Geothermal Energy Resource Potential & Development in the Pacific Island Countries

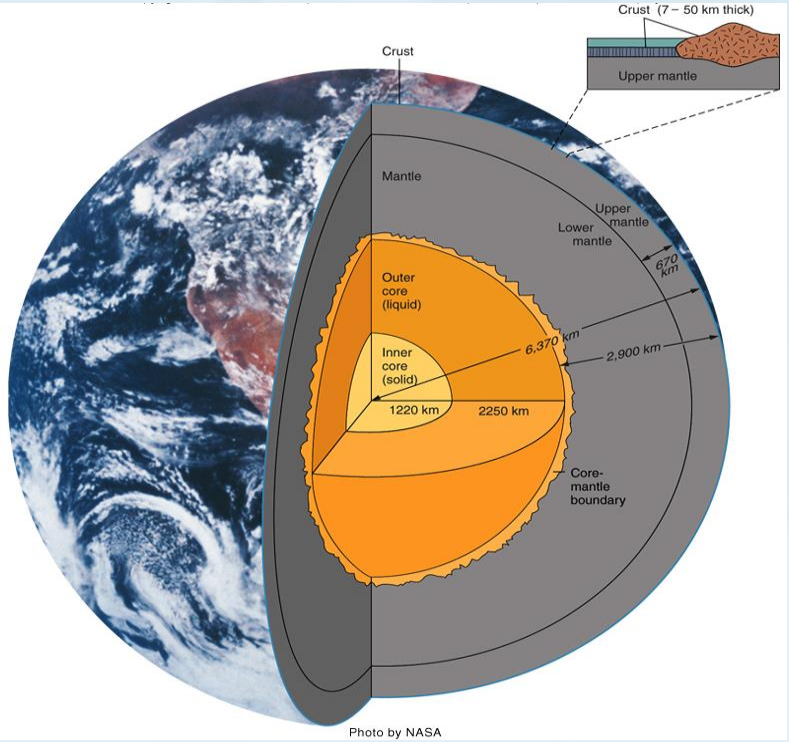
Presentation to:	***Pacific Economic Cooperation Council (PECC) International Project on Energy Transition & New Economic Models 2013-2014***
Location:	***Noumea, New Caledonia***
Date:	***26-28 November 2014***
Presenter:	***Kifle Kahsai, Chief Geoscientist, Geoscience Division***

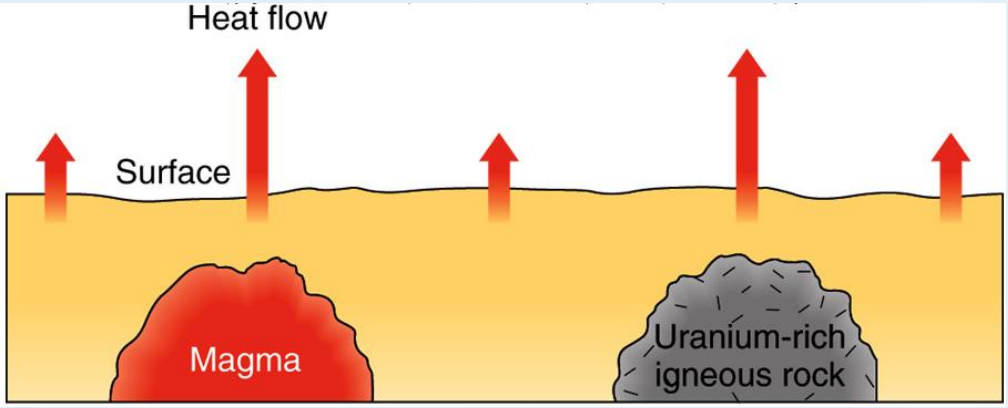
Outline

1. What is a Geothermal System or Energy Resource?
2. Geothermal Energy Resource Potential in Southwest Pacific Island Countries
3. Exploration and Development Processes
4. Project Cost and Risk Profile at Various Stages of Development
5. National and International Level Initiatives for Risk Mitigation Fund Facility
6. Benefits and Challenges/Risks
7. An Integrated Approach
8. Conclusion

1. What is a Geothermal Energy Resource?

- Heat Energy from within the Earth
- Massive deep heat energy resource
- High temperature resources at accessible depth in particular conditions
- High temperature geothermal development in volcanic systems
- Essential factors for a successful geothermal resource include:
  - ✓ Heat
  - ✓ Fluid
  - ✓ Permeability



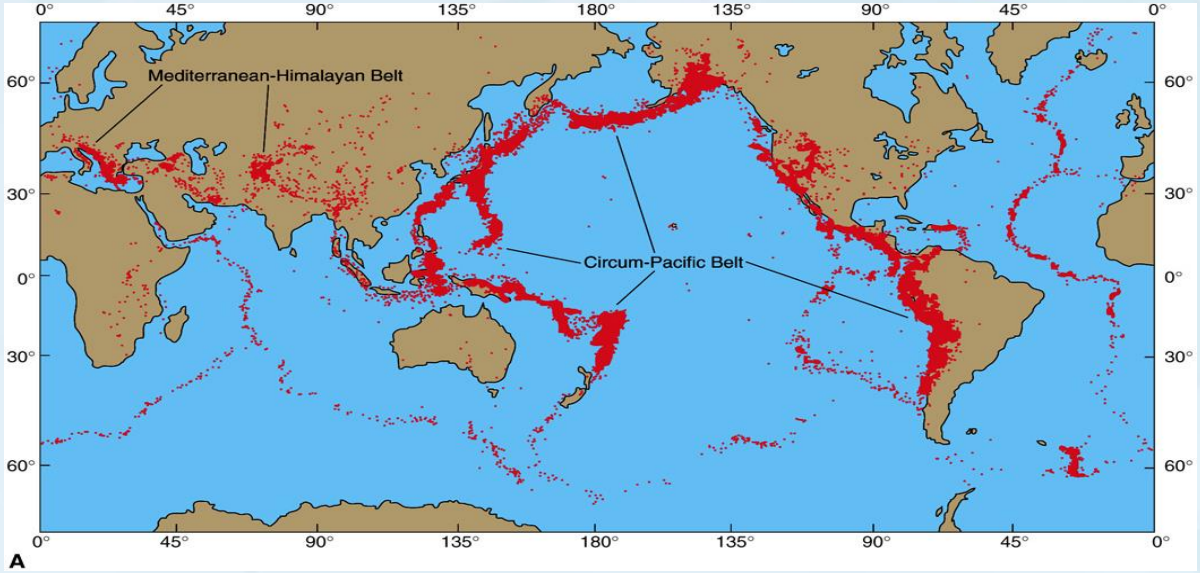


Types of Geothermal Systems

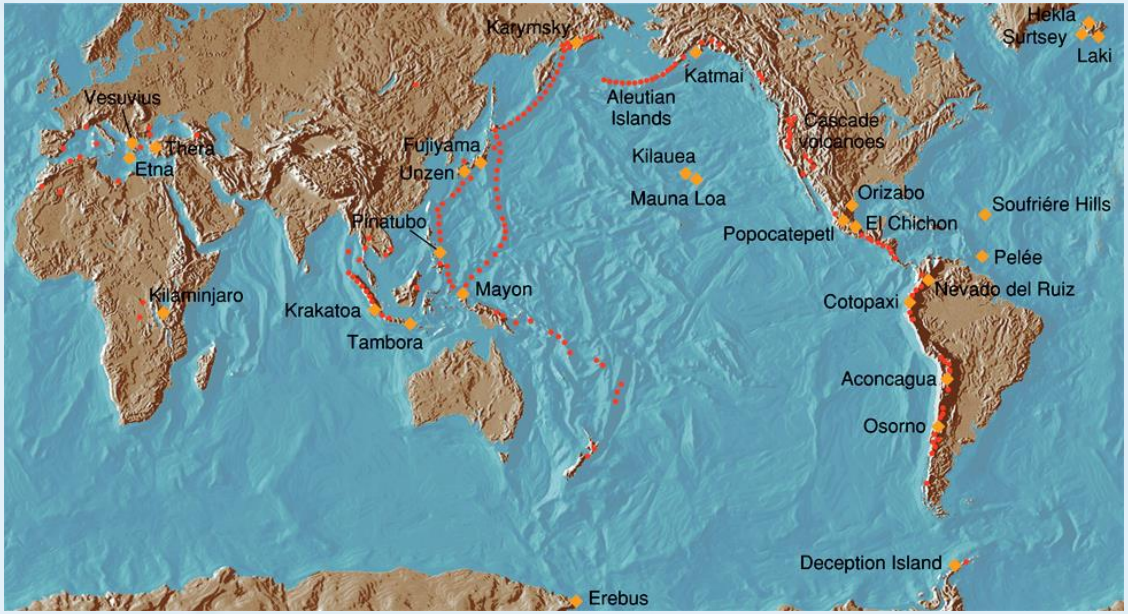
A. Hydrothermal Systems
B. Engineering Enhanced Geothermal Systems (EGS)

A. Hydrothermal Systems

- Plate tectonics
- Convergent and divergent plate boundaries
- Active seismic zones

