Geothermal Goes to Campus

Introduction to Geothermal

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Rindang Riyanti

ITS, 21 Oct 22

Speaker Profile

Introduction to Geothermal Systems

Name Deea Alya

Career History

2019 – present	Star Energy Geothermal Darajat Production Engineer
2018 – 2019	Star Energy Geothermal Indonesia Star Energy Geothermal Technical Trainee
2018	Arai Rubber Seal Indonesia Cost Engineer

Education

2013 – 2017	UCSI University Kuala Lumpur, Malaysia B.Eng (Hons) Petroleum Engineer

Professional

2020 – present	Jakarta Drilling Society
2022 – present	Women in Geothermal

Hobbies Cooking, Travelling, Festival

Speaker Profile

Introduction to Geothermal Systems

Name Rindang Riyanti

Career History

2019 – Now	Star Energy Geothermal Salak
	Production Engineer
2018 – 2019	Star Energy Geothermal Indonesia
	Star Energy Geothermal Technical Trainee Program

Education

2017	Institut Teknologi Bandung
	Petroleum Engineering

Hobby & Skill

Reading, Travelling

Outline

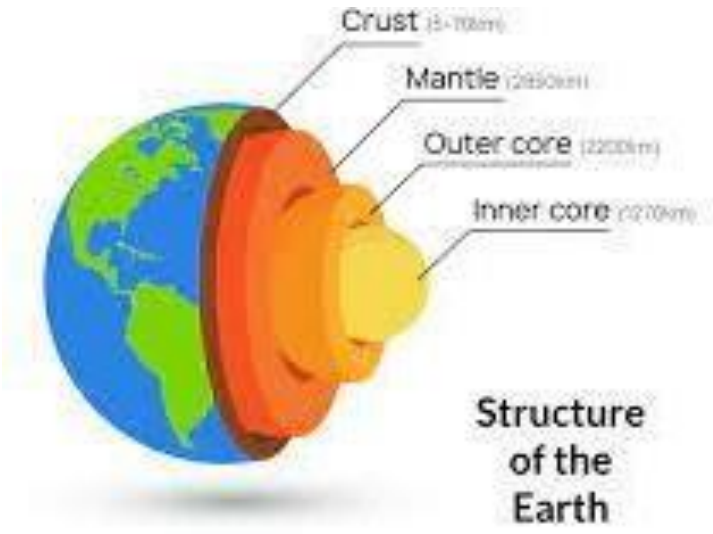
1. Introduction to Geothermal
2. Geothermal Energy Overview
3. Geothermal Systems
4. Geothermal Resources
5. Geothermal Power Production Cycle
6. Geothermal Monitoring & Surveillance
7. Well Analysis and Optimization
8. Well Intervention Program

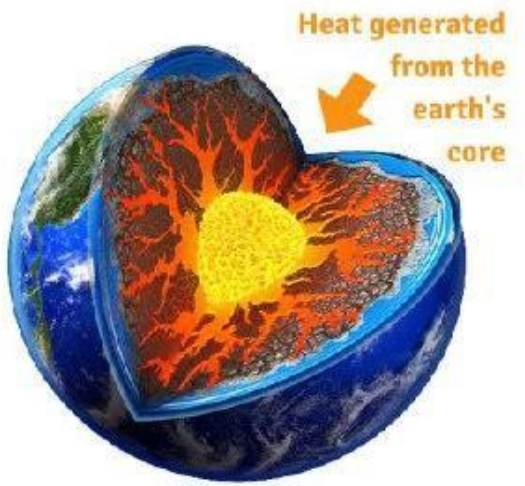
Geothermal Energy

What is Geothermal?

Introduction to Geothermal

Geo (earth)

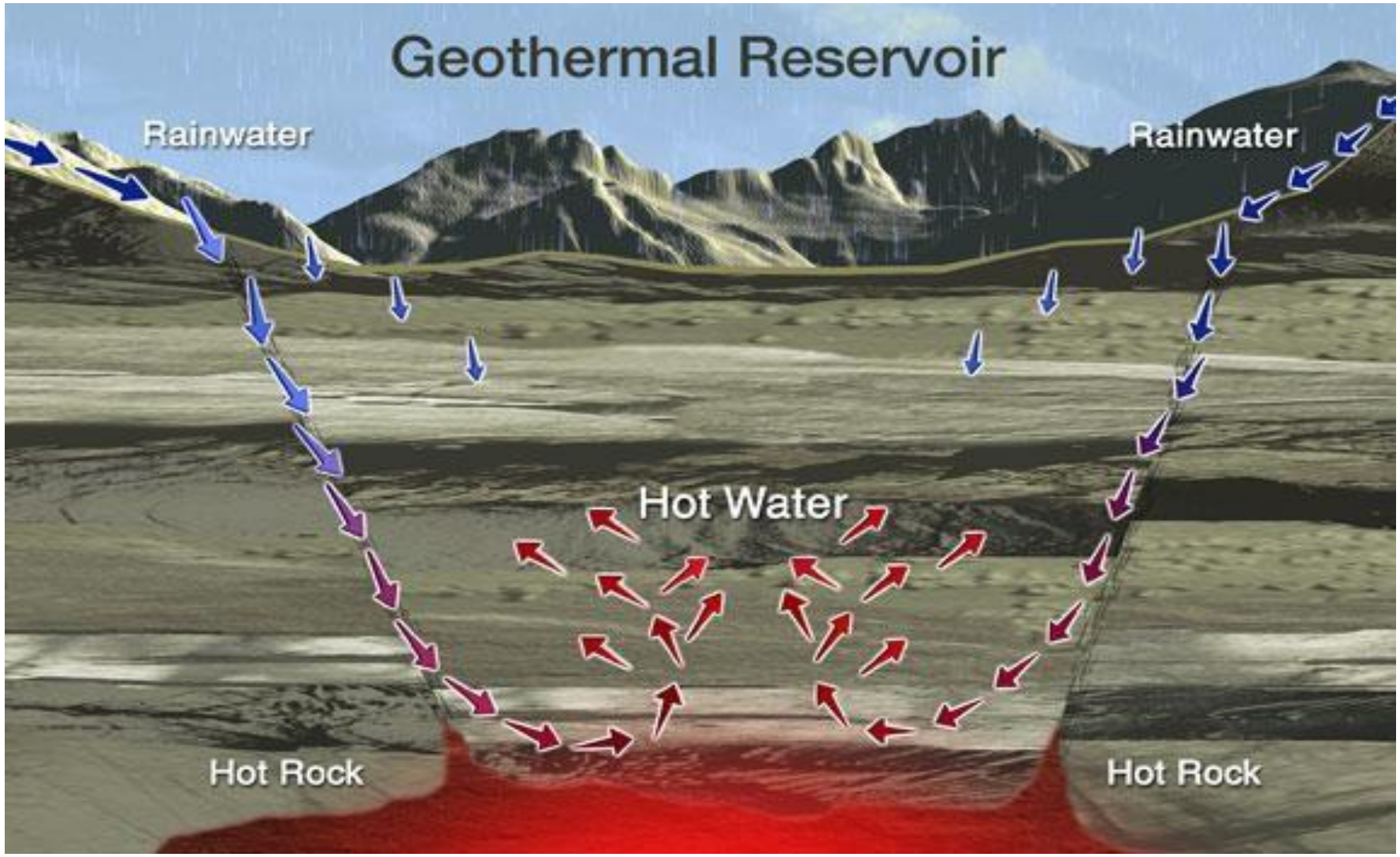




Thermal (heat)

