ENGINE- *Geothermal Lighthouse Projects in Europe*

Information gathered during the ENGINE co-ordination action (ENhanced Geothermal Innovative Network for Europe)
http://engine.brgm.fr/
Last update April 2008

Project Name: Husavik Kalina plant
Project Institute/Company Leader: Husavik Energy / Orkuveita Húsavíkur
Contact Person: Hreinn Hjartarson, Magnús Gehringer
Web-site: www.oh.is, www.exorka.com

Country: Iceland
Location: Husavik

Type(s) of resource Goethermal low enth.
Main on-site operators [3 geoth. wells, Piping, Power plant 2 MWe, district heating, waste disposal plant
Number of wells [3 wells x ca. 800 m.
Type of wells Production
Well configuration [Three single wells without reinjection
Distance between well at Depth [Horiz. Dist at Depth]:
Temperature at total depth:
Combination with other energy sources Waste disposal plant owned by communities

Potential of the geothermal resource 124 °C at wellhead, 121 °C at PP, pipeline between wells and power plant ca. 16 km,
Average flow rate kg/s 100

Main production [Heat or Power]: Power 2 MWe, 2,5 MWe with incineration plant
Total capacity of geothermal area: 44 MW
Capacity of Husavik district heating system (installed) 24 MW
max. heat sold to customers: 19 MW
Annula production of dirstrict heating system: 169 GWh/year

Co-generated production [Heat or Power]: District heating of Husavik town and surroundings
Installed/Expected capacity [MWe or MWt at Date (if expected)]:
Running/Expected capacity [MW/*time* at Date (if expected)]:

Short description of ***Exploration History*** ***(Limit this section; no more than 200 words):***

- see more info at www.oh.is

or especially:
http://www.oh.is/skjol/kynningarefni/english/oh_energy_multiple_use.pdf

Please fell free to use from www.oh.is whatever you think is most appropriate for the Lighthouse project.

Geothermal area

Located some 20 km south of Húsavík is the Hveravellir geothermal area. Geothermal fluid from the three boreholes that were drilled there in 1974 – 1998, ranges in temperature from 120° to 130°C. Close by are several natural hot springs and pools that discharge about 100°C hot water. The production wells range between 400 – 1.000 in depth. Two of the wells are considered amongst the greatest hot water producers of all low temperature wells in Iceland.

The geothermal area has been extensively explored and studied over a period of decades and is thus well understood. The reservoir's capacity potential has been assessed applying up-to-date reservoir modelling techniques and the results show that it can sustain a 75-100 MW artesian flow development.

Geothermal utilisation

Húsavík started utilising the geothermal hot water from Hveravellir as early as 1970. The Hveravellir fluid was flashed to 100°C on site and the hot water fed under gravity to the town through a 20 km long buried asbestos pipeline. In Húsavík it was used for space heating, drying and also to heat greenhouses and farmhouses in the district. Some 15°C were lost en route to the town and significant thermal energy was lost in the flashing process. The geothermal fluid contained within the Hveravellir reservoir is of a quality suited for direct use.

