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Geothermal Reserves Standards: A Study of the Applicability of the SPE Petroleum Resources Management System, a Proposed Classification Framework for Geothermal Reserves and Resources

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Keywords

Reserves, resources, geothermal resources classification framework, thermal recovery factor, SPE, PRMS, GRMS, EGS, power density

ABSTRACT

The global geothermal industry is over 100 years old and is growing as suppliers seek to meet ever-increasing energy demands in an era of de-carbonization. Yet, unlike the petroleum industry, the geothermal industry has no universally accepted set of guidelines, standards, or protocols to guide what are called '*reserves*' in financial statements and reports. Consistency in reserves and resources classifications (wherein reserves are a subset of resources), estimation methodologies, and the related disclosures is needed by investors, regulators, and corporate management teams to compare geothermal opportunities and clearly communicate the differences in terms that are well defined and understood. Another benefit of such standards is to show value added during the exploration and early development phase of a project as resources mature from one classification to another. In this study, a literature survey was conducted of existing classification standards in order to provide the backdrop for an evaluation of a geothermal resources classification framework based on the SPE Petroleum Resources Management System (SPE-PRMS). A brief review of methodologies for estimating recoverable heat was also conducted. The SPE-PRMS is a widely recognized international standard for petroleum resources, and its applicability to the formulation of a classification framework for geothermal resources was explored. Additional terminology is introduced to define geothermal reserves, resources, and associated concepts. An initial geothermal resources management system (GRMS) is presented.

1. Introduction

As many observers are aware, the geothermal industry is poised for an investment surge due to several factors. One such factor is the continued push toward de-carbonization of energy sources driven by environmental and social concerns; another is the need for growth in base-load renewable power, and a third is the emerging economic viability of Enhanced Geothermal Systems (EGS). The large resource base in the earth's crust to 4 km depth is a major driver of EGS. New geothermal projects require capital for exploration, wellfield development, and power plant construction. Total project costs can be \$4 million to \$6 million per developed MWe (the electrical power output from a power plant is specified in megawatts electric, or MWe), and projects may take several years to generate first revenue. The California Public Utility Commission has called for 1000 MW of new, base-load renewable power by 2028 to help supply the state's growing needs and energy transition goals, requiring \$4 billion to \$6 billion, or more. In Utah, Fervo Energy is developing 400 MWe of EGS power at a reported cost of \$1.1 billion (Fervo 2023). These large capital projects require outside investment from financial institutions, private equity, investment banks, and other sources.

Many of these potential new investors are likely to have experience investing in the petroleum industry and are familiar with many common and shared activities with the geothermal industry, such as subsurface geoscience evaluation, well drilling and completions (including horizontal wells), and fluid production through surface pipelines and facilities. These investors may also have experience with petroleum reserves standards and have some expectation that there are similar standards and protocols for geothermal reserves. For other new investors, geothermal projects may be their first foray into subsurface assets and development. Both types of investors are likely unfamiliar with the nuances of geothermal exploration, development, power plant operations, and selling produced power to a utility or a large power purchaser (e.g., a server farm, a mine, etc.).

At this point, it is important to note that *reserves*, whether for petroleum or geothermal, are a subset of *resources*. As such, *resources* encompass the full spectrum of estimated quantities: discovered as well as undiscovered, recoverable as well as unrecoverable, commercial as well as uneconomic, and produced as well as remaining. *Reserves*, as will be further defined in section 3.3, comprise the portion of *resources* that are discovered, recoverable, commercial, and remaining as of a given date. Throughout this work, we sometimes refer to the terms *reserves and resources* together, simply for emphasis.

The geothermal industry in the United States history is blotted by projects[1,2,3,4,5] that did not meet economic expectations. While there may be many technical reasons why a project experiences commercial difficulties, the issue often revolves around a mismatch between expectations of what the asset could produce, i.e., the asset's reserves, and the associated production profile with respect

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[1] Johnson, G., *Imperial Valley Project: SDG&E Pins Hopes on Geothermal Plant*, Los Angeles Times, June 20, 1985.

