



GEOHERMAL DEVELOPMENT IN KENYA

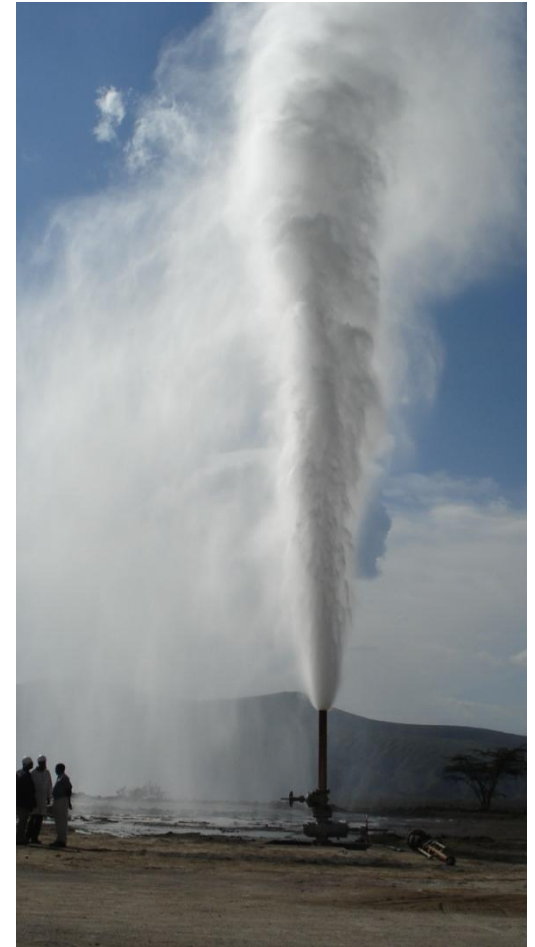
**SREP SUB COMMITTEE VISIT – 10th
March 2012**

Presented by

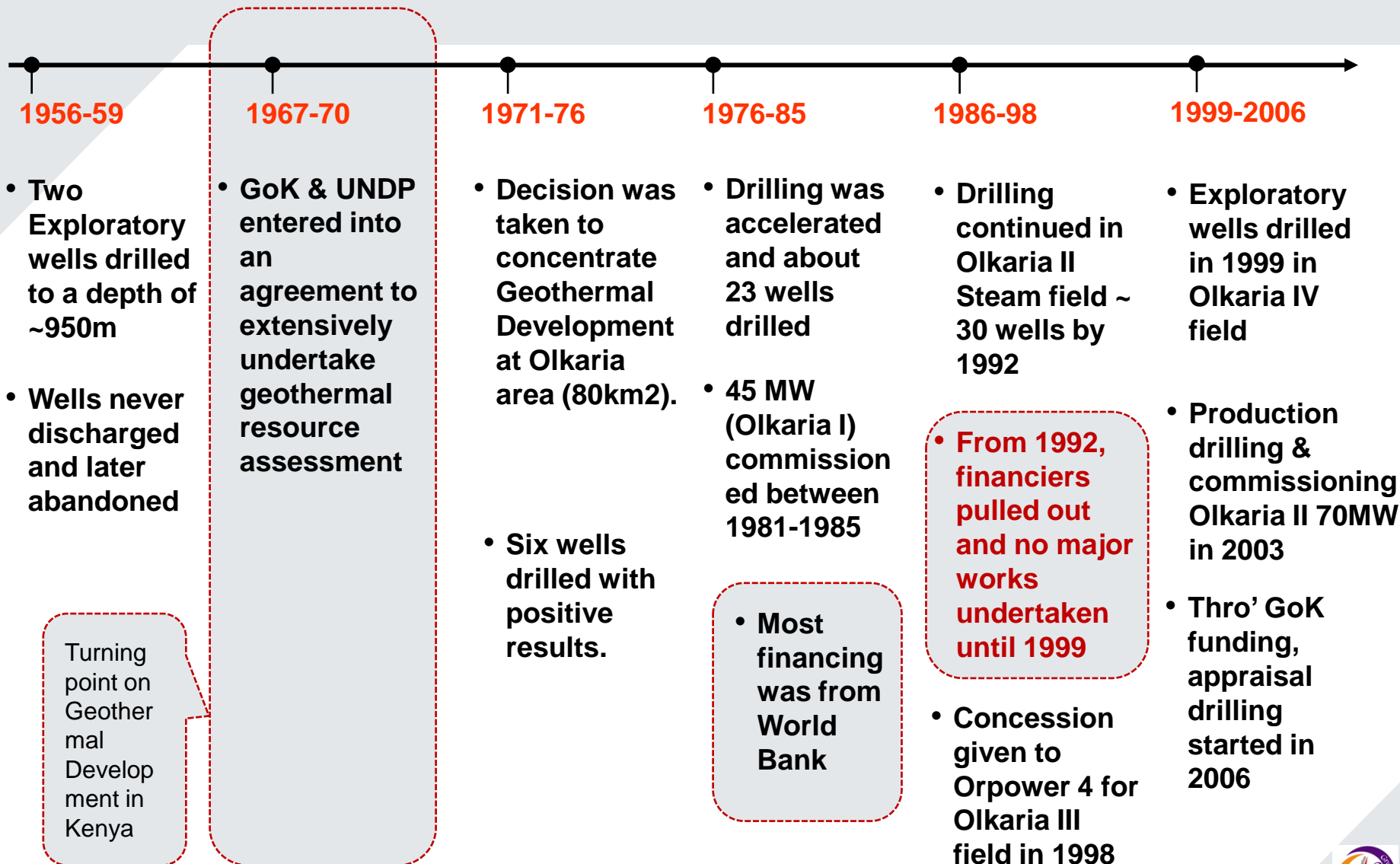
**Cyrus Karingithi
Asst Manager Resource Development**

Introduction

- ❑ **Geothermal energy utilizes natural steam from the earth**
- ❑ **Geothermal electricity generation in Olkaria**
 - Total installed capacity - 202 MW
- ❑ **KenGen Operates two power plants**
 - Olkaria I - 45 MWe
 - Olkaria II - 105 MWe additional
 - Planned; Install 280 MWe at Olkaria I and IV
 - Wellhead Generation – 5 MW under construction
- ❑ **IPPs generate 52 MW at Olkaria**



A RICH HISTORY OF GEOTHERMAL DEVELOPMENT IN KENYA



GEOHERMAL DEVELOPMENT IN KENYA


 2007 - date

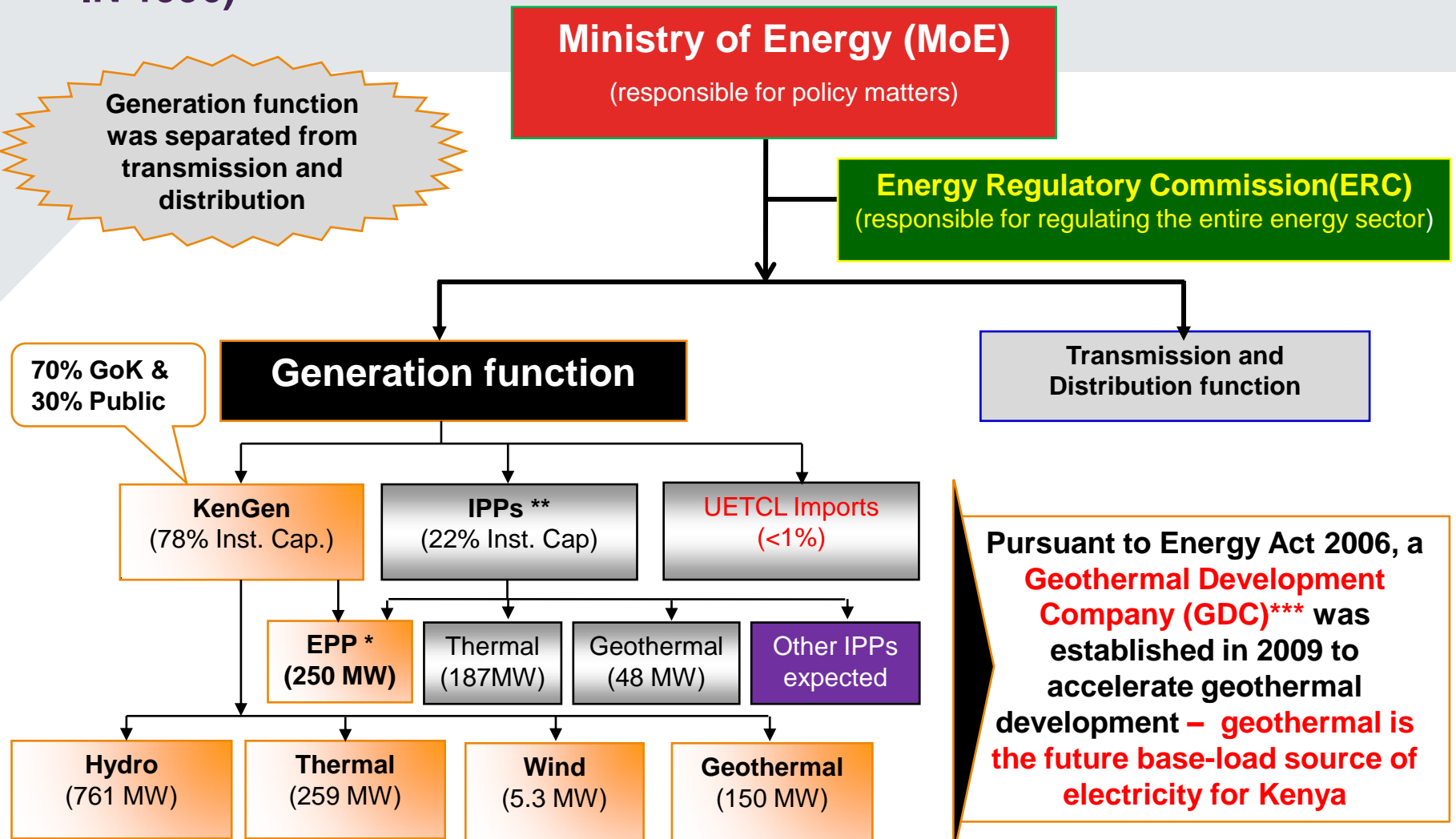
- Production drilling started in Olkaria I&IV (over 50 wells drilled ~ 300MWe)
- Olkaria II 3rd Unit 35MW commissioned
- GDC formed in 2009 and drilling in Menengai field started in 2011
- Olkaria I&IV 280MW planned for 2014
- Olkaria Optimization study

Power plant
~US\$ 61m

	Olkaria I (45MW) [1981-85]	Olkaria II (70MW) [2003]	Olkaria II 3rd Unit (35MW) [2010]	Total
IDA (US\$ 'm)	118	108	29	255
EIB (US\$ 'm)	8.8	39	50	98
KfW (US\$ 'm)	11	12	-	23
CDC (£ 'm)	15.5	-	-	15.5
AfD (US\$ 'm)	-	-	28	28

The balance has been contributed by Government of Kenya, UNDP and KenGen

KENYA POWER SUB-SECTOR –YEAR 2010 (REFORMS STARTED IN 1996)

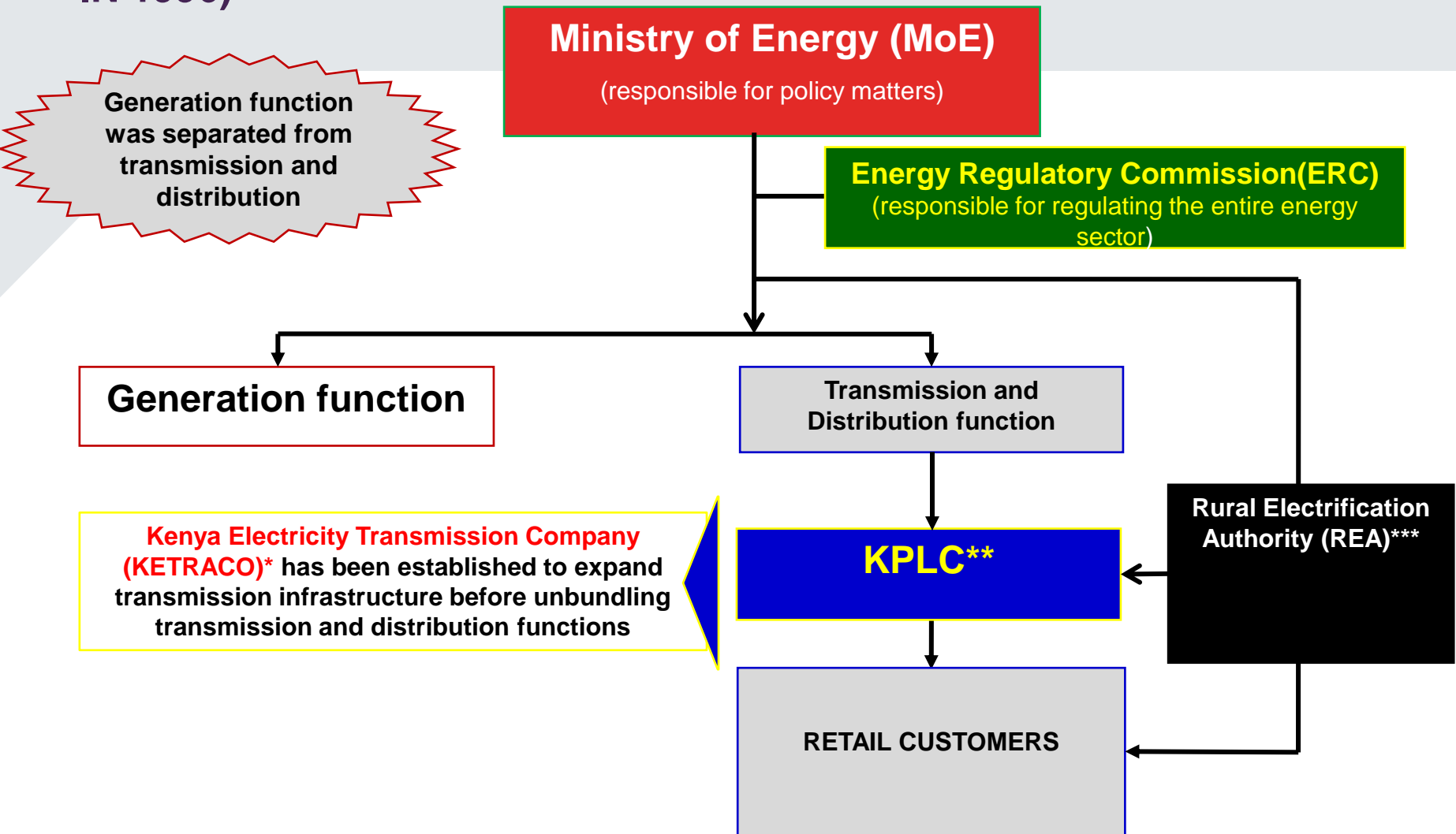


* - KenGen manages the Emergency Power Project (EPP) on behalf of the GoK

** - More Independent Power Producers (IPPs) expected in thermal, wind, solar and geothermal

*** - GDC is 100% owned by GoK to drill geothermal wells in Kenya's Rift Valley

KENYA POWER SUB-SECTOR –YEAR 2010 (REFORMS STARTED IN 1996)