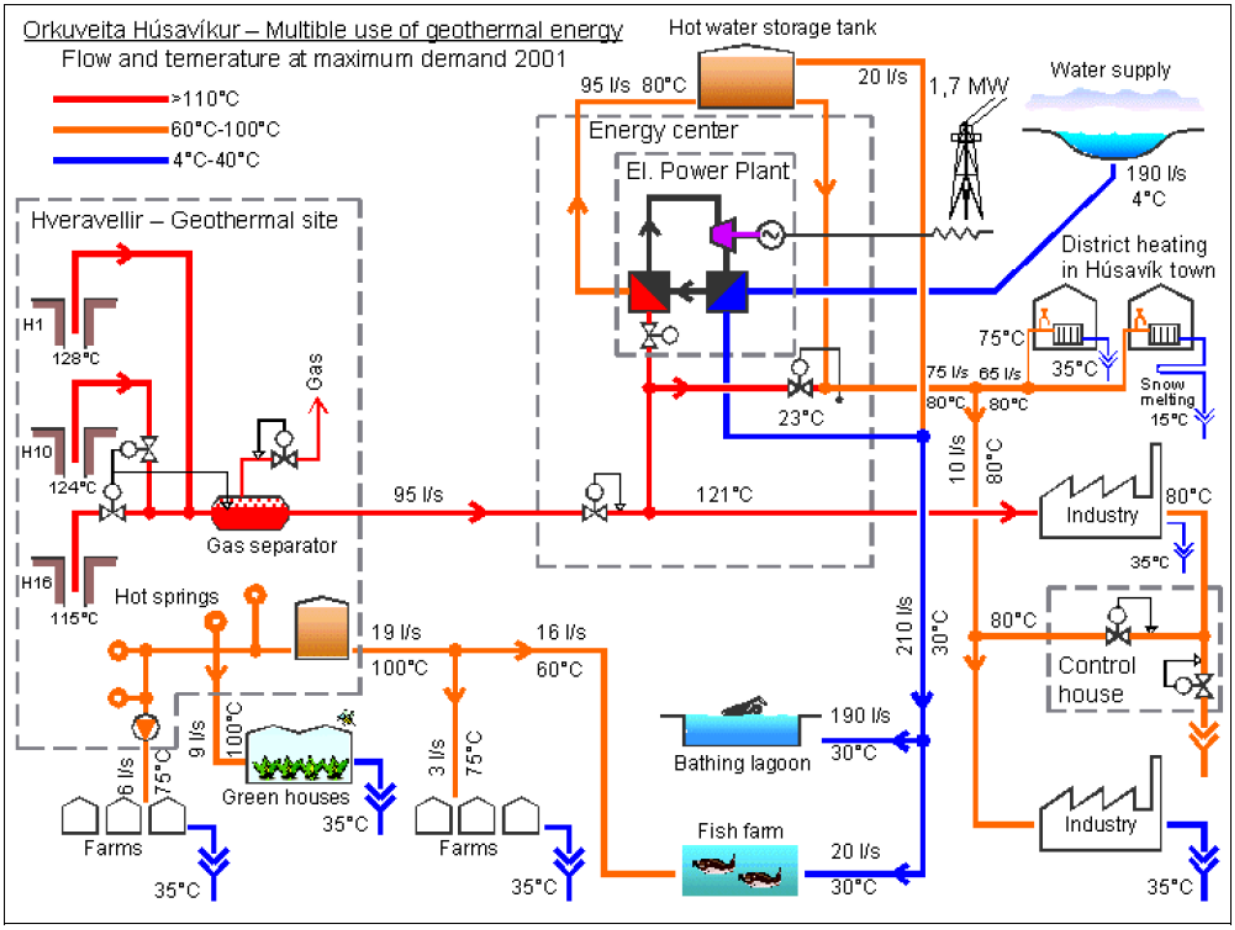
In recent years it became clear that the old pipeline needed a thorough overhaul. In Húsavík new markets were opening up for 80°C to 120°C hot water both for heating and industrial use. This prompted the idea of expanding the foreseen refurbishment of the existing system to include diverse cascaded use. The current highly innovative multi-utilisation development plan for the Hveravellir geothermal resource was primarily conceived to increase its value and reap added environmental benefits. This is achieved by combining in a single system the production of electricity and the provision of suitably hot water for industrial, fish farming, greenhouse, health centre and heating applications. Such an integrated system effects vastly improved efficiency in the utilisation of the thermal energy. The provision of inexpensive thermal energy that is suitable for a multitude of applications close to the consumer location has a great potential to improve the overall economy and employment situation of the township of Húsavík and its surroundings.

The 124°C geothermal fluid from the production wells is transported under pressure to the Energy Centre located in the town. A new thermally insulated steel pipeline is buried along the old pipe for most of the way. The temperature loss en route is expected to be approx. 3°C.

The Energy Centre building houses the Kalina Binary Electric Power Plant. It also houses banks of heat exchangers and control equipment. The net output of the electrical plant is 1,6 MW, which suffices to meet about three-quarters of the town's current electricity demand. From the Energy Centre, water of up to 120°C in temperature and of the appropriate quantity, will be piped to the diverse industrial users in Húsavík and to the town's District Heating system.

A trout and salmon farm is located close to the town requiring hot water to adjust th rearing temperature that promotes optimal growth rate and health conditions for th fish. In addition to these there is a fish drying facility in Húsavík that uses geotherm water. A steady growth in the demand for 80°C hot water for space heating and healt use in Húsavík added further urgency for considering a major renewal of the geotherm hot water supply.

Picture 2 depicts in a simplified diagram the new integrated geothermal energy supp system and the highly diversified utilisation planned.



Picture 2 *Húsavík Energy: Multiple-use of geothermal energy – Process diagram*

3.3 Power Plant

The role of the Power Plant in the system is twofold: to produce electricity and to cool the geothermal water to a temperature suitable to the district heating system.

