

### STATUS OF GEOTHERMAL DEVELOPMENT IN KENYA

### KENGEN'S PLANS FOR EXPANSION

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### Geothermal electricity -Installed capacity 2005 in MWe

celand 202 Russia 79 Germany 0.2 Austria 1 Italy 790 Turkey 20 USA 2544 Japan 535 Azores 16 Mexico 953 China 29 Ethiopia (8) Guatemala 33 Thailand 0.3 Guadeloupe 15 Philippines El Salvador 161 1931 Nicaragua 77 Kenya 130 Papua N Guinea Costa Rica 163 Indonesia 797 Australia 0.2 New Zealand 43

## **Geothermal Resources in Africa**



## **Kenya's Geothermal Potential**



 Kenya's potential estimateover 4,000 MW.

- Geothermal potential areas (>20 fields) within Kenyan Rift.
- Current installed geothermal power: KenGen 115 MW and IPP's 15 MW.
  - From above values, only a small fraction of the estimated resource has been harnessed.

## **Rift Geothermal Model**



### **Generation Modes in Kenya**



### Geothermal electricity Utilization 2005 - Top 10 countries

No	Country	Geothermal Electricity Consumed (GWh)	% of National Electricity Consumed
1	Kenya	1,088	19.5%
2	Philippines	9,419	19%
3	Iceland	1,406	17%
4	Costa Rica	1,145	15%
5	Indonesia	6,085	7%
6	New Zealand	2,774	7%
7	Mexico	6,282	3%
8	Italy	5,340	2%
9	USA	17,840	0.5
10	Japan	3,467	0.3



# **Manifestations**







# Lake Baringo Prospect





## Current Generation and Demand



#### **KenGen's Analysis**

#### DEMAND IN KENYA IS EXPECTED TO GROW SIGNIFICANTLY AND CURRENT SUPPLY PLANS FALL WELL SHORT OF DEMAND



#### **Opportunities and Challenges**

- Significant demand growth in Kenya over the next several years (8% per year)
- Demand from neighbouring countries could result in even greater growth
- However, Kenya will struggle to meet demand, especially over the medium and longer term
- Current plans rely on importing power from countries like Ethiopia (e.g., ~30% of power in Kenya to be imported by 2030)
- Kenya has significant natural power potential in the form of geothermal (~4 000 MW), hydro (~1 500 MW), wind (~4 400 MW) and potentially coal to not only meet its own demand, but also supply the region

\* The LCDP starts to import 100 MW of capacity from 2012, and 900 MW by 2028. Imports are designed to close the supply demand gap, and does not provide for a surplus reserve margin Source: Update of Kenya's Least Cost Power Development Plan 2008 - 2028

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Most attractive for KenGen

#### GEOTHERMAL, WIND, COAL AND NATURAL GAS ARE THE MOST ATTRACTIVE GENERATION OPTIONS FOR KENGEN

Generation Option	<b>Low cost</b> US\$c/kwh	Availability	Fast delivery*	Environment friendly	Natural potential	Location and transmission benefit	Comments		
Geotherma	al 6.4	$\checkmark$	*	✓	✓	✓	Significant proven potential		
• Wind	5-8	x	$\checkmark$	$\checkmark$	$\checkmark$	$\checkmark$	<ul> <li>Significant potential, but dependent on weather</li> </ul>		
Nuclear	8.6	$\checkmark$	×	$\checkmark$	×	×	<ul> <li>Min plant size of 500 MW required, politically sensitive</li> </ul>		
• Gas	8.4	$\checkmark$	$\checkmark$	s	SC	$\checkmark$	<ul> <li>Need to import, liquify for transport and re-gas</li> </ul>		
Coal	9.3	$\checkmark$	×	×	?	?	Coal potential in Kitui		
• MSD	10.2	✓	✓	*	×	×	<ul> <li>Attractive intermediate capacity, but not large base load</li> </ul>		
<ul> <li>Hydro**</li> </ul>	12.5	SC .	32	$\checkmark$	$\checkmark$	30	<ul> <li>High exposure to hydrology risk (65% of current capacity)</li> </ul>		
<ul> <li>Gas Kerosene</li> </ul>	16.5	$\checkmark$	$\checkmark$	x	x	$\checkmark$	<ul> <li>Current GTs running at high loads, need more base load</li> </ul>		
<ul> <li>Solar</li> </ul>	30-50	s	$\checkmark$	$\checkmark$	?	x	<ul> <li>Dependent on weather with low average availability</li> </ul>		
<ul> <li>Co-gene- ration</li> </ul>	tbd	?	x	$\checkmark$	?	s	<ul> <li>Could pursue along side coal opportunity</li> </ul>		

