New, Specific Methodological Approach to Medium Enthalpy Shallow Geothermal Resources for Africa’s Rift Valley

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Summary

1. Introduction

2. A common type of geothermal resource in EARV

3. A radically different approach first based on local demand

4. Shallower and more economic

5. Implying a new methodological approach and appropriate technical tools

6. Conclusion: a real perspective for geothermal stakeholders
1. Introduction

- Small-size, Low and Medium enthalpy developed all over the world even in normal gradient areas.

- Present procedures in Africa only favor large-size projects for electricity production serving the grid with feed in tariffs (FiT).

- EARV allows for shallow most economic geothermal systems.

- Geothermal provide options of resilience du climate change (cc).

- Local communities affected by cc lack information.

- Despite artisanal use of these resources.

- This paper intends to break this gap.
2. A common type of geothermal resource in the EARV

- Open active faults affecting the rift floor
- Normal faults at the bottom of the escarpment
- Steam vents exploited for water condensation in arid areas
- Frequently only source of water (condensation)
- Hot water + steam (or gas lift) in Western Rift and the whole EARV and Afar scarps

- Steaming faulted Rift floor Kenya (Oklaria) photo J. Varet
2. A common type of geothermal resource in the EARV

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• *Steaming caldera rim Aluto MER (Ethiopia)*
  photo J. Varet
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- Thermal springs affecting the MER floor North of Fantale (Afra regional State, Ethiopia). Photo J.Varet
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- *Thermal springs emerging along the normal fault limiting the western shore of Lake Bogoria, Kenya. Photo J. Varet*
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*Steaming open fissure, sub-parallel to the nearby graben seen in the back, affecting the basaltic necked surface of the Afar stratoid series. Condensing towers were built to collect the water with the support of APDA. Elidaar, central western Afar (Photo J. Varet, 2014)*
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Left: Open steaming fissure, Fiale, Asal, Djibouti. Right: Detail of Steam vent, Olkaria, Kenya. Photos J.Varet
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Top: Steaming normal fault Ta’Ali N. Afar, Ethiopia
Bottom: Steaming open-hole (detail of the same)
(Photos J. Varet)
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Google map showing Nubian plateau border (Ethiopia): right: Nile hydrographic basin, left: the Afar depression and Awash River basin. Marginal grabens developed along the escarpment. Location of major hot-springs sites (Harbu, Shekla, Borkena and Shewa Robit) shown in yellow. The nearest hot-springs sites in the Afar depression are shown in red. Limit of Regional States drawn as white dotted lines.
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Geological interpretative section of the hydrogeological system feeding the hot-springs and geothermal systems in the marginal graben and Southern Afar volcanic ranges
2. A common type of geothermal resource in the EARV

Hot-springs aligned along Kilwa fault along the Eastern shore of Lake Kivu (Rwanda). The structural context is very similar to the above scheme, with normal faults limiting the Butare Horst and springs occurring along the hanging block (see Uwera & Varet, this volume).
2. A common type of geothermal resource artisanally exploited in the EARV

Artisanal steam condensing well, Dabbahu, N.Afar, Ethiopia;
Condensing tower, N. Ghoubbet, Djibouti;  
Photos J. Varet
2. A common type of geothermal resource artisanally exploited in the EARV

Left: water condensing pipes, Otttu rift, N Eburru, Kenya
Right: drying plant using geothermal steam, Eburru, Kenya. When visited in 2017, the plant was not maintained and no more used. (Photos J. Varet).
2. A common type of geothermal resource artisanally exploited in the EARV

Left: hot-springs engineered for washing clothes and bathing near Gawani, southern Afar, Ethiopia.
Right: steam bath, Tulu Moye MER, Ethiopia

(Photos J. Varet)
Geothermal appropriation: some idioms for geothermal features in local languages (EARV)