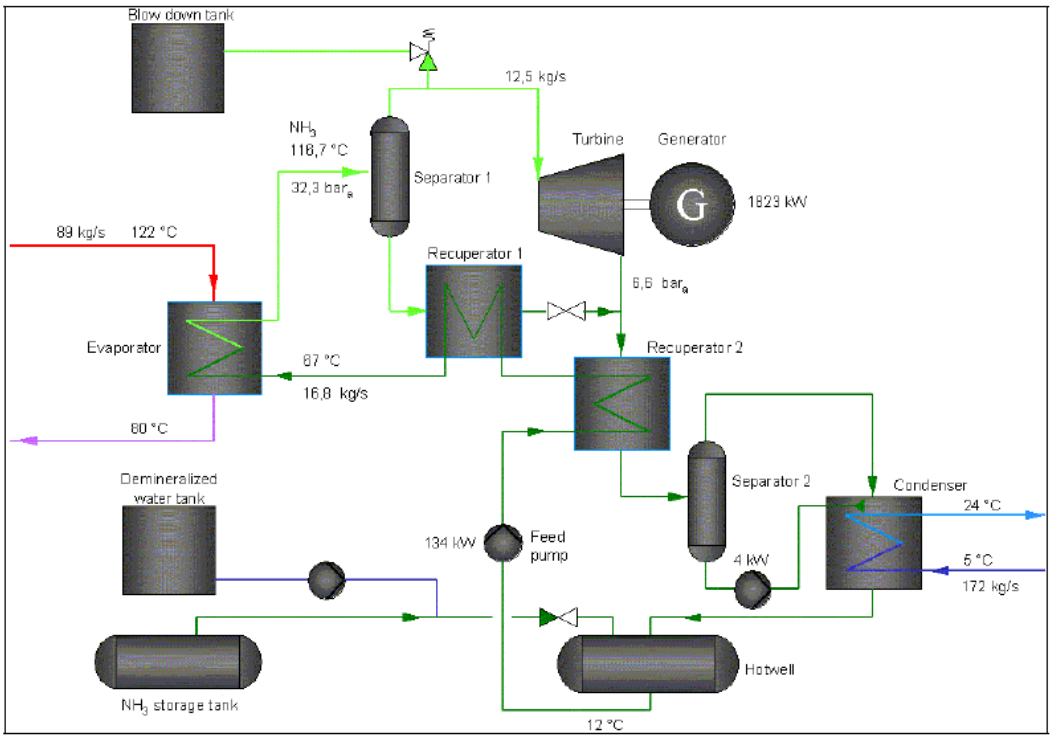


Fig 3.3.1 Power Plant – Schematic diagram

The Power Plant operates under the so called Kalina-technique, which is based on a closed cycle in which a water and ammonia mixture (NH_3-H_2O) serve as the transfer medium (refrigerant). Unlike pure substances, which remain at a constant temperature during boiling or condensation, the mixture's temperature changes during these phase changes.

Once the transfer medium has been heated using geothermal water, it enters a separator, where liquid is separated from vapour. The vapour, rich with ammonia (NH_3), is then led through a turbine where it expands when pressure is decreased. The energy created during this process is turned into electricity in a generator connected to the turbine. The liquid separated from the gas in the separator, is used to preheat the returning mixture in recuperator 1. Following this the liquid is reunited with the vapour and is cooled down in recuperator 2. Before entering the condenser a second separator is installed separating the phases and the water is pumped thorugh inlet nozzles into the condenser wher the ammonia vapour is condensed. .

The cooling water exits the condenser into an effluent pipeline that leads to a man-made bathing lagoon, located south of the Power Plant. On its way there, part of the cooling water is withdrawn from the pipeline and used in fish-farming.

A schematic diagram of the production cycle is shown in **figure 3.3.1.** Initial design assumptions have been modified to reflect the actual geothermal characteristics encountered. All numbers in the diagram represent theoretical values based on the present conditions. The calculated output under the given conditions is some 7% less than theoretical calculations indicate. With proper selection of equipment the output can be calculated as high as 2,150 kW net as a recent offer from an expander manufacturer proves. During the final acceptance testing in November 2001 this output could not be reached but the acceptance certificate was issued as a result of an agreement with the contractor.

The Kalina-technique is recently developed and has never been applied to geothermal heat prior to the installation at Húsavík. Binary fluid systems are not new but the difference between the Kalina system and traditional versions lies in the type of transfer medium used in the closed electricity production cycle. As mentioned, the transfer medium in the Kalina cycle is a mixture of water and ammonia, while traditional ORC cycles use pentane. **Figure 3.3.2** shows the difference between these two fluids while boiling, namely that pentane boils at a constant temperature while temperature varies in a boiling water-ammonia mixture. This property of the transfer medium makes the efficiency of the Kalina cycle much better than that of a typical ORC cycle, given the conditions present at Húsavík.

Reservoir Characteristics ***(Limit this section; no more than 200 words):***

Keywords: geothermal, multiple use, effective use, efficiency, flexibility, sustainability

- Type of reservoir [fractured, porous or both]
- Hosted lithology/rock/mineralogy/fluids [composition]
- Fracture system
- Stress field
- Temperature range or temperature profile

- Main reservoir characteristics [porosity, (natural) permeability etc.]
- Occurrence of natural brines
- Stimulation types [hydraulic, thermal, chemical]
- Wells characteristics [injectivity, productivity etc.]
- Connectivity between wells

- Storage capacity

Please see text above !!!

