

# Developing Geothermal Energy: Lessons & International Collaboration

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University of Auckland  
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Geothermal now meets some **20%** of New Zealand's electricity demand; almost **85%** of our generation is from renewable resources.



We continue to consider new geothermal resources; innovative solutions to enhance productivity and financial returns.

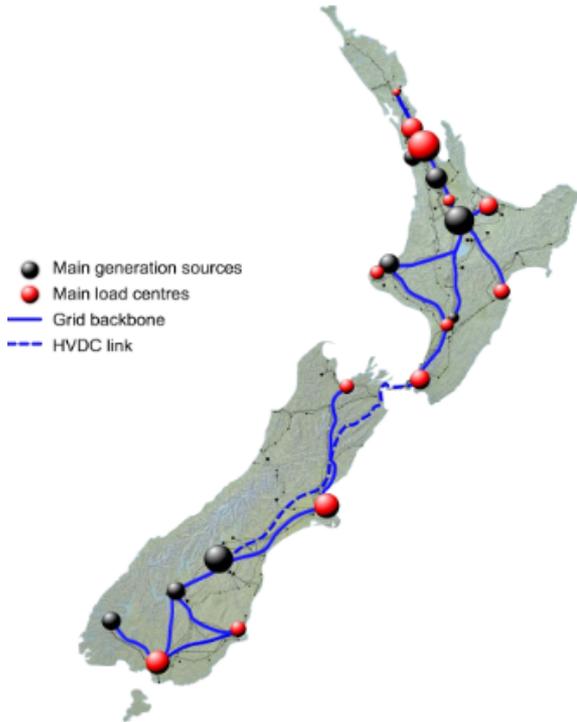
**On a commercial and bilateral basis we are active globally.**



What follows touches on:

- Our geothermal strategy
- Lessons we have learned
- International collaboration
- Key issues in capability development

