Introduction

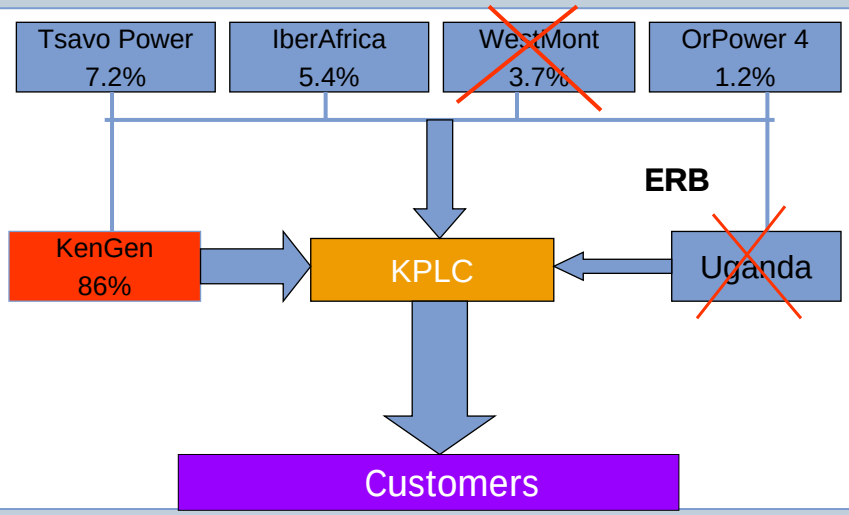
KenGen

- Kenya relies on three major sources of energy.
  - Biomass -68 %
  - Petroleum - 22 %
  - Electricity -9 %
- In the Electricity sub-sector
  - Hydropower - 57 %
  - Thermal - 32 %
  - Geothermal - 11 %
  - Other forms of renewable energy (wind, solar, biogas, micro hydro etc) - 1 %

2

Power Industry Players

KenGen



3

Installed and effective capacities

KenGen

		INSTALLED	EFFECTIVE	SHARE (% Effective)
KenGen	Hydro	677.28	641	62%
	Geothermal	115	115	11%
	Thermal	214.2	133	13%
IPPs	Geothermal	13	13	1%
	Thermal	174	132	13%
UETC	Imports	30	0	0%
	TOTAL	1223.48	1034	

- Current Peak demand 920 MW

4

Power Demand

KenGen

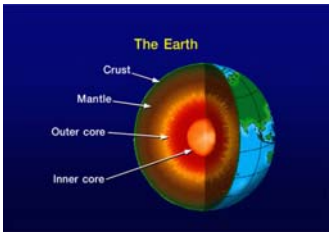
- Only 15.3% of Kenyans have access to electricity.
- Therefore there is vast potential for load growth.
- LCDP 2005-2025
- Assumption sales growth 5%, 6.5% and 6%
- The current load growth is about 8%

5

What is Geothermal Energy?

KenGen

- It is Heat from the earth



6

Occurences

KenGen

- Mountains form where hot rocks erupt to the surface.