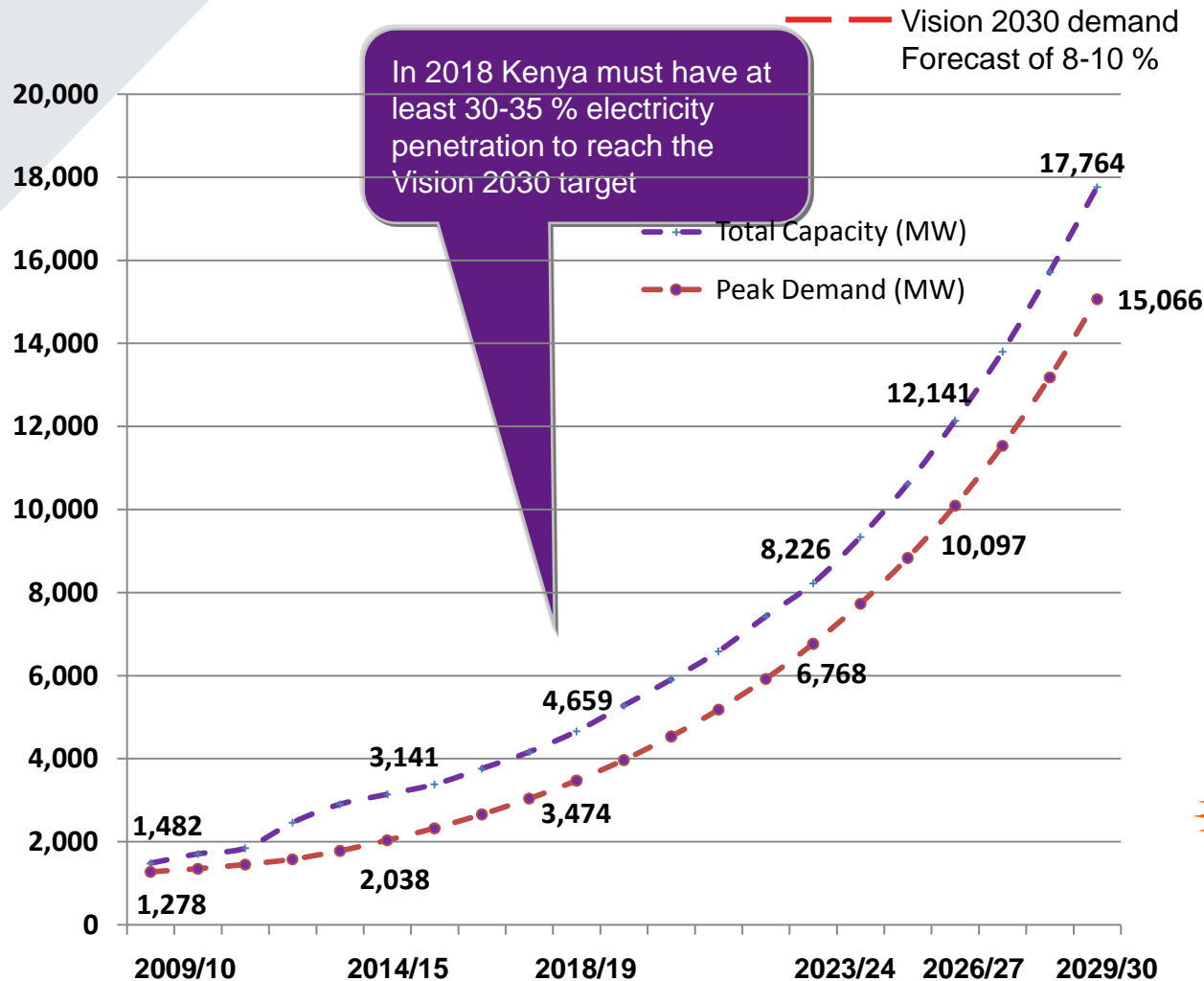
* - KETRACO is a 100% owned by GoK and will implement all new transmission lines.

** - KPLC will retain the existing transmission network and remain a single buyer for sometime before further unbundling

*** - REA was established to accelerate rural electrification and works with KPLC in implementing the rural programme

NATIONAL PEAK DEMAND FORECAST – 2010 to 2030

Peak Demand (MW)



Significant Kenya's generation potential exist

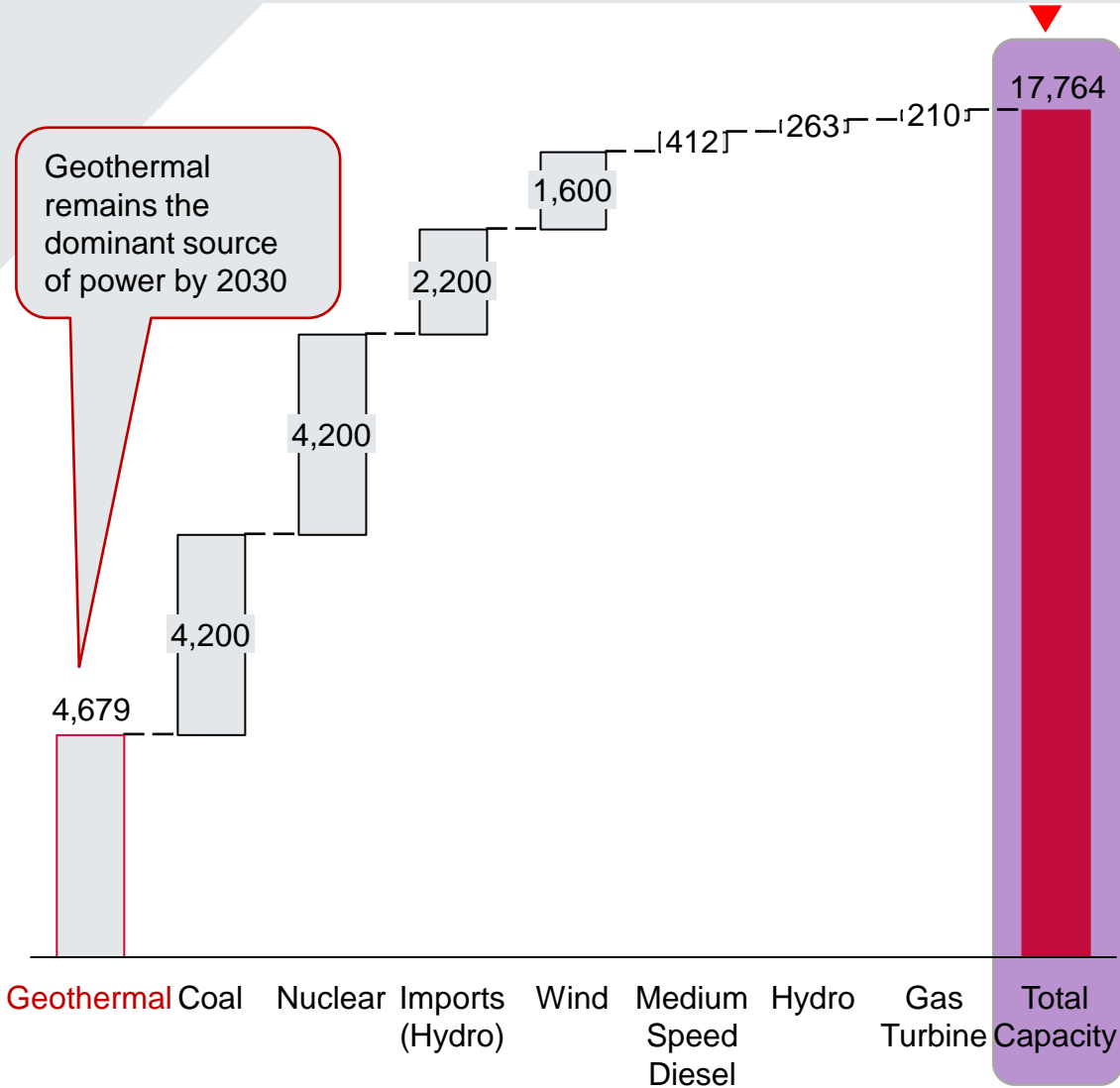
Kenya has significant natural power potential in form of :

- (i) Geothermal (~ 7,000MW);
- (ii) Hydro (~1,500MW);
- (iii) Wind (~4,400 MW); and
- (iv) Potentially Coal and Gas.

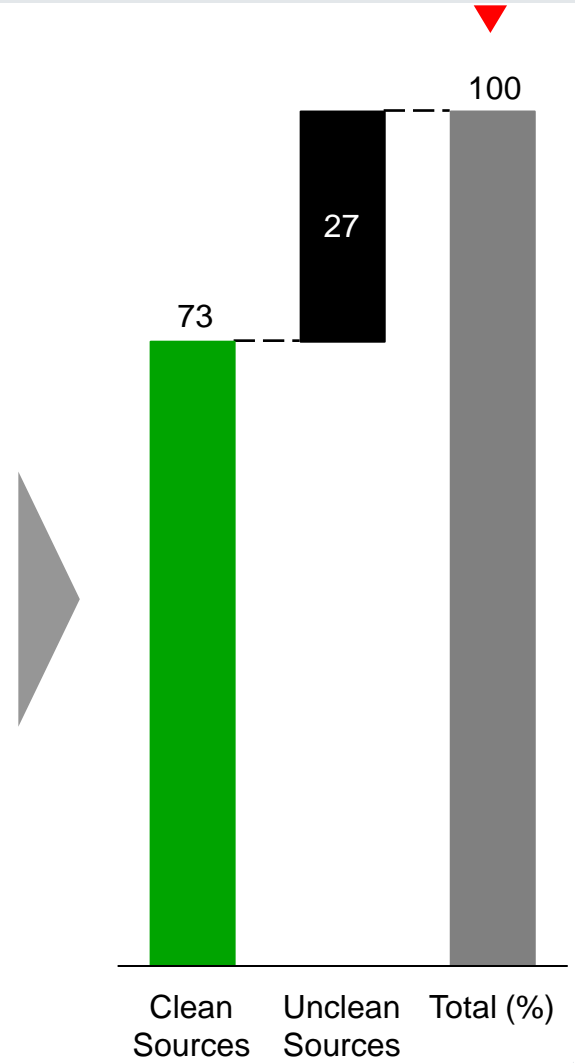
Vision 2030 ~
15,000MW

NATIONAL CAPACITY EXPANSION PLAN – 2010 to 2030

National Capacity Expansion (17,764MW) - 2030



% of Clean Sources



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

Assessment criteria

Generation Option	Low cost US\$/kwh	Availability	Fast delivery*	Environment friendly	Natural potential	Location and transmission benefit
• Geothermal	8.5	✓	✗	✓	✓	✓
• Wind	12	✗	✓	✓	✓	✗
• Nuclear	8.6	✓	✗	✓	✗	✗
• Gas CNG	8.4	✓	✓	✗	✗	✓
• Coal	9.3	✓	✗	✗	?	?
• MSD	10.2	✓	✓	✗	✗	✗
• Hydro**	12.5	✗	✗	✓	✓	✗
• Gas (Kerosene)	16.5	✓	✓	✗	✗	✓
• Solar	30-50	✗	✓	✓	?	✗
• Co-generation	tbd	?	✗	✓	?	✗

* 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, Euroelectric, McKinsey EPNG model, US Electricity Market Module March 2007, team analysis



Benefits of Geothermal Energy

- **Indigenous resource**
- **Provides clean and safe energy using little land**
- **Is renewable and sustainable**
- **Generates continuous, reliable “base load” power**
- **Conserves fossil fuels and contributes to diversity in energy sources**
- **Offers modular, incremental development and village power to remote sites**