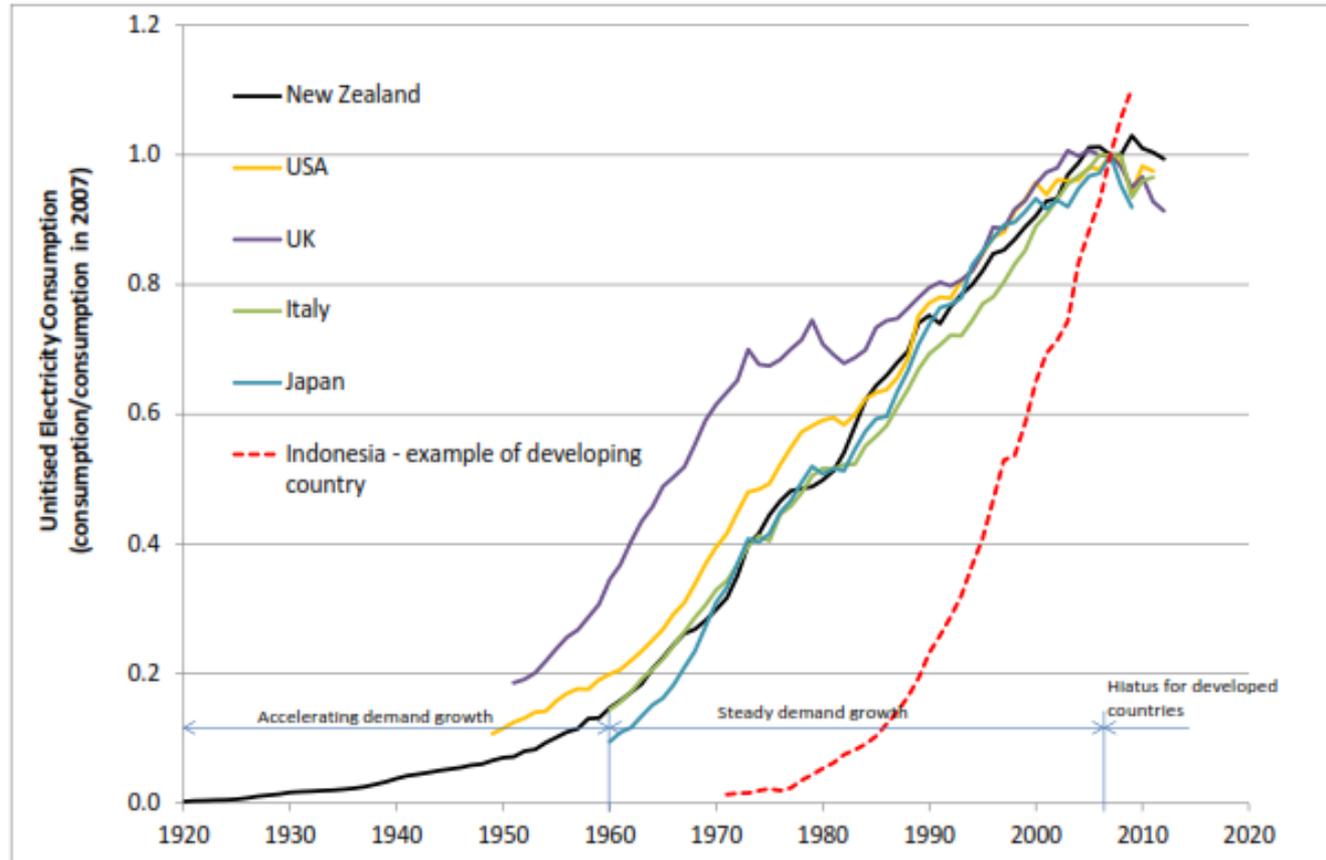
## New Zealand's electricity system



- Installed generation 9,800 MW
- Peak demand 6,750 MW
- Total energy supply 43,000 GWh/yr
- Connected by 700 MW HVDC link
- Power mainly transferred northwards from southern hydro systems
- Large thermal plant in north island aids peak demand and dry years

# THE START OF THE JOURNEY

- Like many countries in the late 1940s New Zealand saw a steady growth in electricity demand
- Satisfied by hydro in pre war days, new and secure alternative sources were needed as concerns grew over the supply of fossil fuels



# STRONG SCIENCE, A WILLINGNESS TO EXPERIMENT & EXPLORE - EARLY SUCCESS



Power from beneath  
the earth harnessed  
for electricity  
production

# WAIRAKEI – A WORLD FIRST AND THE CORNERSTONE OF THE NZ GEOTHERMAL INDUSTRY



A reliable source of some 1200 GWh for 60 years and still delivering.....



# KAWERAU – LARGEST INDUSTRIAL USE OF GEOTHERMAL

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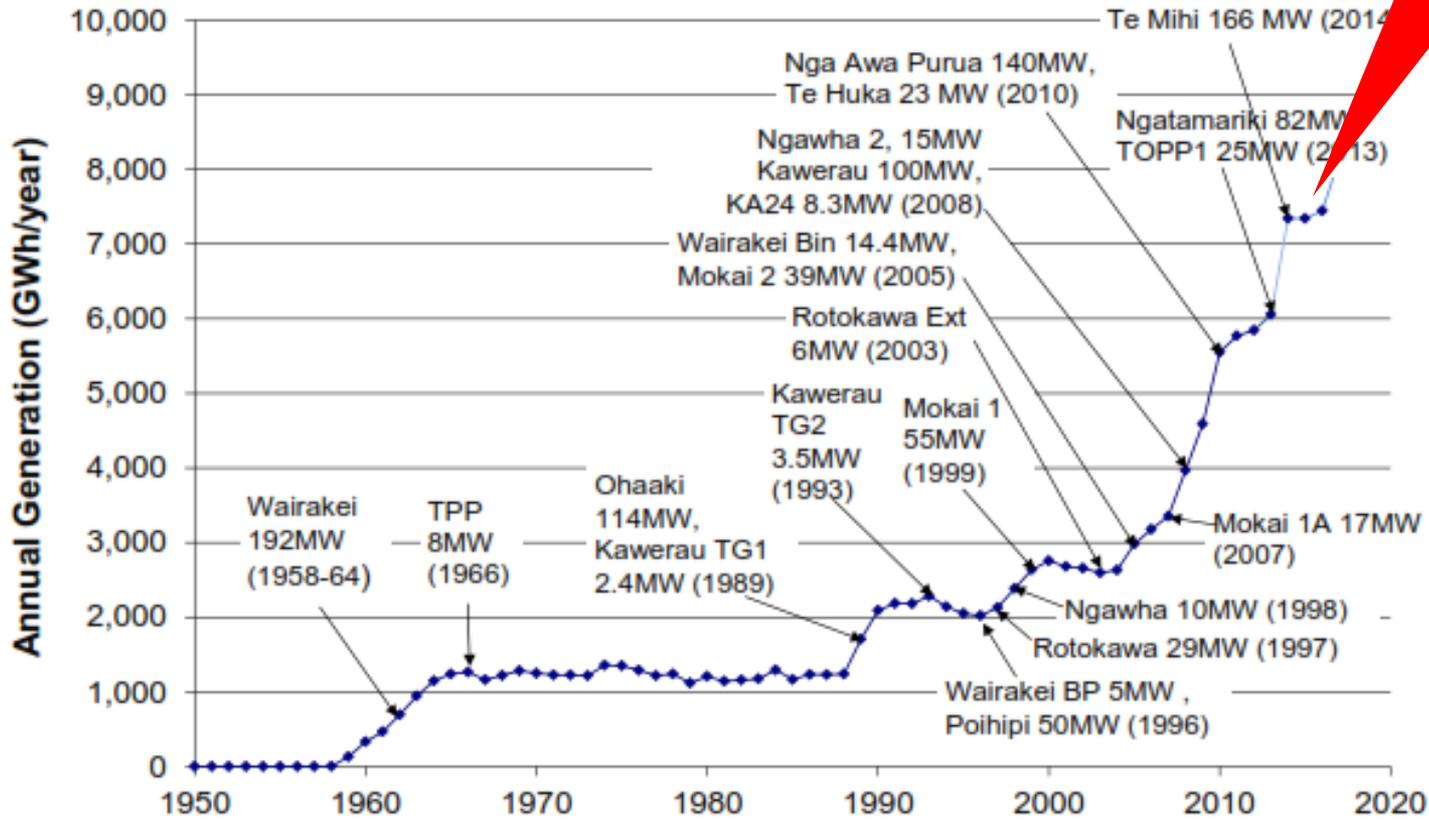
- Early commercial (private sector) opportunities identified for the use of geothermal for both process heat and electricity within the pulp and paper industry
- Progressively increasing level of captive power generation for paper and forestry processing;