7

Manifestations

KenGen

8

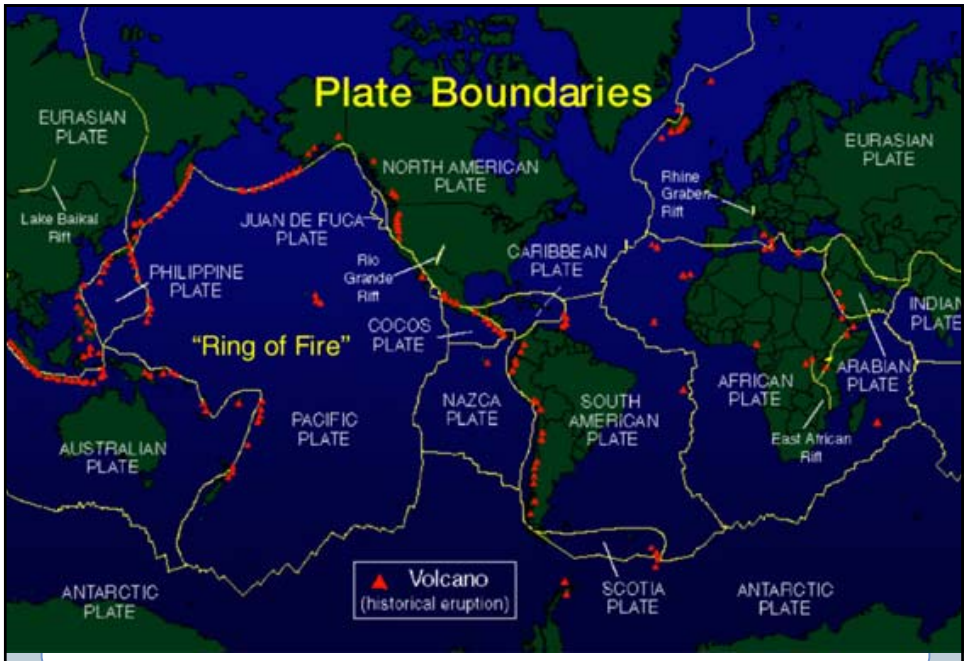
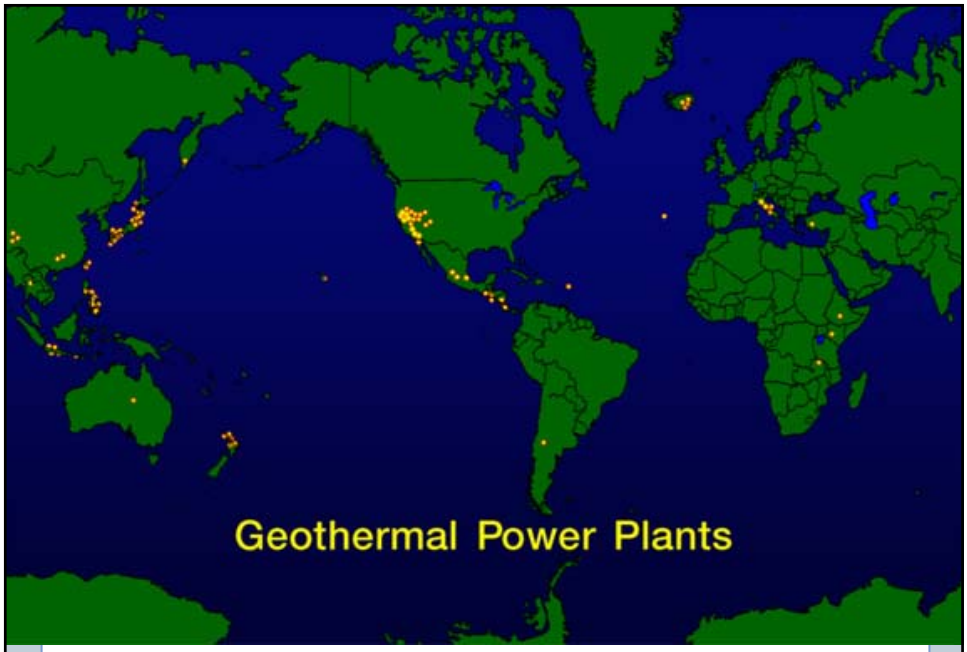
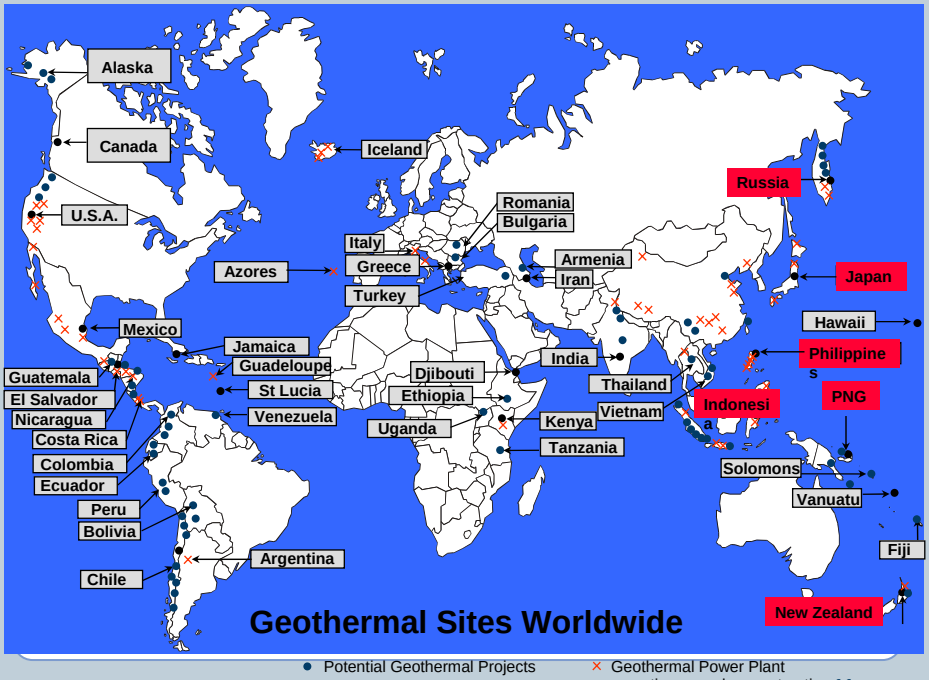


Plate Boundaries
EURASIAN PLATE
Lake Baikal Rift
NORTH AMERICAN PLATE
JUAN DE FUCA PLATE
PHILIPPINE PLATE
Rio Grande Rift
CARIBBEAN PLATE
Rhine Graben Rift
EURASIAN PLATE
INDIAN PLATE
"Ring of Fire"
COCOS PLATE
ARABIAN PLATE
AFRICAN PLATE
NAZCA PLATE
SOUTH AMERICAN PLATE
PACIFIC PLATE
AUSTRALIAN PLATE
East African Rift
Volcano
(historical eruption)
ANTARCTIC PLATE
SCOTIA PLATE
ANTARCTIC PLATE

