Geothermal Resource Uses in OECS

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Jacobs

Challenging today.
Reinventing tomorrow.

A bit about me….

- Since 2014, Lead Advisor for New Zealand Caribbean Geothermal Technical Assistance Facility, leading:
  - Geoscience studies
  - Project development and due diligence
  - Drilling supervision
  - Power plant procurement
  - Environmental studies
  - Grid studies

Purpose

2021 Government of New Zealand and OECS partnership

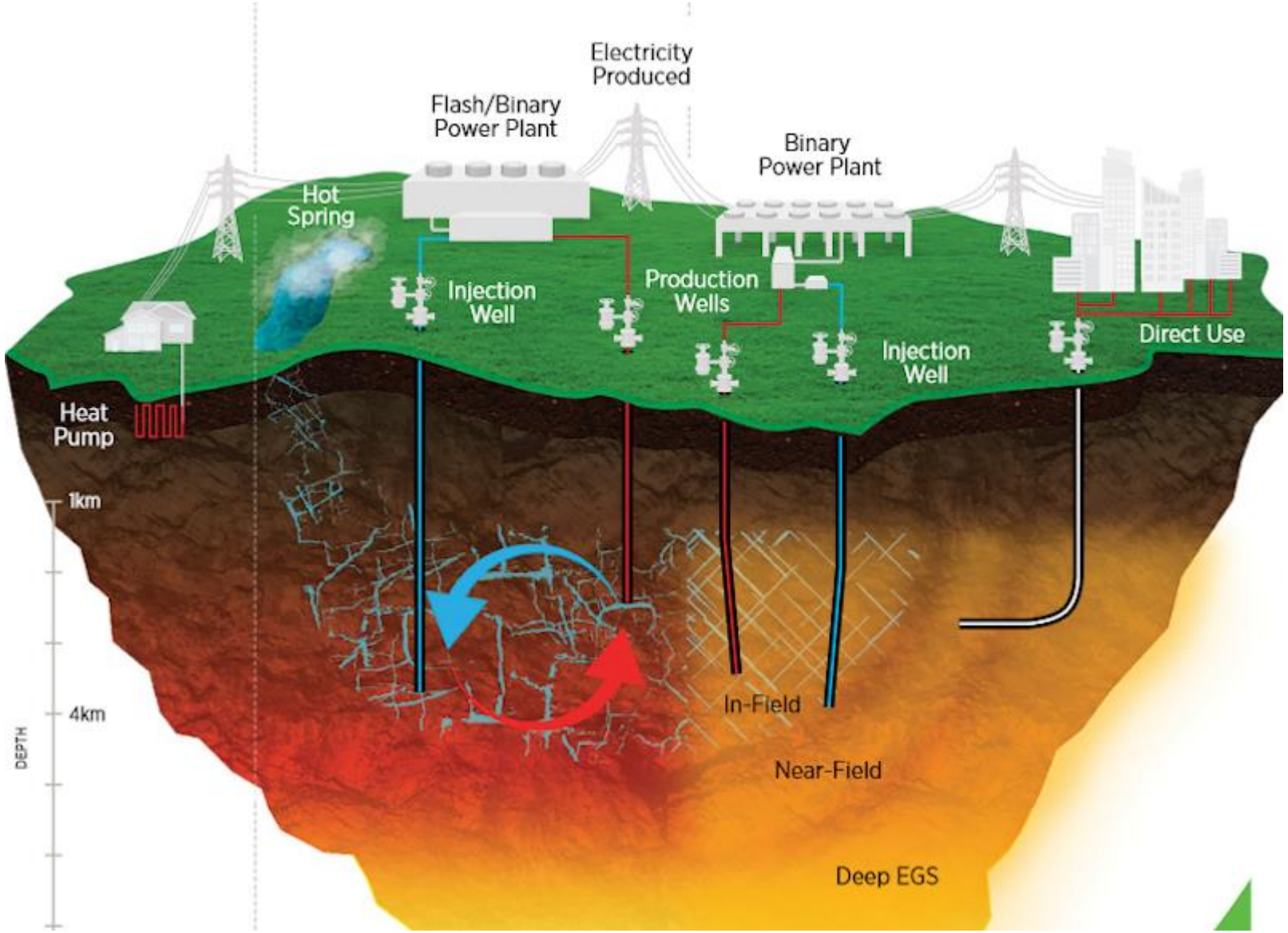
Objective:

