Tanzania Green Energy Approach

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Outline

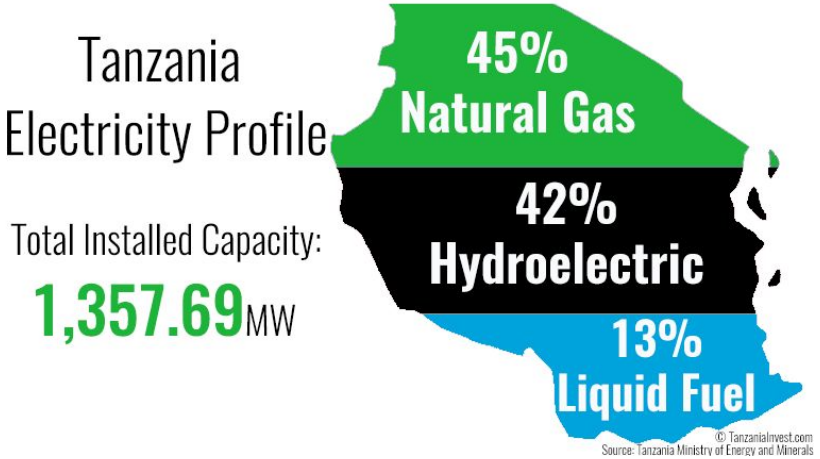
1. Tanzania Demographics
2. Current Energy Situation
3. Climate Change in Tanzania
4. Main Issues
5. Potential Solutions
6. Geothermal
7. Wind Power
8. Solar
9. Education
10. Past, Present and Future

Tanzania Demographics

- Land area of 945,000 square km
- Population of 44,929,002 people (2012)
  - Growth rate of approx 2.9% per year
  - Expected to reach 64 million by 2025; 83 million by 2035
- 75% of population lives in rural areas
  - Urbane populations projected to increase by 2035, but rural will still dominate
- Economy
  - Grew 6.7% a year on average from 2000-2012
  - GDP per capita grew to 1379 (US$2005, PPP)
  - 33% of population (2007 number) still lives in poverty (2% decrease from 2001)
  - 50% GDP from tourism, 25% from agriculture
  - 67% of workforce employed in agriculture
- Significant underdeveloped mineral reserves exist in the country

Current Energy Situation

- National Energy Policy (1992,2015)
  - Promotes efficient energy use
  - Ensure availability of reliable & affordable energy
- Resources:
  - Hydro
  - Natural Gas
  - Coal
  - Uranium
  - Geothermal
  - Other renewable (wind, biomass, solar, tidal and wave energy)
- +/- 85% Energy supply from Biomass (Charcoal and Firewood)
  - >80% of energy from Biomass is consumed in rural areas; deforestation



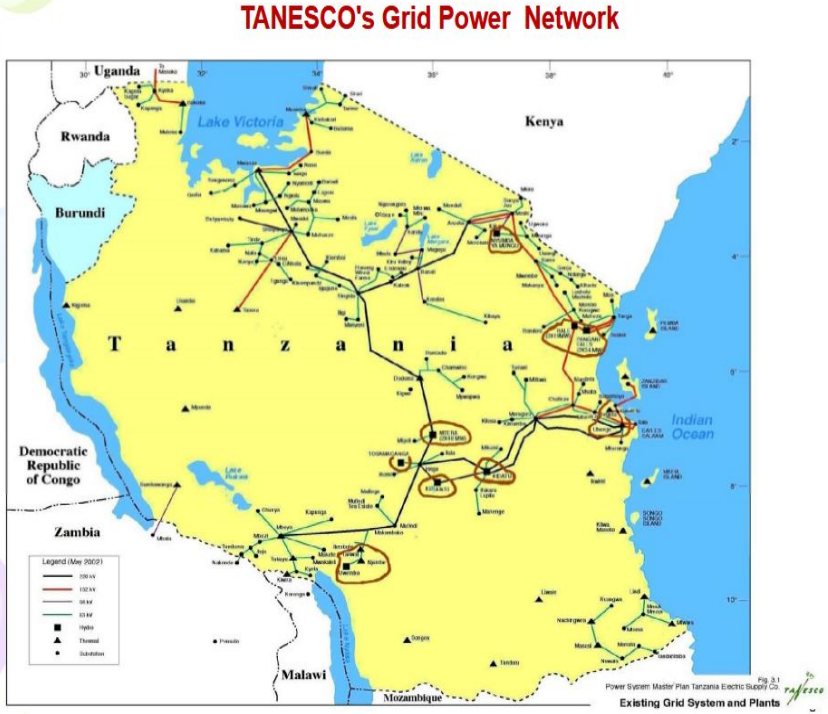
- Launched in 2013 by President Obama
  - Double electricity coverage in sub-Saharan Africa
  - Add 30,000 MW new, clean energy to 60 million new connections(clients)
- 150 MW Kinyerezi I gas-fired thermal plant has been commissioned
- 2015, TANESCO (public utility) established independent transmission system operator, or TSO through Power Africa
  - Developed TSO Business Plan and Transition Roadmap
  - Fully operational TSO expected by 2021
- Supports off-grid power providers for rural areas
  - Devergy (Social energy services company)
  - Deploys micro-grids for customers to run appliances and lights

Climate Change in Tanzania

- Rainfall and Rivers
  - 1 wet season, dry season getting drier
  - Annual flow reductions of 6-10% in rivers (VPO-URT, 2003)
  - In Tanzania,two of three rivers have reduced flow due to declining regional rainfall, which has had ecological and economic impacts such as water shortages, lowered agricultural production,increased fungal and insect infestations, decreased biodiversity and **variable hydropower production**(Orindi and Murray, 2005).
- Sea Level Rise (SLR)
  - SLR and coastal erosion leading to coastal management issues with coral reef loss
  - SLR will cause salt-water intrusion into freshwater supplies in aquifers and deltas
- (Hansen et al., 2003). Initial vulnerability assessments and adaptation planning from Tanzania point to the need for mangrove protection, reforestation with “climate-smart species”,integrated land-use and marine planning, as well as activities to improve resource use technology.