# A LONG TERM GEOTHERMAL STRATEGY

## Over sixty years of development

980 MW &  
7,500 GWhr



# RECENT PLANT ADDITIONS > \$2B INVESTED



Nga Awa Puru 140MW



Ngatamariki 82MW



Te Mihi 166MW

# INTEGRATED USE OF GEOTHERMAL RESOURCES



Miraka Dairy  
Factory

Glasshouses  
5.5 Ha

100 MW  
Binary Plant

"We will act as a beacon of hope and prosperity for our people"  
Tuaropaki Trust, owners and developers of the Mokai resource

# TE AHI O MAUI – 25 MW ADDITION 2018

— A partnership between Eastland Generation Ltd and Kawerau A8D Ahu Whenua Trust.





# **Silica Extraction from Geothermal Waste**

***Marketable Si, additional power generation  
through enhanced heat recovery, simpler  
reinjection***

- The GEOHEAT Strategy seeks to unlock untapped potential, capitalising on interest in renewable geothermal energy, assisting to coordinate efforts and resources of industry and government, to drive increased interest and direct geothermal utilisation.
- Implementing the GEOHEAT Strategy will assist in meeting New Zealand's energy needs and strategic energy targets, contribute to economic and social development, and further New Zealand's commitment to increased renewable and clean energy use.



## **GEOHEAT STRATEGY FOR AOTEAROA NZ**

**2017-2030**

# KEY FEATURES OF SUCCESS

- Government funded early exploration including exploratory drilling
  - Wairakei and a number of subsequent plants built by state electricity corporation
  - More recent projects have been “brownfield” using existing information collected by government activities
  - Geothermal is treated like water – rates of withdrawal and reinjection defined
  - Development rights are controlled through land ownership
  - Resource consent processes well established
  - Geothermal commercially attractive within available energy mix
- Utilities have invested some \$2 billion over last 10 years in new plant so that geothermal now supplies almost 20% of New Zealand’s electricity:

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# INTERNATIONAL ACTIVITIES



# IN INDONESIA FOR OVER 40 YEARS



- Kamojang first plant 30 MW
- New Zealand funded; led by GENZL; team effort
- 30 years of operation
- 200MW and expanding



- Kiwi's involved in first 1,000 MW
- Indonesia looking to 4,000 MW+
- 30,000 MW potential?
- Continue as key service providers

# INDONESIA – BILATERAL AID CONTINUES

- *Providing training support from surface exploration through to construction and commissioning – early parallel programme in Philippines also continues*
- Involved since 1970's with bilateral support to Kamojang - commissioned in 1982
- Providing advice at Ministry level on improving quality of field data collection, storage and dissemination
- Assisting in development of concession tendering and evaluation
- Training at all levels within technical institutes, universities, state companies and IPPs
- Running drilling engineering workshops in country; project management courses in NZ.



# PHILIPPINES A KEY EARLY FOCUS



- 1976 – bilateral government agreement
- Early exploration at Leyte and Palimpinon
- New Zealand supplied rig
- Undertook early drilling
- Extensive involvement through KRTA
- 2<sup>nd</sup> largest geothermal production globally 1800 MW
- Plants privatised
- Modest future new potential
- *Continuing activities, new and upgrades*

# KENYA THEN AND NOW..



- GENZL took up UNDP 45 MW Olkaria project in 1978
- Involved in field extensions - 200 MW
- Now adding some 1,000 MW
- Possible 5,000 MW
- New fields
- NZ consultancies and contractors playing key roles
- ***Growing roles as contractors in EPC activities***

# ETHIOPIA



- Development of Aluto – Langano under UNDP
- 7 MW first and only geothermal plant – 30 MW expansion now



- Considerable potential
- Hydro dominates but low annual rainfall limits production
- *Significant new projects underway*

# EAST AFRICA REGIONAL BILATERAL ACTIVITIES

- Full surface exploration on Comoros with GRMF support.
- Working with Govt of Comoros to secure exploration drilling funding
- Establishing New Zealand-Africa Geothermal Facility in partnership with the African Union Commission. This is a 5 year programme with a total \$10m commitment.
- Already provided New Zealand Drilling Code of Practice as basis for drilling operations in East Africa.



