IRENA Workshop: Lessons from EAGER

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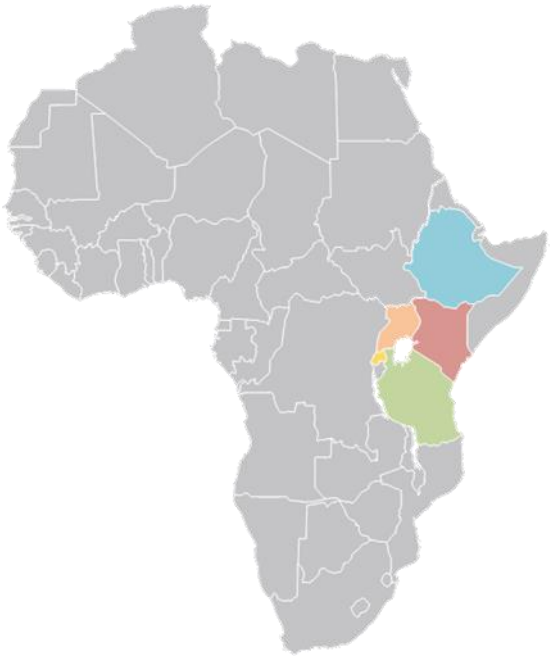
EAGER East Africa Geothermal Energy Facility

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



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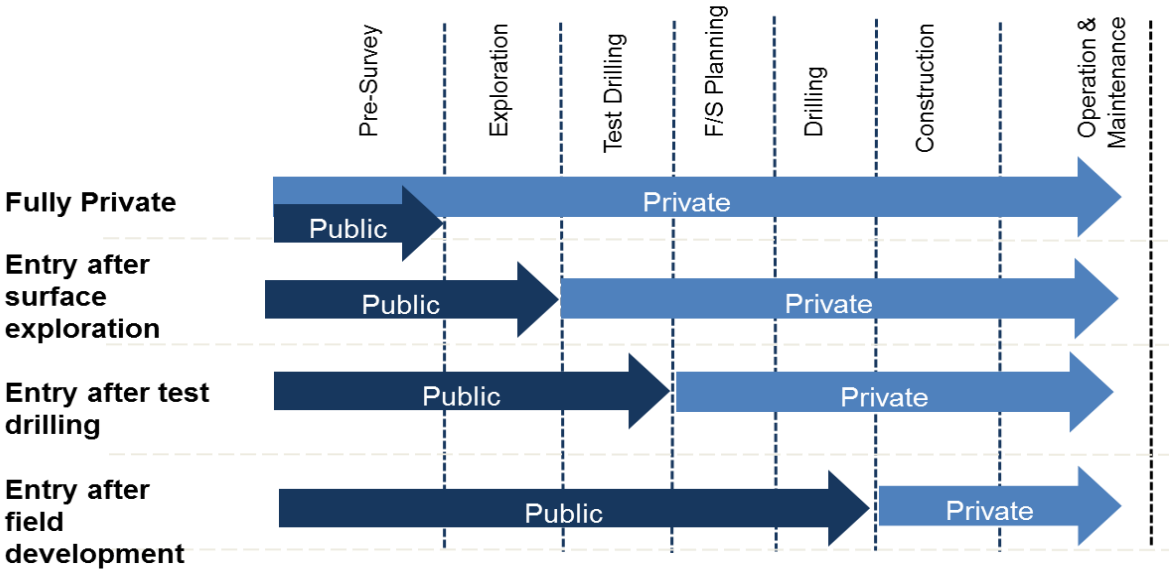
Summary of Work To-Date

- 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.