9


Geothermal Power Plants

10



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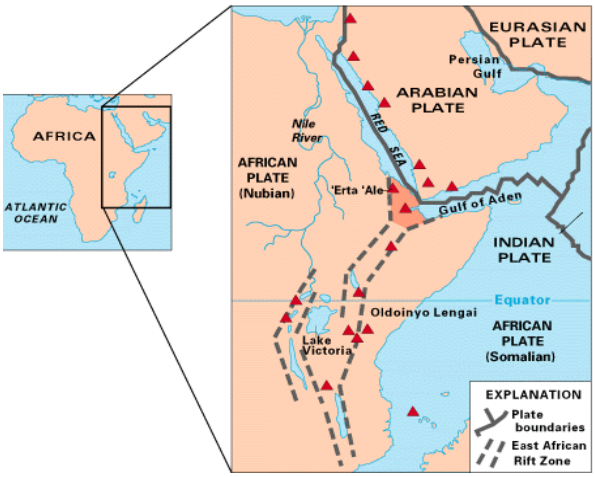
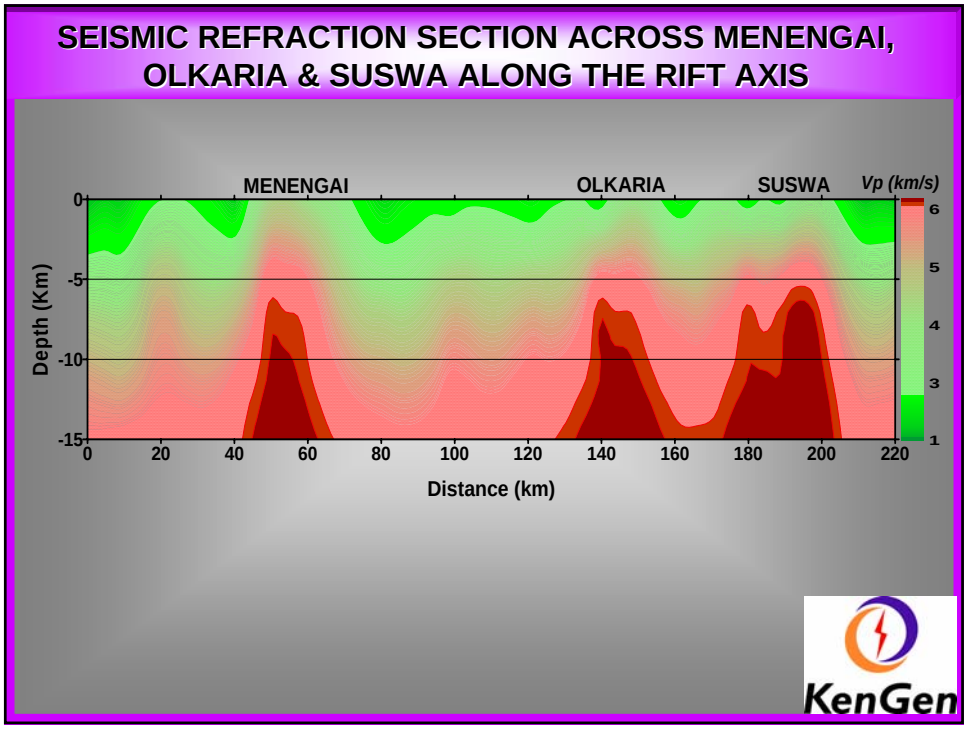
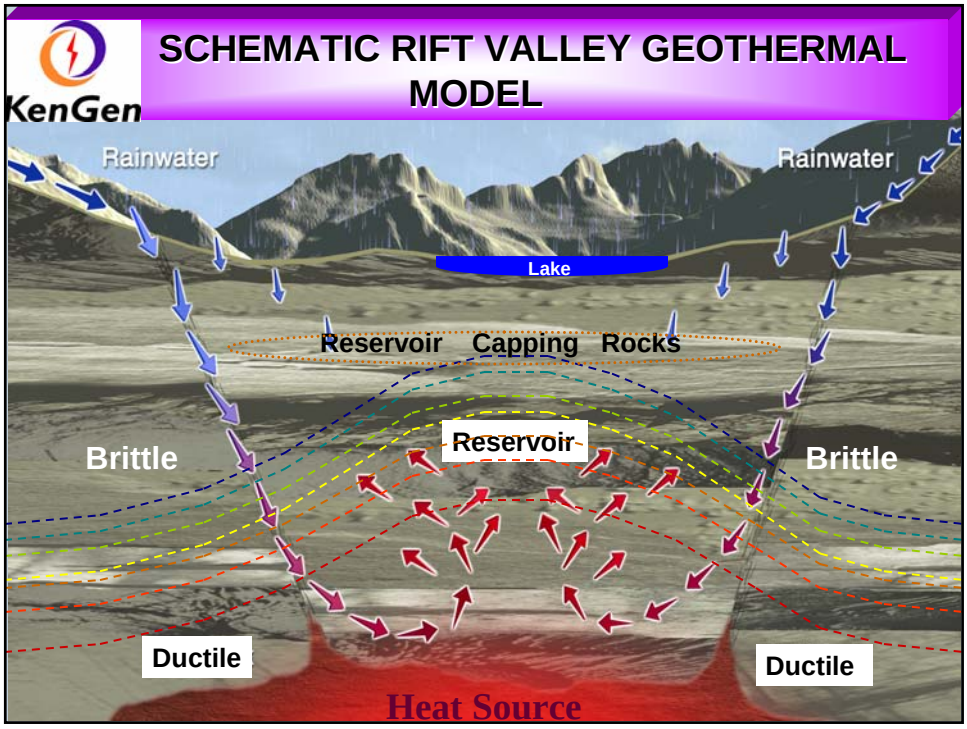
Geothermal Resources in Africa