To investigate near term opportunities to utilize geothermal resources in the OECS for purposes other than electricity production

- Overview of resource use globally
- Review characteristics of known geothermal resources in OECS
- Concept project considerations
- Recommendations to progress direct use

Geothermal Resource

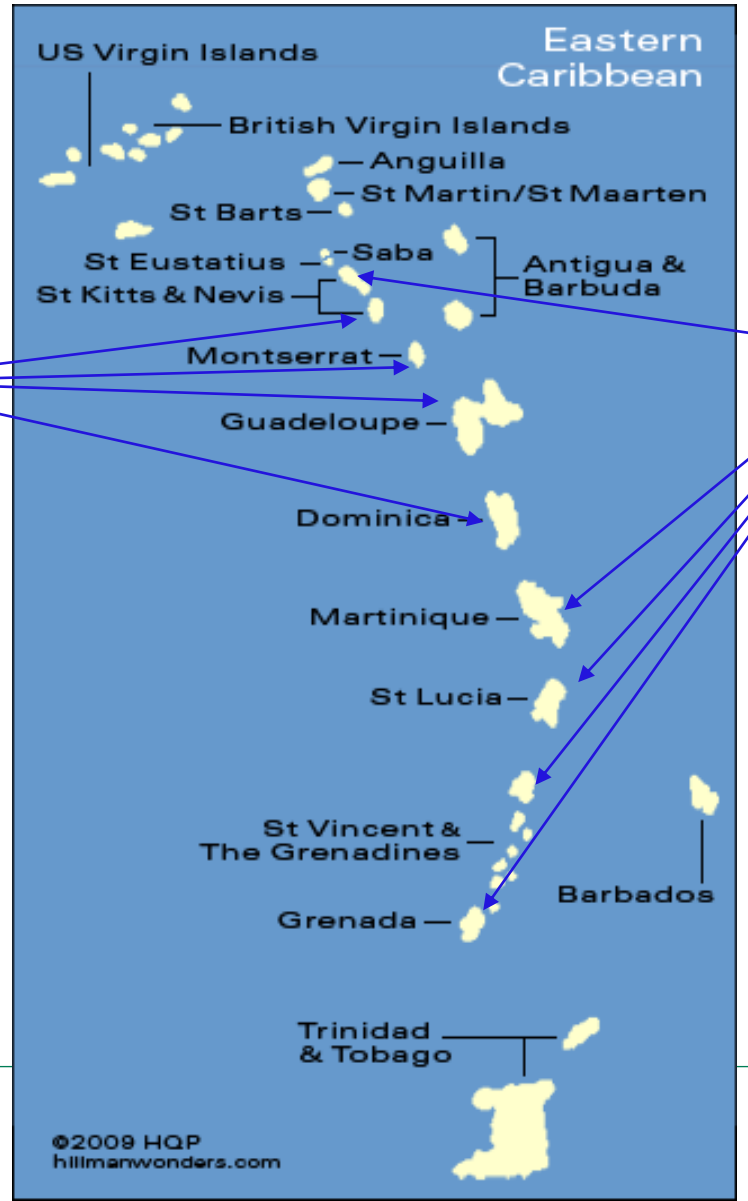
- **Hot water or steam reservoirs** accessed by drilling: (Dominica, Guadeloupe, Montserrat and Nevis)
- The **shallow ground** near the earth's surface that maintains a relatively constant temperature.
- Deep high temperature rock



Geothermal energy overview (source: GeoVision report by the U.S. DOE)

Geothermal Resources in OECS

Proven Deep Resources:
~1100m - 2000m deep
200-250°C
Liquid-dominated



Indicated deep geothermal resources. Not proven by drilling.

