

Generating Base Load Electricity, from Geothermal Technologies in Pakistan

Green Energy with no Fuel

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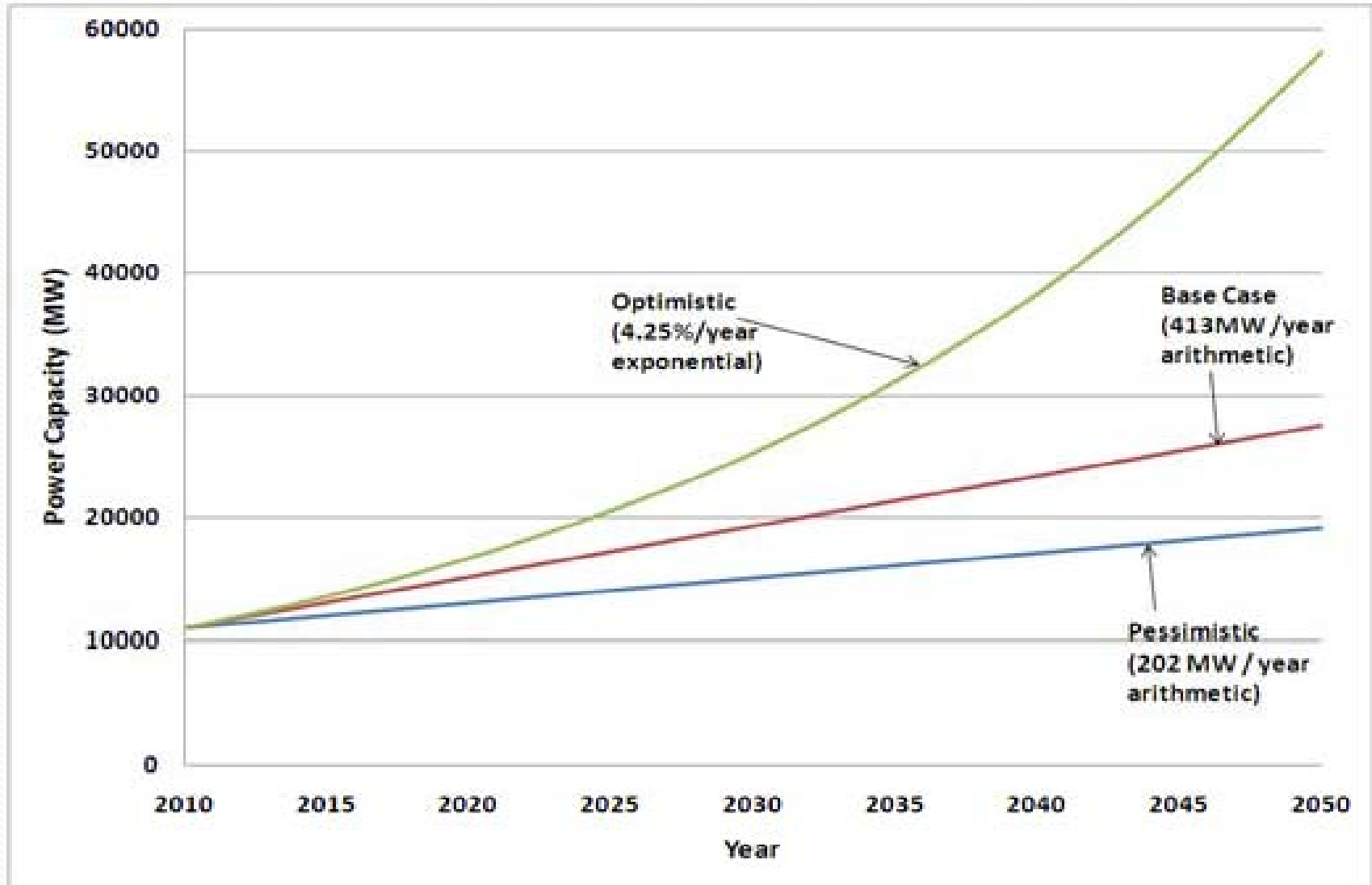
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What is Geothermal Energy

- Electricity is produced using sub-surface low temperatures and water, not just from hot springs.
- Low temperature Geothermal (LTG) uses a Binary process called Organic Rankine Cycle (ORC) and **100-150degrees C** heat found **3-5Km** below the surface.
- An **LTG** plant sends cooled water down a well, which is then heated by fractured hot rock before pumping back up to the surface.
- The Hot water is passed through a heat exchanger, where it heats a low boiling point liquid (**-30/-60degC**) till it **vaporises** and drives a turbine, creating electricity. After cooling the water the cycle is repeated.