Business Models and Risk Mitigation



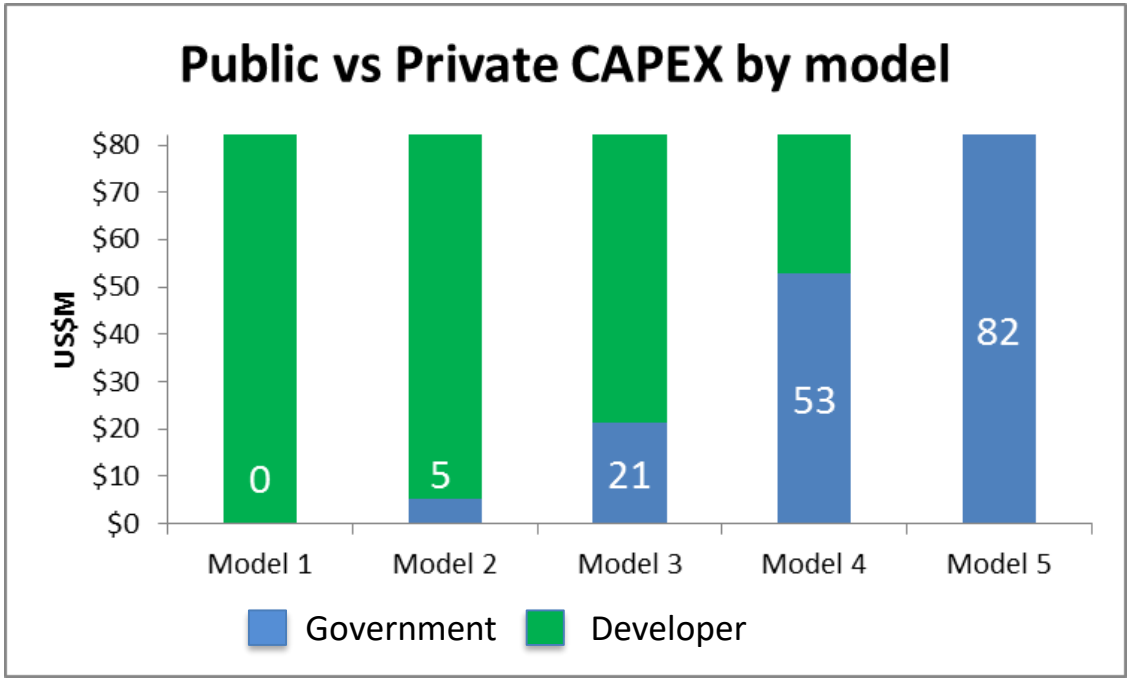
Model choice depends on:

- Size and characteristics of resources
- Government technical and financial capacity
- Level of private sector interest
- Tariff regime
- Regulatory environment

- 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)

5 major models for geothermal development

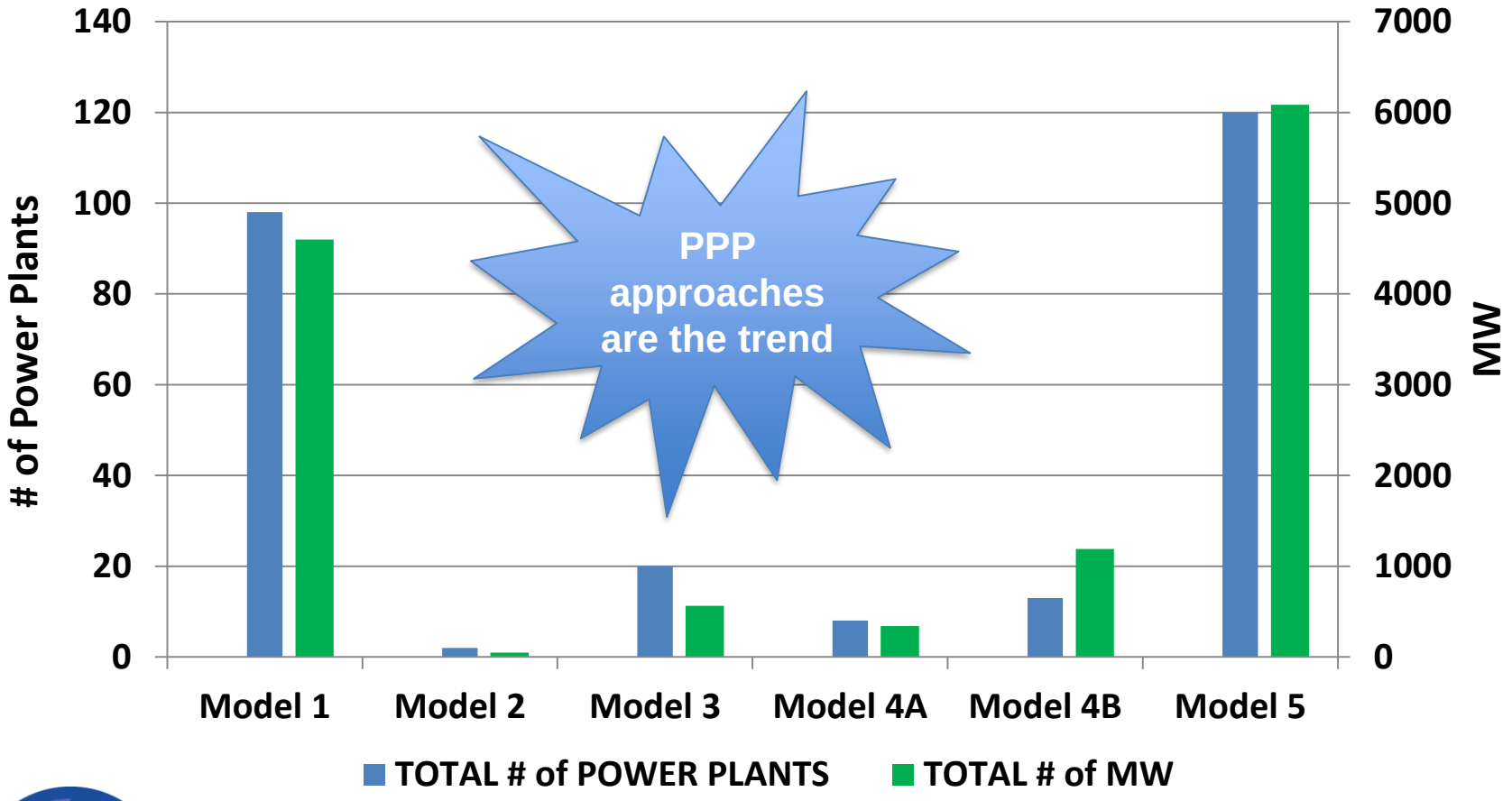
- From left to right, public sector involvement and share of expenditure increases



