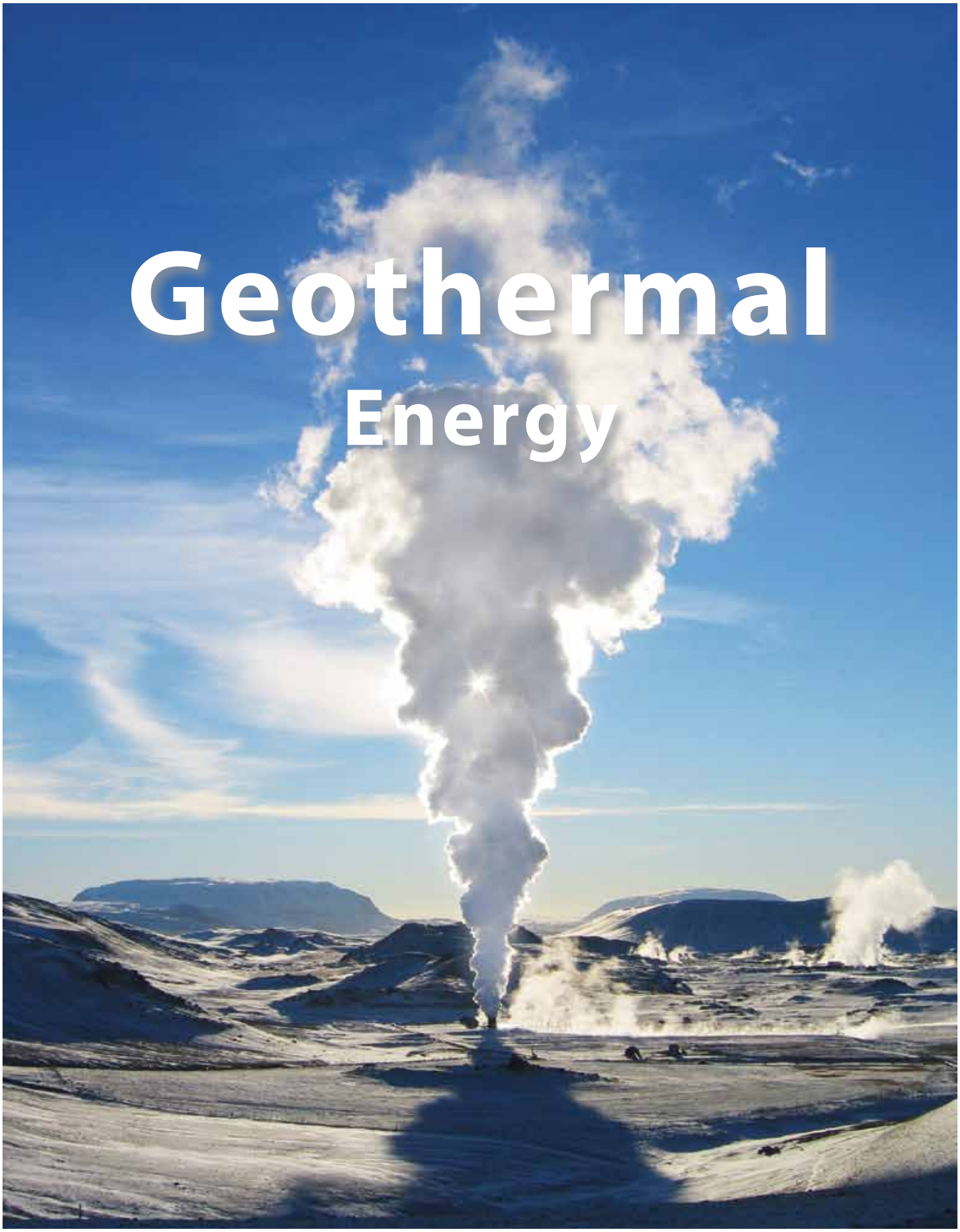


MANNVIT

Leaders in

Geothermal Energy

Geothermal District Heating

CONTENT

OVER 40 YEARS OF GEOTHERMAL DEVELOPMENT EXPERIENCE

Iceland´s history is uniquely tied to geothermal energy. In fact, the capital city, Reykjavik, literally means 'smoky bay,' a name given by the first settlers who observed 'smoke' rising from the ground. Icelanders put this resource to use right from the beginning. First for bathing and washing, later for space heating, and then in the early 1970´s, the country started building geothermal power plants.

