

Contribution of Geothermal Energy to Climate Change Mitigation: the IPCC Renewable Energy Report



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Paper 0225, WGC2010, April 2010, Bali

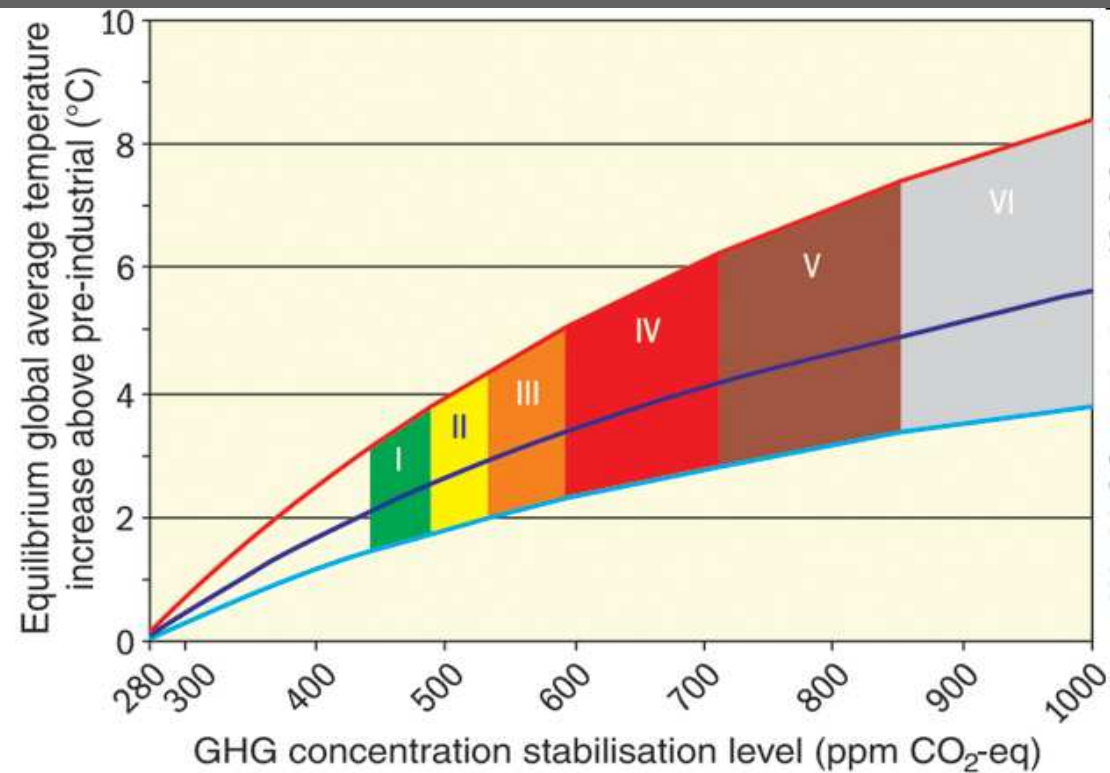
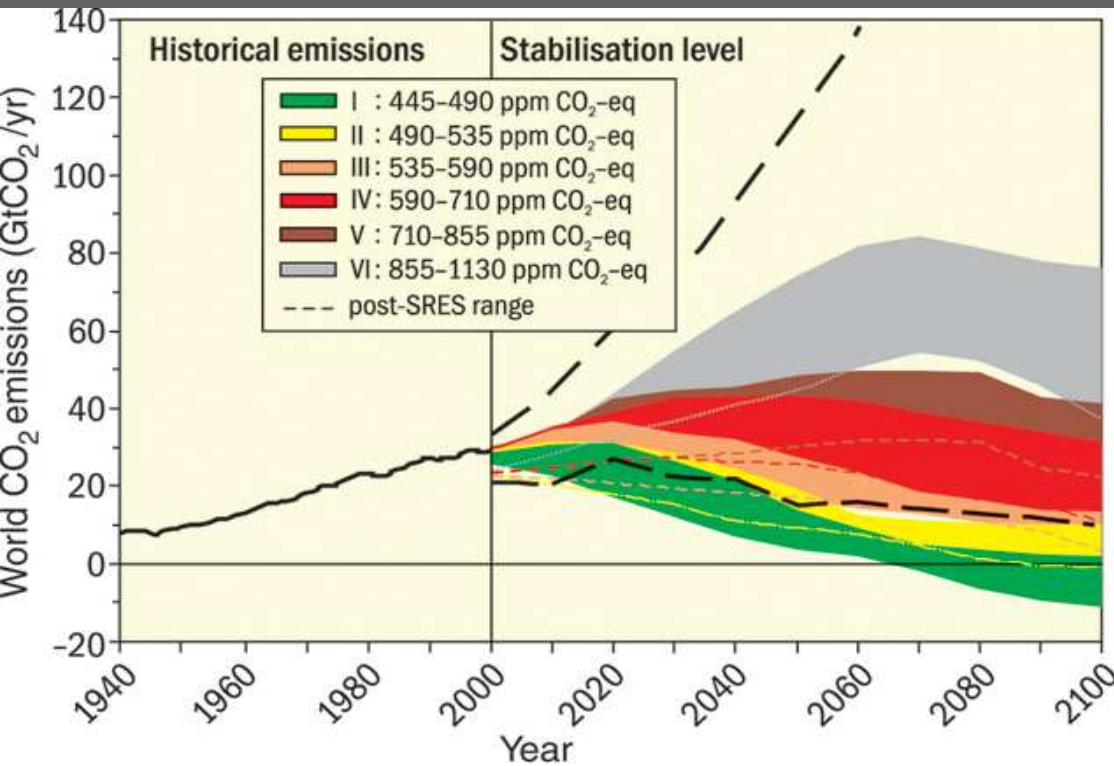


Introduction

- A Special Report on Renewable Energy was commissioned by the IPCC (Inter-Governmental Panel on Climate Change) to provide guidance on future mitigation options for climate change through reducing CO₂ emissions.
- Information is needed on potential global and regional geothermal resources (convection or conduction-dominated; in volcanic, sedimentary or crystalline rocks).
- Important issues affecting future utilization include: status of current applications, future technology advances, cost predictions, projected deployment rates, energy security and sustainability, energy integration and infrastructure requirements, environmental risks and benefits, technology transfer, and **policy options**.

