few points of the users views:

a. They really want to stay with their core-business.
b. They like the idea of an organisation which takes care of their energy supply on the basis of through life costing and through life support.
c. The installation should be designed on the basis of the American design principle Keep It Simple and Stupid (KISS).
d. From step one onwards international cooperation should be part of the project.
e. Users accept testing and trial periods, but the first installation should be a production unit which is temporarily used as trial and test unit and not the other way around.
f. Well-proven technologies, assembling techniques and components should be used, to minimize the risks for the user.
g. The installation must be modest in size and clean. A papermaking industry wants to see steam clouds from the drying process and not a huge silo containing their energy production unit.
h. The through life costing for the new installation must be comparable to the existing plants for competitive reasons.
i. Financial targets are: a pay-back time of 10 years and an internal return rate of 15%. Considerable higher targets as the utilities demand. For the Netherlands the costs for CHP would be less than 5.5 Dutch cents per KWh (3 Dollar cents) and 8 cents per KWH (4.4 Dollar cents) in stand-alone electricity generation applications (at a crude oil price of 16 USD/barrel and an exchange rate of Dutch Guilder/USD - 1.8).
j. The energy generation process must be well controllable, depending on the demand and must be of constant quality. At the moment many users of CHP have additional firing in the exhaust boilers to control the quantity and quality of the steam for their industrial process. For this the nuclear installation is unsuitable, so a solution has to be found.

k. Prototype testing is very important as proof of safety. Its credibility increases considerably if the plant is constructed to serve as operational unit after the testing itself has been completed.

l. Although they do not refuse to believe the high availability factors you promise them, they do not like too high a price and do like to stick to their existing procedures concerning maintenance, redundancy and flexibility.

This last paragraph is an important one: an industry using a maximum of 60 MWheat prefers 6 installations of 10 MWheat instead of 2 installations of 30 MWheat or one unit of 60 MWheat. It produces the required flexibility and redundancy. In practice the investment cost of a fossil fueled Combined Heat and Power (CHP) installation is practically independant of the installed power. (see appendix)

There seems to be no reason why this trend should not be applicable to nuclear installations of comparable power.

The procedure as described requires extra time, especially when the product, like our HTR-GT design, is a combination of well-proven technologies. This is logical, a lot of time is needed before people from different parts of the business community are comfortable with each other's opinions and capabilities. Only then they are able to get some feeling about the why and how of the other participants and to extend their support into their industry and their part of society.

The growth of this kind of public opinion has to be supported by publications in newspapers and magazines, presentations at schools, colleges and universities, by visits to potential users, suppliers and maintainers, your presence at exhibitions and by the supply of regular information to politicians and leading managers.

As was mentioned before, the support for nuclear technology is slim, the reasons why do not matter anymore. Stop being afraid of publicity and public relations. Fight back and play bluff poker. The other side is just as clever as you are.

The efficiency of the plant must at least be comparable to that of the existing plants. Not so much because of the fuel price, but because the potential owners have been fighting for high efficiency as a result of the ever increasing price of fuel and related taxes and it will frighten them to suddenly leave this path. In addition the young people in the Netherlands are well aware of the fact that the energy waste will be high on the agenda for environmental reasons after the CO2 problem has been brought under control.

Maintainability is another aspect on which you must listen to the customer. He likes an organisation which takes care of the whole through life support, including cooperation between all users, new production, training, control, new infrastructure, licency, maintenance, documentation, and scrapping; in other words the full logistic support. This is only possible if the installation is made suitable for this design from day one onwards. There exists a management system which is able to do all this. This will be discussed in part two of this publication.

The Pooling system.

In this paragraph an aspect will be discussed, which is growing in importance; namely that of the user's ideas on the management of their Co-generation plants. The pooling-system fits with trends like "back to core business", "we will take care of you" and through life costing in combination with through life support and shared costs.
The pooling system also seems to be a set of tools to make the owner costs of an INCOGEN installation comparable to those of the existing fossil fuel fired CHP-plants.

The history.