Possible Growth Trends in Worldwide Geothermal Power Capacity



Organic Rankine Cycle LTG Plant

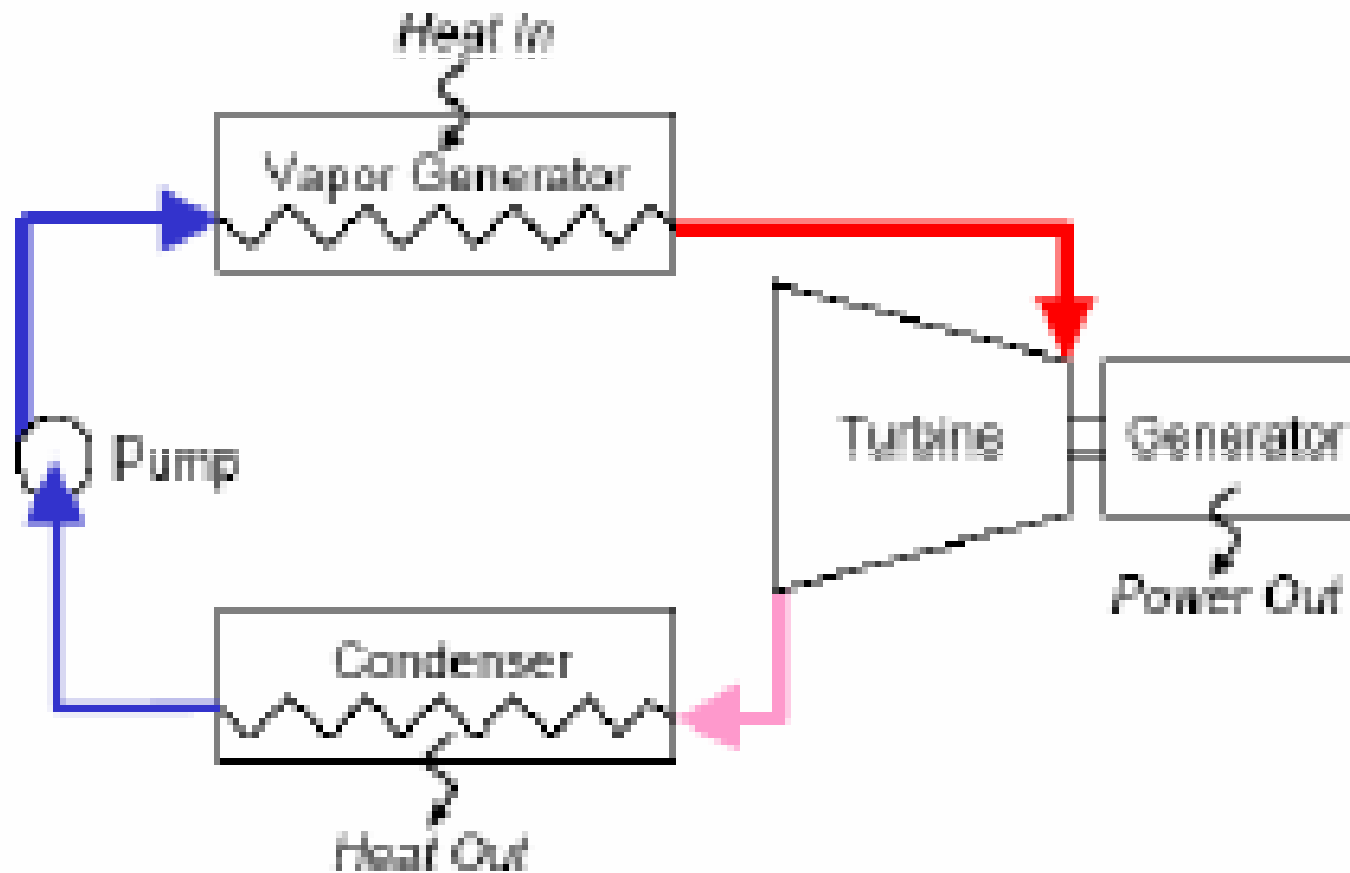


Organic Rankine Cycle (ORC)

Geothermal Energy

- LTG is the latest generation of Geothermal electricity technology.
- In previous Geothermal plants, high temperature geysers have been required that emit high pressure, high temperature steam to the surface, that drive steam turbines.
- LTG uses much lower temperatures, as little as **100degC** that can be found in many more places, though in Pakistan we expect they will be found **5-6km** below the surface.
- The hot water heats a low boiling point fluid such as propane, or iso-pentane which vaporises and drives a turbo-expander directly driving a generator.

