GENDER AND GEOTHERMAL WORKSHOP – GUADELOUPE

An Introduction to Capacity Building in the Caribbean region and the need to be inclusive in the Renewable Energy Space

Indra Haraksingh
The University of The West Indies
TRINIDAD

Women & Energy Poverty

- 1.3 billion people worldwide living in poverty, 70% of them are women
- Energy poverty is:
  - "the absence of sufficient choice in accessing adequate, affordable, reliable, high quality, safe and environmentally benign, energy services to support economic and human development." (UNDP, 2000)
- Women are more likely than men to suffer from energy poverty; Lack of access to energy affects women and girls disproportionately
- Culturally, women are not associated with energy interest or skills; and they are let out in decision-making process



Women Exclusion

- Women's exclusion is due to:
  - Underrepresentation in decision-making bodies at the national and local levels
  - Limited training in technology fields
  - Perceptions that women are not interested in technology

Source: www.businessinsider.com

Source: www.freewestpapua.com

Gender Beliefs Over Time

- Gender beliefs can change over time, in response to changes in:
  - Social-economic circumstances
  - Natural and man made disasters (drought, war) technological development
  - Expectations about human development
- Gender-based expectations can be encouraged to change
- Many groups are working to change them at local, national and international levels
- These changes in beliefs about women's competencies benefit the community as a whole

(BRIDGE Project)

What do we need as a Region?

Build human capacity

Executives and other professionals - Policy makers

Scientists

To manage the more efficient use of energy

Technologists

To facilitate the uptake rate of renewable energy technologies

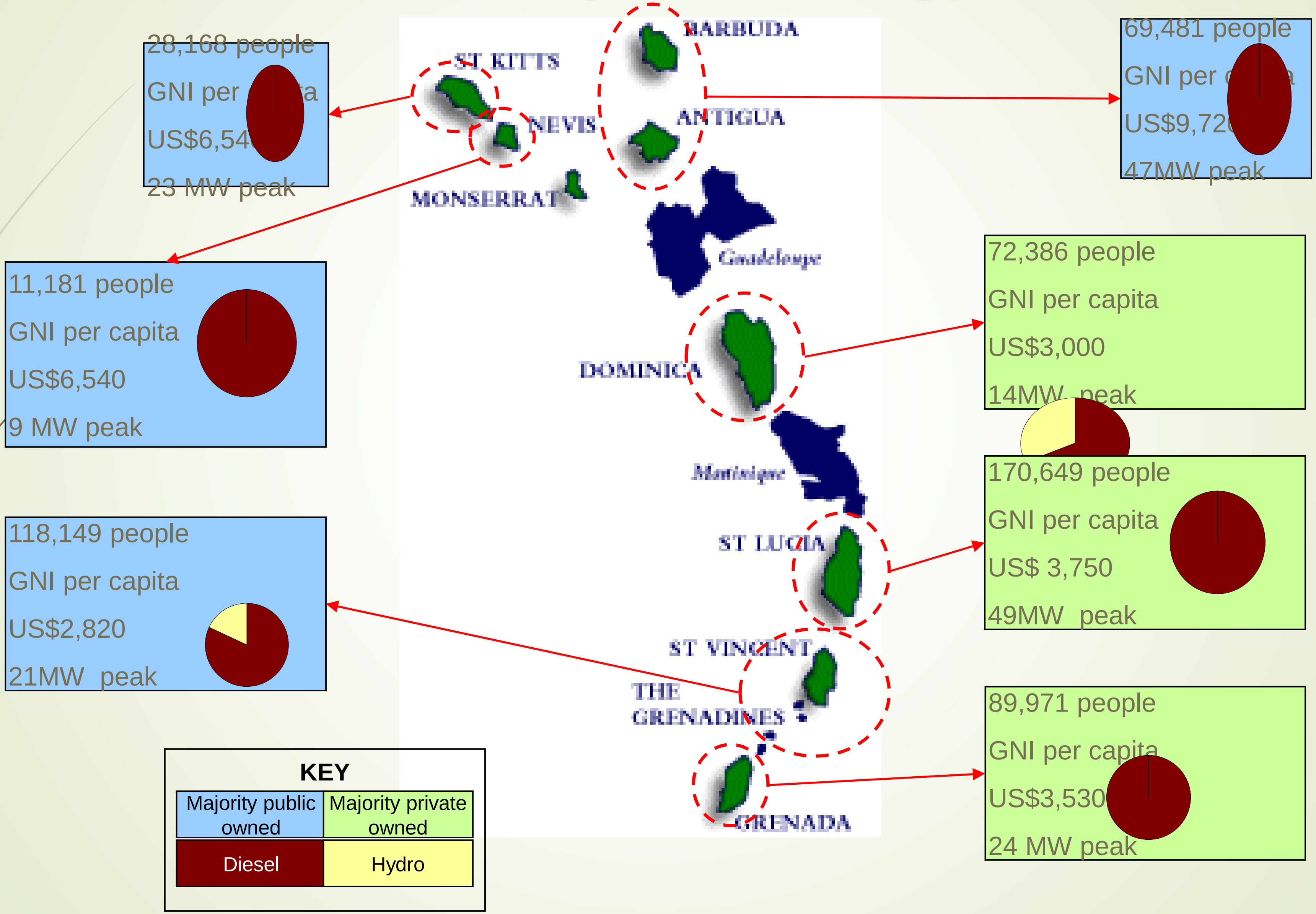
Essential transition to utilizing a more distributed indigenous renewable energy resource.