KenGen

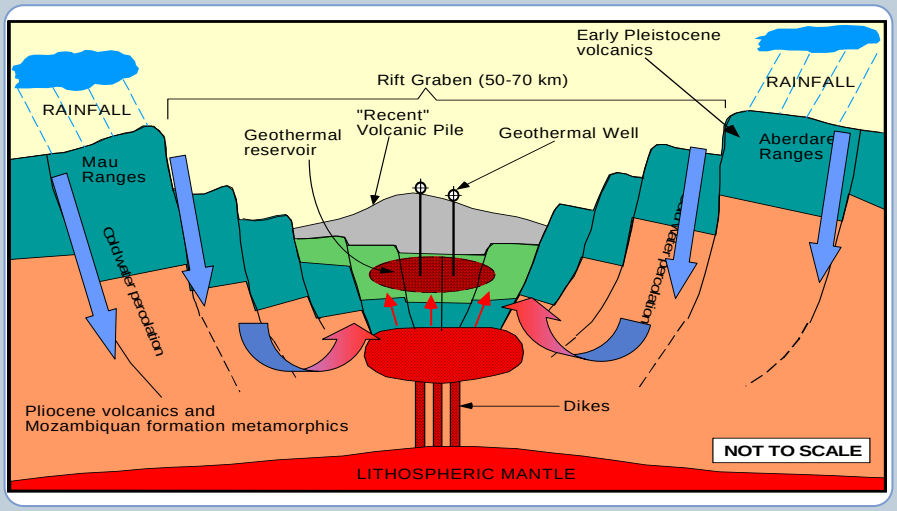


12


SEISMIC REFRACTION SECTION ACROSS MENENGAI, OLKARIA & SUSWA ALONG THE RIFT AXIS
MENENGAI
OLKARIA
SUSWA
Vp (km/s)
Depth (Km)
0
-5
-10
-15
0
20
40
60
80
100
120
140
160
180
200
220
Distance (km)
6
5
4
3
1
KenGen


KenGen
SCHEMATIC RIFT VALLEY GEOTHERMAL MODEL
Rainwater
Rainwater
Lake
Reservoir
Capping
Rocks
Reservoir
Brittle
Brittle
Ductile
Ductile
Heat Source

Rift Geothermal Model



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World's Geothermal Producers

	COUNTRY	1995	2000	2005
1	USA	2816.7	2228	2534
2	Philippines	1227	1909	1931
3	Italy	631.7	785	790
4	Mexico	753	755	953
5	Indonesia	309.75	589.5	797
6	Japan	413.7	546.9	535
7	New Zealand	286	437	435
8	Iceland	50	170	202
9	El Salvado	105	161	151
10	Costa Rica	55	142.5	163
11	Nicaragua	70	70	77

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World's Geothermal Producers

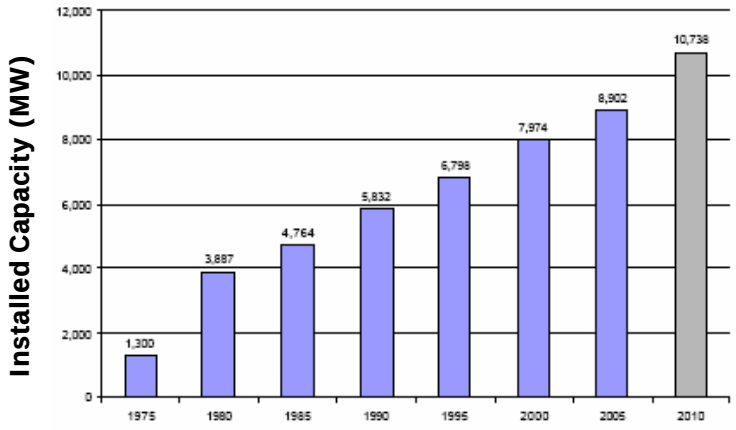
KenGen

	COUNTRY	1995	2000	2005
12	Kenya	45	57	129
13	Guatemala	0	33.4	33
14	China	29	29	28
15	Russia	11	23	79
16	Turkey	20.4	20.4	20
17	Portugal	5	16	16
18	Ethiopia	0	8.5	8.5
19	France	4.2	4.2	15
20	Thai Land	0.3	0.3	0.3
21	Australia	0.17	0.17	1
22	Papua New G	0.67	0	6
	Total	**6833**	**7982**	**8904**

17

World installed capacity forecast

KenGen



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Geothermal Development process

KenGen

- Exploration
- Drilling (2000 -3000m)
- Well testing
- Feasibility studies/EIA
- Power station Construction

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Field and Environmental Management

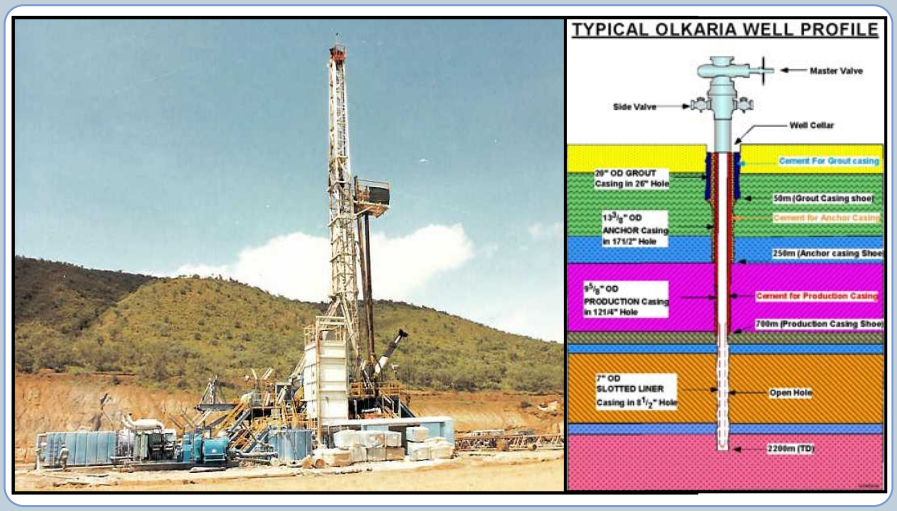
KenGen

- Make up wells
- Reservoir monitoring
- Reinjection.
- Rehabilitation.
- Friendly designs.
- Wise use of lake water.