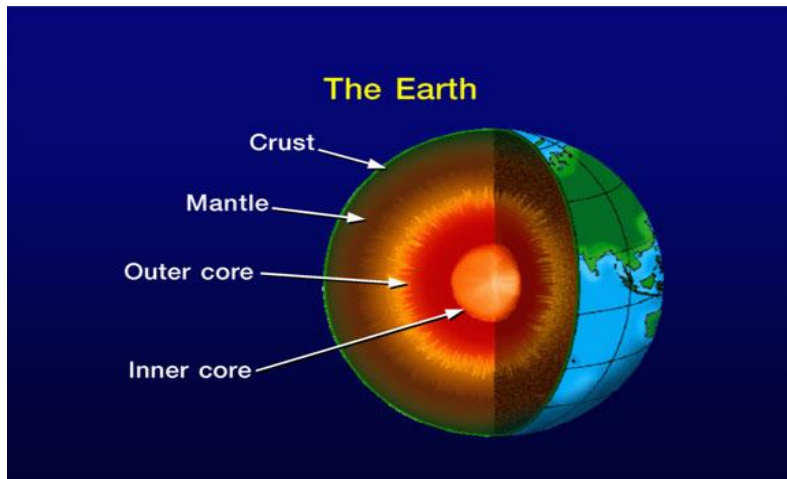


Geothermal Energy

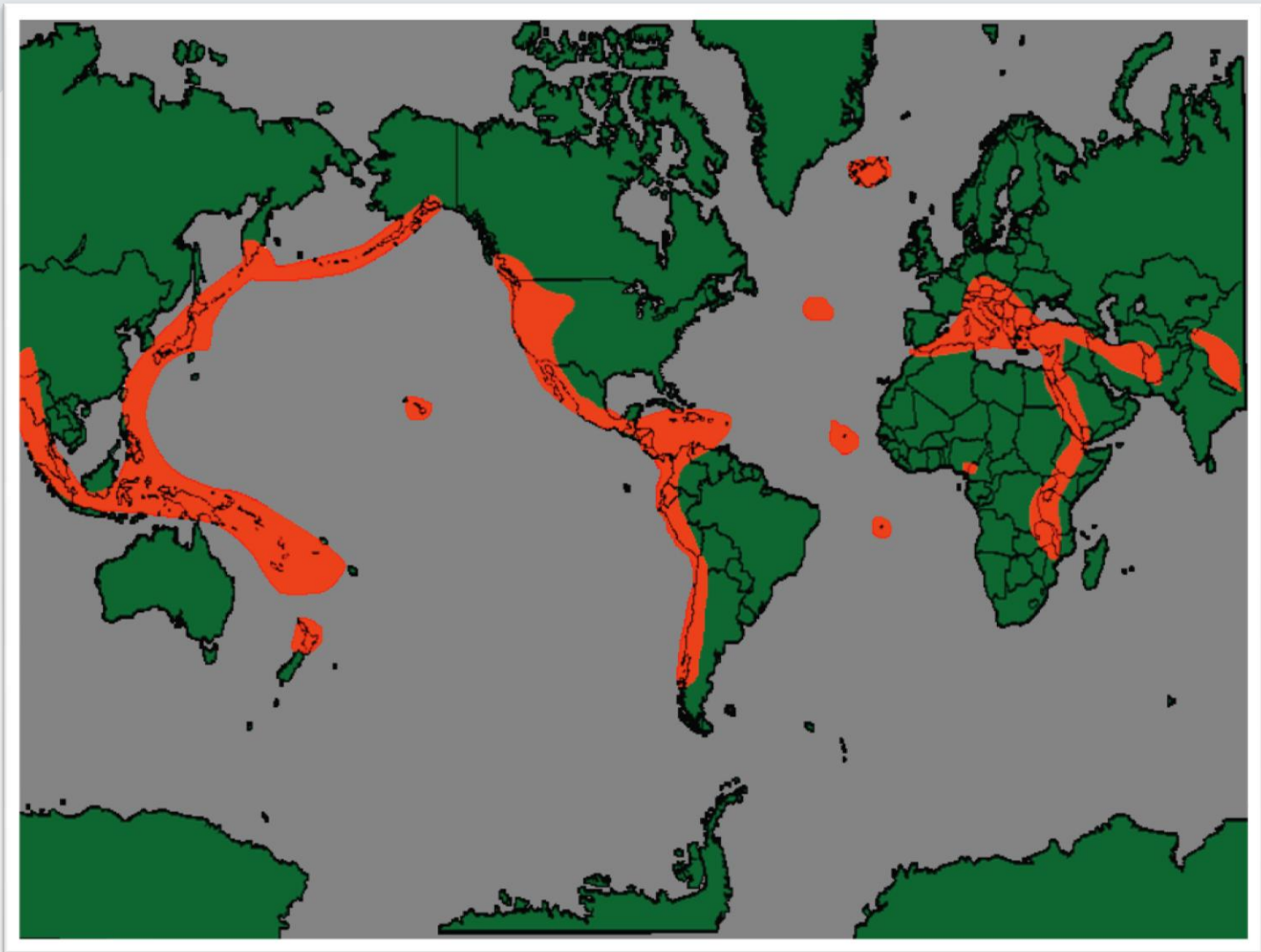
Development and technology

WHAT IS GEOTHERMAL?

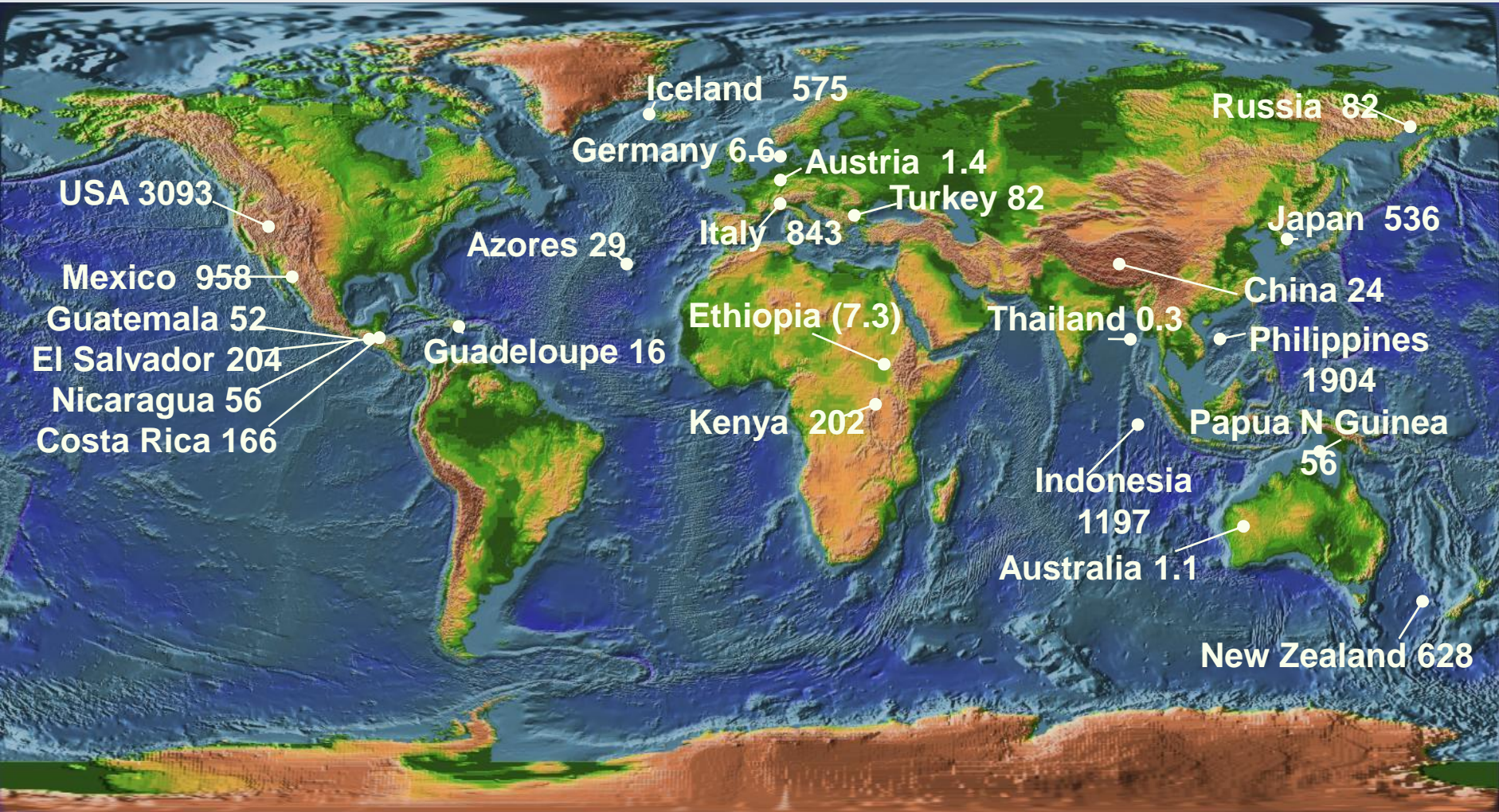
Geothermal is energy from the Earth's interior!



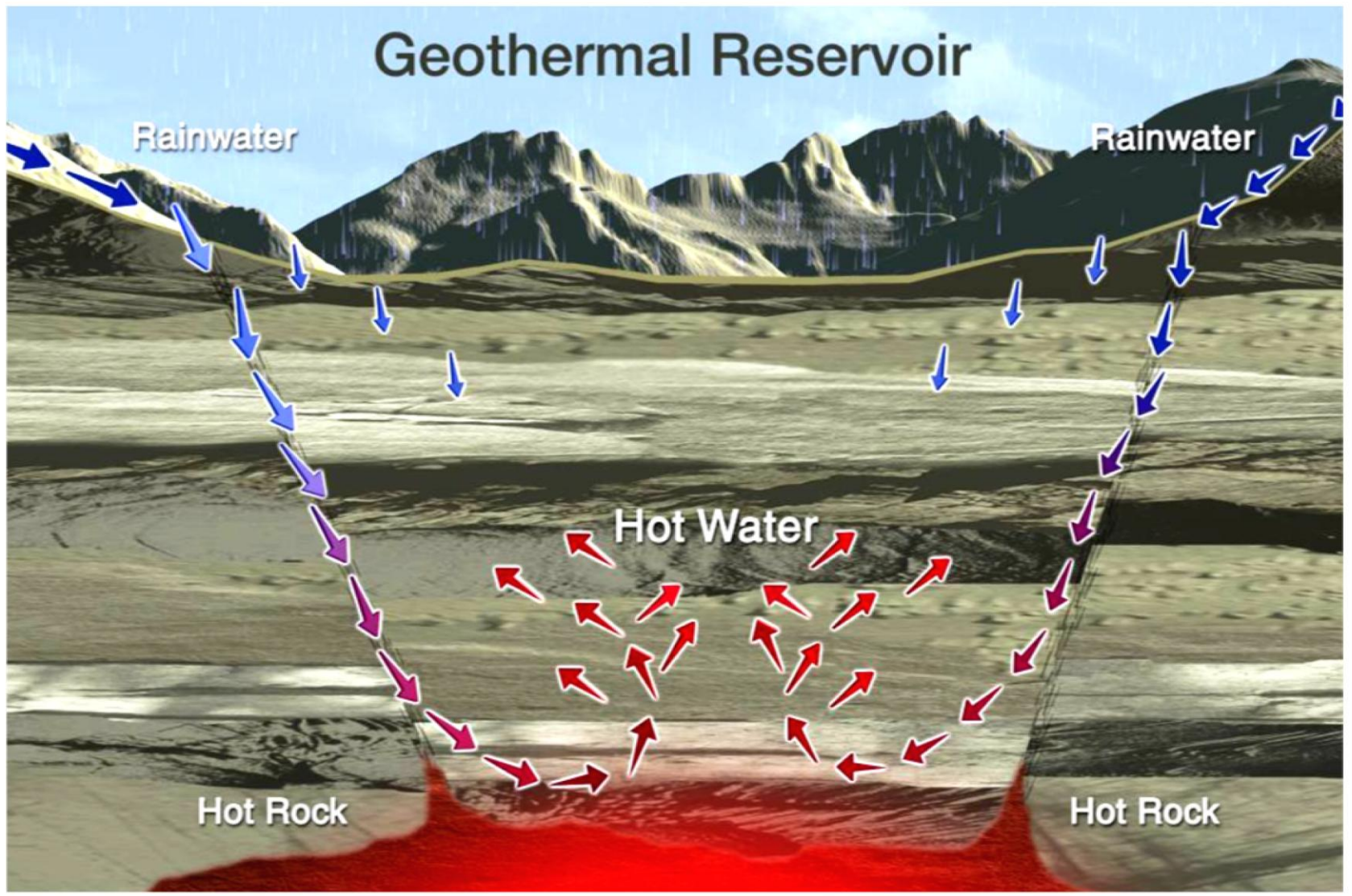
High Potential Geothermal Areas



Geothermal Electricity Review - Installed capacity 2011 in MWe



Geothermal Reservoir



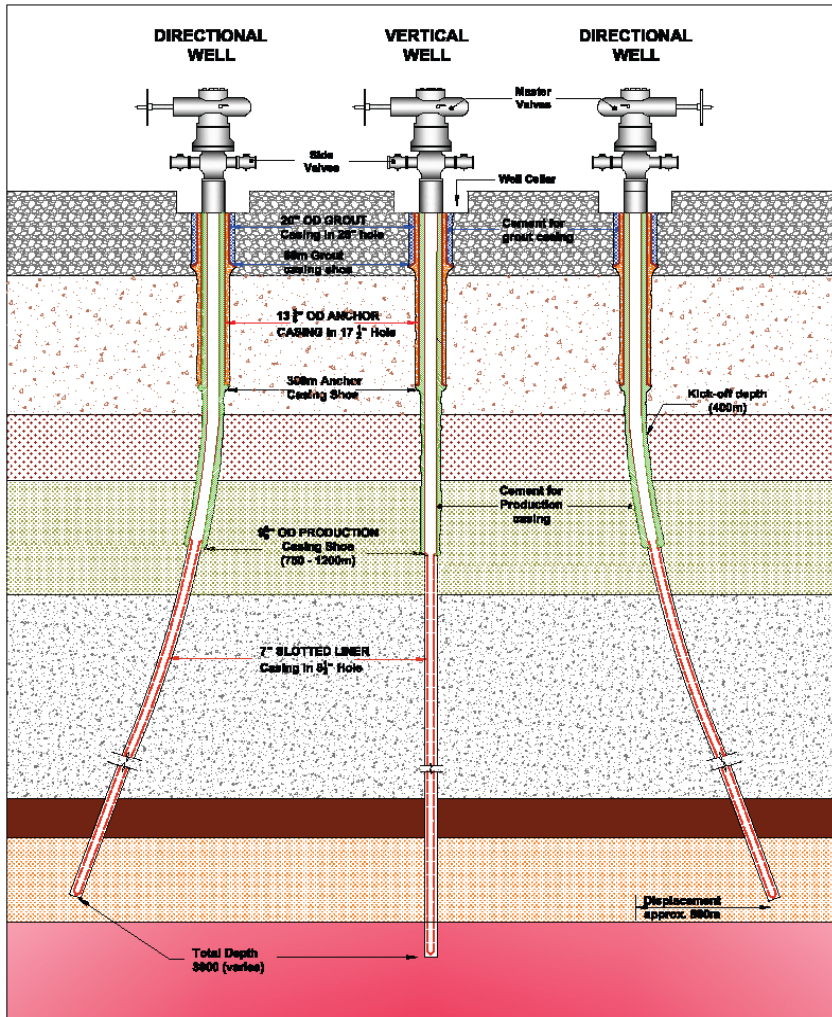
Geothermal Development Stages

- ❑ Stage I: Planning and logistics
- ❑ Stage II: Surface exploration
- ❑ Stage III: Exploratory drilling
- ❑ Stage IV: Appraisal drilling and feasibility Studies
- ❑ Stage V: Production drilling and power plan construction
- ❑ Stage VI: Power Generation & Reservoir and steamfield Management



