

## Wellhead Geothermal Power Plant at Eburru, Kenya

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### Keywords

*Eburru, Kenya, Kenya Electricity Generating Company, KenGen, Geothermal, Geothermal Development Associates, GDA, Elliott Company, small-scale, wellhead, geothermal plant, power generation*

### ABSTRACT

Geothermal Development Associates (GDA) provided engineering and major equipment to the Kenya Electricity Generating Company (KenGen) for a modular 2.4 MW geothermal wellhead plant for a project located at Eburru, Kenya. The plant was constructed by Civicon Limited under a separate contract with KenGen. Commissioning took place in January 2012, and plant output exceeded expectations. GDA provided construction support, start-up and commissioning supervision, and training for KenGen personnel. The project represents a successful application of the geothermal wellhead plant concept.

### I. Overview

Geothermal Development Associates (GDA), based in Reno, Nevada, USA, responded to an international tender issued by the Kenya Electricity Generating Company (KenGen) for the engineering design, supply of major equipment, supply of materials, and commissioning of a 2.4 MW wellhead geothermal power plant at Eburru, Kenya. GDA was awarded an Engineering and Procurement (EP) contract to provide the design, equipment, and piping materials for the project. Civicon Limited, a Kenyan general contractor selected by KenGen under a separate tendering process, constructed the plant and installed GDA's equipment.

The Eburru geothermal site is located in Kenya's Rift Valley approximately 140 km northwest of Nairobi, on the flanks of the Ol Doinyo Eburru Volcano, 11 km northwest of Lake Naivasha. Twenty years ago KenGen drilled six geothermal exploration wells to an average depth of 2.5 km. One of these wells has a bottom hole temperature of 270°C and serves as the production well for

the project. The Eburru site is thought to have the potential to support up to 30 MW of geothermal power.

KenGen is the main electric power generation company in Kenya, producing about 80 percent of the electricity consumed in the country. The company utilizes various sources to generate electricity, including hydro, geothermal, fossil-thermal and wind.

Currently, the installed geothermal capacity operating in Kenya is 212 MW, representing 16% of the total power generated. Of this, 150 MW is owned and operated by KenGen. KenGen is principally a government-owned company, with a workforce of approximately 1,500 people that manage and operate its power generation facilities.

### II. GDA Engineering and Procurement (EP)

The plant design conditions are presented below:

Turbine Steam Flow	21,100 kg/hr
Non-Condensable Gas	1.5% by weight
Turbine Inlet Pressure	585 kPa (abs)
Condenser Pressure	10 kPa (abs)
Gross Generator Output	2,400 kW

The process is a typical single-flash condensing steam cycle with a separator pressure of about 6.0 bar (abs). Steam from the wellhead separator is conveyed to the turbine generator set to produce 2.4 MW gross and approximately 2.25 MW net. Steam exhausting from the turbine is condensed in a direct contact condenser and heat is rejected in a counterflow fiberglass cooling tower. Figure 1, overleaf, presents a simple process diagram.

The only significant variation from the typical single-flash arrangement is the gas extraction system arrangement. Due to the relatively low non-condensable gas content, and the 2,600 m elevation of the project, only a single-stage of gas extraction using a liquid ring vacuum pump (LRVP) was required.

GDA provided the following engineering services for the project:

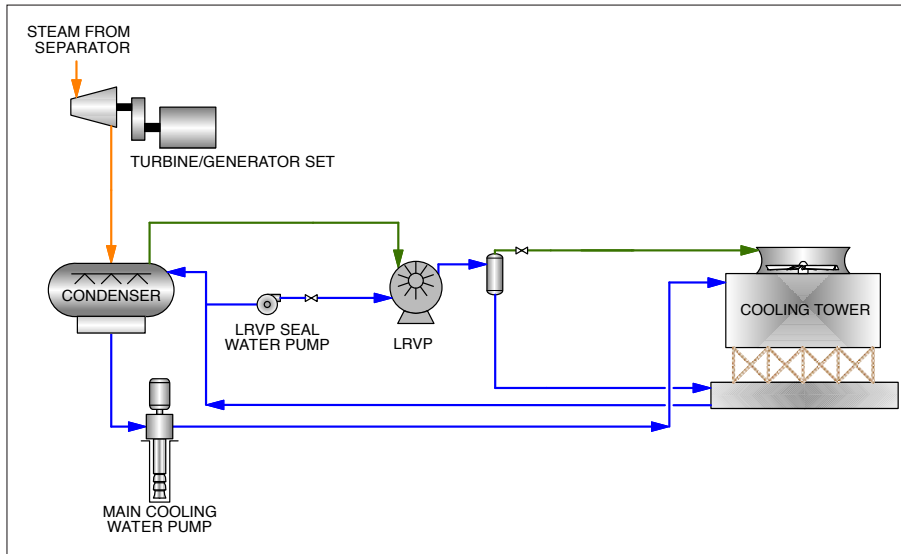


Figure 1. Eburru Single Flash Condensing Plant Process Diagram.