Energy Security

Sustainable Development

Environment & Climate Change

Small island economies with limited indigenous energy



POTENTIAL

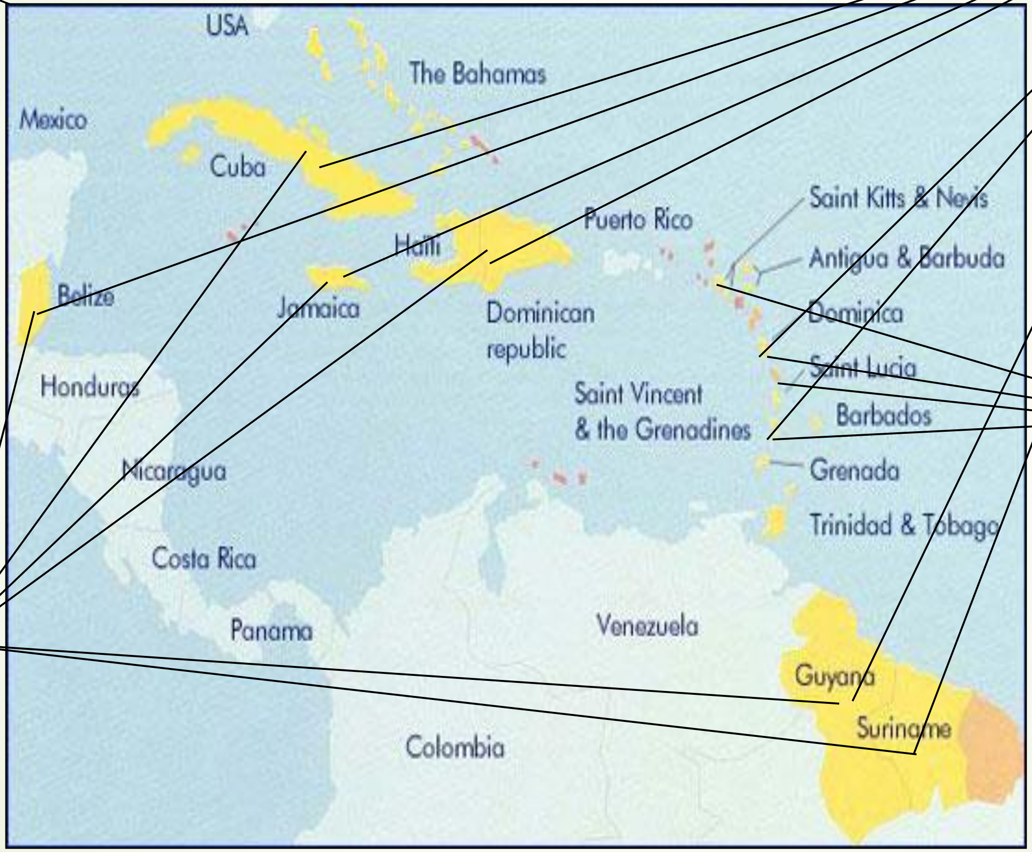
Solar

Wind

Hydro

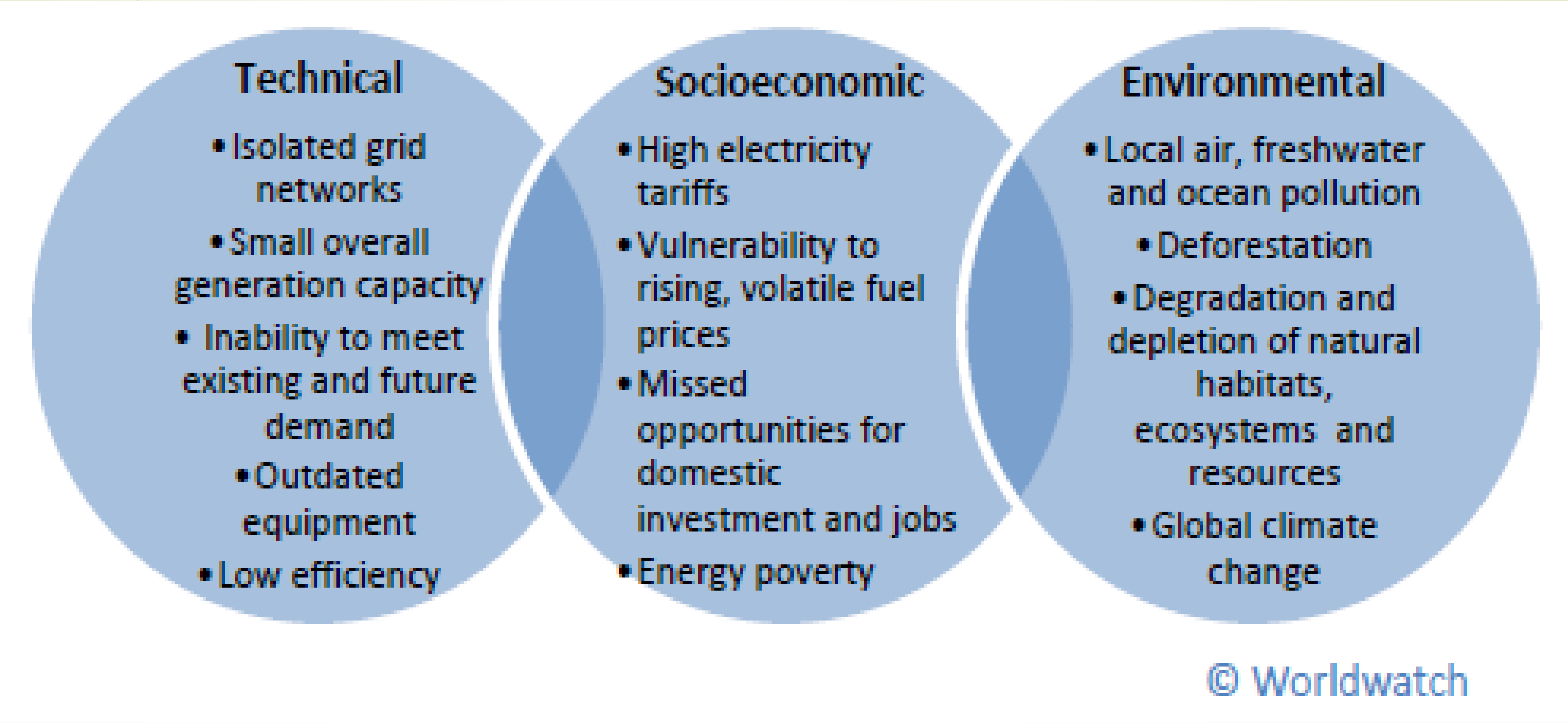
Geothermal

Biomass



RE Sources in the Caribbean

CHALLENGES FACED



CARICOM REGIONAL INITIATIVES

- Caribbean Renewable Energy Programme (CREDP)
- Regional Energy Policy
- Caribbean Sustainable Energy Road Map and Strategy (C-SERMS) and Platform
- Caribbean Renewable Energy Capacity Support (CRECS) Project
- Sustainable Energy Technical assistance (SETA-OECS/CDB) Project
- Caribbean Sustainable Energy Program (CSEP)
- CARICOM Energy Awareness Initiatives
- Renewable Energy and Energy Efficiency Technical Assistance (REETA)
- Technical Assistance Programme for Sustainable Energy in the Caribbean (TAPSEC)

  - Focus is on Capacity Building

The Caribbean Renewable Energy Development Programme - CREDP

- In 1998, 14 Caribbean countries and 2 British dependencies agreed to work together on a regional project aimed at removing barriers to the use of RETs and encouraging the development and commercialisation of RETs.
- CREDP: "To reduce barriers to the increased use of renewable energy thus reducing the dependence on fossil fuels while contributing to the reduction of greenhouse gas emissions“.
- CREDP is an initiative of the Energy Ministers of CARICOM region established to change the market environment for Renewable Energy in the Region.
- Funding for the Project is provided by: UNDP/GEF Co-Financing by: GTZ, UNDP Trac, In-kind contribution from OAS, and Regional Governments and Institutions.