Geothermal Well Drilling Profiles

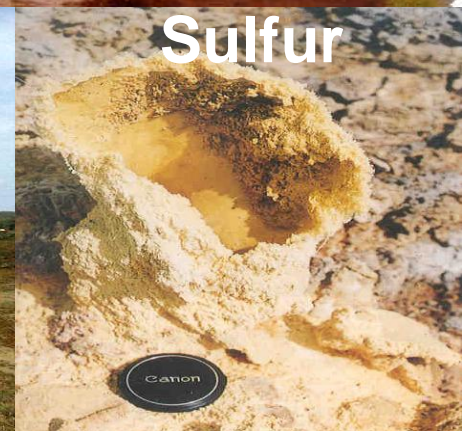
TYPICAL OLKARIA WELLS PROFILE



Well Programme

- ❑ Deep drilling to 3000m
 - Production casing shoe 500 - 1200m
 - Average depth Olkaria I = 1200
 - Average Depth Olkaria II = 2200m
 - Current average Depth 3000m (Directional & Vertical)
 - Reservoir bottom not yet reached

Geothermal Manifestations (indicators)

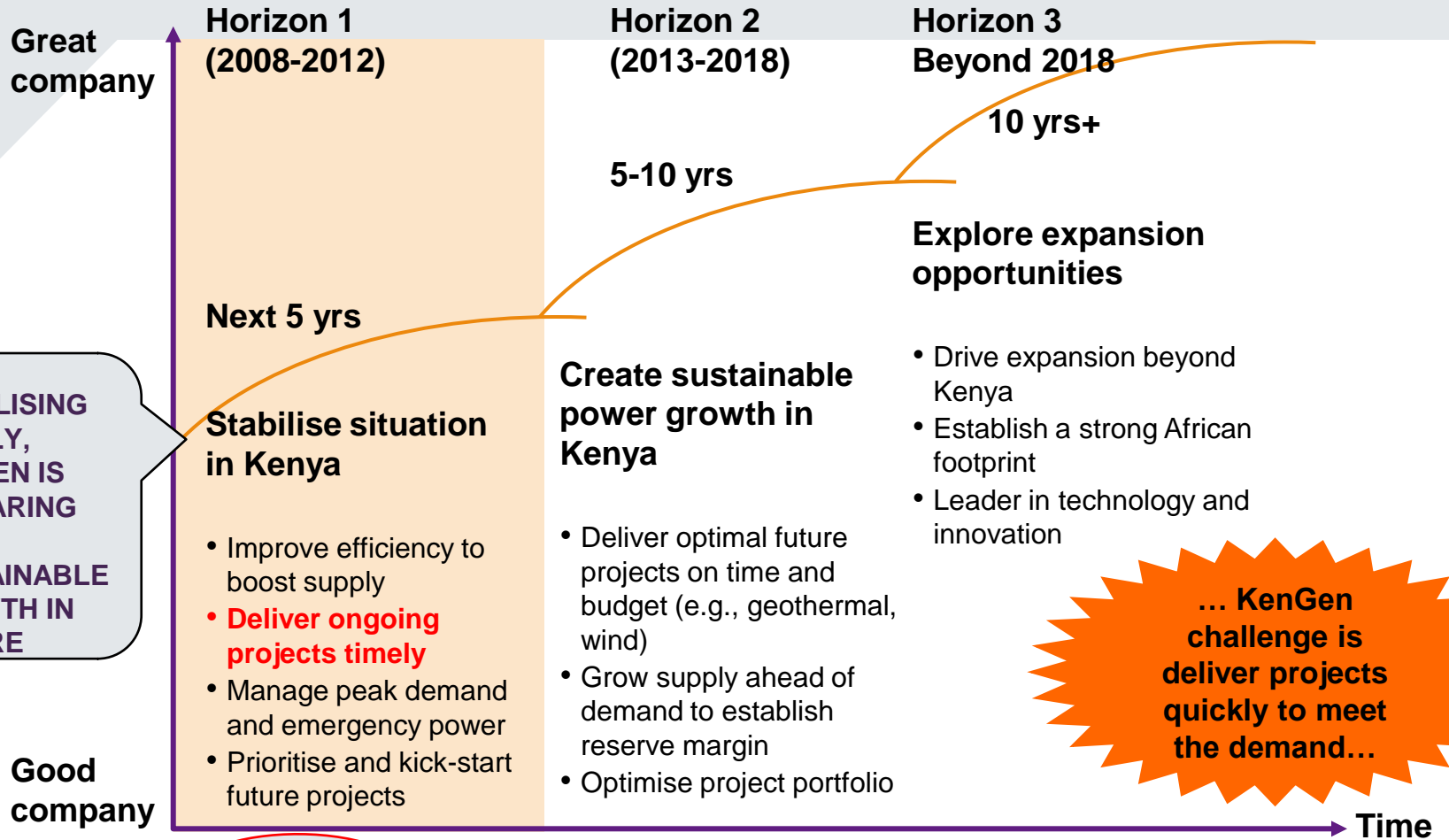




KENGEN'S STRATEGIC PLANS 2008-2018

Geothermal Baseload Strategy

KENGEN TEN-YEAR STRATEGY TO INCREASE CAPACITY TO 3,000MW BY 2018.



WHILE STABILISING SUPPLY, KENGEN IS PREPARING FOR SUSTAINABLE GROWTH IN FUTURE

- Stabilise situation in Kenya**
- Improve efficiency to boost supply
 - **Deliver ongoing projects timely**
 - Manage peak demand and emergency power
 - Prioritise and kick-start future projects

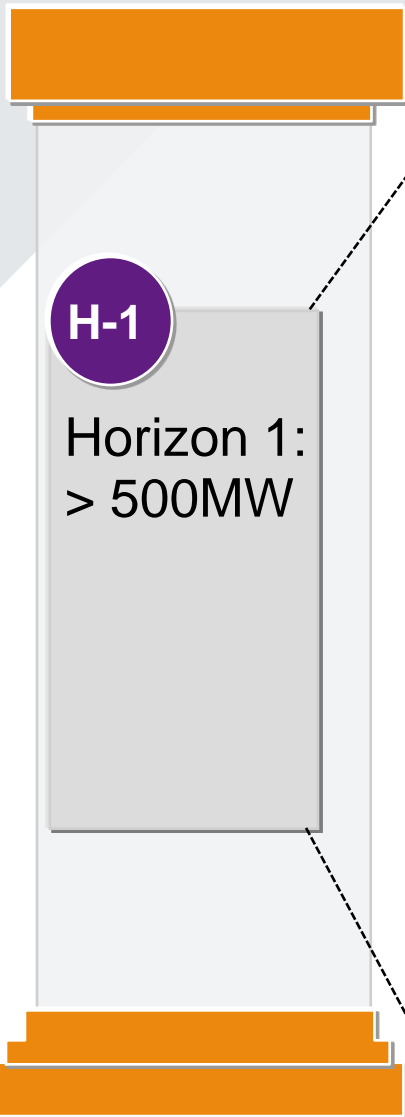
- Create sustainable power growth in Kenya**
- Deliver optimal future projects on time and budget (e.g., geothermal, wind)
 - Grow supply ahead of demand to establish reserve margin
 - Optimise project portfolio

- Explore expansion opportunities**
- Drive expansion beyond Kenya
 - Establish a strong African footprint
 - Leader in technology and innovation

... KenGen challenge is deliver projects quickly to meet the demand...

Capacity addition	KenGen today	~500MW	>1,500MW	Year 2030
Total Capacity	1,020MW	~1,500MW	~3,000MW	~9,000MW

...HORIZON I CAPACITY EXPANSION PROJECTS...



2014



Wind ~50MW
Coal Plant ~600MW

2013



Kindaruma ~32MW
Olkaria I ~140MW
Olkaria IV ~140MW

2012

Ngong Wind ~15MW

2011

Raising Masinga ~81GWh
Sang'oro ~21MW

2010

Kipevu III ~120MW
Eburru ~2.5MW

Olkaria II 3rdUnit ~35MW
Tana ~20MW

2009

Kiambere ~12MW
Ngong Wind ~5MW
Kiambere ~12MW
Sondur ~60MW

1022 MW

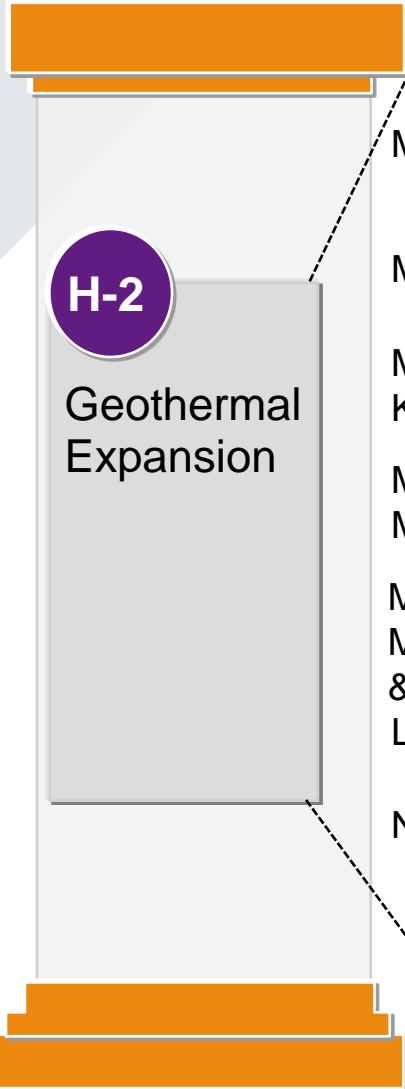
Estimated project cost is ~US\$ 1.68 billion

- Geothermal ~318MW
- Thermal ~120MW
- Hydro ~157MW
- Wind ~20MW

Total in the next 5 years ~ 615MW

Early Generation Strategy -
Install Wellhead Generators
Olkaria I and IV = 75 MW 2010/2011

...OUR PLANNED HORIZON II CAPACITY EXPANSION PROJECTS...



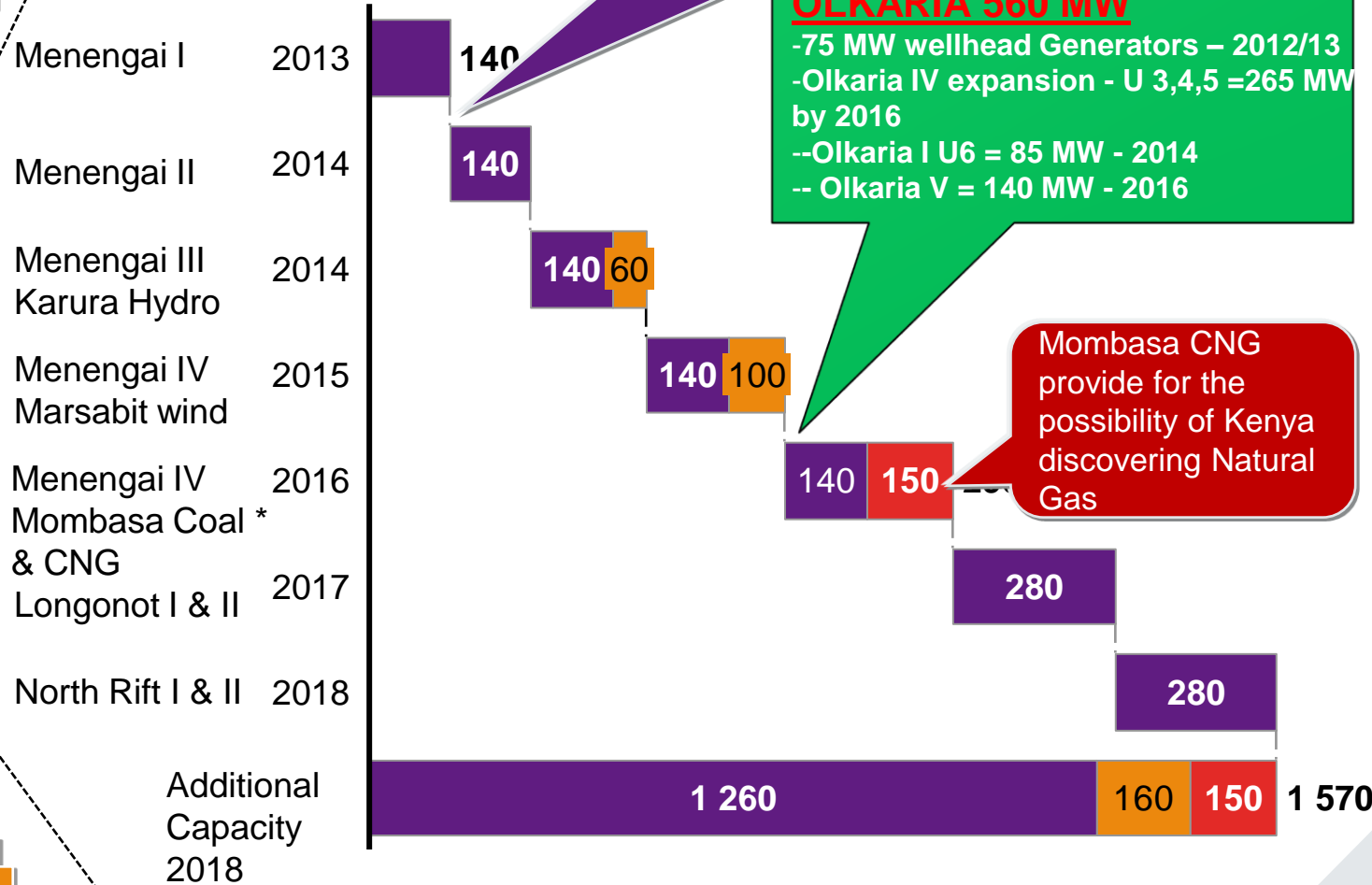
Horizon 2 project capacity
MW

■ Geothermal
■ Wind & Hydro
■ Thermal (Gas/Coal)

A 600 MW coal plant is planned by 2013/14 to provide breathing space for the geothermal ramp up