Simple Geothermal System Model

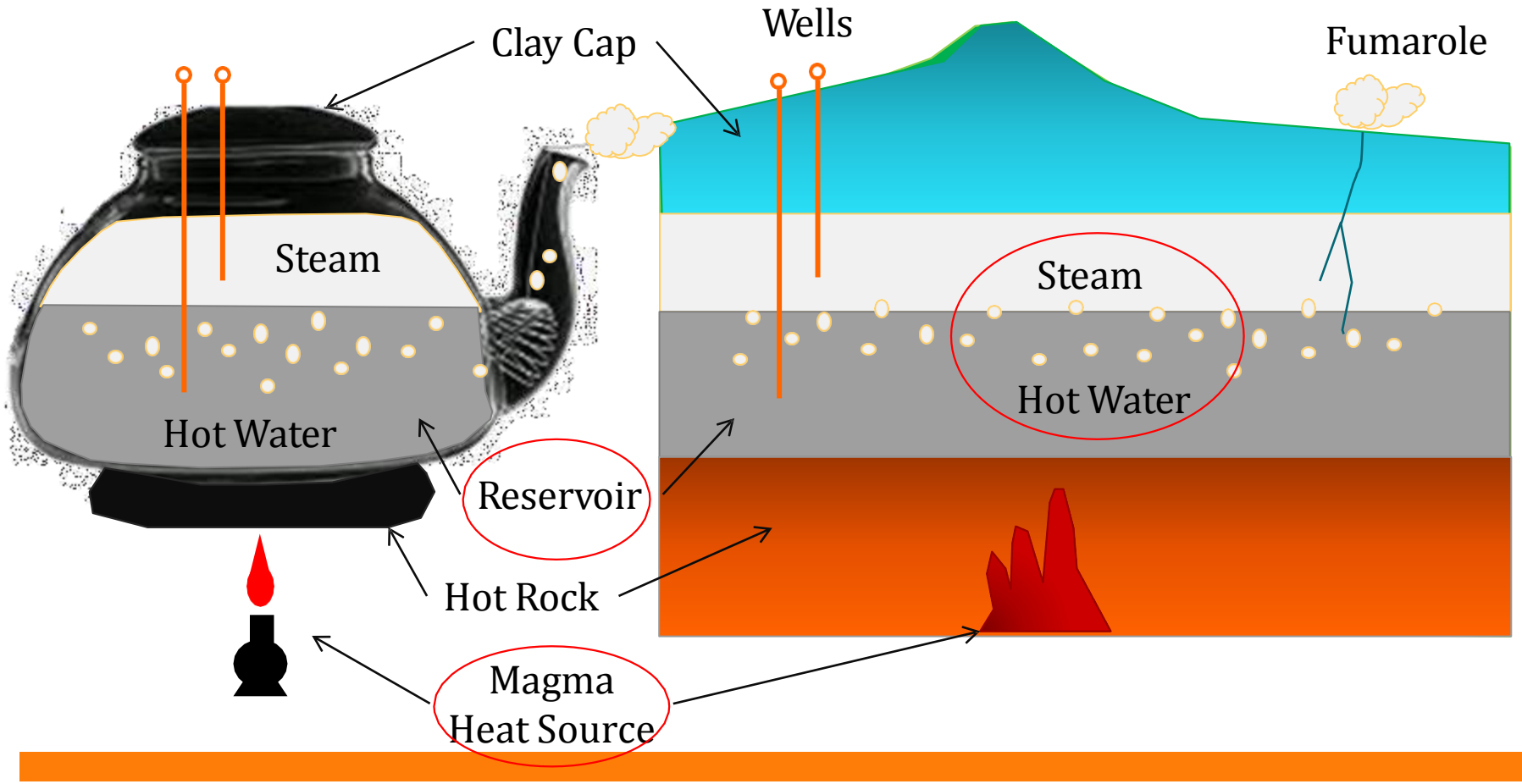
Introduction to Geothermal Systems



Geothermal System Model Analogy

Introduction to Geothermal

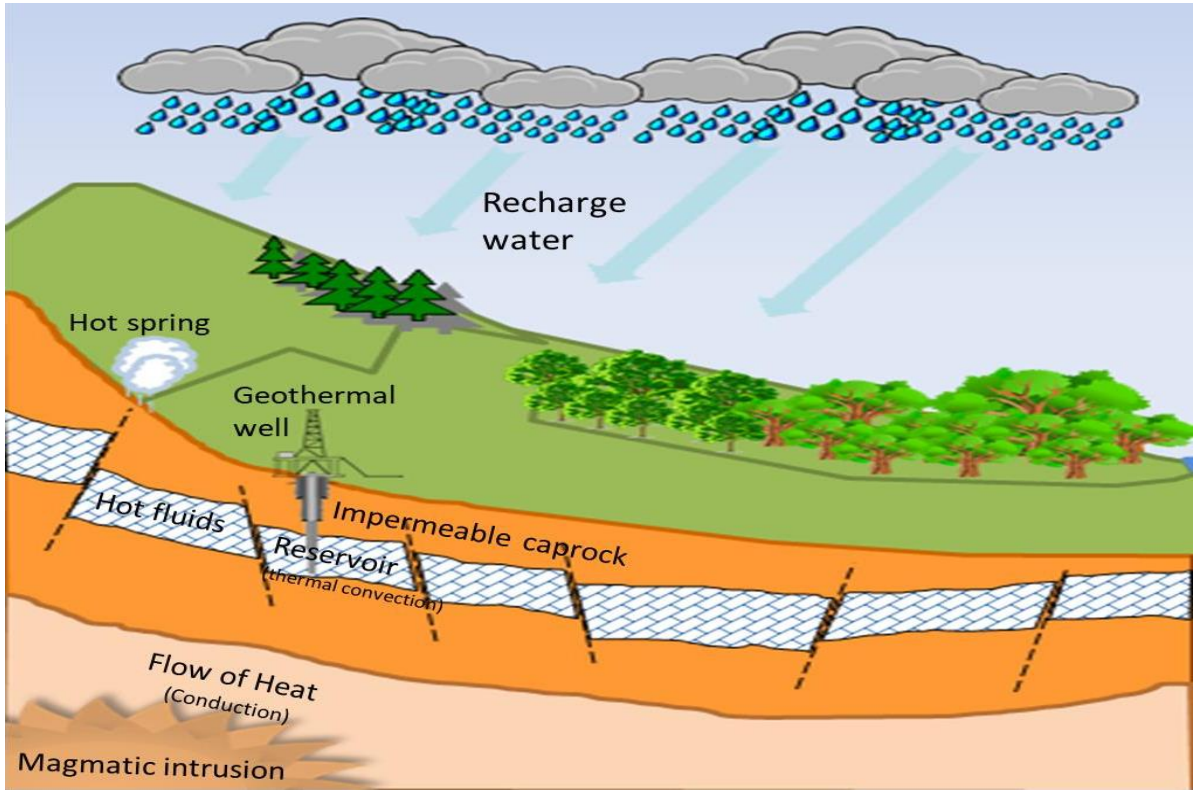
- Geothermal system is a transfer of heat energy from the inner part of the Earth to the surface.



1. **Heat source**: shallow levels (<6 km) in the crust
2. **Permeable and porous reservoir rocks**: store and transmit the water to well
3. **Sufficient water for convection** (recharging system): medium to carry the heat
4. **Impermeable cap rock**: to maintain pressure and prevent water or steam the heat and escape freely to the surface

Characteristics of Geothermal Resources

Introduction to Geothermal Systems

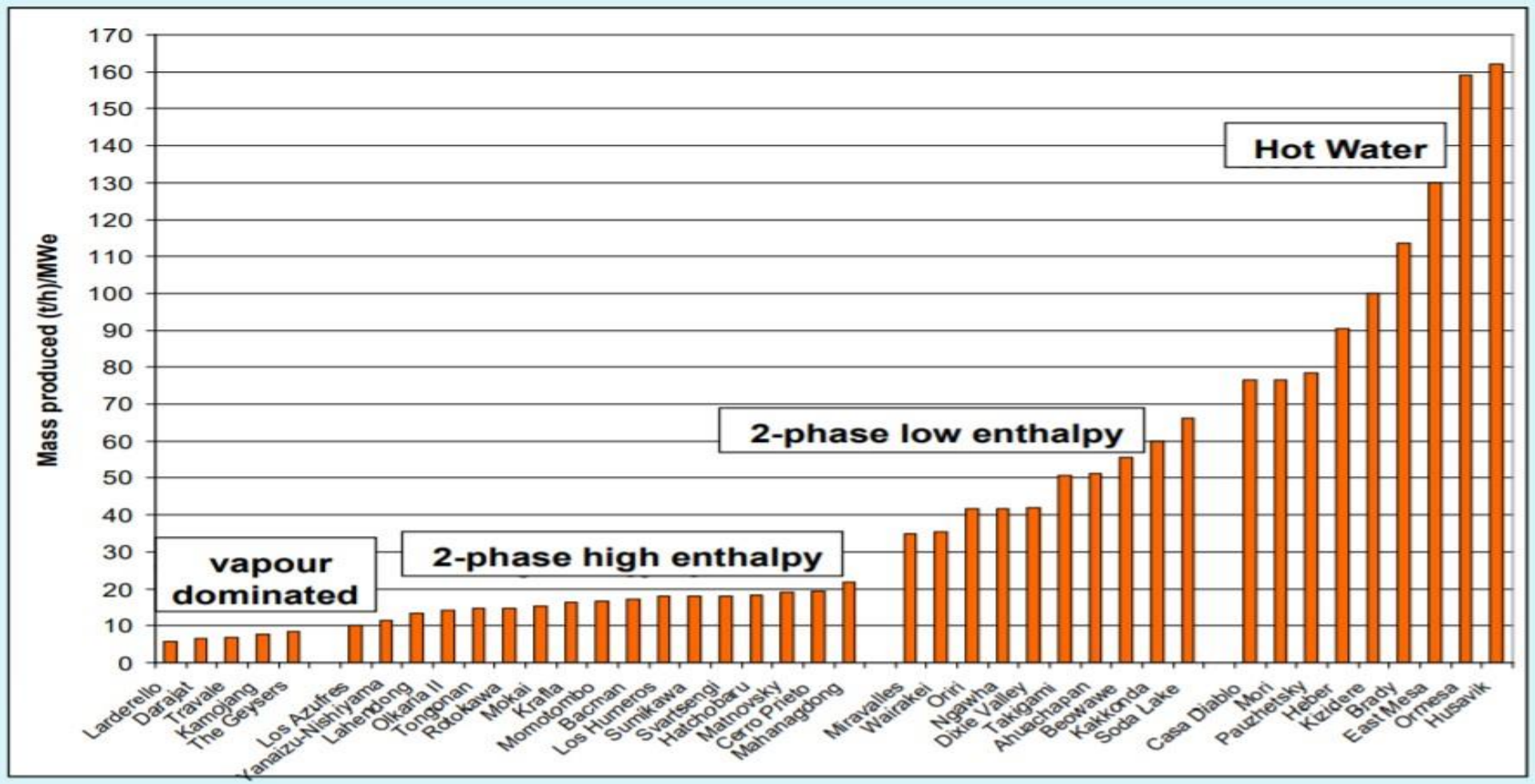


- Special Conditions
  - Super-critical fluids (T>705˚F)
  - High salinity brines (up to 30 wt.% solids)
  - High non-condensable gas content (up to 10 wt.%)