[2] Johnson, G., *SDG&E: to Shut Geothermal Plant" Unocal, Chevron Unit Late Drilling Wells, Utility Says,* Angeles Times, June 24, 1987.

[3] Johnson, G., *Chevron Seeks Ruling on SDG&E; Contract Liability*, Los Angeles Times, August 13, 1987.

[4] Johnson, G., *SDG&E: Files Suit Over Geothermal Contract*, Angeles Times, August 19, 1987.

[5] Johnson, G., *SDG&E: Negotiating to Sell Heber Geothermal Plant*, Angeles Times, August 19, 1987

to time, rate, pressure, and enthalpy. A review of the financial statements from domestic U.S. companies that produce geothermal energy, such as NCPA (Baker Tilly 2018-2023), Chevron (2005-2022), and Ormat (2005-2023), suggests a current capacity factor of ~52% (i.e., current electrical power production as a percentage of the initial installed plant capacity). As a project is incentivized toward profitability, the question may be asked, *why is the average project delivering only about half of its installed capacity?* At least part of the answer to that question, and others, may be found in properly understanding the uncertainty around a project's geothermal reserves and resources.

2. Literature Review

The passage of the 1970 Geothermal Steam Act by the U.S Congress, provided for the leasing of Federal lands for geothermal exploration and development. The Act defined a *known geothermal resource area* as "an area in which the geology, nearby discoveries, competitive interests, or other indicia would, in the opinion of the Secretary, engender a belief in men who are experienced in the subject matter that the prospects for extraction of geothermal steam or associated geothermal resources are good enough to warrant expenditures of money for that purpose." It should be noted that several criteria are specified: geologic favorability, subject matter experts, and commercial opportunity.

In response, the first national assessment of the domestic geothermal resource base was performed by the United States Geologic Survey, USGS (White and Williams 1975). This assessment reviewed a comprehensive catalog of hot springs and thermal features in order to estimate the size, temperature, and heat-in-place using either direct temperature measurements or inferred from geothermometry. The national assessment was updated several times by the USGS, with the last update in 2008 (Muffler 1975, 1979; Reed 1983; Williams et al. 2008). They described a volumetric methodology for calculating the usable heat-in-place above a given reject temperature using either deterministic or probabilistic methods.

These USGS studies all referred to the geothermal *resource base* as *reserves*, highlighting the differences on how to define this key term. Furthermore, the USGS did not rely on economic criteria in defining reserves, thus missing a key factor, commerciality. This is understandable, since the early years of the industry were not concerned about precise reserves definitions and protocols as the technology was still evolving, experience was being gained, and the limited number of projects worldwide were still in their infancy. This is not the case today, as the industry has matured, with over 50 U.S. domestic power projects and more than 100 globally.

2.1 An Evolution of Geothermal Reserves Classification Standards

The U.S. domestic geothermal industry experienced a number of major oil companies, new entrants, and other players leaving the space throughout the 1990s, a period characterized by industry reorganization. Serious discussion of geothermal reserves started appearing in the literature post-2000 and has advanced toward formal protocols and standards. Three stages can be discerned from the literature.

The first stage spans about 2000 to 2008, with discussion of reserves categories and estimation methods. An early paper by Sanyal et al. (2005) proposed a process for booking geothermal reserves. It provides an excellent summary of basic principles with suggested categories and a discussion of deterministic and probabilistic reserves estimation methods. A review by Clotworthy et al. (2006) suggested reserves categories of Proven, Probable, and Inferred and included an economic test as reserves were only to be considered “that are generally accepted to be commercially extractable with existing technology and prevailing market conditions.” These authors referenced the SPE/WPC guidelines for petroleum in using deterministic and probabilistic methods.

