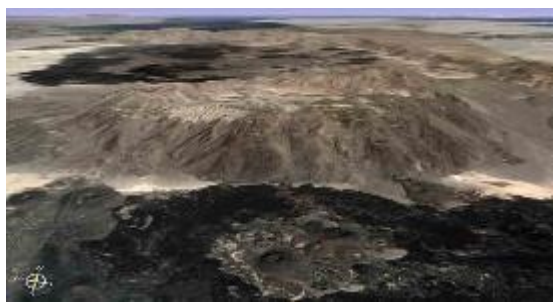


# PROSPECTS OF GEOTHERMAL ENERGY IN ETHIOPIA

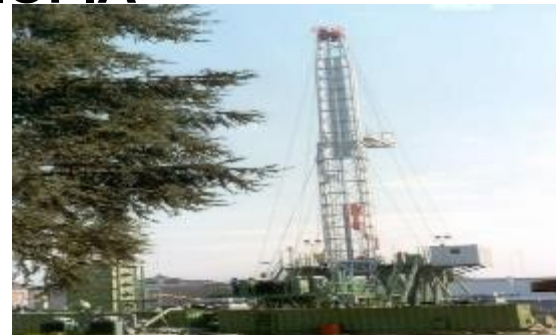


**MESERET T ZEMEDKUN**

**ETHIOPIAN WATER AND ENERGY WEEK**  
**MOWIE**

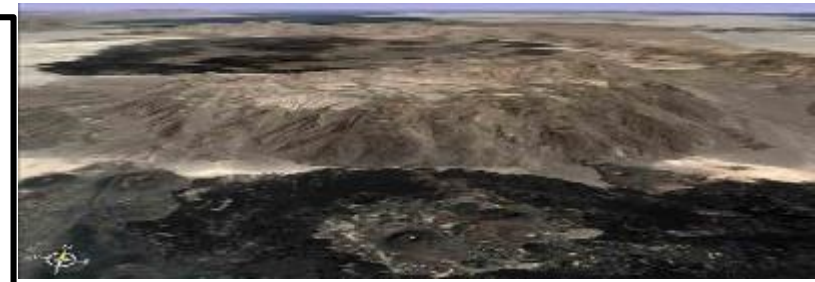
**18 JUNE 2019**

**ADDIS ABABA, ETHIOPIA**



## PRESENTATION OUTLINE

- Geothermal Energy, distribution and uses
- The East African Rift System and geothermal resource
- Prospects of Geothermal Energy in Ethiopia
- Solutions to fast track geothermal resource development in the country
  - ✓ The Resource
  - ✓ Government
  - ✓ Laws and regulations
  - ✓ The People
  - ✓ Technology
  - ✓ Private Investors
- ✓ Conclusion



## RE Development in responding to Global and continental development agendas and policy processes

Combination of adoption of Paris Agreement 2015 &  
GOAL 7 of SDG 2030

Designation of 2014-2024 as a decade of UN SE4ALL

Continental AU AGENDA 2063- Africa We Want

AU-Programme for Infrastructure Development in Africa

AFRICA RENEWABLE ENERGY INITIATIVE

AFRICA ENERGY MINISTERS (CEMA) DECLARATIONS

NATIONAL DEVELOPMENT STRATEGY (CRGE)

New integrated approach of **decarbonized, decentralized, de-risked investment and democratized energy paradigm services**

Reach universal modern energy access by 2030  
in pursuit of  
**the global agenda of the Sustainable Development Goals and AU Agenda 2063.**