- Model 1: Fully private development
- Model 2: Public sector conducts early exploration
- Model 3: Public sector carries out test drilling
- Model 4a: Public sector develops and operates steam field
- Model 4b: Private sector develops and operates steam field
- Model 5: Public sector as developer and operator

- 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



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Other approaches to improving geothermal economics

- Bring in early revenue (or offset costs) through wellhead generators
  - Use WHG to power rig during drilling (no diesel costs)
  - 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
  - Pipelines are inexpensive to build
  - Direct Use can provide low-cost power to industry
  - Revenue from Direct Use supplements project power revenues
  - EAGER working with Uganda (GRD) and Tanzania (TGDC) to explore the feasibility of Direct Use applications at some resources.

Geothermal Direct Use Has Value!

- 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!

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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

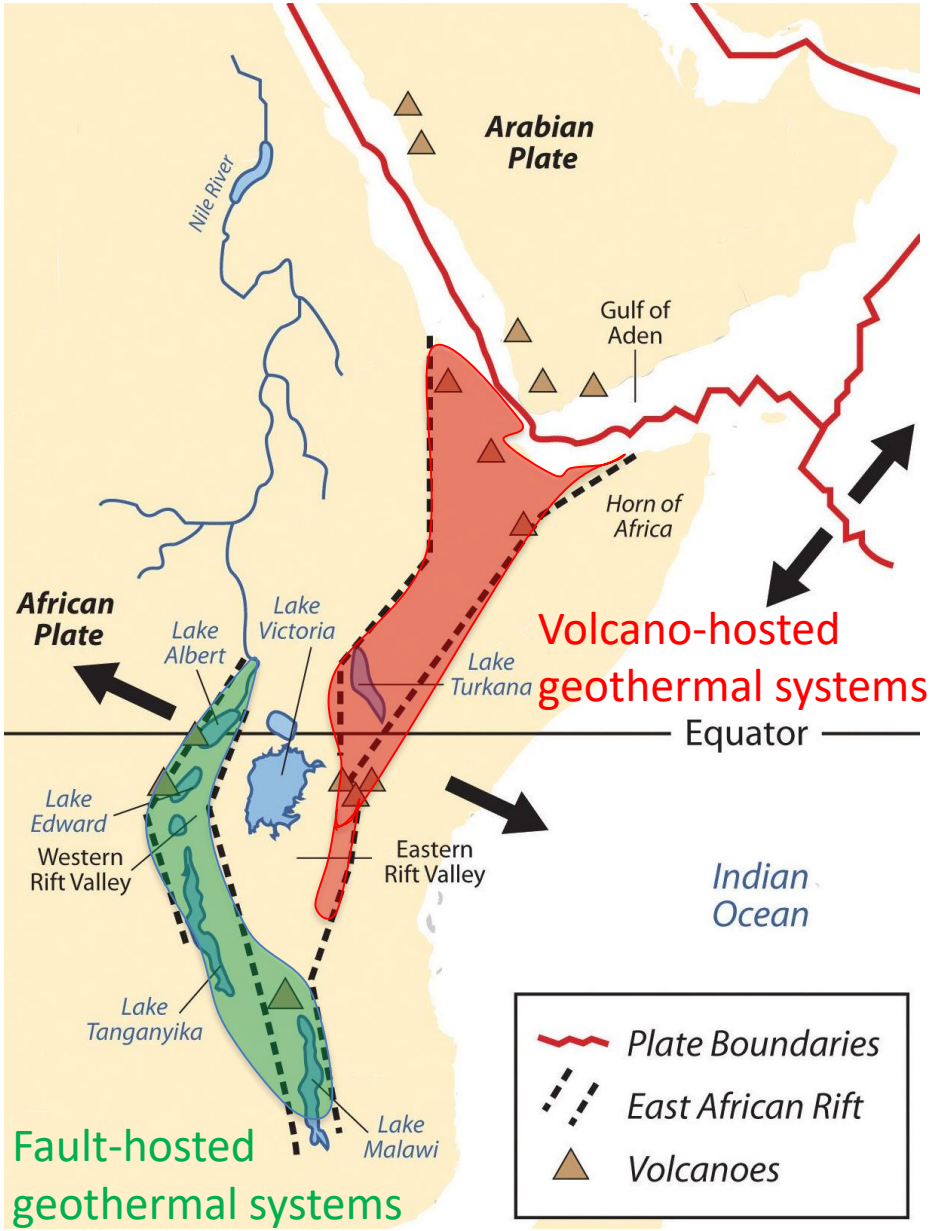
Contrasting the East & West Branches of EARS

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



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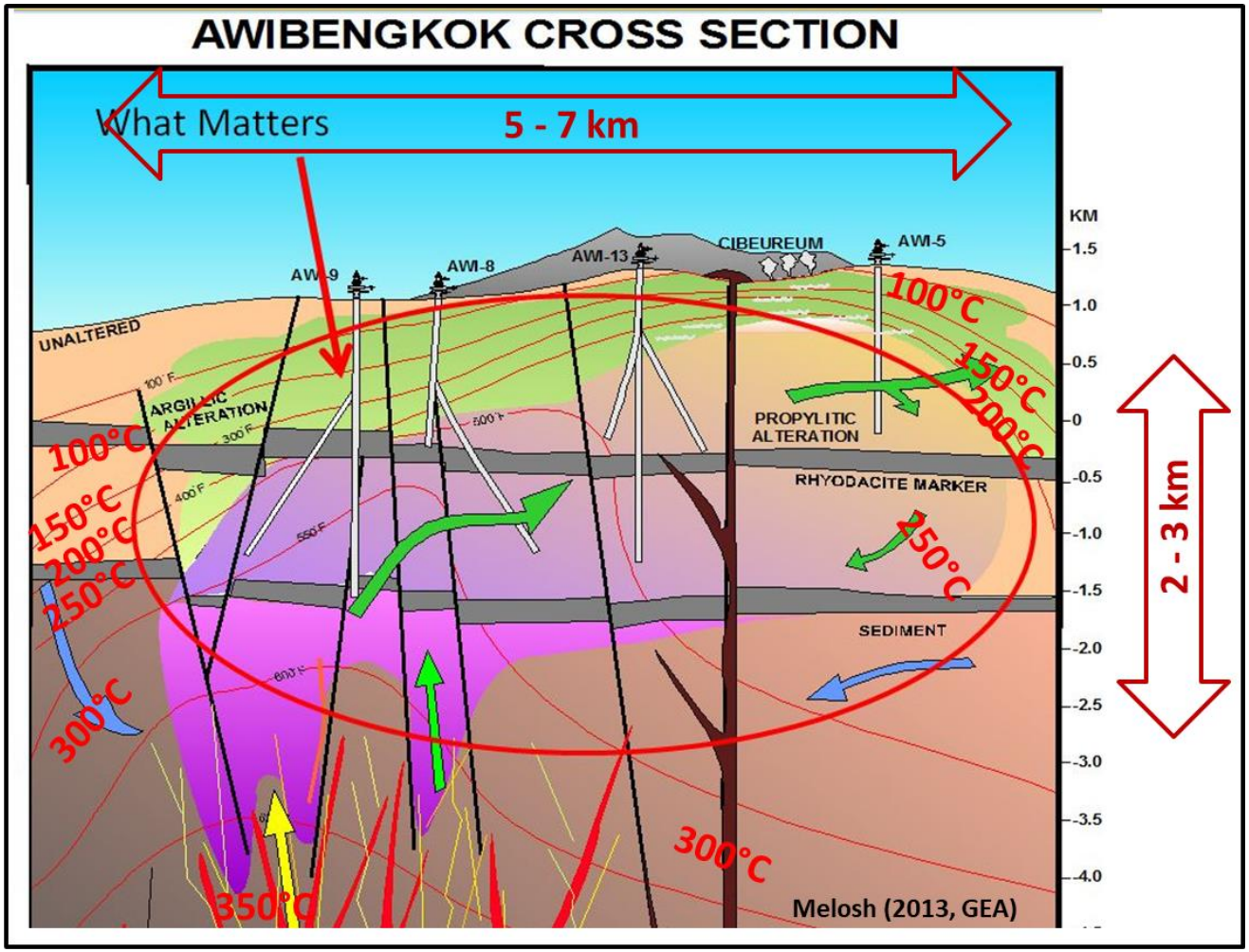
Analog for East EARS System