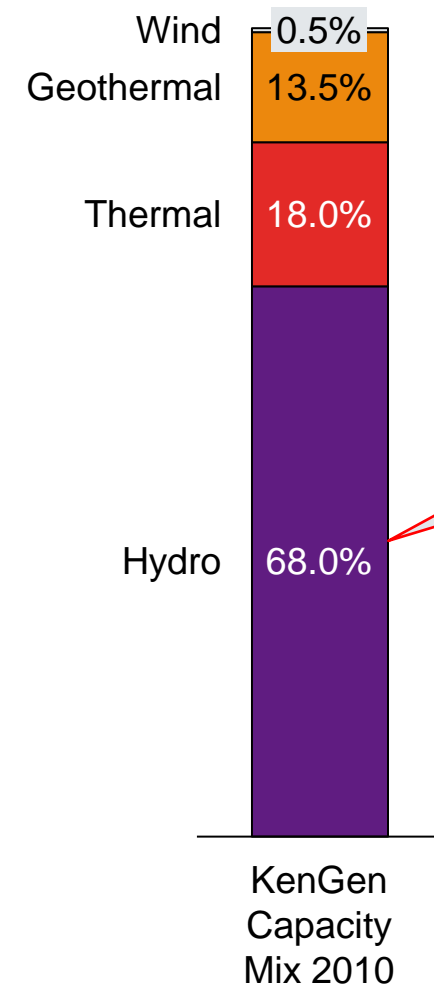
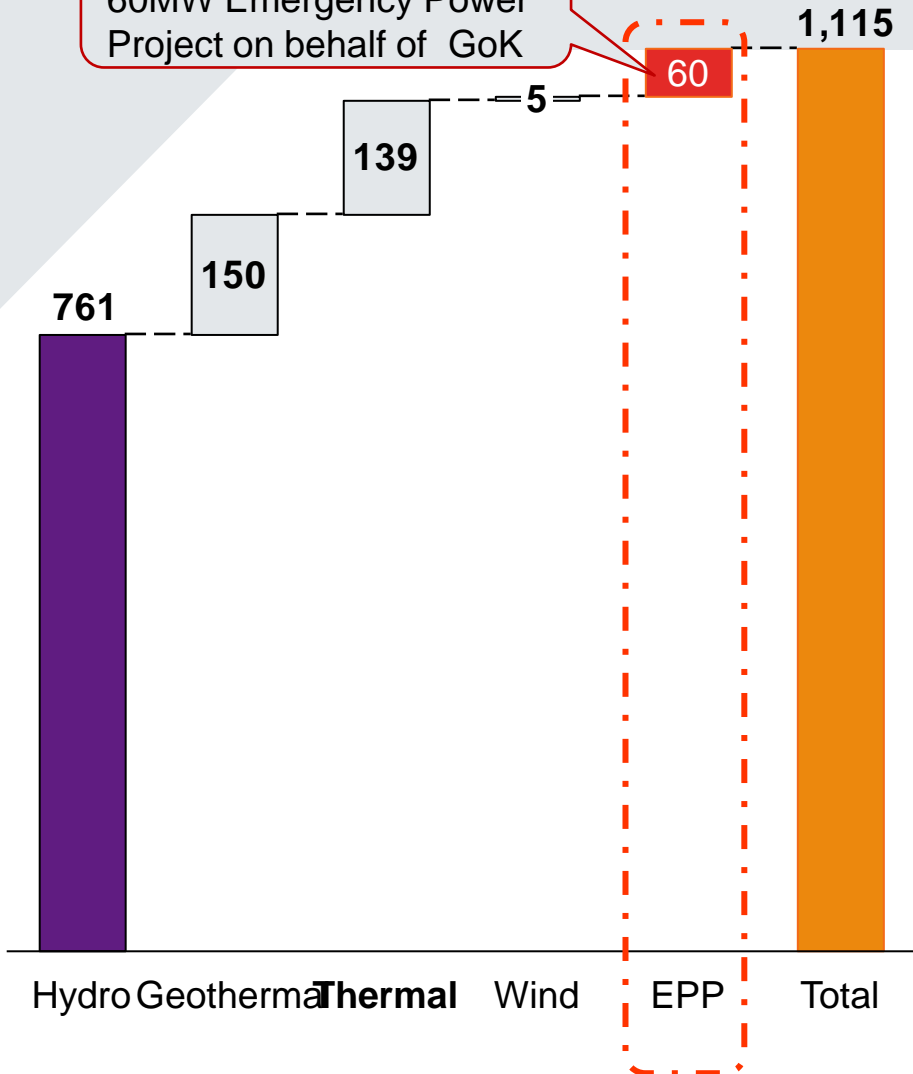
OLKARIA 560 MW
 -75 MW wellhead Generators – 2012/13
 -Olkaria IV expansion - U 3,4,5 =265 MW by 2016
 --Olkaria I U6 = 85 MW - 2014
 -- Olkaria V = 140 MW - 2016

Mombasa CNG provide for the possibility of Kenya discovering Natural Gas



OUR GENERATION MIX TODAY TO MEET DEMAND

KenGen is managing the 60MW Emergency Power Project on behalf of GoK

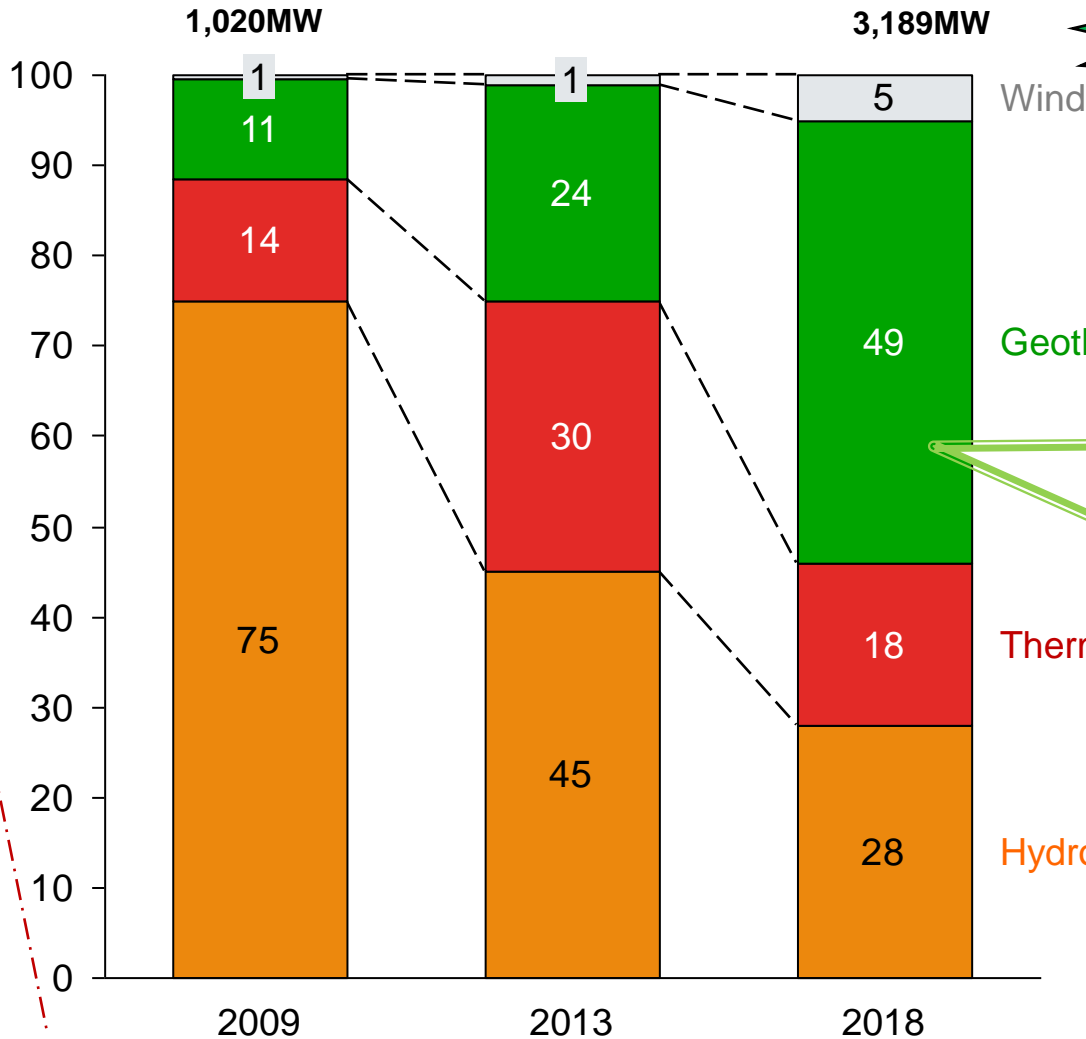
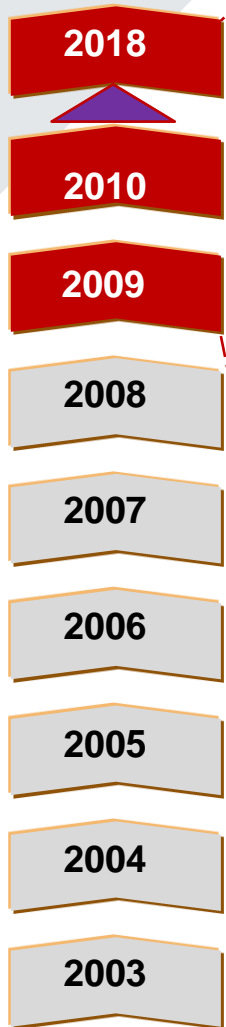


Gearing-up to transform from hydro to geothermal



BY 2018 WE ENVISION A GREEN KENGEN EARNING CARBON CREDITS

% share of generation modes



Expected CER eq = 5.24 m

... the target is a green KenGen by 2018 with 49% geothermal. A strategic shift for the better with stable revenue base...



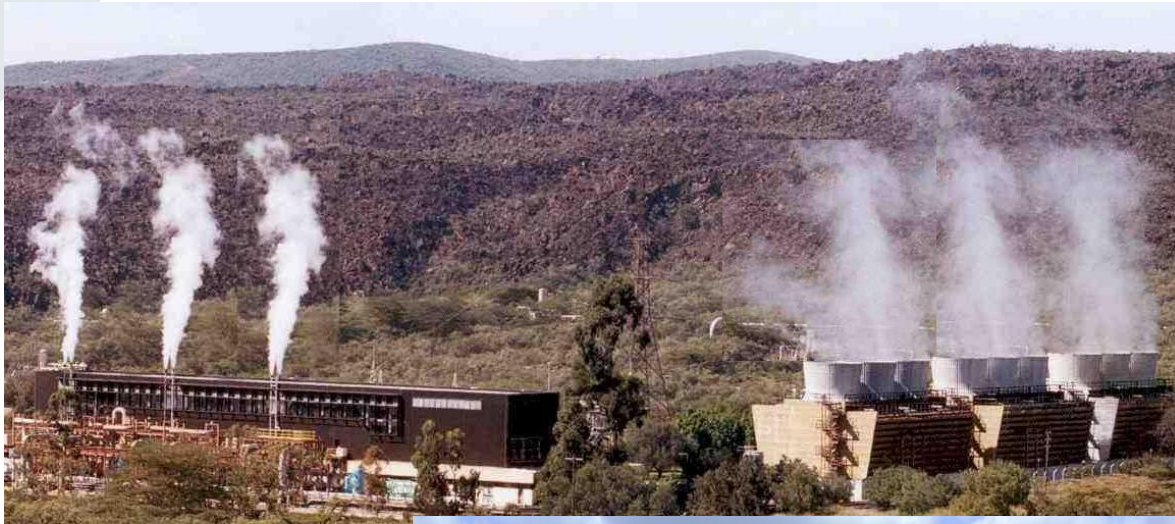
Early Generation Strategy: Installation of Wellhead Generators

- Concept;
 - to utilize existing wells before construction of main plants = **Early revenue**
 - Use makeup wells for early generation = **Early revenue**
 - Use of wells that cannot be connected to main steam system due to low/high pressure = **maximize output**
- KenGen intends to install 15 wellhead generators = 75 MW
- Pilot plant already under construction
- Currently Going to tender for more generator options??

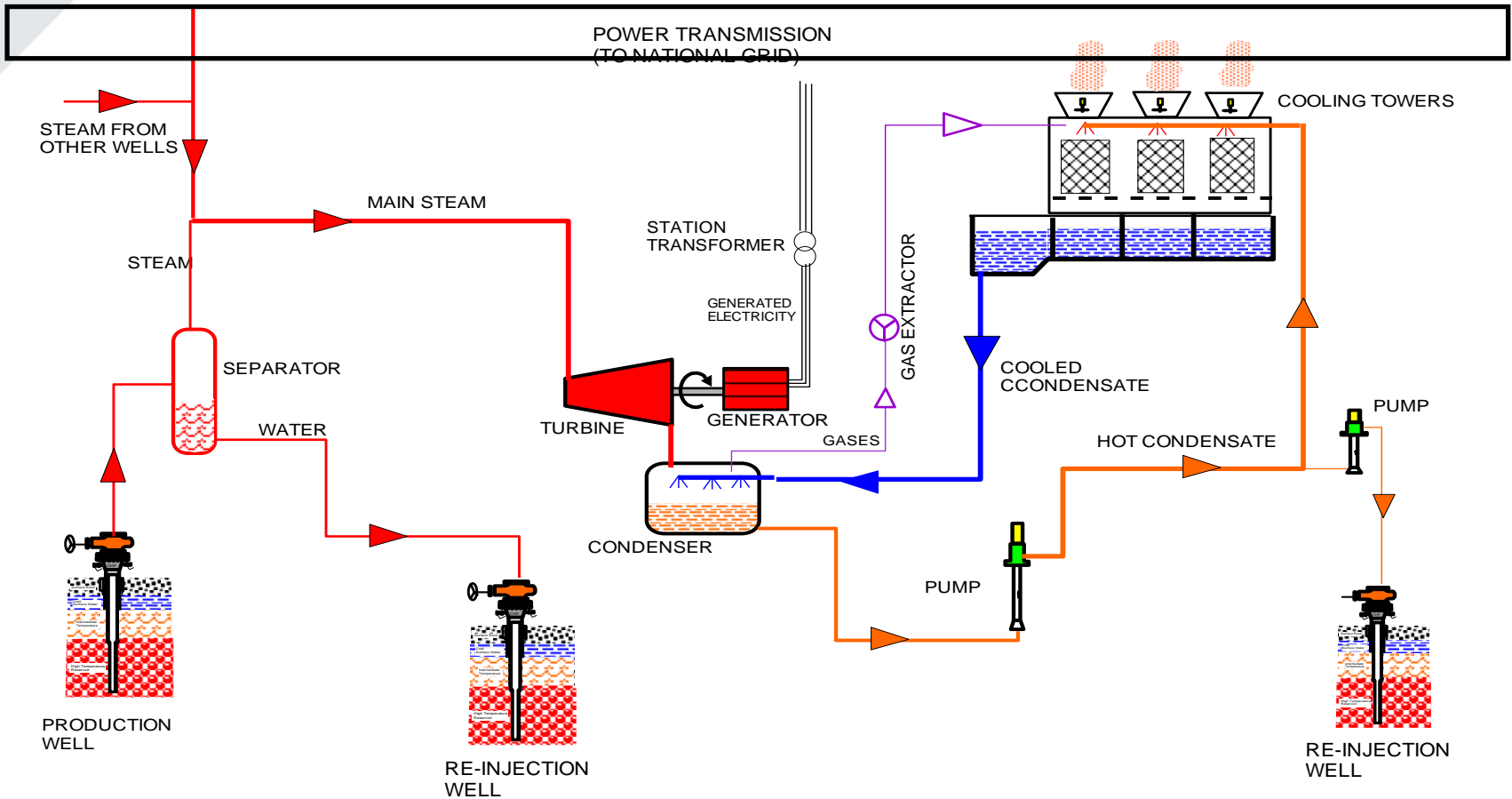


Power Generation

Olkaria I and II Power stations (150MW)