# CARIBBEAN BILATERAL ACTIVITIES

- Full surface exploration on Grenada and St Lucia
- Working with Dominica to develop first small generation facility
- Assisting CDB with GEOSmart financing facility
- Providing peer review and technical input to St Kitts/Nevis, and St Vincent
- Offers considerable potential for island nations totally dependent on diesel generation



# COMMERCIAL ACTIVITIES IN OTHER MARKETS .....

Kamchatka, Greece

Poland, Iran, Colombia

**Armenia**, Turkey, Djibouti

**Iceland**, Japan

El Salvador, Fiji, Chile

Vanuatu, Papua New Guinea

**Nicaragua**, Mexico

Azores, **Comoros**, Rwanda

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# THE GEOTHERMAL INSTITUTE IN AUCKLAND

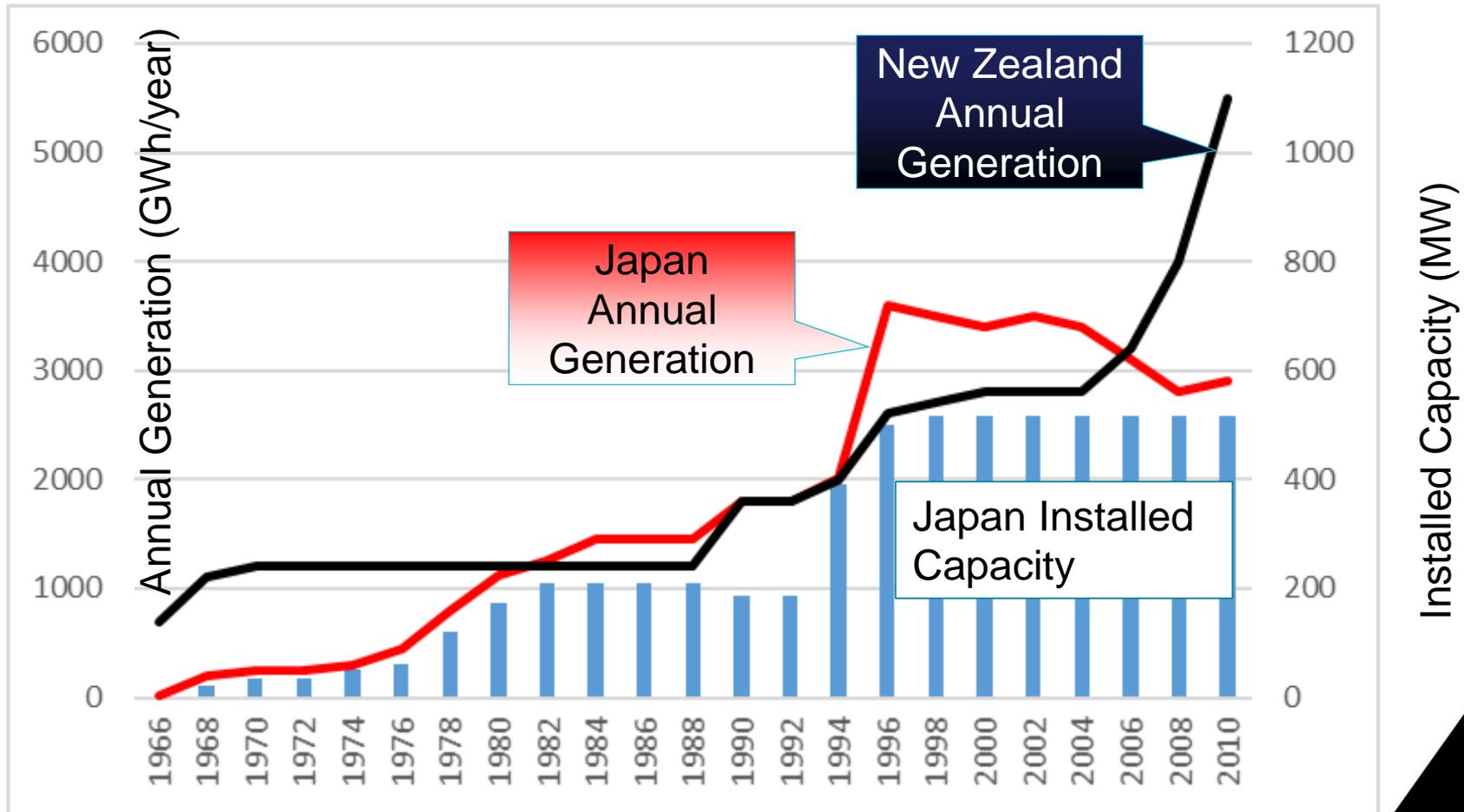


- One of our proudest achievements – ongoing scholarships
- Trained over 1,500 scientists and engineers
- A real opportunity to share international experiences