\* Based on construction time – additional time would be needed for feasibility and other pre-construction activities
 \*\* 6US cents/kwh based on importing hydro power from Ethiopia vs. 12 US cents/kwh based on remaining projects in Kenya, e.g. Mutonga
 \*\*\* Lower than 10 cents/kwh, greater than 80% availability, less than 3 years, lower than 0.20 CO2 kg/kwh and known natural potential
 Source: KenGen, LCDP, Eurolectric, McKinsey EPNG model, US Electricity Market Module March 2007, team analysis



#### HORIZON I: DELIVERING COMMITTED PROJECTS AND SECURING EMERGENCY POWER TO STABILISE SUPPLY IN KENYA







- Ensure delivery of committed projects
- Emergency power secured with 100MW Aggreko contract extended for
   yrs, and a new 80MW emergency Aggreko unit obtained
- 3. Drive an energy conservation programme, along with the ERC, through the regulatory management department

\* Including outage caused by Kiambere optimization in 2008, emergency power, 100 MW existing Aggreko, 80 MW additional emergency power up for tender.
 \*\* 1 010 MW peak capacity in 2007 with gradual growth ramp-up to 10 % per annum, as suggested by vision 2030 Source: KenGen; least cost development plan; team analysis

# **Olkaria II Power Plant 70 MW**

Optimization study determine availability of steam for generation expansion at Olkaria II completed 2006.

Olkaria II Extension by 35 Mwe: Construction work started and plant to be commissioned by 2010.



## Olkaria I Power station (45MW)

•Three 15 MW units (commissioned 1981-1985) still operational. Field has excess 38 Mwe (equivalent) of steam now with zero drawdown.

- Services done: Rewinding of generator coils (Good quality of steam)
- •Units have maintained load and availability factors of over 94% & 98%
- Feasibility study in progress to determine: Replacement or rehabilitation



## Olkaria I & II 70 MW New Plant



To be developed on the un-used area at Olkaria I & II. (Red Boxes)

**Olkara Domes Geothermal Resource Area** 

## **Olkaria IV 140 MW Plant Development**



- Six Appraisal Wells drilled with an average depth of 2,800 m & production casing at 1,200 m.
- Average output of 5 MW
- Temperatures Max 300-354
   Deg Celcius
- Production drilling for 30 production & 6 re-injection wells using two rigs in progress
- Planned commissioning of the 1<sup>st</sup> 70 Mwe unit by Dec 2012



# **Olkaria III Power Plant**

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

□1<sup>st</sup> Phase commissioned in year 2000 is currently generating13 MW.

□ 2<sup>nd</sup> Phase to be Commissioned by December 2008.



#### Geothermal Energy Utilization: Direct Use –Oserian Green houses (Kenya)

 i) Cut Roses Green house Heating ~70 hectares, ii) Refrigeration of cut flowers storage and processing stores, iii) Injection of CO<sub>2</sub> to aid in photosynthesis, iv) Fumigation of soils and sterilization of liquid recycled plant fertilizers





## NEW PROJECT DEVELOPMENT STATUS HORIZON I (5 years)

PHASE			RESOURCE A	SSESSMENT	POWER PLANT DEVELOPMENT			
PLANT	PLANT SIZE	FIELD	APPRAISAL		PRODUCTION	CONSTRUCTION		
			DRILLING	FEASIBILITY	DRILLING			
Olkaria III	35	Olkaria West	Done	Done	Done	Commiss -2008		
Olkaria II 3 <sup>rd</sup>	35	Olkaria	Done	Done	Done	Commiss -2010		
unit		Northeast						
Olkaria I Life	45	Olkaria East	Done	In progress	In progress	Planned		
extension								
Olkaria I & II	70	Olkaria East	In progress	In progress	Planned	Planned -2012		
New plant								
Olkaria IV	140	Olkaria	Done	In progress	In progress	Planned-2013/14		
		Domes						
Eburru	2.5 Pilot Plant	Eburru	Done		Done	In progress -2010		