Mannvit, which was founded in 1963, has played a leading role in this development and has amassed vast experience and expertise in this field. Today, Mannvit is the largest engineering and technology firm in Iceland with impressive credentials in geothermal energy. Mannvit offers a range of services, spanning all aspects of development and utilization including:

- Geothermal Research & Surveys
- Feasibility Studies
- Environmental Impact Assessment (EIA)
- Environmental Consulting
- Resource Assessment & Due Diligence
- Reservoir Engineering
- Drilling Engineering and Management
- District Heating
- Power Plant
- Project Management and EPCM
- Procurement and Tendering
- Operational Services
- Investment Workshop

Recent projects:

• Iceland • Hungary • USA • Germany • Nicaragua • Greece • India • El Salvador • Chile • Serbia • Kenya

Technical due diligence

Mannvit offers technical due diligence reporting to geothermal project developers, financial institutions and investors.

A technical due diligence report provides our clients with up-to-date assessment of costs, expert data review, risk assessment & mitigation measures and evaluation of alternatives in every discipline and phase of geothermal project development.

Environmental Consulting

An important consideration to any geothermal development project is the assessment, monitoring and mitigation of the environmental impact of a power plant throughout all stages of its development and utilization. In this regard too, Mannvit offers turn-key consulting services carried out by experienced environmental engineers, geologists, geographers, biologist and other specialists.

Services include:

- Soil investigation
- Air and water quality monitoring
- Environmental modeling
- Environmental management
- Strategic environmental assessment
- Operational licenses
- Environmental impact assessment
- Environmental monitoring
- Environmental mitigation

Project example:

Geothermal development in NE-Iceland

Two of the largest geothermal fields in NE-Iceland are the Krafla and Theistareykir areas. The plan is to build a geothermal power plant in both areas for a total electric power of 180 MW. Mannvit has provided the two developers - Landsvirkjun since 1998 and Theistareykir since 2006 - with environmental consulting services regarding geothermal utilization in NE-Iceland.
Several wells have already been drilled at Theistareykir. At Krafla the new geothermal power plant is planned near the existing power plant that produces 60 MW of electrical power. At Krafla 38 boreholes have been drilled and further drilling is planned for a new power plant.

Mannvit services:

- Regional plan for geothermal areas NE-Iceland, including strategic environmental impact assessment
- Environmental reports on exploratory drilling
- Project management of environmental impact assessment:
  - Exploration drilling
  - Geothermal power plant
  - Combined environmental impact assessment of geothermal power plants, transmission lines and aluminum smelter
- Geography (GIS systems)


Environmental Consulting

Geothermal Exploration

Geothermal Exploration is the bridge between early-stage ideas for geothermal development and fully committed planning and start-up of geothermal production. In the broadest sense, Geothermal Exploration involves proving the viability of geothermal energy as a practical means of generating power and/or heat in a particular location. The knowledge obtained through exploration is the basis for an assessment of energy-producing potential and the subsequent creation of engineering plans and construction cost estimates. The quality of the assessment depends on the quality of the available data. Accurate information from the exploration stage is crucial to assess not only the overall viability of energy production but the detailed physical challenges of drilling, operational expectations and costs.