- Heat source (shallow magma)
- Heat carrier (water and steam)
- Temperature (450 – 650˚F)
- High permeability, naturally fractured reservoirs (100-1000 mD)
- Porosity (up to 20%)
- Several thousand feet thick
- Benign fluid chemistry
  - Low scaling potential
  - Non-corrosive
  - Low non-condensable gas content (<3 wt.% in steam)
- Dynamic conditions at initial state
- Marginal recharge, surface discharge

Types of Geothermal Systems

Introduction to Geothermal Systems

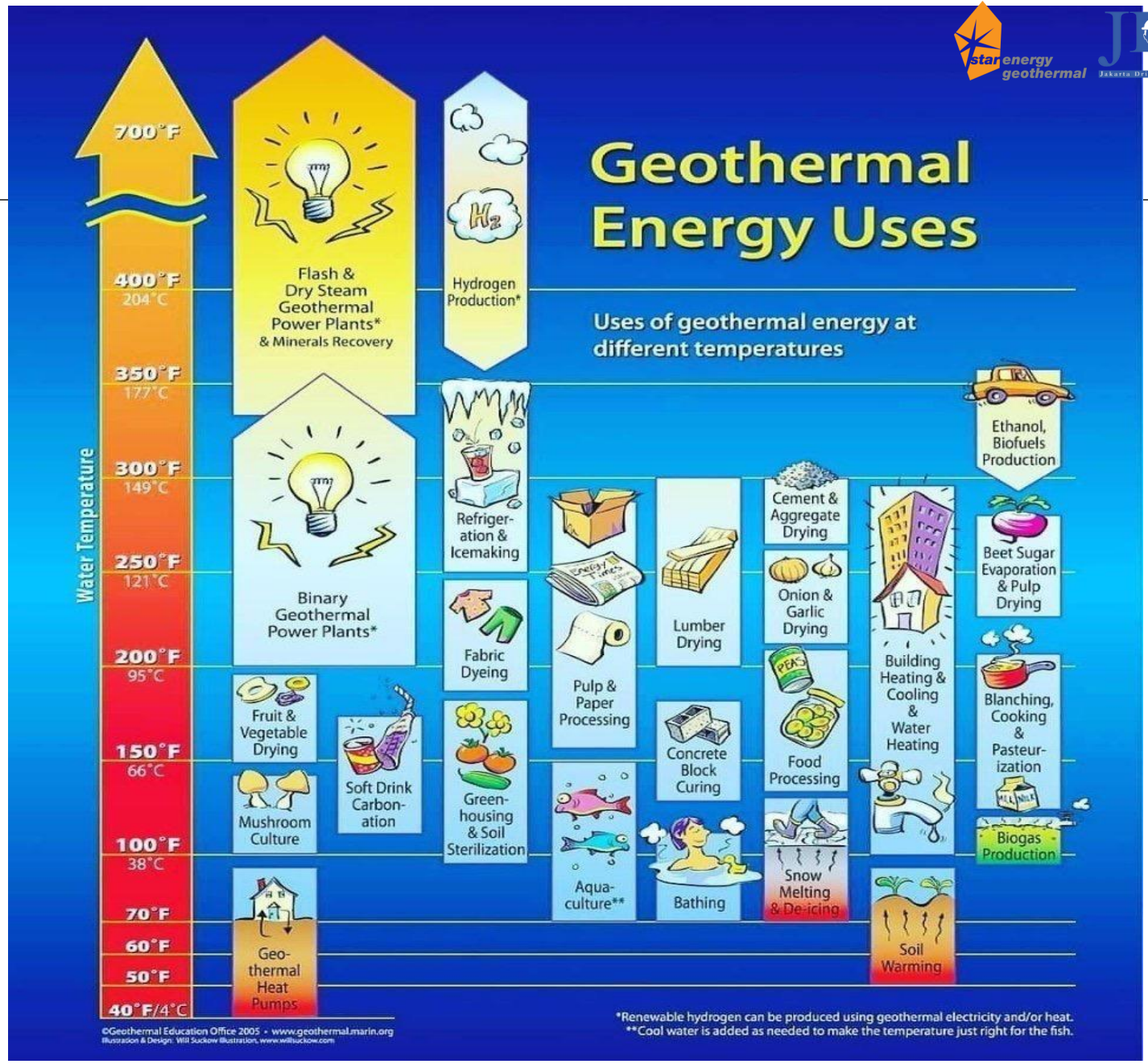


(From course material of GEOTHERM-602 Postgraduate Certificate in Geothermal Energy Technology, University of Auckland, New Zealand)

Geothermal Utilization

Introduction to Geothermal Systems

- At low temperatures, mostly direct use for space heating, bathing, cooking, space heating (and cooling), agriculture (greenhouse and crop drying), extraction of minerals
- At >180°C, conventional flash and dry steam power plants are utilized for electricity generation
- Now, geothermal resources with reservoir temperature as low as 95°C can be used for electricity generation using binary power plants



Geothermal Compared with Oil and Gas

Geothermal Overview

Geothermal

- Renewable/sustainable energy
- Energy is sourced from the inherent heat produced by the earth
- Produced fluids are *hot brines* and *steam*
- High temperature : 300-650++ ^{o}F (150-350++ ^{o}C)
- High production flow rates
- Energy is directly converted to electric power or for direct uses (cannot be exported)

Oil & Gas

- Non-renewable energy
- Energy is derived from fossilized remains of living things
- Produced fluids are hydrocarbons / oil and gas
- 300-350 ^{o}F (150-175 ^{o}C) is ‘hot’
- 5000 bpd oil is ‘high flow’
- Oil & gas can be transported and exported

Geothermal Compared with Oil and Gas: Location

Geothermal Overview

Geothermal

Location: Mountainous Area

Oil & Gas

Location: Land and Offshore Area

Geothermal Compared with Oil and Gas: Lithology

Geothermal Overview

Geothermal

Lithology: Volcanic / Intrusive – Abrasive & Hard

Oil & Gas

Lithology: Sedimentary Rock

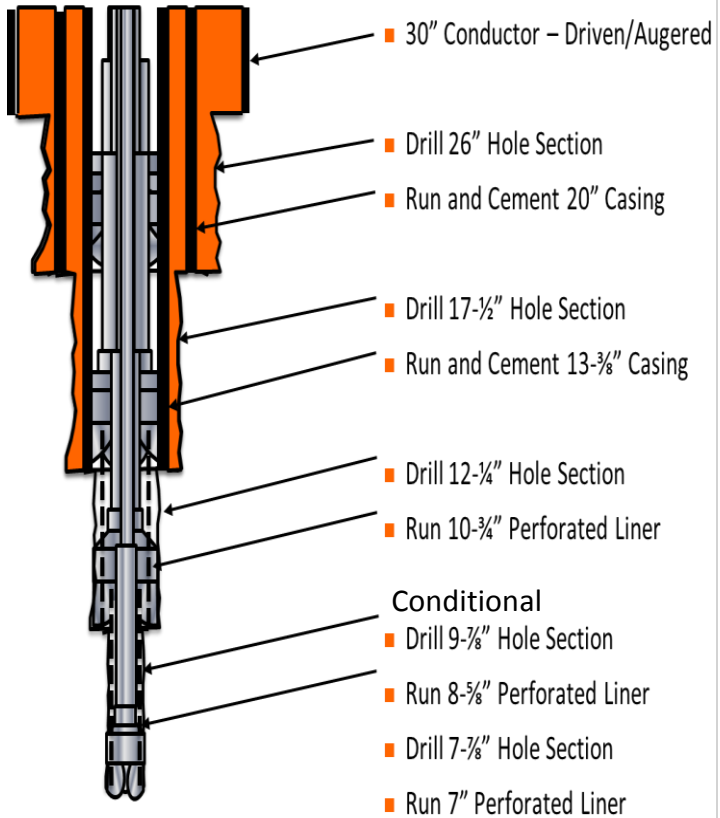
Igneous rock is harder than sedimentary rocks because of the lithification process (how igneous becomes a rock) that involves heat and pressure along the way. Volcanic rock is mostly crystalline and hard to break.