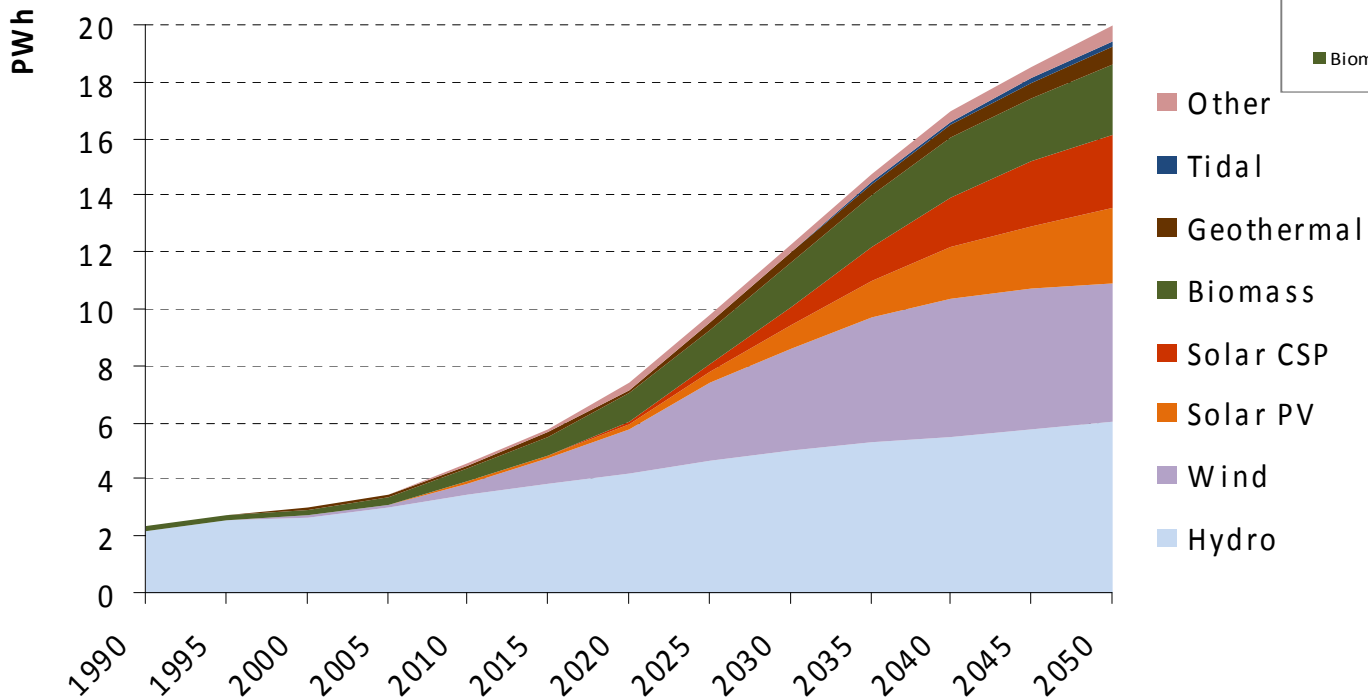
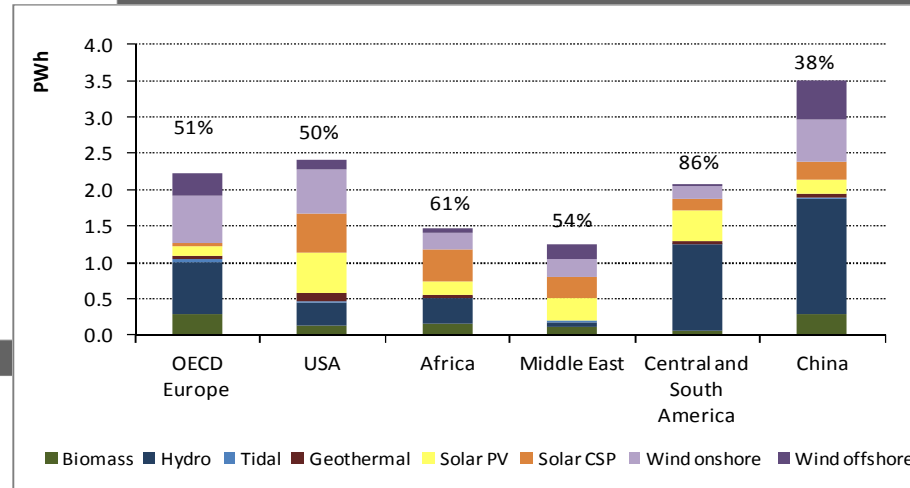
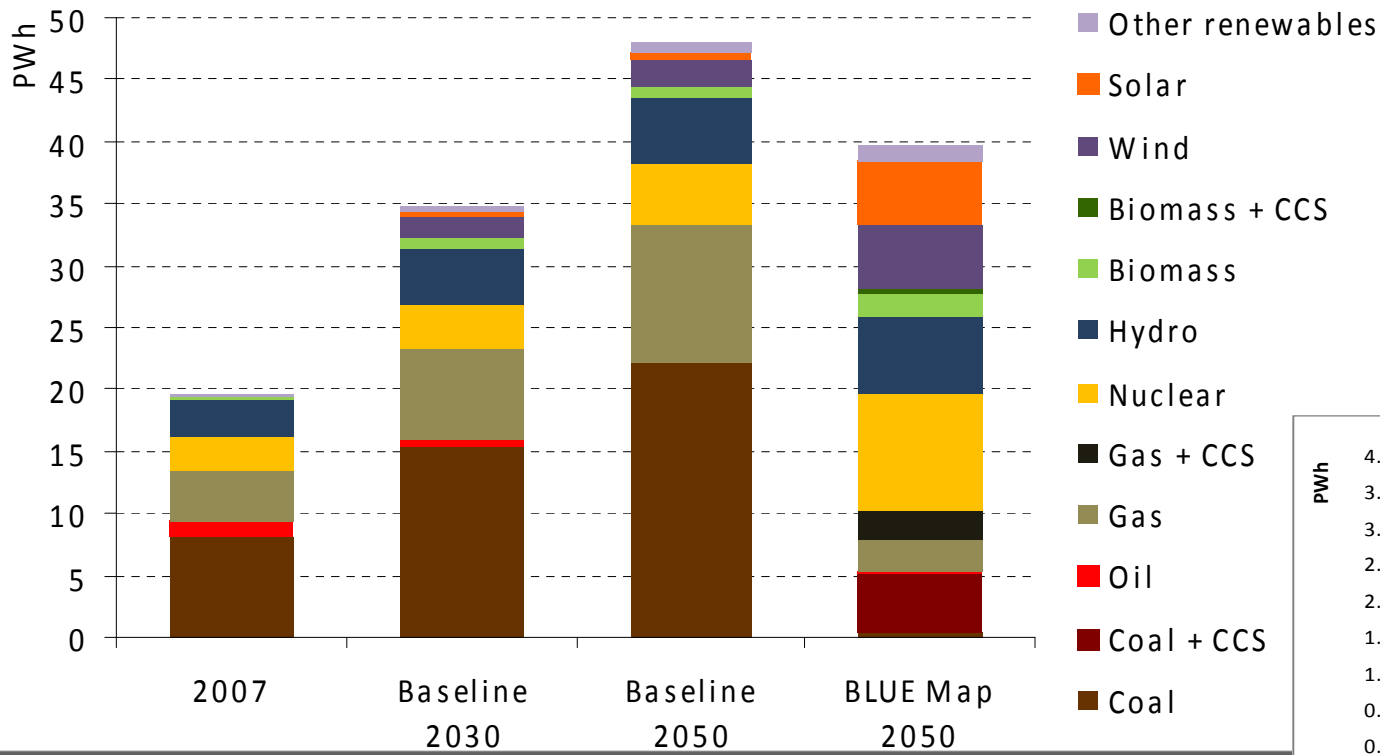


IPCC climate change predictions to 2100 : global average temperature increases versus CO₂ emissions and atmospheric stabilisation levels



What contribution can geothermal make ?