CREDP / Capacity Building

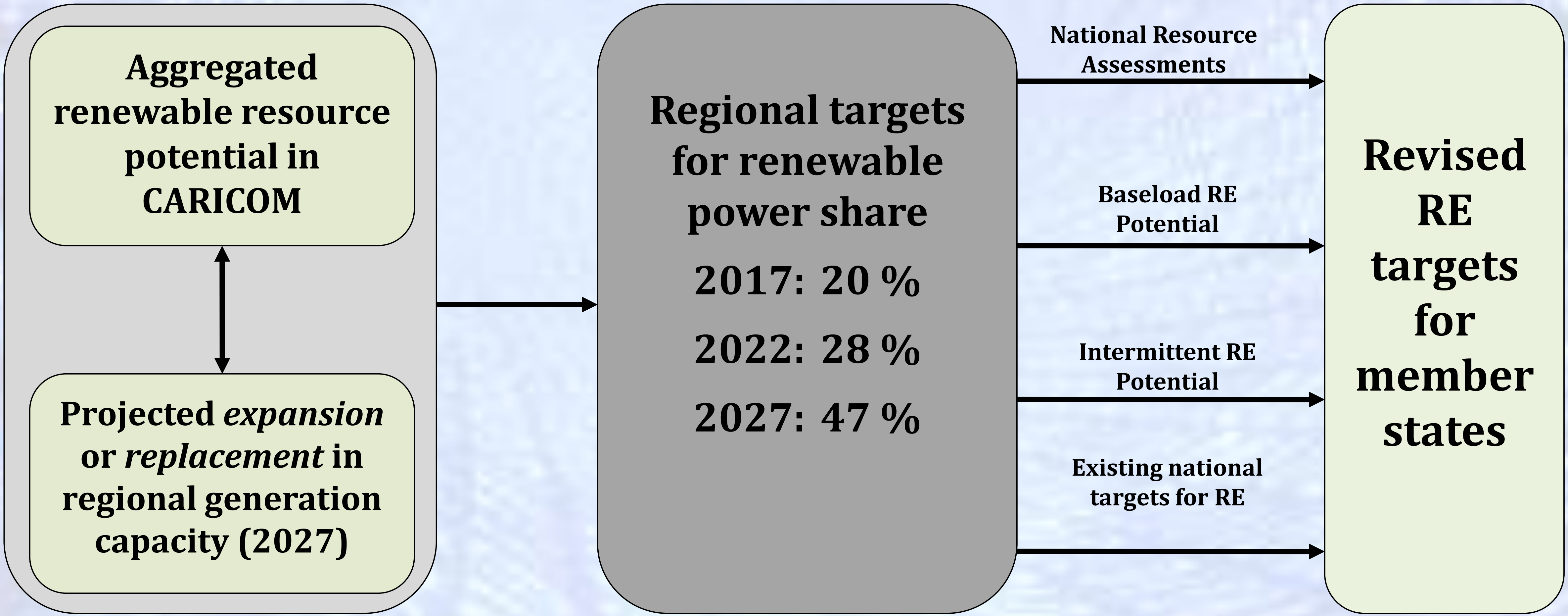
- A Project Steering Committee was created with the specific mandate to advise the project's implementation, in direct consultation with the Executing Agency and the Project Management

- CREDP has been highly instrumental in accelerating the growth of renewables in the region in terms of policy development, project implementation, upgrading of existing facilities, training and capacity building, among other initiatives.

- The first phase and the second phase of the CREDP project have been completed. The second phase had emphasis on energy conservation and energy efficiency

- **CREDP – TRAINING WORKSHOPS**
  - Wind Energy
  - Hydropower
  - Combined Heat and Power
  - Solar Water Heating
  - Solar Photovoltaics
  - RetScreen

National target-setting within the context of the C-SERMS (CARICOM)



Offerings in Renewable Energy at The UWI Department of Physics, Trinidad

- MPhil and PhD programme – Solar Energy, Wind Energy, Fuel Cells, Geothermal & other areas
- M.Sc. Renewable Energy Technology Programme
- Undergraduate courses in Renewable Energy
- Training Programmes / Short Courses in Solar Water Heating, Solar Photovoltaics, Wind Energy, Geothermal Energy, Energy Efficiency and Energy Auditing.

MSc in Renewable Energy Technology

Programme Developer and Coordinator:
Dr. Indra Haraksingh

International Cooperation:

- University of Flensburg
- Flensburg University of Applied Sciences
- Partner universities in Germany, Suriname, Bangladesh, Colombia and Ghana
- CARICOM

Department of Physics
Faculty of Science and Technology
The University of the West Indies
St. Augustine Campus

Course of Study
MSc in Renewable Energy Technology

- 15 months full-time
- 27 months part-time

Preparatory course	Not-for-credit
8 Core courses	24 credits
4 Elective courses	12 credits
Research project (6 months)	9 credits
Total	**45 credits**

Course of Study – MSc in Renewable Energy Technologies

Core Compulsory (8 courses – 24 credits)

- **Semester I**
- Energy Economics
- Shaping Sustainable Energy Systems
- Programme and Project Management
- Solar Energy Conversion
- Wind Energy I
- Bioenergy I
- **Semester II**
- Energy Use and Energy Auditing
- Electrical Integration of Renewables

Course of Study –
MSc in Renewable Energy Technologies

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Electives (4 courses – 12 credits)

Semester II

6 courses will be offered in

- Hydro and Marine Power
- Geothermal Energy
- Energy Storage
- Advanced Solar Energy
- Wind Energy II
- Bioenergy II

- **Research Project** (9 credits)
- Six months research work + Thesis Report and Oral Presentatio

TRIMESTER STRUCTURE

Trimester 1	Trimester 2	Trimester 3
Energy Economics Shaping Sustainable Energy Systems Programme and Project Management Solar Energy Conversion Wind Energy I Bioenergy I	Energy Use and Energy Auditing Electrical integration of Renewables Hydro and Marine Power Geothermal Energy Energy Storage Bioenergy II Wind Energy II Advanced Solar Energy	Research Project
TOTAL CREDITS - 18	TOTAL CREDITS - 18	TOTAL CREDITS – 9

Compulsory (24 Credits)

Elective (12 credits)

INTERNATIONAL COOPERATION WITH THE UWI and OTHER INSTITUTIONS

- CSES - Caribbean Solar Energy Society
- OAS - Renewable Energy Education project
- OLADE - Professional Development programmes
- INEES - International Network on Energy and Environmental Sustainability, project, a consortium of six universities led by University of Flensburg, in collaboration with Flensburg University of Applied Sciences, Germany

  Through the INEES partnership she has managed to send four Graduate students to University of Flensburg on scholarships funded by the DAAD to study in the SESAM, Sustainable Energy Systems And Management, programme, and students from Germany have also studied here at the UWI.

- DIREKT - A knowledge transfer project between The University of Hamburg, The University of Mauritius and The University of the South Pacific
- BRIDGE – In Sustainable Energy and ICT – IDB funded - Internships
  - *Focus of the BRIDGE project is to:*
    - *provide training that combines technical expertise and gender inclusion*
    - *make renewable energy projects successful and sustainable*
- TRAINING WORKSHOPS AND INTERNSHIPS

M.Phil. and Ph.D. Programmes

- SOLAR ENERGY: Solar Thermal and PV, Solar Cooling
- WIND ENERGY
- FUEL CELLS
- GEOTHERMAL ENERGY
- WAVE and TIDAL POWER
- UWI SMART GRID PROJECT

Fuel Cell Materials Research Laboratory, FCMRL

- ➢FCMRL is equipped with a new Fuel Cell Test Station
- ➢Three temperature and vacuum controlled ovens
- ➢An Eco-Chemie Precision Impedance Analyzer Bridge Model 302N - use in the measuring of an electrolyte ionic conductivity.
- ➢Ozone Generator – use in polymer synthesis

Dr Marisa Singh analysing impedance measurements of Polymer Electrolyte Membrane Samples using the Eco-Chemie Precision Impedance Analyzer Bridge Model 302N

Dr Kerrilee Stewart-Thomas carrying out polymer synthesis and characterization testing on membrane samples