#### LARGE GREEN GEOTHERMAL AND WIND PROJECTS DOMINATE HORIZON 2

Horizon 2 projects, MW



Geothermal Wind & Hydro Thermal (Gas/Coal)



# Menengai – 750 MW Potential





# Inside Menengai Caldera





#### NEW PROJECT DEVELOPMENT STATUS HORIZON II

PHASE			F	RESOURCE ASSES	SMENT	POWER PLANT CONSTRUCTION		
PLANT	PLANT SIZE	FIELD		SURFACE EXPLORATION	EXPLORATION DRILLING	APPRAISAL DRILLING	FEASIBILITY	
Eburru	15-30	Eburru		Done	Done	Done	Planned	
Menengai I	140	Menengai		Done	Planned 2009	Planned 2010	Planned	
Menengai II	140	Menengai		Done	Planned 2010	Planned 2010	Planned	
Menengai III	140	Menengai		Done	Planned 2010	Planned 2011	Planned	
Menengai IV	140	Menengai		Done	Planned	Planned	Planned	
Longonot	280	Longonot		Done	Planned 2009	Planned	Planned	
North Rift	280	North Rift		Done	Planned	Planned	Planned	

## **Challenges to geothermal development**

- Large up-front investment in exploration, appraisal and production drilling
- Funding Constraints:Long financial closure (WB)
- Technological Constraints: Manpower (development and retention) & Equipment
- Environmental & Social issues: Land & etc
- Commercial & Legislative Framework Risks: Country, Market, Corruption, Level Playing Field etc



## **Overcoming Challenges**

- The Government to carry exploration, appraisal and production drilling costs through GDC
- GDC to be managed under contract by KenGen
- Manpower: KenGen has developed a 10 year capacity building plan & recruited 150 graduates
- Lab & Field Equipment: Developed a continuous acquisition and upgrade program
- Strengthened KenGen's Environment, legal & Social department capacity.
- Government addressing the Commercial & Legislative Risks issues.

## **GDC** – When fully Oprational



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#### FINANCIAL REQUIREMENTS (Million US\$)

YEAR	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	TOTALS
<b>Operations /Staff</b>												
Development Costs	2.51	3.70	4.76	5.51	6.24	7.49	9.36	10.30	11.33	11.90	12.49	86
Olkaria IV (140 MW)												
Scientific and Drilling												
Facilities Upgrade	-	57	60	62	-	-	-	-	-	-	-	179
												100
Olkaria IV (140 MW)	96	41	159	136	-	-	-	-	-	-	-	432
Olkaria I (Life												
extension)	-	8	111	87	-	-	-	-	-	-	-	206
Olkaria I (New Plant)	-	18	28	120	90.	-	-	-	-	-	-	256
Eburru (15 MW)	-	4	8	1	3	44	-	-	-	-	-	59
Menengai I (140 MW)	18	17	82	169	166	-	-	-	-	-	-	452
Menengai II (140MW)	-	-	-	44	255	155	-	-	-	-	-	453
Menengai III (140												
MW)	-	-	-	-	47	271	151	-	-	-	-	469
Menengai IV (140												
MW)	-	-	-	-	-	49	279	156	-	-	-	485
Longonot I (140 MW)	-	-	-	-	-	22	102	207	190	-	-	521
Longonot II (140 MW)	-	-	-	-	-	-	12	95	213	196	-	516
Disbursement/yr	118	149	451	623	568	548	554	468	415	208	13	4,516

# CONCLUSIONS

- Geothermal capacity to increase by ~ 1,500 MW (>140 MW per year) by 2018
- •KenGen is developing adequate human capacity through focused recruitment & specialized training
- •Enabling commercial and Legislative environment to attract and retaining private investors in the Geothermal power industry. (2008 GOK committed –US\$ 120 m)
- •Government given a 10 year tax holiday to investors in Geothermal Development.
- KenGen is looking for joint venture partners, supplier credits, commercial loans and public-private partnerships to raise funds for power plants.





**Clean Renewable Energy**