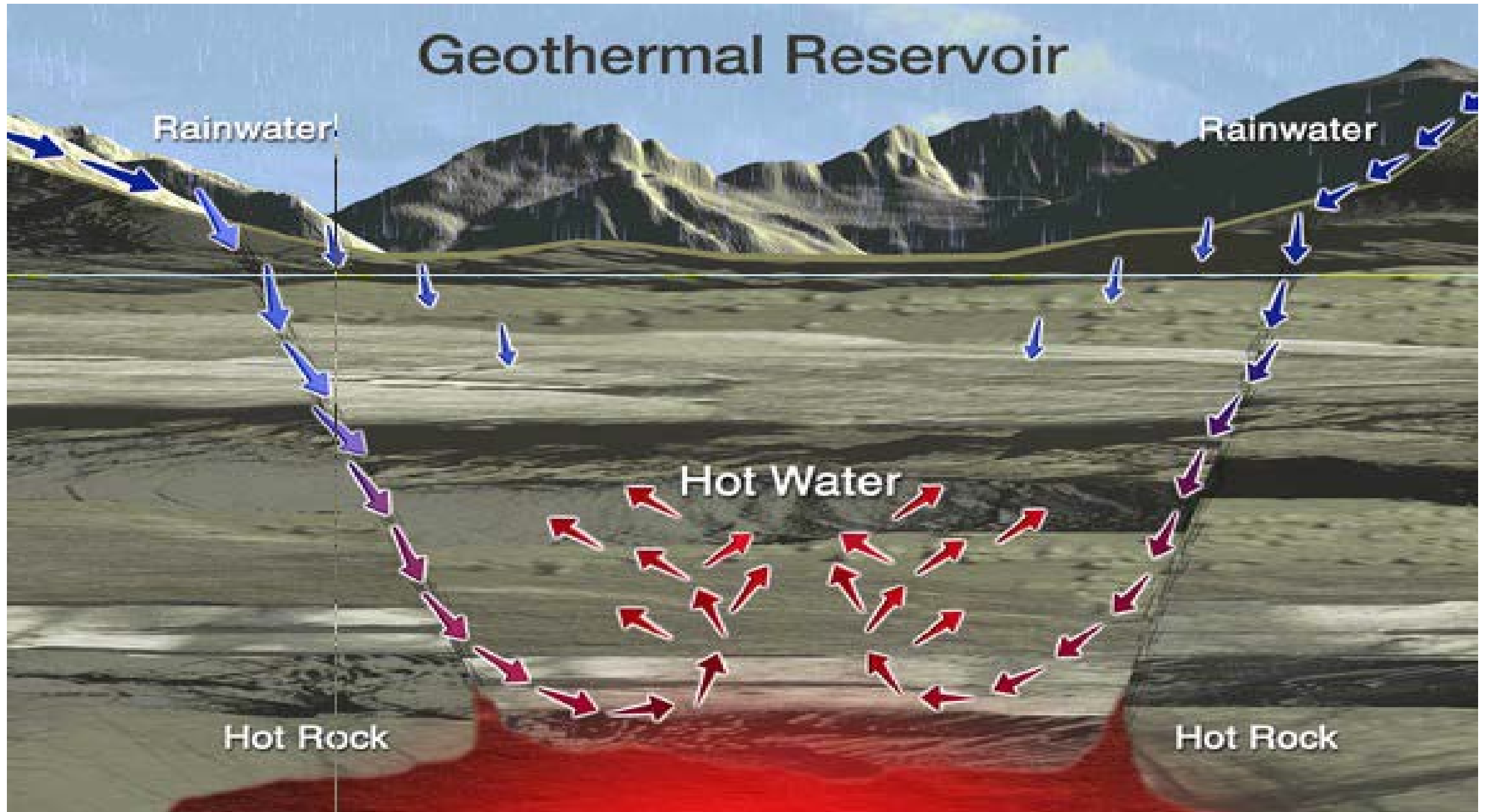




## ENERGY TRANSITION- RENEWABLE ENERGY SOURCES



**Geothermal Energy** is the thermal energy produced and stored in the center of the earth.



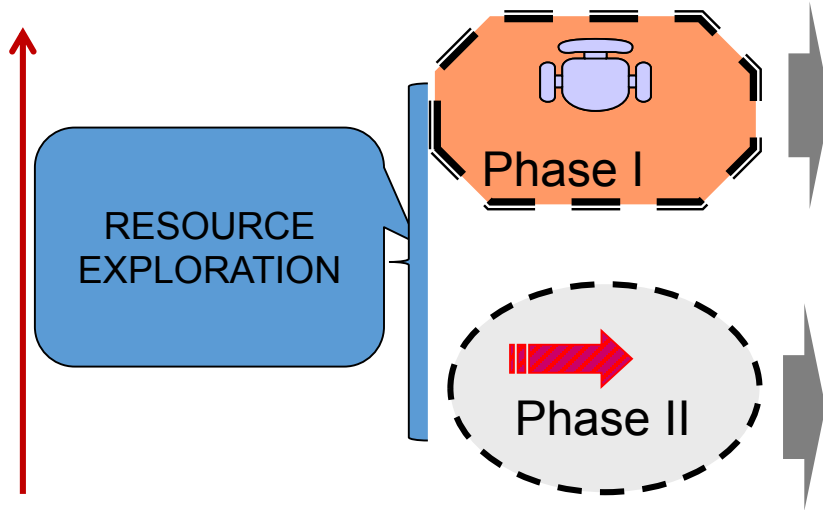
# Why Geothermal?



- Indigenous and Renewable
- High degree of availability (>98%)
- Base load power generation, Generation Mix
- Reduced vulnerability to weather & climatic variations- ES
- Provides clean and safe energy using little land
- Proven technology
- Flexible expansion to meet demand
- Power generation and direct heat applications
- Reduced GHG emissions



# Geothermal Exploration and Development



## Resource Exploration

1. Prospecting
2. Detailed Surface Exploration
3. Exploration Drilling and Well Testing

## Resource Assessment

1. Appraisal Drilling
2. Feasibility Studies

## Power Plant Development & Operations



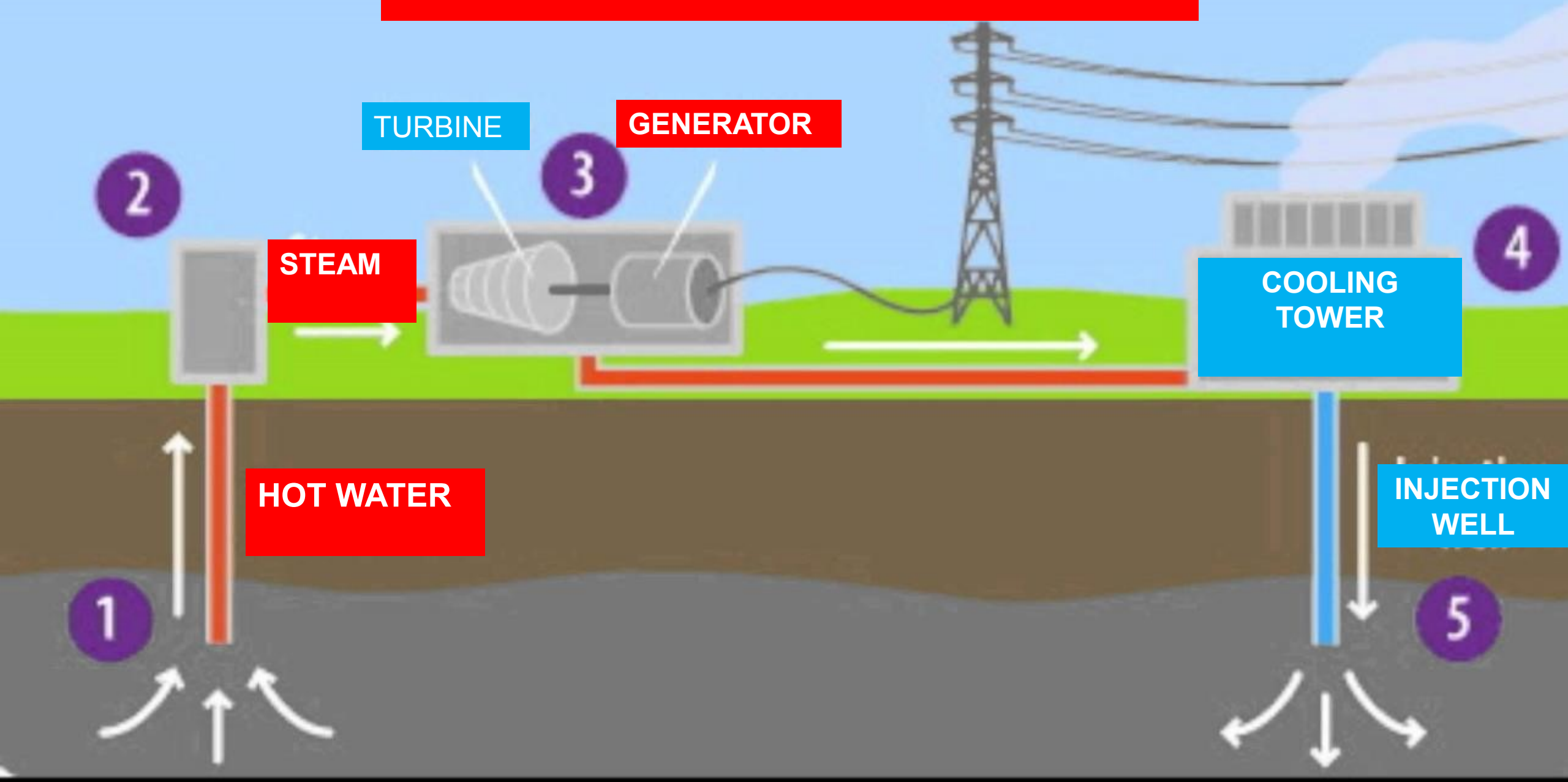
Phase III

1. Production Drilling & Well Testing
2. Environmental & Social Impact Assessment(ESIA)
3. Steam Field Development
4. Substation & Transmission Line Development
5. Power Plant Construction & Operations
6. Resource Management & Further Development