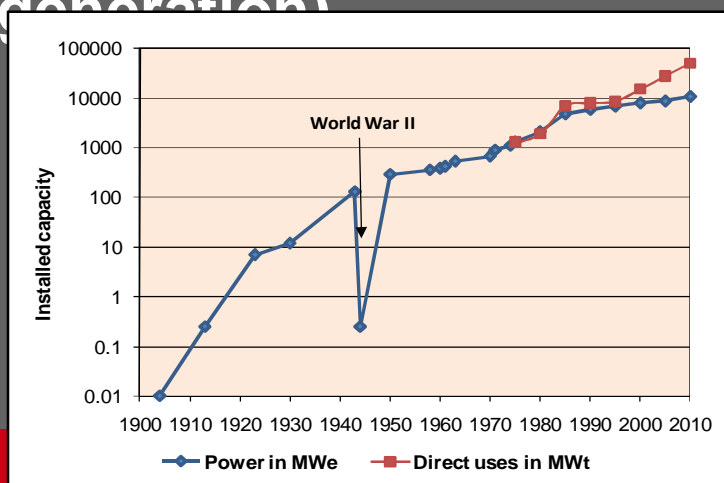
Baseline and Blue Map scenarios – for electricity



Growth of renewable power generation (PWh) in 'Blue Map' Scenario
 Geothermal capped ~0.7 PWh/yr by 2050 (2%), twice baseline value of ~0.3 PWhr (1%),
 10 times 2007 value of .062 PWhr (0.31%)

Future Geothermal Deployment : Key Messages

- Increased geothermal energy development is well suited to **climate change mitigation** because it provides base-load power and heating (or cooling) from a large energy resource that is well-distributed globally.
- Geothermal has a good track record of **sustainable** production using existing technology, is universally applicable, and generates cost-effective and highly-dispatchable power.
- Geothermally-heated fluids are available for space **heating and cooling** and a variety of other industrial applications, ranging from small-scale to district-wide installations.
- Geothermal heat pumps (**GHPs**) can be deployed worldwide, enabling substantive gains in heating and cooling efficiency of buildings.
- Relative to other renewable energy technologies, geothermal resources are utilised at high average **availability** factors (typically > 90% for electricity generation)



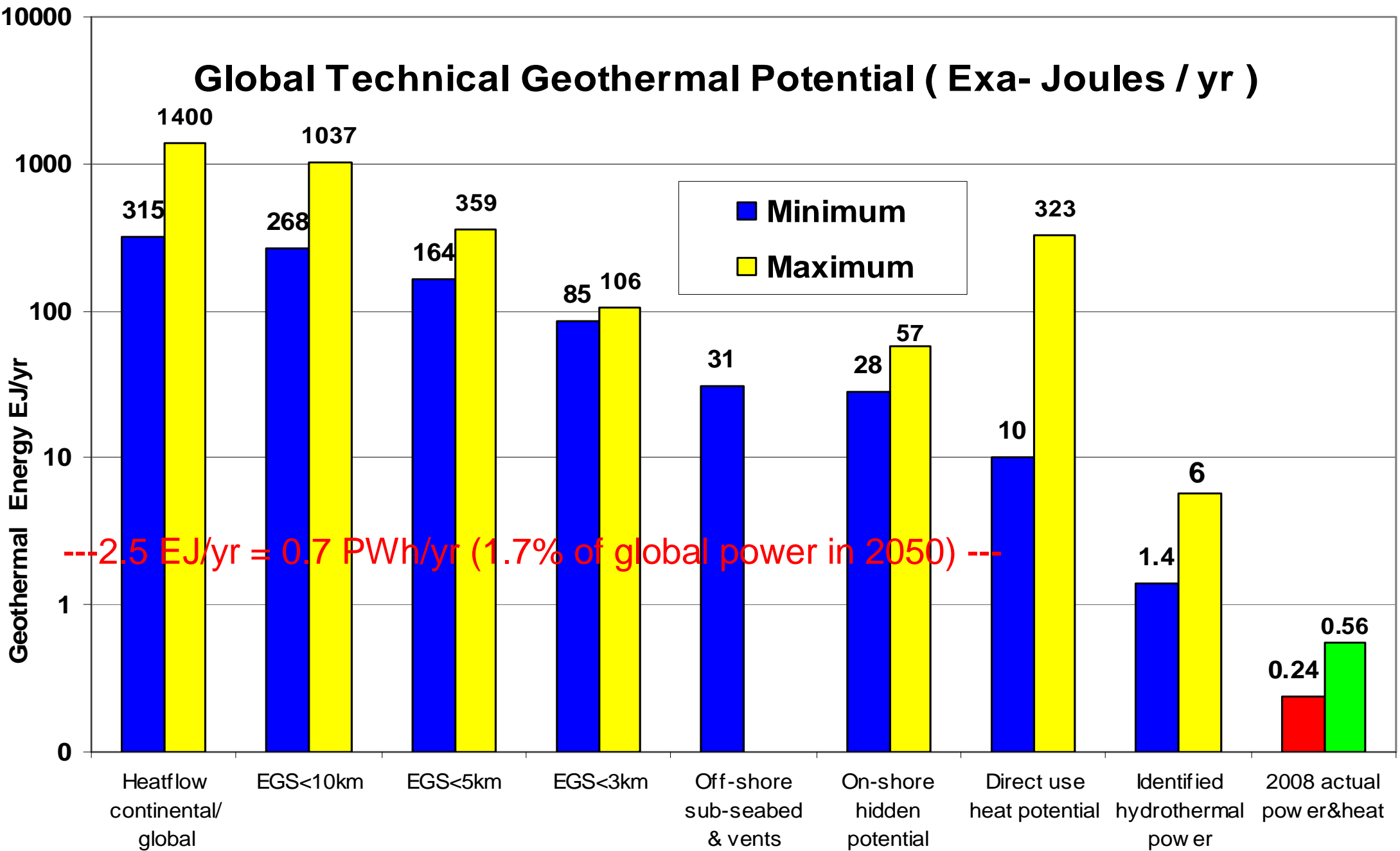
Projecting
historic to future
growth rates ?

Some Barriers and Opportunities

- Overall, geothermal is socially acceptable with some positive social and environmental impacts, including a relatively small land-use footprint.
- Adverse impacts are manageable using best practice reservoir management practices.
- Wider deployment of existing technology and application of new technologies under demonstration will significantly increase the use of geothermal resources at all temperatures.
- Future projections suggest that EGS offers great potential for global scale utilization. For this potential to be realized, research and field testing is required with government and private support. The benefits will include mitigation of climate change through provision of CO₂ offsets at competitive costs, and improved energy security.

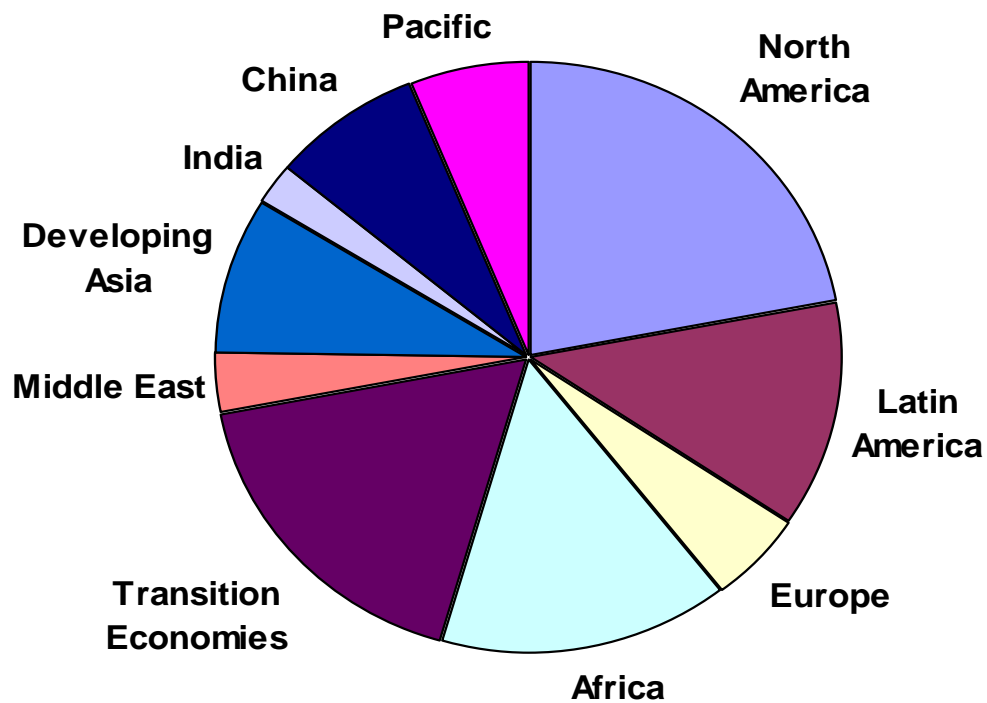
Theoretical and Technical Resource Potential