Geothermal Exploration Services

The Mannvit Geothermal Exploration Team offers a full range of services within geothermal exploration and development. The Mannvit Team can manage the entire geothermal exploration effort, from initial reconnaissance stage to resource management of the developed geothermal field, or defined parts of the process as the Client wishes. Examples of services:

- Review and interpretation of existing data, data mining and desktop study
- Geological mapping, e.g. structure, stratigraphy and thermal manifestations
- Geophysical exploration such as resistivity, gravity, seismic and geodetic measurements
- Geochemical sampling and analysis, geothermometry, assessment of corrosion and scaling
- GIS services and cartography
- Geothermal databases and data management
- Conceptual modeling
- Well siting and well design
- Well site geology and drilling supervision
- Well coring program and logging
- Well testing and stimulation program
- Geothermal evaluation for feasibility studies
- Geothermal reservoir assessment and classification according to Geothermal Reporting Code
- Geothermal reservoir modeling including statistical, lumped, distributed and multiphase
- Geothermal reservoir monitoring
- Surface runoff and groundwater modeling
- Environmental modeling
- Underground cold and heat storage
- Assistance with applications and licensing procedures
- Software development
- Teaching and training

Mannvit Geothermal Exploration Team

The exploration stage involves specialist participation from various science and engineering disciplines relating to the Earth's geology, hydrology, geochemistry and geophysics. The Mannvit Team consists of leading consulting firms in geothermal exploration, basic research and applied research, with decades of experience in these areas arising from numerous projects in Iceland, Europe, Asia and the Americas. Mannvit hf is a stakeholder in all of the firms and as such the common denominator in the cooperation.

The Mannvit Geothermal Exploration Team comprises over 100 highly-trained professionals across all relevant disciplines, capable of carrying out geothermal exploration under diverse conditions.

VATNASKIL CONSULTING ENGINEERS

- Geothermal reservoir engineering
- Reservoir modeling
- Groundwater hydrology
- Surface runoff
- Environmental modeling

Vatnaskil
Land & Water Resource Consultants

- Geological and hydrological studies
- Water resources assessments

GTN LA INGENIERÍA & GEOLOGÍA

- Offering Mannvit and GTN services in Chile and Latin America

MANNVIT

Geothermal Exploration

- Geothermal exploration management
- Geological, geochemical and geophysical surveys management and interpretation
- Resource estimation
- Cartography

Geothermal Energy

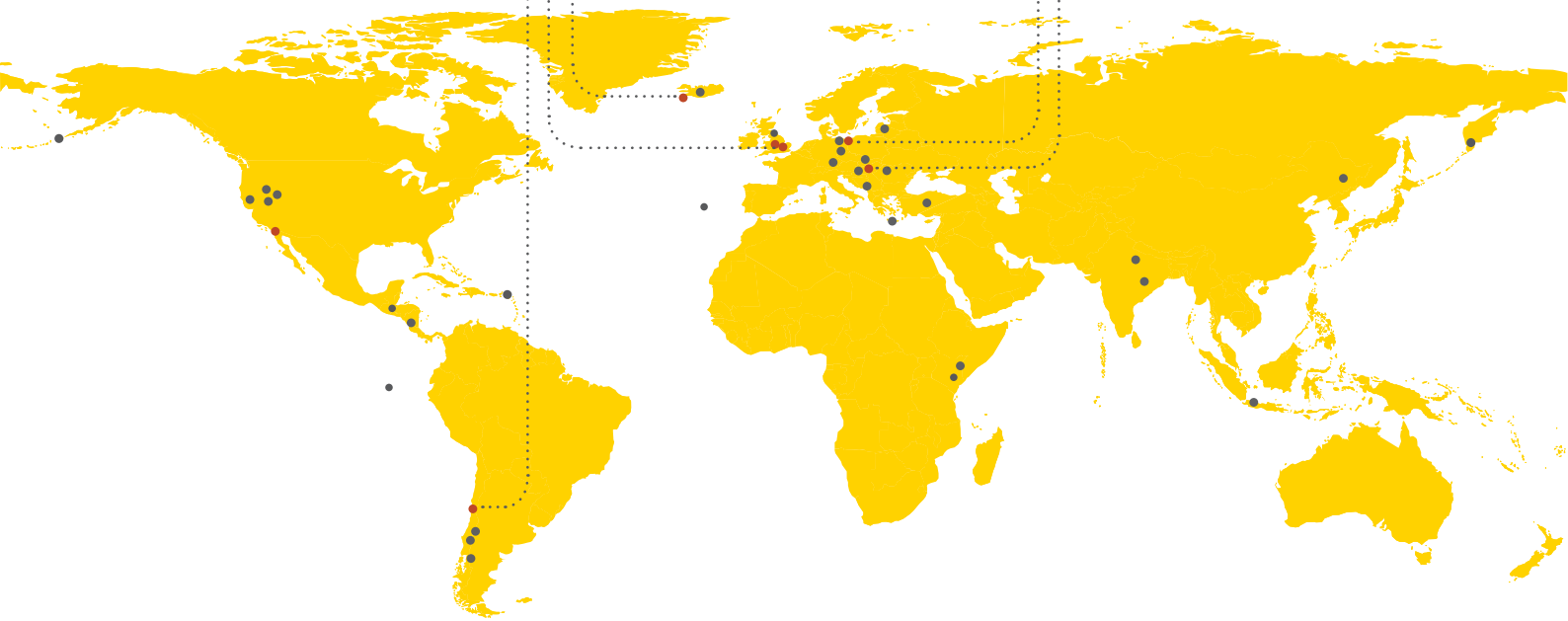
- Pre-engineering
- Cost estimation
- Drilling supervision