The system was developed at the end of World War II by the Royal Airforce of Great Britain. The aim was to improve in all aspects the world-wide exploitation of the Rolls Royce Merlin engines of the Spitfire. Since then it has further been developed and is now used by aircraft companies like KLM and British Airways. The propulsion engines are taken from the wing when needed for repair, overhaul or modification and are replaced immediately by a spare one to keep the aircraft available as much as possible. KLM manages a pool of CF-6 General Electric Engines for KLM itself and a number of other aircraft companies. British Airways does the same for the Rolls Royce aero gasturbines. Similar systems are in operation by European Airforces, for example for the Grumman F-16. A very special version is a pooling-system called "Memorandum of Understanding for the logistic support of Rolls Royce marinized gasturbines". It manages (on 01-08-'96) a pool of 109 Olympus, 97 Tynes and 46 Spey gasturbines in use with the navies of Great Britain, France, Belgium and the Netherlands. The savings are considerable. For example to keep operational all ships in the Royal Navy, using Tyne gasturbines for cruising, 22 Tynes should be available and 14 Tynes for the Royal Netherlands navy. By pooling the two navies 29 engines should suffice. A saving of 7 engines. The same saving occurs with all the spares, tooling and the workload of the repair and maintenance lines. From the military point of view one of the advantages of the pooling-system is its flexibility, which has been proven time and again in periods of war and crisis control; most lately during the Falkland crisis and the war in the Persian Gulf.

Very recently the United States Department of Justice said it approved a plan by eight nuclear utilities, to pool their equipment purchases, to share personnel and other resources in a move to cut costs. The reason this Department became involved is the Anti-Trust law in the United States.

This Pooling-organisation is called Utilities Services Alliance and manages 7% and intends to grow to 35% of the US nuclear power production.

The aim.

The objective of a Pooling-system is to establish arrangements for the logistic support of common equipment. The main advantage of a pooling-system is the economy of scale. In other words to increase the efficiency of the availability, the flexibility, the readiness, the new production, overhaul and repair capacity with its tooling, dedicated personnel, documentation, spares etc. for a particular type of engine or equipment. This takes place through the pooling of all available know-how, experience and investments and will lead to a reduction in exploitation costs and thus to the cost of ownership by through life support of the technical installations concerned.

How does it work?

A Pooling-system is only applicable when there is a commonality of equipment. It can comprise a whole installation like a stand-alone nuclear gasturbine installation employed to generate electricity or it can be a part of a technical installation, such as similar control equipment on different types of installations. In this article we will only consider the effect of a pooling-system on a nuclear gasturbine plant like the HTR-GT for the low power range. The owners of such a plant own, manage and share out the benefits and losses of a pool of spares, tooling, spare equipment, documentation, training facilities, test equipment en facilities, overhaul and repair shops and similar investments with subcontractors, know-how to build, maintain and scrap equipment and experience concerning the exploitation of the equipment.
The actual management is done by a dedicated team, which reports periodically to the shareholders, the owners and users of the plant.

The pool takes care of: new production in dedicated workshops, setting to work, remote control, the planned maintenance in situ and on the overhaul line, the replacement of the fuel, the handling of the nuclear waste, the analyses of defects and possible development, testing, implementation and configuration control of modifications, the training of operators, safety personnel, maintainers, the subcontractors, the planned maintenance, the investment in spares, the rest life of spares, tooling, overhaul, repair and maintenance equipment, documentation, construction, special legislation and generally applicable legislation.

**Modular construction.**

An important aspect in considering a pooling-system is the aspect of a modular construction. Modular built means that the total installation can be divided into units that are easy to manage and which can be replaced with spare units for repair, planned maintenance or overhaul.

So in a nuclear gasturbine installation the non-nuclear part can be and should be divided into at least the following modules: recuperator, power control, engine health monitoring system, helium cleaning system, heat exchangers, auxiliary equipment and the gasturbine itself. This will lead to a minimum of stand-down time, one of the biggest problems of the existing nuclear installations.

The maintenance time can be decreased even further by the joining together of combinations of modules in a bigger replacement unit. For the shipping applications this seems advantageous, because of scheduled docking periods.

The modules have to be interchangeable; in other words the installations will have to have a very high degree of standardization, because otherwise special procedures, tools, spares and so on would be required. This would increase the cost of ownership which is shared by all partners. So a stringent configuration control is a necessity.

This is very important. Equipment which is customer designed, built, maintained etc. is very common in the existing nuclear world (applies to most (nuclear) power plants), but increases the cost of ownership drastically. So if nuclear energy generation is to be more widely applicable, this existing way of thinking and working has to be reconsidered.