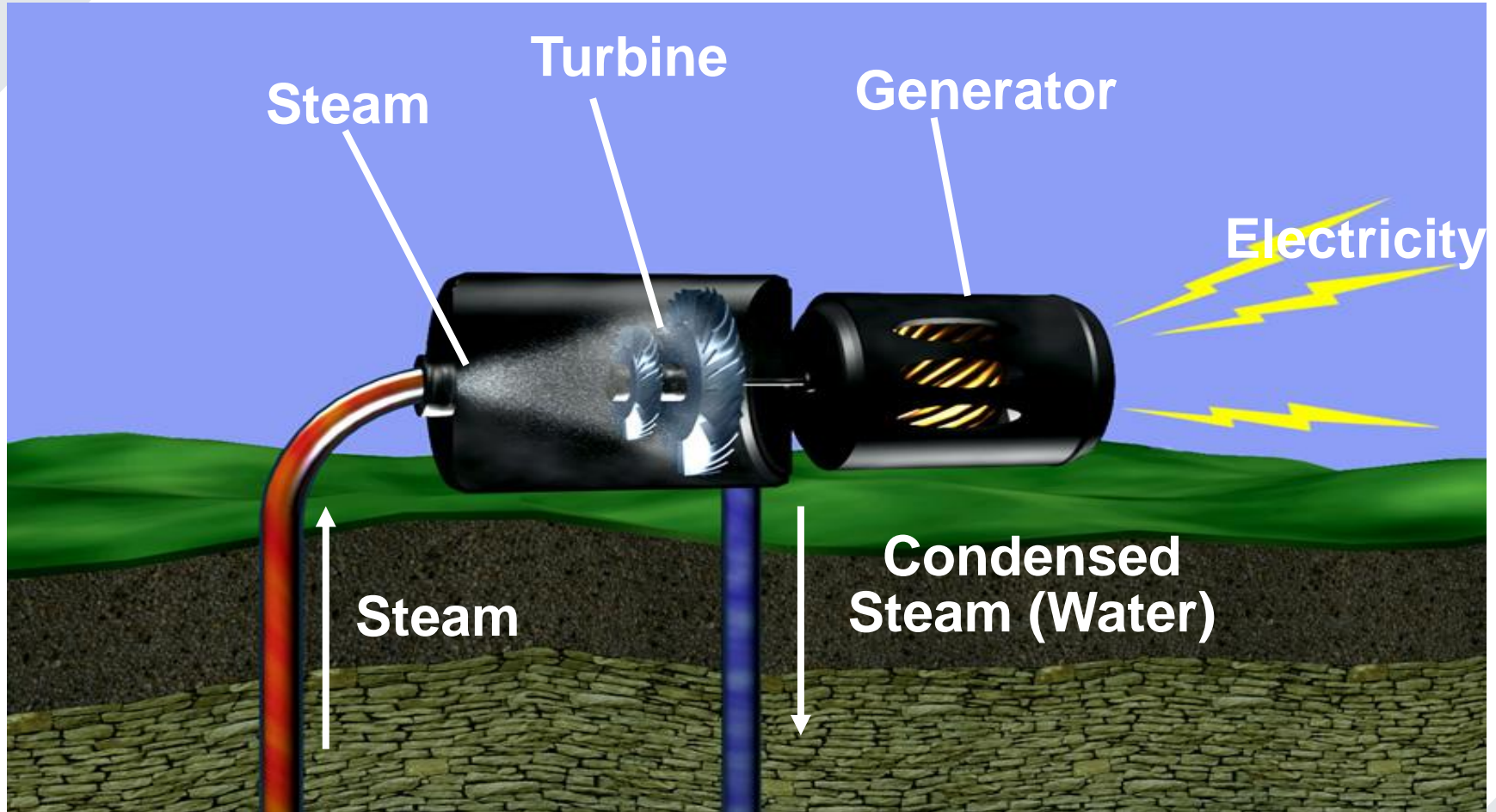


Condensing Flash Steam Plant (Olkaria I & II)

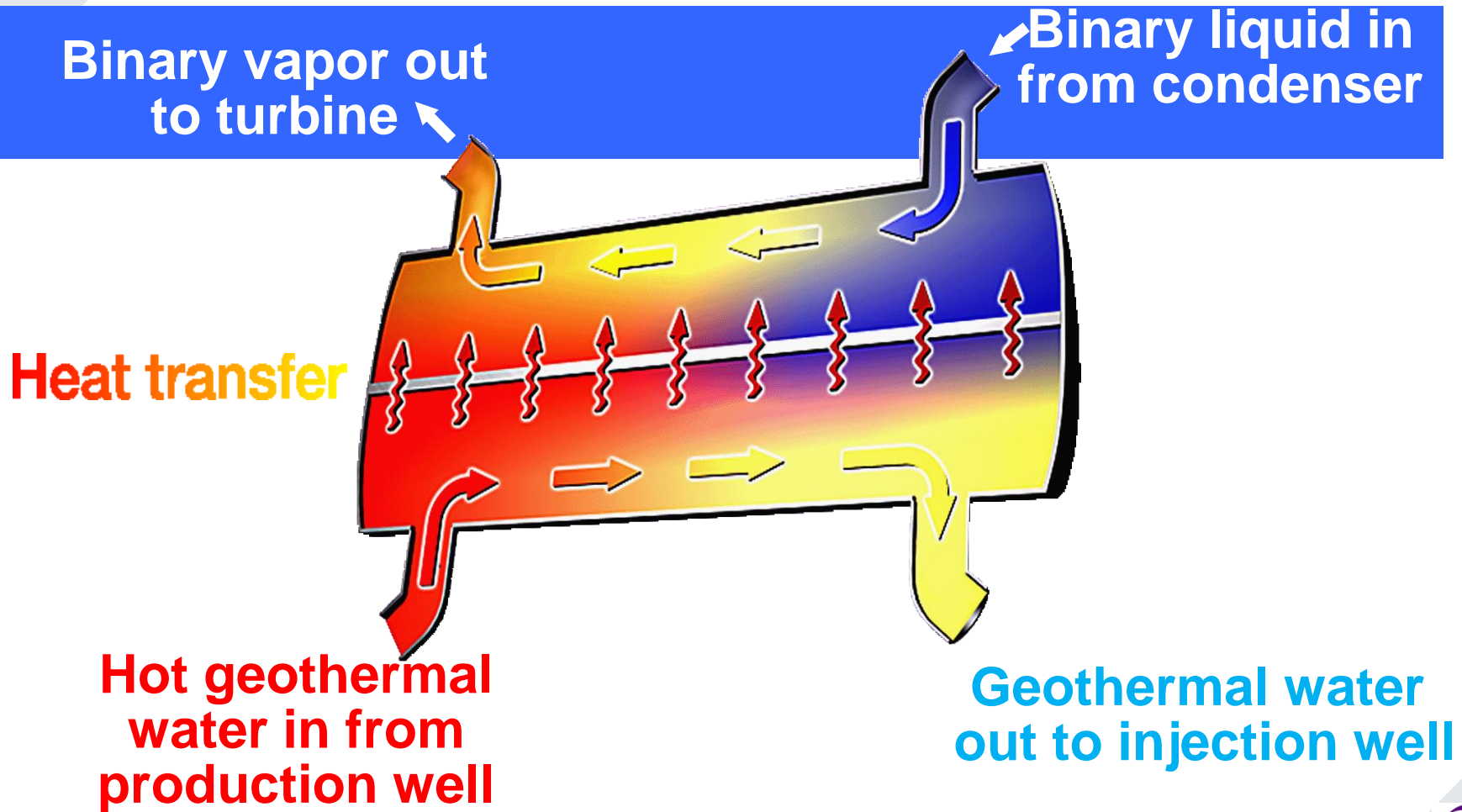


FLOW DIAGRAM

Condensing Steam Power Plant



Binary Cycle Power Plant: Heat Exchanger





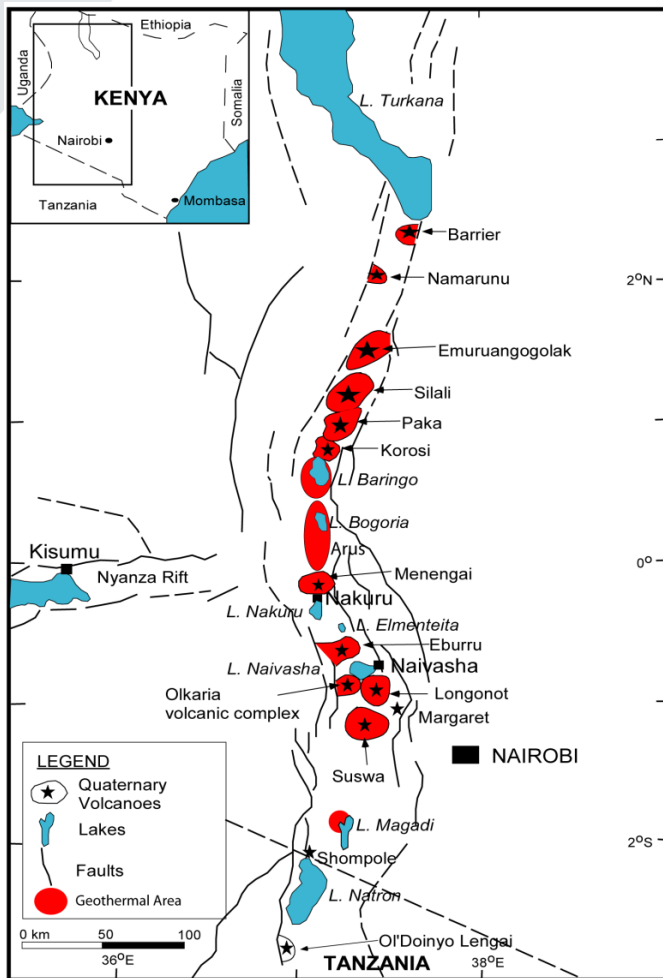
GEOHERMAL DEVELOPMENT

Kenya's Potential

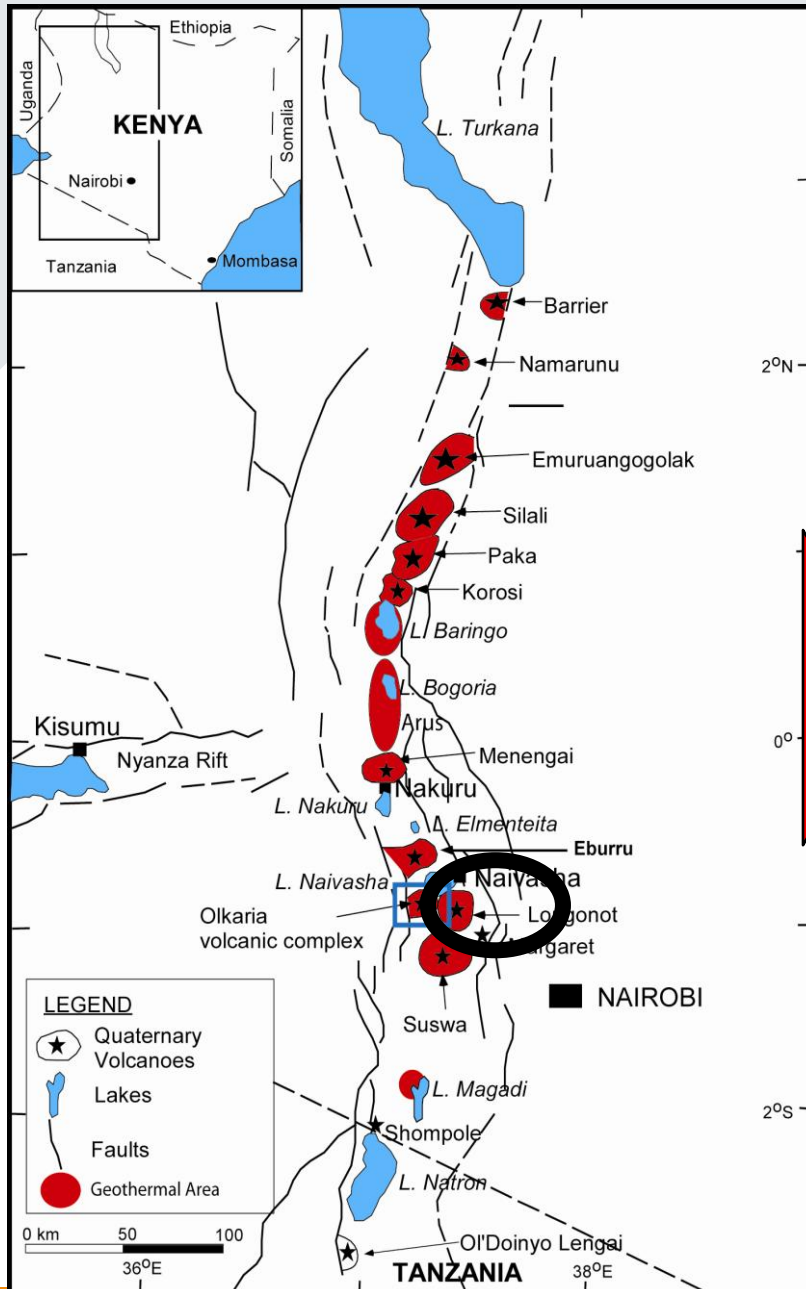
Kenya's Geothermal Potential

- Geothermal potential areas (>20 fields > 7,000 MW) within Kenya Rift.
- Current installed geothermal power: KenGen 150 MW
- IPP's 52 MW.
- Planned 280 MW