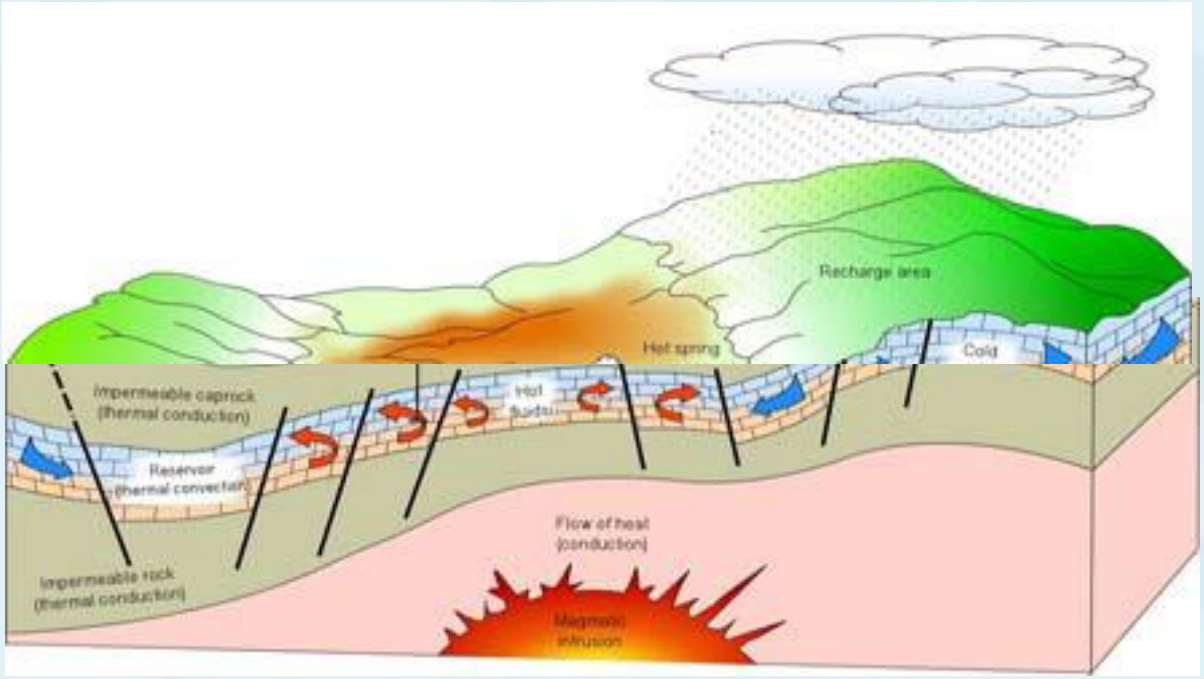


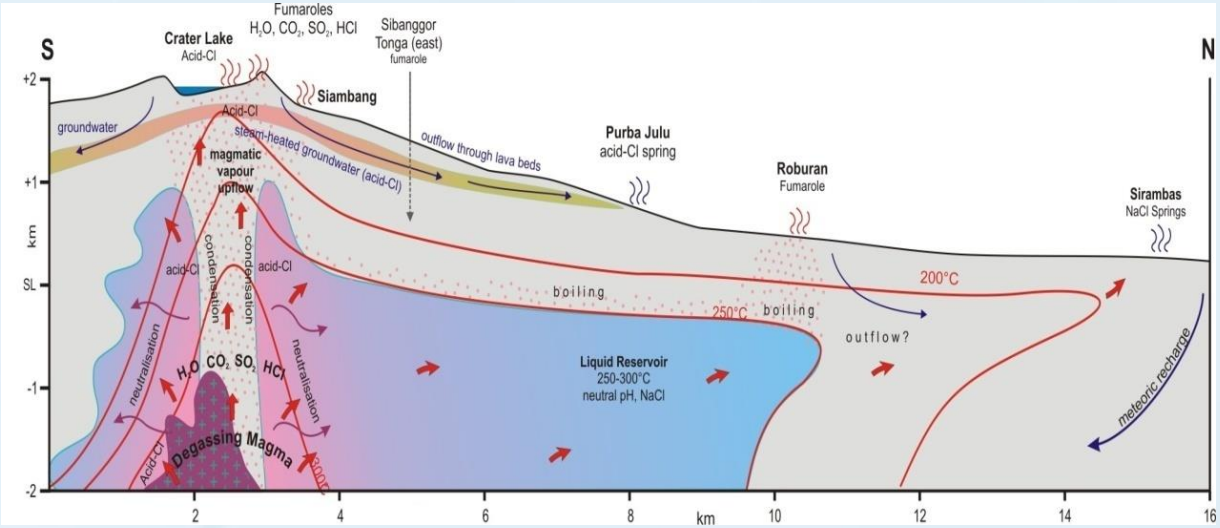
- Active volcanic zones



A. Hydrothermal Systems (conventional magmatic-related)

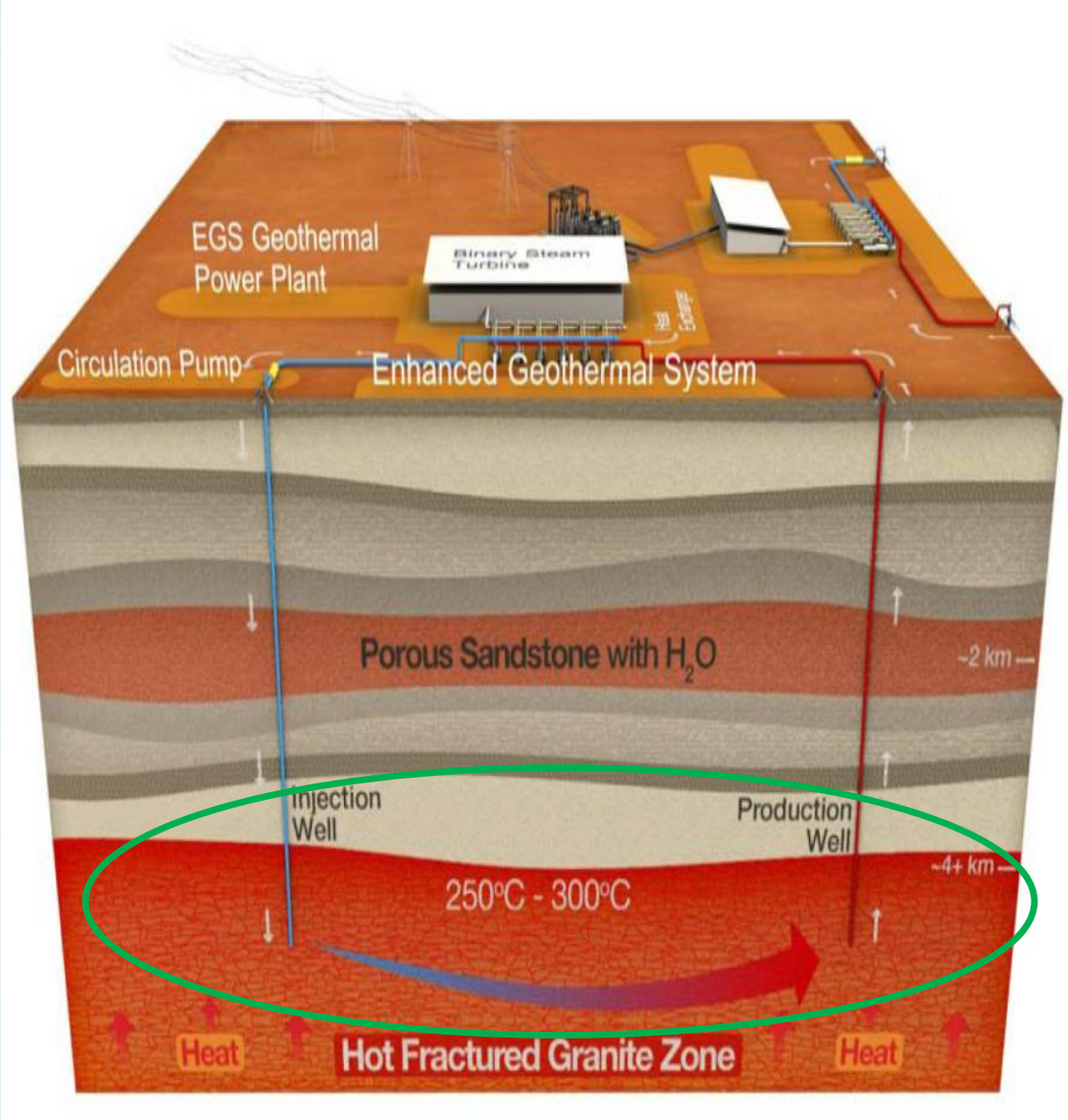
- Natural processes
- Heat source
- Fluid
- Host rocks/fractures
- Convection system (heat transfer)
- Temperature & pressure gradients
- Gasses & chemical species
- Hot water plume
- Size/depth