Geothermal Compared with Oil and Gas: Drilling

Geothermal Overview

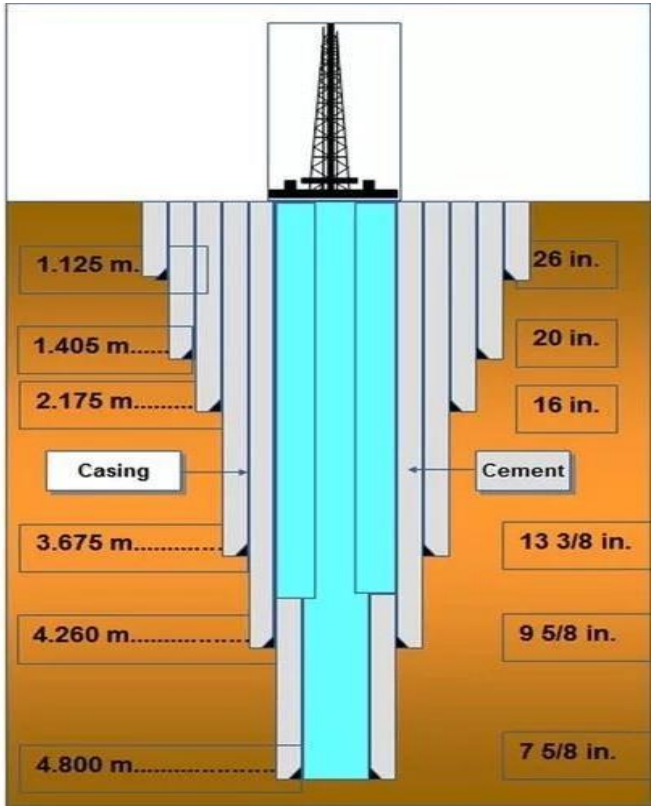
Geothermal

- Lost circulation is desired
- Large diameter production casing
- Casing strigs fully cemented up to surface
- Perforated liner
- Thermal Cycle



Oil & Gas

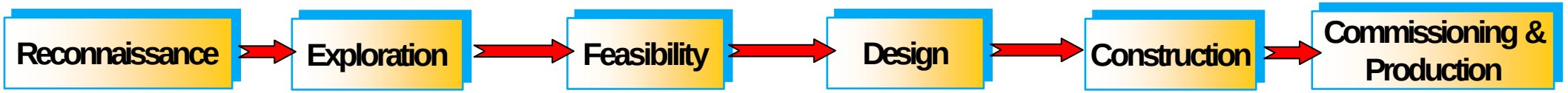
- Lost circulation is avoided
- Small production tubing
- Casing strings are often not fully cemented to surface.
- Perforated at designated zone
- Non thermal application



That's why it is more expensive

Finding Geothermal Resources:
Geothermal Exploration and Development Flow Chart

Geothermal Development Process Flow



Objectives and Tasks	Geology, surface geochemistry, engineering, environmental impact, pipeline routes, weather and hydrology, preparation of exploration budget	▪ Stage 1 – Field exploration – Exploration Drilling (resource identification) ▪ Stage 2: Development Drilling (resource delineation & quantification)	▪ Environmental Impact Assessment ▪ Feasibility Studies of Power Plant, etc. ▪ Discharge Testing ▪ Reservoir Assessment ▪ Other Studies & Tests	▪ Environmental Impact Report ▪ Preliminary Design ▪ Bid Document Preparation ▪ Contract Award (power plant & civil) ▪ Pipeline Routing & Design ▪ Production & Injection Wells ▪ Final Design	▪ Construction & Plant Installation ▪ Contract Management, Supervision and Inspection of Construction ▪ Field Management & Long Term Testing
PICs (**bold** if major)	▪ **Geochemist** ▪ **Geologist** ▪ **Geophysicist**	▪ **Geologist** ▪ **Geophysicist** ▪ **Drilling Engineer**	▪ **Environmental, Civil, Electrical,**	▪ **Electrical, Mechanical, Civil Engineers**	▪ **Civil, Mechanical,** Electrical,

How to Identify and Measure at Early Stage?

Geothermal Development Process Flow

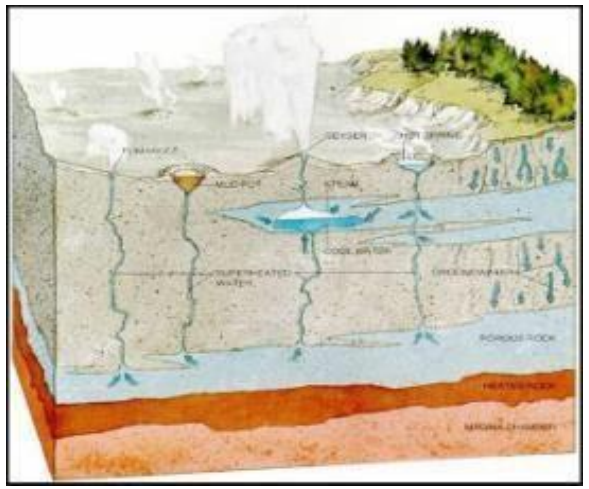
Geothermal systems are often discovered with surface thermal manifestations: fumaroles, hot springs/pools, geysers, silica sinter, mud pools, steaming ground, etc.

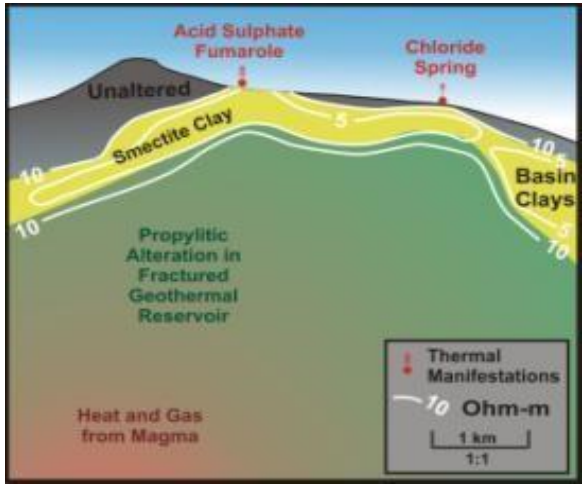
- Geologists – study rock types, structures, volcanic history, and geohydrology of the area
- Geochemists – estimate temperature and chemistry of the geothermal fluids from water and gas samples
- Geophysicists – conducts surveys (e.g., electrical, magnetic, etc.) to estimate the size (i.e., extent, depth, etc.) of the reservoir

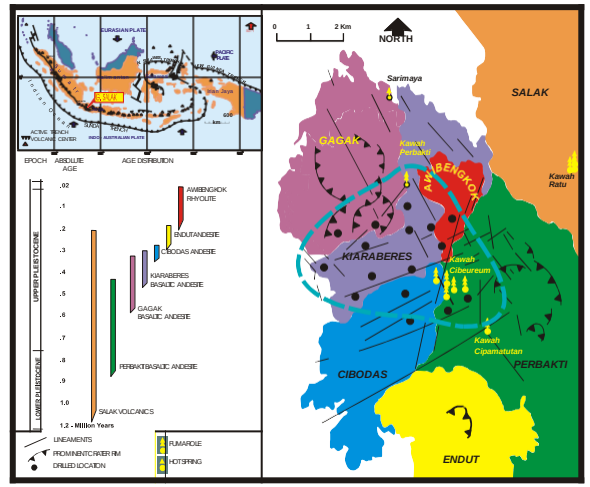
Geothermal Exploration and Appraisal Techniques

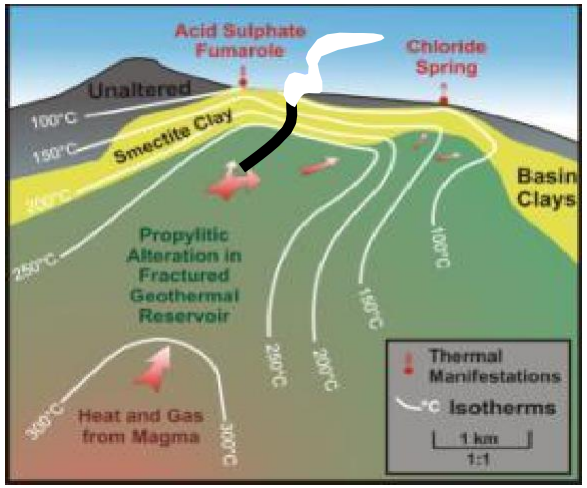
Geothermal Development Process Flow

- Surface thermal features indicate chemistry and reservoir temperature
- Resistivity and gravity surveys indicate depth, thickness and area
- Regional and local geologic studies reveal features that affect permeability distribution
- Exploration and appraisal wells confirm resource characteristics and size
- Reservoir simulation is used to evaluate development alternatives and assess uncertainties