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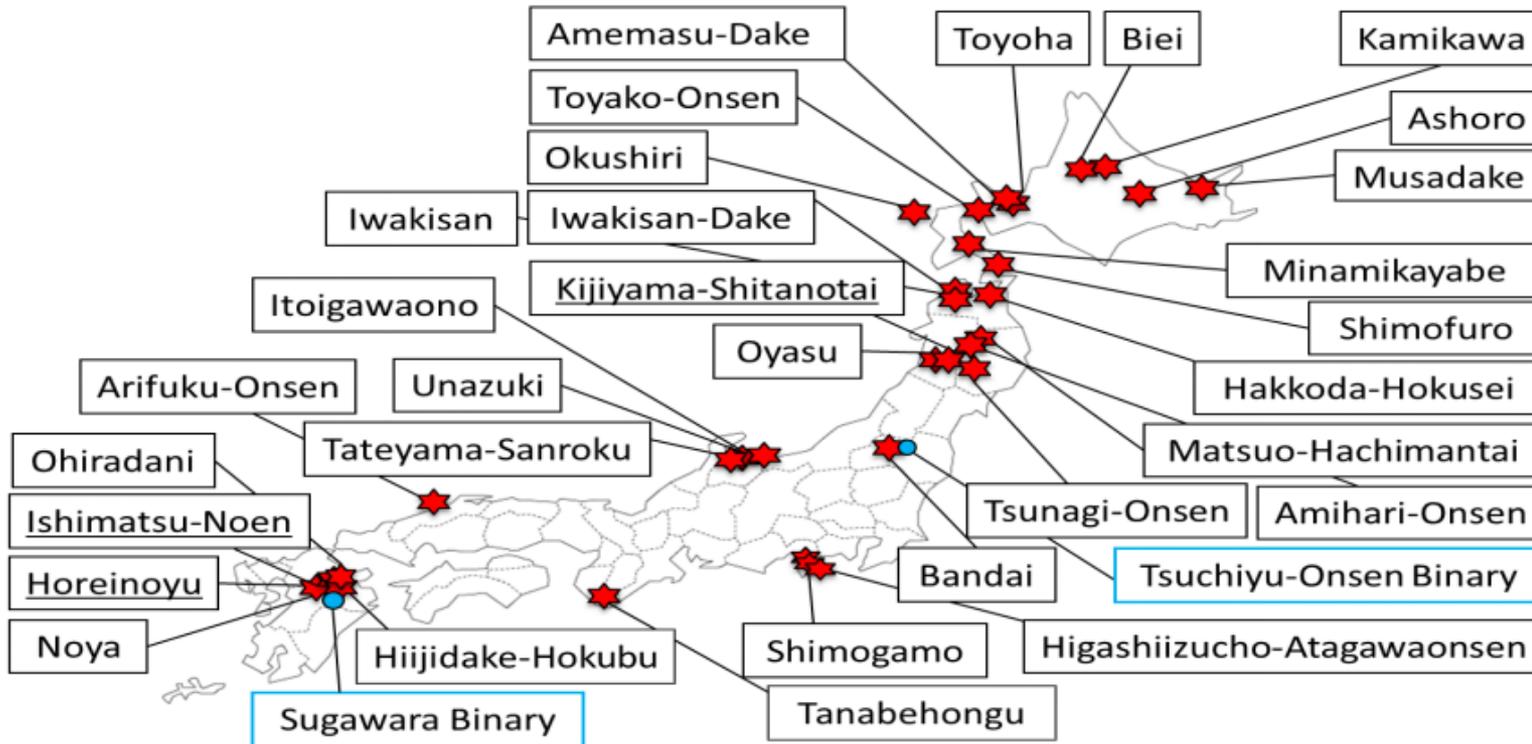
# JAPAN – A CASE STUDY

# NEW ZEALAND - JAPAN GEOTHERMAL COMPARISON



# GOVERNMENT SUBSIDY FOR GEOTHERMAL SURVEY

- 23 projects were subsidized in FY2014 and closer to 30 in FY2015.
- JPY 9 Billion (NZ\$ 108 Million) for the government subsidy in FY2015.



# FEED IN TARIFFS

## Japan's Feed-In-Tariff



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- Japanese government initiated Japan's Feed-In-Tariff(FIT) in 2012 to accelerate the introduction of renewable energy.

