Business Models for Successful Geothermal Electricity Development

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Geothermal Generation Status

- First generation: over 100 years ago
- First large scale generation: over 50 years ago
  - It is a mature technology,
- Current Worldwide capacity: 11,300 MWe (net)
- Current growth rate: ~ 3%
- Largest projects restricted to highest temperature resources therefore only in certain geology/geography, but:
  - New technology is evolving especially at the low temperature end of the market
  - As energy prices rise, an increasing number of projects become economic so the resource base and geographical coverage increase
- Direct use of geothermal heat is also significant but not considered here

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Geothermal Environmental Impacts

- Generally benign: some industry specific issues e.g. subsidence, but manageable
- Minor GHG emissions, but much less than fossil fuels/MWe
- Lower land use/MWe than hydro or coal mining
- Greatest impact in tropical developing countries may be secondary, through providing access to remote/forested areas

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Geothermal General Characteristics

- Well suited to base-load: capacity factors >95%, but can also load-follow to some extent
- Large geothermal resources which can be utilised with “conventional” technology rarely exceed 400 MWe
- Significant economies of scale so projects <20 MWe only economic if displacing high-priced alternatives
- Power prices are site specific and there is limited capacity for export
- Economics strongly dependent on resource quality
- In *some* cases (e.g. New Zealand), geothermal can directly compete on price with other electricity sources without incentives or subsidies

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Geothermal Financial Characteristics

- High CAPEX and low OPEX compared to many sources except e.g. hydro
- Drilling may be up to 50% of total project cost
- Exploration and delineation drilling comprise significant **resource risk**:
  - At the exploration stage (say first 3 wells) that the whole project may not be feasible as planned
  - At the delineation stage, that the project may be smaller or take longer and/or be more costly than planned.
- Requires substantial investment in drilling before commercial financial closure is possible
  - Exploration cost independent of project size
- Requires at least 5 -8 years investment before any revenue

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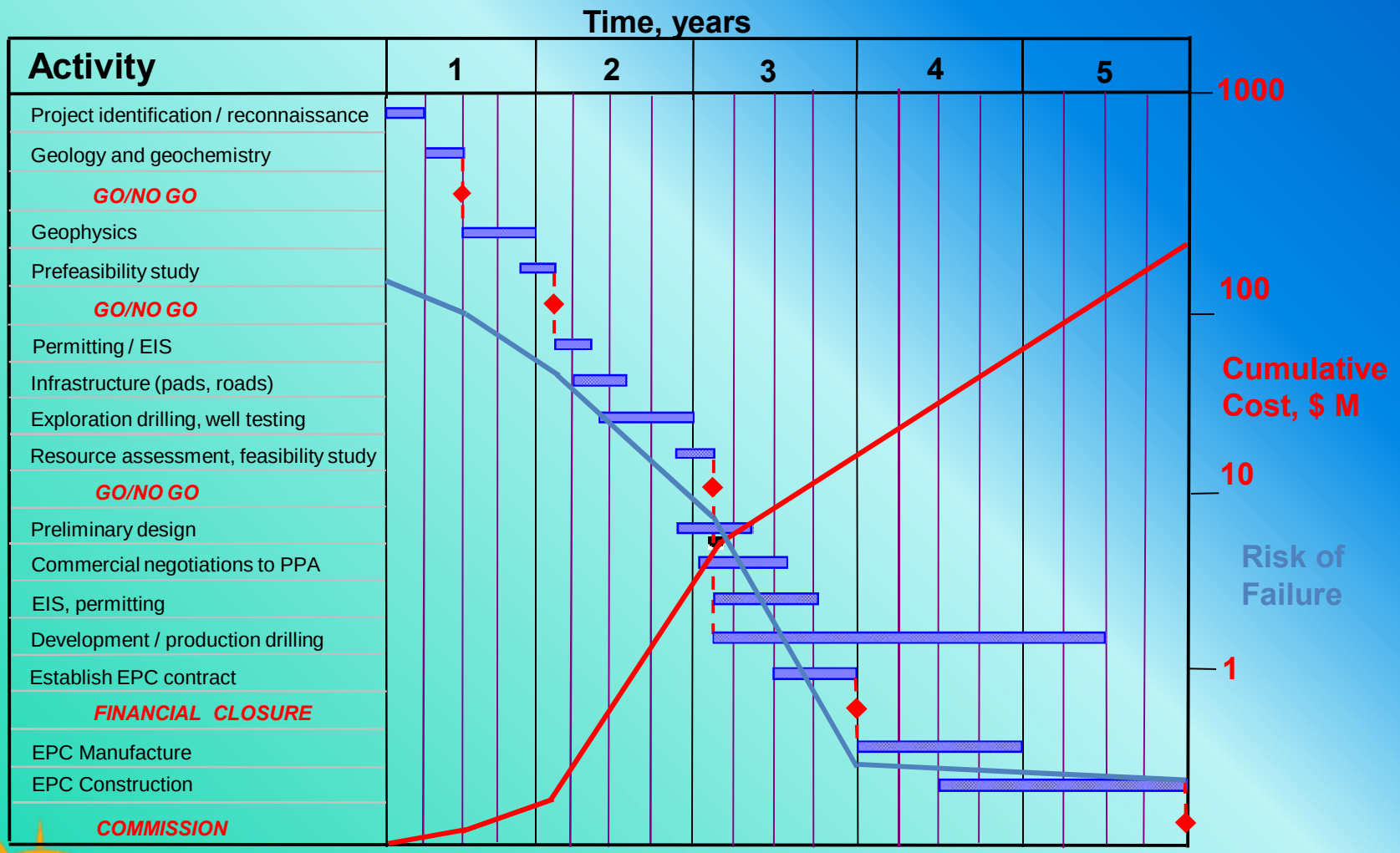
Cost and risk: Fast Track Scenario