Power Developers



# GEOHERMAL POWER PLANT





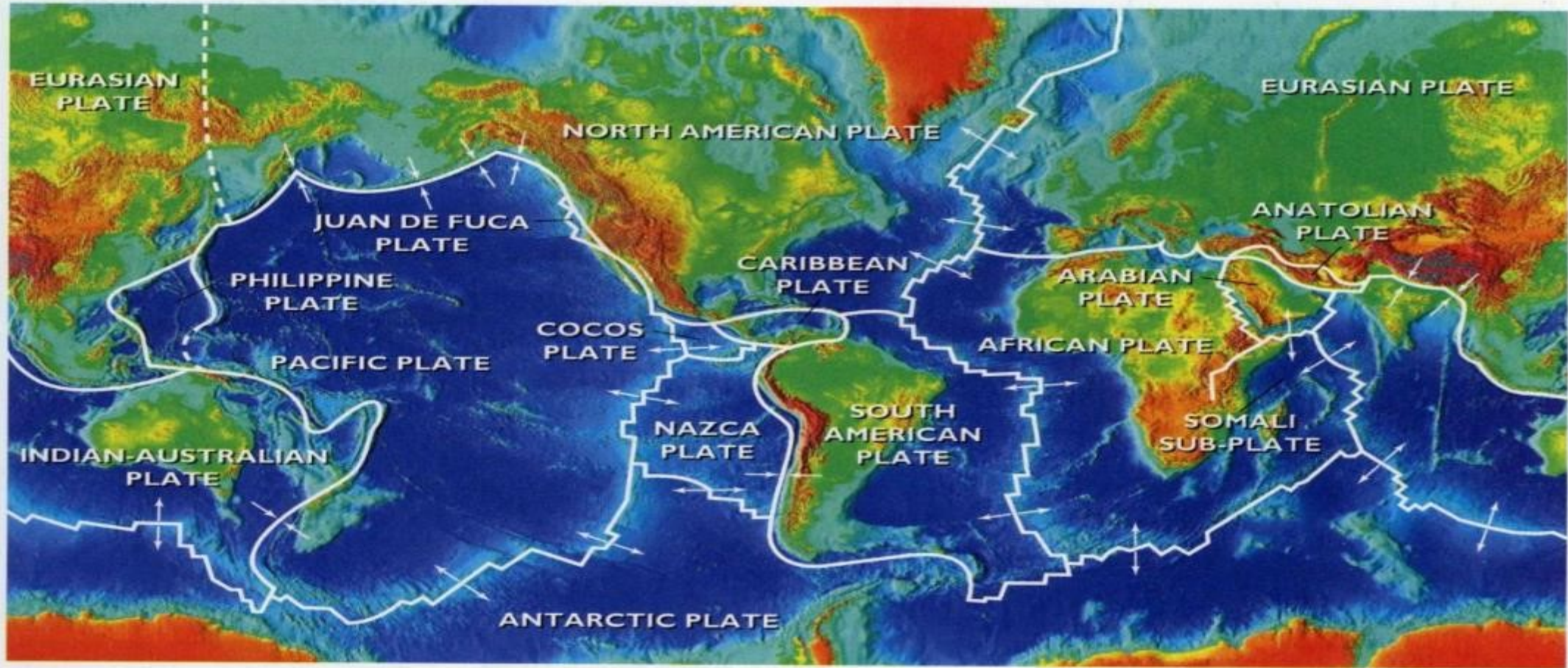
# Irrigated & Greenhouse Farming





# WORLD GEOTHERMAL RESOURCE

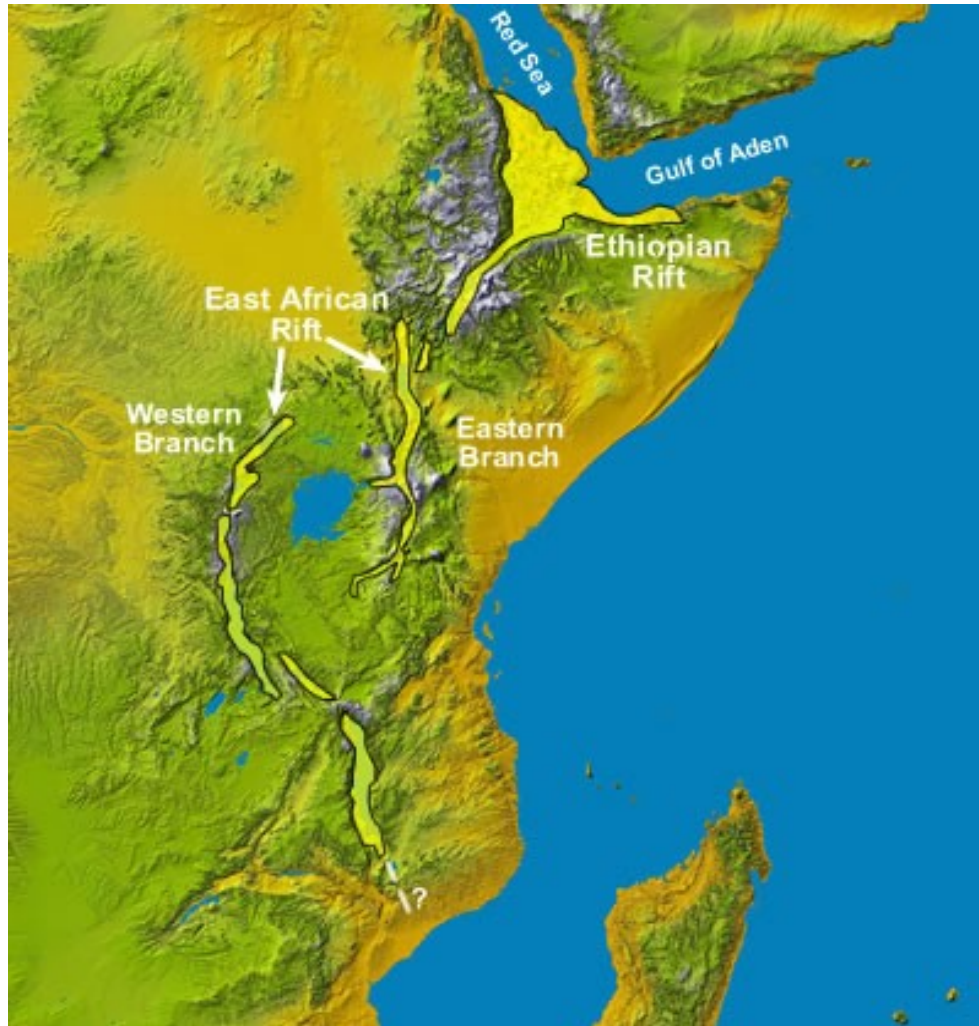
Associated with various Tectonic Regimes



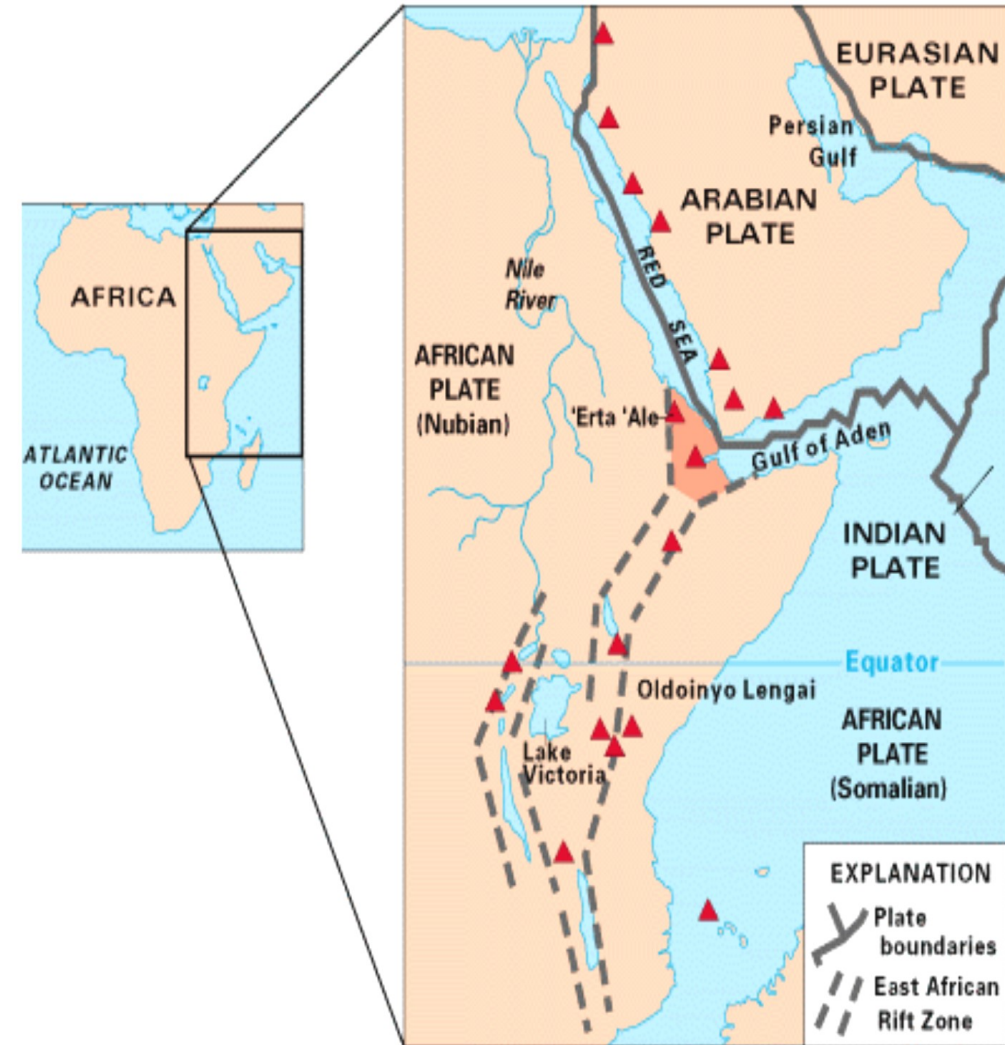
Globally - **24 countries use geothermal for power generation 14.2 GW (2018)** and about 83 countries for direct uses:



# THE EAST AFRICAN RIFT SYSTEM



**Extends about 6500 Km from the Dead Sea (North) to Mozambique (South)**



**Huge Geothermal Resource with Estimated Potential of > 20,000 MWe**



# African Countries with Geothermal Resources

Geothermal resource for both power generation and direct use application



- Algeria
- Burundi
- Comoros
- Djibouti
- DRC
- Egypt
- Eritrea
- Ethiopia
- Kenya
- Madagascar
- Malawi
- Morocco
- Mozambique
- Nigeria
- Rwanda
- South Africa
- Sudan
- Tanzania
- Tunisia
- Uganda
- Zambia

# Geothermal Resource **Potential** in EA

- Africa's geothermal **potential in the Eastern Africa Rift** > 20,000 Mwe
- Currently (2019) **only Kenya** has operational **geothermal power stations** (about 673 MWe)
- There are plans to increase geothermal installation in Eastern Africa by over **3,000MW over the next 10 years**
- Geothermal energy in North African countries is mainly low to medium temperature **for direct applications**

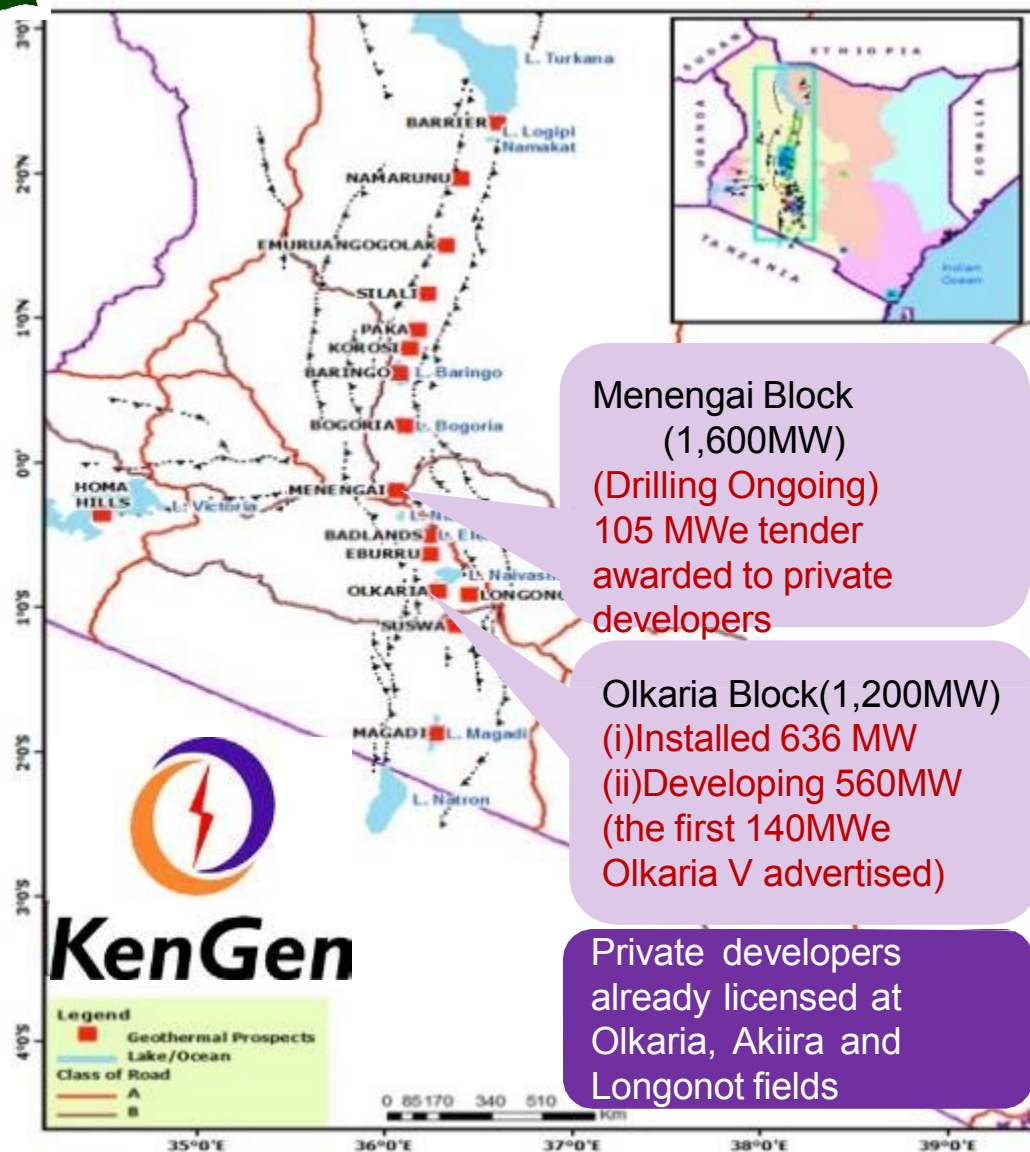




# GEO THERMAL POTENTIAL IN KENYA

> 10,000MW in over 23 sites

- Suswa,
- Longonot,
- **Olkaria,**
- **Eburru,**
- **Menengai,**
- Arus-Bogoria,
- Lake Baringo,
- Korosi,
- Paka,
- Lake Magadi,
- Badlands,
- Silali,
- Emuruangogolak,
- Namarunu
- Barrier
- Mwananyamala
- Homa Hills
- Nyambene Ridges
- Chyulu Hills