<table>
<thead>
<tr>
<th>English</th>
<th>Afar</th>
<th>Maasai</th>
<th>Oromo</th>
<th>Pokot</th>
<th>Luo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water point</td>
<td>Lê</td>
<td>Enchoro</td>
<td>To’á</td>
<td>Kompa pogh</td>
<td>Wath</td>
</tr>
<tr>
<td>Lake</td>
<td>Bad</td>
<td>Olare</td>
<td>Haroo</td>
<td>Wöiwöi</td>
<td>Nam</td>
</tr>
<tr>
<td>Well</td>
<td>Ela</td>
<td>Ewell/Empakaa</td>
<td>Booll</td>
<td>Akwicha</td>
<td>Soko</td>
</tr>
<tr>
<td>Hot spring</td>
<td>Ni’il Lê</td>
<td>Lopuri</td>
<td>Gara Ifar</td>
<td>Enchoro nairowua</td>
<td>Bala tedo</td>
</tr>
<tr>
<td>Hot ground</td>
<td>Oloirowua</td>
<td>Ibidda</td>
<td>Nakorkorion</td>
<td>Wang’bala</td>
<td></td>
</tr>
<tr>
<td>Degasing water</td>
<td>Kahouh Ye</td>
<td>Empakaa</td>
<td>Gaazi Ifar</td>
<td>Ighöt</td>
<td>Ich bala</td>
</tr>
<tr>
<td>Steam vent</td>
<td>Boïna</td>
<td>Köpö/kompa ighöt</td>
<td>Aara</td>
<td>Impakaani</td>
<td>Muya</td>
</tr>
<tr>
<td>Steam bath</td>
<td>Oldisol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking mountain</td>
<td>Erta Ale</td>
<td>Oldoinyo opuru</td>
<td>Tullu aara</td>
<td></td>
<td>God yiro</td>
</tr>
<tr>
<td>Smelling bad</td>
<td>Abhe</td>
<td>Enguwuan</td>
<td></td>
<td>Arar</td>
<td>Tik</td>
</tr>
<tr>
<td>White clay</td>
<td>Ado Bodo</td>
<td>Munyan nyo pîrir</td>
<td>Reeffa</td>
<td>Munyan nyo rel</td>
<td>Lop bala marachar</td>
</tr>
<tr>
<td>Red clay</td>
<td>Asa Bodo</td>
<td>Ereko</td>
<td>Abaaboo</td>
<td>Munyan nyo pîrir</td>
<td>Rongo</td>
</tr>
<tr>
<td>White ash</td>
<td></td>
<td>Enturuto/Ewutwut</td>
<td></td>
<td>Orion</td>
<td>Pundo</td>
</tr>
<tr>
<td>Algae</td>
<td>Nyalga</td>
<td>Nyaara</td>
<td>Kröngrwö</td>
<td>Tuodo</td>
<td></td>
</tr>
<tr>
<td>Geothermal grass</td>
<td>Fiale</td>
<td>Loimuitiai</td>
<td>Sus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crater, hole</td>
<td>Bodu</td>
<td>Ekapunia</td>
<td>Afaan, Ifan</td>
<td>Kötöng’</td>
<td>Bugo</td>
</tr>
<tr>
<td>Open fissure</td>
<td>Adale</td>
<td>Olbaata</td>
<td>Eree</td>
<td>Körerut</td>
<td>midimidi</td>
</tr>
<tr>
<td>Fault</td>
<td>Andidou</td>
<td>Olbattata</td>
<td>Harka</td>
<td>Körerut</td>
<td>Okak</td>
</tr>
</tbody>
</table>
2. A common type of geothermal resource artisanally exploited in the EARV

<table>
<thead>
<tr>
<th>Country</th>
<th>Number identified</th>
<th>Total number (estimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Kenya</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Djibouti</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Tanzania</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Eritrea</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>125</td>
<td>275</td>
</tr>
</tbody>
</table>

Estimate of the number of small-size sites displaying superficial geothermal resources in the EARV

(Géo2D’s estimate from observation and work over time in the field)
1. The first stage of the approach is to collect information from the local inhabitants on their traditional knowledge and uses of these resources.

2. Then to study with them how a better use of these resources, when improved with appropriate technologies like drilling and other devices using heat exchangers,

3. Applications like fish farming, cooking, drying processes (for cereals, fruits, vegetable, meat or fish), green houses, direct uses of the thermal water for washing or sanitary applications are the most commonly identified

4. Other more sophisticated devices like binary plants for electricity production, would answer local needs

5. These should allow to improve incomes and pay for the devices investment and maintenance (particularly through food preservation and sales of derived products).