As of 2017

Energy source	Solar PV			Wind power		Geothermal power		Small and medium-scale hydraulic power			
	More than 2,000kW	10kW or more but less than 2,000kW	Less than 10kW	20kW or more	Less than 20kW	15,000kW or more	Less than 15,000kW	5,000kW or more but less than 30,000kW	1,000kW or more but less than 5,000kW	200kW or more but less than 1,000kW	Less than 200kW
Procurement price (yen/kWh)				55		26	40	12~20	15~27	21~29	25~34
Procurement period (years)						15	15	20	20	20	20

**Geothermal tariffs between 25 and 50c/kWh**

# JAPAN

## Outlines of Financial Assistance



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Potential Survey	Exploration	EIA	Development	Operation
<ul style="list-style-type: none"> <li>- Geological Survey</li> <li>- Geophysical Exploration</li> <li>- Structural Boring</li> </ul> 	<ul style="list-style-type: none"> <li>- Drilling of Investigation Well</li> <li>- Discharge Test</li> </ul> 	<ul style="list-style-type: none"> <li>- Environmental Impact Assessment</li> </ul> 	<ul style="list-style-type: none"> <li>- Drilling of Production Well &amp; Reinjection Well</li> <li>- Construction, Start-up &amp; Commissioning of Power Plant</li> </ul> 	<ul style="list-style-type: none"> <li>- Commercial Operation</li> </ul> <p>Hatchobaru (Oita Pref.)</p> 

Resource Risk

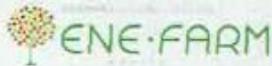
## Financial Assistance provided by JOGMEC

Subsidy	Equity Capital	Liability Guarantees
<ul style="list-style-type: none"> <li>- Up to 50%~100%* of necessary funds (* depends on terms and conditions)</li> </ul>	<ul style="list-style-type: none"> <li>- Up to 50% of equity capital (JOGMEC is not allowed to be the largest shareholder.)</li> </ul>	<ul style="list-style-type: none"> <li>- Up to 80% of loan provided by financial institutions</li> </ul>

# HYDROGEN ECONOMY – OPPORTUNITIES FOR NZ?

## Residential Fuel Cells

Marketed in 2009...



200,000 units (MAR, 2017)

## Targets

- 1.4 million units by FY2020
- PEFC : 800,000 yen  
(approx. \$7,000) by FY2019
- SOFC : 1,000,000 yen  
(approx. \$8,700) by FY2021

## FCV & HRS



1,800 FCVs

\*End of Mar 2017

90 Stations\*

(8 in process)

\*End of Apr 2017



## Targets

### FCV

- 40,000 by FY2020
- 200,000 by FY2025
- 800,000 by FY2030

### HRS

- 160 by FY2020
- 320 by FY2025

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LOOKING MORE AGGRESSIVELY OVERSEAS



# NEW CHALLENGES, DIFFERENT MODELS



- Mighty River Power (Mercury) undertook greenfield development in Tolquaca, Chile

Mighty River Power (Mercury) invested in USA plant – 49.9 MW John Featherston – Imperial Valley, California



# BUILDING CAPACITY INTERNATIONALLY

Recognise critical areas of capabilities;

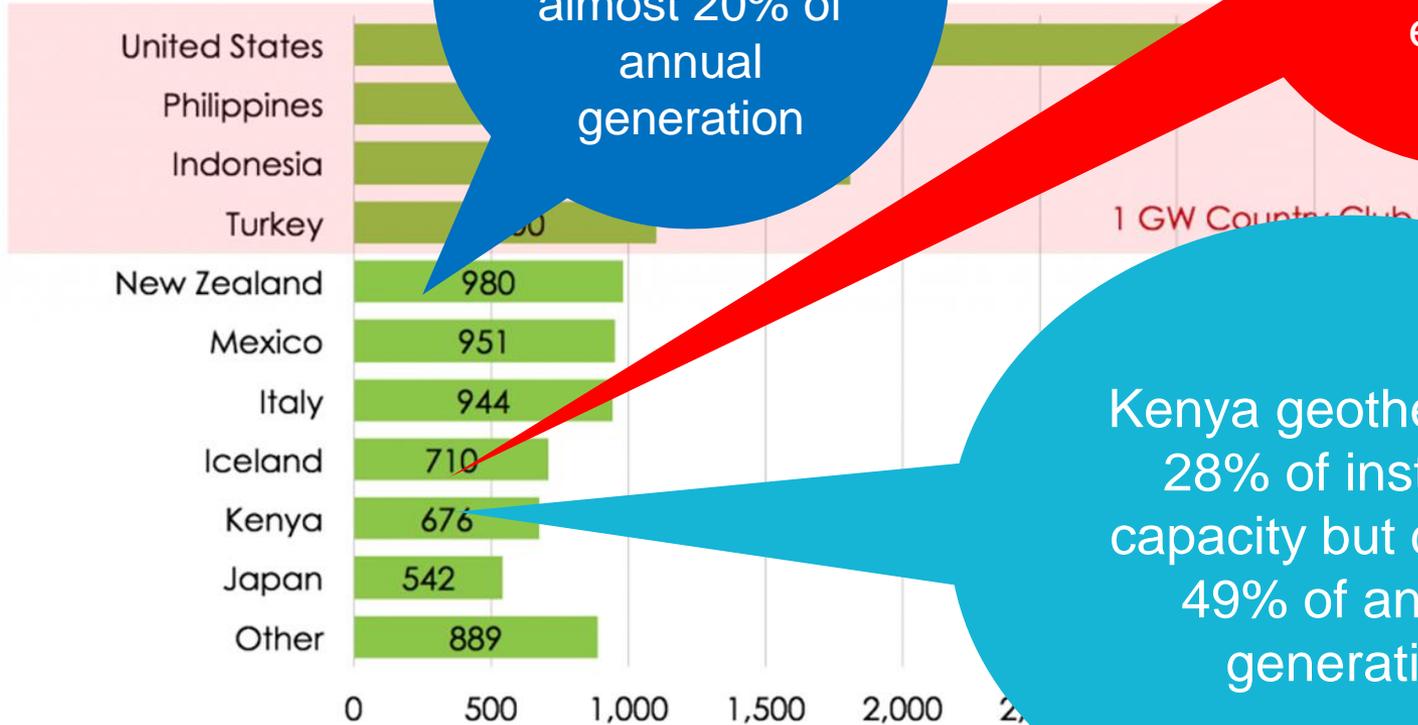
- No substitute for the highest quality surface exploration and resource estimates
- Public offers of concessions must be based on best quality, reliable data
- Public sector playing renewed role in confirming resources – accepting early stage risk
- Reservoir modelling and engineering critical from exploration, through development and on into long term operations and field management
- Drilling is expensive – design and implementation must be appropriate and competently managed
- Power plant design and engineering relatively well established – EPC driven by funders
- Effective operations and management of reservoirs critical to ensure returns and longevity of resources
- National educational support at technical college, undergraduate and graduate levels to meet growing demand for qualified staff.