Global Technical Geothermal Potential (Exa- Joules / yr)

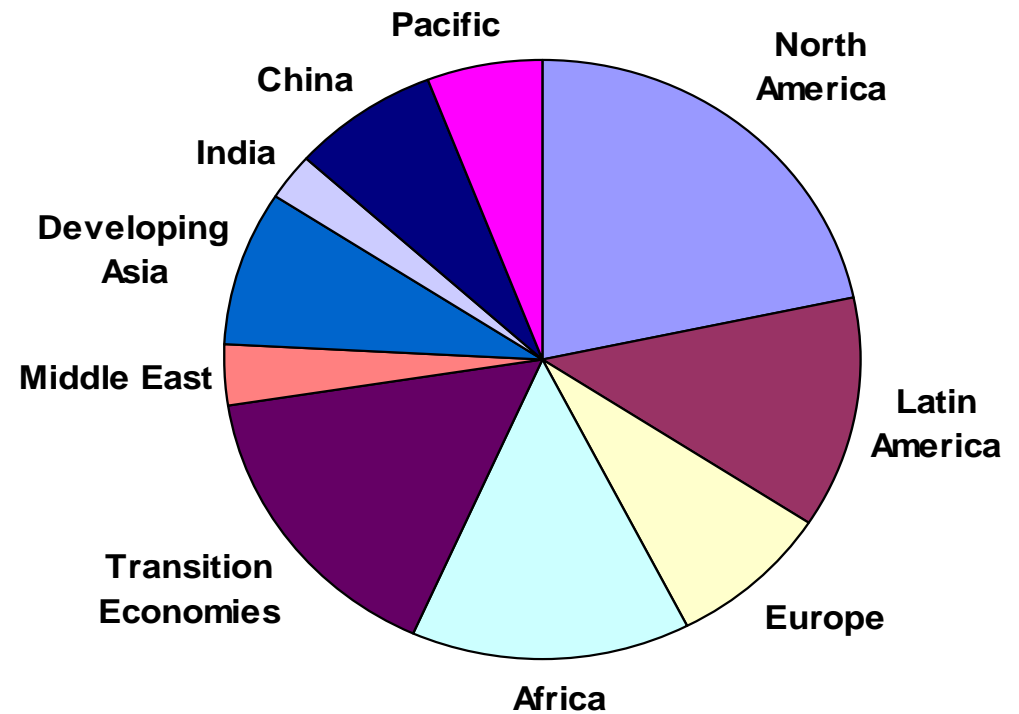


Regional Potential

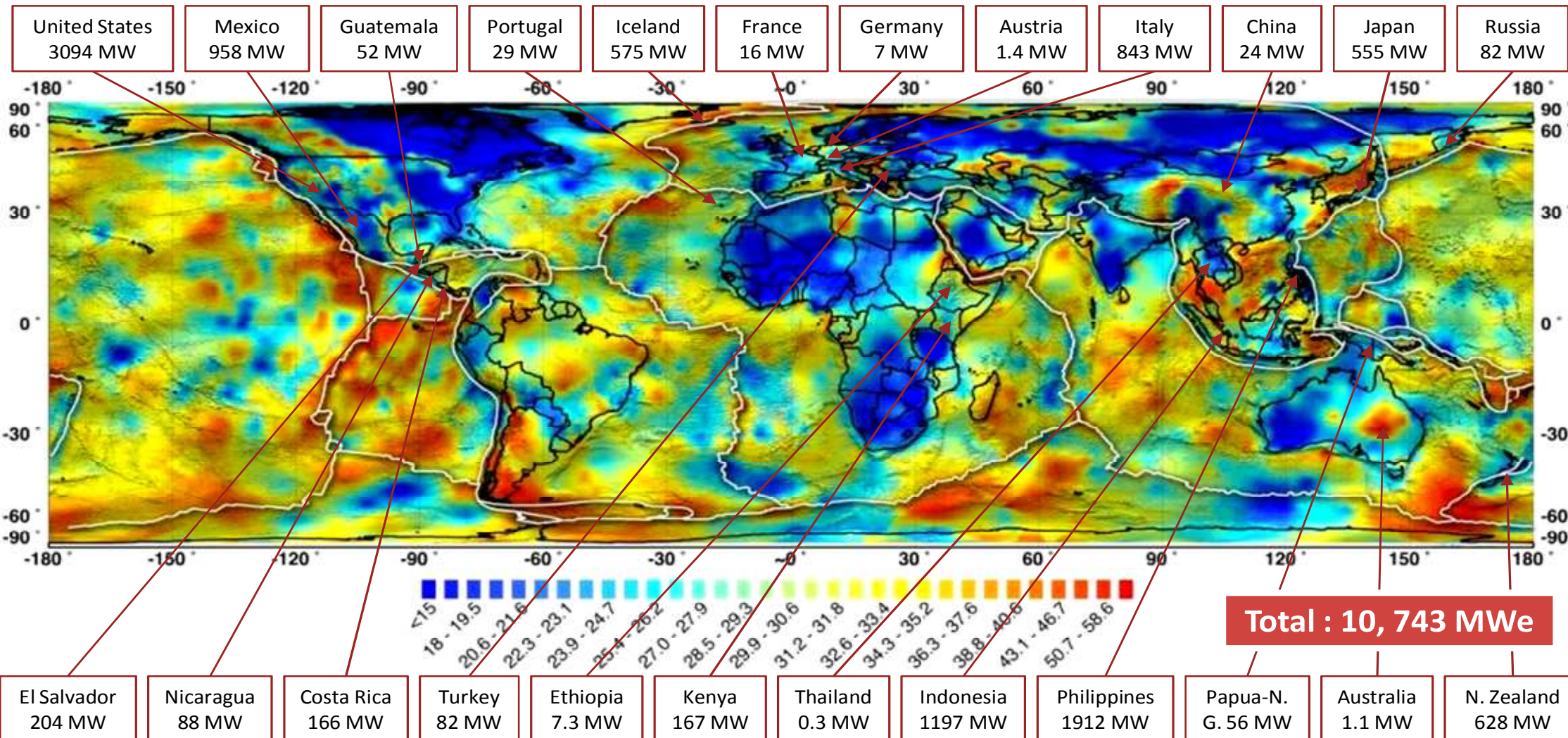
Global distribution of technical electrical geothermal potential