Exploitation ***(Limit this section; no more than 200 words):***

Keywords: geothermal, multiple use, effective use, efficiency, flexibility, sustainability

- Type of exploitation/power plant [direct, binary or combined cycle]
- Type of binary cycle [ORC, Kalina cycle etc.]
- Nature of working fluid
- Cooling system [water, air]
- Injection fluid [water, salty water etc.]

- Annual production [GWh_e or GWh_t at Date (if expected)]
- Seasonal production
- Capacity factor (%)

- Need for special tools [pumps, turbine etc.]
- Development/improvement of methods (chemical fracturing, new tracers, seismic etc..)
- Monitoring and optimising of field/area using computer models
- Assessment of environmental impact

please see text above!!!
and more info from www.exorka.com or www.oh.is

On-going or future works planes ***(Limit this section; no more than 200 words):***

Possible keywords (non-exhaustive list):

- Next important event [major hydraulic test, new geophysical measurements etc.]
- Future plans? e.g.:
  - New wells
  - Optimizing of existing or building new power plants..
  - Implementation of new tools..
  - Implementation of new methods..
  - New exploration phase..

Start –up of waste incineration plant and utilization of heat at the Kalina plant, see www.exorka.com “news”

ENGINE partners involved in the Project:

- Use list of partners from ENGINE Web-site http://engine.brgm.fr/partners.asp

ISOR, Iceland

Main References *(no more than 5 references):*

NB: Please provide a site picture, - and if possible, a few relevant figures would be appreciated

see attached fotos and Exorka brochure

Kalina
power plants
and know-how

Utilization of waste heat and geothermal energy

Nutzung von Abwärme und geothermaler Wärme

Kalina Kraftwerke
und Know-how

exorka

Exorka

Exorka ehf. (Ltd.) was founded in April 2001 by Husavik Energy and three engineering companies, VGK in Reykjavik, Utras in Akureyri and Tæknithing in Husavik. The strategy of Exorka is clear and simple: we design, build and sell Kalina plants for waste heat and geothermal utilization. The license-agreement between the license owner and us, grants us access to the Kalina markets in all of geographical Europe.

Exorka headquarters are located in Husavik, Northern Iceland, close to our reference Kalina plant, producing 2,1 MW_e from geothermal heat. The plant has been running constantly since 2000 and is Exorka's main source of experience and knowledge.

Our Kalina-Center

Viewing ourselves as a knowledge-based company, we run our own "Kalina Know-how Center" which provides:

- Practical training in operating and running Kalina plants.
- Theoretical knowledge and courses about Kalina cycles and thermodynamics, in collaboration with experts from two universities, power companies and Dr. Alexander Kalina, the inventor of the Kalina cycle, himself.
- Supervision, controlling and technical advice to power plants sold and managed by Exorka.
- Knowledge about how to use Kalina plants for the benefits of the surroundings, like district heating, fish farming, swimming pools and industrial processing.
- New knowledge, progress and improvement of the existing Kalina method. Having the most knowledge will make Exorka even more competitive in the future.

Husavik geothermal Kalina plant

Das geothermale Kalina Kraftwerk in Husavik

Exorka

Exorka ehf (GmbH) besteht seit April 2001 und wurde von drei Ingenieurbüros gegründet, von VGK in Reykajvik, Utras in Akureyri und Tæknithing in Husavik. Die Strategie von Exorka ist klar und einfach: wir entwerfen, bauen und verkaufen Kalina-Anlagen zur Nutzung von Abwärme und geothermaler Wärme. Ein Lizenzabkommen zwischen uns und dem Lizenzbesitzer ermöglicht uns den Zugang zu Märkten im ganzen geographischen Europa.

Exorkas Geschäftsleitung ist in Husavik, Nordisland, ganz in der Nähe unseres Referenzkraftwerkes, das 2,1 MW_e aus geothermaler Wärme produziert. Das Kraftwerk läuft seit 2000 ständig und ist eine wichtige Quelle für Exorkas Erfahrung und Know-how.