20

Drilling Rig & Typical Well Profile

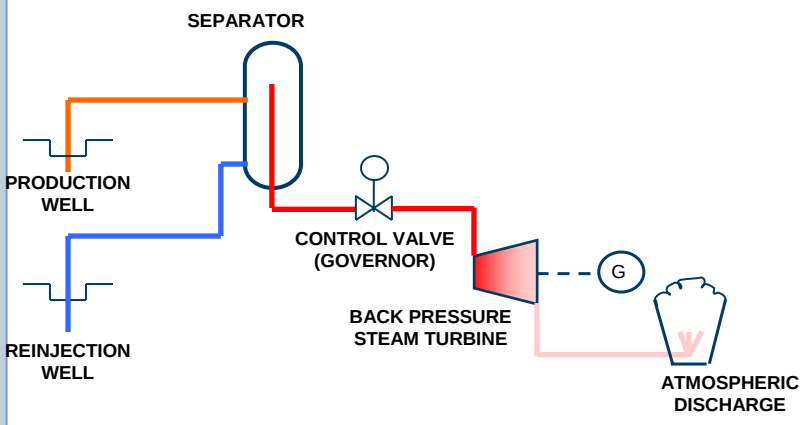
KenGen



21

Back-Pressure Steam Turbine

KenGen



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Back-Pressure Steam Turbine

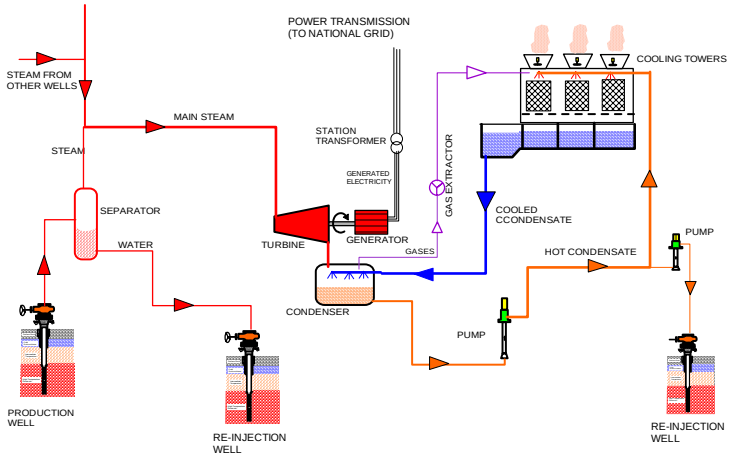
KenGen

5MW Back Pressure Power Plant, Los Azufres, Mexico

23

Conventional Steam Plant

KenGen

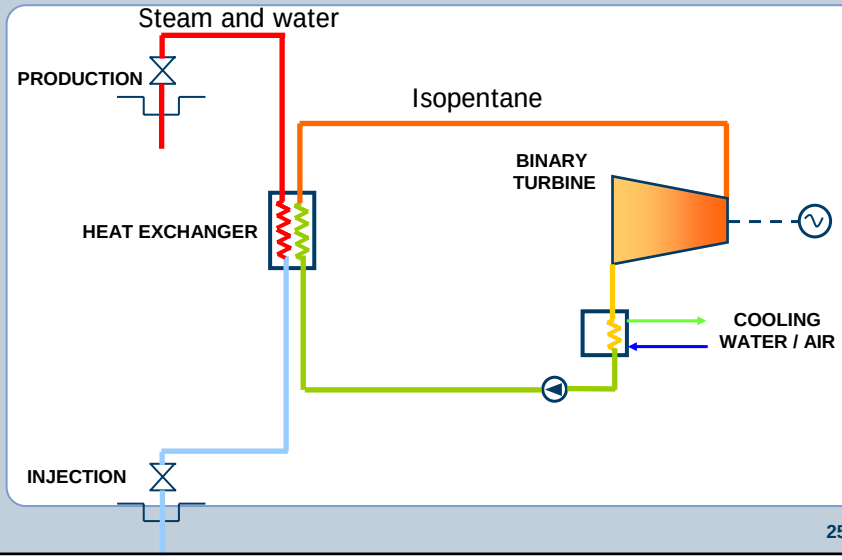


FLOW DIAGRAM

24

Simple Binary Cycle

KenGen



25

Kapisya binary plant (160kW)

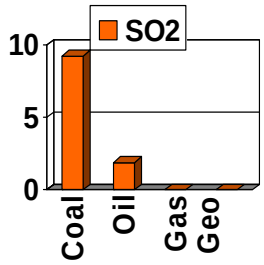
KenGen

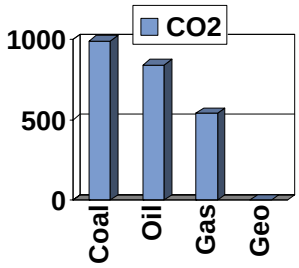
26

Geothermal and the Environment 1

KenGen

- Geothermal energy is clean energy and renewable
- Geothermal power stations emit less greenhouse gases compared to other sources of energy