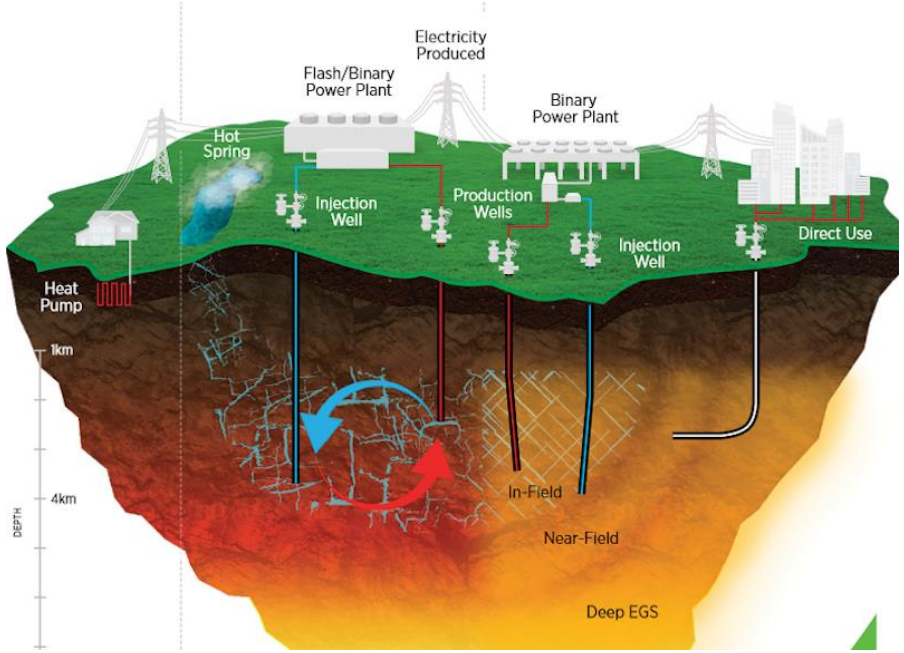
Geothermal Resource Opportunities

1. **Indirect uses** – Use the heat available. Ground source heat pump (shallow) or enhanced geothermal system (deep)

2. **Direct use** of geothermal resource

Resource Properties:

- **Water**
- **Minerals** – Lithium, silica, boron
- **Gases** – carbon dioxide, hydrogen sulphide
- **Heat energy –** steam or hot water