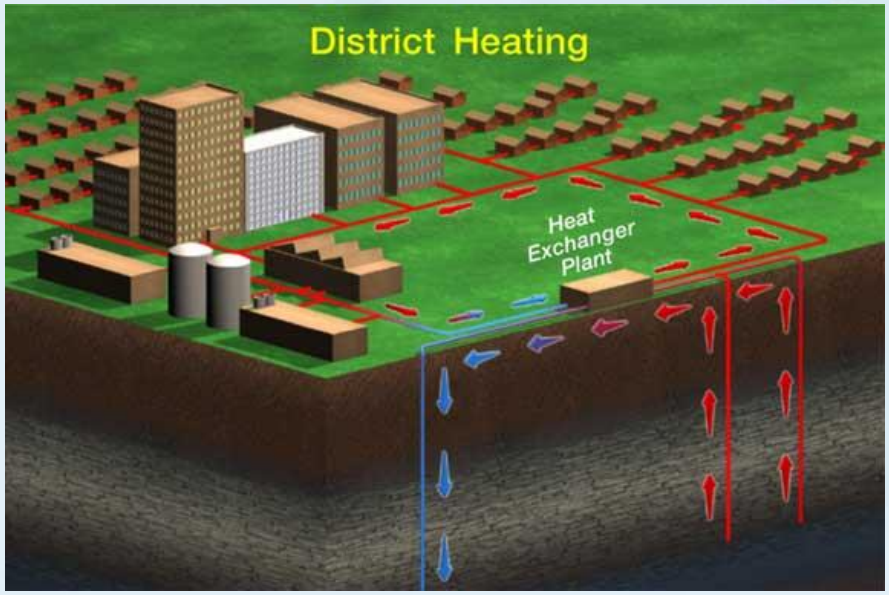
Source: Dickson & Mario, CNR, 2004

B. Hot Rock or Enhanced Geothermal System (EGS)



Geothermal Applications

1. Direct heat use



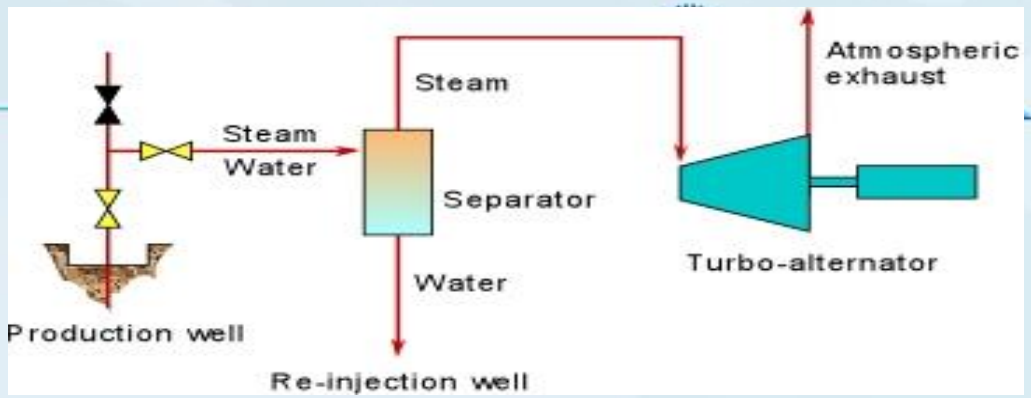
- Space heating
- Aquaculture
- Greenhouses
- Industrial processes

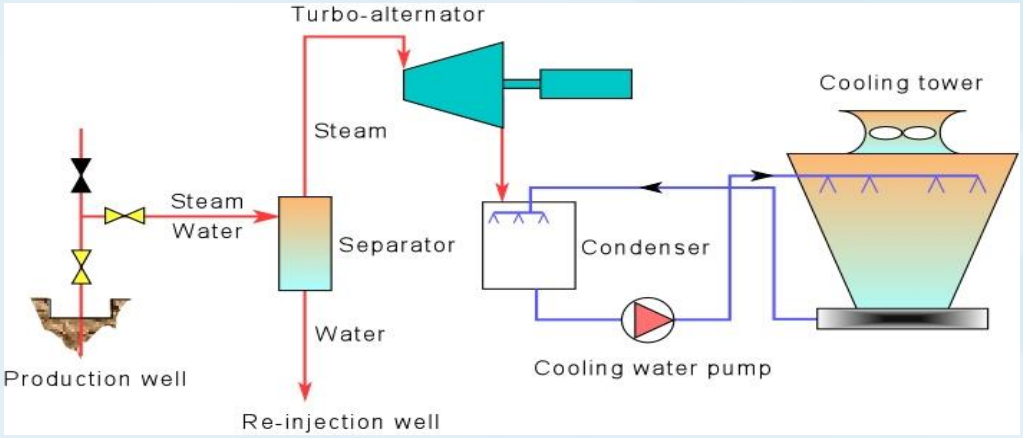
Geothermal Applications cont.

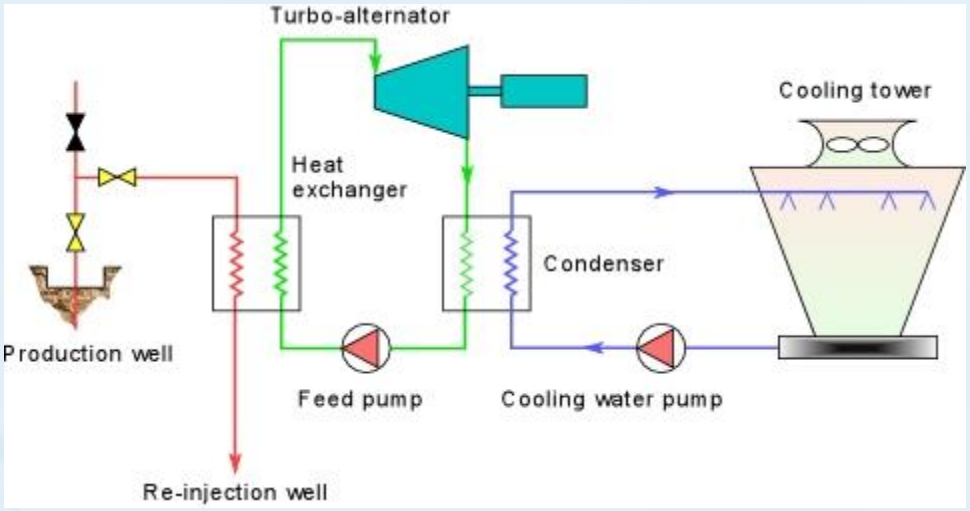
2. Electrical Power

- Hot water and steam from geothermal system
- Steam or secondary fluids to drive turbines/generators
- Excess fluid is reinjected back into the reservoir to extend the life of the system