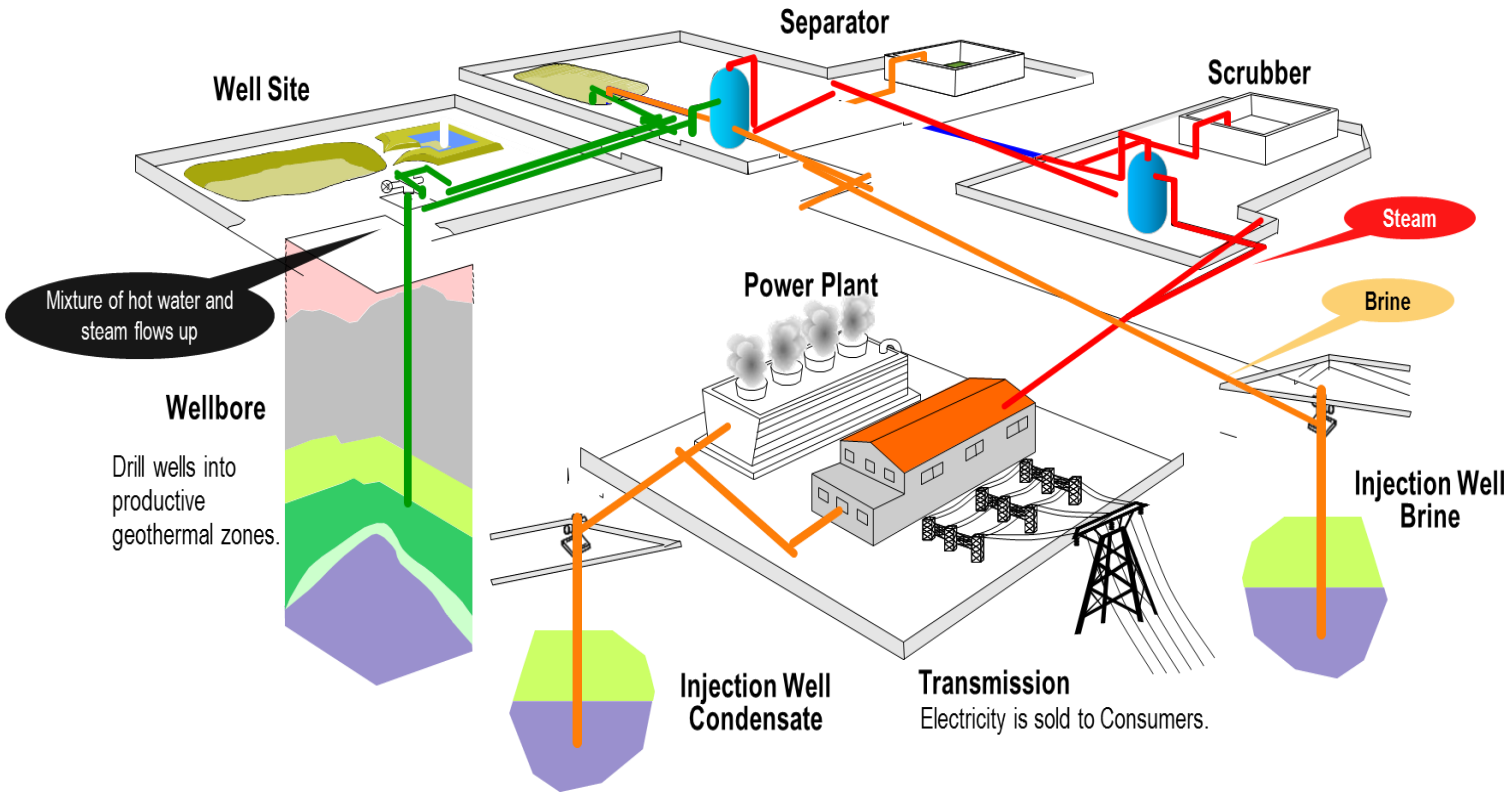




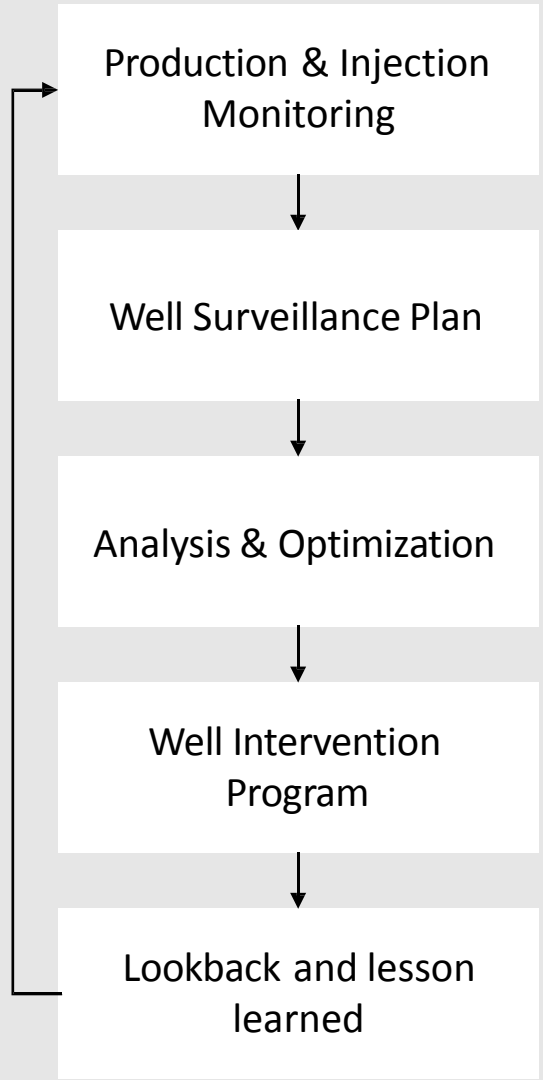


Geothermal Production

Geothermal Development Process Flow



- During commissioning and production stage, there is an integration of subsurface and surface process which ties well deliverability with the surface facility systems used to process all associated streams and deliver the steam to power generation facilities.



Challenging Issue in Geothermal Field

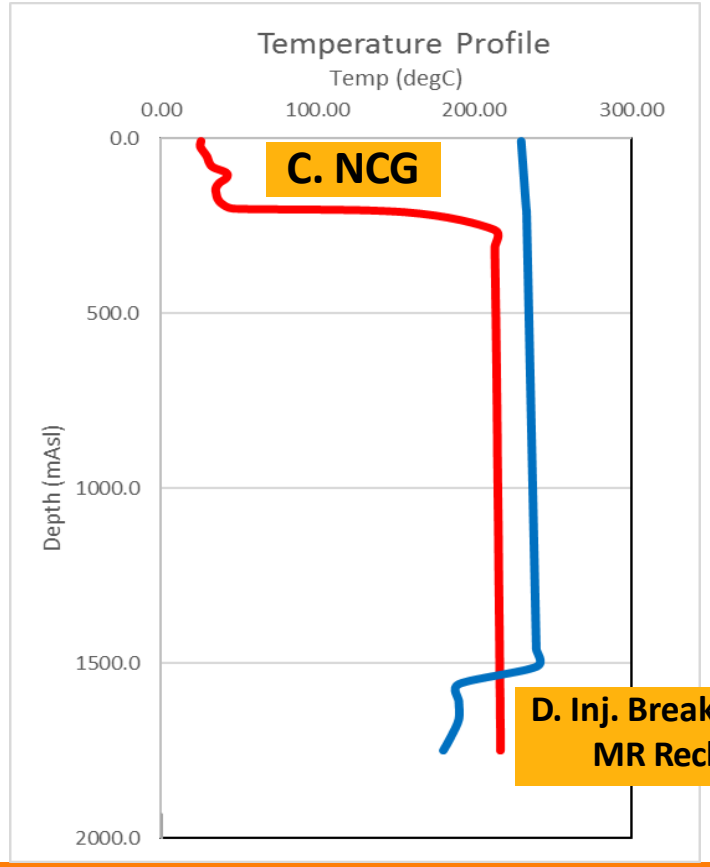
Subsurface:

A. Scaling

B. Corrosion

C. NCG

D. Injection Breakthrough / MR Recharge



Surface:

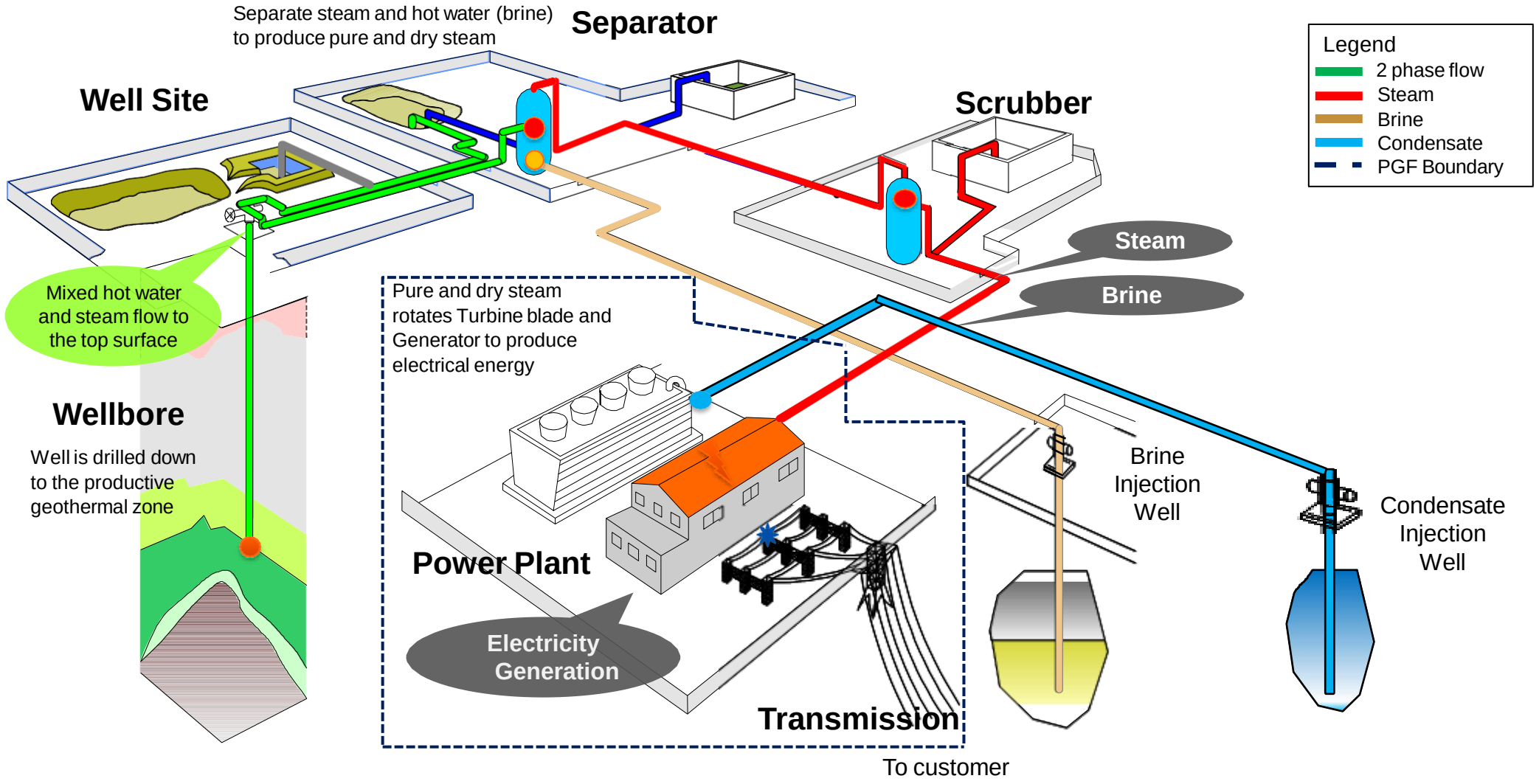
- Landslide
- Hydrothermal eruption risk
- Flooding

Others:

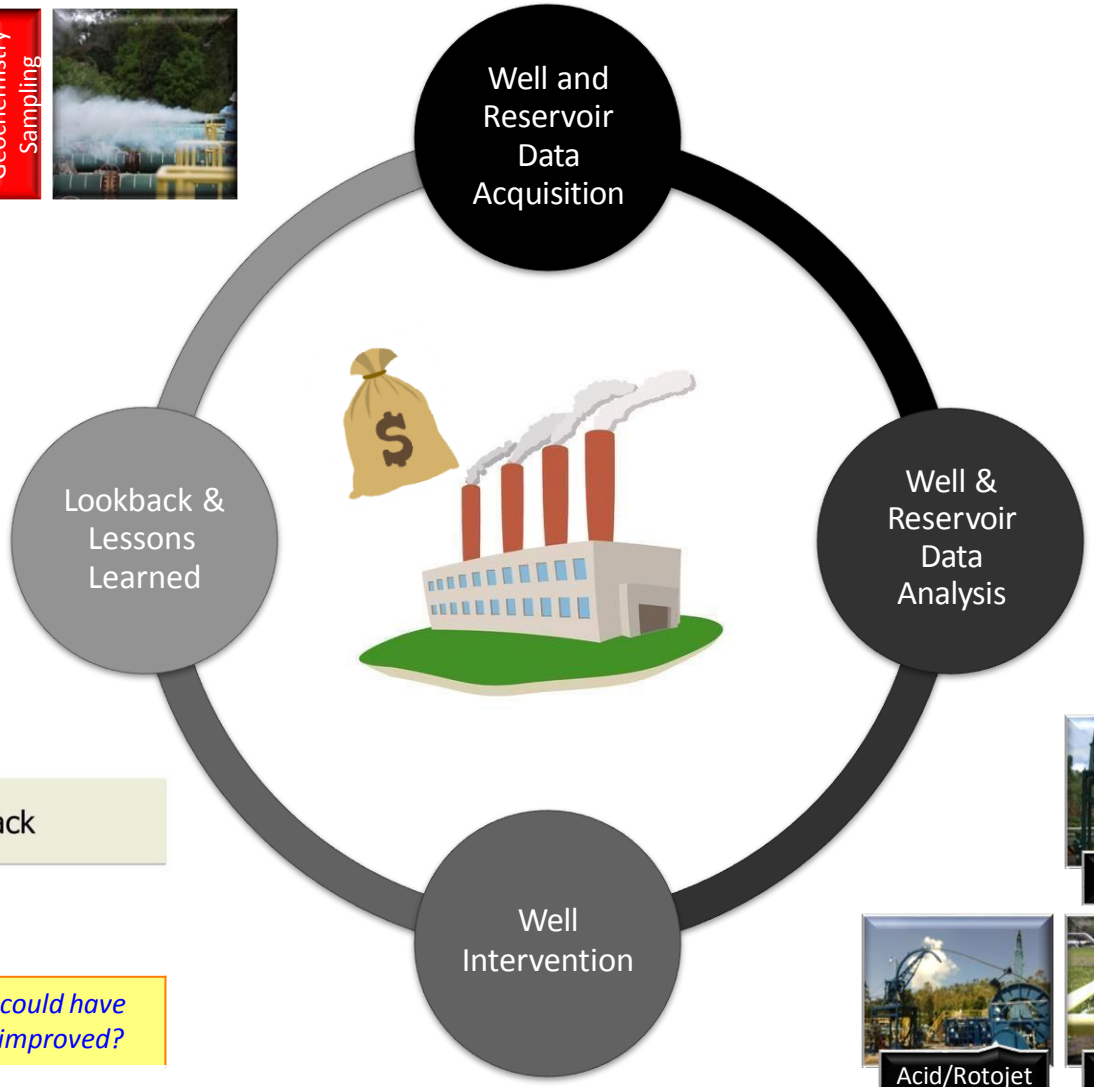
- Social community
- Farmer community
- Forestry Permit
- Steam quality / purity