GEOTHERMAL ENERGY RESEARCH PROJECTS

- Investigation of the Subsurface Heat Transfer Effects of a Horizontal Geothermal Heat Exchanger for a Tropical Climate
- Analysing the geothermal capacity through the development of Reservoir profiles to evaluate the implementation of an Enhanced or Engineered Geothermal System for Trinidad
- Mathematical Modelling and Simulation of Selective Stratigraphy within the Province of Saskatchewan, Canada for Geothermal Energy Prospecting
- Sampling Bias of Fracture Orientation caused by Linear Borehole Sampling
- Modelling the Montserrat Geothermal System

Enhanced or Engineered Geothermal System for Trinidad – *C. S. Ragoonath*

Supervisor: Dr. I. Haraksingh

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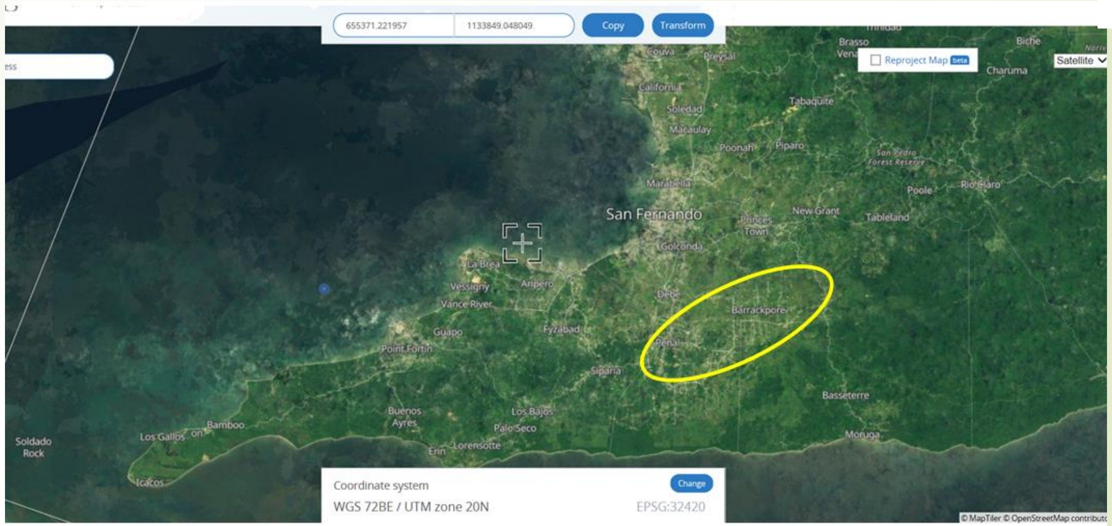
- ✓ This Research takes into account the use and manipulation of pre-existing hydrocarbon well data for a specific location in Trinidad.
- ✓ Results can then be used as preliminary findings to assess and estimate the geothermal capacity for the proposed area
- ✓ This research is Unique as there is exists *NO* documented Geothermal data or assessment for this country
- ✓ Since the country is situated on a sedimentary basin, and its geo-structure is highly influential on the rich hydrocarbon industry, therefore the geology of this country has the capacity to support an enhanced geo-system.
- ✓ The research attempts to provide geothermal parameters that will be used to assess and develop geothermal reservoir profiles for a particular area within the country Trinidad in the Southwest of the island.

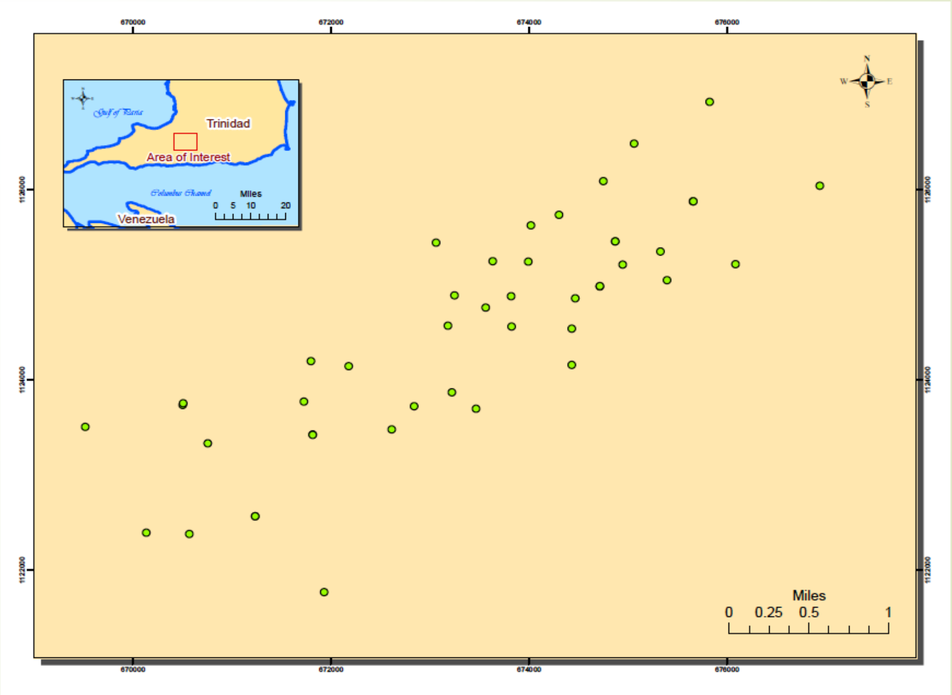
Enhanced or Engineered Geothermal System for Trinidad

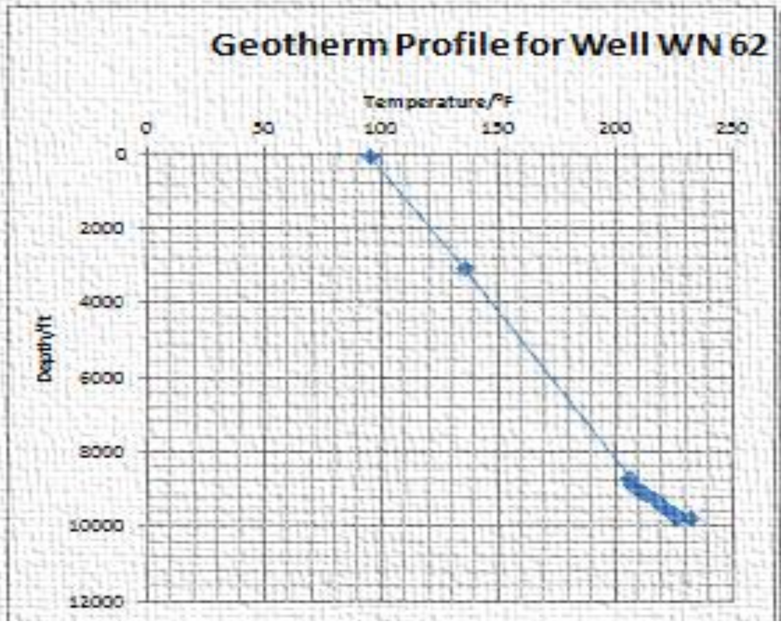
Temperature depth profiles developed for this region provided values of 85 ^{0}C to 115^{0}C at depths of 3 km, with a geothermal gradient of 2^{0}C per 100 metre.