Main Issues

- No major development in the laws regulatir the energy sector
- Low income country
    - Lack of creditworthy off-taker
    - Lack of cost-reflective tariffs
    - Heavy reliance on expensive energy methods
- Majority of population live in rural area
    - Restricted access to affordable and reliable electricity
- Climate change affects hydropower reducing production



Potential Solutions

- Wind
  - Offshore availability for building
  - Strong onshore winds with monsoon influences
- Solar
  - Off-grid energy solutions becoming popular
  - Availability to rural population
  - Gov. support through no import tariffs
- Geothermal
  - Gov has commissioned Geothermal Strategy and Regulatory Framework and Risk Guarantee
  - Still in early stages, may not happen for many years
- Hydropower
  - 2,100 MW Stieglers Gorge hydropower plant in the works
  - Climate Change issues will lessen power output
  - Hydrological issues are ever present as well, lessening reliability

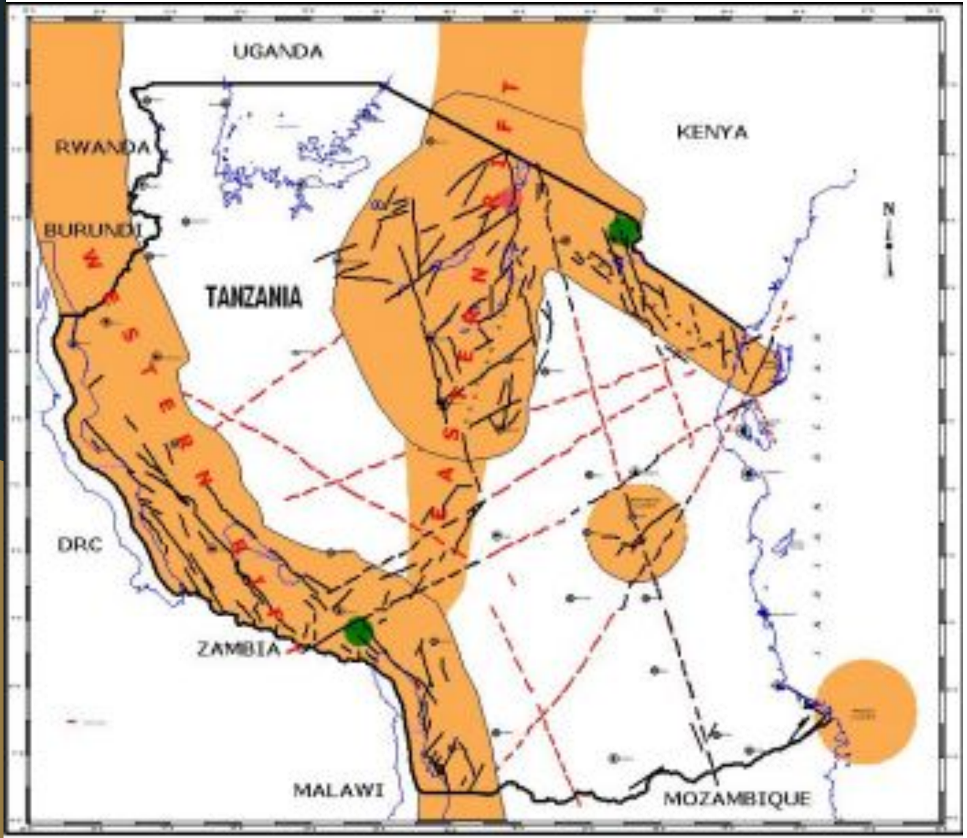
Geothermal

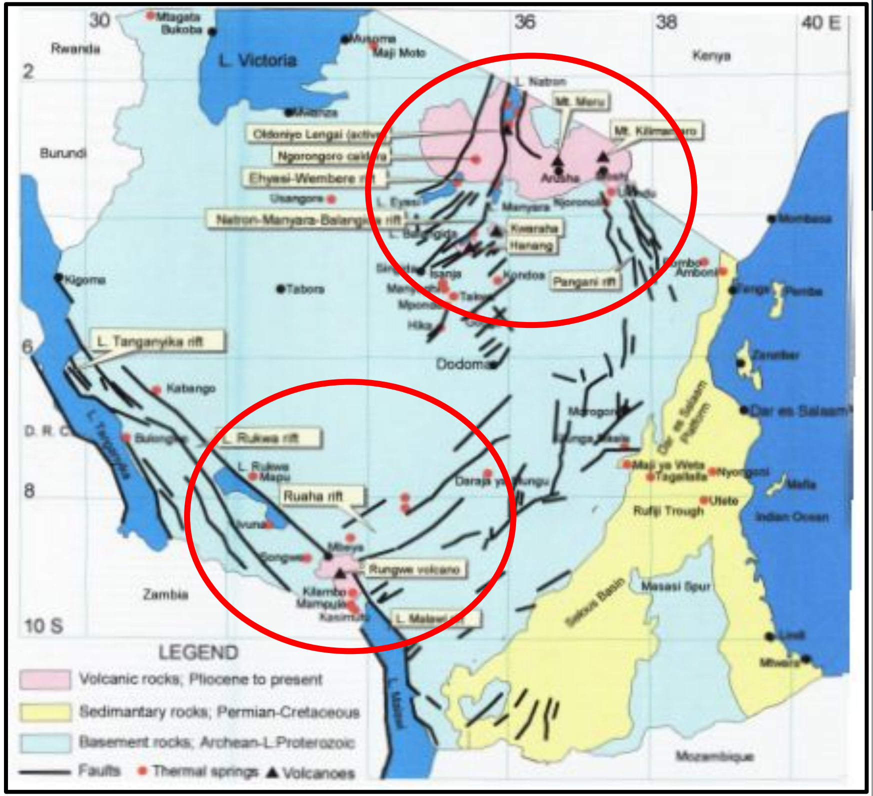
Tanzania has significant geothermal potential