GTN INGENIEURE & GEOLOGEN

- Geothermal development of low-enthalpy basins
- Reservoir modeling
- Well design and Drilling supervision
- CO_2 storage
- EGS technology

MANNVIT HUNGARY

- Geothermal exploration and utilization of Hungary's Pannonian basin
- Geothermal exploration in Slovakia, Romania and Greece
- Drilling supervision



● Offices
● Selection of projects


Iceland Drilling

Geothermal Drilling

Geothermal project developers are aware of the importance of risk mitigation during the most important phases of their development. Successfully connecting the well to the geothermal aquifer is amongst the most important tasks undertaken during the project implementation. This will determine the success of the whole project.

Owing to the long history of geothermal utilization in Iceland, Mannvit has amassed significant expertise and experience in this unique field, which is not directly transferable from other industries. Mannvit offers 40 years of experience in providing engineering services for geothermal drilling as well as acting as the client´s representative during third party drilling.

Services include:

- Well siting and pad preparation
- Well design
- Bid preparation and tender evaluation
- Supervision of drilling contracts
- Well logging
- Drilling engineering
- Mud logging – on site geology
- Stimulation
- Inspections of rigs, equipment materials
- Well work-over programs

Project example:

Icelandic Deep Drilling Project (IDDP)

The IDDP consortium includes: HS Orka, Landsvirkjun, Orkuveita Reykjavikur and the National Energy Authority of Iceland.

The consortium is preparing the drilling of a 4-5 km deep borehole into three of its high-temperature hydrothermal systems to reach 400-600 °C supercritical hydrous fluid at a rifted plate margin on a mid-ocean ridge. The first well, IDDP-1, was drilled in Krafla geothermal field in 2009. At 2,1 km depth the drill bit got stuck in the well after hitting magma, which stopped drilling of the well. The well produced almost 400 °C hot steam when it was discharge tested in 2010. Further testing for fluid handling has been carried out in 2011. The second well is being planned in the Reykjanes geothermal field.

Mannvit services:

- Well design
- Drilling technology
- Drilling supervision
- Study of technology for fluid handling and evaluation
- Design of discharge testing and pilot plant

District Heating

Mannvit is a leader in geothermal district heating and offers comprehensive design and consulting services including: surveys, piping systems, systems analysis, flow calculations and measurements, water catchments, supply mains, distribution systems and pumping stations.