Emissions (kg/MWhr). From Reed and Renner, 1995

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Geothermal and the Environment 2

KenGen

- Environmental Impact Assessment
- Careful Design
- Rehabilitation
- Reinjection
- Monitoring and mitigation

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The Olkaria Geothermal Field

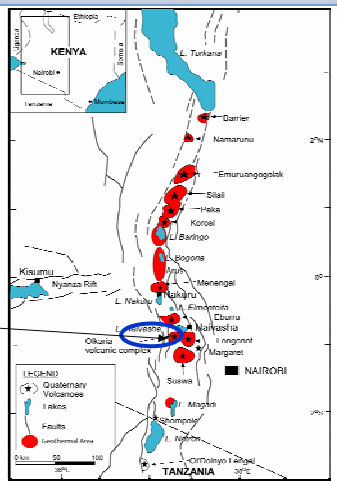
KenGen

- The Greater Olkaria geothermal area is about 80 km$^{2.}$
- It has been divided into seven sectors for ease of development.
- Currently, 129 MWe is generated from the field.
- Olkaria Domes field, the 4th sector to be considered for development, has 3 exploration wells drilled.

29

Kenya's geothermal prospects

KenGen



Olkaria

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Kenya's Geothermal Potential

KenGen

- Kenya's Geothermal potential exceeding 2000MW
- The economic hydro sites have largely been developed

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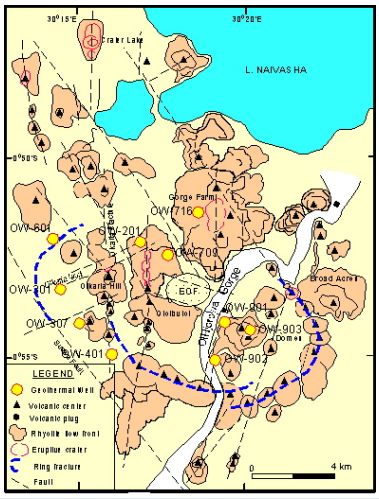
Olkaria

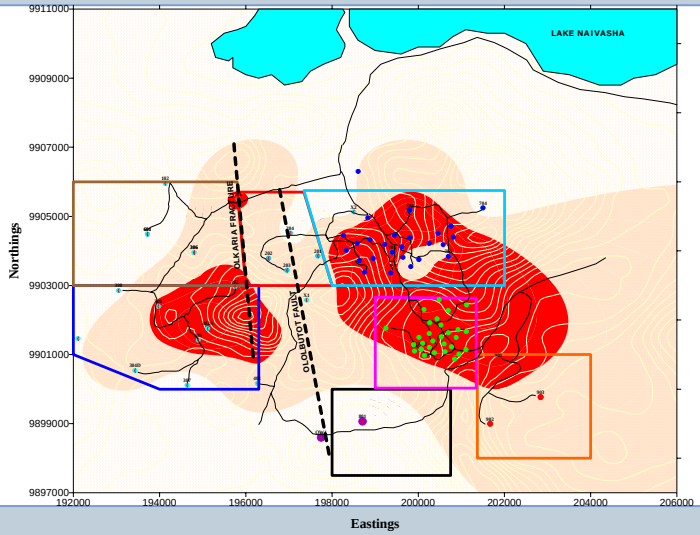
KenGen



32

Temperature distribution

KenGen



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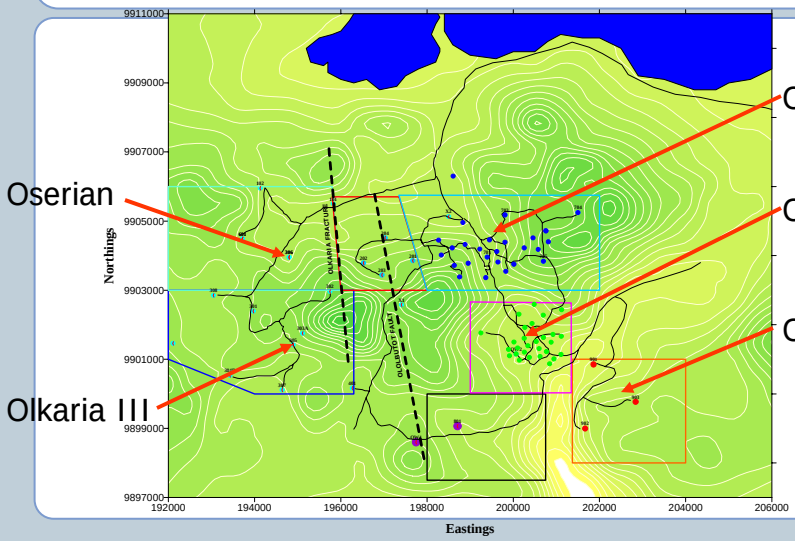
Olkaria Fields

KenGen



34

Olkaria 1 Power station (45MW)

KenGen

35

Olkaria I Power Plant

KenGen

- Exploration 1970
- Drilling 1972
- Feasibility 1976

- Three 15 MW units commissioned between 1981-1985 are still operational.
- Funded by IDA US$ 61m, EIB US$ 8.8m, CDC S£15.5m, KenGen KSh40.8m

- 31 wells interconnected
- 8 new wells
- 1 deepened
- 2 retired
- Excess steam available

- Rewinding of generator coils for Unit 1 was completed in 2004 and for Unit 2 will be done later this year.
- All the machines have maintained availability and load factors of over 90%