Unser Kalina-Center

Da wir uns selbst als Wissensunternehmen sehen, betreiben wir unser eigenes „Kalina Know-how Center" mit folgenden Zielen:

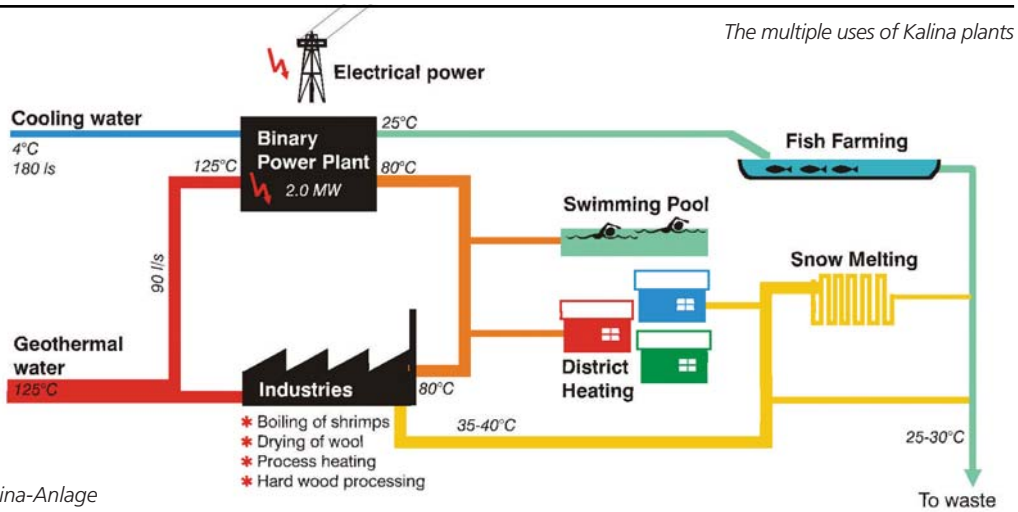
- Praktisches Training für Operateure und Ingenieure von Kalina-Anlagen
- Theoretische Wissens-Schaffung und Kurse zum Thema Kalina Kreislauf und Thermodynamik, in Zusammenarbeit mit Experten von zwei Universitäten, Elektrizitätsgesellschaften und Dr. Alexander Kalina, dem Erfinder der Kalina Technik, selbst.
- Überwachung, Kontrolle und technische Beratung für Exorkas Kalina Anlagen.
- Wissen über die weitere Nutzung der Kalina-Technik zum Wohle der Umwelt, wie z.B. Fernheizung, Fischzucht, Schwimmbäder und industrielle Prozesse.
- Neues Wissen, Fortschritt und Verbesserungen zur existierenden Kalina-Technik. Durch den Vorsprung im Know-how wird Exorka in der Zukunft noch konkurrenzfähiger.

The Kalina technology

Power markets are generally opening up in all parts of the world. More and more emphasis is put on ecological and environmental aspects, partly due to increasing prices for fossil fuels. This leads to growing market opportunities for the kind of equipment Exorka designs and sells.
The company name Exorka ("orka" is Icelandic for "energy") suggests the superiority of the Kalina cycle over conventional methods of power production. Using ammonia – water mixture for steam production, the efficiency of Kalina plants is within a wide temperature range noticeably higher than other technologies, e.g. the ORC Rankine Cycle, can offer today.

The technology itself was invented by Dr. Alexander Kalina, a Russian immigrant living in the United States. It uses low heat sources like for example geothermal water or waste heat from processing plants to boil a mixture of ammonia and water flowing in a closed circuit. Though the technology has been developed over the last two decades, the marketing of the products began just a few years ago.
Comparisons of different kinds of low heat power plants show that the final efficiency can be increased by 20 to 50 % by using the Kalina technology. The competitive advantage of Kalina also includes an often-lower initial investment. Plenty of research on the Kalina technology is accessible at our homepage www.exorka.com.

The multiple uses of Kalina plants



Mehrfache Nutzung der Kalina-Anlage

Die Kalina-Technik

Die Energiemärkte der Welt öffnen sich. Dies ist nicht nur eine Folge ständig steigender Preise für fossile Energiequellen, sondern resultiert diese Tatsache auch aus mehr Betonung der ökologischen Aspekte, die zum Umweltschutz und besserer Energienutzung mahnen. Das Resultat ist eine ständig wachsende Nachfrage nach Produkten wie den unseren.

Der Firmenname Exorka („Orka" ist Isländisch für „Energie") spiegelt die Überlegenheit des Kalina Kreislaufs gegenüber anderen Techniken der Stromerzeugung wieder. Durch den Gebrauch einer Wasser – Ammoniak Mischung ist der Wirkungsgrad einer Kalina-Anlage innerhalb eines großen Temperaturbereichs wesentlich höher als es andere Techniken, wie z.B. der konventionelle ORC Rankine Cycle, zu bieten in der Lage sind.