The Company has played a significant role in the development of Iceland's geothermal district and municipal heating since the early 1960´s and is now involved in geothermal development projects, including district heating, all over the world including, Hungary, China, Germany.

Iceland's various geothermal district and municipal heating entities provide space heating and hot water to over 90% of homes and buildings. And, the capital city, Reykjavik boasts the world's largest and most sophisticated geothermal district heating systems in the world, a development project that began in the 1930´s and continues today. This use of geothermal and other renewable resources over the last 80 years has made Reykjavik one of the cleanest cities in the world.

Iceland uses this abundant source of geothermal energy for many applications beyond space heating and hot water for homes and businesses including, greenhouse heating, snow melting, fish farming, thermal spas, swimming pools and more.

Most of the district heating in Iceland comes from three main geothermal power plants producing over 800 MW of thermal power:

- Svartsengi CHP plant
- Nesjavellir CHP plant
- Hellisheidi CHP plant

Benefits of Geothermal District Heating:

- Environmentally-friendly
- Economically competitive
- Reliable source of energy
- Improved air quality
- Stable energy prices vs. fossil fuels
- Multiple domestic and industrial uses
- Offers competitive advantages to industry
- Improved public image

Geothermal Power Plants

Geothermal power plants utilize heat energy from the Earth to produce electricity and sometimes for combined heat and power (CHP). They are cost effective, reliable and environmentally friendly. And, though previously restricted to certain geographic locations, technological advances in drilling and plant design allow for the development of what were once thought to be non-viable resources. As a result, more and more public and private entities are looking into geothermal power as part of their strategy to mitigate global warming while still meeting growing energy demands.

Mannvit of Iceland is a world leader in geothermal power plant development consulting with decades of experience in Iceland and abroad. The company designs and builds geothermal power plants tailored to match specific resource conditions which, in the most general sense, can be categorized by their thermodynamic potential, or enthalpy.

The specific geothermal power plant configurations must match the heat resource to maximize its potential but also must take into account a variety of other criteria including local conditions and requirements as well as the needs of a community. The geothermal engineers, geoscientists and other company specialists at Mannvit have successfully tackled numerous complex challenges involving geothermal heat utilization all over the world.

Mannvit services:

- Process design
- Cogeneration of electricity & hot water
- Feasibility studies & cost estimations
- Conceptual design
- Site layout & planning
- Overall plant design
- Equipment specifications
- Bid preparation & tender evaluation
- Site supervision & project management
- Commissioning
- Acceptance test
- Training of operators
- Monitoring at well head
- Environmental monitoring

Within Iceland, Mannvit has been involved in all the geothermal power plants built since the early 1970´s. The electricity from these plants provides approximately 27% of the country's electrical needs, whereas hot water from these plants heats over 90% of the homes and buildings.

Iceland Geothermal Power Plants:

- Svartsengi combined heat and power (CHP) geothermal power plant
- Bjarnaflag geothermal power plant
- Nesjavellir (CHP) geothermal power plant
- Krafla geothermal power plant
- Reykjanes geothermal power plant
- Hellisheidi (CHP) geothermal power plant
- Husavik Kalina cycle geothermal power plant
- Theistareykir geothermal power plant
- Bjarnarflag II geothermal power plant

Outside of Iceland the company is applying their experience to projects in Europe, North and South America based on their expertise in high- and low-temperature geothermal resource utilization for power production and heating.

Project example:

Hellisheidi Power Plant

Hellisheidi geothermal power plant is a flash steam, combined heat and power plant (CHP) located in SW-Iceland, on one of the largest wet geothermal systems (high-enthalpy) in Iceland. The plant's purpose is to meet increasing demand for electricity in the industrial sector (aluminum smelting) and hot water for space heating in the capital city area. The development plan was an incremental or phased expansion from 2006 to 2011 to an output of 303 MW of electrical power and 133 MW of thermal power, making it the largest geothermal combined heat and power plant in Iceland. The plant owner is Orkuveita Reykjavíkur.

