

#### **Producer & Manufacturer of ORC Technology**

ENGINE WORKSHOP 14-16<sup>th</sup> of September, Strasbourg, France Electricity Generation from Enhanced Geothermal Systems



### **Enex Binary Plant**





## **Presentation topics**

- 1. Overview of Enex
- 2. Operation experience & experience in handling geothermal fluids
- 3. Projects and developments in the ORC market
  - Use of abandoned Hungarian oil wells for electrical generation in ORC power plants
  - Utilising geothermal in Slovakia through project development
  - Cooperation with DCM for development of 5 binary plants
  - 8 MW ORC bottoming plant in Berlin, El Salvador
- 4. Conclusions

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# This is Enex

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#### **Export of Know-how in the Geothermal and Hydroelectric Sectors**

**Enex** is owned by Icelandic companies, which have led the development of geothermal resource utilization for over 70 years in Iceland. Enex has world leading geothermal expertise and experience that it puts to use when designing the right solution.

**Enex** was established to co-ordinate ongoing efforts of the shareholding companies to export geothermal and hydropower knowledge and experience in a more vigorous and integrated manner than before.

#### Affiliates in cooperation with local partners:

- Enex-China
- Enex-Deutschland, Germany
- Slovgeoterm, Slovakia
- Iceland America Energy, USA



Geysir drill at the 120  $\mathrm{MW}_{\mathrm{e}}$  Hellisheidi Geothermal Plant



690 MW<sub>e</sub> Kárahnjúkar Hydropower Project



# Enex's owners are Europe's largest geothermal and hydro developers

- For the last 20 and foreseeable for the next 20 years

### We offer a work force of 400 experts

100 geoscientists and 300 specialized engineers

### Iceland runs the UNU (United Nations University) Geothermal Program

- Network of 340 fellows from developing countries
- Helping the development of geothermal potential since 1979



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### What we do

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#### Research

- Exploration and Mapping
- Geoscientific Research and Consulting
- Testing of wells and reservoirs
- Resource Assessment
- Feasibility Studies
- Environmental Studies

#### Financing

- Outside Financing
- Direct Ownership, BOO or BOT



Geoscientific research



Geological surveying, high temperature area S-Iceland

### What we do

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#### **Design and Planning**

- Design, Engineering & Construction on Turnkey, BOO or BOT basis
  - Binary Power Plants
  - Flash Steam Power Plants
  - Small to Medium Size Hydropower Plants
  - District Heating Systems
- Distribution System
- Reservoir Modelling
- Project Development

#### **Operation & Maintenance**

- Direct Services
- Resource Management
- Operation & Management programs



Simplified schematic for a flash steam power plant



Tunnel drilling at Kárahnjúkar Hydropower Plant

### **Enex's Shareholders**

- 1. Reykjavik Energy
- 2. National Power Co.
- 3. Iceland Drilling
- 4. Sudurnes Regional Heating Corp.

- 5. Glitnir Bank
- 6. Icelandic Geo Survey
- 7. New Business Venture
- 8. Nordic Energy
- + more than 30 other engineering, design and consulting firms specialized in geothermal, district heating and hydropower projects.



### **Operational Experience**

### **Operational Experience in Geothermal Power Plants**

- Enex's owner group has constructed and operates 6 geothermal power plants
- First geothermal power plant went into operation 1969
- Current installed capacity is 450 MW<sub>e</sub>

### **Experience in handling geothermal fluids**

- Geothermal fluids have been used for district heating since 1930's
- Icelandic power plants use brine from high temperature fields
- Scaling problems are frequent in new developments
- 100 MW<sub>e</sub> Reykjanes plant uses brine at 320 ℃

### **Geothermal Power Plants**

#### Krafla 60 MW<sub>e</sub>

Geothermal Power Plant Owner: National Power Co.

#### Nesjavellir 120 MW<sub>e</sub> - 300 MW<sub>th</sub>

Combined Heat & Power Geothermal Plant Owner: Reykjavik Energy

#### Svartsengi 46 $MW_e - 150 MW_{th}$

Combined Heat & Power Geothermal Plant Owner: Sudurnes District Heating

#### Reykjanes 100 MW<sub>e</sub>

Geothermal Power Plant

**Owner: Sudurnes District Heating** 

#### Hellisheidi 210 MW<sub>e</sub> - 400 MW<sub>th</sub>

Combined Heat & Power Geothermal Project 80 MW in 2006. In construction phase, 2003 – 2015. Owner: Reykjavik Energy



Svartsengi 46 MWe geothermal power plant



Krafla 60  $\mathrm{MW}_{\mathrm{e}}$  geothermal power plant

### Germany

Five 4 MW to 10 MW binary power plants in development stage.