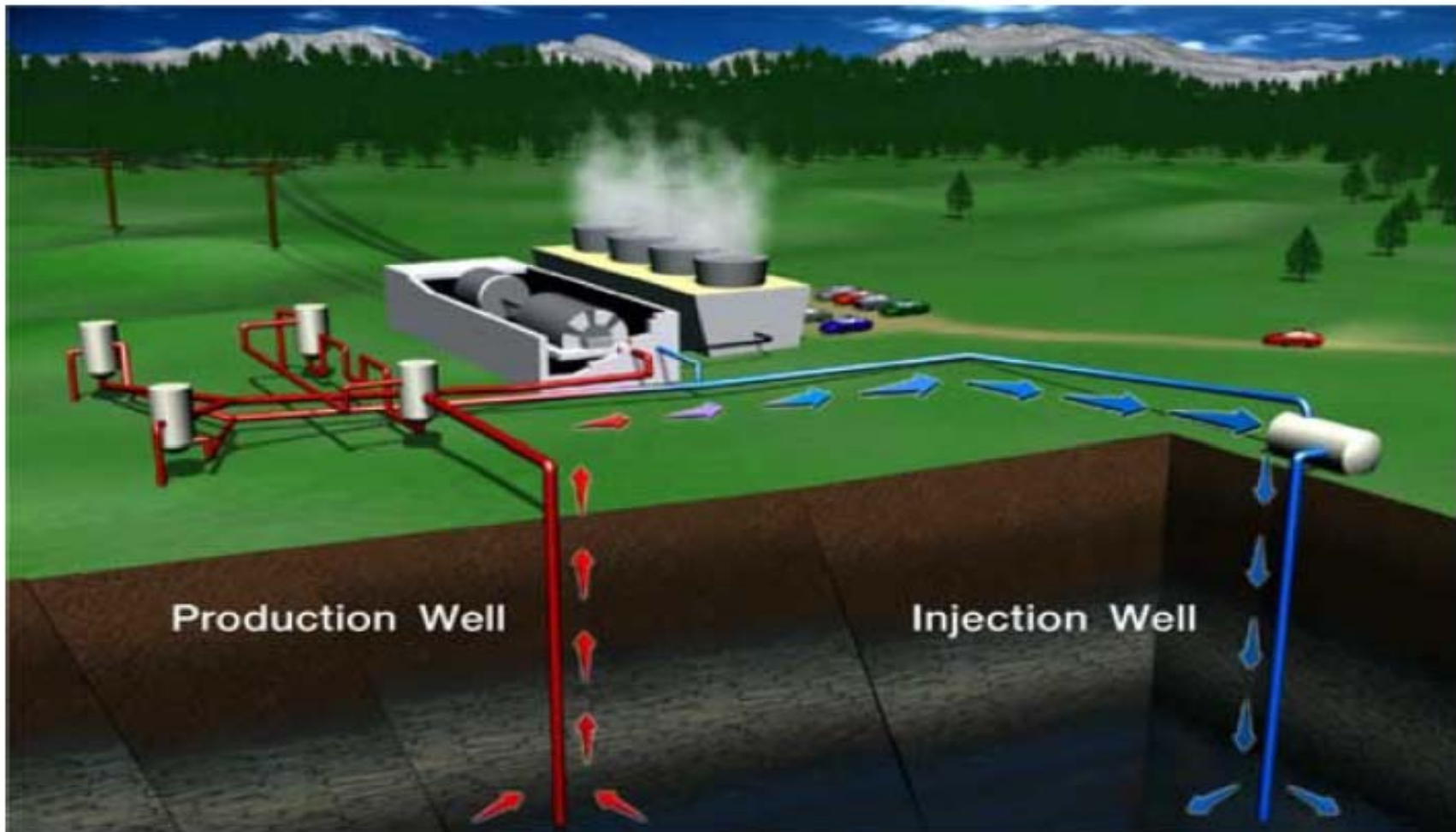
Organic Rankine Cycle (ORC)



Drilling

- Pakistan's temperature gradient is 2-2.5degC per 100m
- To reach over 100deg C, oil drilling equipment is used to drill 4-6,000m production and injection wells.
- The hot rock at that depth is fractured to create a reservoir, and allow water to flow from one well to the other.
- Cooled water is pumped into the reservoir to return to the surface at 100degC+.
- The heat is removed from the water by a heat exchanger and transferred to a low boiling point fluid that vapourizes to drive a turbine, creating electricity.
- After cooling the water is returned to the reservoir for reheating.