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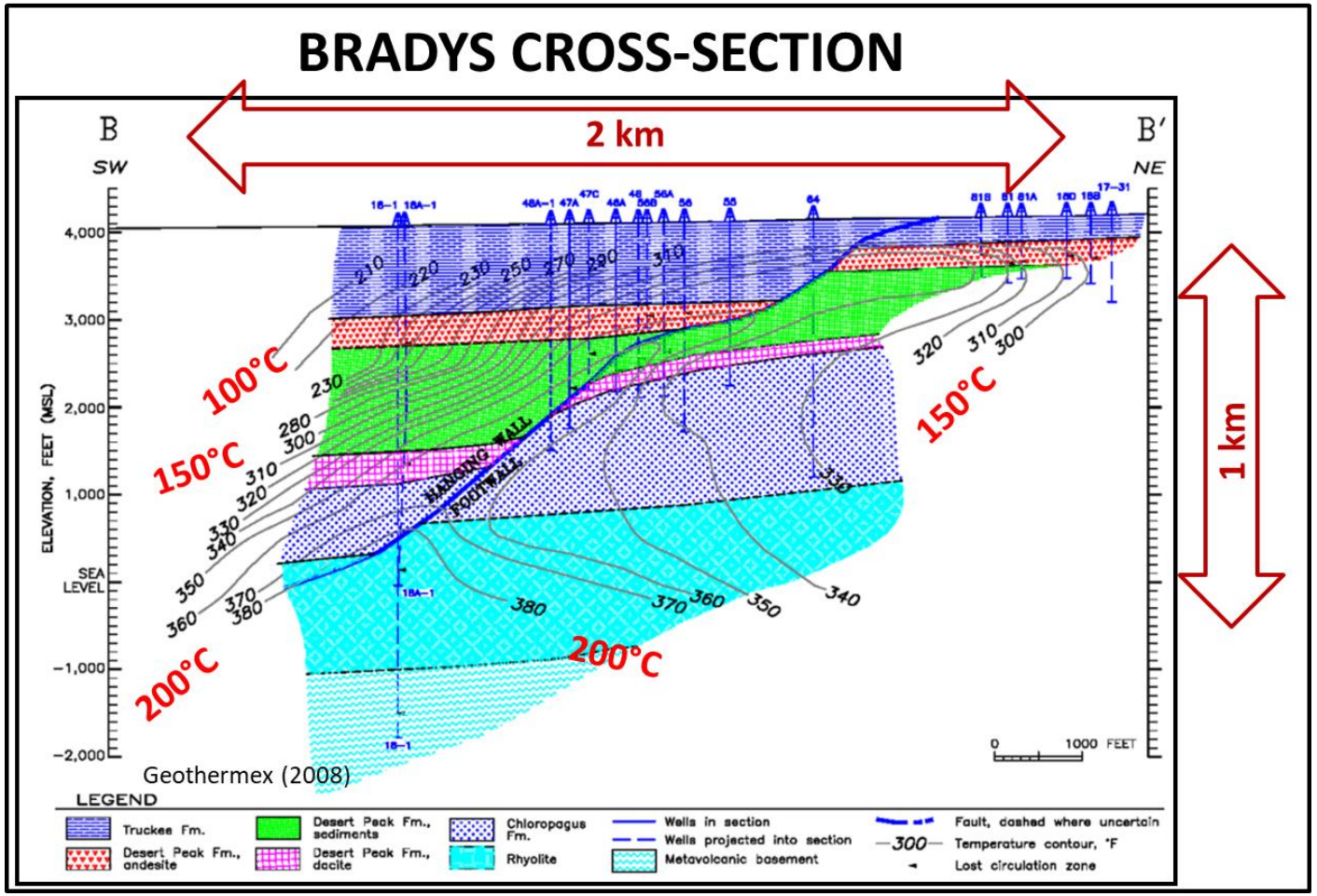
Analog for West EARS System