The first phase included two high-pressure turbines with rated electrical power of 45 MW, which went online in October, 2006 and then one low pressure turbine, with rated electrical power of 33 MW, which went online in the fall of 2007. The next expansion phase consisted of two additional turbines, of the same type, that went online in the fall of 2008. The first stage of three thermal power plants was commissioned in 2010 and produces 133 MW of thermal power. The final phase will put the thermal capacity at 400 MW. Overall, 50 boreholes were drilled, from 1,000-2,200 m. The last power expansion (phase 5) adding two additional turbines, with rated power of 45 MW, went online in 2011, where Project Management, HVAC, mechanical design, control systems, commissioning and training was also handled by Mannvit.

Hellisheidi Geothermal Power Plant details:

- Flash steam, combined cycle power plant
- Planned total output: 303 MW of electrical power and 400 MW of thermal power
- Phase 1: 2 x 45 MW of electrical power
- Phase 2: 33 MW of electrical power
- Phase 3: 2 x 45 MW of electrical power
- Phase 4: 133 MW of thermal power
- Phase 5: 2 x 45 MW of electrical power
- 50 boreholes were drilled, from 1,000-2,200 m

Mannvit services:

- Project management
- Overall plant design
- Environmental impact assessment
- Detailed mechanical design of the plant
- Detailed design of HVAC systems
- Bid preparation and tender evaluation
- Site supervision
- Commissioning
- Acceptance test
- Training of operators
- EIA scoping report
- Environmental modeling
- Reservoir engineering
- Design of control systems

Project example:

Nesjavellir Power Plant

The Nesjavellir geothermal field is a high-enthalpy geothermal system within the Hengill area of SW-Iceland. Construction of the geothermal power plant began in 1987 and the first stage of the thermal plant was commissioned in 1990, following an intensive drilling and testing phase in the 1980s. The last 30 MWe turbine generator unit was commissioned in 2005.

Nesjavellir Geothermal Power Plant details:

- Combined heat and power (CHP)
- 120 MW of electrical power, developed in three phases
- 300 MW of thermal power, or 1,800 L/s of hot water at approximately 83 °C
- 25 boreholes were drilled, from 1,000-2,200 m

Mannvit services:

- Project management
- Overall plant design
- Environmental impact assessment
- Detailed mechanical design of the plant
- Detailed design of HVAC systems
- Bid preparation and tender evaluation
- Site supervision
- Commissioning
- Acceptance test
- Training of operators

The Nesjavellir power plant is a combined heat and power plant (CHP), which produces electricity and hot water for district heating. The plant itself is a combined cycle plant, wherein a mixture of steam and geothermal is transported from the wells to a central separation station at 200 °C and 14 bar.

In the separation station the fluid (steam and liquid) goes into a steam separator and the two phases are separated. The steam is sent through the turbine after which it is condensed in a condenser. Within the condenser, fresh water is preheated. The preheated fresh water is then run through a system of heat exchangers, which utilize the heat from the liquid part of the geothermal water from the steam separator. The fresh water is heated to the required temperature and sent through deareators, which remove the bulk of the oxygen. Then finally a small amount of geothermal steam containing acidic gases (hydrogen sulfide) is injected into the water to remove any remaining oxygen, thereby preventing corrosion.

This hot water is then pumped to a large storage tank at an elevation of 406 m. From there, the hot water flows by gravity to two smaller storage tanks on the outskirts of Reykjavik to be used for heating and hot tap water.

Project example:

Kalina Power Plant

Mannvit was the Owners Engineer during the design and construction of the Kalina geothermal power plant in Husavik, Iceland. The construction supervision was carried out by Mannvit and the resident engineer came from Mannvit.

The plant was installed in 1999 near the small town of Husavik, in Northern Iceland. This binary geothermal plant produces 2 MW of electrical power from a geothermal brine flow of 90 kg/s at 120 °C. The plant was commissioned in mid-2000. The outgoing geothermal water leaves the plant at 80 °C and is then used for district heating and other industrial uses.