Global distribution of technical direct use geothermal potential



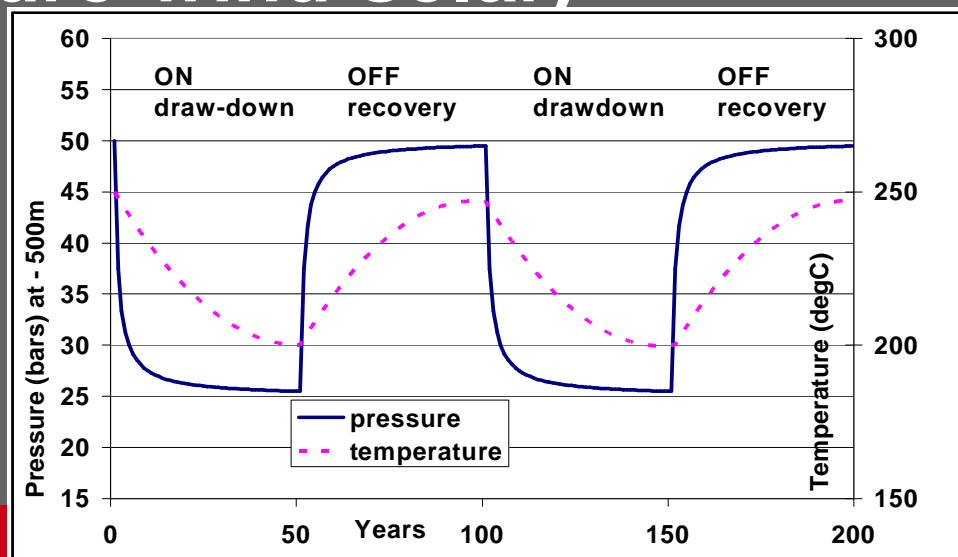
Global status



Geothermal-electric installed capacity by country in 2009. Worldwide temperature gradient in color ($^{\circ}\text{C}/\text{km}$) and tectonic plate boundaries

Sustainability - impact of climate change

- Energy extraction induces pressure/temperature drawdown which increases recharge rates
- Cyclic and rotational operation strategy helps recovery and long-term sustainable operation
- Optimum injection/production strategy sustains reservoir fluids & prevents premature cooling
- Climate change will have negligible effect on geothermal resource utilisation (compared to hydro-wind-solar)



Environmental and social factors

- CO₂, H₂S, life-cycle emissions, pollution reduction
- Land use, footprint, park access
- Water use: streams & groundwater protection
- Hazards: induced seismicity, subsidence, hydrothermal eruptions
- Natural feature preservation
- Local community welfare & participation, access to energy, job creation
- Conflicts with established users (hot spring spa)
- Tourism integration (Blue Lagoon, Wairakei thermal Prawn Park & Terraces)

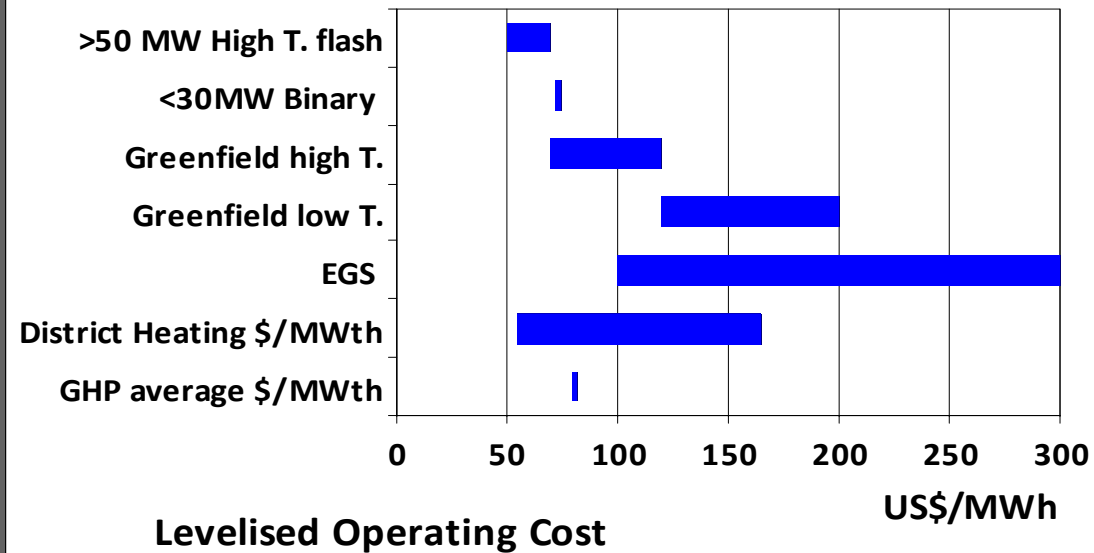
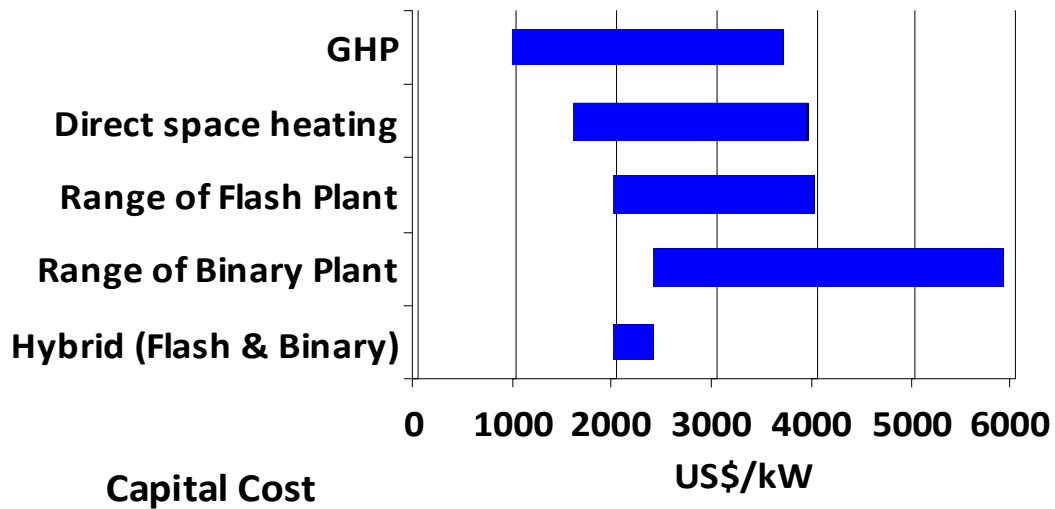


Advanced technology improvements – research tasks

- EGS- fracture stimulation; flow enhancement
- Reduce subsurface exploration risk and hazards
- Drilling cost reduction: improved performance; reduced mud damage; better down-hole tools.
- Reservoir management/ simulation : injection strategy; sustainability; minimize drawdown.
- GHP : improve COP; reduce installation cost
- Efficiency improvements; combined heat and power; cascaded utilisation; modular lower temperature binary plants.
- Water usage, mineral recovery, material improvement for corrosive & super-critical fluids, off-shore development

Cost trends

- High upfront capital costs
- Low operational costs (average US\$10/MWh, range \$4-\$25, regionally variable)