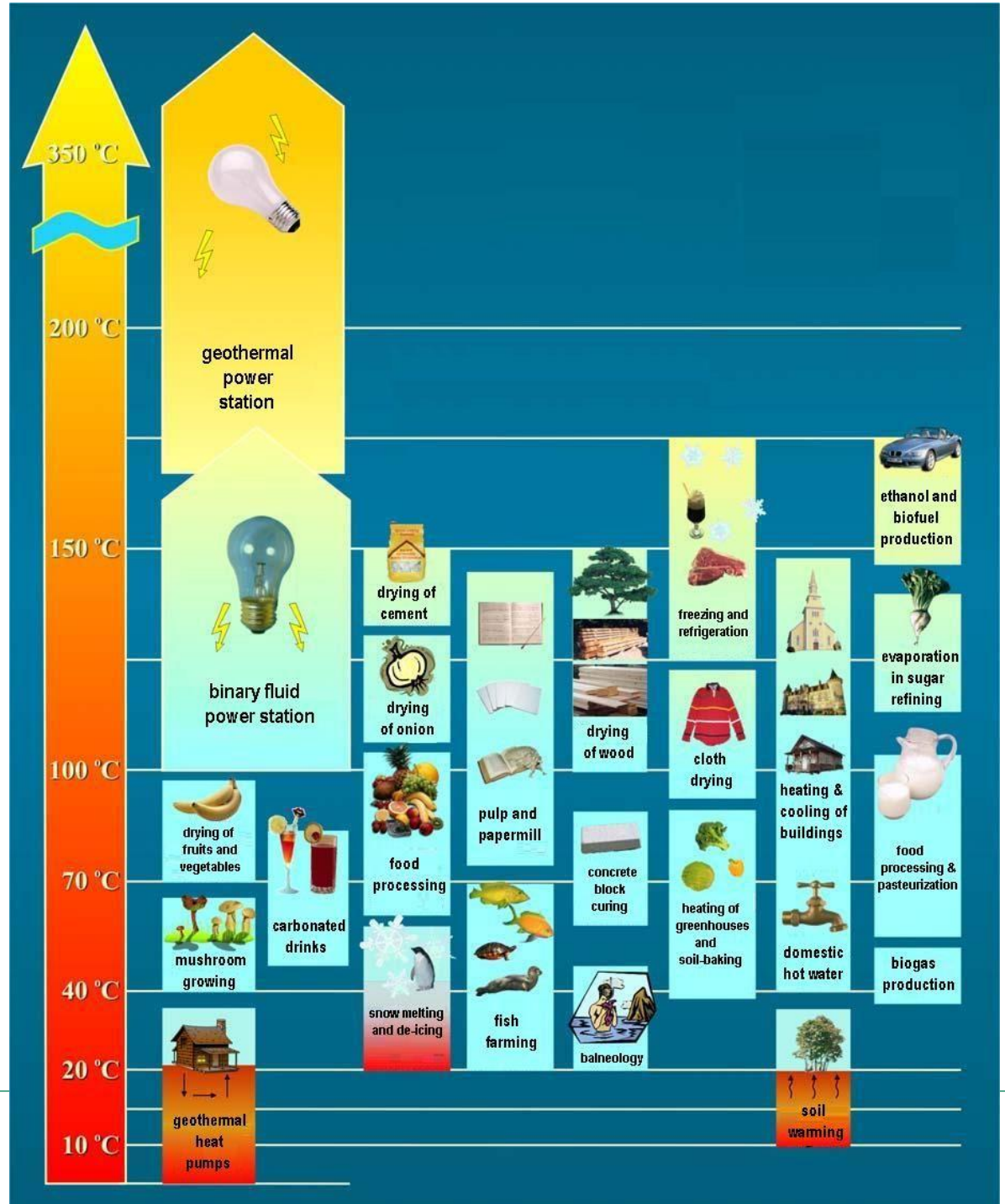


Applicability in OECS

A. **Shallow heat** - Ground source heat pumps are broadly applicable in the region
B. **Minerals** – Technology still developing, requires power plant, resources in region not ideal, scale and access to end markets a challenge.
C. **Water** – Low value, limited uses for agriculture. Willingness to pay?
D. **Gases** – Potential side benefit from power plant. Limited applications for CO2. Further research
E. **Heat -** widest number of applications and can be used in a heat cascade. Simplest to develop in association with a power plant

Drilling for resource is unlikely to be viable for heat only unless the resource is shallow (<500m) and heat demand high.

Geothermal Heat Uses



Agro-industry direct use

- Crop drying
- Dehydration (e.g. tomatoes)
- Pre-heating and heating processes
  - Hot water and steam
- Peeling and blanching processes
  - Pre-processing steps for many fruits and vegetables
    - canning, freezing, dehydrating
  - typically, 77-104°C
- Evaporation and distillation processes
  - Sugar processing, mint distillation, milk evaporation, concentration of food products
  - typically, 80-120°C
- Pasteurization: temperatures 90-150°C
- Sterilization processes
  - Prevent botulism in meat and fish canning >121°C
  - Sterilization of equipment 105-120°C

Grain dryer utilising geothermal steam at Menengai, Kenya (source: GDC)

Tourism – geothermal parks

- Hell's Gate Geothermal Spa, Olkaria, Kenya
  - Bathing, spa, sauna
  - Cooking, drying, crops
  - Fish farming

Olkaria Geothermal Power Development, Hells Gate National Park, Naivasha, Kenya

Tourism & Lifestyle Industry

- Geothermal Breweries (existing)
  - Klamath Basin Brewing, Klamath Falls, Ore
  - Vapori di Birra, Lardarello Italy (dry steam)
  - The Rouge Bore, Wairakei, NZ
- Geothermal Tea & Coffee House
  - Locally grown coffee and tea
  - Dried geothermally (50~60°C)
  - Possibly roasted geothermally (175°C)
  - Brewed with geothermally heated water (100°C)

What opportunities are relevant in the Eastern Caribbean?