✓ Dry Steam Power Plants
✓ Flash Steam Power Plants
✓ Binary Power Plants

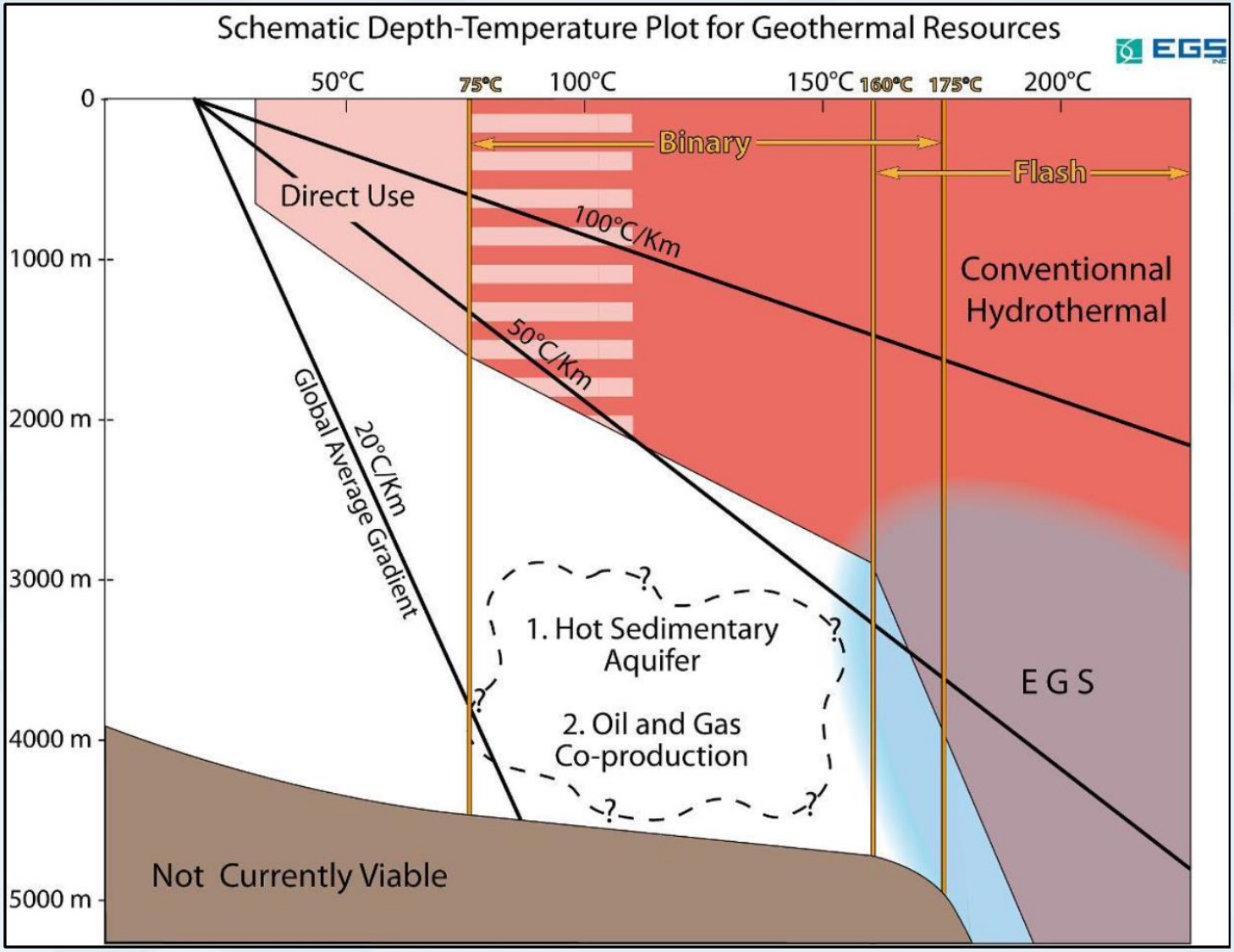






Source: Dickson & Mario, CNR, 2004

Depth vs Temperature Plot for Geothermal Resources

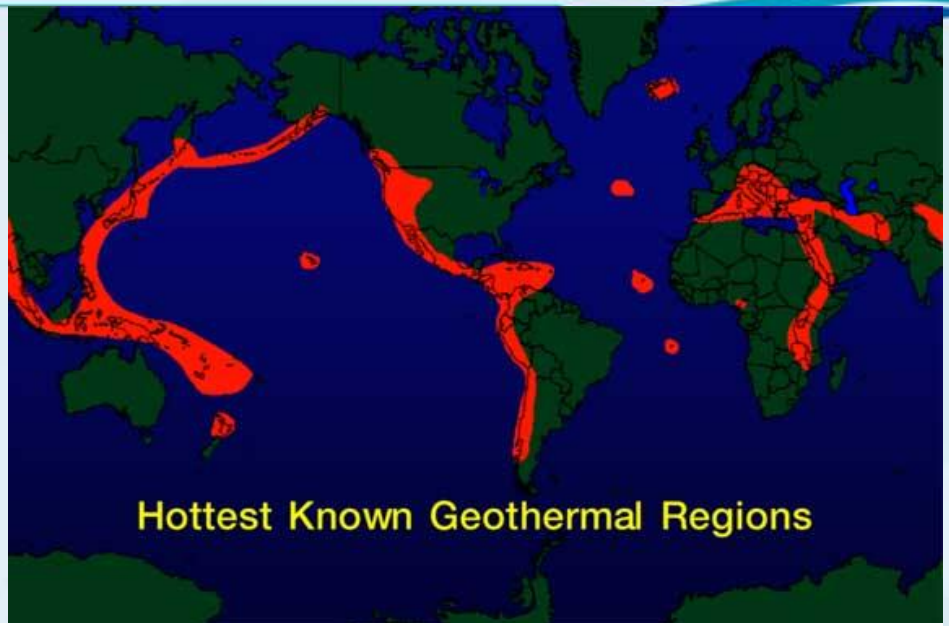


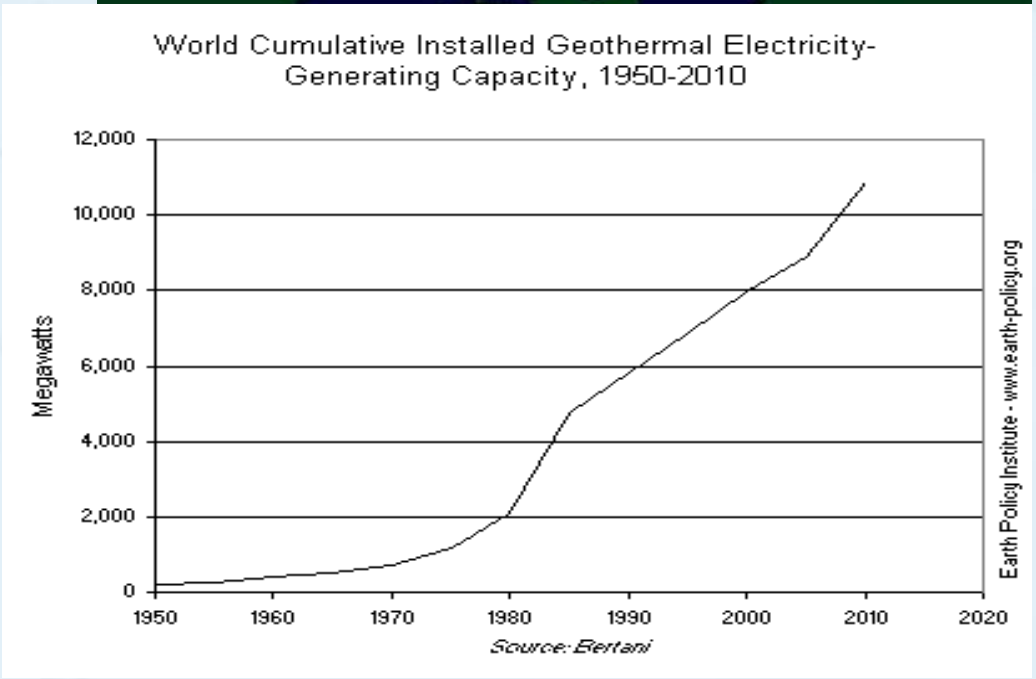
Source: EGS Inc.. 2013

History of Geothermal Resource Exploration & Development

What has changed?

- More and better data on heat flow and subsurface temperatures
- Technology advances
- Global energy economics
- Climate change





Source: 36th WSGRE, USA, 2012

2. Geothermal Resource Potential in Southwest Pacific Island Countries and Territories

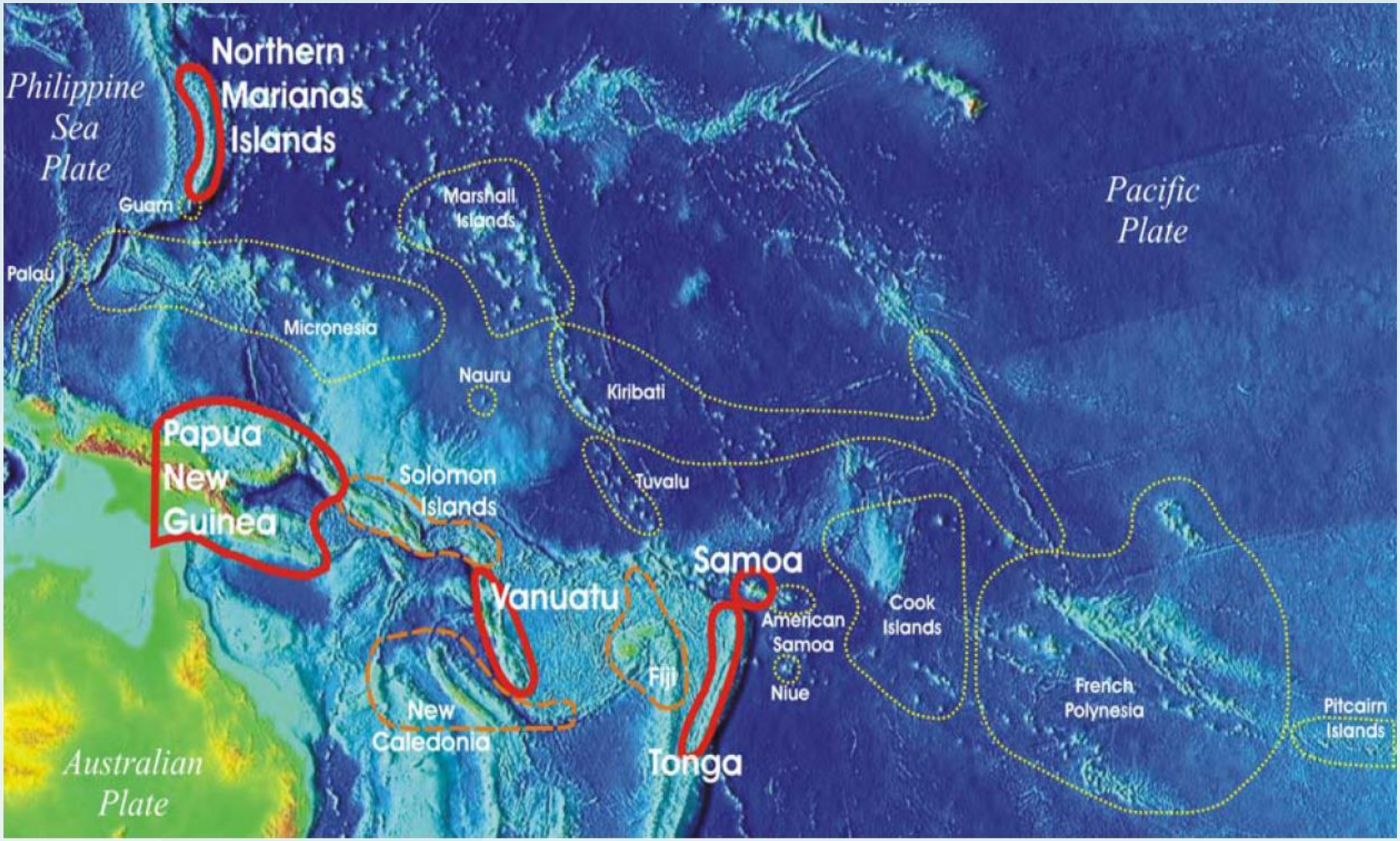
***Table 1**: Summary of the geothermal resource potential of nations and territories in the southwest Pacific*