36

Maintenance-Overhauls

KenGen

- Unit 1 1988, 1995, 2002
- Unit 2 1992, 2000
- Unit 3 1991, 1997
- Unit 1 generator coils -2002

37

Olkaria II Power Plant 70 MW

KenGen

38

Olk. II Project History

KenGen

- Location - 3.5 Km from Olkaria I
- Project inception - 1988 after 6 wells
- Drilling ended - 1993 with 33 wells total and 80 MW steam
- Funding closed in August 1998
- 5 construction & 1 engineering contracts awarded
- Construction works began Sept 2000

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Funding

KenGen

- OG100 Engineering Services - IDA
- OG101 Civil & Structural Works - IDA
- OG102 Mechanical & Electrical Plant -IDA
- OG103 HV Substations - EIB
- OG104 HV Transmission Lines - EIB
- OG105 Steamfield Development – KfW

- US$185 million by the World Bank, the EIB, KfW and KenGen.

40

Olkaria II

KenGen

- Main features are:
  - 2 x 35 MW Mitsubishi turbines commissioned Oct and Nov 2003
  - DCS system
  - 15 steam wells used out of 20
  - 25.7 km of steam and brine lines
  - 4 hot reinjection wells
  - 2 cold reinjection wells
  - 3.8km 132kV transmission between Olkaria I and II
  - 116.4km 220kV transmission line between Olkaria II and Nairobi
  - 3 substations

41

KenGen

Olkaria II - Cold reinjection

Olkaria II – hot reinjection

42

Olkaria II – 7.5t/MW ssc

Olkaria I – 9.2t/MW ssc

43

Olkaria II – hot reinjection

Olkaria I – cold reinjection

44

KenGen

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KenGen

Olkaria II – counter flow

Olkaria I – cross flow

46

KenGen

Olkaria II – 220kV line

Olkaria I – 132kV line

47

KenGen

Olkaria II - Hot well pump

Olkaria I – seal pit

48

KenGen

Olkaria II – Gas Ejector pump

Olkaria I – Gas Ejectors

49

KenGen

Olkaria II- loop seal

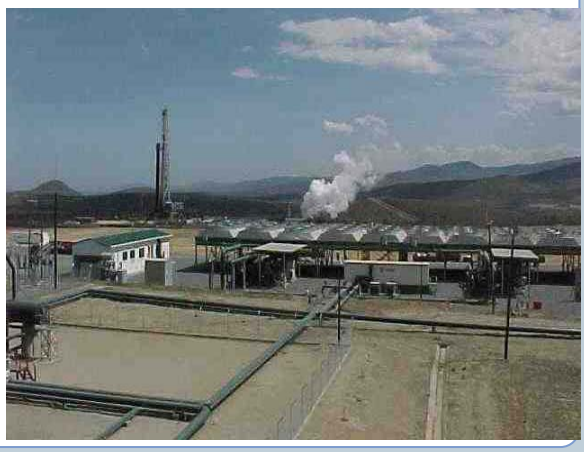
Olkaria I – Ball check valve

50

Olkaria III Power Plant

KenGen

- Exploration drilling done by KenGen.
- Field bidded under BOOT by ICB in 1996.
- Orpower 4 entered into PPA with KPLC in 1998 for 20yrs
- Being developed by Orpower 4. It will generate a total of 48 MW when complete
- 1st Phase commissioned in year 2000 is currently generating13 MW. Drilling completed.



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Oserian Power Plant 2MW

KenGen

- **Binary plant owned by Oserian Flower Farm**
- **Commissioned July 2004**
- **Steam leased from KenGen.**

52

Well Blowout at Olkaria

KenGen

53

Oserian Greenhouse Project

KenGen

54

Oserian Greenhouse Project

KenGen

- In 2003 Oserian started commercial heating of greenhouses for flowers in 3 ha.
- Currently heating 30 ha
- Plan 40 ha
- CO2 added

55

Oserian Greenhouse Project

KenGen

56

Oserian Greenhouse Project

KenGen

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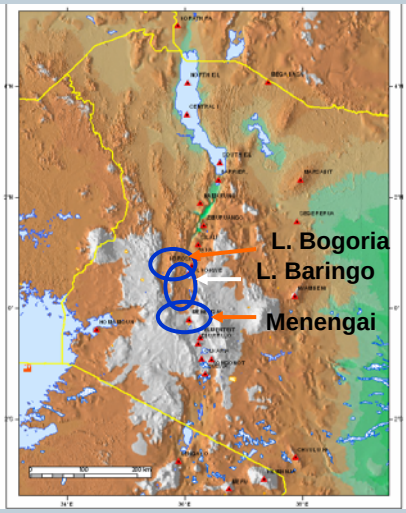
Exploration Activities

KenGen



- Fourteen (14) high temperature prospects in the Kenya Rift
- Exploration undertaken in Suswa, Longont, Menengai and Lake Baringo (2004)
- Current studies in Lake Bogoria area

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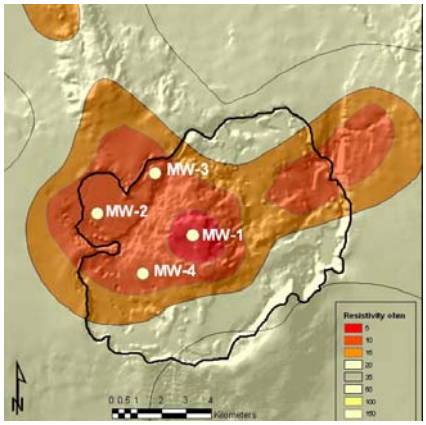
Menengai