Existing industries

- **Agriculture**
  - Drying
  - Cool storage
- **Tourism**
  - Hot pools
  - Tourist parks
  - Hotels
- **Light manufacturing**
  - Liquor, beer
  - Tourism products

New industries

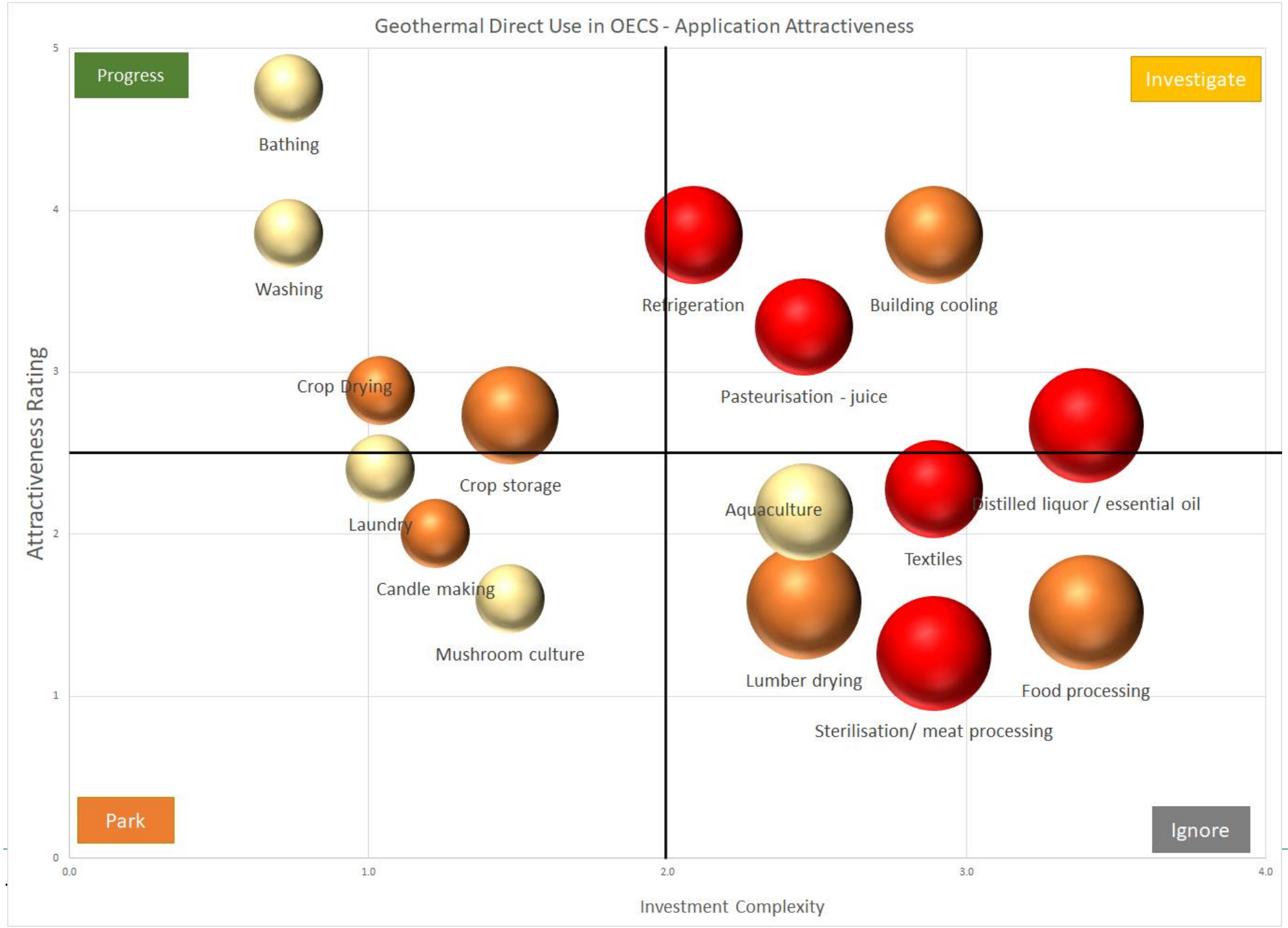
- **Agro-processing**
  - Pasteurization
  - Aquaculture
  - Mushroom culture
- **Tourism**
  - Spas, health retreats
  - Laundry
- **Light manufacturing**
  - Freezing
  - Essential oils
- Green hydrogen

Assessing Opportunities in OECS Caribbean?