### USA

- Truckhaven, California, 50 MW<sub>e</sub> geothermal plant
- Mammoth Mountain

#### **El Salvador**

– Berlin, 8 MW ORC bottoming power plant

#### China

District heating projects

- Xianyang
- Bejing
- Tengchong, geothermal consulting

#### Poland

- Zakopane, geothermal consulting

#### Hungary

- MOL, 2-5 MW binary power plants
- Budapest, Fötav, district heating
- Altener II-EU

#### Slovakia

- Galanta, district heating
- 3 cities have joined a district heating development this summer



#### Enex is using abandoned Hungarian oil wells for ORC power plants.

In cooperation with MOL (Hungarian Oil & Gas Company) and Vulcan (Australian investment company) Enex is developing a project for a 2 – 5 MW<sub>e</sub> ORC power plant utilising abandoned oil wells. The Joint Venture contract was signed March 6th 2006.

This will be the first geothermal power plant in Hungary. The wells are ~3000 m deep providing geothermal fluid at a temperature of ~140 ℃

Risk mitigation through a GEF fund insurance (WB).

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- Phase 1 Flow test of one doublet
- Phase 2 Second doublet established and power plant constructed.
- Phase 3 Operation of the ORC plant with direct heat sales.
- Defined decision points between phases.
- Preparation of flow test has begun.



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#### Enex is utilising geothermal in Slovakia through project development.

3 companies have been founded in cooperation with local companies and towns in Slovakia for district heating purposes and 3 more are on the way.

The three established companies are:

Enex Sobrance Enex Trebisov Enex Vranov

If the sources allow electricity generation will be considered.

These development projects are on the first stages. Pre-feasibility studies have started.

#### Enex cooperates with DCM for development of 5 binary plants.

#### Cooperation with DCM (German investment fund) for the development of 5 binary plants in:

- Geretsried / Wolfratshausen

The binary plants are Combined Heat and Power 1 doublet with 5 MW<sub>e</sub> or 2 doublets with 10 MW<sub>e</sub>.

– Tutzing

The binary plant is Combined Heat and Power 1 doublet with 4,4 MW<sub>e</sub> or 2 doublets with 8,8 MW<sub>e</sub>.

- Kehl

Geological feasibility study received, no calculations regarding power plant.

#### **Options for 3 more concessions:**

- Polling
- Schäftlarn
- Starnberg

## **Binary Power Plant, El Salvador**

# Enex is currently constructing an ORC bottoming plant in Berlin, El Salvador.



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# **Binary Power Plant, El Salvador**

### Constructed under an EPCM contract with LaGeo SA de CV signed in El Salvador in May 2005.

Gross output: 9,3 MW<sub>e</sub> Guaranteed net power: 7,8 MW<sub>e</sub>



EL SALVADOR



# **The Location**

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Reservoir depth: 2000 – 2500 m

2 x 28 MW completed in 1999

A 40 MW addition (Berlin III) is currently being installed.

Final installed power 105.3  $MW_e$ 

# **Berlin Power Plant**



Aerial view of Berlín power plant in eastern El Salvador.

http://www.geothermal.org/articles.html

# **The Location**

# An existing platform

Brine from 2 separators (4 wells).

The two fluids are not to be mixed.







### Isopentane as working fluid.



## Heat Exchangers

### Evaporators:

- 2 pre-heaters in series and reboiler
- Unit 1: 221 kg/s at 22  $bar_a$ Unit 2: 79 kg/s at 11  $bar_a$

300 kg/s of 180 °C brine



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# Heat Exchangers

Recuperator: 2 units in series

Condenser: 2 units in parallel

All Heat Exchangers from Melter in Mexico.



# Turbine, gear and generator

Radial inflow turbine from GE Oil & Gas.

Turbine 6500 rpm

Generator from ABB



# **Cooling Tower**

Wet Cooling Tower of the counter flow type from CTDepot.

Two cells

Cools 4,122 M<sup>3</sup>/hr from 38.3 ℃ HWT to 28.3 ℃ CWT at a 23.9 ℃ IWBT with a pump head height of 7.0 M and a BkW/cell of 105.1.



MODEL CFD-364227-2I-28

# **Evolution of Building Architecture**

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### 2-D Layout



### 3-D Model ,

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# **Changes at Site in 2005**









# **Berlin ORC Plant**

# August 2006



# **Berlin ORC Plant**

# Heat exchangers put in place



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- 1. Extensive experience of geothermal harnessing and operation.
- 2. Concept design from Iceland in all Enex ORC plants.
- 3. Cost optimisation in utilisation of the geothermal reservoir.
- 4. Strong partners in all project development.
- 5. Modern architecture makes the power plant a tourist attraction, benefits the plants image and adds to staff satisfaction.





#### Thank you for your attention



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