# NEW DISCOVERIES : 30 MW Well (Among the largest geothermal wells in the world)

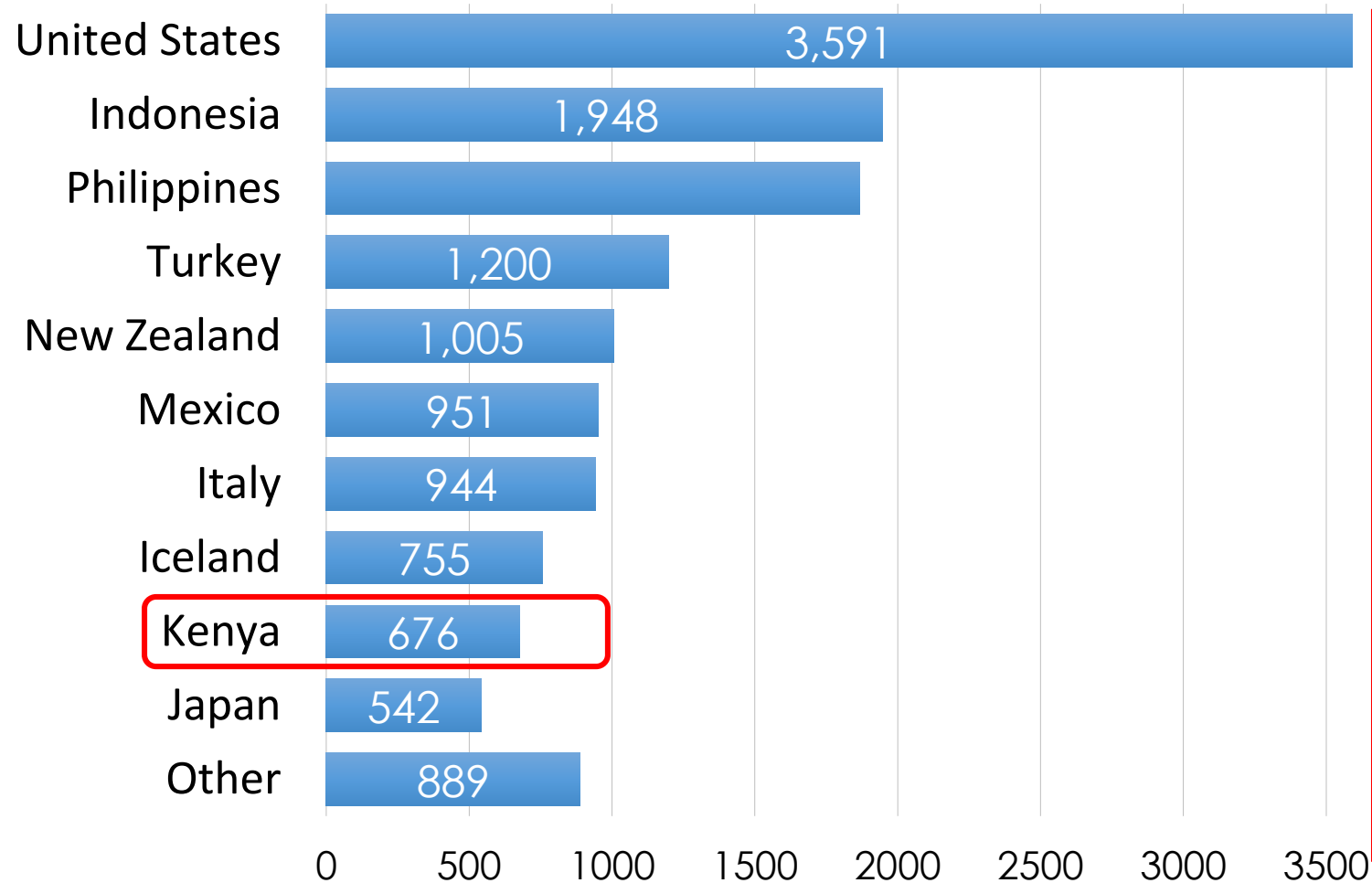
**Direct Cash  
Savings by  
striking 30 MW  
Wells**

**OW - 921A**  
DRILLED DEPTH : 3000M  
CASING SHOE : 1084M  
MAXIMUM TEMP : 330°C  
**OUTPUT PARAMETER (CHOKKOTLED)**  
TOTAL MASS OUTPUT : 414 T/hr  
BRINE OUTPUT : 207 T/hr  
STEAM OUTPUT : 176 T/hr  
**POWER OUTPUT : >30MW<sub>e</sub>**



# TOP 10 GEOTHERMAL COUNTRIES

Total Installed capacity (MW) as of Sept. 2018 Total 14,369 MWe



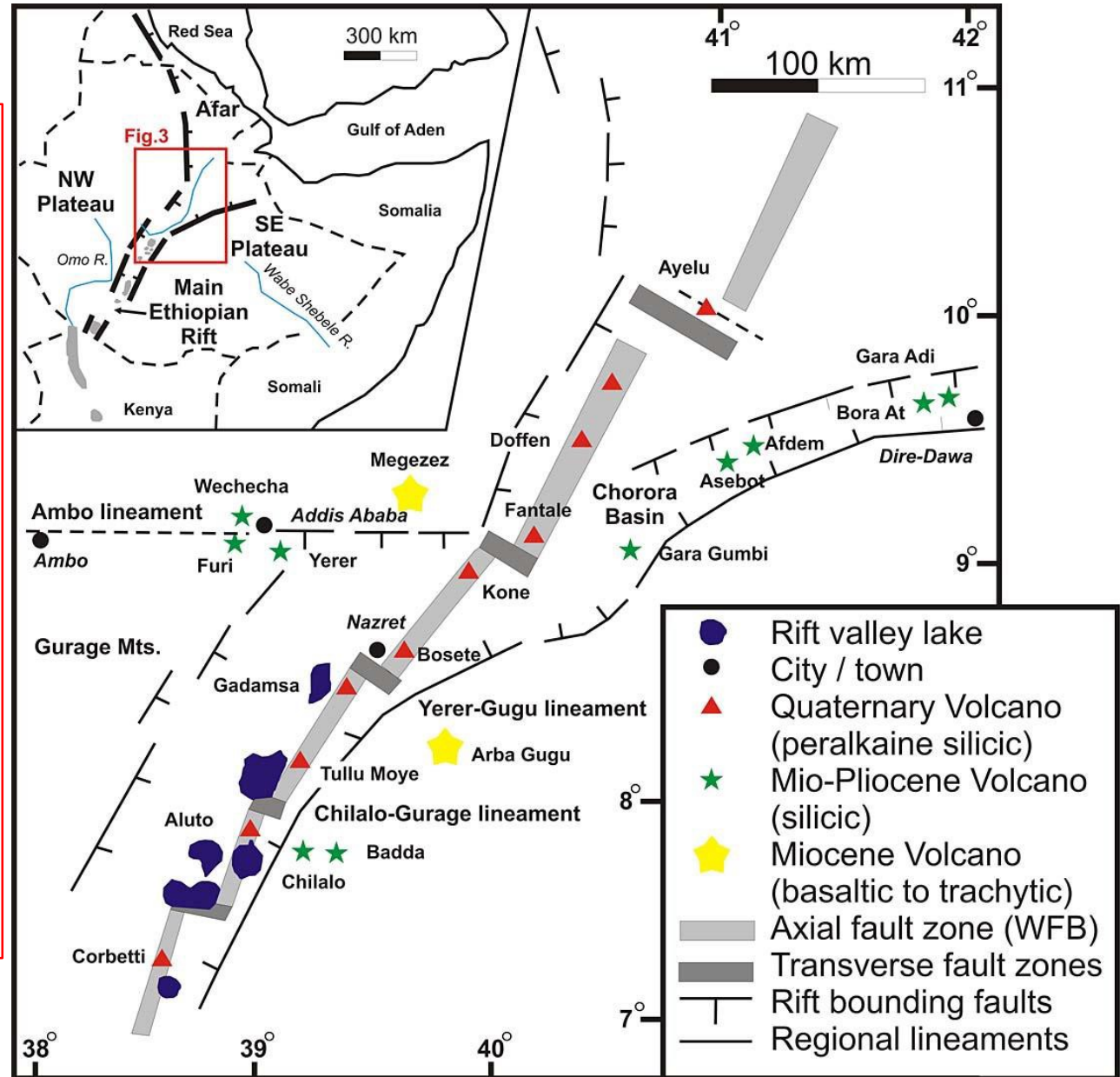
Africa Plans expansion as follows by 2025:

- Kenya- 1,352 MW (Menengai, Olkaria, Barrier, Homa Hills, Akiira, Suswa)
- Ethiopia -985MW (Aluto, Corbeti, Tulu Moyo, Tendaho)
- Djibouti-250MW

# ETHIOPIAN RIFT SYSTEM

## Main Ethiopian Rift and Afar RIFT

- The Wonji Fault Belt
- Volcano hosted high temperature **geothermal systems with fracture permeability**







# ETHIOPIA



- Ethiopia has actively been exploring for its **geothermal resources since 1969 – 50 YEARS**
- Over **23 high temperature geothermal potential areas** identified and only two geothermal prospects are subjected for drilling.
- Estimated potential of more than **10,000 MWe**
- A larger number of areas **have potential for medium to low temperature resources** throughout the Ethiopian Rift System.
- Only **two prospects** are subjected to drilling.



