ECONOMIC MODELLING OF HDR ENERGY SYSTEMS

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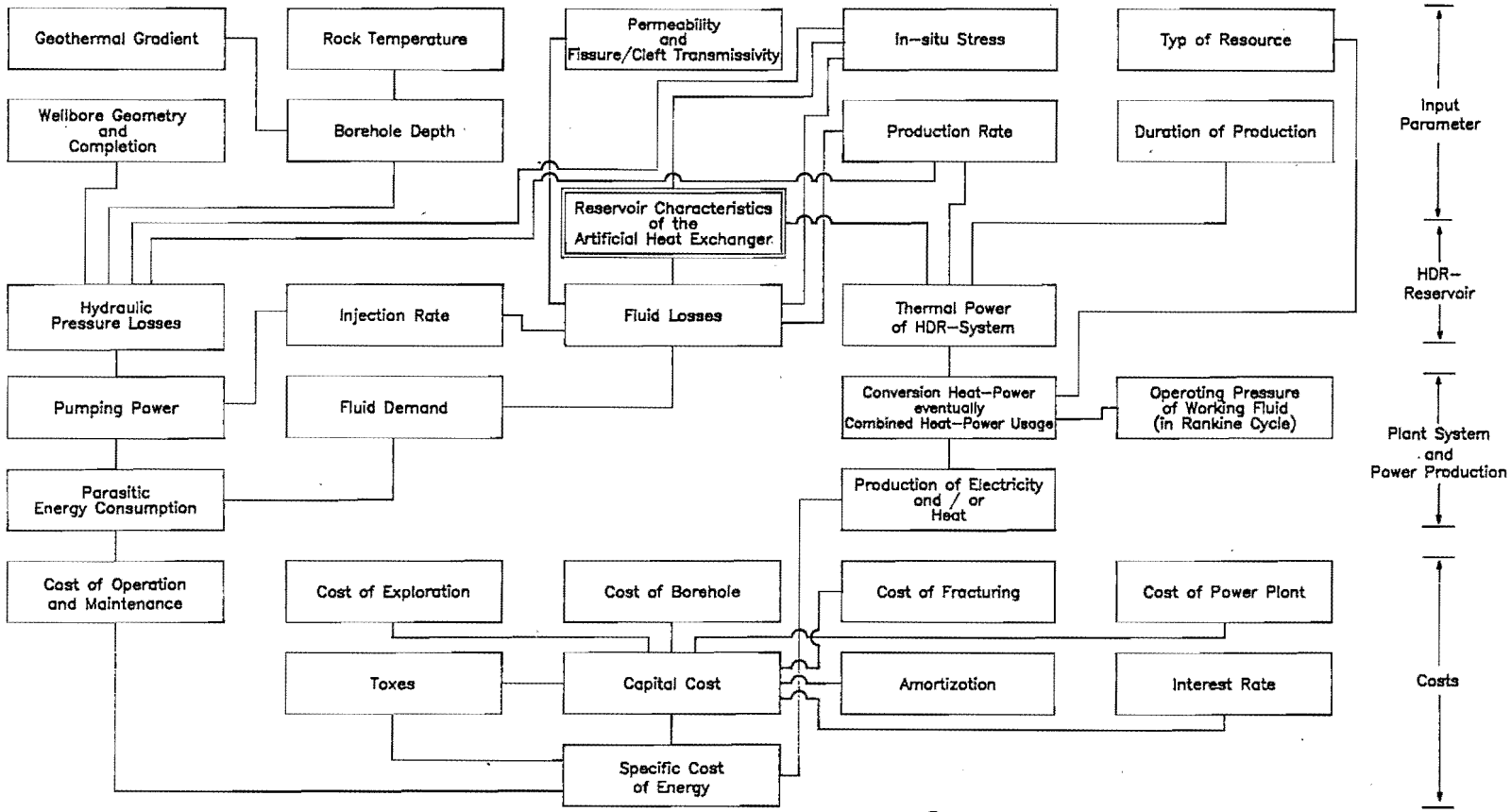
The components of a HDR energy production system were defined and compiled to a structure diagram in which the various interdependencies are considered. The natural parameters determining the HDR potential as there are: geothermal gradient, rock permeability, fissure transmissivities, in-situ stress field, structure (fracturation), hydrology in the fractures, have to be determined by in-situ measurements in boreholes.
Depth and completion of boreholes (diametre and casing of injection and production boreholes) are closely related to the demands for: temperature of the produced heat, flow rate and thermal power of the system and tolerable flow impedance in the boreholes.
The central part of a HDR system is the artificially stimulated heat exchange system which is the HDR reservoir. The thermal power of this reservoir is given by its thermal effective surface area and the natural rock temperatures at the depth of the reservoir.
For an economic evaluation it is necessary to consider water losses during circulation (in dependence of pressure in the circulation system). In the course of heat extraction from the rocks the temperature of the circulating fluid will be reduced and the thermal power diminishes. The thermal power of the system and its draw down in the course of 20 - 30 years have to be predicted by theoretical modelling.
The cost for fracture stimulation and HDR reservoir generation are also determined by the amount and the geometrical configuration of the in-situ stress field.
Considerable expenses may arrise due to the hydraulic impedance in the circulation loop. The consumption of electricity for pumps driving the fluid through the artificial geothermal heat extraction system is high, if the transmissivity is low, because very high flow rates in the order of 100 l/s are necessary to achieve an economic relevant power transmission from the reservoir to the earth's surface.
If the heat production is used for electric power generation high temperatures (great depth) are a prerequisite for acceptable efficiencies during heat to power conversion. Temperatures in HDR systems will always be lower as the steam temperature in conventional power stations. Best efficiencies can be achieved by using ORC (Organic Rankine Cycle).
All the above mentioned parameters, procedures and features are considered in the computer program HDREC. This computer-cost-model determines the specific energy cost for HDR-reservoirs recognizing the investments for: exploration, boreholes, frac operations, parasitic power consumption for circulation, power station and maintenance cost. The result is a cash flow analyses in dependance of: geologic-geothermal conditions, depth and completion of boreholes, technical performance of power station as well as financial parameters (interest rate, time of amortization, tax, inflation rate, residual value).
The program comprises 600 kByte.