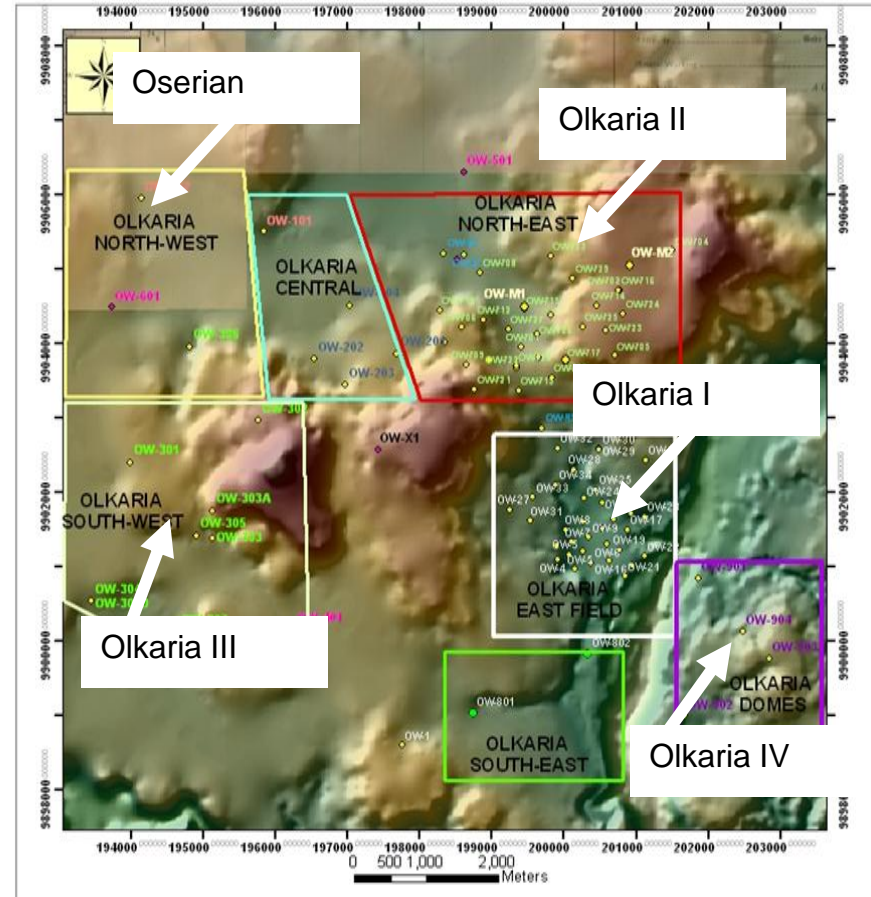
- Only a small fraction of the estimated resource potential has been developed.



LARGE GREEN GEOTHERMAL PROJECTS SITES



Greater Olkaria Geothermal Wells Map





280 MW Olkaria I and IV Development

KENYA ELECTRICITY EXPANSION PROJECT (KEEP)

FINANCING PLAN FOR OLKARIA I & IV 280MW

Million US\$

Items	GOK	KenGen	JICA	WB	AFD	EIB	KfW	TTL
Drilling Costs	313						15	328
Steam fields		7		107			54	168
Power Plant		35	323		210	135		703
Substation & Transmission	3.4					31.6		35
Consulting Services							30	30
Admin		29		12				41
Resettlement Action Plan		10						10
BoC				1				1
IDC		57						57
TOTAL	316.4	138	323	120	210	166.6	99	1,373

Exchange Rate

1 Euro = 1.4 US\$

1 US\$=KES76.5=JPY.91.5



280MW PROJECT: DRILLING STATUS

Olkaria IV Project

Over **100%** of the required steam already available – **194 MW** (tested wells)

Well testing ongoing for the remainder of the drilled wells

Re-injection well drilling to be drilled by August 2012

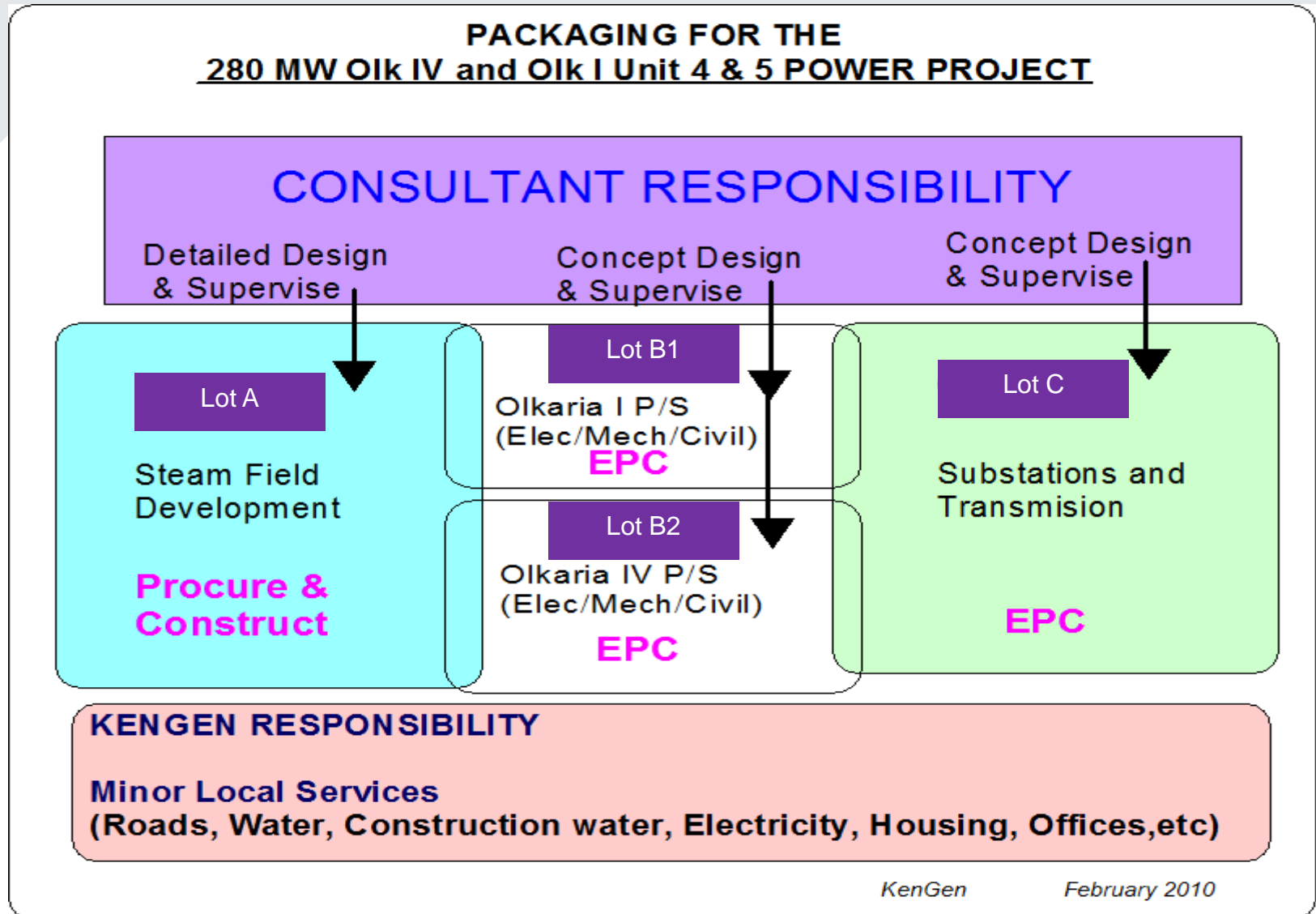
Olkaria I Unit 4&5 Project

Over **100%** of steam available at wellhead – **168 MW** (tested wells)

Drilling ongoing with hired rigs (3 GDC rigs & 1 Hired) together with KenGen N370 rig and 2 new KenGen Rigs

Well testing in progress for the drilled wells

280MW Project: PROJECT MANAGEMENT STRUCTURE

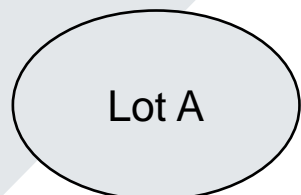


280MW Project : PROJECT INTERNATIONAL LOTS

Lots

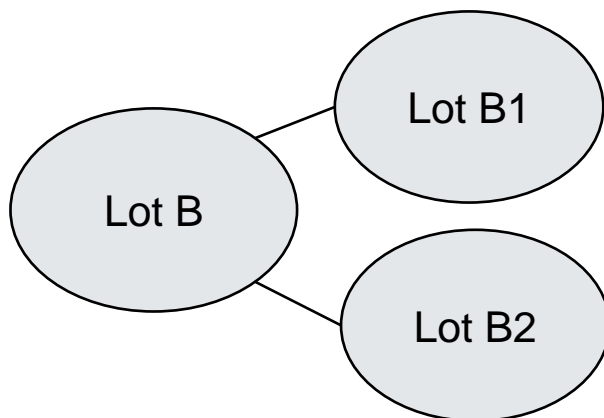
Component

Financier



Steam Field Development

IDA
KfW
KenGen

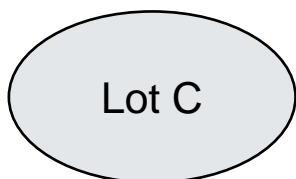


Olkaria I – Unit 4 & 5 (2x70 = 140MW)

JICA
KenGen

Olkaria IV (2 or 3 Units a total of >140MW)

AfD
EIB
KenGen



High Voltage Substations & Transmission Lines

EIB
GoK/KenGen

Consultancy

KfW
KenGen



FINANCING PLAN OF OLKARIA I&IV 280MW – AFTER LOT B EVALUATION

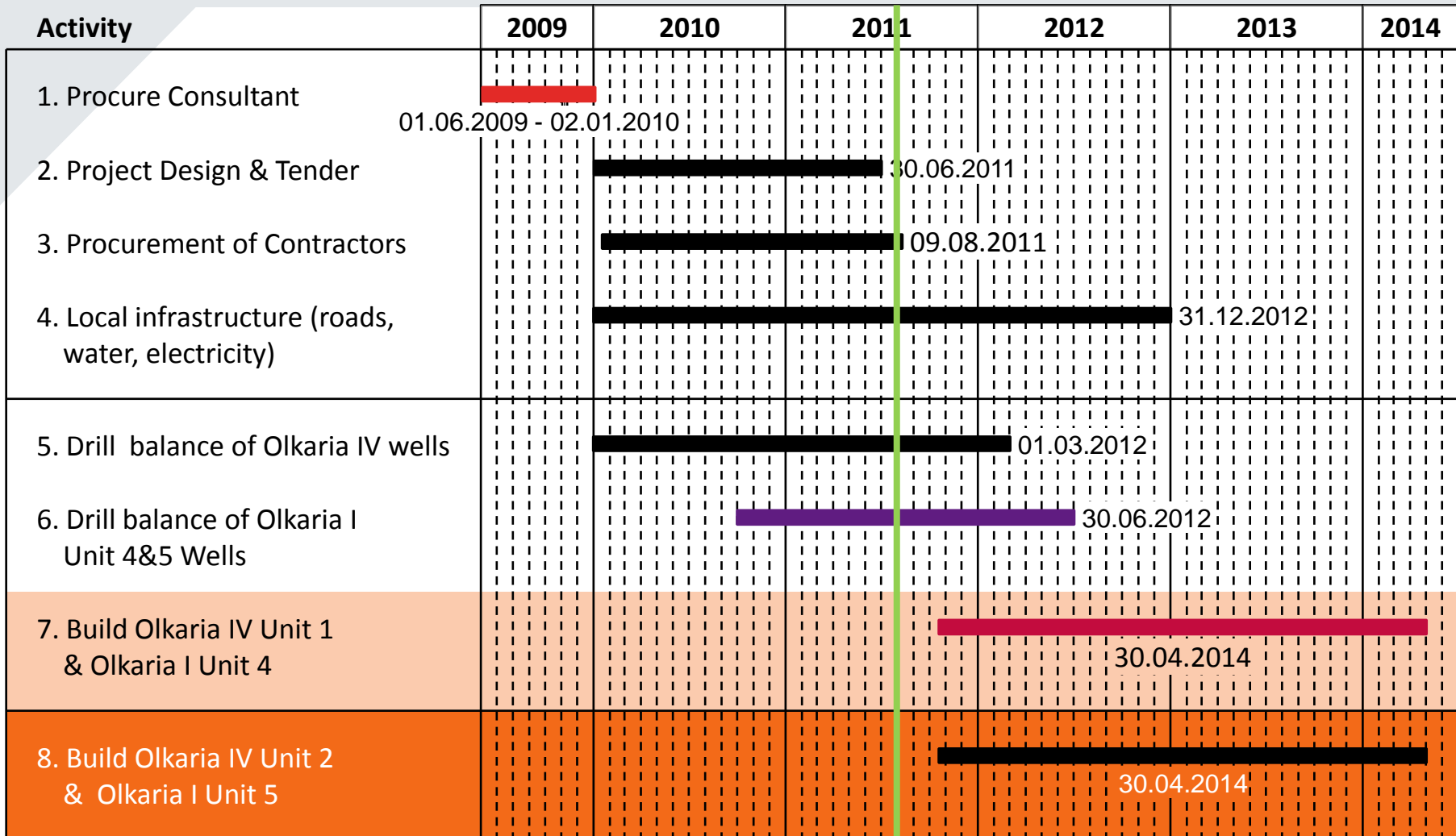
US\$ 'million				Financing Breakdown							
	Olkaria I (140MW)	Olkaria IV (140MW)	Total	GoK	KenGen	IDA	JICA	KFW	EIB	AFD	Total Funds
Drilling Costs	142	186	328	313				15			328
Steam Field	100	68	168		7	107		54			168
Power Plant	201	194	395				201		76	118	395
Substation & Transmission	22	13	35	3					32		35
Consultancy	16	14	30					30			30
Administration	20	21	41		29	12					41
Resettlement Action Plan	-	10	10		10						10
Board of Consultants	1	1	1				1				1
IDC	24	33	57		57						57
Total	526	540	1,065	316	103	120	201	99	108	118	1,065

Euro = 1.4 US\$; US\$=KES 76.5 = JPY 91.5

280MW Project : ESIA

ACTIVITY	Status
1	Environmental & Social Impact Assessment study done. License issued by the National Environmental Management Authority (NEMA).
2	EMP attached as part of Bid document for all Lots.
3	Discussions are ongoing with Project Affected Persons (PAPs) in view of the implementation of the Resettlement Action Plan (RAP).