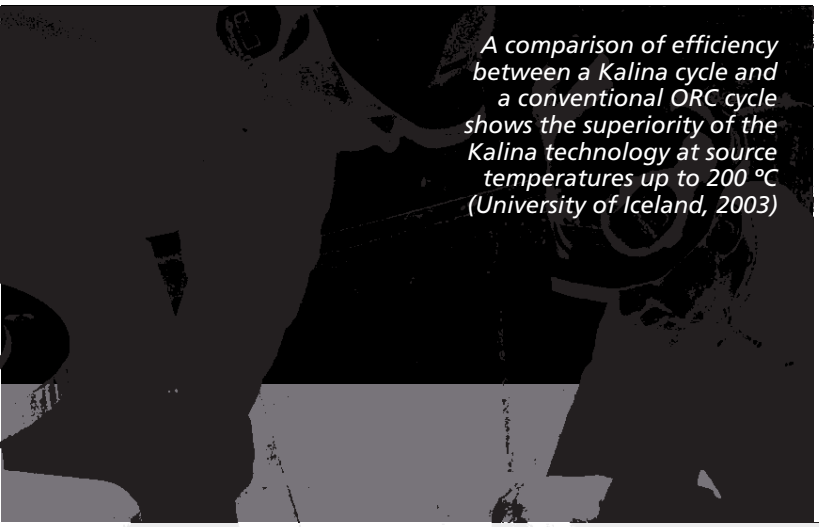
Der Erfinder der Kalina-Technologie ist der in den Vereinigten Staaten lebende russische Einwanderer Dr. Alexander Kalina. Relativ niedrige Temperaturen bringen in einem geschlossenen Kreislauf ein Wasser – Ammoniak Gemisch zum Kochen. Obwohl die Technik schon seit Jahrzehnten in der Entwicklungsphase ist, begann der praktische Einsatz erst vor wenigen Jahren. Vergleiche von verschiedenen Arten von Niedertemperatur-Kraftwerken zeigen, dass durch Einsatz der Kalina-Technik der endgültige Wirkungsgrad um 20 bis 50% erhöht werden kann. Ausserdem basiert der Wettbewerbsvorsprung von Kalina-Anlagen auf einem oftmals niedrigeren Investitionsbedarf. Vielerlei Forschungsergebnisse über Kalina sind auf unserer Homepage www.exorka.com zugänglich.

Our core competency

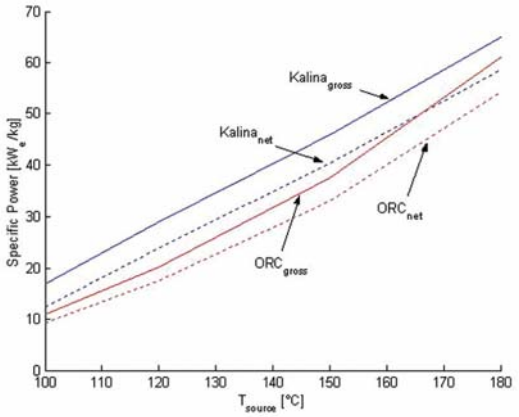
The mission and strategy of Exorka is straightforward: We do what we do best. We do neither pretend to know everything nor to be outstanding in many fields. Most companies leading worldwide in a certain field of expertise have a very narrow focus. All we want to do is designing, producing and selling Kalina plants, both for geothermal and for waste heat utilization. So once you decide to take a closer look at the Kalina technology, you will be in good hands.

Our experience

Exorka is the only company in the world having real practical experience in designing, building and operating a geothermal Kalina plant. Moreover, some waste heat plants will soon be added to the scope. The Husavik Kalina plant is our reference. Designed in 1999 and built 2000, it has been producing over 100 Gigawatthours of electricity. It is one thing to design the first plant, but another to run it in practice. So, we frankly admit that mistakes were made in the design that had to be fixed. Despite of all these problems, the plant has continuously been producing electricity.



A comparison of efficiency between a Kalina cycle and a conventional ORC cycle shows the superiority of the Kalina technology at source temperatures up to 200 °C (University of Iceland, 2003)



Der Vergleich von Wirkungsgraden von Kalina- und ORC- Anlagen zeigt die Überlegenheit der Kalina-Technik im Temperaturbereich bis 200 °C

Unsere Kernkompetenz

Exorka hat eine ganz geradlinige Strategie: Was wir gut können, das tun wir. Wir wollen weder vorgeben, alles zu wissen, noch auf allen Gebieten hervorragend zu sein. Die meisten Unternehmen, die auf einem Gebiet weltführend sind, haben einen recht engen Fokus. Wir wollen also nur Kalina-Anlagen entwerfen, bauen und verkaufen. Wir arbeiten dabei mit Geothermie und Abwärme. Wenn Sie sich mit der Kalina-Technik einmal näher beschäftigen wollen, werden Sie sich bei uns in guten Händen finden.