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Geothermal Financial Characteristics: The Fundamental Problem

- The ***risk*** (and therefore upfront cost profile) of geothermal projects resembles oil and gas projects
  - But a barrel of hot water is worth $0.50, not $100!
- The ***returns*** on a geothermal project resemble utility projects
  - And both utility companies and banks are risk averse
- Perversely, rising oil prices *increase* the up-front cost of geothermal projects because of competition for human resources, drilling rigs and materials
  - In recent years drilling costs have increased relative to general inflation

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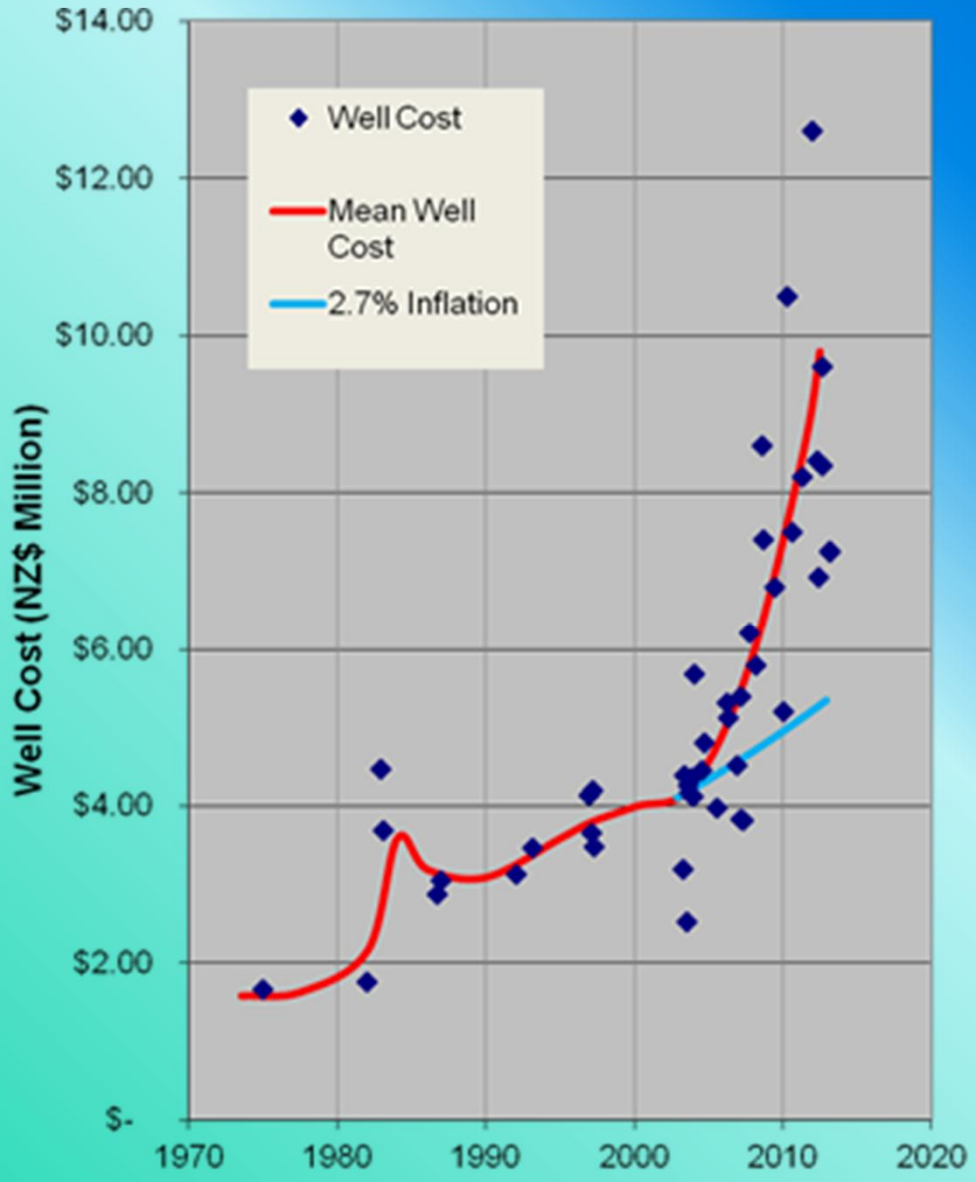
Geothermal Drilling Costs