## Aluto-Langano Field

- Drilling commenced in 1981 where a total of eight deep exploration wells were drilled.
- The 7.2 MWe Geothermal Combined Cycle Unit was commissioned in 1998.
- The plant had intermittent operation between 1998 and 2014 with challenges of maintenance







## Ethiopia - Aluto

- Drilling is in preparation to allow for expansion of **the field for 70 MWe**
- Financing **for drilling is from World Bank, Iceland, JICA** and Government of Ethiopia
- Two wells **were drilled between 2013 and 2015** (LA-9 &10)
- Progress **has slowed since 2015** due to various challenges







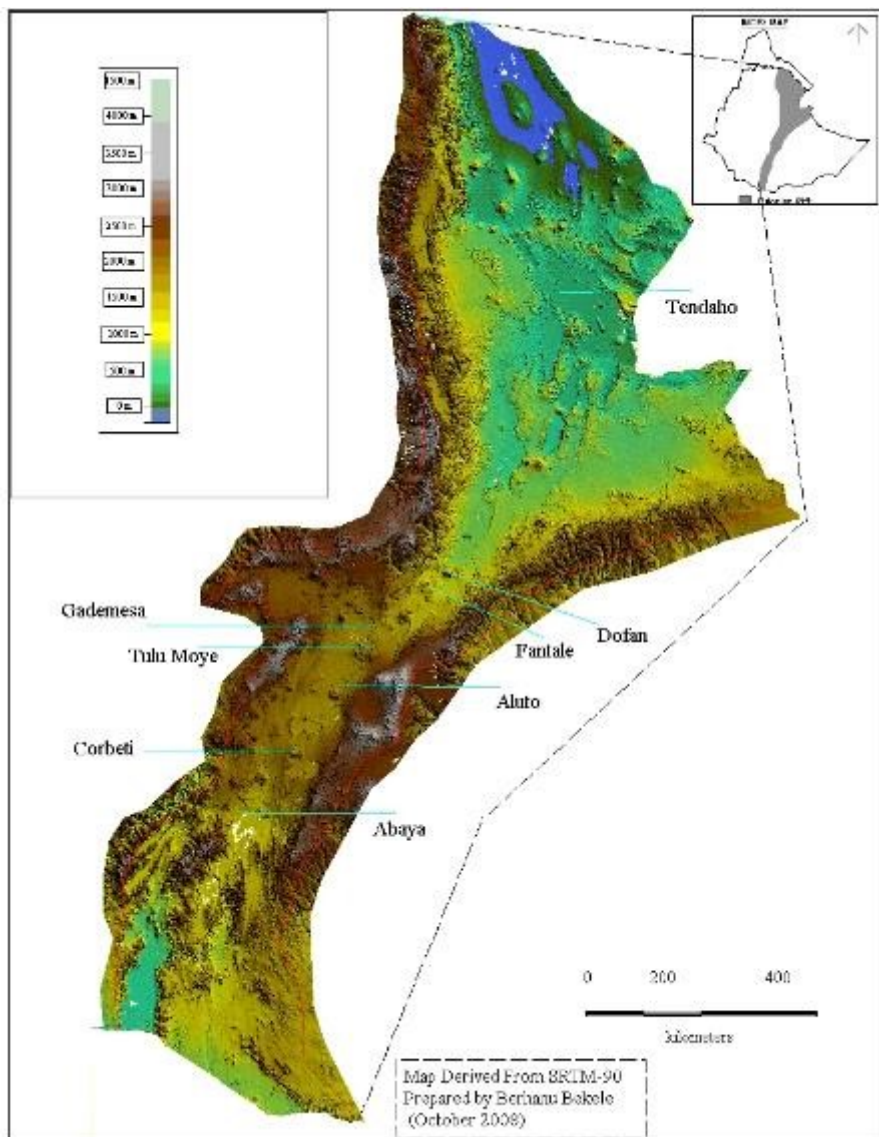
## Ethiopia – Tendaho

- A total of **Six (3 deep and 3 shallow)** exploration wells drilled between 1993-1998 at Dubti confirmed presence of high temperature geothermal resources
- A mix of **shallow and deep appraisal wells** are planned for year 2019-20
- Tendaho-Alalobeda is **being evaluated for development of a 12 MWe pilot plant** in phase one (WB)
- Expansion to **100 MWe** in subsequent **phases**





## CURRENT ONGOING IPP PROJECTS in Ethiopia



- CORBETTI P.L.C. 500 MWe Corbetti
- MERIDIAN P.L.C. Tulu Moye, 500 Mwe
- CLUFF: Fantale 100 MW
- ORMAT: (4 Prospects) Dofan, Butajira....
- The Government of Ethiopia, through the GSE is also carrying out geothermal exploration in the ERV to mitigate the risk associated with resource exploration .

# FUTURE DEVELOPMENT PLAN

Geothermal in the long term power development

- 2,500 MW by 2030
- 5,000 MW by 2037

By 2037:

- 30% of energy TB generated from GR
- Around 40,000 GWh
- Capital cost about \$ 4,000,000 /MW







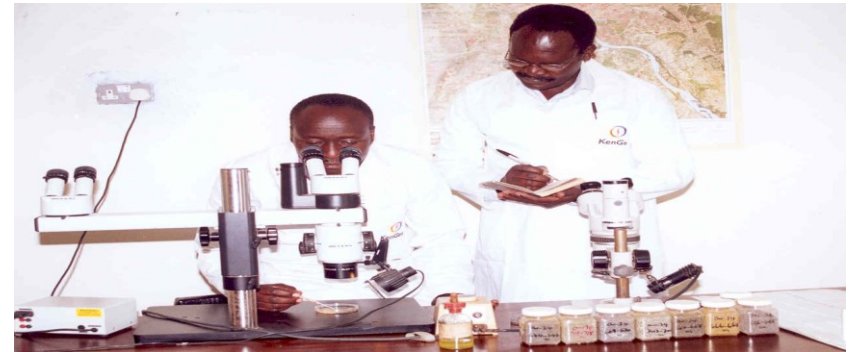
# SOLUTIONS TO MAKE THE PLAN A REALITY

“FAST TRACK GEOTHERMAL DEVELOPMENT”



# ITEMS TO CONSIDER

- The Resource
- Government's Readiness
- Laws and regulations
- The People
- Technology
- Private Investors





# THE RESOURCE- LTLCNPDMP





# Comparisons with others sources

GDC, 2015

Assessment criteria							
Generation Option	Low cost US\$/kwh	Availability	Fast delivery*	Environment friendly	Natural potential	Location and transmission benefit	Comments
• Geothermal	8.4	✓	✗	✓	✓	✓	• Significant proven potential
• Wind	8.8	✗	✓	✓	✓	✓	• Significant potential, but dependent on weather
• Nuclear	8.8	✓	✗	✓	✗	✗	• Min plant size of 500 MW required, politically sensitive
• Gas CNG	8.4	✓	✓	✗	✗	✓	• Need to import, liquify for transport and re-gas
• Coal	8.3	✓	✗	✗	?	?	• Coal potential in Kitui
• MSD	10.2	✓	✓	✗	✗	✗	• Attractive intermediate capacity, but not large base load
• Hydro**	12.5	✗	✗	✓	✓	✗	• High exposure to hydrology risk (60% of installed capacity)
• Gas Kerosene	16.5	✓	✓	✗	✗	✓	• Current GTs running at high loads, need more base load
• Solar	30-50	✗	✓	✓	?	✗	• Dependent on weather with low average availability
• Co-generation	Ind	?	✗	✓	?	✗	• Could pursue along side coal opportunity