Geothermex (2008)

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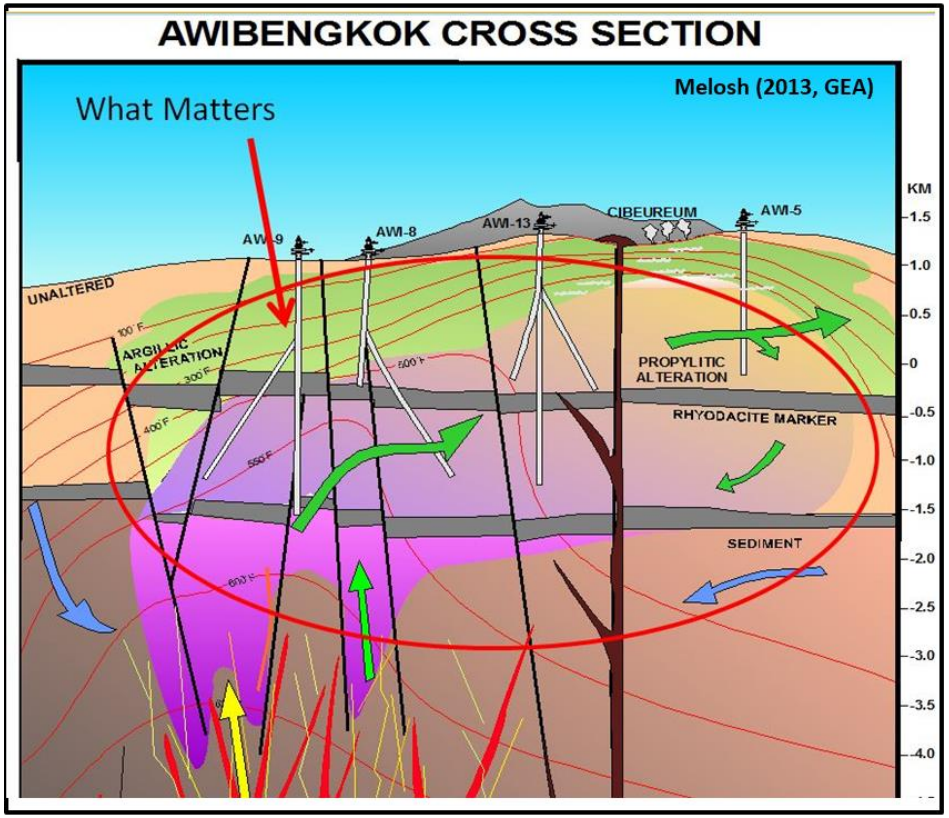
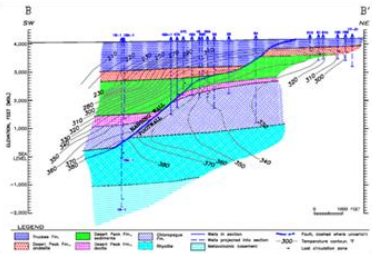
East vs. West EARS Development Analogy

Awibengkok 377 MW



Bradys 15 – 20 MW



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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 de-forestation.