This 2 MW plant provides up to 80% of the town's electric power demand. The heat source for the plant comes from geothermal wells located 20 km south of Husavík.

The distinguishing trait of the Kalina Cycle is its working fluid of ammonia-water. The efficiency gain is achieved by the ability of this working fluid to closely parallel the temperature of the heat source (in this case – hot geothermal water) and the heat sink (cooling water). Cost effective energy recuperation within the cycle is also possible due to the unique characteristics of the ammonia-water mixture. Mannvit is participating in further development of the Kalina Cycle.

Outside of Iceland the company is applying their experience and expertise to projects in Europe and North America based largely on their innovations in binary technology, which allows the production of electricity from low temperature geothermal resources.

Project example:

Bjarnarflag and Theistareykir Power Plants

Landsvirkjun (Iceland's national energy company) and Theistareykir (A joint-owned municipal development company) plan to build two geothermal power plants with electrical power of 90 MW at Bjarnarflag and Theistareykir in NE Iceland. Over the last 10 years, Landsvirkjun and Theistareykir ehf., have invested over $100 million USD on researching geothermal areas in northeast Iceland. EIA's for a 90 MW power plant in Bjarnarflag and a 200 MW power plant in Theistareykir are completed and steam for 45 MW is already available for Bjarnarflag. Full project design will start in the beginning of 2012.

Bjarnarflag Geothermal Power plant details:

- Phase 1: 45 MW - start-up at the end of 2014
- Phase 2: 45 MW – decision on additional unit will be taken at the end of 2013

Theistareykir Geothermal Power plant details:

- Phase 1: 45 MW - start-up mid-year 2015
- Phase 2: 45 MW - start-up at the end of 2015

Mannvit services:

- Project management for the consultants
- EIA
- Preliminary design
- Preparation of tender documents
- Detail design
- Supervision assistance for mechanical installation
- Supervision assistance electrical equipment installation

Project example:

Geothermal Research in Kenya

The Olkaria geothermal field is located in Kenya's Rift Valley, which is northwest of Nairobi and south of Lake Naivasha. Utilization of the area began more than three decades ago and included consultation from Icelandic scientists and engineers. Currently there are three power plants producing a total of 200 MW of electrical power. Plans for two 140 MW power plants are underway and KenGen anticipates that the harnessing capacity of the area is approximately 1000 MW. A consortium of four Icelandic consulting firms, including Mannvit and Vatnaskil (Mannvit's subsidiary) were hired by Kenya Electricity (KenGen) for a capacity assessment and feasibility study of the Olkaria geothermal fields.

Consortium's role

- Develop a model to simulate the behavior of the geothermal reservoir to predict the future capacity of the area
- Conduct technical and economic assessments of the current power plants as well as for future power plants
- Prepare an environmental report

Mannvit of Iceland was founded in 1963 and currently employs a staff of over 400. The company provides a broad range of engineering, technical research services and project management. Since the early seventies, Mannvit has been active in the area of renewable energy and has been involved in the development of most power plants in Iceland, both hydroelectric and geothermal. Services for these projects range from research and other preparatory work to complete design and construction management.

All Mannvit's operations are certified under international quality, environmental and safety management standards ISO 9001:2008, ISO 14001:2004 and OHSAS 18001:2007.

FS 551557 EMS 567779 OHSS 567778

The Mannvit website

Mannvit's corporate web site, www.mannvit.com contains further information and project examples for hydroelectric and geothermal power plants as well as contact information.

Additional information:

Sigurður St. Arnalds I e-mail: ssta@mannvit.is

MANNVIT

Mannvit hf. I Grensásvegi 1 I 108 Reykjavík I Iceland I @: mannvit@mannvit.is I w: www.mannvit.com I t: +354 422 3000 I f: +354 422 3001

May 2012