In the nuclear part of the INCOGEN-installation the replacement of the fuel is the only maintenance action which can be done in the modular way. It is advisable to place the fuel, during the usage, in some kind of open "shopping basket" which will be taken out periodically and placed in a transport container and replaced by another "shopping basket". The HTR-fuel is very suitable for such a timesaving and thus moneysaving treatment.

For the non-nuclear part the number of spare modules depends on the planned maintenance of the modules themselves and the plant they belong to, the failure rate, the accepted time to replace or to repair, etc., as discussed before. The minimum replacement time is most likely dictated by the nuclear part of the installation which has to cool properly before the helium circuit can be managed and opened for the maintenance as described.

There is nothing new in using containerizing, modular constructions and palletization of equipment. It is a well-known proven management technique. All gasturbines are modular of construction nowadays, all engineering plants have transport routes to replace and to transport heat exchangers, electromotors, generators, valves, control systems etc. for testing, maintenance, etc., especially when the stop must be as short as possible to fit in with the industrial process. Whether the unit is called a container, a module or a pallet depends mostly on the size or the professional language of the OEM and/or the owner.
Nuclear standards and norms.

Another tool to reduce the through life costing is the reconsideration of the existing nuclear norms and standards. A lot of courage is needed for an operation like this. A comparable study has been finished very recently by the Royal Netherlands Navy. The aim was to replace two very important frigates within the shrinking defense budgets. It took 5 years and they considered very carefully but seriously the existing military norms and standards, international cooperation on R & D and exploitation, modular building procedures to reduce building time, pallerizing of weapon and sensor systems, usage of aero-space technology where possible, using civil (a.o. ferries) experience and by putting this question on every aspect “what will be the penalty if we do not apply the military norm or standard?” The result is shown in the graph in the appendix. The result was a bigger ship, with less crew, a bigger flexibility for future modifications to weapon and sensor systems, less R & D costs, no loss of employment, same speed and fuel costs, same through life costing and same through life support. See Appendix 1.

The market analysis for the Netherlands.

The first step was to study the existing market of fossil-fueled, gasturbine driven plants in the Netherlands.

A preferred power range was established by analysing the total existing population of gasturbine driven power plants for the markets as mentioned before. See appendix page 2-A.

The next step was to take out the gasturbines used by electricity generating companies, de Gasunie and oil companies. See appendix page 2-B.

Thereafter we had to establish the age of the existing plants. See appendix page 2-C.

The last step was to establish the shipping market. See appendix page 2-D.

During each step the philosophies of experienced users were taken into consideration.

The results of this market analysis are:

1. The 20 MWth installation is dominant as well for Co-generation as for ship propulsion.
2. The total number for Co-generation is 75 units.
3. There seems to be no market in this power range for stand-alone electricity generation or heat generation in the Netherlands.
4. The market for shipping (Dutch and Dutch Antillian flag) is 205 units.
5. The replacement market will start to come into effect in about 2010.

Western Europe.

In Europe Co-generation, and thus nuclear CHP, has real possibilities for export, mainly because of the positive effect on the production price in an industrial process. This is of special interest to companies in countries with comparable salaries, because this gives the owner of a Co-generation plant an advantage over his competitor. After all, separate generation of heat and electricity is more expensive. In the open market this effect will be the main driving force behind the export possibilities of Co-generation. Another positive force will be the lower burden on the environment as far as emissions of combustion gas and waste heat are concerned, as well as the higher total efficiency of the Co-generation installations, although we are of the opinion that this issue plays a lesser role outside the Netherlands. The promotion efforts have not been very impressive so far, but the Advisory Committee of the Ministry of Economic Affairs will start coordinating the promotion efforts in 1997. When the realisation of any export could actually start, is difficult to estimate. There is, of course, a negative force in this process as well. In many countries the national power generating boards have and will try by all means to maintain their monopoly. This monopoly can only be broken by pressure from governments as part of the open market policy.
The project bureau "Warmte/Kracht Koppeling" did a study on the export possibilities of CHP (Combined Heat and Power) in Europe. An extract was published in the magazine "IPG - International Power Generation", issue September, page 38:

"The following are some recommendations for European and national government actions to unlock the potential for CHP, and given in descending order of importance:
- Political will is needed to remove barriers and to provide a framework, giving clear opportunities to those wishing to benefit from the development of high efficiency CHP systems.
- The efforts of the energy industries, in particular the electricity industry, to move from suppliers of energy to providers of energy services, including CHP, should be reinforced.
- Liberalisation in electricity markets can bring major opportunities for the development of CHP through, for example, access to grid networks and the introduction of greater competition in power generation.
- Under circumstances where the economical conditions are similar, priority should be given to CHP investment over a conventional plant.
- The internationalisation of environmental costs in energy prices should be supported as a mechanism for promoting CHP, while ensuring that industry and other energy users derive real economic benefits from it.
- Member state governments and the EU as a whole should set ambitious but achievable targets for CHP for 2005 and 2010.
- Wider efforts should be made to reinforce and develop CHP/DH networks at the urban level. Such systems can be multi-fuel, offering significant economic flexibility."

The conclusions are mentioned here with the permission of the "Project bureau Warmte/Kracht Koppeling".

Stand-alone electricity or heat production with an installation of 20MWth seems to be a small market in Western Europe.

The possibilities in the market for shipping are comparable to the Dutch shipping market.

The market worldwide.

The possibilities for the export of a Nuclear Gasturbine Installation of 20 MWth around the world do not differ widely from the possibilities in Europe, although the requirement for stand-alone electricity generation is much bigger. Diesel generators in the power range of 5 to 15 MW are in use on most islands around the world (such as Indonesia, the Philippines, the Dutch Antilles and the Seychelles) or in places were the investment in a distribution system is not very cost effective or not feasible.

The market for the small HTR-GT is not only the replacement market for these diesel engines but also occurs in areas where the supply of fossil fuel and/or the investment and maintenance costs are a major factor in the cost of power generation and distribution. In other words, areas with:
1. a low population density, difficulty to maintain distribution systems and remote from a fossil fuel supply.
2. a high density of population and industry and remote from a fossil fuel supply or from the sea or main rivers.

For the development of these markets priority should be given to areas where industry is very much needed to create employment. In other words energy means employment, which leads to economic growth.

Which application (stand-alone power generation, heat generation or co-generation) will be chosen, depends on the climate and/or the industrial process for which the installation is intended.

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As mentioned before the number of diesel engines used for electricity generation in remote areas and on islands is enormous. This is another huge potential market which should be developed.

**The market for shipping.**

The market for shipping has a very conservative and peculiar character. This has always been the case and history teaches us that changes in the propulsion of ships have always been emotional and have taken place in a relatively short time. This last aspect has mainly been caused by economic (smaller crews or better delivery schedules) or military reasons. So it is most likely that history will repeat itself in this case. An additional negative force in this market is the reluctance to accept nuclear driven ships in many harbours.

**Conclusions.**

Due to trends like "back to core business", future owners of an energy plant will increasingly look for means to reduce costs of ownership in combination with guaranteed through life support.

The pooling-system satisfies these aspects to a great extent. For the design the tool of reconsidering the existing nuclear norms and standards is absolutely necessary.

It should be pointed out that all the markets mentioned above, can best be opened by building a Nuclear Gasturbine Installation. This installation can prove and show time and time again the inherent safety of the design to anybody. In this installation all the modern philosophies like modular construction, containerizing where practical, remote control, easy to maintain, pooling-management system etc., are implemented, leading to an acceptable and understandable price.

The modular construction makes it possible to build and use the described HTR-GT installations in even the most remote areas.

The HTR-GT fully satisfies the intentions to stop further climatic changes due to the CO₂ emissions around the world.
Energy Density

Estimated changes in future Energy supply per type users

E. Utilities, see A.

D. High Temperature heat, industry

C. Low temperature heat
beer/paper/dairies

B. Transport

Air

1000 x A

Road

Sea

A. Households

Offices

see abv. E
Appendix 1

Decrease of military norms and standards

[Diagram showing ship costs and displacement over time]
Gasturbine population in the Netherlands

 Combined cycle  □ STEG unit  □ standalone electricity, heat or booster
Gasturbine Population privately owned
Gasturbine population privately owned. Replacement market 40 years later.
Propulsion of the Dutch and Antillian merchant fleet