6. Public support is required for capacity building and first demonstrations (national, regional, donors and development agencies)
Water and energy: women’s and girls role in patoralist communies (Afar, Ethiopia)
Pokot North Baringo: community meeting raising awareness on geothermal
3. A radically different approach first based on local demand

<table>
<thead>
<tr>
<th>Number</th>
<th>Temperature range (°C)</th>
<th>Direct use application</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>120-140°C</td>
<td>Caning of food</td>
</tr>
<tr>
<td>9</td>
<td>80-110°C</td>
<td>Milk processing</td>
</tr>
<tr>
<td>8</td>
<td>80-100°C</td>
<td>Cooking</td>
</tr>
<tr>
<td>7</td>
<td>60-90°C</td>
<td>Food drying (cereals, vegetable, fruits, meat, fish)</td>
</tr>
<tr>
<td>6</td>
<td>70-80°C</td>
<td>Cold storage</td>
</tr>
<tr>
<td>5</td>
<td>50-70°C</td>
<td>Air conditioning</td>
</tr>
<tr>
<td>4</td>
<td>40-60°C</td>
<td>Green housing</td>
</tr>
<tr>
<td>3</td>
<td>30-50°C</td>
<td>SPA,</td>
</tr>
<tr>
<td>2</td>
<td>25-40°C</td>
<td>Bathing, washing</td>
</tr>
<tr>
<td>1</td>
<td>18-28°C</td>
<td>Fish farming</td>
</tr>
</tbody>
</table>

Possible applications of geothermal resources according to temperature for local uses in the EARV.
3. A radically different approach first based on local demand

Various options available for electricity production from geothermal fluids (temperatures range 100-240°C). Kalina and ORC (Organic Ranin Cycle) allow for the best performance in the range 90-180°C. Abscissa provides the power production in kWe per ton/hour of geothermal fluid. E.g.: at 120°C, 250t/h provide an installed power of 1 MWe.
4. Shallower and more economic

Investment cost breakdown of utility scale geothermal power development based on data from Iceland (ESMAP, 2012)
4. Shallower and more economic

Indicative costs for geothermal development (generator capacity of 50 MWe). Figures are in US$ Millions (from ESMAP, 2012).

<table>
<thead>
<tr>
<th>PHASE / ACTIVITY</th>
<th>LOW ESTIMATE</th>
<th>MEDIUM ESTIMATE</th>
<th>HIGH ESTIMATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Preliminary Survey, Permits, Market Analysis</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2 Exploration</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3 Test Drillings, Well Testing, Reservoir Evaluation</td>
<td>11</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>4 Feasibility Study, Project Planning, Funding, Contracts, Insurances, etc.</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>5 Drillings (20 boreholes)</td>
<td>45</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>6 Construction (power plant, cooling, infrastructure, etc.)</td>
<td>65</td>
<td>75</td>
<td>95</td>
</tr>
<tr>
<td>Steam Gathering System and Substation, Connection to Grid (transmission)</td>
<td>10</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>7 Start-up and Commissioning</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>142</strong></td>
<td><strong>196</strong></td>
<td><strong>274</strong></td>
</tr>
</tbody>
</table>

In US$ Million per MW Installed

2.8 3.9 5.5
indicative costs for geothermal development based on shallow (300 – 800m) geothermal resources (generator capacity of 50 MWe). Figures are in US$ Millions (author’s source).
Founders of AGAP (from right to left): Colonel Anbesit Nebro, Ismail Ali Gardo (APDA), Abako (N Afar clan elder), Lul Mengesha Seyoum first meeting, 2015, Northern Afar
Vote of the status of AGAP &
Election of the board members
Bringing the initial capital from all communities in Northern Afar (2015)
5. Implying a new methodological approach and appropriate technical tools

5.1 Reconnaissance studies

- Satellite imagery and air photos
- Field surveys with indigenous people; IR drone complements
- Temperature measurements and flow rates estimates
- Identification of the local demand and readiness

5.2 Pre-feasibility studies

- Technological solutions answering community’s demand (quantity and quality)
- Geoscientific survey: detailed structural mapping, 3D shallow hydrothermal plumbing, fluid composition
- Local drilling capacities and necessary adaptations

5.3 Feasibility studies

- Exploration drilling (300-700m)
- Production tests (flow rate and composition)
- Community based entity to be established
- Technological device including storage and mini-grids

5.4 Site development

- Cascade use of energy and water
- Run by local company with community and professional stakeholder
- Sales and maintenance
6. Conclusion: a real perspective for geothermal stakeholders

- Most favorable sites in pastoralists areas
- Geothermal offers resilient solution to cc (sustainable water + energy)
- It is readily economic, partly adaptable to local capabilities
- Should imply local communities, particularly most concerned (gender)
- However lack information and capacity building
- New methodologies to be implemented at regional level (Argeo, GRMF…)
- Should be a priority for national/regional governments and development agencies (bi- and multi- lateral)
- As well as for private developers of a new kind
Vote of the statutes and election of the board of the Afar Geothermal Development Company (Ethiopia)

Thank you ! Merci !