(from Hole 2013)



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Leading Geothermal Countries

Country	Installed Capacity MWe	Number of Projects> 40 MWe	Largest Project MW	Proportion of Resources developed
USA (including Hawaii)	3129	9	1584	Medium
Philippines	1904	8	583	Large
Indonesia	1197	6	377	Small
Mexico	983	3	720	Medium
Italy	883	3	595	Medium
New Zealand	842	6	233	Medium
Iceland	675	5	313	Large
Japan	535	6	104	Small
Kenya	205	1	202	Medium
El Salvador	204	2	109	Medium
Costa Rica	200	1	165	Medium
Nicaragua	148	2	78	Medium
Turkey	99	1	47	Small
Russia	82	1	62	Small
Papua New Guinea	56	1	56	Small

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Characteristics of Leading Geothermal Countries

Country	Govt. funded research?	Govt. funded drilling?	Generators	Price incentives for renewables?	Vertically Integrated?	Electricity Market
USA	Yes	No	IPPs and utilities	Yes	Mostly	Open
Philippines	Minor	Yes in past	IPPs and SOEs	No	Some	Open
Indonesia	Minor	Minor in past	IPPs and SOEs	No	Mostly	State monopoly
Mexico	Minor	Yes by SOE	SOE	No	Yes	State monopoly
Italy	Yes	Yes in past	Mainly SOE	Yes	Yes	Open
New Zealand	Yes	Yes in past	Mostly IPPs	No	Yes	Open
Iceland	Yes	Yes in past	IPPs and utilities	No	Yes	Open

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Key Development Success Factors

- High quality resources and data thereon
- Access to expertise
- Attracting investment!
  - Ability to raise *equity* funding for drilling
  - Ability to raise *debt* funding for power plant and steamfield
  - Both of these require project de-risking as early as possible

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Key Business Factors: Price and Incentives ?

- Direct (e.g. FIT in Germany) or indirect (e.g. PURPA in USA) price support does *not* seem to be necessary for development of *high temperature* resources
- Geothermal can compete on price with other sources, when externalities are included
- But if there are other negative factors, tariff may need to increase to compensate e.g. regulatory obstacles

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Key Business Factors: Ownership

- For drilling, IPPs *may* be able to accept risk, but this will be reflected in the overall power price
- For power plant IPPs may find it easier to raise commercial finance, SOEs may find it easier to raise institutional finance – both require a bankable Feasibility Study
- Split ownership is favourable for development: government agency or SOE takes resource risk, IPP builds and operates power plant e.g. Philippines

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Key Business Factors: Bankability

- Apart from resource risk issues, projects need to be bankable through:
  - Secure tenure of concessions
    - E.g. lack of exploration licence regime a hindrance to new investment in NZ
  - Clear regulatory regime
    - E.g. complex system a hindrance in Indonesia
  - Credible PPA or other access to market – may require sovereign guarantee
    - E.g. an issue in Indonesia
  - Financially sound developer – requires access to substantial equity for first stages
    - E.g. currently a problem in USA due to depressed energy stocks

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Key Business Factors: De-risking to Accelerate Development

- At the exploration stage:
  - Good quality geoscientific data
  - Very helpful for government agencies to carry this work out and make it accessible
    - E.g. NZ, Philippines in earlier times
  - Government agencies doing exploration drilling
    - E.g. Philippines, NZ in earlier times
    - But this raises issues of later transfer of wells and environmental liability for unsuccessful wells e.g. in NZ

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Key Business Factors: De-risking to Accelerate Development

- At the delineation stage:
  - Comprehensive drilling and testing program related to the size of the proposed development and following a clear strategy
  - Resource estimation and certification under an internationally recognised Code or standard
  - Early attention to related issues such as geohazards and environmental sensitivity
  - Bankable Feasibility Studies by an internationally credible, preferably independent agency

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The Australian and Canadian Geothermal Reporting Codes

- All listed companies report resources and reserves to this code
- All companies applying for Government geothermal subsidies and grants must have a resource report completed according to the code

http://www.agea.org.au
http://www.cangea.ca/

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Key Business Factors: De-risking to Accelerate Development

- At the EPC stage:
  - Good bidding and procurement procedures
  - Comprehensive reservoir monitoring and on-going assessment

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Conclusions (1)

- Geothermal is an indigenous, environmentally benign energy source which is cost-competitive when externalities for fossil fuels are included
- Currently price support mechanisms are not needed where high temperature resources exist
- The main barriers to greater development are resource risk and the high up-front cost of drilling
- Key features in a successful business model are:

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Conclusions (2)

- De-risking through access to good exploration data
  - Greatly advantageous if that can be provided by government or multi-lateral agencies*
  - Grant or insurance funding for exploration drilling may be helpful*
- Certainty in regulatory and market aspects
- Financial credibility through resource certification *
- Appropriate assignment of risk
  - May mean splitting steam supply and generation ownership

* These aspects provide an opportunity for multilateral assistance

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