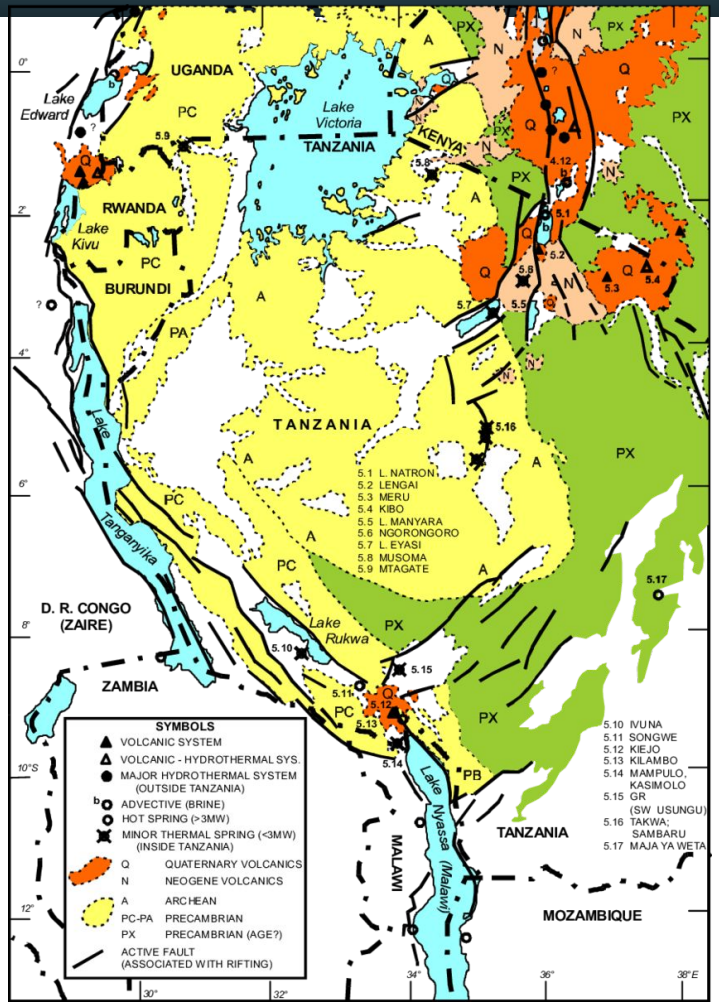
- Geothermal sites are located in areas transected by the East African Rift Valley System (EARVS)
- Estimates indicate potential exceeding 650MW
- Clean and renewable energy source that could provide sufficient and reliable energy, and bridge electricity supply gap in Tanzania

Geothermal steam rising from the Rufiji Valley Basin

Geothermal


UGANDA
KENYA
RWANDA
BURUNDI
TANZANIA
DRC
ZAMBIA
MALAWI
MOZAMBIQUE
N


30
36
38
40 E
2
6
8
10 S
Rwanda
Burundi
Kenya
D. R. C
Zambia
Mozambique
L. Victoria
Mtagata
Bukoba
Musoma
Maji Moto
Mwanza
L. Natron
Mt. Meru
Mt. Kilimanjaro
Arusha
Oldoniyo Lengai (active)
Ngorongoro caldera
Eyasi-Wembere rift
Usangore
L. Eyasi
Natron-Manyara-Balangida rift
Manyara
Kwaraha
Hanang
Kondoa
Pangani rift
Kigoma
Tabora
L. Tanganyika rift
Dodoma
Kabango
Rukwa rift
L. Rukwa
Ruaha rift
Mbeya
Rungwe volcano
L. Malawi
Tanga
Pemba
Mombasa
Zanzibar
Dar es Salaam
Dar es Salaam Platform
Rufiji Trough
Indian Ocean
Mafia
Masasi Spur
Selous Basin
LEGEND
Volcanic rocks, Pliocene to present
Sedimantary rocks, Permian-Cretaceous
Basement rocks, Archean-L.Proterozoic
Faults
Thermal springs
Volcanoes