	Youngest Volcanism[1]	Heat Source	Geothermal Locations	Geothermal Surveys	Temp. Range[2]	Power Demand[3]	Renewable Energy[4]	Development Barriers	Development Potential
Papua New Guinea	Active	Excellent	41 thermal areas	Development	36-101	2674	46%	Rugged Terrain	High
Vanautu	Active	Good	20 thermal areas	Reconnisance	30-78	40	19%	Active Volcanism	High to Moderate
Samoa	Active	Good	Prospective Rift Valley	None	-	101	42%	-	Moderate
Tonga	Active	Good	Hot springs	None	-	43	0%	Distance to population	Moderate
N. Marianas Islands	Active	Excellent	Submarine only	Reconnisance	-	4	50%	Active Volcanism	High to Moderate
Fiji	Recent	Excellent	53 thermal areas	Detailed	31-102	970	82%	-	High
Solomon Islands	Active	Good	8 thermal areas	Reconnisance	57-99	70	0%	-	High to Moderate
New Caledonia	Unknown	Unknown	2 thermal areas	Reconnisance	22-43	1490	24%	-	Moderate
French Polynesia	Recent	Possible	Submarine?	None	-	442	39%	-	Low to Moderate
American Samoa	~1 Ma	Possible	None	None	-	167	0%	-	Low
Cook Islands	1.5 Ma	Possible	None	None	-	28	10%	-	Low
Pitcairn	0.45 Ma	Possible	None	None	-	< 0.5	0%	-	Low
Palau	~20 Ma	None	None	None	-	122	0%	-	Extremely Low
Guam	~32 Ma	None	None	None	-	1664	0%	-	Extremely Low
Niue	> 20 Ma	None	None	None	-	4	0%	-	Extremely Low
Kiribati	~80 Ma	None	None	None	-	9	0%	-	Extremely Low
Marshall Islands	~80 Ma	None	None	None	-	100	1%	-	Extremely Low
Micronesia	Unknown	None	None	None	-	179	0%	-	Extremely Low
Nauru	Unknown	None	None	None	-	29	0%	-	Extremely Low
Tuvalu	Unknown	None	None	None	-	Unknown	0%	-	Extremely Low

1) Active: volcanism in the last 500 years; recent: volcanism in the last 50 ka. 2) Observed hot spring temperatures in °C. 3) Annual power consumption in M kWh. 4) Renewable energy refers to the percentage of power generated from sources other than fossil fuels. Electricity demand and generation sources are taken from Energy Information Agency (2009).

Source: 36th WSGRE, USA, 2012

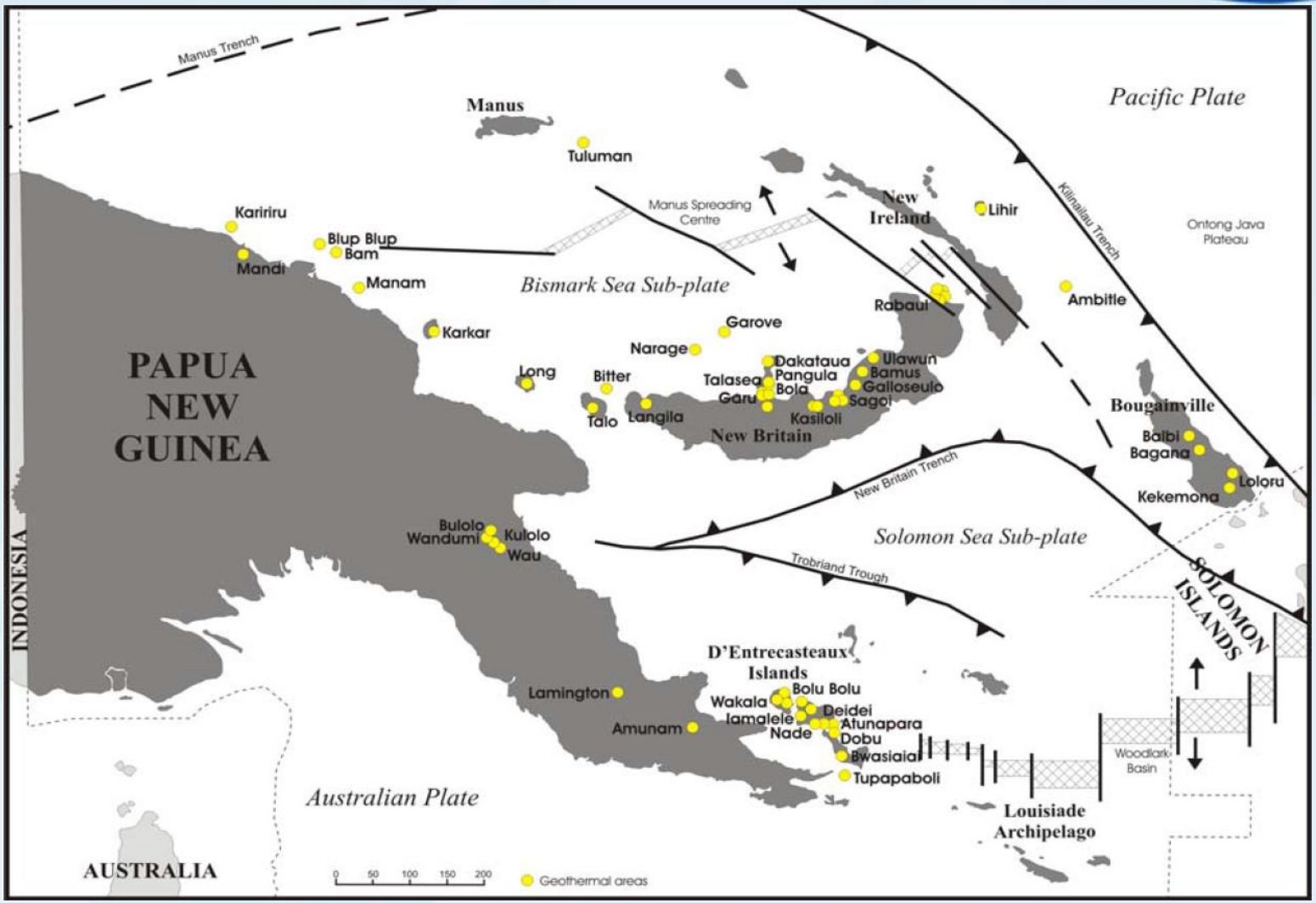
Southwest Pacific Countries with Potential Geothermal Energy Resources



Red = Nations reviewed in detail; Orange = Nations with high to moderate temperature geothermal potential; Yellow = Nations with low to extremely low temperature geothermal potential

Source: 36th WSGRE, USA, 2012

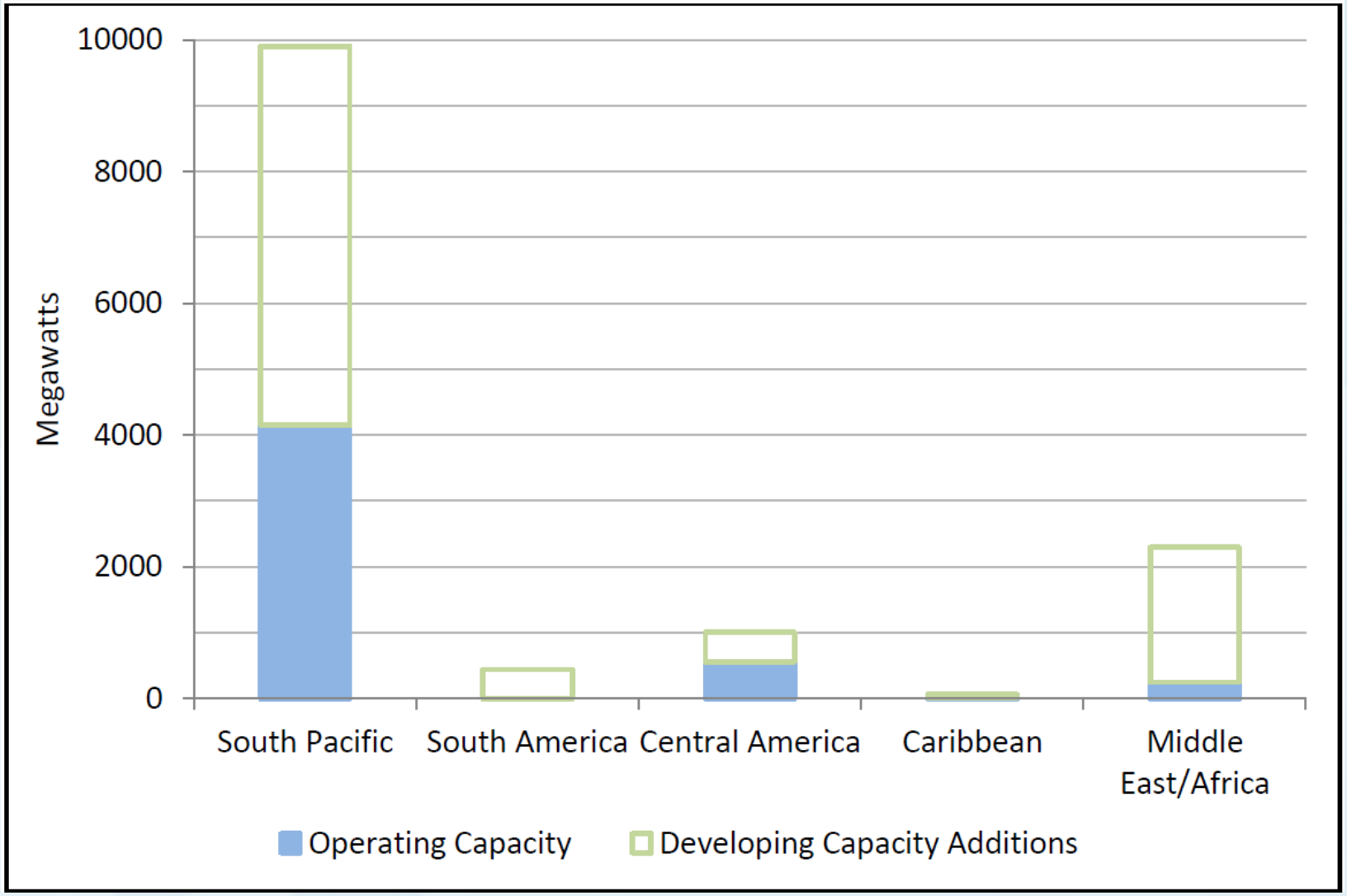
Map of PNG Showing Locations of Thermal Features



Map of Papua New Guinea showing the locations of known geothermal areas from Mosusu (2018) and Heming (1966). The plate/micro-plate are modified from Williamson and Hancock (2005) by McCoy-West et al. (2012).