\* 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



# GOVERNMENT's COMMITMENT

- Specific Policy, laws and regulations governing geothermal resources
- Develop Human capacity in the region to drive a robust geothermal industry
- Set up dedicated institutions for exploration and development
- Adequate Capital risk insurance for private investors
- Specific Geothermal Feed in tariff



**Successful Development of Geothermal Resource, is Governed by Laws and Fulfilled by Appropriate Institutions**





## Effective Planning

- **National Level Planning (NPDMP)**
- **Tactical Level Planning (Prioritization/Ranking)**
- **Strategic Level Planning (Single Govt.entity or Concession in the form PPP/IPP)**



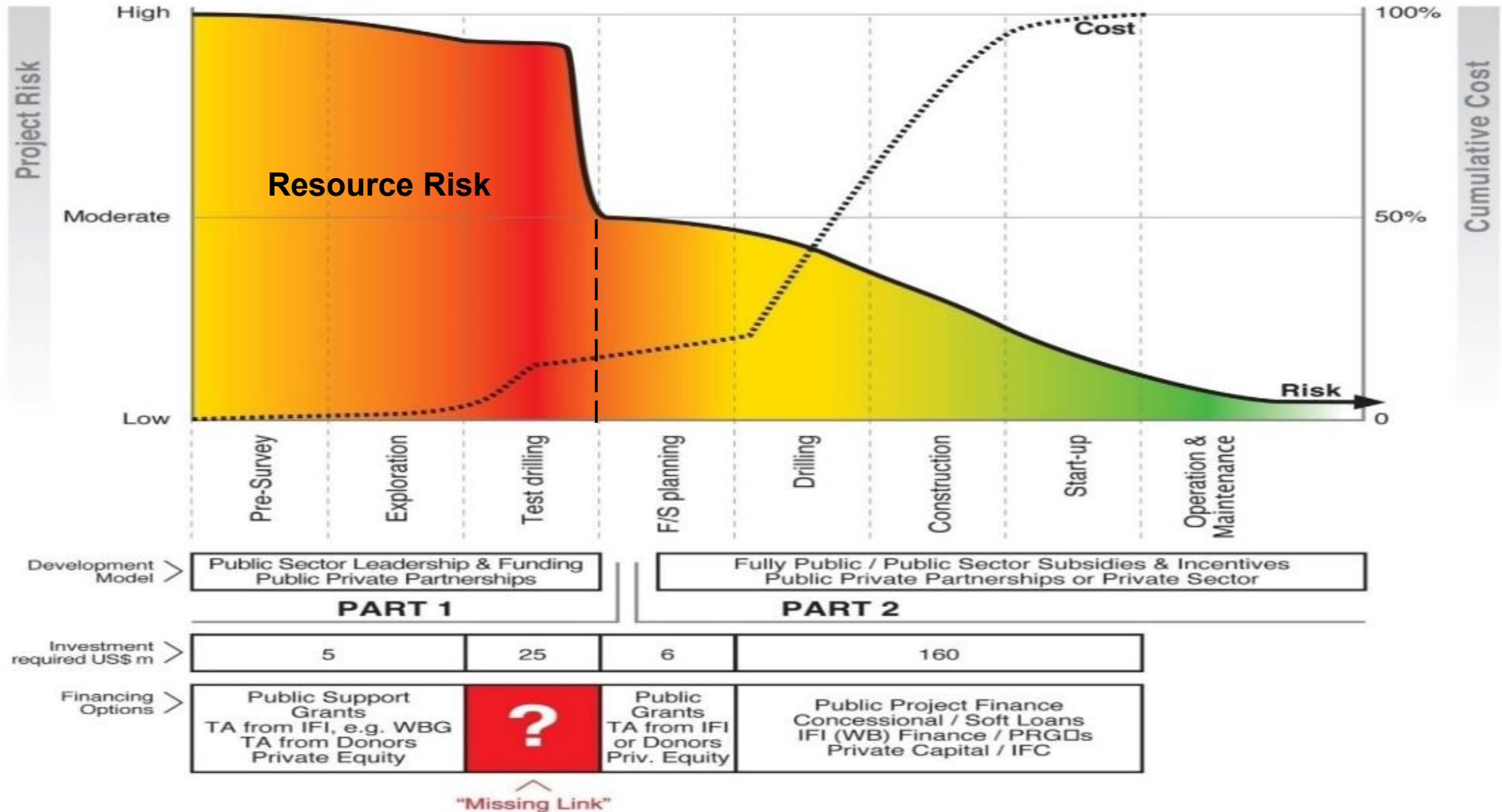


## THE PRIVATE SECTOR



# Financing Gap in the Test Drilling Phase

Financing a Typical Medium Size Geothermal Power Project (50MW)

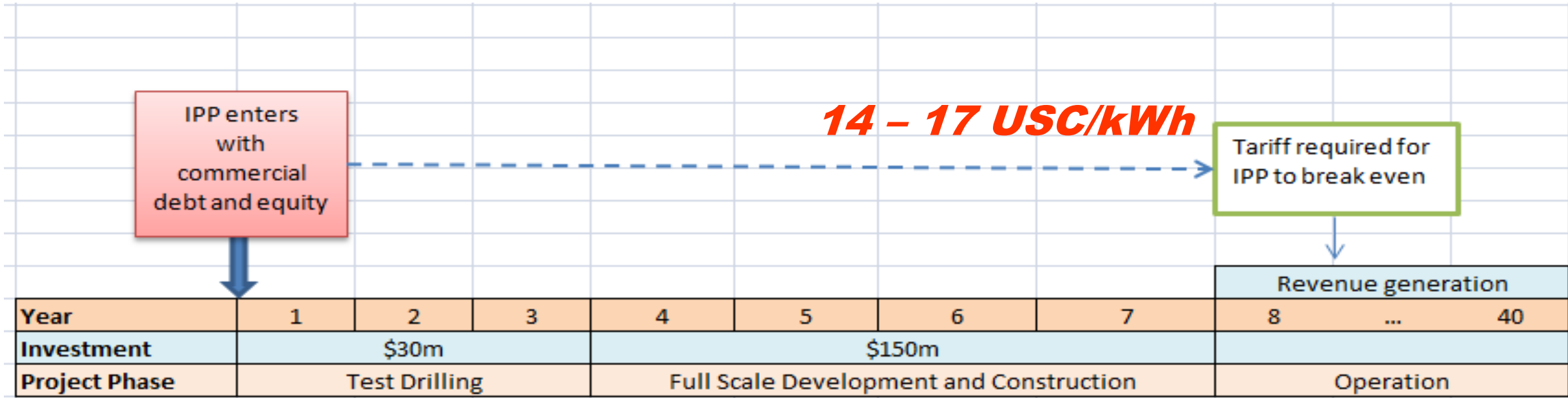




# PUBLIC PRIVATE PARTNERSHIP - OPTIONS

		POWER GEN. OPTION	JOINT STEAM DEV.	PROD. DRILLING & POWER GEN	STEAM DEV. & GEN.	FULL CONCESSION	
VIABILITY ANALYSIS	DETAILED SURFACE STUDIES	GOVT.	GOVT		GoVT		EQUITY FINANCE OR SOVEREIGN LOAN
	INFRASTRUCTURE DEVELOPMENT		GOVT	GOVT			
	EXPLORATION DRILLING						
	APPRAISAL DRILLING						
	FEASIBILITY STUDY						
IMPLEMENTATION	PRODUCTION DRILLING	IPP	IPP	IPP	IPP	EQUITY & DEBT FINANCE	
	STEAM GATHERING						IPP
	POWER PLANT CONSTRUCTION		IPP	IPP			
INCOME	OPERATION AND MAINTENANCE	Govt.					VENUE FINANCE
	STEAM FIELD MANAGEMENT	GOVT					