GEOHERMAL DEVELOPMENT IN KENYA – THE NEXT BIG PROJECT FOR US – OLKARIA I&IV 280MW (TIMELINES)



10th Aug 2011





Olkaria Optimized Development

Olkaria 560 MW Development

Olkaria Expansion – 560 MW

❑ Olkaria Optimization –

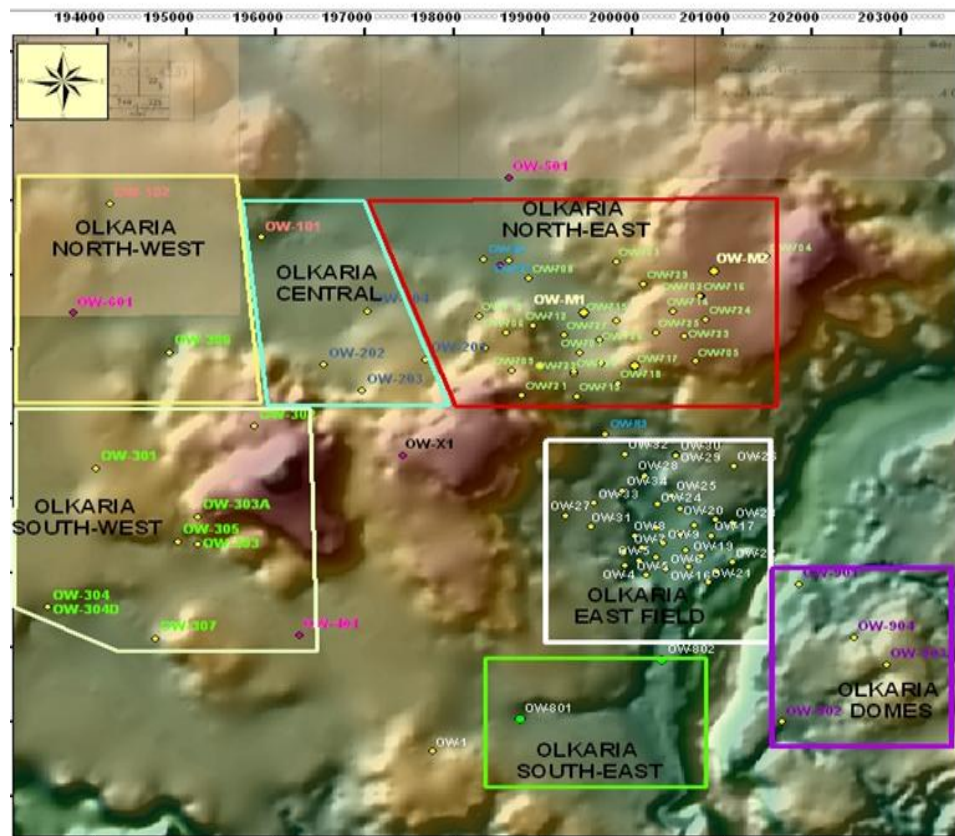
- Current licence area = 204 Km²
- Area under utilization by 2013 (after 280MW) = 24 sq km

❑ Propose to develop additional 560 MW

- Update conceptual model
- Update Reservoir Model
- Optimization study
- ESIA study

Estimated Resource Size = 80 km²
~ 1,200 MW

Greater Olkaria Geothermal Wells Map

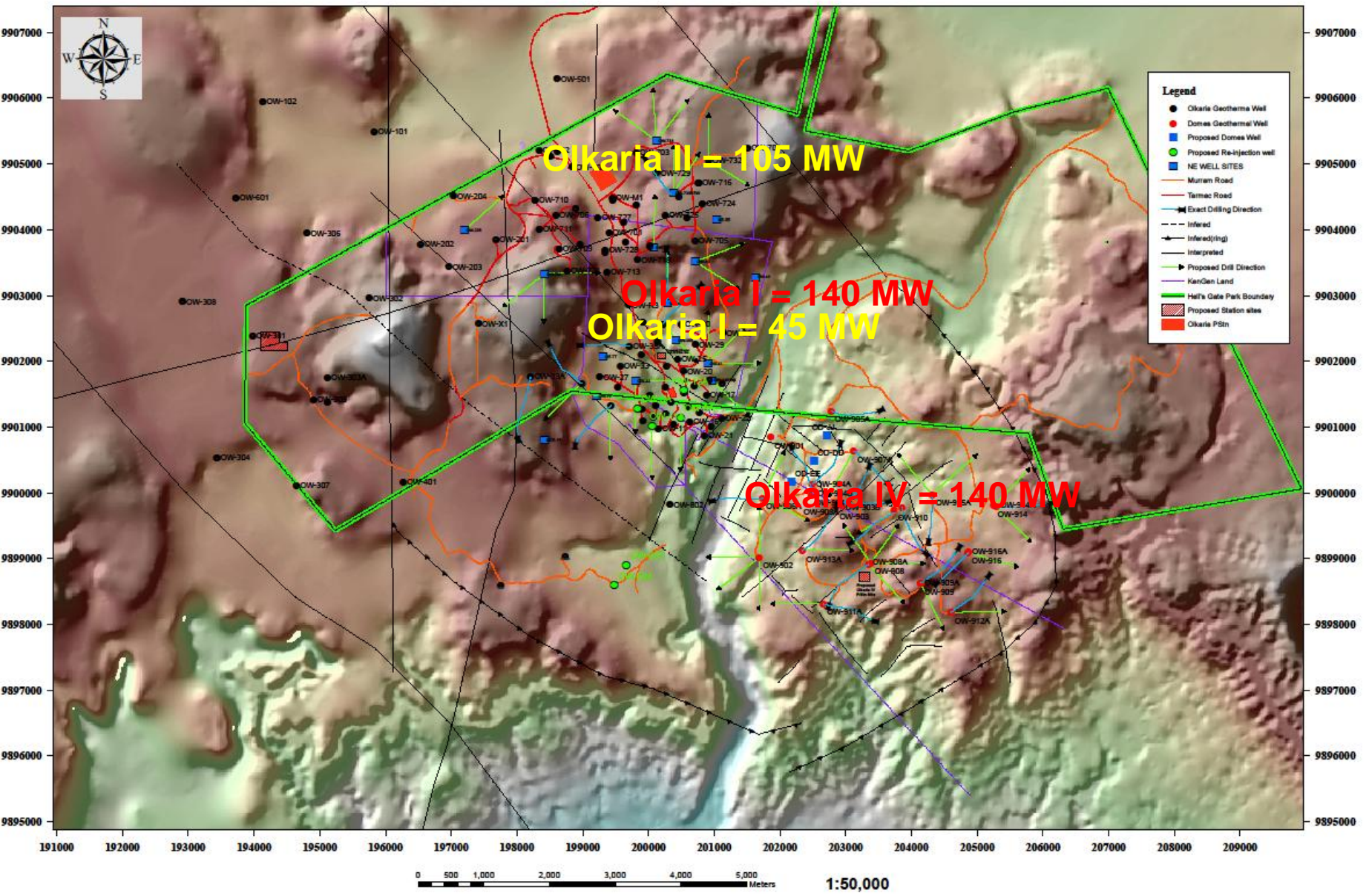


Optimization Study 2011 Schedule

Completion and submission of reports Months	Start	Finish	Duration	0	1	2	3	4	5	6	7	8	9	10	11
	Inception report	-	-		▲										
Revised conceptual model.	-	-						▲							
Short report on results of volumetric assessment and lumped parameter modelling								▲							
Preliminary assessment of the electrical generating capacity of greater Olkaria geothermal system						▲	▲								
Report on the numerical model and model predictions.	-	-										▲	▲		
Report on field development plan.	-	-										▲	▲		
Short report on evaluation of physical constraints										▲					
Report on feasibility study for stabilizing power generation with an optimized capacity of the existing plants and environmental project report	-	-									▲		▲		
Report on feasibility study of additional generating units and environmental project report	-	-												▲	▲
Final reports	-	-													▲



GEOHERMAL RESOURCE MAP



GRD MAJOR PROJECTS & DUE DATES

Plant	Capacity, MW	Due date
Eburru	25	2014
Olkaria IV (units 3, 4 & 5)	240	2015
Olkaria I (unit 6)	70	2016
Olkaria V	110	2016
Olkaria II Unit 4 & 5	140	2017
Total	585	2017

DRILLING PLAN

PLANT	Proj.	Mwe	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	Balance WELLS	
280 MW Development											
Olkaria IV Unit 1 & 2	280 MW	140	2		Comm					2	
Olkaria I Unit 4 & 5		140	19		Comm					19	
545 MW Development											
Eburru	25 MW	25		5	2	Comm				7	
Olkaria IV Unit 3 (Wellhead)	520 MWe	75	4	18		Comm				22	
Olkaria IV Unit 4 & 5		165		6	24	18	Comm			48	
Olkaria I unit 6		70			3	8	10	Comm		17	
Olkaria V		110				3	13	17	Comm	33	
Olkaria II Unit 4 & 5		100					6	12	13	Comm	41
Menengai I		400						Comm			
Total		1262	18	25	30	36	42	42	33		
No of Rig required			3	5	6	6	7	7	6		

- ✓ The plan requires 3 Kengen Rigs and 3 hired rigs to be actualized
- ✓ Eburru to be drilled first to get returns earlier
- ✓ KenGen Rig 1 & 2 have rigged up

CP2 BUDGET (MUSD) REQUIREMENTS

PROJECT	Mwe	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	
Olkaria IV Unit 3 (Wellhead)	75	24.72	109.17						133.89
Eburru	25		15.47	6.19					21.65
Olkaria IV Unit 4 & 5	165		26.79	135.96	117.40				280.14
Olkaria I unit 6	70			9.28	24.74	55.62			89.64
Olkaria V	110				9.28	77.24	106.08		192.60
Olkaria II Unit 4 & 5	100					18.56	32.93	40.21	91.70
Total CP2	545	24.72	151.42	151.42	151.42	151.42	139.01	40.21	809.62

- ✓ Hired Rigs Cost/Well – 7.208MUSD
- ✓ KenGen Rigs Cost/Well – 3.093



Direct Uses

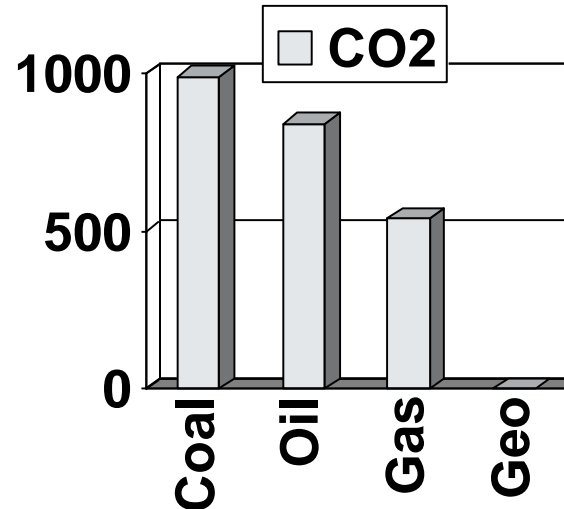
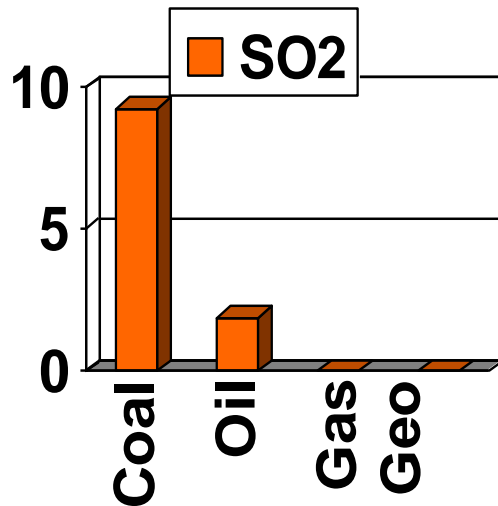
Geothermal Energy Utilization: Direct Use –Oserian Green houses (Kenya)

- i) Cut Roses Greenhouse Heating, ii) Refrigeration of cut flowers storage and processing stores, iii) Injection of CO₂ to aid in photosynthesis, iv) Fumigation of soils and sterilization of liquid recycled plant fertilizers



Geothermal and the Environment

- 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

Environmental Management 1

Exploration Stage:

- Carry out Baseline Environmental conditions assessment -
 - Determine the in-situ condition
 - High-light and assess the sensitivity of the area to development
 - Cost the possible environment impact and mitigation measures
 - Determine the potential Social Economic Impacts of the project
 - Gather data on the potential Volcano Seismic hazards of the area
 - Use the data as a basis for a **GO** or **NO GO** decision making

Feasibility study stage:

- Carry out a full ESIA with disclosure
 - Use it as a basis for planning, monitoring and management
 - Requirement for licensing of the project by NEMA
 - Part of the feasibility study

Environmental Management 2

Put in Place and Enforce Sound Field and Environmental Management Procedures

- Community based Corporate Social Responsibility (CSR) program

- Reservoir monitoring and management

 - Re-injection.

 - Maintain reservoir pressure and fluid mass recharge

 - Avoid contamination of ground water & Subsidence

 - Rehabilitation of disturbed areas during construction

 - Return the area close to its natural beauty

Ecological monitoring and friendly designs of works.





THANK YOU



Clean Renewable Energy