Managing Geothermal Production

Geothermal Power Production Cycle



Managing Geothermal Energy



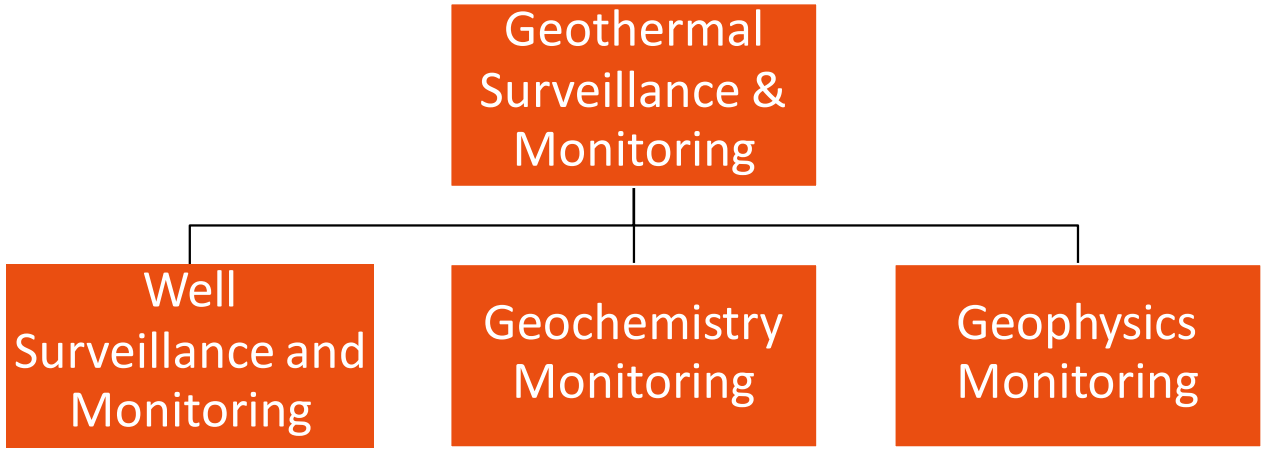
Plus/Delta Feedback

+/Δ

What went well? *What could have been improved?*

Geothermal Surveillance & Monitoring

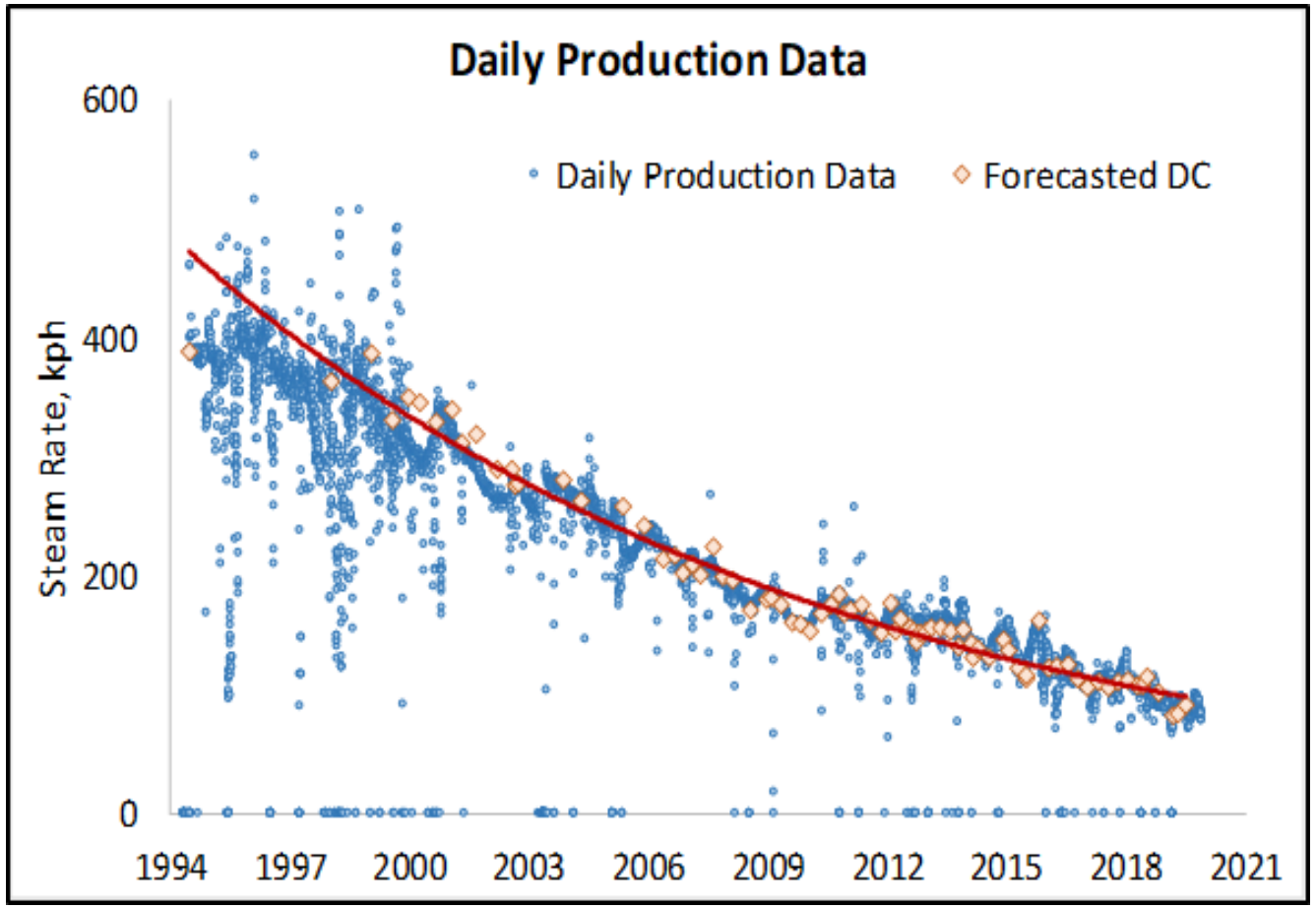
Surveillance and Monitoring Plan



The objective of the reservoir monitoring program is to ensure 'health' of the reservoir and its following development risk in order to maintain optimum field production.