Unsere Erfahrung

Nach wie vor ist Exorka die weltweit einzige Firma, die auf echte praktische Erfahrung im Bau und Betrieb einer geothermalen Kalina-Anlage verweisen kann, wobei wir bald auch mehrere Abwärmeanlagen hinzufügen werden. Das Kalina-Kraftwerk in Husavik ist unsere Referenz. Es wurde 1999 entworfen, 2000 gebaut und hat seitdem über 100 Gigawattstunden Elektrizität produziert. Der Entwurf dieser ersten Anlage ist nur eine Seite der Medaille, die praktische Erfahrung aus dem jahrelangen Betrieb jedoch eine andere. Wir geben daher gern zu, dass Fehler im technischen Entwurf, beruhend auf fehlendem Wissen, korrigiert werden mussten. Trotz aller Vorkommnisse hat die Anlage über den gesamten Zeitraum fast kontinuierlich Strom produziert.

With years of experience, this has changed considerably. Having changed and altered many items of the Husavik power plant, it now runs without any trouble. The owner is more than satisfied with the outcome. This is the result of Exorka investing a lot of time and money into the Kalina technology in order to be able to say: "We have a Kalina plant running, is anyone else doing better?" When buying complex equipment like a power station, is it not the experience of the producer that counts the most? Experience leads to security. Would you buy the first car made by a new and inexperienced car manufacturer?

Connecting Kalina plants to district heating systems is easy

Fernheizung und Kalina passen gut zusammen

Durch jahrelange Erfahrung hat sich viel geändert. Nachdem an vielen Stellen Änderungen vorgenommen wurden, läuft das KW Husavik nun ohne Probleme. Die Betreiber sind mehr als zufrieden. Exorka hat also viel Zeit und Kapital in die Kalina-Technik investiert, um nun sagen zu können: Bei uns läuft eine Kalina-Anlage, was könnte besser sein? Ist die Erfahrung des Kraftwerk-Bauers nicht der entscheidende Faktor bei der Wahl eines hochkomplizierten Gerätes wie einer Kalina-Anlage? Aus Erfahrung resultiert Sicherheit. Würden Sie das erste Auto von einem neuen und unerfahrenen Autoproduzenten kaufen?

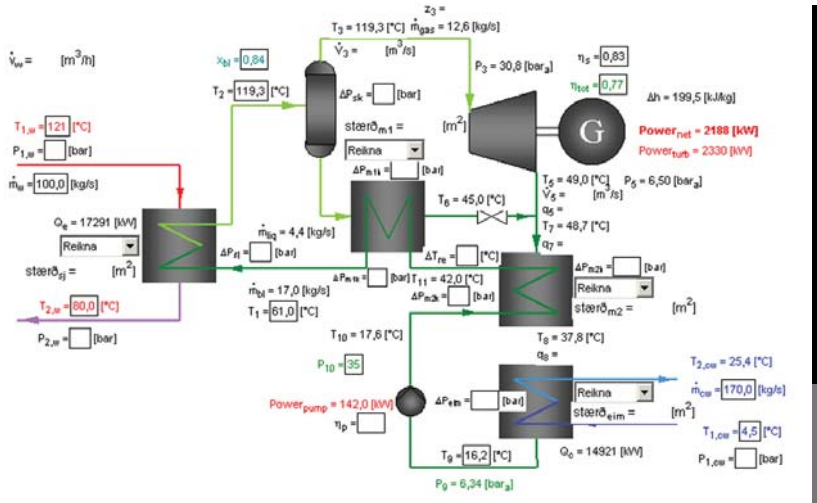
Our design, project management and construction

The designing of new plants is based on the experience of the engineers working in the company. Besides from using our own personell, we are proud to say that we get backup from a world leading engineering company on the geothermal sector, our parent company VGK in Reykjavik (www.vgk.is). Additionally, Exorka will offer district heating systems for all applications, since this is also one of VGK's specialities. We at Exorka have got immediate access to our partner Husavik Energy (www.oh.is) and their experience from the running of the Husavik power plant. Together, the Icelandic companies make a strong team.

Designing and constructing are done as much in collaboration with our clients as possible. Our goal is to provide the best equipment available and fulfill the expectations of our customers at any means. Therefore, VGK and Exorka have collaborated with universities in building an outstanding software program for the design of Kalina plants, including all necessary calculations of all equipments, devices and cost.