The second stage covers approximately 2008 through 2015, coinciding with the development of Enhanced Geothermal Systems (EGS) in Australia. This required Australian regulations, protocols, and standards for determining geothermal reserves for financial reporting (Australian Reporting Code Committee 2010). The code used for its conceptual basis the Joint Ore Reserves Committee (JORC) approach and was adopted with minimal changes in Canada by the Canadian Geothermal Code Committee (2010a, 2010b). These codes recommended using a thermal recovery factor of 25% based on reservoir numerical model studies or a probabilistic model with a triangular distribution of 15%, 20%, and 25% for min, median, and max. The thermal recovery factor was then used to define proven reserves for the early Australian EGS pioneers. Somewhat in contrast, Grant (2015) presented a pervasive argument that for mature hydrothermal systems, a best estimate thermal recovery factor is 8% to 10% and that the Australian Code and Lexicon overstates hydrothermal recovery factors by 75%. Since EGS developments can have lower recovery factors than traditional hydrothermal projects, the overstatement becomes even greater in those instances.

In a review of the Cooper Basin, Habanero project, Geodynamics Ltd. (2014) presents an excellent summary of said project, including geoscience and financial information with over $400 million expended. It was apparent that the *proven reserves* that were booked were an attraction for initial capital investors, based on the Australian protocols. The company was incorporated in 2000 and listed on the Australian Securities Exchange in September 2002. After extensive testing, the project demonstrated 1 MWe in October 2013. The post project study estimated capital costs of $21 million per developed MWe, which is four to six times greater than a typical 50 MWe binary power plant. One observation from this situation is that if a project is to fail financially, it is better to do so sooner than later.

The third stage started approximately 2015, with the literature providing documentation of project data from around the world. Ciriaco et al. (2020) presented an excellent summary on current methods of estimating in-place thermal resources and thermal recovery factors for over 40 fields worldwide. It is interesting to note the legacy impact of the Australian probabilistic methodology described earlier (i.e., min, median, max of 15%, 20%, and 25%), with fifteen projects using probabilistic thermal recovery factors of 20% or greater. The United Nations has published detailed classification and specifications for geothermal resources in an effort to establish an international standard (UNECE 2019, 2022). This standard has yet to gain wide use by the geothermal industry; however, it does demonstrate a maturing technical understanding and an increasing emphasis on geothermal reserves standards worldwide.

2.1 Estimation Methodologies for Geothermal Reserves

Early discussions on booking geothermal reserves included a review of existing methods conceptually based on the Society of Petroleum Engineers (SPE) and the World Petroleum Congress (WPC). Various methods including volumetric analysis, production decline curve analysis, lumped parameter modeling, numerical simulation, and the application of sophisticated stochastic methods were reviewed. Additional authors referred to Clotworthy in 2006 for establishing a conceptual framework for geothermal reserves and sub-categories reflecting different degrees of resource confidence. They used a three-level classification system; Proven, Probable, and Inferred, based loosely on the McKelvey diagram used by SPE. A general consensus has developed since then to use proved, proved plus probable, and proved plus probable plus possible categories to represent the 90th percentile (P90), the 50th percentile or median (P50), and the 10th percentile (P10) of the cumulative probability of exceeding the reserves estimate. Deterministic methods were assumed to represent a P50 estimate.

A key difficulty in differentiating between proved and non-proved categories is the thermal recovery factor. Given a typically large heat-in-place, a small difference in the recovery factor can have a large impact on the estimated proved reserves. An excellent review of geothermal resource assessment methodologies by Ciriaco et al. (2020) summarized thermal recovery factors from the literature for a number of fields worldwide to be from 5% to 38%, with most of the fields using probabilistic methods and triangular distributions (min, median, max). This compilation included three U.S. domestic fields: Coso, Dixie Valley, and The Geysers, all very well characterized and with long production histories that exhibited thermal recovery factors of 8% to 11%. These low thermal recovery factors from large, well-managed assets with over 30 years of production history suggest that recovery factors much greater than this may be optimistic. Moreover, optimistic thermal recovery factors may be related to high porosity assumptions since they are proportional in a given analysis. Zarrouk (2013) proposed that thermal recovery factors should consider the host porosity and type of geothermal system.