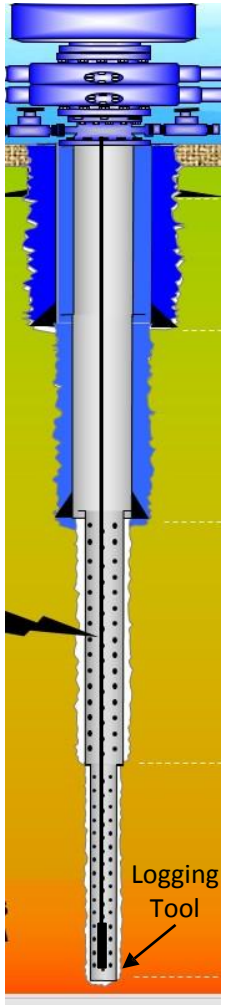
Geothermal Surveillance & Monitoring

Daily Data Monitoring



Geothermal Surveillance & Monitoring

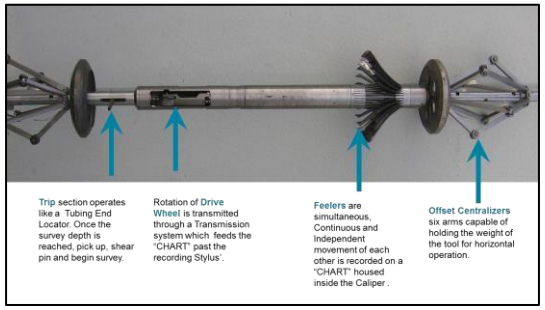
Downhole Logging Survey



PT/PTS

Downhole Video

Downhole Sampler



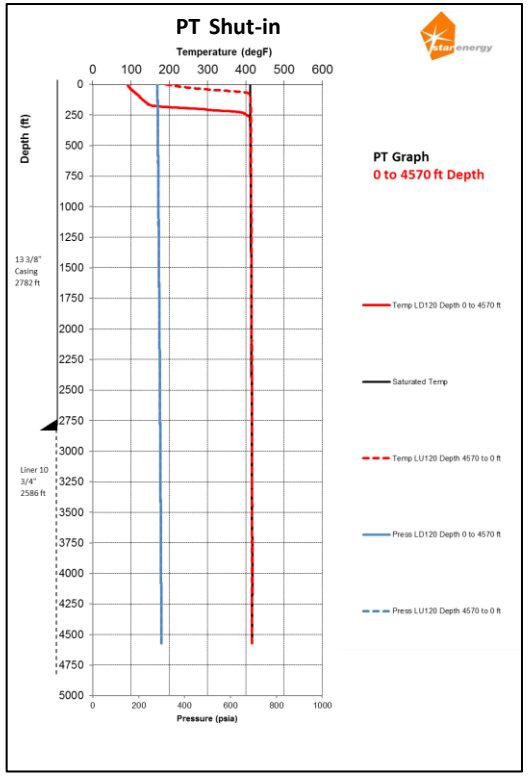
Mechanical Caliper

Impression Block

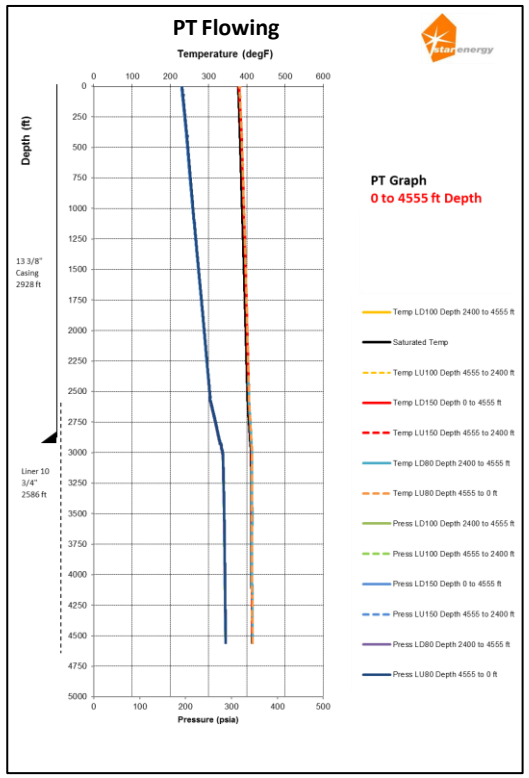
Scale Cather

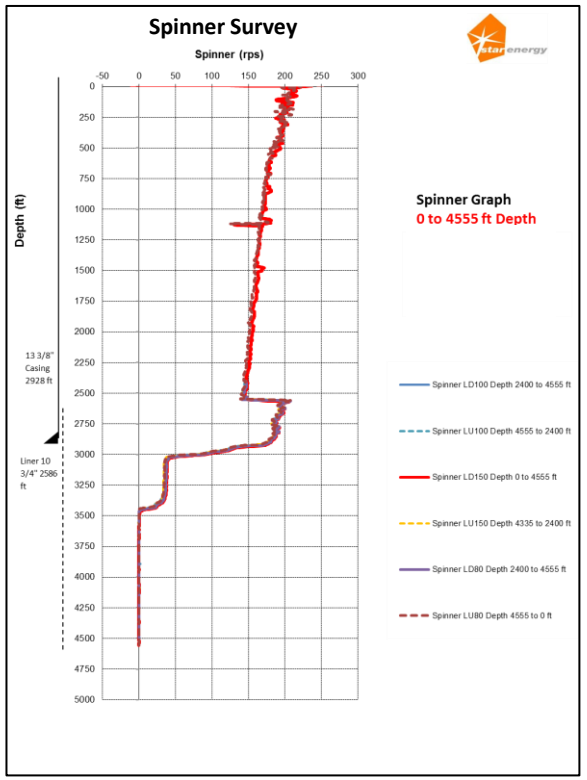
Geothermal Surveillance & Monitoring

Downhole Logging Survey



PT Shut-in Profile





PTS Flowing Profile

Downhole Video Survey

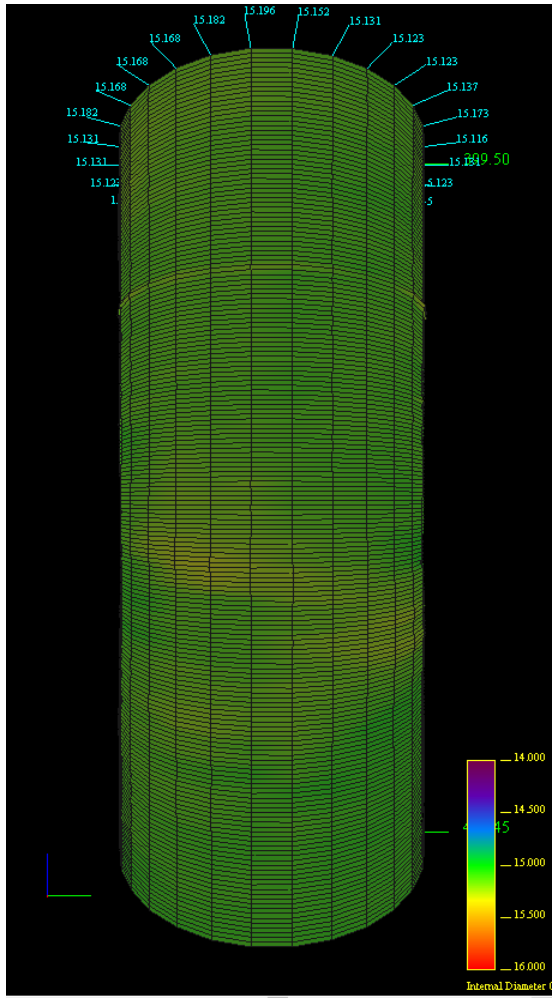
Impression Block Survey

Scale Sample

Geothermal Surveillance & Monitoring

Wellhead and Well Integrity Monitoring

Wellhead Integrity Monitoring



Casing Caliper Survey

Geothermal Surveillance & Monitoring

Geochemistry Monitoring

Geochemistry Well Sampling

Surface Manifestation Monitoring

Downhole Sampling

Geothermal Surveillance & Monitoring

Geophysics Monitoring

Microseismic Monitoring

Precision Gravity Monitoring

Precision Leveling Monitoring

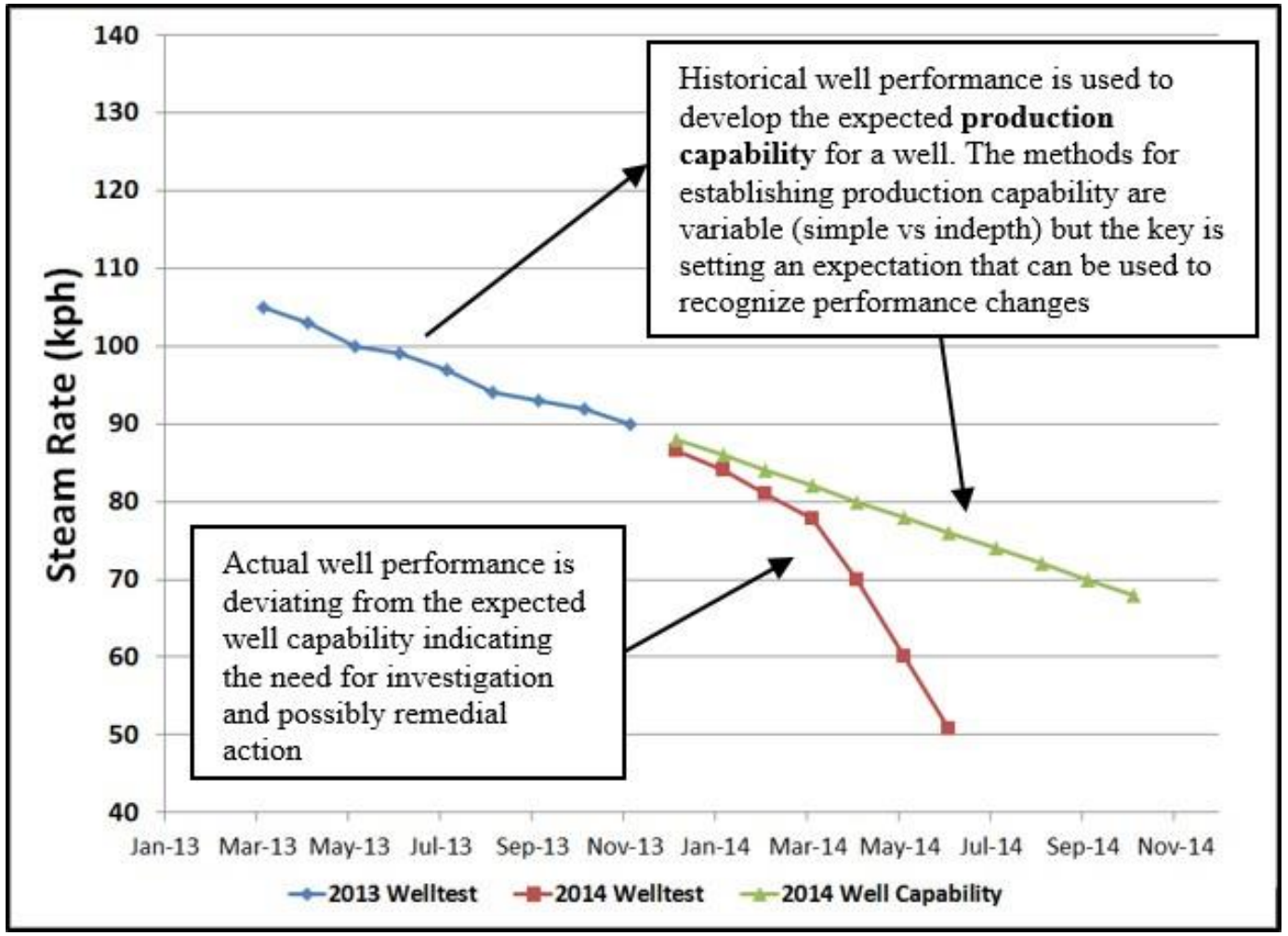
Data Analysis and Optimization

Production Assurance – Comparing Actual Data with Forecast

Daily data obtained for reservoir monitoring include :

- Production Well Status (FCV opening, WHP, discharge status)
- Production Separator (Steam Rate, Separator Pressure)
- Injection Well Status (Injection Rate, WHP, header pressure)
- Power Plant (power generation, steam rate to power plant)

Actual data monitoring is then compared to the expected performance to determine well production variance and possible remedial action.



Well Intervention Program

Well Intervention Methods

Coil Tubing Unit

Rotojet Tool

Broaching Tool

Master Valve Change using Packer

Plug and Abandon

Thank you

Q&A