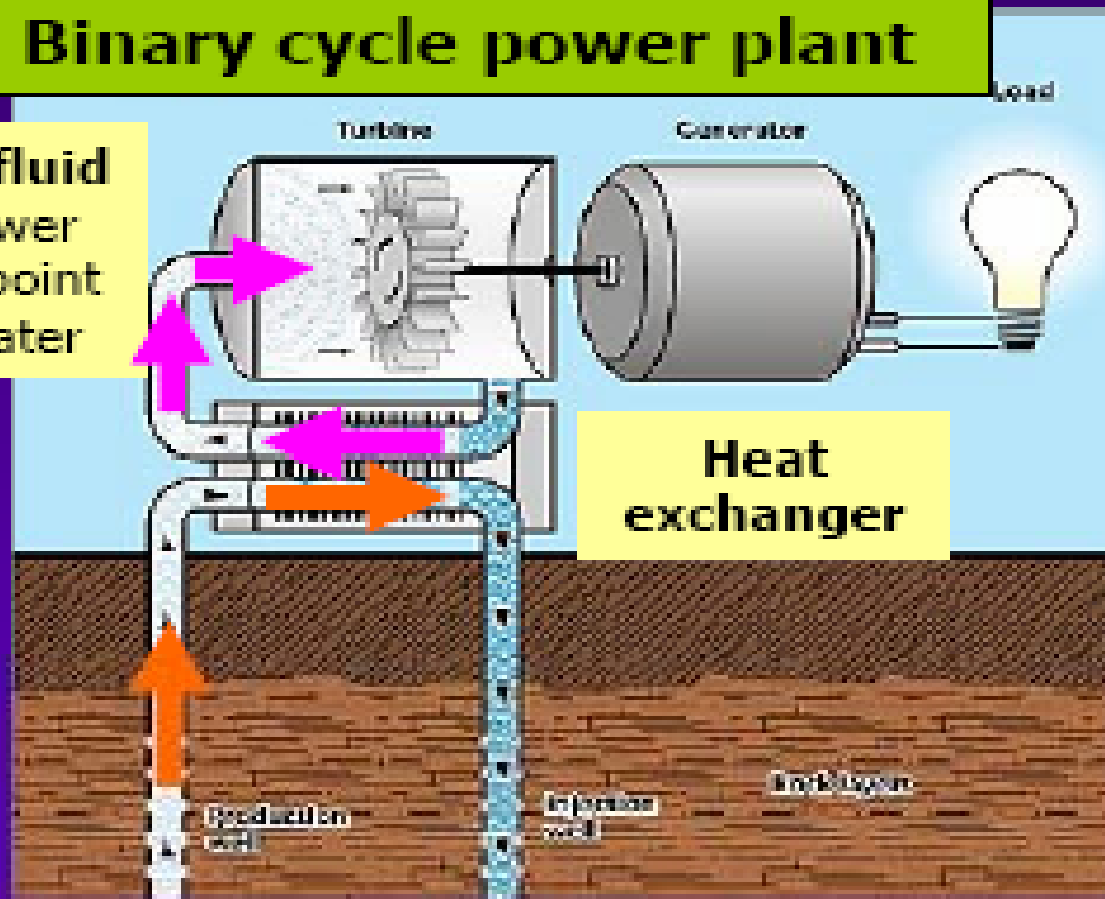
Geothermal Installation



Equipment

Binary cycle power plant

Binary fluid with lower boiling point than water



Processes

- LTG cost fall into 3 main categories
- Survey and resource identification
- Drilling of production and injection wells
- Installation of ORC generating equipment

Costs \$3-\$3.5m per Megawatt Capacity

- Survey and resource identification
- Typically 10-15% of the total budget will be used in the initial stages of identifying the LTG resource, and preparing the site, financials, technical and sales documentation.
- Depending on the scale of production this can be in the region of \$1-\$5m

Costs \$3-\$3.5m per Megawatt Capacity

- Drilling of production and injection wells.
- Deep wells of 4-6km require oil drilling equipment
- This aspect is the most challenging since costs can vary depending on substrate, and other geological conditions.
- Drilling costs in developing countries are generally lower than in the west and so make LTG more economic.
- Typical costs are 35-40% of the project budget

Costs \$3-\$3.5m per Megawatt Capacity

- Installation of ORC generating equipment.
- Modern LTG plants use modified refrigeration components and so cost much less than previously at 50-60% of project cost
- Cost varies from \$1.5-\$2m per Megawatt of production capacity.

Conclusion

- Electricity is critically deficient in Pakistan
- LTG can provide electricity with no fuel required.
- The cost is lower than wind and solar and it is base load 24/7 generation.
- Pakistan can save foreign currency spent on oil.
- Carbon Credits (CER's) under the UNFCCC Clean Development Mechanism can be earned.
- LTG can be installed anywhere in Pakistan though well depth will vary in different regions.
- A serious full scale LTG program should be initiated immediately.
- There is no limit on LTG Electrical Capacity other than availability of **finance** and **drilling** capacity.

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**Thank You for your
attention**