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.

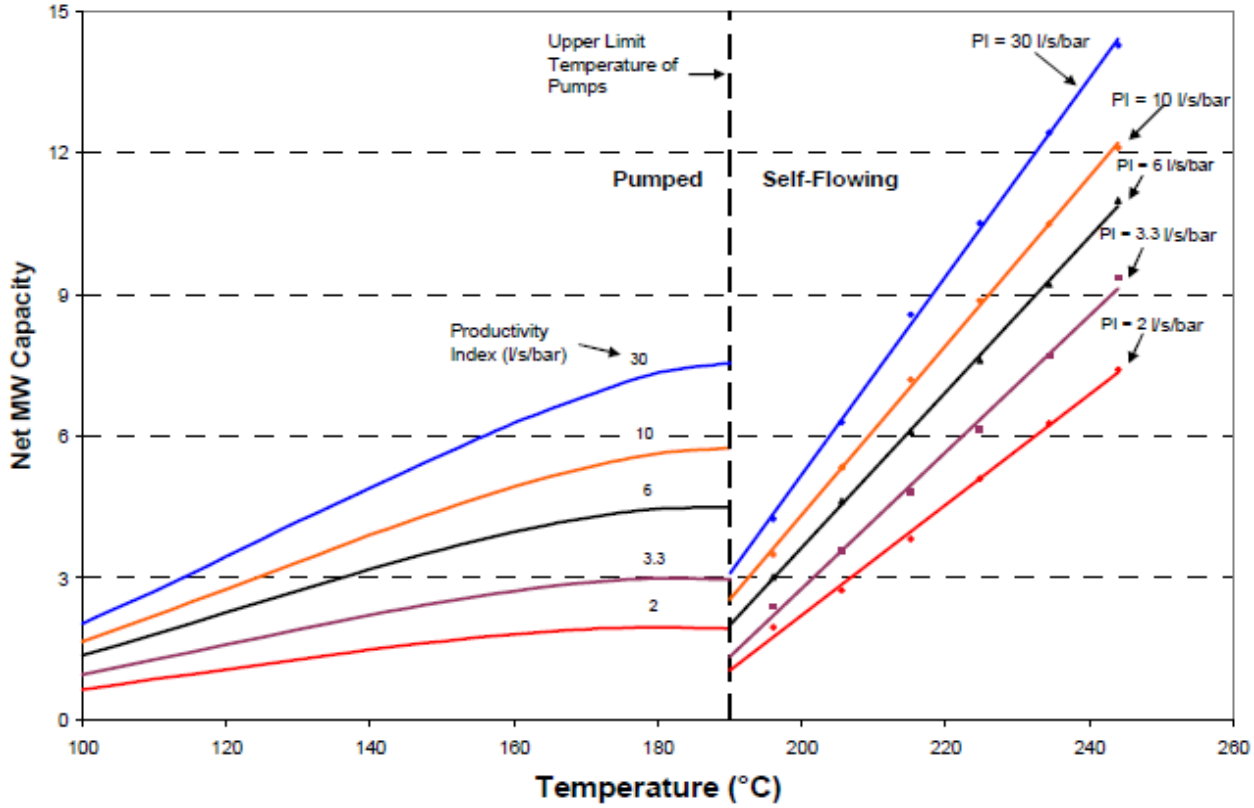
Need for Early Commercial Analysis

- Given market uncertainty, technical analysis needs to be linked to commercial analysis…
  - 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…
  - This enables early quantification of risks and opportunities..
  - 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.
  - 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.
  - 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…
  - 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.

Capacity Building

- Government agencies outside Kenya are short of technical and commercial expertise and experience.
  - Geosciences, drilling, reservoir engineering, financial analysis, market analysis, project management, business planning.
- Training and overseas courses are only part of the solution.
  - 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…
  - Technical training through live modelling, drilling, and other activities
  - Commercial training for financial modelling and project management
  - 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?

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