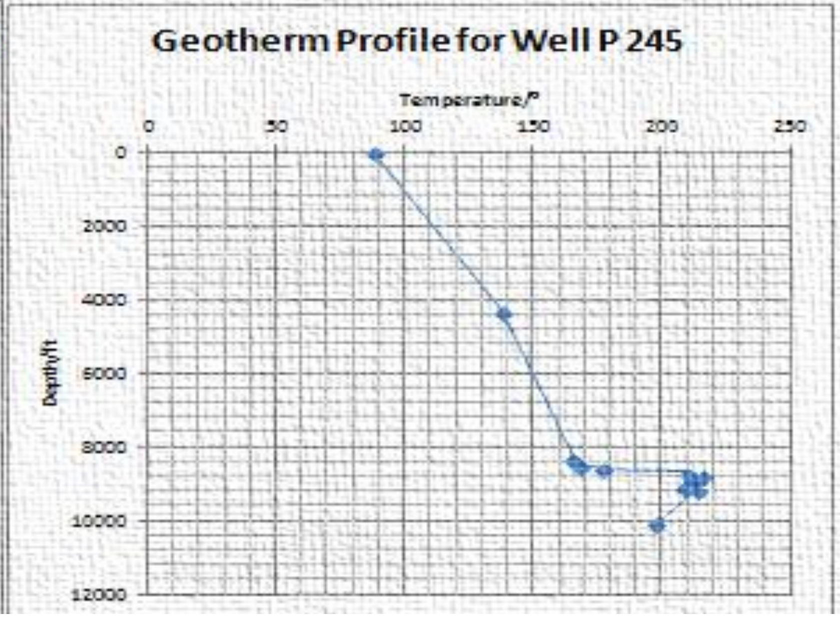
(evident of an intermediate enthalpy driven system)

This supports initial conditions for an Enhanced Geothermal System.









	well A	well B	well C	well D	well E
surface temperature/°C=					
27					
BHT / °C=	116.37	66.322	94.772	72.033	104.25
Depth/ m	688.85	533.4	637.03	579.12	716.28
geotherm/°Cm^{-1}	0.13	0.12	0.15	0.12	0.15

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Enhanced or Engineered Geothermal System for Trinidad

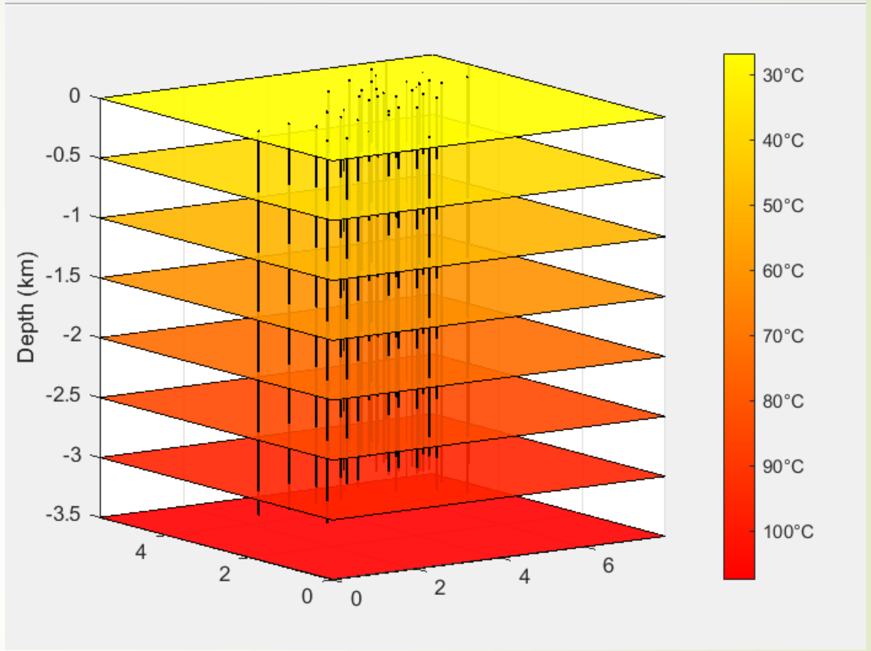
- This data will now be used along with well logging information from existing wells in that region to map isoterms for this site.
- Thermal capacity for a unit area will be assessed
- Reservoir Rock Properties will be used to model flows in the fractured system
- The geology for that region is taken into consideration and the values are being reassessed in order to provide a simple state numerical model

With the use of numerical modelling, for a unit volume reservoir under an abandonment temperature, T_a, 10^0C less than the reservoir temperature,

Is was found that $T_r = 113^0$C for the area under study

The recoverable fraction was found to be, F_r = 11.63%.

The recoverable thermal energy was estimated at $Q_{rec} = 2.50045 \times 10^{16}$ J.



Theoretically,
Converting this to usable electric power under the assumption that a binary plant turbine of thermal efficiency, η_{th} = 11% to 22% was used over a thirty (30) year lifespan produced an average electrical capacity ranging from 2.9075 MWe to 5.8 MWe.

Mathematical Modelling and Simulation of Selective Stratigraphy within the Province of Saskatchewan, Canada for Geothermal Energy Prospecting

Doctoral Thesis

Randy R. Koon Koon

Department of Physics
Faculty of Science & Technology
University of the West Indies, St. Augustine

Supervisor: Dr. I. Haraksingh

THREE CORE ASPECTS OF THE RESEARCH

Geology → Mathematical Model → Simulations-COMSOL

Main Objectives

- Generate full analytical solutions for the established Mathematical model for all well core samples.

  The mathematical model describes the deformation of fracture walls as a function of the fracture radius resulting from the effect of the geothermal fluid flowing through its cavity.

- Investigate the hydraulic properties of these core samples via COMSOL applications

Conclusions

- The Mathematical Model can be utilized as an initial predictive type model for identifying suitable regions of thermomechanical response.

- Based on the BHTs the findings clearly identify specific wells with temperatures of $106\ °C$, $100\ °C$ and $127\ °C$, at depths of $3128.8\ m$, $3165.0\ m$ and $3394.9\ m$ respectively.

- Identification of discharging and recharging zones across the cores are identified and are significant in hydrogeology and water flow patterns.

- Through the collective understanding of all three Distribution maps there is a greater insight into identifying areas for geothermal development.

- In addition, these maps serve as a predictive tool for the location of both injection and production wells.

The Caribbean Pursuit for Geothermal Energy Development

- Certainly, comprehensive simulations of Geothermal prospective sites can be performed.

- Essential data on the geology, formations, well core data logs are necessary to fully generate these simulations.

- Such simulations can assist with the overall definition of the geothermal reservoir, optimum depth that allows the greatest discharge of fluid across the formations.

- Hence a greater insight in fluid behaviour (discharge rates, temperature distribution) within the reservoir can be attained.