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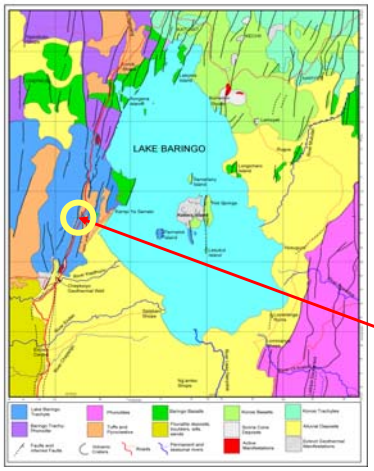
Inside Menengai crater

60

Lake Baringo Prospect

KenGen



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Lake Bogoria Prospect

KenGen

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Future Plans - 1

KenGen

Planned Power additions 2005-2025 in MW

Geothermal	Hydro	Thermal	Diesel	Imports
455	224	780	300	450
20.6%	10.1%	35.3%	13.5%	20.4%

63

Future Plans - 2

KenGen

Planned next 5 years in MW

Geothermal	Hydro	Thermal	Diesel	Wind	Imports
143.5	120	586.2	44	30	100
14%	11.7%	57.3%	4.4%	2.9%	9.8%

64

Future Plans – 3 (Olkaria Ext)

KenGen

- An IDA funded optimization study will commence June/July 2005 to allow for generation expansion in the Olkaria I/II/IV geothermal fields.
- Conceptual Design of Olkaria II Extension by 35 MWe complete.
- Unit construction planned to be commissioned in March 2008.
- Funding – EIB, IDA and KenGen
- EIB 41m$ (32.5mEuro)
- IDA 24m$
- KenGen -6.9m$

65

Future Plans - 4 (Olkaria IV)

KenGen

- **Appraisal drilling of Olkaria-Domes Field for Olkaria IV will commence in October 2005 and commissioning of a 70 MWe power plant in 2010 or earlıer.**

66

Future Plans – 5(Heating)

KenGen

67

KenGen

68

Heated swimming pools

69

Future Plans - 6 (Eburru)

- KenGen plans to construct a 5 MW binary geothermal power plant at Eburru starting Oct 2005. The resource in Eburru was previously used for drying pyrethrum and domestic water supply via condensers
- Create drinking water for the local people

70

Eburru

71

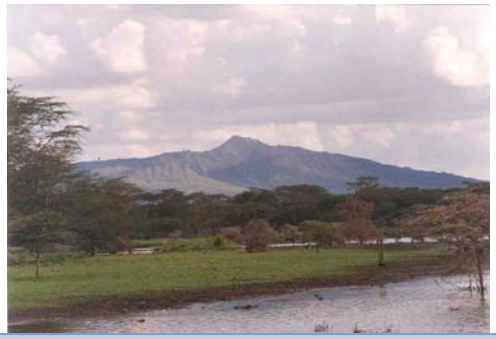
Drinking water and Drying

72

Future Plans – 7 (Longonot)

KenGen

- Joint Geophysical Imaging study at Longonot 2004
- African Rift Geothermal initiative (Argeo) exploration drilling of Longonot prospect to be undertaken in 2007 and lead to commissioning of a pilot plant in 2009.



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Future Plans- 8 (Exploration)

KenGen

- Source for funds for exploration drilling of Suswa, Menengai and other geothermal prospects

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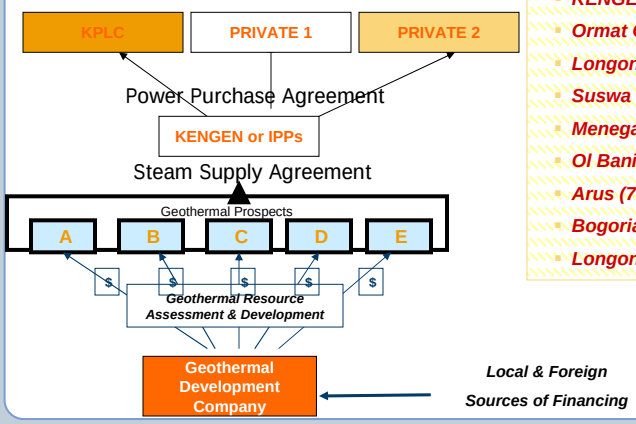
Development Strategy

KenGen



GEOTHERMAL PROJECTS

- *KENGEN Olkaria IV (70 MW)*
- *Ormat Olkaria III (48 MW)*
- *Longonot (70 MW)*
- *Suswa (70 MW)*
- *Menegai (70 MW)*
- *Ol Banita (70 MW)*
- *Arus (70 MW)*
- *Bogoria (70 MW)*
- *Longonot (70 MW)*

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Summary

KenGen

- 23-year history of Olkaria I Power Plant demonstrates high potential, cost effective and reliability of geothermal power.
- Geothermal offers a critical generation mix.
- Kenya plans to generate additional 450MW_e from geothermal sources by 2025.
- Vast resources exists in Kenya and expected to make major contribution in future.

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Summary

KenGen

- Funding for exploration drilling the biggest problem
- Establishment of GDC is expected to accelerate geothermal development in the next five years > 144MW.
- Public/Private partnership to be used.
- ARGeo Initiative is expected to increase development activities in the Eastern Africa region.
- Take advantage of carbon credit

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