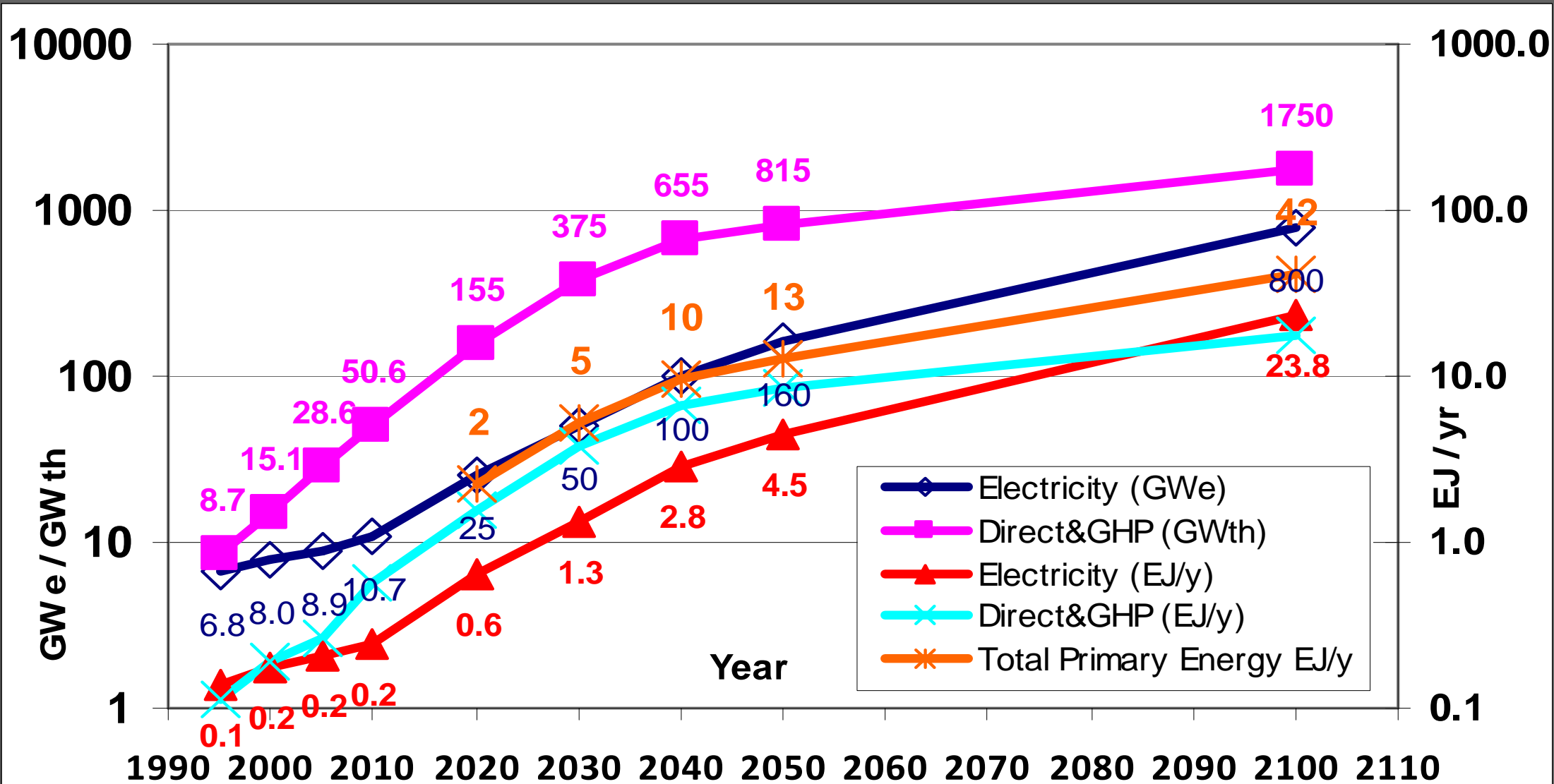
Projected future cost trends : by 2050

- average capacity factor increases from 70% to 90%
- average drilling cost reduces by 15%
- power-plant costs remain unchanged
- >>> levelised cost reduces by 9% -14%

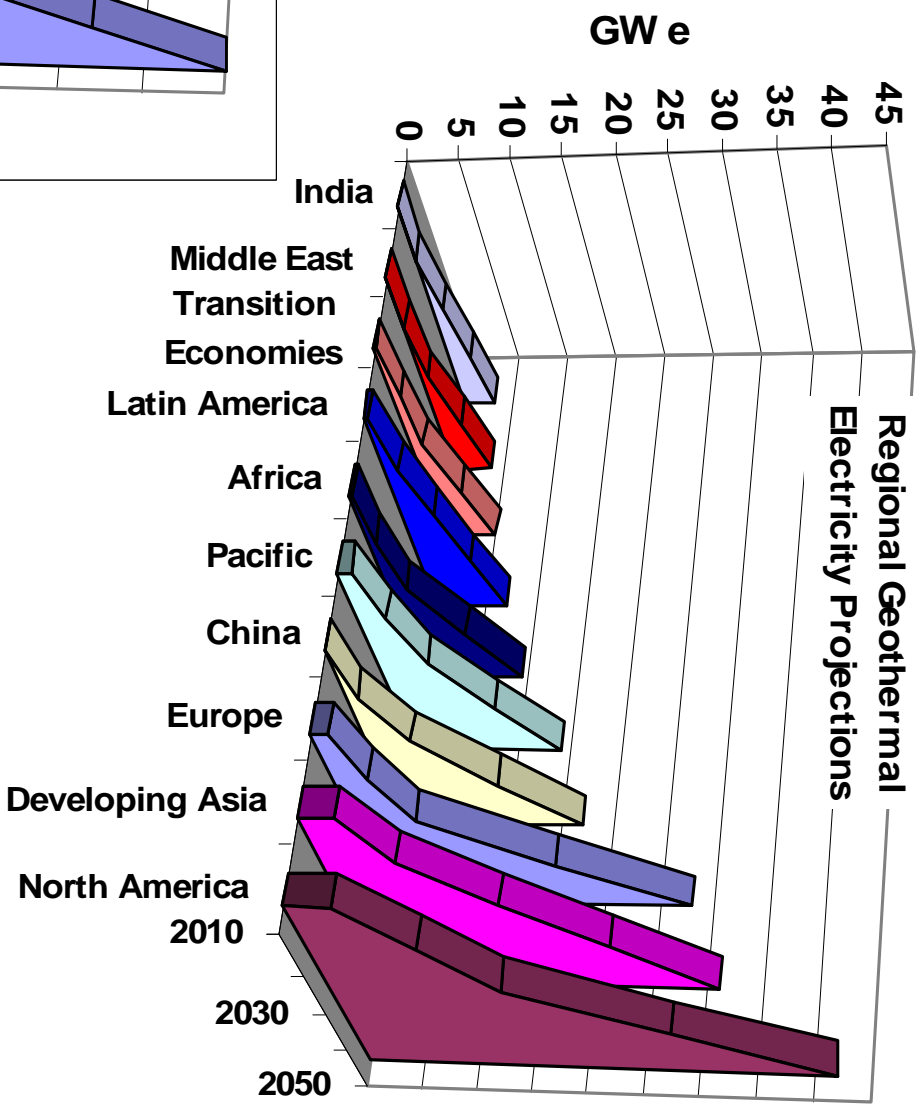
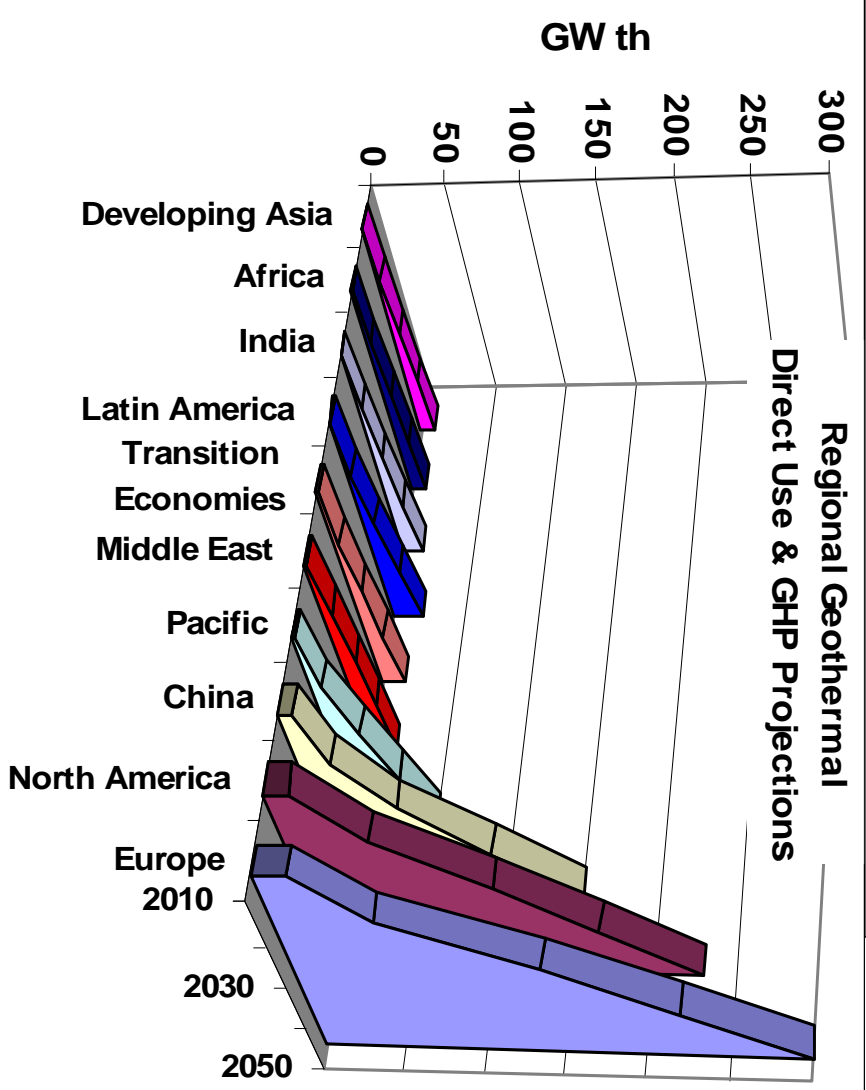
Geothermal Deployment factors : barriers and opportunities