Geothermal

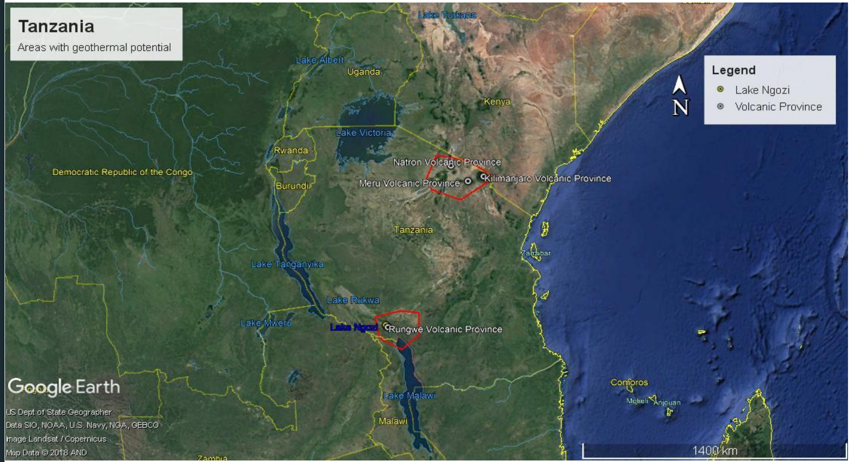
- ★ Sites identified with hot springs located proximal to EARVS
- ★ Areas include:
  - Northern Volcanic Provinces
    - Kilimanjaro, Meru & Natron
  - Southwestern Tanzania
    - Rungwe Volcanic Province
  - Eastern Coastal areas (South of Dar - es - Salaam)
    - Surface manifestation of geothermal resources (Utete and Luhoi area)

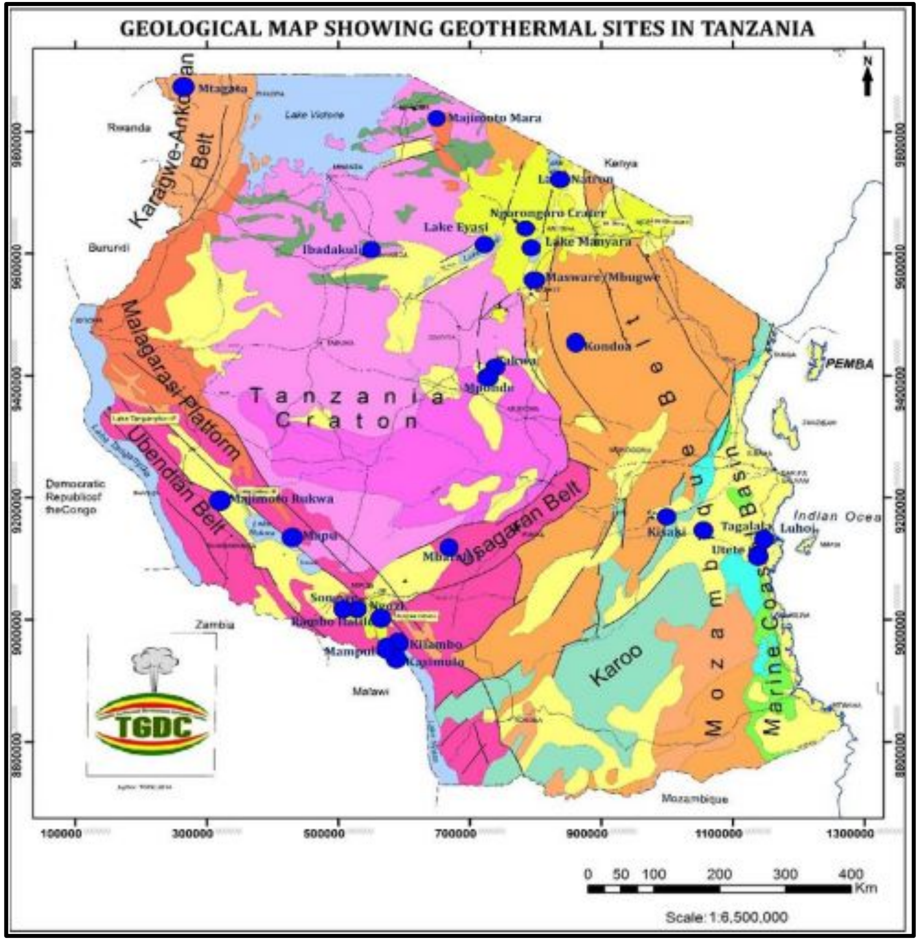
Geothermal - Exploration History

Year	Institution	Study	Results	Area
1976 - 1979	SWECO through Sida	Reconnaissance exploration	50 hot springs sampled	Lake Natron, Manyara, Utete, Mbeya, Musoma
1983	UNDP funded geothermal mission	Reconnaissance exploration	Mbeya considered a good prospect	South Mbeya
1997 - 2004	First Energy Company Ltd	Reconnaissance Exploration, Power project pre feasibility study	Samples collected and analyzed, good results, (promising site)	Luhoi - Coast region
2004 - 2005	DECON through African Development Bank (ADB)	Rural electrification study Magnetometric, gravity and resistivity surveys	Recommended detailed assessment of Mbeya area.	Lake Natron, Manyara and Mbeya (Songwe, Kasumulo, Mampulo)
2004 - 2005	Regional Consultant for Geothermal in East Africa	Status of geothermal resource development in Tanzania	Recommended further studies on Songwe, Luhoi and Lake Natron	Lake Natron, Songwe river, Luhoi (Coast region)