A process diagram calculated by our software

Unsere Software kalkuliert das ganze Prozessdiagramm



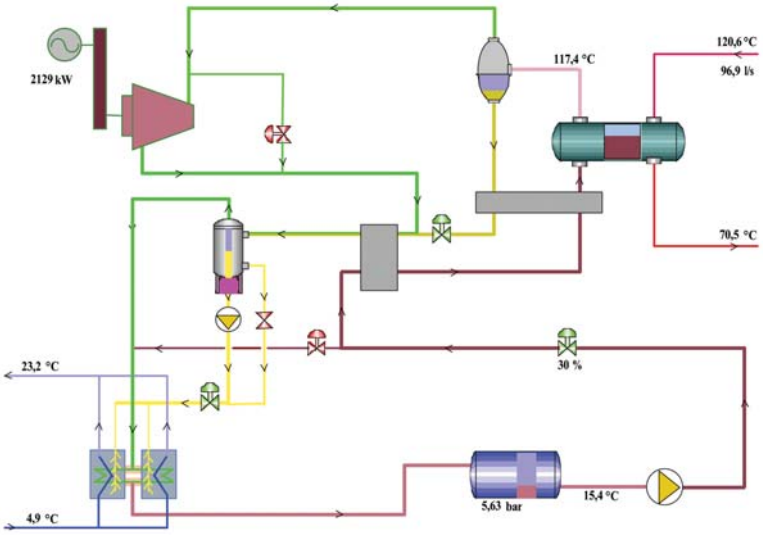
Unser Design, Projektmanagement und Konstruktion

Der Entwurf eines neuen Kraftwerks basiert auf der Erfahrung der in der Firma arbeitenden Ingenieure. Obwohl wir selbst über sehr gute Fachleute verfügen, sind wir stolz auf unsere Zusammenarbeit mit unserer Mutterfirma VGK (www.vgk.is), einem weltweit angesehenen Berater im geothermalen Bereich. Dort bekommen wir technisches Backup. Ausserdem bietet Exorka auch Nah- und Fernwärmesysteme für alle Zwecke, da dies eine von VGK's Spezialitäten ist. Enge Zusammenarbeit mit der Energiegesellschaft Husavik (www.oh.is) sichert uns Zugang zum neuesten Stand der Technik und vermittelt Erfahrungswerte. Zusammen bilden die isländischen Unternehmen ein starkes Team.

Entwurf und Bau eines Kraftwerks erfolgen so weit es geht in Zusammenarbeit mit unseren Kunden. Unsere Strategie besteht darin, nur die bestmöglichen Komponenten zu verwenden und die Erwartungen des Käufers in jeder Hinsicht zu erfüllen. Deshalb haben VGK und Exorka zusammen ein Computer-Programm entworfen, das beim Entwurf der Anlagen alle nötigen Kalkulationen vornimmt, und schliesslich alle technischen Komponenten und sogar deren Kosten berechnet.

Our after-sales services and warranty

Fulfilling our customers' expectations also means keeping a reliable time schedule. The right product must be delivered at the time agreed on. This includes warranties, which gives you the certainty that we will keep our word in every detail. Every occurring problem is a chance for us to improve our know-how, a chance we want to use for your and our own benefit.
Besides extended warranties, we offer a specially designed control system for plants anywhere in the world. This includes distance controlling by our experts from our own control centers, by Internet or telephone. By securing the smooth run of the plant every minute of the day and the optimized power generation, this system provides the outmost security for the plant owner. In case of urgency, our emergency team will be on location as soon as possible and take care of the problem. This we guarantee.
Exorkas customer relations will yet improve significantly through our daughter companies in Bavaria, Germany and in Benelux.



Part of computer screen for distant controlling through internet

Teil des Computer-Bildschirms vom Fernüberwachungssystem

Unser Kundendienst mit Garantie

Die strikte Einhaltung vereinbarter Übergabe-Termine und Daten ist eine der wichtigsten Grundlagen, die zur Zufriedenheit unserer Käufer beitragen. Das richtige Produkt muss zur rechten Zeit geliefert werden. Diesbezügliche Garantie gibt dem Kunden die Gewissheit, dass wir unser Wort in jedem Detail einhalten. Wir sehen jedes auftretende Problem als eine Chance für uns, um damit unser Know-how zu verbessern und somit als Vorteil für den Kunden und uns gleichermassen.
Ausser weitreichender Garantie bieten wir auch ein speziell entworfenes Fernüberwachungssystem für Kraftwerke in der ganzen Welt. Es basiert auf Fernkontrolle per Internet und Telefon durch unsere eigenen Experten. Somit werden problemloser Lauf der Anlage und optimale Stromerzeugung zu jeder Zeit garantiert und die höchstmögliche Sicherheit für den Kraftwerkbetreiber gesichert. Bei einem unerwarteten Ereignis wird unser Not-Team so schnell wie möglich an Ort und Stelle sein und den Schaden beheben. Das garantieren wir.
Durch Gründung unserer Tochtergesellschaften in Bayern, Deutschland und in Benelux wird Exorka den Kundendienst noch weiter verbessern.

graphic design • imago

We take delight in
answering further questions!
Please contact us.

Gerne beantworten wir alle
weiteren Fragen und beraten Sie!
Bitte fragen Sie uns.

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