Qualitative approach to identify near-term opportunities

1. **Attractiveness of potential application**
   - Technical complexity (to develop/operate)
   - Industry readiness (is this existing industry?)
   - Macro-economic considerations (will product sell nationally, internationally?)
   - Characteristics of heat demand (A steady demand is more attractive)

2. **Investment complexity**
   - Process heat complexity (is heat a major input?)
   - Additional equipment or building requirements
   - Availability of local equipment/skills
   - Minimum magnitude of investment


Geothermal Direct Use in OECS - Application Attractiveness
Progress
Investigate
Park
Ignore
Bathing
Washing
Crop Drying
Crop storage
Laundry
Candle making
Mushroom culture
Refrigeration
Building cooling
Pasteurisation - juice
Aquaculture
Distilled liquor / essential oil
Textiles
Lumber drying
Food processing
Sterilisation/ meat processing
Attractiveness Rating
Investment Complexity
0
1
2
3
4
5
0.0
1.0
2.0
3.0
4.0


EASTERN CARIBBEAN USES FOR GEOTHERMAL HEAT
Geothermal energy is always available from heat inside the earth. There are many ways to use this heat. The OECS and Government of New Zealand identified possible uses in the Eastern Caribbean to support sustainable economic and community development.
Potential Uses
GROUND SOURCE HEAT PUMP
HOT SPA
DRYING
COOL STORAGE
FOOD PROCESSING
REFRIGERATION
DISTILLATION
AIR CONDITIONING
BRITISH VIRGIN ISLANDS
ANGUILLA
SAINT KITTS & NEVIS
ANTIGUA & BARBUDA
MONTSERRAT
GUADELOUPE
DOMENICA
MARTINIQUE
SAINT LUCIA
SAINT VINCENT & THE GRENADINES
GRENADA
<50°C LOW
50°C–100°C MEDIUM
>100°C HIGH
Benefits of Geothermal Heat
RENEWABLE
RELIABLE
LOCAL
Organisation of Eastern Caribbean States
Sustainable Energy Unit
For further information please contact the OECS SUSTAINABLE ENERGY UNIT
sustainableenergy@oecs.int
NEW ZEALAND FOREIGN AFFAIRS & TRADE
Manatū Aorere

Defining an Opportunity

Development Scenarios

1. **Scenario One** - Standalone use of resource for multiple direct heat users.
2. **Scenario Two** – Direct use project(s) in conjunction with a geothermal power station.
3. **Scenario Three** - Shallow lower temperature resources: Lower temperature (<100°C) resources that are at the surface, or can be accessed with shallow drilling