Decline curve analysis (DCA) has long been used in the petroleum industry to forecast reserves from properties that are actively producing. While many geothermal fields use pumped wells at fixed rates, several geothermal fields use flowing wells and are subject to mass depletion, such as Coso and The Geysers. DCA has been used for many years at The Geysers for estimating remaining steam reserves and to estimate well flow capacity (*kh*) (Faulder 1996, 1997; Reyes 2004). In another instance, a common petroleum evaluation software was utilized to observe the historical performance trends in an established geothermal field and then apply DCA to multiple data streams, including steam and water mass, in order to forecast the future production (Ryder Scott Company 2021).

The difficulty in using strictly volumetric methods of heat-initially-in-place and a thermal recovery factor leads to considerations of how to estimate the production potential of a new prospect or a discovery without extensive geoscience and engineering data. The concept of power density has been studied by Wilmarth and Stimac (2015), Cummings (2016), Wilmarth et al. (2021), and Holmes (2024). Power density is defined as generating capacity divided by producing area. Figure 1 shows power density (MW_e/km^2) plotted vs. reservoir temperature (°C) for over a hundred fields worldwide. Distinctions were made between different tectonic environments, and an exponential regression was performed. The resulting plot showed a range of power density at each temperature, empirically representing the lognormal distribution of key underlying data, primarily area.

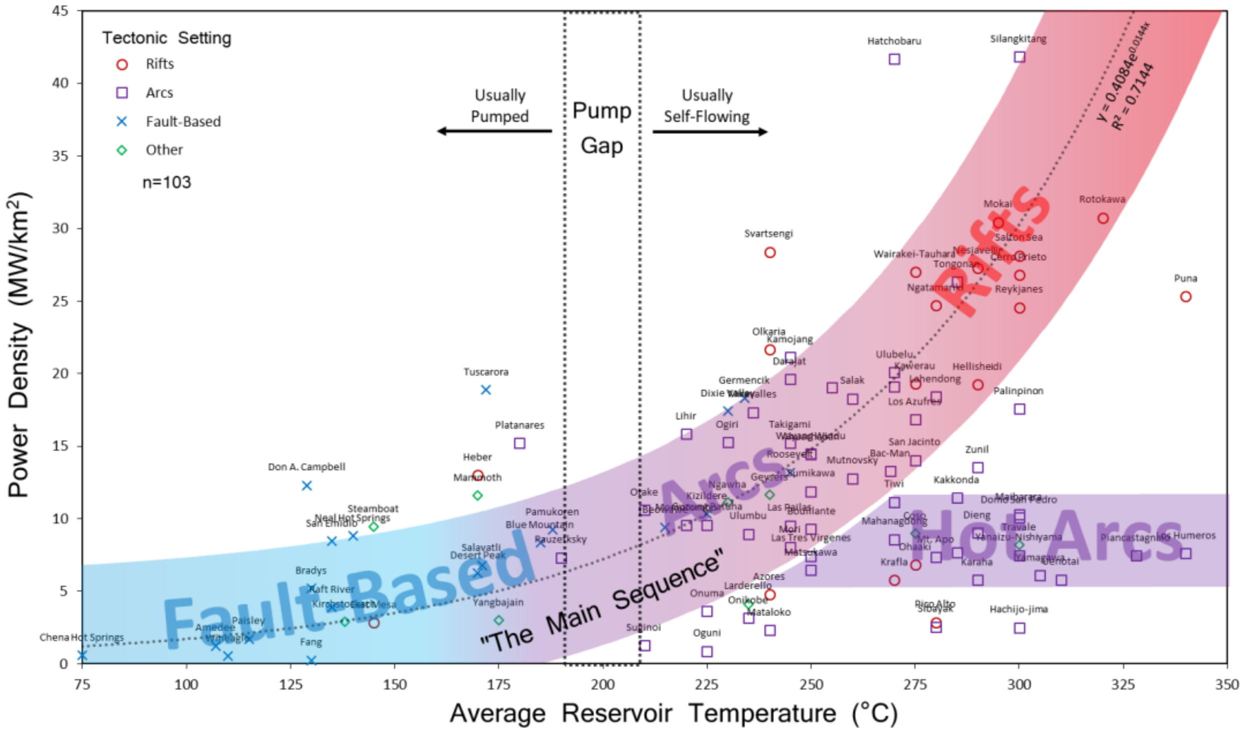

Figure 1: Power Density versus average reservoir temperature, from Wilmarth et al. (2020).

