APPLICATION OF MONTE CARLO TO ESTIMATE GEOTHERMAL RESOURCE USING VISUAL BASIC: A CASE STUDY OF SIBAYAK GEOTHERMAL FIELD IN KARO, NORTH SUMATRA, INDONESIA

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Abstract

The assessment of geothermal energy reserves within the Sibayak Geothermal Field employs both the volumetric method and Monte Carlo probability simulation. This approach hinges on reservoir physical parameters to derive meaningful insights. The simulation results yield a probability distribution for the comprehensive system value, thereby establishing a range of probability values that encompass proven (P90), probable (P50), and suspected (P10) geothermal reserves classifications. Executing the intricate Monte Carlo calculation process manually is notably time-intensive. Thus, this study pioneers the development of a specialized software using Visual Basic Application, amplifying calculation efficiency and efficacy. Parameters pivotal to these calculations are derived from assumptions rooted in SNI 13-6482- 2000 standards, along with geoscience data and production test analyses from preliminary survey activities. Through the input of P10, P50, and P90 values for each parameter, encompassing factors like area (4.5, 7, and 19 km^2), reservoir thickness (1074, 1190, and 1275m), rock density (2400, 2500, and 2600 kg/m^2), porosity (0.1, 0.125, and 0.15), reservoir temperatures (226, 270, and 300 °C), recovery factors (0.1, 0.2, and 0.3), initial saturations (0.9, 0.95, and 0.99), and estimated final saturations (50%, 80%, and 90%), a comprehensive analysis emerges. The envisioned operational lifespan is set at 30 years, while the rock's heat capacity is acknowledged as 1 kJ/kg °C, culminating in a final temperature of 180°C. Through this comprehensive approach, pessimistic (P10), optimistic (P90), and most likely (P50) estimates of geothermal energy yield from the Sibayak geothermal field stand at 34 MW, 60 MW, and 101 MW, respectively.

Keywords: Volumetrics, Monte Carlo Simulation, Software, Geothermal Energy

Introduction

Geothermal energy is fundamentally derived from the Earth's heat—a renewable energy source that boasts qualities such as consistency, substantial energy density, stability, and environmental friendliness, largely due to its minimal exhaust emissions[8]. Indonesia, colloquially known as the Ring of Fire, boasts a substantial geothermal prowess, housing nearly 40% of the global geothermal potential. This potential finds expression in approximately 252 geothermal fields that span Indonesia's volcanic formations, collectively holding a remarkable potential of about 28 GWe[4]. Estimating this geothermal potential assumes paramount importance for the industry, serving as a benchmark for devising technical and economic strategies. The pursuit of potential geothermal reserves estimation typically falls within four main methodological categories: the Surface Thermal Flux method, Volume method, Planar Fracture method, and Magmatic Heat Budget method. Among these, the Volume method emerges as particularly apt for reservoirs characterized by lower temperatures, systematically guiding hypotheses toward proven reserves[3].

This study aims to compute potential geothermal reserves through the application of the volume method within the Sibayak geothermal field, utilizing a Monte Carlo probability simulation. The volume method delineates three key categories for estimating geothermal reserves: proven reserves, probable reserves, and possible reserves[9]. These categories are respectively denoted by P90 (90% probability), indicating proven reserves; P50, signifying proven and probable reserves; and P10, encompassing proven, probable, and possible reserves. The outcomes generated by the Monte Carlo simulation manifest as a histogram, presenting a comprehensive probability distribution for the entire system's value, encompassing a spectrum of probability values[10].