Geothermal - Exploration History

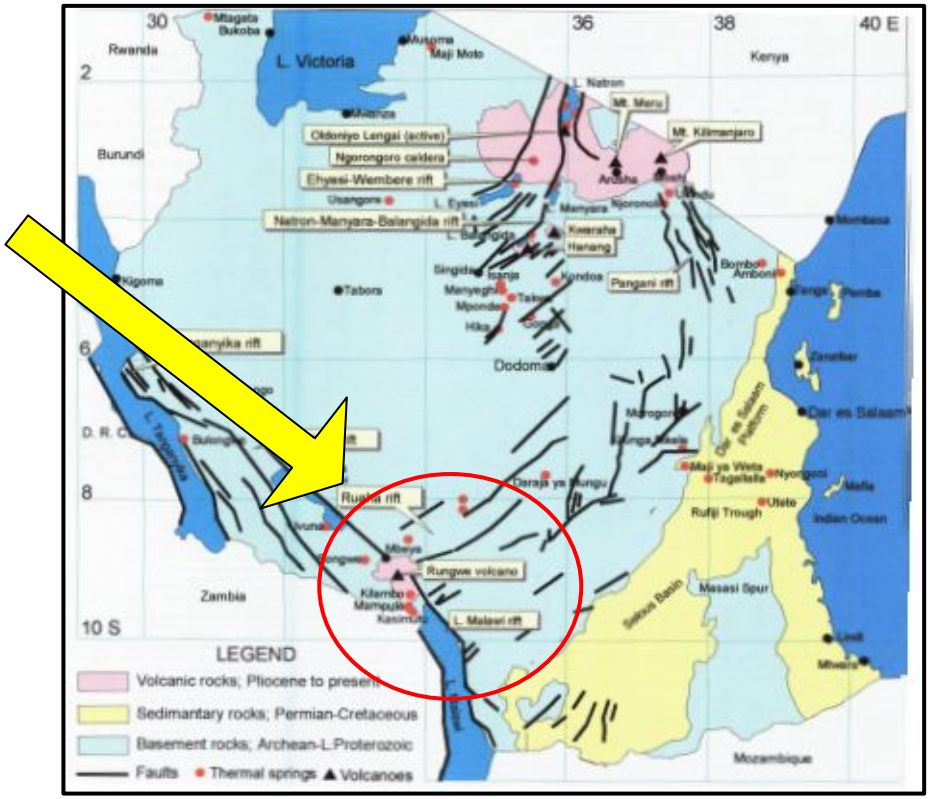
2006 – 2009	MEM collaboration with Geological Survey of Tanzania and Federal Institute for Geosciences and Natural Resources (BGR) German	Reconnaissance study on geophysics method of exploration by using Transient Electro Magnetic (TEM) and Vertical Electric Sounding (VES)	One site for detailed assessment identified	Songwe river in Mbeya region
2009 – 2012	GoT in collaboration with Federal Institute for Geosciences and Natural Resources (BGR) German; GEOTHERM phase 2	Pre-feasibility study by using (TEM) and Magnetotellurics (MT).	Low resistive layers encountered in the subsurface (report not yet out)	Lake Ngozi area in Mbeya region


Tanzania
Areas with geothermal potential
Legend
Lake Ngozi
Volcanic Province
N
Lake Turkana
Lake Albert
Uganda
Kenya
Lake Victoria
Rwanda
Burundi
Democratic Republic of the Congo
Natron Volcanic Province
Meru Volcanic Province
Kilimanjaro Volcanic Province
Tanzania
Zanzibar
Lake Tanganyika
Lake Rukwa
Lake Mweru
Lake Ngozi
Rungwe Volcanic Province
Lake Malawi
Malawi
Comoros
Zambia
Google Earth
US Dept of State Geographer
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Map Data © 2018 AND
1400 km


GEOLOGICAL MAP SHOWING GEOTHERMAL SITES IN TANZANIA
Mtagata
Majimoto Mara
Rwanda
Burundi
Kenya
Lake Natron
Ngorongoro Crater
Lake Eyasi
Lake Manyara
Ibadakuli
Maswa
Kondoa
PEMBA
Karagwe-Ankolean Belt
Malagarasi Platform
Ubendian Belt
Tanzania Craton
Usagaran Belt
Majimoto Rukwa
Mapu
Democratic Republic of the Congo
Kisaki
Tagalala
Luhoi
Utete
Indian Ocean
Ngozi
Kilambo
Kapimolo
Zambia
Malawi
Karoo
Mozambique Belt
Mozambique Basin
Marine Coast
Mozambique
TGDC
100000
300000
500000
700000
900000
1100000
1300000
0 50 100 200 300 400 Km
Scale: 1:6,500,000

Geothermal - Results

- High - enthalpy resources are mainly favourable in Mbeya region (SW Tanzania in Rungwe Volcanic Province)
  - Active Faults present → allowing fluid flow
  - Surface manifestation of geothermal activity → hot springs seen
- Geochemical nature of Mbeya hydrothermal fluids were used to help predict the potential for other regions (Mbeya waters used as a standard or minimum standard to ID geothermal resource viability)



Geothermal - Results

- **Geochemical Data:**
    - Low B/Cl ratio in water = water belong to old hydrothermal system
    - Mbeya regional waters and water from Lake Ngozi area show geothermal character
- **Geophysical Data:**
    - TEM and MT surveying around Ngozi area show low resistivity layers → thus alteration zones → geothermal potential