- field-erected fiberglass cooling tower designed and supplied by Cooling Tower Depot
- wellhead separator
- main switchgear manufactured by Schnieder Electric
- motor controls manufactured in Kenya by PowerTechnics
- generator step-up and station service transformers manufactured by Cooper Power
- plant control system designed and manufactured by GDA

In addition to the major process equipment described above, GDA provided auxiliary systems and equipment including:

- fire pump skid and fire detection and alarm system
- uninterruptable power system (UPS)
- compressed air system
- piping materials for cooling water, steam, and fire protection
- remote monitoring system by radio link to the Olkaria II geothermal power station

- process design
- site survey and geotechnical testing
- drawings and specifications, including
  - foundation design
  - steamfield design
  - piping design
  - guide specifications for power shelter for design-build
  - utility system design
- bills of quantities in support of installation tendering

Major equipment supplied by GDA included the following:

- turbine generator set and auxiliaries
  - 8-stage, axial flow turbine manufactured by the Elliott Company, Jeanette, PA, specifically for geothermal service
  - brushless synchronous air-cooled generator manufactured by Kato Engineering, Mankato, MN
  - parallel shaft speed reduction gear manufactured by Lufkin Industries, Lufkin, TX.
  - lubrication system designed and manufactured by GDA
  - inlet steam control valve system designed and manufactured by GDA
- direct contact condenser manufactured by Graham Manufacturing
- LRVP manufactured by Graham Manufacturing
- vertical turbine can-type cooling water pump manufactured by Goulds Pump

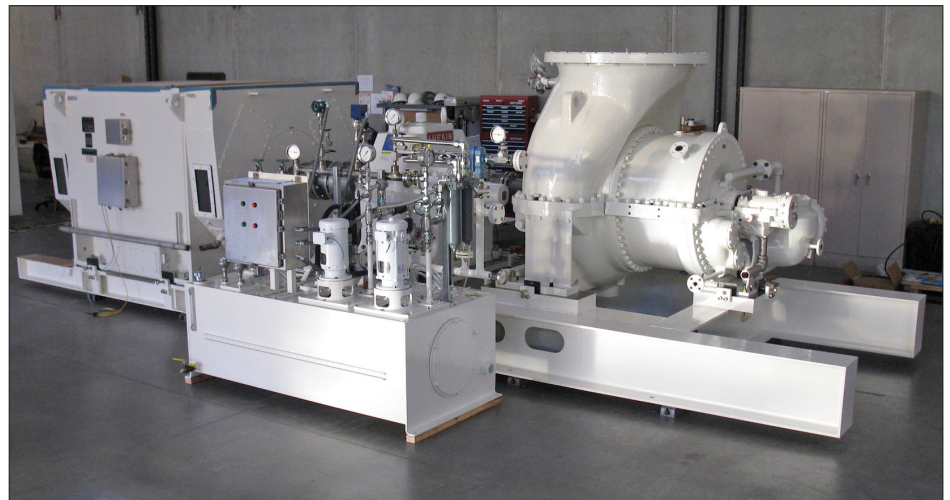


Figure 2. Turbine Generator Set and Lube Oil Console.

### III. Construction and Commissioning

GDA provided construction support to ensure compliance with the plans and specifications. When the plant was substantially complete, GDA supervised the cold checks, hot checks, start-up and commissioning of the plant. From turbine roll to passing the performance test took only seven days. The gross output of the plant was over 2,500 kW, which exceeded expectations.

#### Training

In August 2010, GDA provided training for KenGen representatives at its Reno facility during the manufacturing stage of



**Figure 3.** Production Well, Separator, and Rock Muffler.



**Figure 4.** Power Shelter with T/G Set, Condenser, LRVP, and Main Cooling Water Pump.

the project. This included classroom presentations by a number of GDA's OEM suppliers. KenGen personnel were also able to observe testing of the equipment manufactured by GDA.

The training at GDA focused on operation and maintenance of the following:

- lube oil console
- compressed air system
- fire pump system



**Figure 5.** Condenser and Single-Cell Cooling Tower.

- control valves
- remote control panel
- emergency power system
- process design and modeling

GDA coordinated for training of KenGen engineers at OEM factories, including the turbine, condenser and LRVP, and the generator. During start-up and commissioning, GDA provided training of engineers, operators and maintenance personnel.



**Figure 6.** Training of KenGen Personnel at GDA's Reno Facility

#### **IV. Geothermal Wellhead Power Generation Units**

The application of modular wellhead units during development of geothermal power projects can yield important benefits.

Wellhead power generation units can be used for the following purposes:

- power generation to the grid during resource development of a large project
- power in support of drilling activities during resource development for a large project
- utilization of wells deemed non-commercial for large projects, but still have small-scale application potential

Characteristics of wellhead power generator units can include:

- standardized design and construction
- portability to be relocated to newly-drilled wells
- simplicity of installation, operation and maintenance
- high reliability
- low operating cost

GDA supplied a similar modular plant to the Oserian Development Company, Naivasha in June 2007. This plant was based around a similar turbine-generator set but was a non-condensing application. These types of plants have the advantages of opti-

mizing on simplicity and cost, and are the most portable type of wellhead plant.

#### **V. Conclusion**

The Eburru project is an excellent example of the potential for applying wellhead geothermal power plants for economic advantage. It demonstrates that a small, single-flash, condensing geothermal power plant can be a viable alternative to other technologies, such as binary, for medium to high enthalpy geothermal resources in a small-scale application. Simplicity results in a short time frame for design, shipment, and start-up of such a plant.

The project also demonstrates that the initial wells drilled as part of a large plant development effort may be put to use generating power in the short term. During operation of the wellhead units, reservoir productivity may be assessed through monitoring over time, which will provide important data regarding the long-term potential of the resource. Small-scale wellhead plant projects can also be very beneficial as a way to catalyze political support for larger geothermal projects.

#### **VI. References**

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