IRENA Workshop: Lessons from EAGER

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What is EAGER?

• **Funded by DFID**
  - Regional Technical Assistance programme running for 3.5 years from May 2015 – ends November 2018
  - GBP 6 million and covering 5 countries (Ethiopia, Kenya, Rwanda, Tanzania, Uganda)
  - Seeks to cover gaps in Government role to support geothermal development by removing barriers and speeding progress
    - No duplication with other donors
Summary of Work To-Date

• Advisor to EEP (Ethiopia) on PPA negotiation, financial modeling, and technical aspects of geothermal development. Has also advised Ministry and EEA on aspects of regulations and regulatory processes and organisation.

• Advisor to TGDC (Tanzania) on business models for development, commercial and financial aspects of development, organisational development, resource prioritization, data management, technical regulation and exploration planning.

• Advisor to GRD (Uganda) on policy, exploration methods and conceptual modeling, data-driven resource analysis and prioritization, financial modeling, business development models, data management, and TGH planning.

• Advisor to GDC (Kenya) on financial modeling and business development models. Advisor to the Ministry and regulator on geothermal in the market, including time of use tariffs.

• Advisor to GRD and TGDC on the feasibility of integrating direct use into geothermal energy exploitation (planned).
Main Lessons

- Political realities and competition against other energy sources create a challenging environment for geothermal projects to be profitable.
- Risk sharing from governments (if properly chosen and executed) can serve to offset financial and technical risk to private developers, improving project profitability.
  - There are 5 key business models for geothermal development with differing levels of cost and technical risk sharing between the public and private sector.
- In a competitive pricing environment, alternatives like wellhead generators and direct use can improve project profitability.
- Not all geothermal systems in Africa possess the same resource characteristics. The western branch of the rift is very different from the eastern branch.
- Early linkage of technical understanding with commercial analysis will prevent wasted exploration costs – “pre-feasibility”.
- Exploration planning involves careful refinement as new data is obtained – an ongoing process.
- Data is the key to the value of the resource to the country.
- Capacity building is critical – from training through to learning by doing – and needs to be appropriate to a government’s chosen business model.
Governments have generally become more involved in early stage geothermal development

- Offset financial and technical risk
- Prove commercial resources
- Keep end tariffs down
- But the greater the role of Government the greater the capacity need (people and money)

Business Models and Risk Mitigation

Model choice depends on:

- Size and characteristics of resources
- Government technical and financial capacity
- Level of private sector interest
- Tariff regime
- Regulatory environment
5 major models for geothermal development

- From left to right, public sector involvement and share of expenditure increases

<table>
<thead>
<tr>
<th>Model</th>
<th>Government</th>
<th>Developer</th>
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</thead>
<tbody>
<tr>
<td>Model 1 (Fully private)</td>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>Model 2 (Public sector conducts early exploration)</td>
<td>50</td>
<td>30</td>
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<tr>
<td>Model 3 (Public sector carries out test drilling)</td>
<td>20</td>
<td>60</td>
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<tr>
<td>Model 4a (Public sector develops and operates steam field)</td>
<td>53</td>
<td>27</td>
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<tr>
<td>Model 4b (Private sector develops and operates steam field)</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Model 5 (Public sector as developer and operator)</td>
<td>80</td>
<td>0</td>
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- Estimated expenditures based on hypothetical 15 MW flash plant
  - This is a broad analysis – there are variations within each model
Geothermal Plants and Installed MW by Business Model

PPP approaches are the trend.

EAGER
East Africa Geothermal Energy Facility
Other approaches to improving geothermal economics

• Bring in early revenue (or offset costs) through wellhead generators
  
  o Use WHG to power rig during drilling (no diesel costs)
  o Generate electricity from single production well to bring in cash flow early in the project (fund remaining development, lower equity requirements)

• Supplement project returns through Direct Use
  
  o Pipelines are inexpensive to build
  o Direct Use can provide low-cost power to industry
  o Revenue from Direct Use supplements project power revenues
  o EAGER working with Uganda (GRD) and Tanzania (TGDC) to explore the feasibility of Direct Use applications at some resources.
Since pre-history, hot springs have been used for bathing.

Japan is world leader in balneology: Beppu alone has 4,000 hot spring baths serving 12 million tourists/year.

Revenues from Beppu spas, hotels, etc. are higher than all the geothermal electric generation revenue in Japan!
Two Main Types of Geothermal Systems

Volcano-Hosted
- Magma = heat source
- Typically >200°C
- Average capacity = 150 MW
- 75% of fields and 91% of installed MW

Fault-Controlled ("Basin & Range")
- High T gradients & steep faults that extend up to ~5km depth
- Typically <180°C
- Average capacity = 30 MW
- 25% of fields and 9% of installed MW
Contrasting the East & West Branches of EARS

Eastern Branch
- High extension rate
- High volcano concentration, shallow magma bodies
- Primarily volcano-hosted geothermal systems

Western Branch
- Low extension rate
- Few volcanoes, deep-seated magmas
- Primarily fault-hosted geothermal systems
Analog for East EARS System

AWIBENGKOK CROSS SECTION

What Matters 5 - 7 km

100°C 150°C 200°C 250°C 300°C

2 - 3 km

Melosh (2013, GEA)
Analog for West EARS System

BRADYS CROSS-SECTION

2 km

1 km

100°C

150°C

200°C

Geothermex (2008)

