Geothermal Development in Central America

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WEST JAPAN ENGINEERING CONSULTANTS, INC.
Related Topics to Geothermal Energy in the Region

- Tectonic Plates in the Region
- Mesoamerican Trench
- Seismic Hazard Map in Central America
- Seismicity Map in Central America
- Volcanoes in Central America
- Central American Energy Inter-Connection
Stress Direction of Tectonic Plates
Mesoamerican Trench
Seismic Hazard Map in Central America (USGS)
Seismicity Map - 1900 to March 2012 in Central America (USGS)
Volcanoes in Central America
Línea SIEPAC, primer sistema de transmisión regional

<table>
<thead>
<tr>
<th>País</th>
<th>KMS</th>
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<tbody>
<tr>
<td>Guatemala</td>
<td>293</td>
</tr>
<tr>
<td>El Salvador</td>
<td>286</td>
</tr>
<tr>
<td>Honduras</td>
<td>269</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>307</td>
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<tr>
<td>Costa Rica</td>
<td>493</td>
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<tr>
<td>Panamá</td>
<td>150</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>1799</strong></td>
</tr>
</tbody>
</table>

300 MW de capacidad + 300 MW
28 bahías en 15 subestaciones
Cable OPGW de 36 fibras

Fuente: SIEPAC
Central American Countries

For each country:

- Geothermal Plants in Operation
- Future Geothermal Developments
- Identified Geothermal Areas
- West JEC’s Geothermal Work in the country
- Main Remarks
Panama

Current Geothermal Developments:
- There are no geothermal plants in operation

Future Geothermal Developments:
- Barú-Colorado Geothermal Area - Centram Geothermal Inc. (5 MW)

Identified Geothermal Areas:

West JEC’s Geothermal Work:

Main Remarks:
Empresa de Transmisión Eléctrica S.A.
Potencial Geotérmico

Área Barú-Cerro Colorado
Área Valle de Antón
Área Chitra Calobre
Área Isla de Coiba
Área Tonosi

Zona de Prefactibilidad Avanzada
Zona de Reconocimiento Geotérmico
Manifestaciones Térmicas
Barú-Colorado Geothermal Area
## Identified Geothermal Areas in Panama

<table>
<thead>
<tr>
<th>#</th>
<th>Geothermal Area</th>
<th>Estimated Potential (MW)</th>
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<tbody>
<tr>
<td>1</td>
<td>Barú-Colorado Area</td>
<td>24</td>
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<tr>
<td>2</td>
<td>Valle de Antón Area</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>Chitra-Calobre Area</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>Coiba Island</td>
<td>--</td>
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<tr>
<td>5</td>
<td>Tonosí</td>
<td>--</td>
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</tbody>
</table>
West JEC’s participation in Panamá

- 1997-1998, Feasibility Study for Valle de Antón, IDB.
- August 2006, under the program “Puebla-Panamá-Plan” (PPP) West JEC carried out an estimation of the geothermal potential of two geothermal areas (Barú-Colorado & Valle de Antón áreas). The study was financed by the Japan Bank for International Cooperation (J BIC).
Main Remarks in Panama

- There are no geothermal plants operating in Panama.
- In Barú-Colorado Geothermal área, Centram Geothermal Inc. plans to make a development of 5 MW.
- The government is preparing the Terms of Reference to carry out a study; to better identify their geothermal potential as well as a pre-feasibility study for one geothermal area.
- Not much further development is planned in Panama.
Costa Rica
Costa Rica

- **Geothermal Plants in Operation:**
  - **Las Pailas**, 35 MW-ICE: Unit 1 (35 MW, 2011)