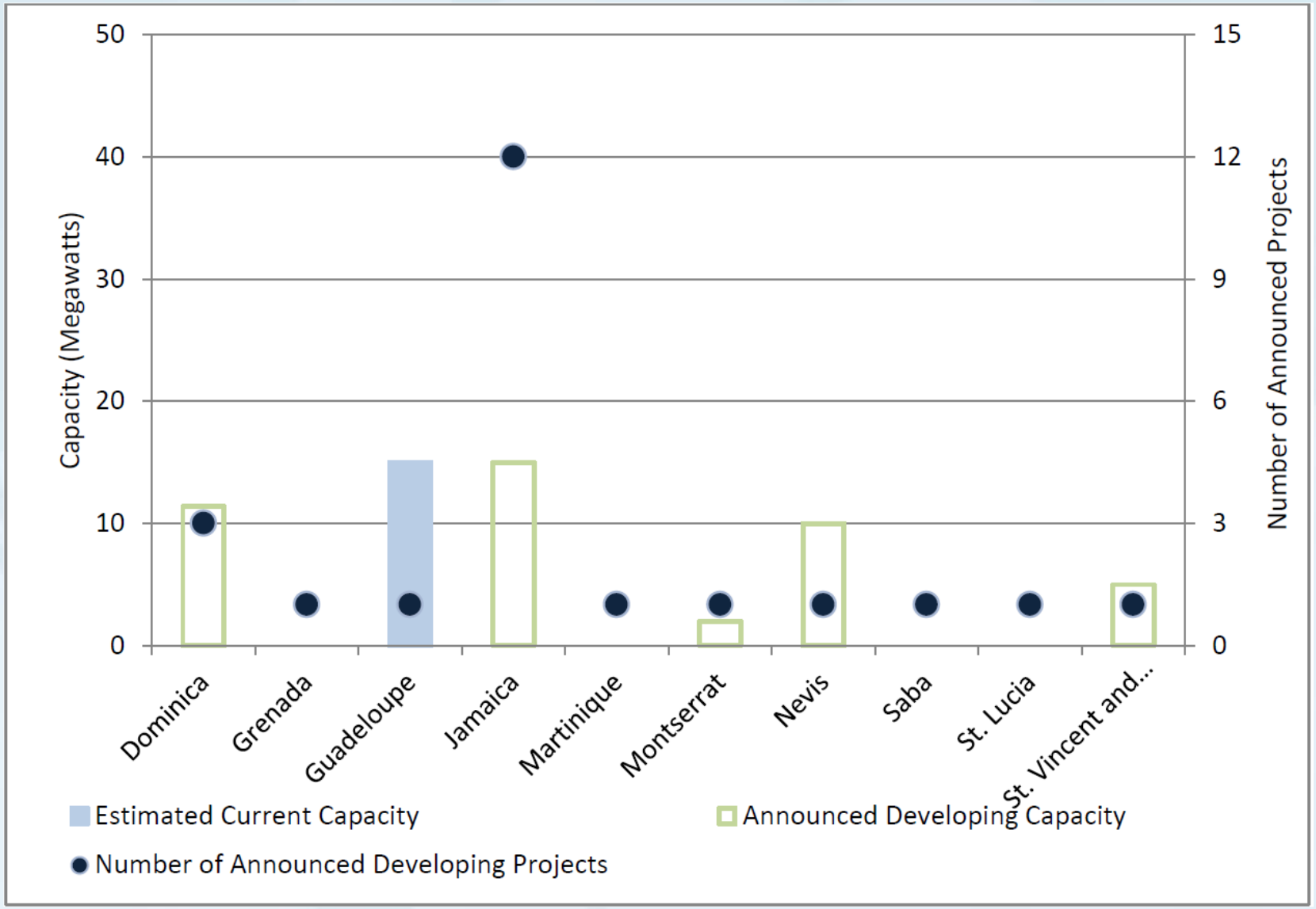
Source: 36th WSGRE, USA, 2012

Geothermal Power Operating & Developing Capacity by Developing Region



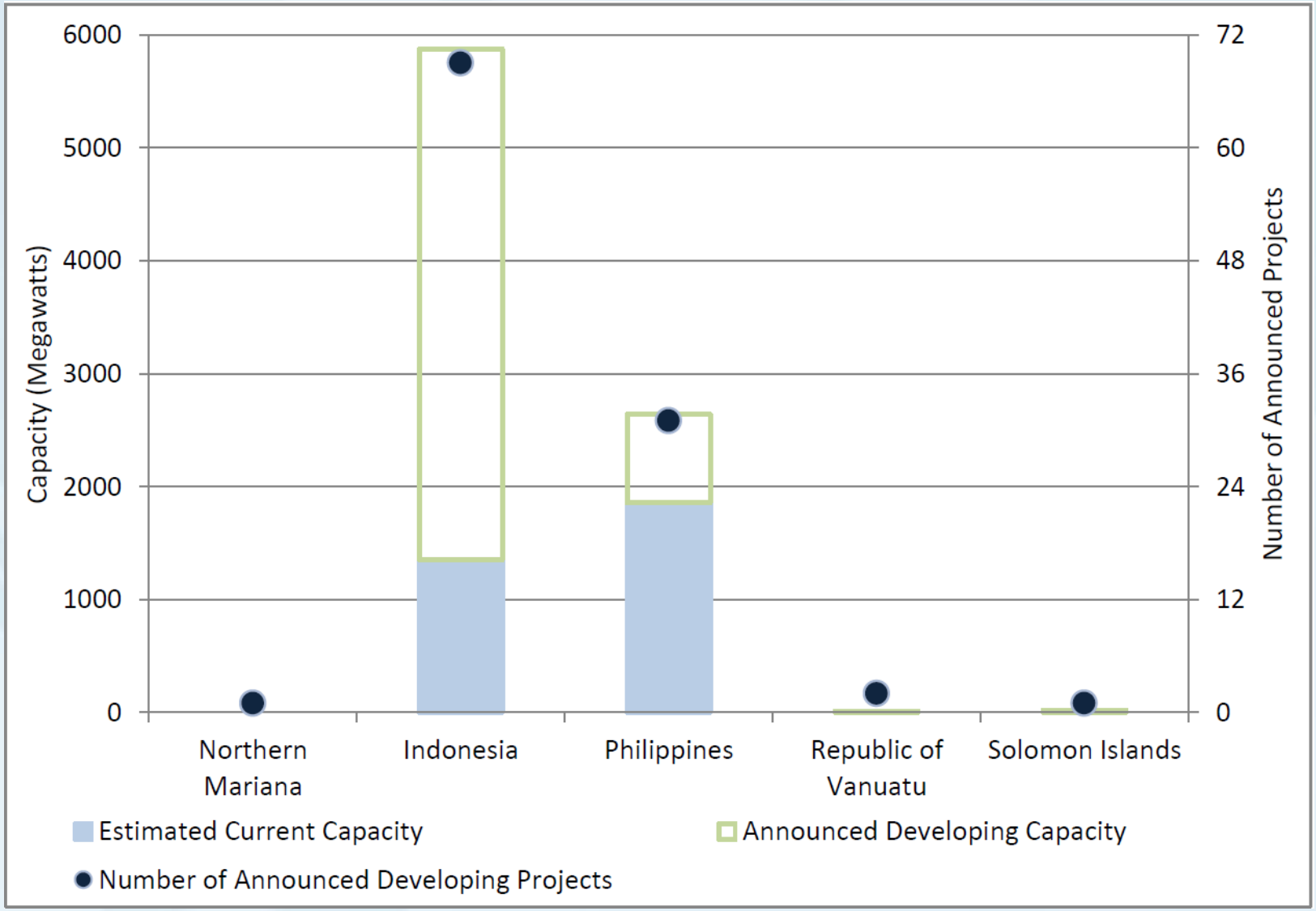
Source, GEA, 2014

Caribbean Geothermal Potential



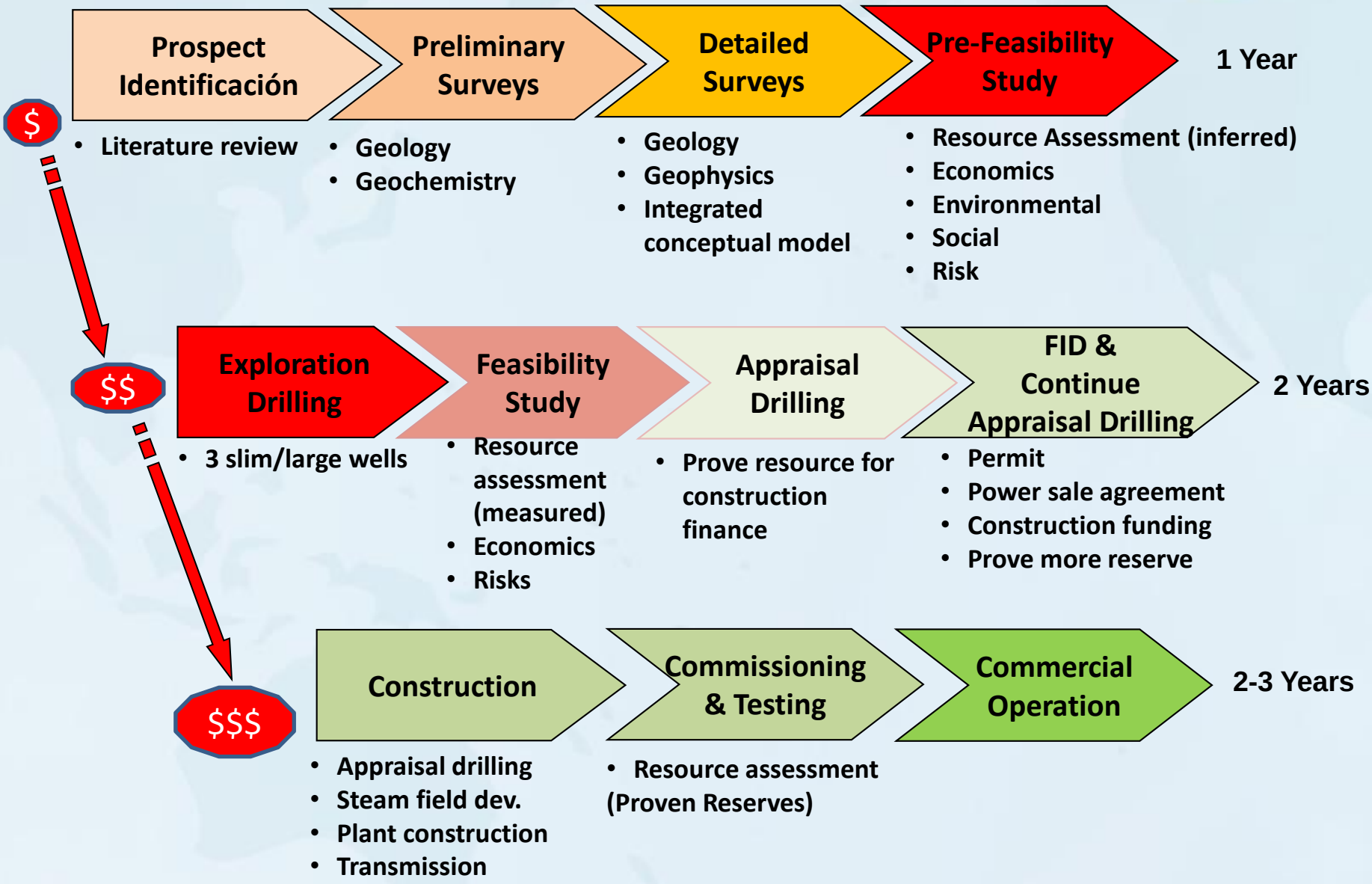
Source: GEA, 2014

South Pacific Geothermal Capacity

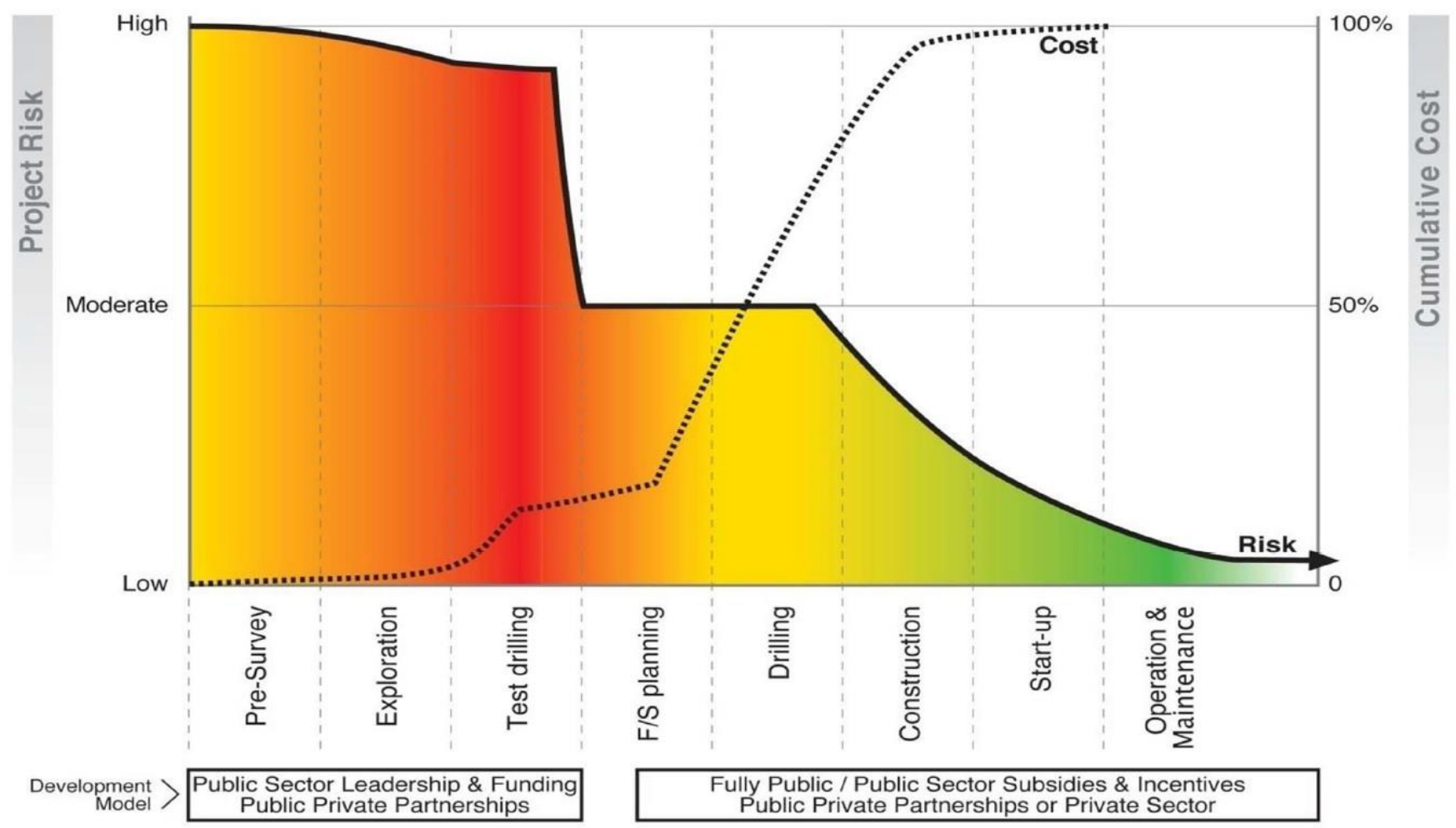


Source: GEA 2014

3. Exploration and Development Process



4. Project Cost and Risk Profile at Various Stages of Development of Geothermal Energy

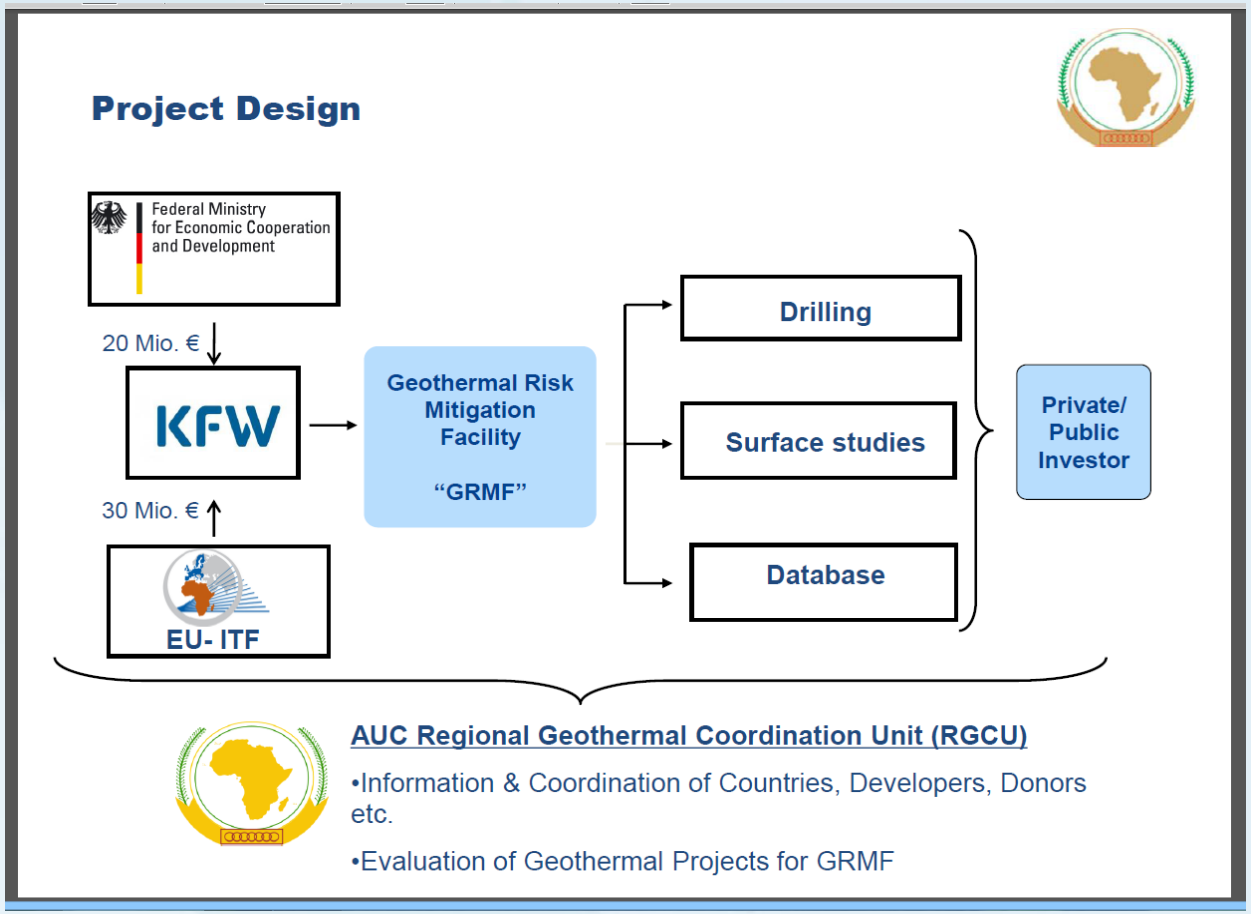


Source: Gehringer and Loksha, 2012

5. Risk Mitigation Funding/Facility (RMF)

- **National and Regional Networking** in management of geothermal information system, capacity building (including sharing of resources, human and equipment) and raising awareness or promotion).
  - National Geothermal Data System
- **Technical assistance** in (i) surface exploration to investigate the presence of an active geothermal system and (ii) promotion of institutional structure and advice on legal and regulatory framework.
  - California Geothermal Grant and Loan Program
  - East African Risk Mitigation Facility (2012)
- **Cover risky investments** in exploration and appraisal drilling.
  - Geothermal Risk Insurance