- **EGS : economics - finance, water, transmission infrastructure, population density, power heating & cooling demand.**
- **GHP: awareness, costs, incentives**
- **High temperature systems : regional factors, policies, land access - parks, grid limitations, hazards**
- **Hidden/deep/low temperature systems: limited information, exploration risks, drilling/pumping costs**
- **Supercritical fluids; offshore/seafloor vents**

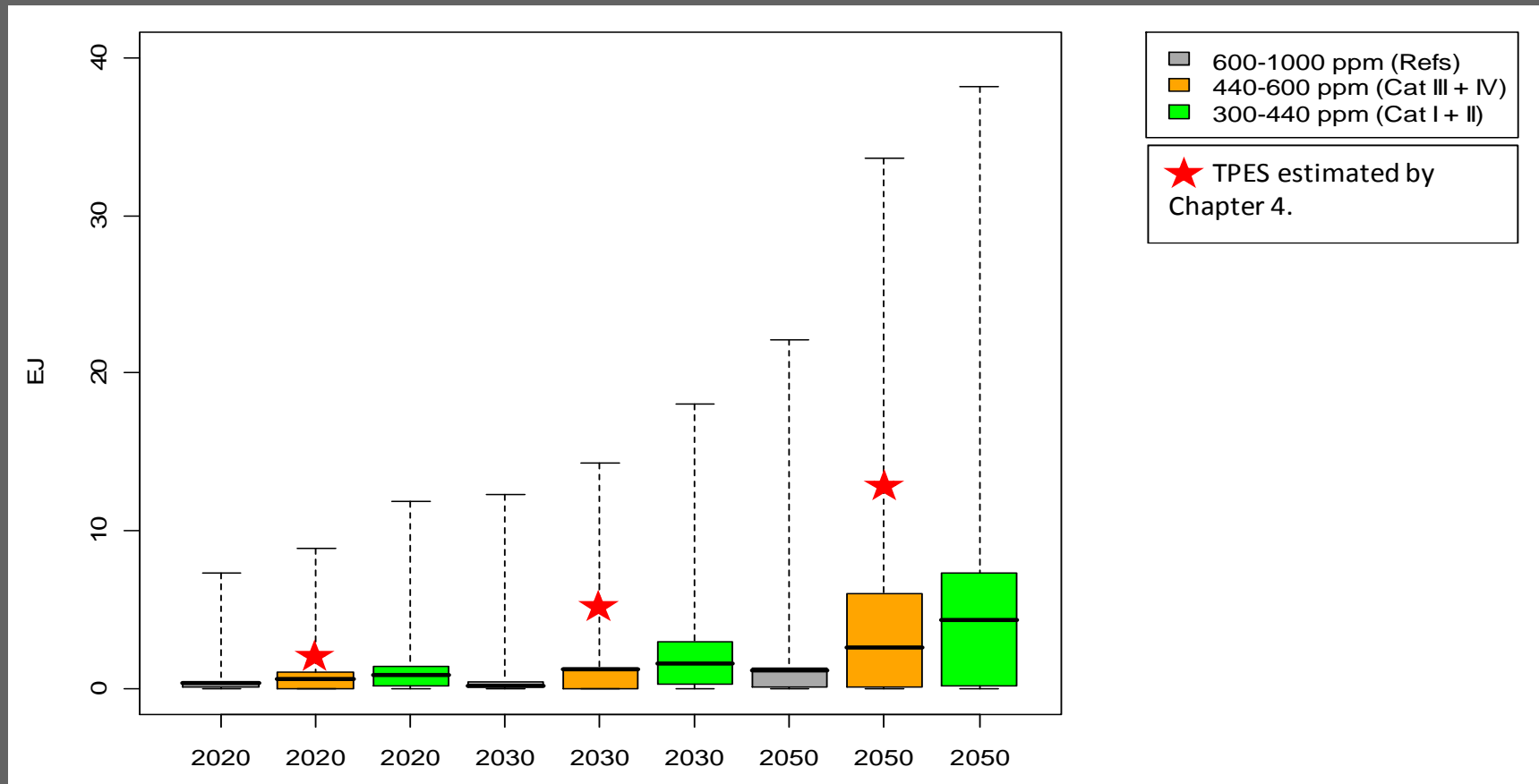
Actual and projected global geothermal deployment (installed GW & energy supplied/yr)



Comparisons of Regional Geothermal Deployment Projections



Potential Geothermal Deployment – comparison with previous carbon mitigation scenario models



Total Primary Energy Supply from geothermal resources as assumed by carbon mitigation scenario modellers for 2020 to 2050. Median, 25th-75th percentile, and whiskers correspond to the range across all scenarios. Red Stars show our latest projections.