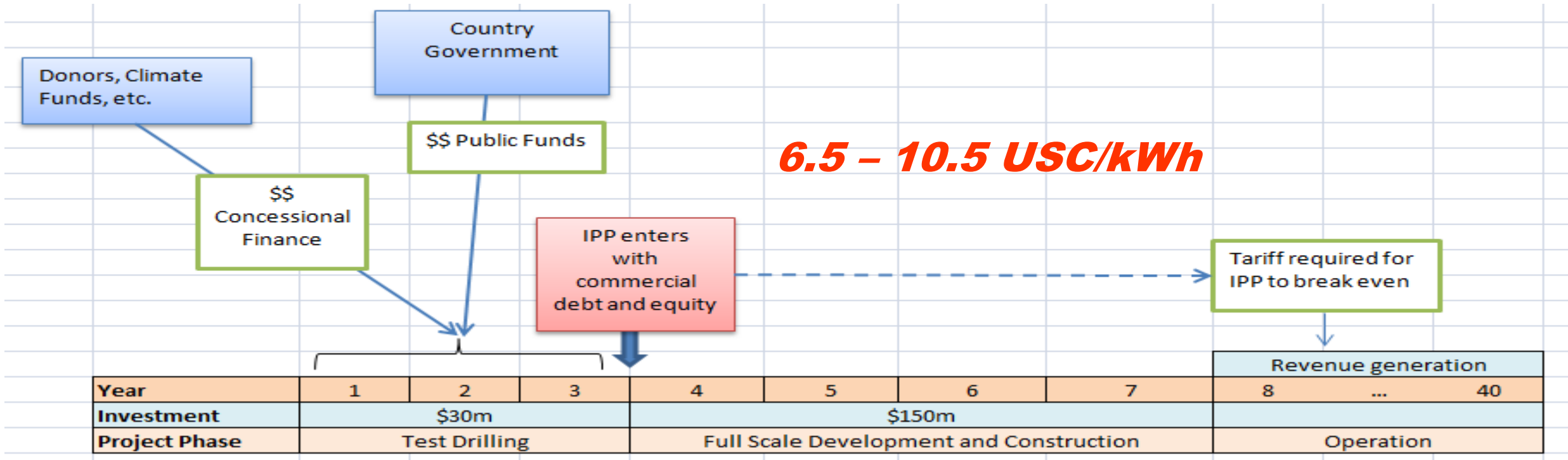
## PS: Entering BEFORE Test Drilling



❖ Much higher levelized tariff (LT) is required because:

- ✓ Lead time is longer by 3 years
- ✓ Required rate of return on equity ( $R_e$ ) is higher (25%) due to high risk premium of early entry
- ✓ The \$30m cost of exploration is still ahead
- ✓ Result:  $LT > 14$  US cents/kWh (for 50 MWe power plant!!)

PS: Entering after Test Drilling (Example: 50 MWe power plant)



Available infrastructure, Size of Wells, Environment & Community Issues, Reservoir (Chemistry) quality, Choice of Technology, and Commercial Risk mitigation measures





# Enablers –Technology

## Wellhead Generation



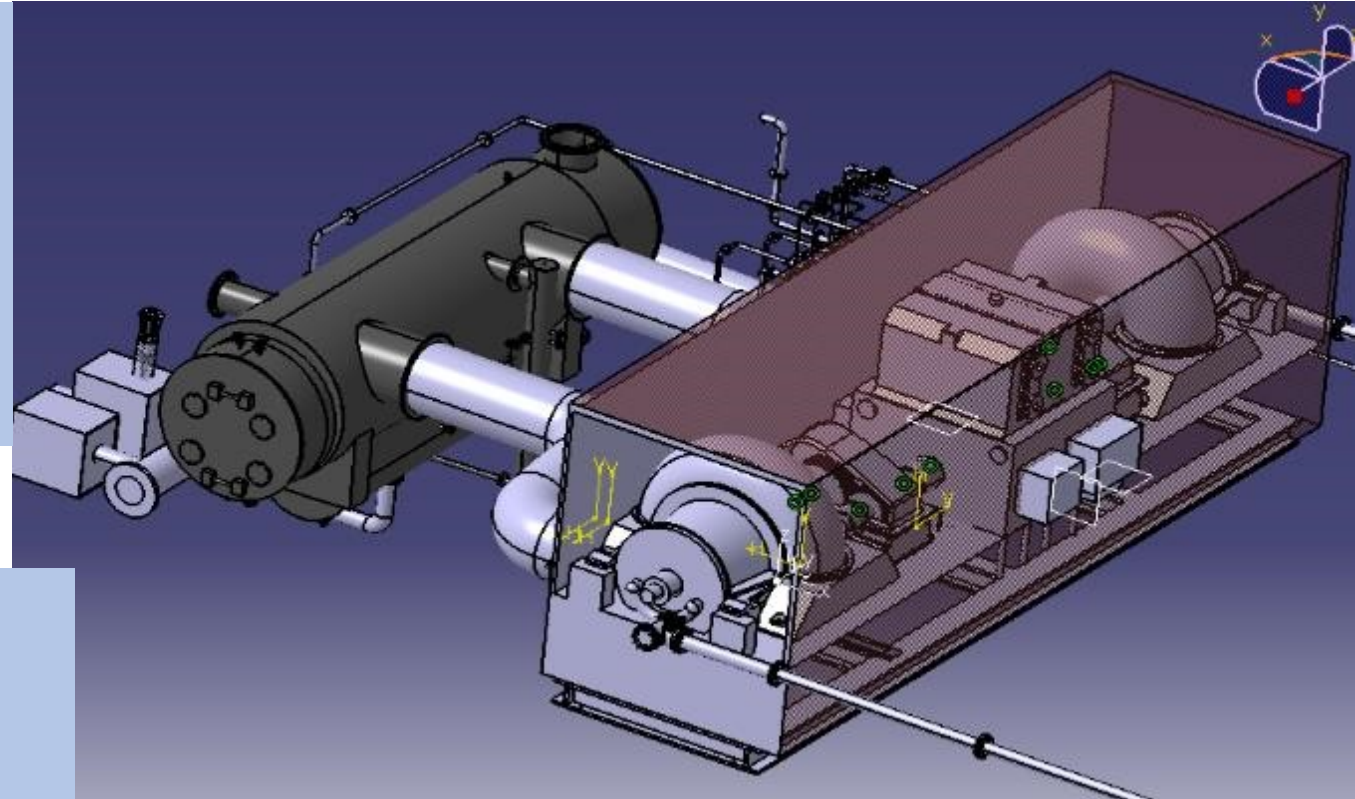
INVESTORS TO INSTALL WELLHEADS FOR EARLY GENERATION

### Characteristics

- ✓ Typical Sizes – 5-10 MW
- ✓ Containerized/portable
- ✓ Mounted on the well pad
- ✓ 9 months to manufacture, ship and install
- ✓ Cost USD 1.5 million/MW

### Importance

- ✓ Provide power shortly after drilling
- ✓ Cheaper than conventional power plants
- ✓ Provide revenue early
- ✓ Improve the profitability of the project







## ENABLERS

### THE PEOPLE- Capacity and skill development



# CONCLUSION

## Government commitment:

- Policies and regulatory framework
- Dedicated entity/ agency to facilitate exploration, development and investment in Geothermal
- Resource and commercial risk mitigation measures for the investor (risk funds and risk guarantees)
- A clearly defined investment tax regime
- Skilled manpower in geoscience, engineering, financing, procurement etc..

## Financing arrangements:

- Very responsive to the unique country needs
- Have included capacity development in all funding arrangements
- Emphasize technologies with added direct benefits to local communities and the environment (e.g Direct use)



*THANK YOU*

CONTACT



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