Geothermal Energy Development: Present to Future

TGDC is a subsidiary company of TANESCO, established by the GoT in 2013

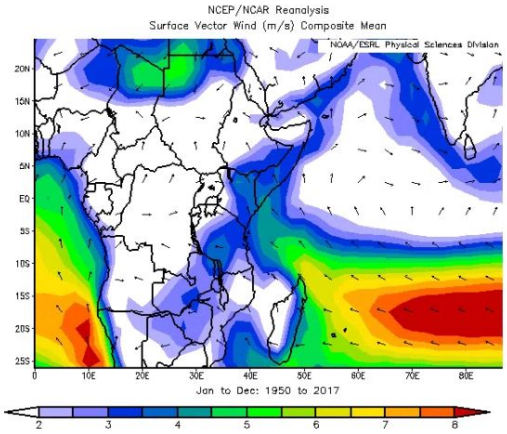
- Purpose: Oversee, Expedite and Guide geothermal energy development in Tanzania
- TGDC aims to generate electricity from geothermal resources as a “clean” & renewable source
- In addition, dry spells directly affect energy supply from hydroelectric plants → GTE could help the country to meet supply demand by 2025
- Geothermal Energy Generation goals:
  - 200 MW by 2020
  - 500 MW by 2022
  - 800 MW by 2025

Barriers to Geothermal Energy

Barriers	Solutions and Approach
Lack of awareness to stakeholders, decision makers and land planners	Create awareness, emphasising importance of geothermal as clean and renewable energy source
Lack capacity to develop GTE: Few trained professionals and lack of training on GTE	Provide and develop training approach: Train Tanzanians in various fields related to GTE
★ High cost involved in GTE exploration and start-up costs (1 exploratory well ± $ 5 mil.) ★ Not enough interest from private sector	★ Produce new & detailed geothermal maps (update) → attract research opportunities and investors ★ GoT should become more involved with regional geothermal initiatives (ARGEO)

Wind Power

- Estimated need at least 5 m/s average wind speeds
  - Locations along/off coastline and in south central Tanzania are ide
  - Seasonal variance in other areas due to
- Could generate 50 - 100 MW additional power in localized regions
  - Potential for up to 500 MW total production
- 1st Wind Farm just built
  - Wind East Africa in Singida
- Problems:
  - Monsoon season and changes in ENSO
  - Variable wind speeds
  - Cost
  - Lack of research



