

UNIVERSITY OF ICELAND The Kalina power plant in Husavik - why Kalina and what has been learned

Electricity generation from Enhanced Geothermal Systems 14.-16. September in Strasbourg



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Geothermal Dual Usage

- Electricity Generation
- Hot Water for Space Heating and:
 - Horticulture
 - Health and Fitness
 - Industrial
 - Thermophilic enzymes
 - Fish Farming
 - Tourist Attractions



Primary energy consumption in Iceland 1940-2003



The cycles

- Flash

 Bjarnarflag (backpressure), Nesjavellir

 Double flash

 Krafla, Svartsengi

 ORC

 Svartsengi

 Kalina
 - Husavik



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Table A.3 Geothermal power plants: by number of units for each type of plant.								
						Flash-		
Country	Dry Steam	1-Flash	2-Flash	3-Flash	Binary	Binary	Hybrid	Total
USA	27	3	28	1	117	10	1	187
Philippines	0	36	10	0	6	5	0	57
Mexico	0	29	5	0	3	0	0	37
Italy	31	1	0	0	1	0	0	33
New Zealand	1	2	9	4	3	14	0	33
Japan	1	16	3	0	2	0	0	22
Iceland	0	7	2	0	8	0	0	17
Indonesia	3	12	0	0	0	0	0	15
China	0	2	10	0	1	0	0	13
Guatemala	0	1	0	0	0	7	0	8
Kenya	0	5	0	0	1	2	0	8
Russia	0	8	0	0	0	0	0	8
Costa Rica	0	4	0	0	2	0	0	6
El Salvador	0	4	1	0	0	0	0	5
Azores	0	1	0	0	4	0	0	5
Nicaragua	0	2	0	0	2	0	0	4
Austria	0	0	0	0	2	0	0	2
Guadaloupe	0	0	2	0	0	0	0	2
Turkey	0	1	0	0	0	0	0	1
Australia	0	0	0	0	1	0	0	1
Germany	0	0	0	0	1	0	0	1
Papua	0	1	0	0	0	0	0	1
Thailand	0	0	0	0	1	0	0	1
Total	63	135	70	5	155	38	1	467
Percent of								
total	13,5%	28,9%	15,0%	1,1%	33,2%	8,1%	0,2%	100,0%

From DiPippo



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Degrees of freedom

- A binary power plant has around 25-30 design parameters for the thermal design
- The power plant design has to be optimized for each application
- The performance criteria have to be carefully selected





Efficiency and geothermal power

- Fixed mass flow
- Efficiency and effectiveness
- Efficiency alone is not a quality measure



Efficiencies

- Total efficiency
- Power plant thermal efficiency
- Effectiveness
 - Income is proportional to produced net power
 - Little cooling of the geothermal fluid means high power plant efficiency and low cooling efficiency
 - High power plant efficiency can result in low income!!!







Exergy flow







The cycles again...SF









Regeneration

- Serves to increase power if geothermal return temperature is limited
- Cycle without regeneration will have more power if there is not any temperature limit

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Steam vs ORC vs Kalina

- Steam requires high temperature and geothermal fluid separation
- Kalina is better fit for liquid water at lower temperatures
- ORC is better at moderate temperatures and partial steam



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Price comparison, ORC vs Kalina

- Turbine cost ORC higher, Kal lower
- Pressure class Kal higher; ORC lower
- Piping material Similar
- Piping dimensions ORC larger, Kal smaller
- Fluid safety measures Similar
- Heat exchanger area ORC larger, Kal smaller §
- Parasitic loss ???
- Process complexity ???



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Example

- Study of the technical possibilities
- No economic considerations
- No regeneration
- 150 kg/s geothermal water source
- 10 ℃ to 20 ℃ cooling water













VGK REKSTUR





In 2000 a 2 MWe binary plant started operation.

Uses 125 ℃ geothermal water, cooled to 80 ℃, then used for district heating.

Provides 80% of electrical demand of the town.

Húsavík







Total Well Concept

- Electricity
- Space Heating
- Industrial
- Recreational
- Health and Fitness
- Horticulture
- Fish Farming
- Tourist Attractions
- Molecular & Biochemical Research







Husavík – block diagram















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VGK REKSTUR

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Mayor problem areas

- Startup problems related to original design, especially separator
- A single water quality incident
- The much publicized turbine corrosion
- What else ???

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Experience

- Experience is obtained by making mistakes and learning from them
- Kalina 5 years experience
- ORC 20 years experience
- Steam 40 years experience