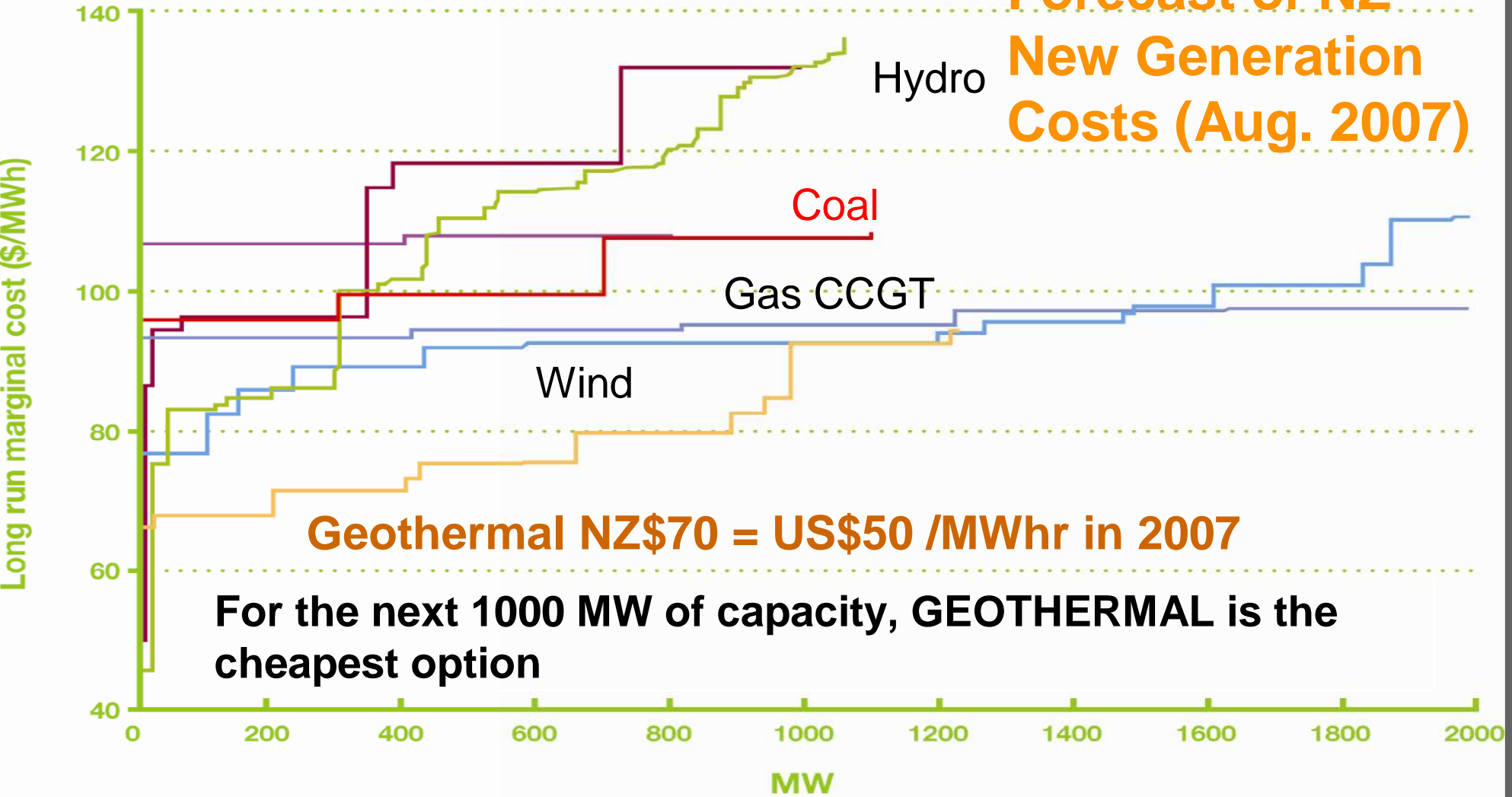
Thank You



**Examples of accelerating geothermal development :
Economic and other factors have driven rapid growth
since 2005
in New Zealand and Iceland**

NZES new build generation costs

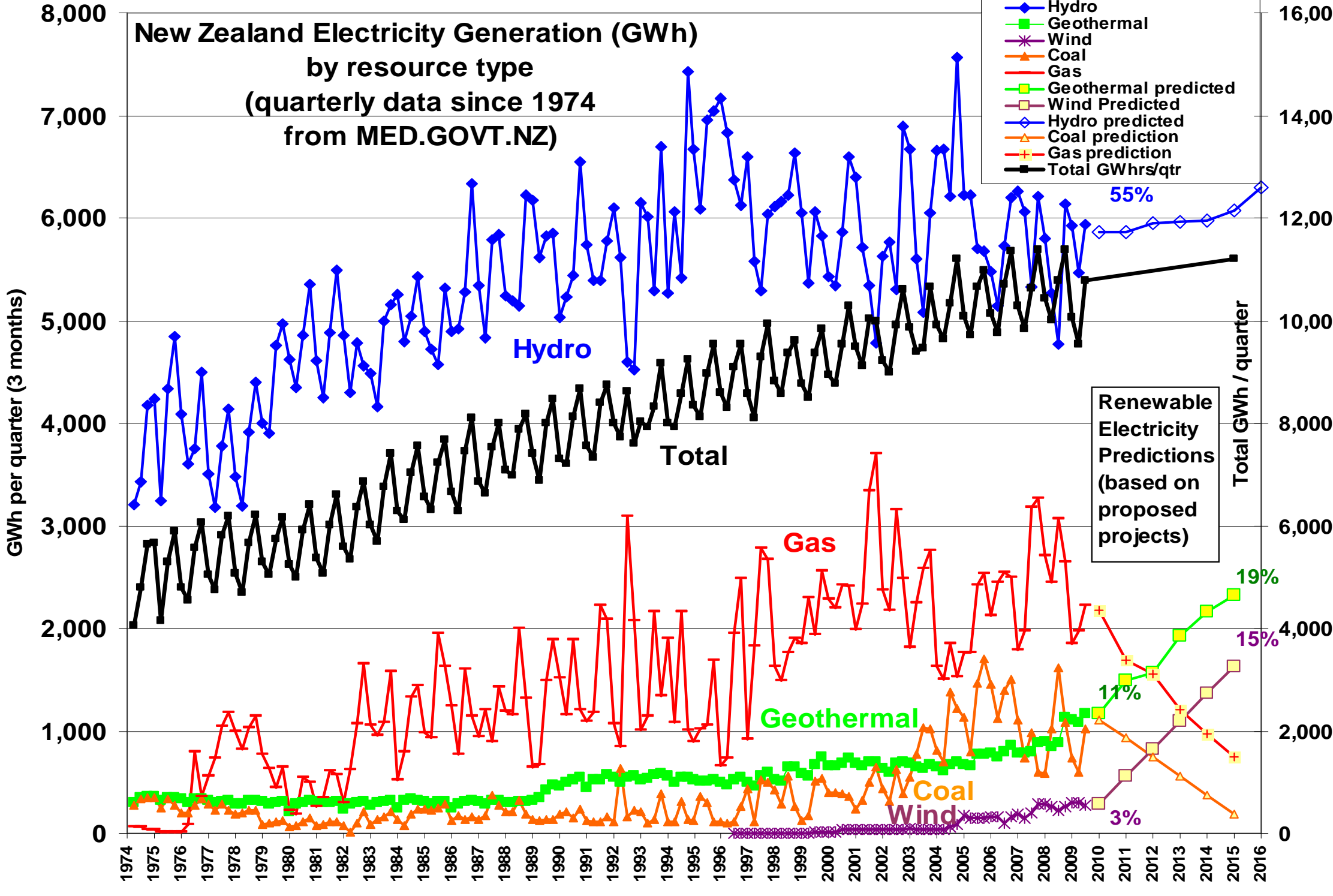
Forecast of NZ
New Generation
Costs (Aug. 2007)



- Wind
- Geothermal
- Hydro run of river
- Hydro storage
- Coal
- Lignite
- Gas CCGT

New Zealand Electricity Generation (GWh) by resource type (quarterly data since 1974 from MED.GOV.T.NZ)

- Hydro
- Geothermal
- Wind
- Coal
- Gas
- Geothermal predicted
- Wind Predicted
- Hydro predicted
- Coal prediction
- Gas prediction
- Total GWhrs/quarter



Renewable
Electricity
Predictions
(based on
proposed
projects)