  - WB Global Geothermal Development Plan (2013)

Example of GRMF Project Design



- **Initial Countries involved: Ethiopia, Kenya, Rwanda, Tanzania and Uganda.**
- **Additional countries in 2013: Burundi, Comoros Islands, Djibouti, DRC, Eritrea and Zambia.**

Source: (Rashid Abdullah, AUC, RGCU)

6. Benefits

- ✓ Renewable type of energy
- ✓ Environmentally-friendly
- ✓ Accessible and clean energy
- ✓ Reliable source of energy
- ✓ Economically competitive
- ✓ Price stability vs. fossil fuels
  - Stable energy prices
- ✓ Low carbon – lower greenhouse gas emissions
- ✓ Improved air quality
- ✓ Multiple domestic and industrial uses
- ✓ Offers competitive advantage to industry
- ✓ Improved public image
- ✓ Employment

Challenges / Risks

- ❖ Resource
- ❖ Reinjection
- ❖ Market
- ❖ Financial
- ❖ Management
- ❖ Construction
- ❖ Political
- ❖ Country (regulatory, environmental, social)
- ❖ Governance
- ❖ HSE

California Renewable Portfolio Standard Commission

Large IOU RPS Costs (cents per kWh) for 2013				
	PG&E	*SCE*	*SDG&E*	*Average*
Biogas	5.94	6.82	7.93	6.98
Biomass	9.73	-	9.25	9.67
Geothermal	7.19	6.75	Confidential	7.03
Small Hydro	8.72	8.91	5.30	8.66
Solar PV	15.18	11.90	10.39	13.96
Solar Thermal	14.23	13.48	-	13.52
Wind	8.40	9.77	6.10	8.68
UOG Small Hydro	4.60	12.38	-	5.71