# WE HAVE THE TECHNICAL SKILLS

Phase of Work						Drilling			Design			Construction					IPP
	International Operations	R&D	Educate & Train	Earth Sciences	Project Mgmt	Drilling Mgmt	Rig Services	Well Services	Reservoir Engr / Software	F/S	S/F Design	Plant Design	Fabricator	Precision Engineer	EPC	O&M	
Company																	
Advanced Boilers																	
ARANZ GEO	✓	✗															
AECOM New Zealand Limited	✓																
Allied Industrial Engineering Ltd (AIE)																	
AMTEC Engineering																	
Beca	✓																
Callaghan Innovation		✗															
Cheal Consultants Limited	✓																
Contact Energy	✓																
Eastland Generation																	
Environmental Mgmt Services (EMS)	✓																
Fitzroy Engineering Limited	✓																
Gallagher	✓	✗															
Geothermal Consultants NZ (GCNZ)	✓																
Geothermal Energy Solutions(GES)	✓																
Geothermal Institute, Uni of Auckland	✓	✗															
GNS Science	✓																
Heavy Engineering Research (HERA)		✗															
Inst of Earth Sciences & Engr (IESE)	✓	✗															
Jacobs	✓																
Kawerau Engineering Limited																	
Mace Engineering Limited	✓																
Maskell Productions	✓																
MB Century	✓																
Mechanical Technology Limited (MTL)	✓																
Mercury Energy (Mighty River Power)	✓																
Ngati Tuwharetoa Geo Assets (NTGA)																	
Page Macrae Engineering	✓																
Plant & Platform Consultants																	
Progen Limited	✓																
RCR Energy	✓																
Switchfloat	✓																
Tauhara North No2 Trust																	
Thorndon Cook	✓																
University of Canterbury		✗															
Waikato Institute of Tech (WINTERC)	✓																
Western Energy Services	✓																