- **Future Geothermal Developments:**
  - **Las Pailas-ICE:** Unit 2 (55 MW, 2019)
  - **Borinquen-ICE:** Unit 1 (55 MW, 2023)
  - **Borinquen-ICE:** Unit 2 (55 MW, 2024)
Miravalles: Units 1 & 2
Miravalles: WHU-1
Miravalles: WHU-2
Miravalles: Unit 3
Miravalles: Unit 5 (Binary Plant)
Las Pailas: Unit 1
Las Pailas: Unit 1
Las Pailas: Unit 2 (plant site)
Borinquen: Unit 1
<table>
<thead>
<tr>
<th>Zona (Volcán)</th>
<th>1 (flash)</th>
<th>2 (flash)</th>
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<tr>
<td>Miravalles</td>
<td>164</td>
<td>213</td>
</tr>
<tr>
<td>Rincón de la Vieja</td>
<td>137</td>
<td>177</td>
</tr>
<tr>
<td>Irazú Turrialba</td>
<td>101</td>
<td>130</td>
</tr>
<tr>
<td>Tenorio</td>
<td>97</td>
<td>123</td>
</tr>
<tr>
<td>Platanar</td>
<td>97</td>
<td>122</td>
</tr>
<tr>
<td>Poás</td>
<td>90</td>
<td>116</td>
</tr>
<tr>
<td>Barva</td>
<td>85</td>
<td>109</td>
</tr>
<tr>
<td>Fortuna</td>
<td>61</td>
<td>77</td>
</tr>
<tr>
<td>Orosí-Cacao</td>
<td>33</td>
<td>41</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>865 (564)</strong></td>
<td><strong>1108 (718)</strong></td>
</tr>
</tbody>
</table>
West JEC’s participation in Costa Rica

- **Miravalles Geothermal Field:**
  - 1984, Study to Finance Unit 1 (55 MW), OECF
  - 1986-1994, Unit 1 (55 MW), Owner Engineer for Construction and Commissioning, ICE-OECF

- **Las Pailas Geothermal Field:**
  - 2003-2005, Feasibility Study for Unit 1, under PPP, JBIC
  - 2009-2011, Reservoir Study for Unit 1, BCIE
  - 2011-2012, Feasibility Study for Unit 2, JICA
  - 2014, Consulting Services for Unit 1, JICA

- **Borinquen Geothermal Field:**
  - 2011-2012, Feasibility Study for Units 1 & 2, JICA
Main Remarks in Costa Rica

- The geothermal installed capacity (GIC) is now 198 MW, but it will be increased by 165 MW in the coming years, and therefore, the GIC will be 363 MW by 2023-2024.

- The Costa Rican Institute of Electricity has and will continue carrying out the development in the country.

- All the geothermal development has been done through “soft loans” with major banks such as the International Development Bank (IDB), Japan International Cooperation Agency (JICA), Central American Bank of Economic Integration (CABEI) and the European Bank of Investments (EBI).

- Las Pailas Unit 2 project has already started: all the drilling platforms are ready, 2 production and 2 injection wells have been already drilled, the site for the plant has been prepared.
Main Remarks in Costa Rica

- Up to now, laws do not allow geothermal developments inside National Parks
- Currently the geothermal installed capacity is 198 MW
- There are no geothermal concessions in Costa Rica
- There are some more identified geothermal areas
- ICE has already raised financing (JICA, EBI) for the next geothermal developments:
  - Las Pailas, Unit-2 (55 MW), 2019
  - Borinquen, Unit-1 (55 MW), 2023
  - Borinquen, Unit-2 (55 MW), 2024
Nicaragua

- Geothermal Plants in Operation:
    - Units 1 & 2 (35 MW each, 1983, 1989) and Binary Plant (7.5 MW, 2002)
  - San Jacinto-Tizate: Ram Power Corporation, 76 MW (2005-2013)
    - WHU 1& 2 (5 MW each, 2005-2011), Unit 1 (36 MW, 2012), Unit 2 (36 MW, 2013)

- Future Geothermal Developments (Concessions):
  - Casita-San Cristobal: Cerro Colorado Power (RAM Power Corporation, 225 MW)
  - Managua-Chiltepe: Alba Geotermia (ALBANISA, 111.5 MW)
  - El Hoyo-Monte Galán: Geotérmica Nicaragüense (GEONICA, 159 MW)
Momotombo Volcano
Cooling Tower 2 in Momotombo, Photo by Melvin Vargas, El Nuevo Diario
San Jacinto-Tizate Geothermal Plant,
Photo by Otto Mejía, 2012
## Identified Geothermal Areas in Nicaragua

<table>
<thead>
<tr>
<th>#</th>
<th>Geothermal Area</th>
<th>Estimated Potential (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Volcán Cosigüina</td>
<td>106</td>
</tr>
<tr>
<td>2</td>
<td>Volcán Telica-El Ñajo</td>
<td>78</td>
</tr>
<tr>
<td>3</td>
<td>Tipitapa</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Caldera de Masaya</td>
<td>99,5</td>
</tr>
<tr>
<td>5</td>
<td>Caldera de Apoyo</td>
<td>153</td>
</tr>
<tr>
<td>6</td>
<td>Volcán Mombachó</td>
<td>111</td>
</tr>
<tr>
<td>7</td>
<td>Isla Ometepe</td>
<td>146</td>
</tr>
</tbody>
</table>
West JEC’s participation in Nicaragua

