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Implementing New Power Plant Technologies

Technical and Economic Aspects

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STATUS OF GEOTHERMAL ENERGY

- Installed base and potential: Geothermal is a mature competitive industry
- Geothermal has the lowest environmental impact
- Difference with and dependence on technology transfer from oil and gas drive the cost reduction in geothermal, exploration, drilling and production
- Continuous improvement in plant design: steam turbines, ORC and combined cycle



Environmental Features of Geothermal Energy

Comparison with Other Energy Sources

Land Area Occupied

*CO*₂ *Emissions*

Technology	Land area (m² per GWhr/year for 30 years)
Geothermal	1,000
Wind (land with turbines and roads)	1,500
Photovoltaics	3,500
Solar Thermal	4000
Coal (including open pit mining)	5000





Global Geothermal Installed Capacity & Potential (MW)



Geothermal - A Mature and Competitive Industry

Geothermal electricity	y production	Geothermal direct use	
Country	GWh/yr	Country	GWh/yr*
United States	16 603	China	20 932
Philippines	10 311	United States	15 710
Indonesia	9 600	Sweden	12 585
Mexico	7 047	Turkey	10 247
Italy	5 520	Japan	7 139
Iceland	4 597	Norway	7 000
New Zealand	4 055	Iceland	6 768
Japan	3 064	France	3 592
Kenya	1 430	Germany	3 546
El Salvador	1 422	Netherlands	2 972
Costa Rica	1 131	Italy	2 762
Turkey	490	Hungary	2 713
Papua New Guinea	450	New Zealand	2 654
Russia	441	Canada	2 465
Nicaragua	310	Finland	2 325

* 1 000 GWh = 3.6 PJ



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Typical Project Development Process

- Geothermal power plants provide dependable base load power
- Geothermal projects are site specific, complex, requiring high level of expertise in development and operation
 - "Every thing should be made as simple as possible, but not simpler"



Geothermal Power Plant Technologies

Conventional Steam Power Plant



Conventional steam power plant

- Widely used with medium steam pressure sources
- The condensate is used as cooling tower make up water
- Reinjection of only a part of the geothermal fluid to the reservoir
- Direct contact between geothermal steam and turbine components
- Visual impact of large structure and vapor plume
 Steam wetness limitation on high pressure
- Steam wetness limitation on high pressure resources
- Energy consumption for disposal of NCGs may be substantial



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Binary

Combined Cycle





Binary/Combined cycle power plant

- Used for liquid dominated and high pressure steam resources
- Mostly air-cooled, low visual impact, no chemical consumption
- All the geothermal fluid is reinjected in the reservoir
- No contact between the geo fluid and the binary turbine components
- Low wetness at the (back-pressure) steam turbine part of the combined cycle
- No energy consumed for disposal of NCG

Continuous Improvement of Power Plants



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84 MW Ormat plants at Steamboat NV supply electricity

to all households in Reno





Barriers of Financing in Developing Countries

- COMMERCIAL FINANCING: barriers due to relatively small sizes and high initial investment cost
- CREDIT ISSUES: barriers due to risks: political, resource and off-takers
- INSTITUTIONAL ISSUES: barriers due to fossil fuel subsidies, accounting for GHG emissions avoided, and societal costs of fossil fuels
- STRUCTURAL ISSUES: Need mechanisms enabling market entry of renewables under deregulated structures





24 MW Zunil Geothermal Power Plant, Guatemala



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Public – Private Partnerships

Key Points for Success

Risk Sharing

- Industry to underwrite risks in construction, performance, and operation
- MFI's and ECA's and national agencies to underwrite other risks: country, payment
- Resource development risks: if borne by private sector leads to expensive power

□ Financial institutions to seek innovative FAST TRACK solutions

- Streamline the review process avoid micro management
- One stop financing One lead agency to act as financing coordinator
- Innovative technologies should be welcomed (guaranteed by private sector)
- Resolve the internal competition in IFI's between public and private sector departments

National Policy Legislation: level the playing field

- Price should reflect value of environmental value of energy mix (WB Carbon Fund), base load dependability, price stability (no oil imports)
- Educate the stake-holders (important role for IEA-GIA, and UNEP)
- · Set asides for renewable energy technologies, e.g. RPS
- Adapt deregulation to renewables (merchant plant issue)



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