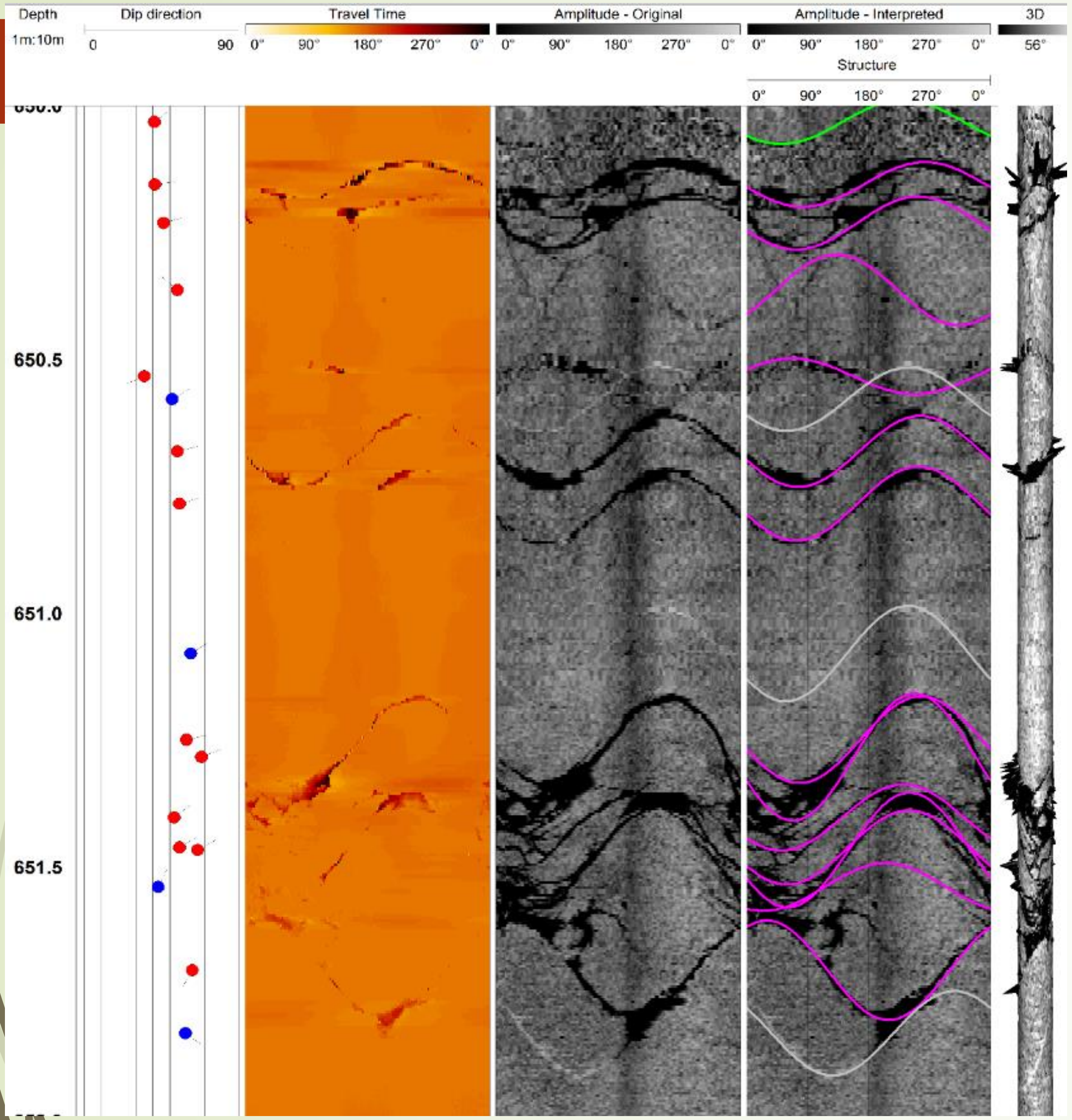
SAMPLING BIAS OF FRACTURE ORIENTATION CAUSED BY LINEAR BOREHOLE SAMPLING – KIMAMA, SNAKE RIVER PLAIN, IDAHO, USA

MPhil student: Elizabeth Bullock

Supervisor: Dr. Indra Haraksingh

Department of Physics

University of the West Indies, St. Augustine



Fracture trace matching for a 2 m length of borehole in WellCAD

Overview

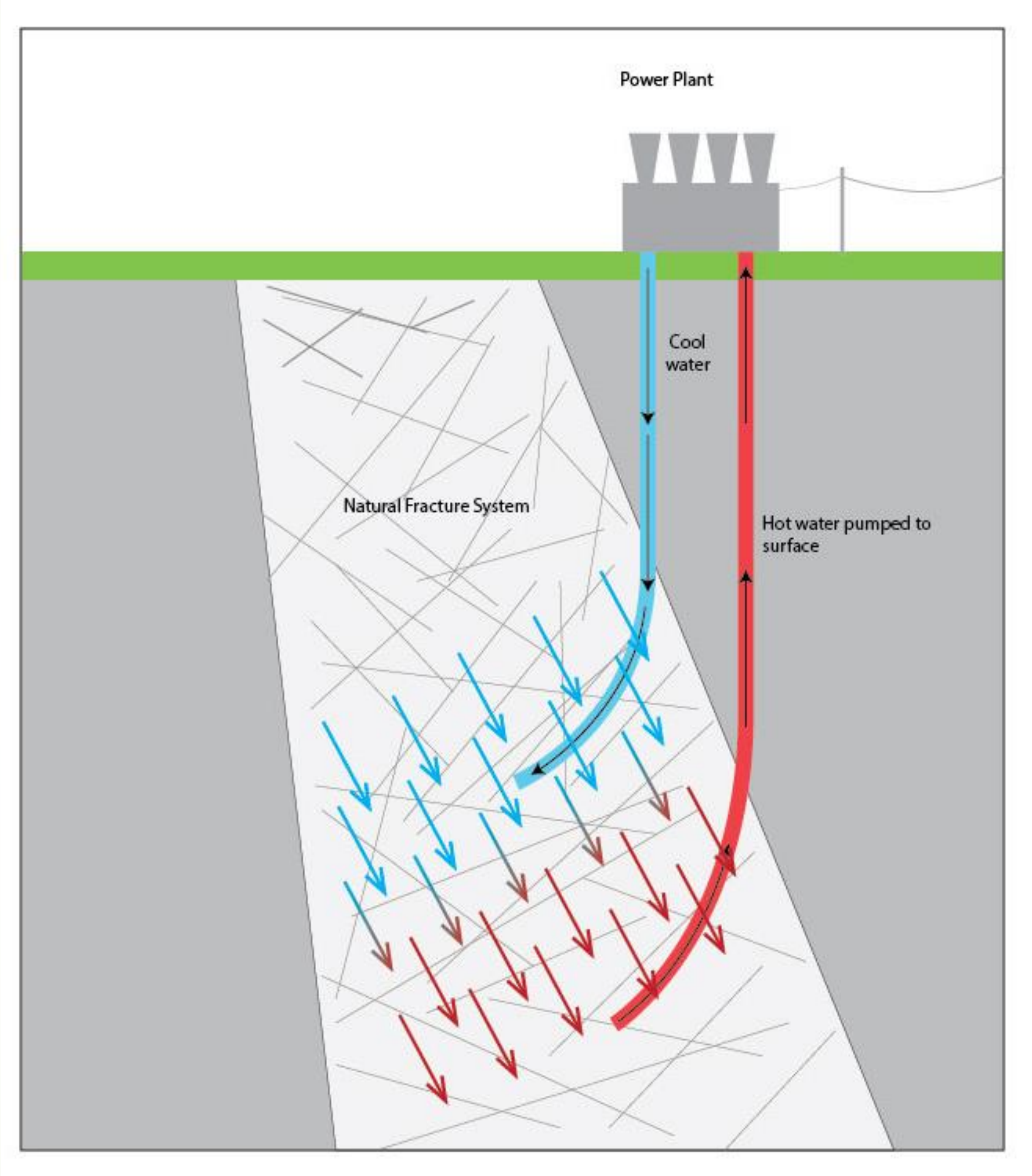
- Subsurface fracturing
- Acoustic image logs
- Fracture orientation
- One-dimensional borehole sampling bias
- Applications:
  - Hydrocarbon production
  - Geothermal production
  - Mining
  - Groundwater management