Defining the Opportunity - Dominica

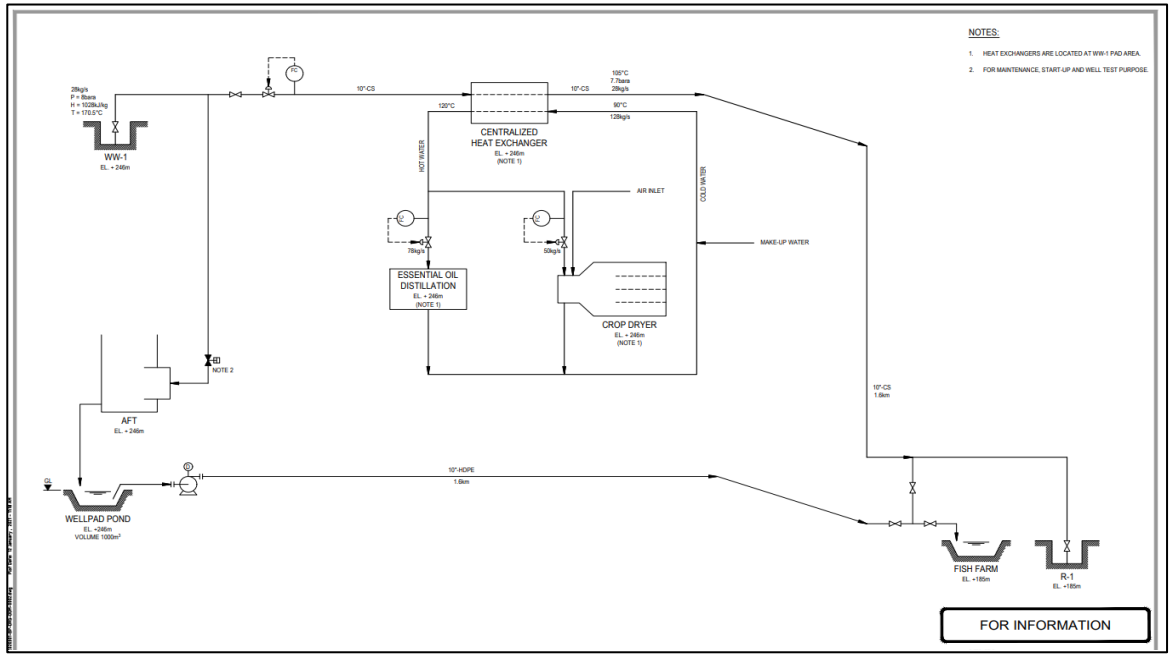
- Dominica options
  i. Use existing wells WW-01 to WW-R1
  ii. WW-02 to new injection well (if capacity available)
  iii. Heat exchanger on power plant reinjection line

Concept Project imagined standalone project WW-01 to WW-R1

Dominica exports agricultural produce and is known for exports of bay oil. The direct use project envisages a crop drying facility and a distillery to produce essential oils.

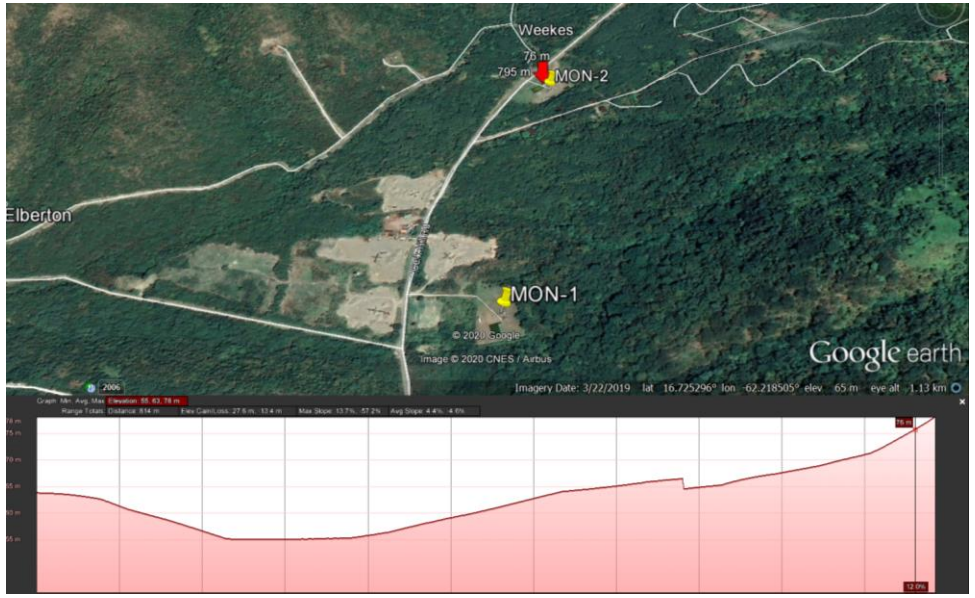
Defining the opportunity - Dominica

- The energy from well WW-01 in Wotten Waven is substantial and the steam alone may be sufficient to distill over 1,000 litres per day of essential oil; with the brine sufficient to dry more than 20 tonnes of fruit per day.
- Material and equipment costs for energy supply alone are of the order of US$2 - US$3 million excluding project management, engineering and installation.
- Distillation equipment ~$200k+
- Drying facility ~$500k
- Plus buildings, land, other equip, etc
- US$5M+ investment



Defining the Opportunity - Montserrat

- Montserrat
  i. Mon-2 to Mon-01
  ii. Heat exchanger on power plant reinjection line
  iii. Use fluids (no injection)



- The direct use project envisages creating a cold storage facility to support exports, provision of heat for an industry (perhaps related to bricks/aggregate), along with residual heat for a spa.