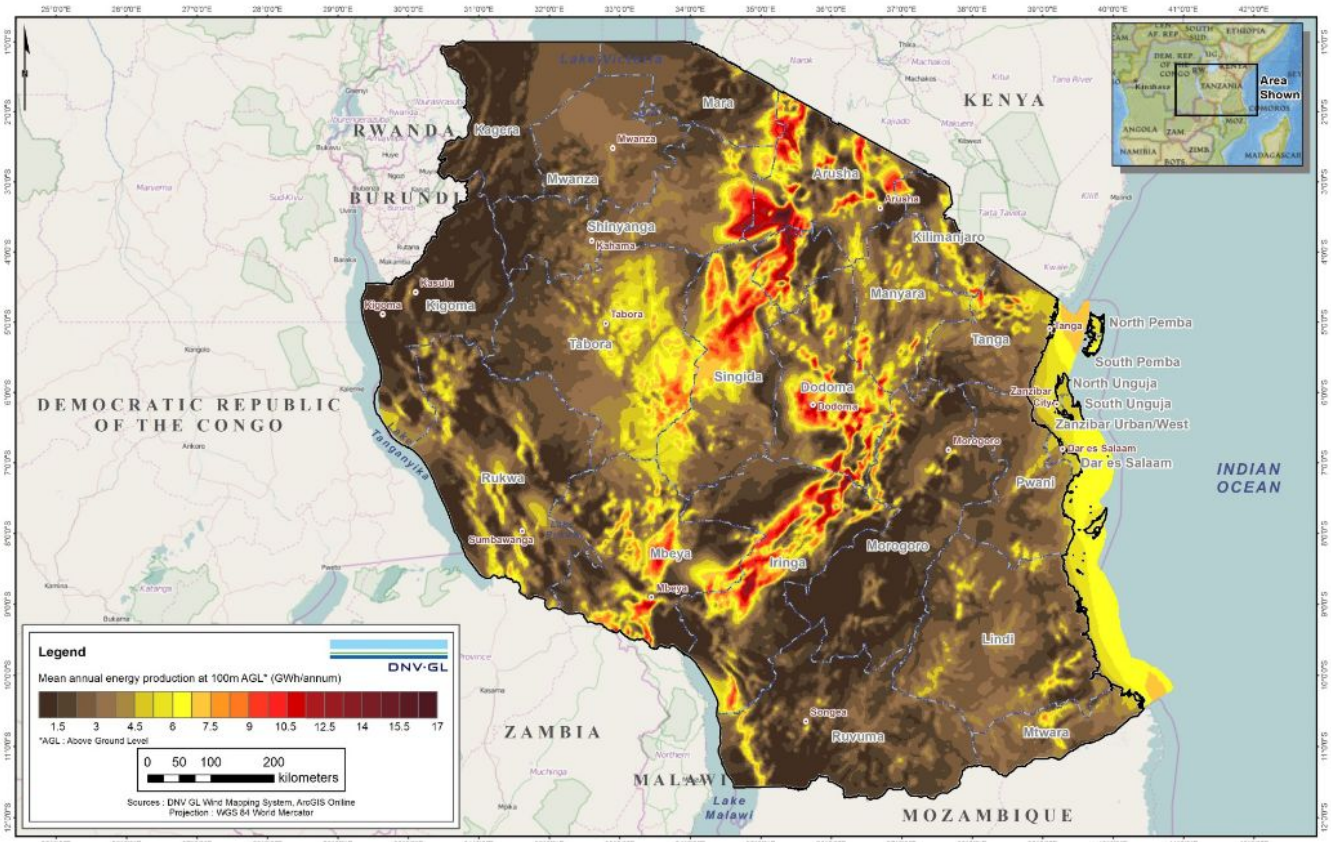


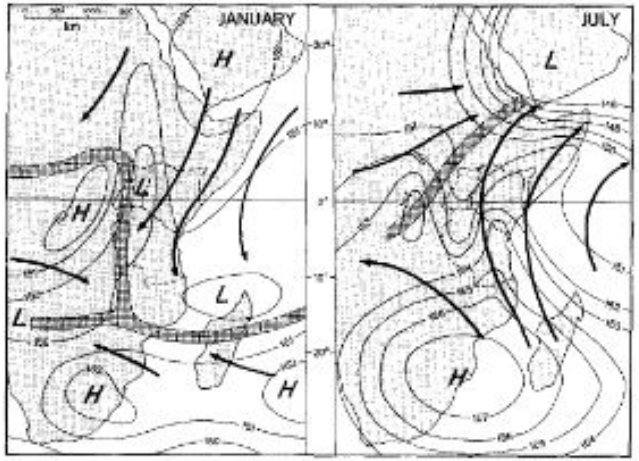
Figure 3-4 Preliminary and unvalidated wind energy map created using the DNV GL Wind Mapping System

East African Monsoon

- Extension of Asian Monsoon
- Causes 1 wet season in southern Tanzania, 2 in central and northern
  - Winds strong from Northeast In spring
  - Southwest in Summer and East in fall
- Consistent wind speeds along the coast on yearly basis
  - Seasonal variations inland
- Climate change
  - ENSO (El Niño Southern Oscillation)
  - Drier regions become drier
  - Affects hydropower and river/lake volume
  - Weakening westerlies weakens overall circulation

Fig 1

Surface winds, pressure distribution and the mean position of the surface I.T.C.Z. in Eastern Africa. Pressure distribution: thin lines, indicating the elevation of the 850 mbar surface in geopotential dekametres.
I.T.C.Z.: indicated by cross shading.

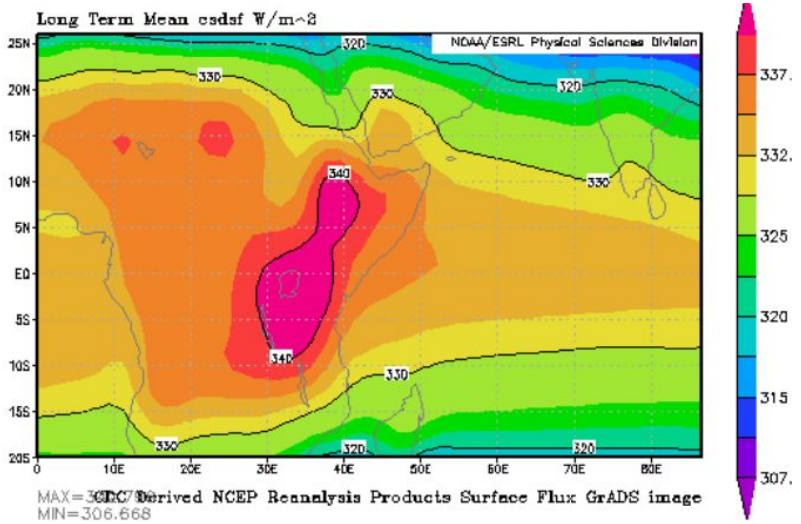


Barriers to Wind Energy

- Government
  - Government support is available
  - Government unsure how to regulate cost and usage
- Cost
  - 1st ever wind farm in Tanzania cost $285 million
  - Investors are prepared to back the country
- Location
  - Must be located on coast or Southwest Tanzania
  - No large scale grid network to distribute power
  - Will only provide localized power
- Research
  - R&D for new technologies
  - Understand current climate and variations (wind speeds, temps, etc)

Solar

- Viable in all parts of the country
  - Especially Central and Western areas
- Individual and micro-grid scale
  - No reliance on national grid
  - Effective solution for remote communities
- Partial roll out by “Lighting Africa”
- Accessibility limited by cost of individual units