Rationale/Need for work

- When geophysical data is collected, especially that of fractures and the networks which comprise them, the data set needs to be as accurate as possible - which will guide developers in the stages of production drilling in regions of highest potential.
- Drilling is one dimensional (linear), i.e. only those fractures intersected by the drilling instrument are detected. Many other fractures are unaccounted for because of a sampling bias.
- There is a need for error reduction when performing fracture orientation analysis.
- The oldest and most common method used to account for these undetected fractures possesses a number of limitations which skews with accurately accounting for them.
- By using real borehole data and comparing this method from qualitative and quantitative perspectives with newer proposed methods, a decision can be made on their accuracy and credibility.

Application to real-world Geothermal projects

- Error reduction is crucial to fracture analysis because it is an important step which must be taken during the preliminary stages of geothermal exploration.
- If the data collected during the testing stage is not of the most accurate and complete nature, subsequent stages of exploration and production will be severely affected.
- An effective error reduction method allows for better visualization of the abundance of fractures within the subsurface, their interconnections and more information about porosity and permeability of the rock formation.
- To account for an area within a geothermal field which my be fracture-rich presents ideal conditions for optimal drilling.



Results / Findings & Recommendations

Analysed and interpreted acoustic image logs to generate fracture dip and strike data using WellCAD software and identified the sampling bias of a vertical borehole with respect to fracture orientations.

Performed an analysis of the Terzaghi (1965) and Fouché & Diebolt, (2004) correction methods on fracture orientation data. Theory was corroborated and Sampling bias was still evident even after correction was performed.

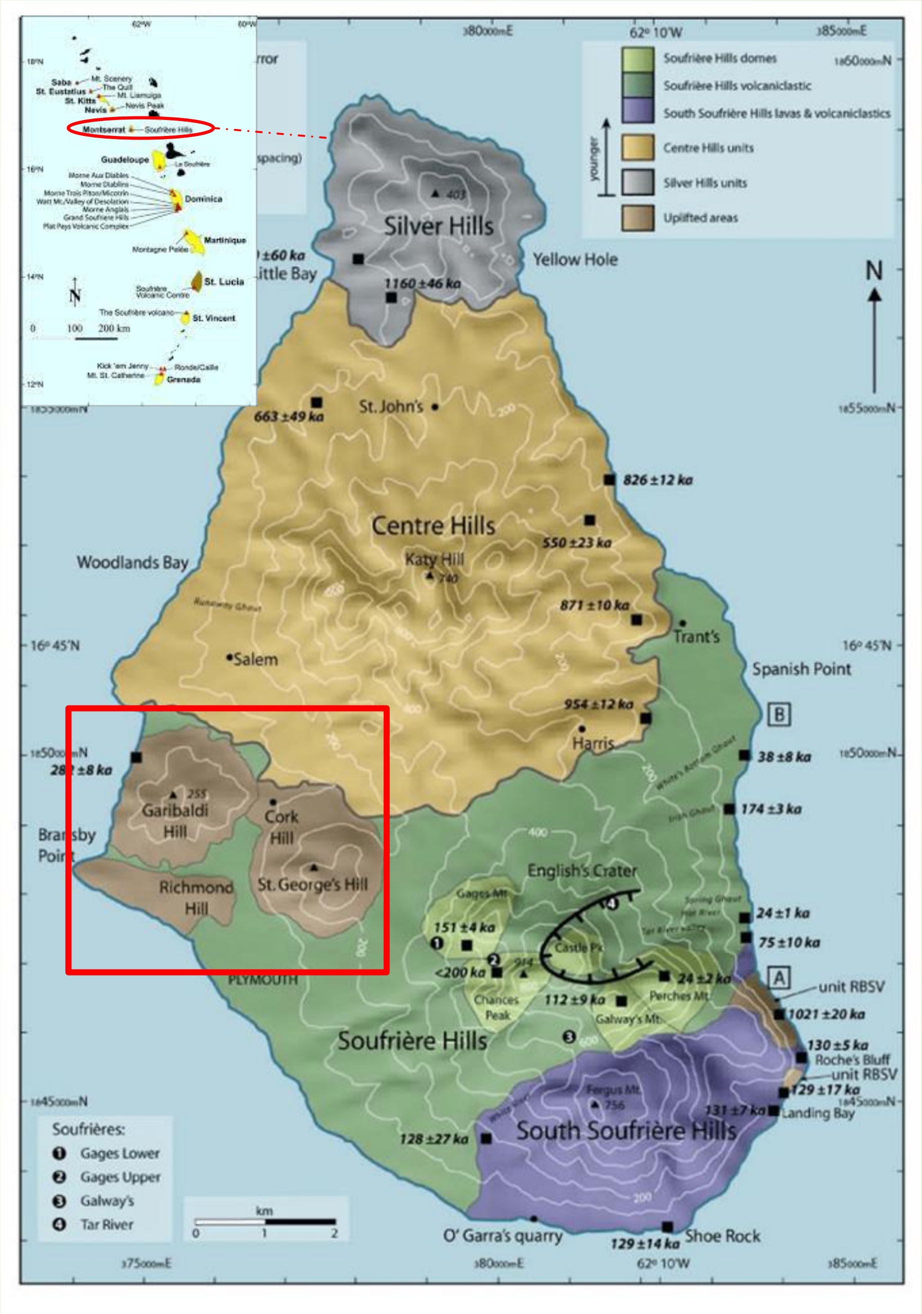
Performed the Chi-squared and Kolmogorov Smirnov (KS) tests on fracture orientation distributions. Tests provided a more sensitive description of the probability distribution of fractures and how they can be better accounted for.

Recommendations are made to drill multiple test wells where feasible and to develop a more accurate method that can incorporate the strengths of each method more succinctly.

MODELLING THE MONTSERRAT GEOTHERMAL SYSTEM

Racine Basant
Supervisor: Dr. Graham Ryan

- Volcanic Island in Eastern Caribbean
- Dependence on diesel
- Advantages of geothermal
- Geothermal exploration in SW
- Two production wells in St Georges Hill



Geological map of Montserrat before 1995.
Source: UWI Seismic Research Centre, Trinidad.