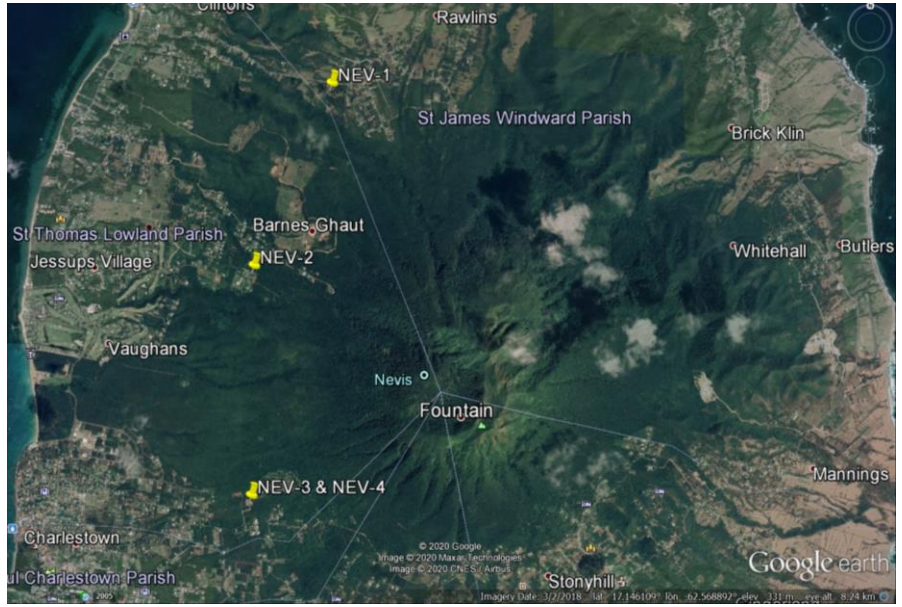
Defining the opportunity - Montserrat

- Energy available from MON-2 could be sufficient for:
  - a cool storage facility with over an area of over 6000m^2;
  - drying of 20 tons of fruit per day;
  - and 24/7 heating for a spa pool the size of two Olympic swimming pools

- Equipment costs for the geothermal energy supply alone (excluding industry) are of the order of US$1.5 - US$2.5 Million and exclude project management, engineering and installation
- Market for end products off-island

Defining the Opportunity - Nevis

- Nevis
  i. N-3 or N-4 could be used for production
  ii. Heat exchanger on power plant reinjection line
  iii. N-1 or N-2 require injection



- Nevis attracts mid to high end tourists. The direct use project envisages a facility (hotel/mall) cooled by geothermal energy with a spa in addition.

Defining the Opportunity - Nevis

- The project uses heat after electricity generation from the 9MW power plant via a heat exchanger on the reinjection line.
- By dropping the temperature up to 5°C, energy available is estimated to be sufficient to cool a facility of over 30,000m^2, and also to provide heat for a spa.

Conclusions

- Use of heat energy most likely near-term options likely in agriculture and tourism.
- Opportunities exist for new industry, however provision of heat energy is only part of the investment consideration.
  - the cost and availability of local inputs, value in end markets and competition
  - facility development costs, environmental and social consideration
- Simplest approach is to take heat from a power plant and co-locate facilities
- Existing wells used in a standalone project requires investment in the USD millions to create the energy supply system, and that the energy available is likely to exceed the demand.
- Co-location of the supply and demand is important to minimise infrastructure costs
- Land may become a key factor in the size of a facility.
- Considerations for ownership, legal access to resource

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