- 2000, together with GeothermEx, Study of the Geological Samples, PPP,
- 2013, Study of the Geothermal Situation in Nicaragua, JICA
Main Remarks in Nicaragua

- The Geothermal Installed Capacity is now 153.5 MW
- The initial geothermal development was done by the government through soft loans
- Currently two private companies run the plants in each geothermal field under operation:
  - Momotombo: Momotombo Power Company
  - San Jacinto-Tizate: RAM Power Corporation
- There are already three concessions given to private companies to develop new geothermal areas
Main Remarks in Nicaragua

- Besides that, there are already 7 additional identified geothermal areas.
- Government seeks private investors to develop and invest in their geothermal areas through concessions.
- Government also looks for risk-mitigation schemes during the drilling stage.
El Salvador

Geothermal Plants in Operation:
- Ahuachapán-LaGeo-95 MW (1975-1981), Unit 1 (1975), Unit 2 (1976), 30 MW each, and Unit 3 (1981), 35 MW
- Berlín-10 MW (1992-1999) WHU
- Berlín-109.4 MW (1999-2009), Units 1 & 2 (56.2 MW, 1999), Unit 3 (44 MW, 2007), Binary Unit (9.2 MW, 2009)

Future Geothermal Developments:
- Chinameca-LaGeo (40 MW)
- San Vicente-LaGeo (30 MW)
Ahuachapán Geothermal Units
Berlín Binary Plant
## Identified Geothermal Areas in El Salvador

<table>
<thead>
<tr>
<th>#</th>
<th>Geothermal Area</th>
<th>Estimated Potential (MW)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Caluco</td>
<td>15</td>
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<tr>
<td>2</td>
<td>Coatepeque</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>Chambala</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>Chilanguera</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>Olomeca</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>Conchagua</td>
<td>13</td>
</tr>
</tbody>
</table>
West JEC’s participation in El Salvador

- 1990, Ahuachapán Rehabilitation Study, ECFA
- 2000-2002, Study to analyze the participation as a Strategic Partner of GESAL for Kyushu Electric Power Co.
- 2001, CSAMT-MT Study in Berlín, GESAL
Main Remarks in El Salvador

- The installed capacity in the country is 204.4 MW
- The initial geothermal development was done by the government through soft loans
- In 1999, the government of El Salvador created LaGeo to be in charge of the geothermal development of the country
- In 2002, LaGeo found a partner (ENEL Green Power, Italy) to develop the geothermal energy in and out of El Salvador
Main Remarks in El Salvador

- Ahuachapán & Berlín Power Plants in operation by LaGeo
- Chinameca & San Vicente concessions were given to LaGeo
- There is an International Legal Dispute between the Government of El Salvador and ENEL Green Power (Italy), which has paralyzed the development of 4 geothermal fields since 2008.
- 3 International Courts have indicated that ENEL is correct, but there is still an Arbitration going on in CIADI
PARIS SUPREME COURT IN FAVOUR OF ENEL GREEN POWER IN EL SALVADOR “LAGEO” CASE

18/09/2014

Appeal ruling confirmed on the joint venture with Inversiones Energeticas (INE) for the development of geothermal energy in El Salvador

Rome, September 18th, 2014 – The French Supreme Court (“Cour de Cassation”) denied the appeal filed in 2013 by Inversiones Energéticas, S.A. de C.V. (INE) and by the Comisión Ejecutiva Hidroeléctrica del Río Lempa (CEL), challenging the decision of the Court of Appeals that upheld the ruling of the Court of Arbitration, made in accordance with the rules of the International Chamber of Commerce (ICC), concerning investments in LaGeo S.A. de C.V. (LaGeo), the joint venture between Enel Green Power S.p.A. and INE for geothermal development in El Salvador.