Modelling the Montserrat Geothermal System

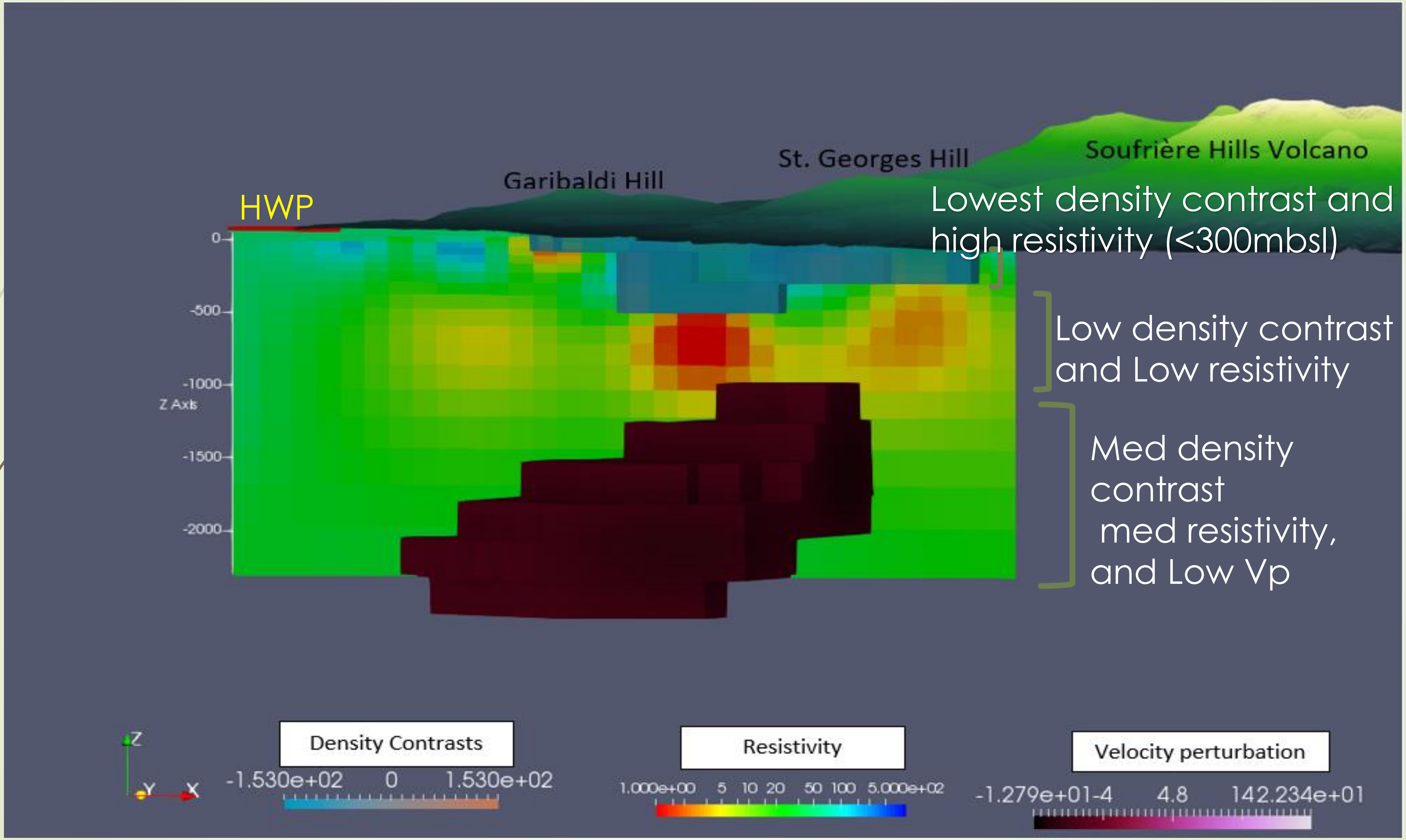
- Joint Interpretation
  - Utilizing multiple geophysical datasets to further constrain the structural features of MGS
- Robust Petrophysical Models
  - Develop petrophysical models for each structure within MGS
  - Integrate core data into petrophysical model

INTEGRATING CORE MEASUREMENTS

- ✓ P and S wave velocity
- ✓ Density
- ✓ Porosity
- ✓ Permeability

- ✓ Core data (velocity and density) comparison to geophysical datasets (velocity and density)
- ✓ Empirical relations for MGS
- ✓ Fracture density analysis

MONTSERRAT GEOTHERMAL SYSTEM (MGS)



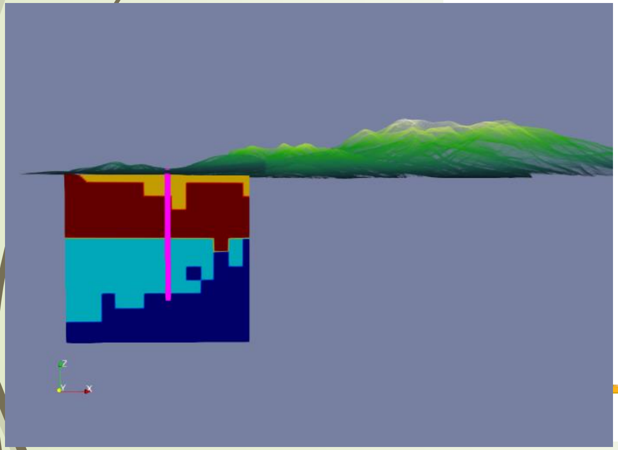
Annotated diagram showing the spatial relations of the 3D geophysical datasets

JOINT INTERPRETATION AND ROCK PHYSICS MODEL

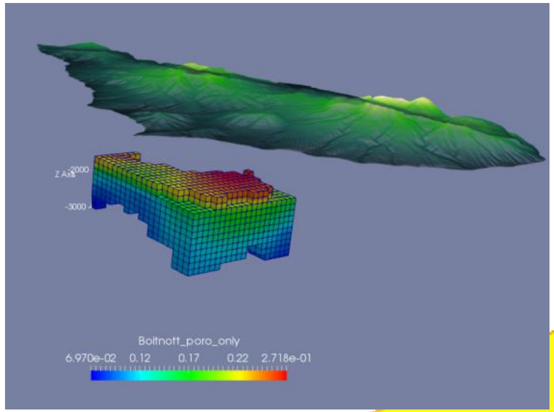
- Unaltered region
  - Archie's equation
- Clay cap
  - Hydrothermal alteration (CEC)
    - $\rho = F / (B\ [CEC(1 - øm)\rho m ø^{-1}] + \rho w^{-1})$
- Geothermal reservoir
  - Boitnott's and Kozeny-Carman relations
    - $V = -7580ø + 5620 + (\text{illite})$
    - $k = B\ \frac{ø^3}{(1-ø)}\ d^2$
- Intrusion
  - Future work

EXPECTATIONS

1. Joint Interpretation
   Structural features



2. Developing Rock
   Physics Model
   i. Geophysical
   ii. Core data integration



3. Reservoir management
   Reduce risk of drilling wells

Importance of Investing in Women (USAID)

- **Improving the welfare of women improves the welfare of all**

Girls' education	Increases a nation's GDP
Girls' education for 7+ yrs	Results in later marriage and fewer children
Women's land ownership	Leads to 10% more in crop yields
Women comprise > 30% political bodies	Increases egalitarianism and democracy

Summary – Key Points

- Gender inclusion yields many benefits for the whole community (e.g., men and women)
- Benefits to gender inclusion in the energy sector are girls' education, income generation, and easier life
- Women are excluded from workforce because of limited technology training and perceptions about women's interest
- University experience shows that the percentage of girls in Higher Education/Postgraduate training is currently much higher than boys in the Physics department
- Geothermal Energy training at The UWI is much stronger on the female front than the male
- The Caribbean region can benefit from the research work done in Geothermal Energy at The UWI.


THANK
YOU