# GLOBAL GEOTHERMAL CAPACITY

TOP 10 GEOTHERMAL COUNTRIES WITH  
INSTALLED CAPACITY - MW IN TOTAL



NZ -10% of our installed capacity – almost 20% of annual generation

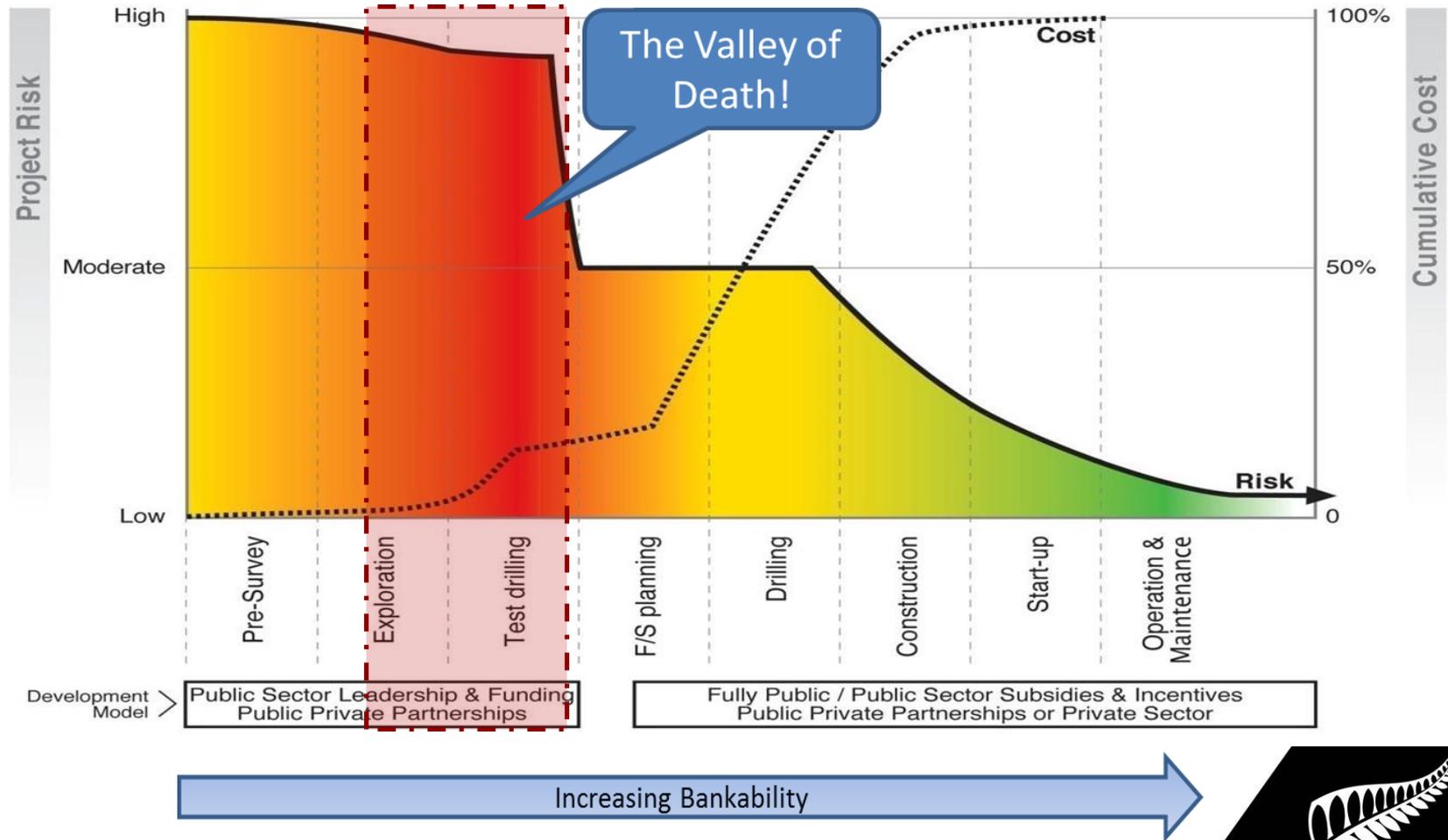
Iceland -26% of electricity but nearly 80% of primary energy

Kenya geothermal is 28% of installed capacity but delivers 49% of annual generation

Source: TGE Research (2017), GEA (2016), IGA (2015), JESDER (2017) Enerji Atlası (2017)



# MOVING INTO GREENFIELDS



# RISKS

- Risks are not just those that are “geothermal”
  - Resource risk
  - Reinjection performance

*but equally important*
- Those we can influence:
  - Construction Risks – an EPC approach
  - Financial risks – appropriate financial structuring
  - Market risks – security of off take agreement
  - Management risk – choose the very best
- Those we may have less control over
  - Country and political risk – some insurance possible

# WHAT'S NEEDED FOR NEW PROJECTS

- Equity for the early phases
  - Need a strong corporate balance sheet or
  - Need investors who will take appropriate risks
  - Need project returns that meet these investors needs
  - Risks are economic, financial and political
  - *This balance is never easy*
- Debt for those stages once risk is reduced
  - Resource capacity and performance defined
  - PPA in place
  - EPC committed
  - *Likely that a syndication of banks may still be required*

# MARKET RESPONSE

- There is a key challenge in all markets to finance the exploration / exploratory drilling phase
- Donor / grant funding has played a key role in opening opportunities in the past
- Emerging market support is attempting to address this financing
- Debt is available but banks still see geothermal as high risk influencing the cost / tenor of debt and a need for syndication
- Private sector interests exist but few specialised facilities have been established; corporates with strong balance sheet entering market
- To attract investment the risk reward profile must be appropriate; we compete with all other investment opportunities in the energy markets, many of which are much better understood and seen as less risky.

# GEOHERMAL NEW ZEALAND INC.

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- A collaboration amongst leading consultants, service providers, contractors and construction companies
- Seeking international opportunities over and above our traditional consulting support and training activities
- Indonesia, Kenya, Ethiopia, Philippines are key target markets.
- Potential opportunities in Japan post Fukushima
- Strong partnerships with international companies – manufacturers and EPC contractors
- We still lack investment partners





**THANK YOU**

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