This decision therefore makes the Arbitration Court ruling issued in 2011 definitive. The arbitration ruling recognised the right of Enel Green Power S.p.A. to increase, through the investments it executed, its equity stake in El Salvador’s company “LaGeo”, through the subscription of new shares in the joint venture.
Honduras

- Current Geothermal Developments:
  - There are no geothermal plants in operation

- Next New Geothermal Developments:
  - Platanares:

- Identified Geothermal Areas:

- West JEC’s Geothermal Work:

- Main Remarks:
Platanares:
- Reservoir appraisal began in August 2014
- One geothermal well already drilled with good results
- Drilling commercial wells to obtain about 18 MW (2016)
- Monitor the reservoir for a year
- If good results, additional wells to obtain 17 MW
- Total, 35 MW by 2017
- Ormat will operate the Project under a BOT structure for 15 years, including the project's wells, land, permits and a Power Purchase Agreement for up to 35 MW with ENEE, the national utility of Honduras
- Expected COD within 3 years
Geothermal Commercial Well in Platanarres Field
**Identified Geothermal Areas in Honduras**

<table>
<thead>
<tr>
<th>#</th>
<th>Geothermal Area</th>
<th>Estimated Potential (MW)</th>
<th>Concession to</th>
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<tr>
<td>1</td>
<td>Azacualpa</td>
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<td>2</td>
<td>Pavana</td>
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<td>GeoPower</td>
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<td>3</td>
<td>Sambo Creek</td>
<td>15</td>
<td>GeoPower</td>
</tr>
<tr>
<td>4</td>
<td>San Ignacio</td>
<td>20</td>
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Slim hole in Azacualpa, Photo by C. García, 2011
Pavana Geothermal Area,
Photo by R. Gómez, 2007
West JEC’s participation in Honduras

- 2013, Study on the geothermal situation in Honduras and the Caribbean Islands, SWG-METI
Main Remarks in Honduras

- There are no geothermal plants in operation
- Private companies are in charge of developing the geothermal resources in Honduras
- Azacualpa & Pavana concessions have been given to GeoPower
- Platanares Geothermal Field is being developed by Ormat, BOT for 15 years
- Geothermal commercial wells are being drilled
- A 18 MW plant is expected by 2016
- A 17 MW plant is expected by 2017
Guatemala

Geothermal Plants in Operation:

- Zunil-1, Orzunil (7 x 4.5 MW = 31.5 MW, 1999-2034), (25 + 10) 35 years, BOT
- Amatitlán, Ingenieros Civiles Asociados (5 MW, 1998-2001)
- Amatitlán, INDE, (5 MW, 2002-2006)
- Amatitlán, Ortílán (22 MW, 2007-2027), 20 years, BOT

Future Geothermal Developments:

- Zunil-2 (50 MW), INDE, Pre-feasibility Study
Zunil-1 and Amatitlán
Zunil-1 Geothermal Plant
Amatitlán Geothermal Plant
Identified Geothermal Areas in Guatemala

<table>
<thead>
<tr>
<th>#</th>
<th>Geothermal Area</th>
<th>Estimated Potential (MW)</th>
<th>Concessions</th>
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<tbody>
<tr>
<td>1</td>
<td>Tecuamburro</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>San Marcos</td>
<td>24</td>
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<tr>
<td>3</td>
<td>Moyuta</td>
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<tr>
<td>4</td>
<td>Joaquina</td>
<td>--</td>
<td>Centram Geothermal Inc.</td>
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<td>Atitlán</td>
<td>--</td>
<td>Centram Geothermal Inc.</td>
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<td>Gloria</td>
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<td>Recursos del Golfo, S. A.</td>
</tr>
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<td>7</td>
<td>La Chinita</td>
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<td>Recursos del Golfo, S. A.</td>
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West JEC’s participation in Guatemala

1989-1994, Pre-feasibility Studies for Zunil-II and Feasibility Study for Amatitlán, BID-INDE
2000-2002, Advanced Feasibility Study for Amatitlán, JICA
2006, Reservoir Studies in Amatitlán, Ormat
2006, Tecuamburro Pre-feasibility Study, JETRO
2012, Actualization Geothermal Study in Guatemala, JICA
Main Remarks in Guatemala

- The initial geothermal development was done by the government through soft loans.

- There are two geothermal plants in operation:
  - Zunil (31.5 MW since 1999-2034) (25+10 years), BOT
  - Amatitlán (22 MW since 2007-2027) (20 years), BOT

- The total installed capacity is 53.5 MW.

- Ormat operates the two geothermal fields in Guatemala.

- Zunil-2 could not be developed due to social problems with the neighbors.

- A new study by INDE is being set up to continue the studies in Zunil-2 (JICA).
Final Remark

West J EC:

- 2003-2005, Regional Geothermal Study for the Puebla-Panamá-Plan (PPP) for all the countries, JBIC
- 2007-2014, Annual Geothermal Technical Courses for Latin America, JICA