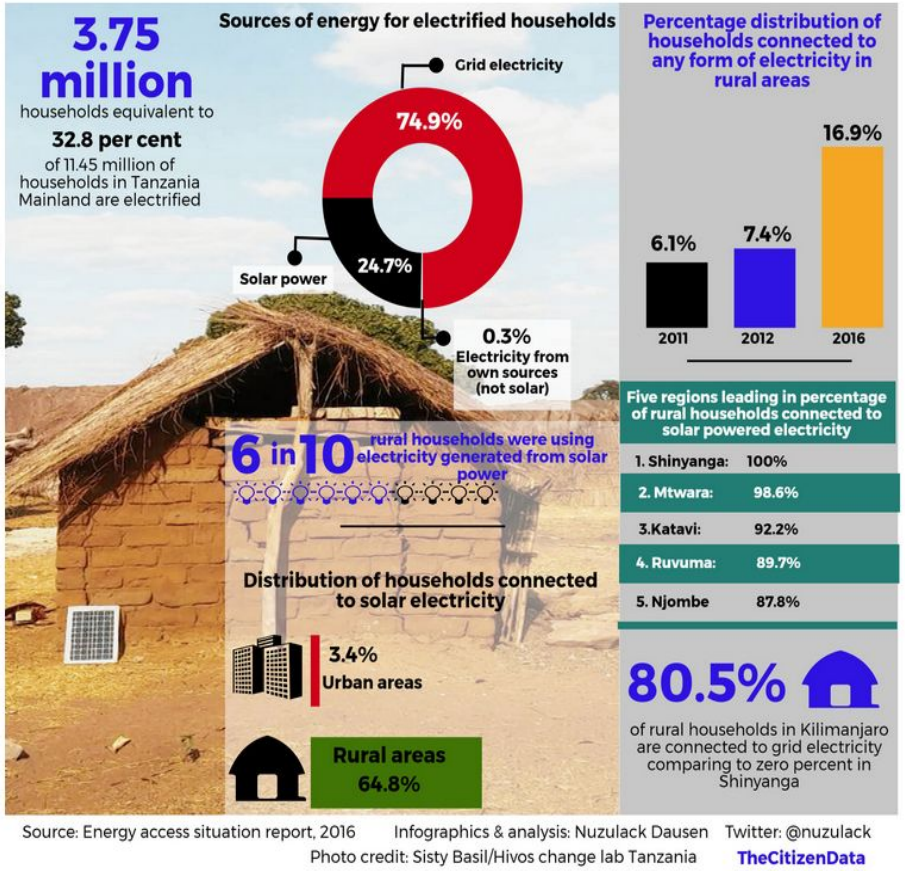
Lighting Africa

- Utilizes private sector to build sustainable markets
  - Has provided power to 7.7 million across Africa
- Has 5 main components:

1. Quality Assurance. Establishing quality specifications and developing testing methodologies to promote the manufacture and distribution of quality products
2. Market Intelligence. Informing the design of suitable products for the African market
3. Business Support and Access to Finance. Assisting manufacturers and distributors in achieving their business goals and supporting new business models to deliver low-cost and high-quality off-grid lighting and supporting distributors and consumers to locate potential sources of funding
4. Consumer Education. Generating awareness about and building demand for modern off-grid lighting products
5. Policy and Regulation. Engaging governments to create an enabling policy and regulatory environment and supporting them in integrating modern off-grid lighting in their electrification plans

Current Solar

- Rural Areas
  - 65% of households receive energy from solar
  - 34.5% of households connected to grid
  - 24.7% total households in all of Tanzania use solar energy
- 10 MW solar panels used
  - Bought by farmers/village persons
  - Provide energy for light bulbs, charging electronics, etc
- Technology becoming cheaper
  - More people adopting
  - Investors want to build solar grids



Barriers to Solar Energy

- Cost
  - Costs have been reduced in the past 3 years
  - Large solar grids need investor backing
  - Rural Areas need to be connected to a grid
- Lack of Government Policies
  - Need to control import of cheaper solar technologies
  - Need to control import of low quality equipment
  - Need to put more off-grid villages in their electrification projects
- Knowledge
  - Many Tanzanians don’t know they have access to such technology
  - R&D needs to be done to better develop technology in the country

Education

- Primary school account for most of public's knowledge
  - Large percentage have never gone to school
- Need to be educated in renewables

Table 3.3: Percentage Distribution of Members of Households Level of Education Attained by Sex and Place of Residence

Level of education	Total	Male	Female	Rural	Urban
Total	**100**	**100**	**100**	**100**	**100**
Nursery Education	4.0	4.4	3.7	4.1	3.8
Primary Education	64.3	65.3	63.4	67.2	57.9
Course After Primary	0.4	0.4	0.4	0.4	0.5
Secondary (O level)	12.7	13.5	11.9	7.9	23.2
Course After Secondary	0.4	0.5	0.3	0.2	0.7
Secondary (A level)	0.6	0.8	0.4	0.2	1.3
Training After High School Education	0.1	0.1	0.0	0.0	0.2
Others Certified Training	0.6	0.7	0.5	0.3	1.1
Higher Learning	2.1	2.7	1.5	0.4	5.6
Adult Education	0.1	0.1	0.1	0.1	0.0
Never gone to School	14.9	11.5	18.0	19.1	5.7

- Public opinion research finds that public awareness and concern about CC vary greatly across the world
  - Other related key factors highlight the need to develop tailored CCE strategies/curriculums for individual nations

How do we Educate them?

- Inform the Public
  - Teach about renewable energy in school
  - Educate the uneducated with pictures and demonstrations rather than numbers
- Inform the officials
  - Scientists need to present the issue in a way that makes it present to officials
  - Show them the near-term effects first
  - Then show the economics of long-term solutions
- When dealing with Economy, need backing of businesses first
  - Industry leaders hold immense political persuasion powers
- Effective Policies need to be enacted to help curb the issue
  - Paris Agreement, Kyoto Protocol set no economic climate change standards
  - Price of carbon needs to be factored in and used as a controlling mechanism
  - How can this be done effectively?

20 years later

- National Development Vision 2025
  - Developed with help of European Union
  - 5-year development plans to become middle-income country by 2025
  - Need 10,000 MW increase in power generation capacity
  - Plan to have 75% of population access to electricity by 2025
- Still majority rural
  - Cannot feasibly build large-scale grid
- We want 100% of rural communities have solar/grid power
  - Localized grids and solar panels
  - 10 MW panels already available
- Higher levels of education through inter/intranet programs
  - Both for public and government
- Wind Energy at coast and Southwest areas

How can we achieve this?

- Rely on coal/oil/natural gas reserves in country to build economy
  - Cannot reliably switch to renewables without first stabilizing economy
  - Should be accomplished by 2025
- Send in scientists and researchers to educate public and government
  - Teach people how renewables work and what they are
  - Train their scientists to work on renewables
  - Help government deal with economic side of renewables
- Begin wind power on the coast
  - Need investors to build turbines and show they are cost-effective
- Mass distribute solar panels
  - Cheaper solar panels distributed to rural regions
  - Done through Gov programs, Private Investors, etc

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