Legend:
- Truckee Fm.
- Desert Peak Fm., sediments
- Desert Peak Fm., andesite
- Chloropogus Fm.
- Walls in section
- Walls projected into section
- Fault, dashed where uncertain
- Temperature contour, °F
- Lost circulation zone

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East Africa Geothermal Energy Facility
East vs. West EARS Development Analogy

Awibengkok 377 MW

Bradys 15 – 20 MW
Western Branch of the Rift

- Prospects are fault controlled and not volcanic, as in much of the Eastern Rift
  - Different knowledge and experience (Basin and Range)
- Will be low enthalpy (<150 °C)
- Binary power plant for local (mini-grid, industrial development) or grid use
- Direct use to help economic development (energy for rural transformation)
- Environmental benefit: helping reduce deforestation.
Power Market Challenges for Geothermal

- Low energy consumption per capita, rapidly increasing access to power for households and the rise of solar power may mean relatively lower baseload growth
  - Use of distributed or off-grid solar by consumers decreasing demand for grid power.
  - Uncertainty re: the timing and level of demand growth will favour energy sources with short development times.
- Hydro and gas are cheaper, can be baseload, but are also dispatchable (if hydro has storage). How flexible can geothermal be?
- Growth in intermittent renewables such as solar and wind impacts on the market in ways that are still not understood.
- Baseload growth will likely be driven by industrial demand – need to link geothermal to industrial strategy.
The Markets for Geothermal Energy

• Grid MW, primarily in the baseload sector of the market.
• Possible mini-grid supply, but linked to economic development and demand in areas close to remote geothermal resources
• Direct use – multiple options at each site. “Energy for Rural Transformation” in more remote areas.
• Price will be an issue in each market.
Need for Early Commercial Analysis

• Given market uncertainty, technical analysis needs to be linked to commercial analysis...
  o From an early stage and then repeatedly as new technical data is established for each prospect.

• Good resources may prove uneconomic if too far from demand or transmission, or too deep.

• EAGER has developed a model linking technical data to financial modelling...
  o This enables early quantification of risks and opportunities..
  o Before Government or donor funds are wasted.
Inputs to a Decision Making Financial Model

- **Technical**
  - Temperature
  - Permeability
  - Reservoir liquid level
  - Power Density (system size)
  - Plant technology

- **Project**
  - Timing and duration of each step
  - Critical path

- **Financial**
  - Steam and power price and escalation
  - Project costs (drilling, construction, transmission, etc.)
  - Operating costs
  - Financing (equity/debt)
  - Availability of concessional finance or grants
Estimating Net MW Capacity of a Well for Pumped and Self-flowing Wells

from Sanyal et al., 2007
Risk Managed Exploration Plans…

• Are more than technical surveys and test drilling.
• Early risk and cost analysis – to reduce risk of wasted exploration and allow prospect prioritisation.
  o More and better planning reduces the early stage risk
• Plans need to be updated as new data gathered.
• Conceptual modelling is critical, but experience in East Africa is limited, especially for fault controlled systems.
  o Linking geology, geochemistry and geophysics.
Managing Geothermal Data

• Validated relevant data is critical for understanding and evaluating the resource.
• Data standards and robust data gathering processes reduce the risk of error and waste.
• Data held by Government should be comprehensive...
  o BUT important to keep confidentiality of developers’ data.
• The cost of data management and control is falling with Open Source systems.
Policy, Law and Regulation

• Development of a proper regulatory framework takes time

• As framework is developed, consultation with private sector is key (don’t legislate in a vacuum)

• Important to find ways of making progress while these are being resolved:
  - Business models involving public sector development can offset early stage risk
  - Contracts (PPAs) can build in protections for developers in absence of framework
  - Insurance products can protect against policy risk
Even with policies & regulations in place…

- Not all E. African geothermal prospects will prove to be commercial...
- Governments may need to de-risk the best prospects to attract investment and potential private sector participants.
- Private companies may request several prospect areas but are unlikely to spend significant exploration dollars without a PPA in-hand.
- Not all of the PPAs signed with private sector developers will result in power generation.
- In some countries, Direct Use applications may provide more real value than power generation.
• Government agencies outside Kenya are short of technical and commercial expertise and experience.
  o Geosciences, drilling, reservoir engineering, financial analysis, market analysis, project management, business planning.

• Training and overseas courses are only part of the solution.
  o Lengthy courses create “brain drain” for small geothermal departments without imparting significant hands-on experience.

• Principal need is capacity building by doing, with mentoring support...
  o Technical training through live modelling, drilling, and other activities
  o Commercial training for financial modelling and project management
  o All capacity building focused on supporting decision making, not just imparting technical or commercial knowledge.
Conclusions

• Governments must consider their commitment to geothermal alongside technical and financial capacity when determining approach to geothermal development.

• New approaches to improving project economics can be key for East Africa.

• Taking the time to determine the characteristics of a resource can save valuable time and money during development (the Eastern and Western Rifts are not the same!)

• Capacity building is critical to project planning and more robust decision-making.

• A commitment to baseload renewable power will help secure a role for geothermal in competition with “lower cost” intermittent power sources.
THANK YOU!

Comments or Questions?