UOG Solar PV	16.21	47.00	-	21.65

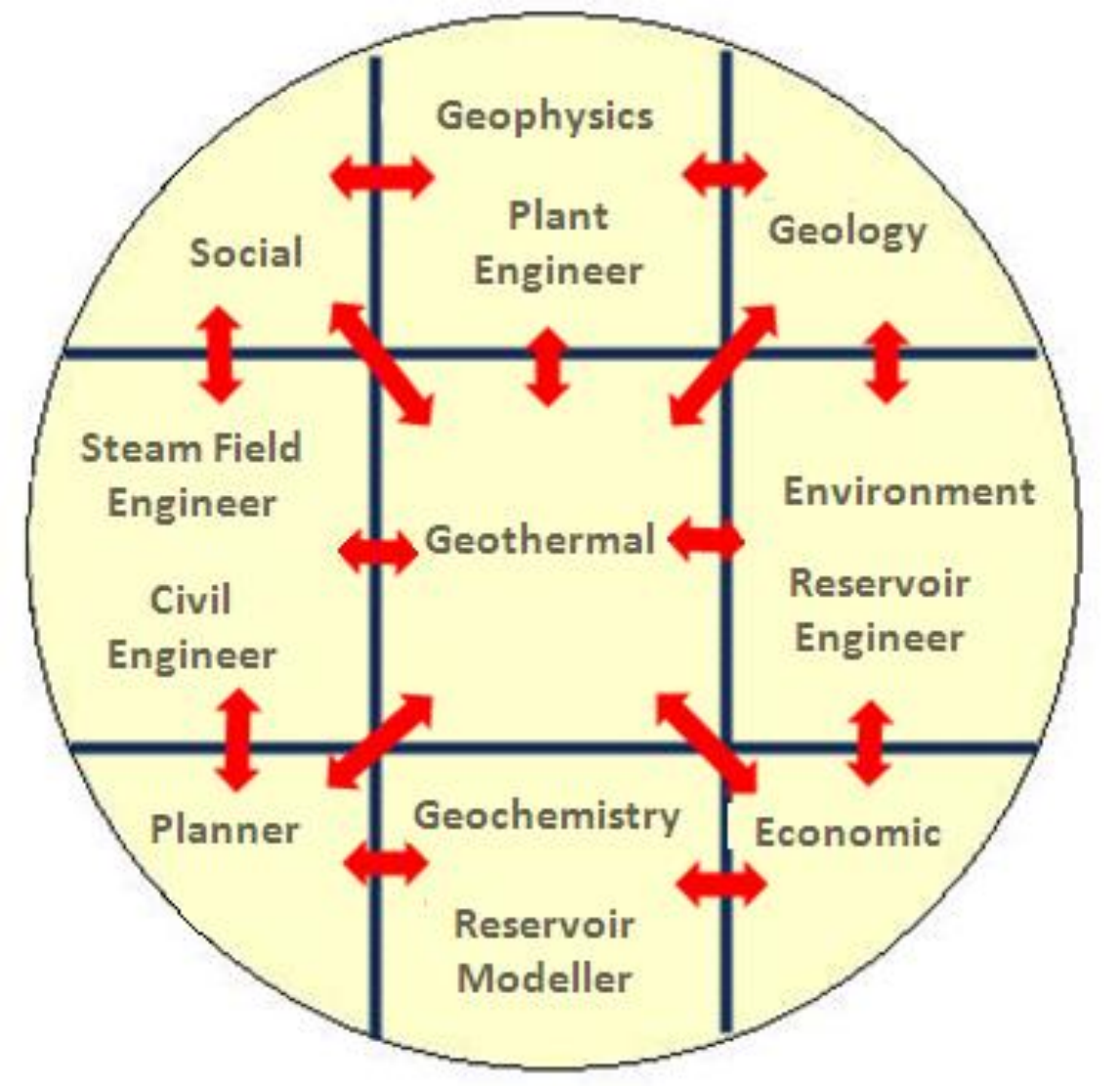
Source, GEA, 2014

Capacity Factor of different Power Plants

Plant type	Capacity factor (%)	Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total system levelized cost
Coal						
Conventional Coal	85	65.7	4.1	29.2	1.2	**100.1**
Advanced Coal	85	84.4	6.8	30.7	1.2	**123**
Advanced Coal with CCS	85	88.4	8.8	37.2	1.2	**135.5**
Natural Gas						
Conventional Combined Cycle	87	15.8	1.7	48.4	1.2	**67.1**
Advanced Combined Cycle	87	17.4	2	45	1.2	**65.6**
Advanced CC with CCS	87	34	4.1	54.1	1.2	**93.4**
Conventional Combustion Turbine	30	44.2	2.7	80	3.4	**130.3**
Advanced Combustion Turbine	30	30.4	2.6	68.2	3.4	**104.6**
Other Technologies						
Advanced Nuclear	90	83.4	11.6	12.3	1.1	**108.4**
Geothermal	92	76.2	12	0	1.4	**89.6**
Biomass	83	53.2	14.3	42.3	1.2	**111**
Non-Dispatchable Technologies						
Wind	34	70.3	13.1	0	3.2	**86.6**
Wind-Offshore	37	193.4	22.4	0	5.7	**221.5**
Solar PV	25	130.4	9.9	0	4	**144.3**
Solar Thermal	20	214.2	41.4	0	5.9	**261.5**
Hydro	52	78.1	4.1	6.1	2	**90.3**

Source: USA EIA, 2013

7. An Integrated Approach



8. Conclusions

- ✓ **Let us PROMOTE RELIABLE RENEWABLE ENERGY SOURCE and MAKE it HAPPEN in SW Pacific Islands Region!**

Thank You

Any questions??