HDR–Model for Cost Evaluation



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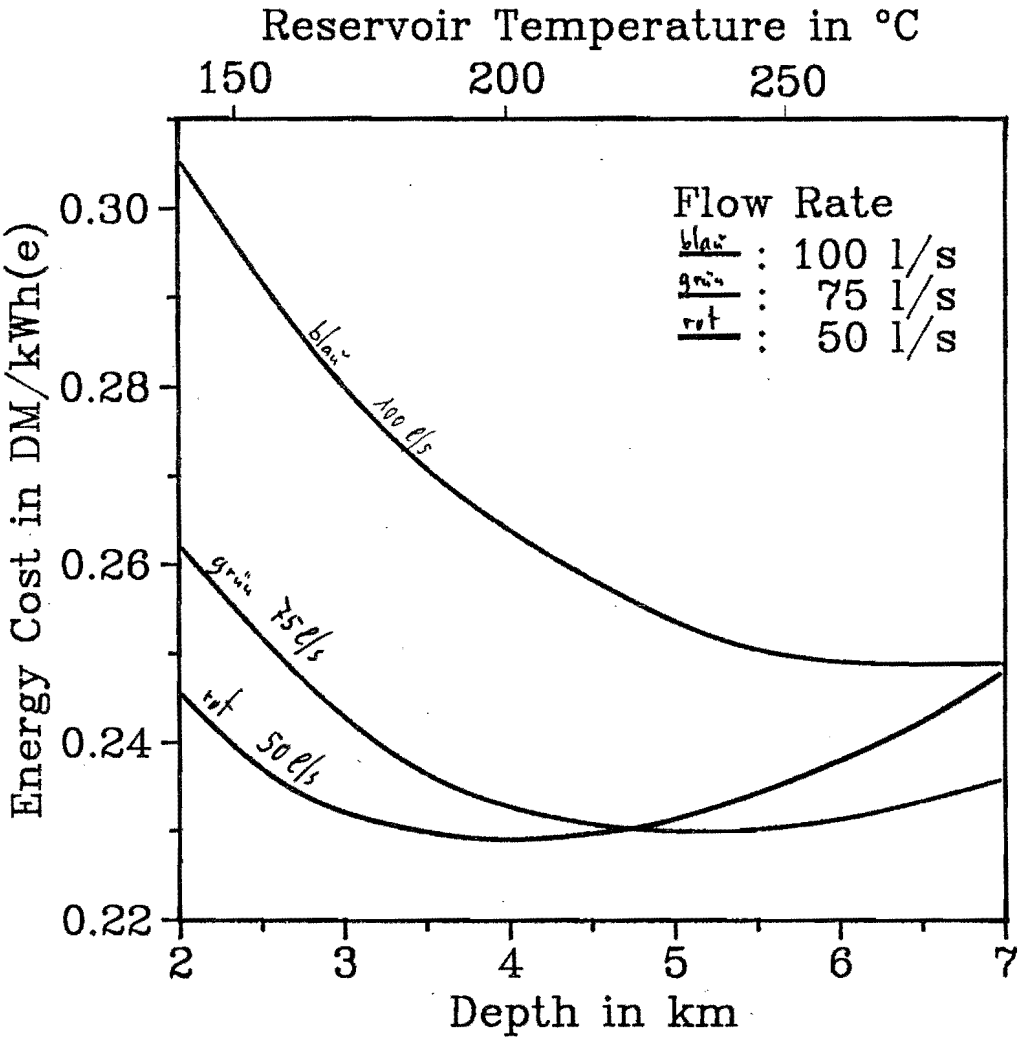

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