One distinct advantage of the power density method is not having to assume a thermal recovery factor, and power density increases with temperature, making intuitive sense. Another advantage is the data is based on actual operating experience for an increasing number of fields. One critique of the method is the choice of which capacity for power generation to use, the initially installed plant capacity or the actual stabilized power generation after some period of time. Another critique is the calculation of field size, since the area of the wellfield operations is dependent on the development strategy used. The power densities presented do not include a table of the underlying data used, and future work on this topic should develop a defined protocol for consistency and transparency. Yet, with refinement and an expanding data set, the power density method may provide a robust method for resource comparison using statistical methods, especially in the early appraisal stage of a project. A minimum and maximum estimated reservoir temperature can be used to bracket the power density distribution. An estimate of the defined field size multiplied by the power density provides an early estimate of the power generation potential.

A number of authors point to the evolving approach of using reservoir simulation to model the dynamic reservoir response during exploitation and to quantify heat recovery (Fang et al. 2022; Sanyal and Sarmiento 2005; Winofa et al 2020). The complex nature of modeling hydrothermal systems requires a large geoscience data set synthesized into a geologic model of the resource, such as temperature, porosity, and permeability within the structural and stratigraphic controls and open hydrologic boundaries. Mature projects typically have sufficient geologic and engineering data to construct and calibrate reservoir simulation models, and where sufficient data is available, reservoir simulation is a preferred method. To ensure their reliability, reservoir simulation models need to be regularly updated and recalibrated, taking care to understand why the forecast and actual operations did not match, for such cases. We note that demonstrating or calculating the reliability of reservoir simulation, or any other estimation methodology, is a key criterion for assigning specific reserves categories to quantities of recoverable heat.

3. A Viable Classification Framework for Geothermal Reserves and Resources

3.1 The Need for Geothermal Reserves Standards

In general terms, reserves are the supply of a certain commodity that is available for future use, and for companies that sell commodities, reserves are a crucial measure of resource magnitude, growth (or decline), and longevity. For the energy industry, particularly for oil and natural gas, this is no exception. The establishment of standards for estimating and reporting petroleum reserves has been of great importance for many decades and is widely accepted as a critical part of carrying out business and defining the value of the company. Corporate management teams use reserves to understand their portfolio and to plan future development activities. Reserves represent an asset and are an integral part of the company’s accounting to determine earnings. Regulators use reserves to plan for public energy needs and infrastructure, to predict tax revenue and inform tax incentives, and to help administer the use of natural resources. Investors use reserves to compare company performance and investment opportunities. Accordingly, reserves standards provide consistency in resource classifications, estimation methodologies, and the related disclosures. This consistency of information promotes reliable estimates and clear communication about such estimates, which then brings stability to the market place. Stakeholders are able to compare opportunities, manage portfolios, and transact with greater comprehension and confidence.

Whether for petroleum or for geothermal energy, this same reasoning and need for reserves standards applies. As discussed earlier, multiple geothermal standards have been in existence for many years (Australia, Canada, UNECE, etc.). However, a particular set of standards has yet to emerge as being widely-accepted. This reality may be at least partly due to the geothermal energy industry being something of a sleeping giant, when compared to the current mix of global energy supply. As worldwide economies continue to seek additional sources of energy to meet ever-growing demand, especially sources with a low carbon intensity, geothermal energy is positioned to become more common and to attract more investment capital. The acceptance and use of reserves standards are necessary to aid in the development and growth of geothermal energy, thus creating favorable conditions for a universal geothermal reserves standard to take hold. Yearsley (2019) discusses using the SPE framework for analyzing the transaction value of geothermal assets.

3.2 Experience from Hydrocarbons

The SPE Petroleum Resources Management System, a.k.a. SPE-PRMS or simply PRMS, is an important international standard for defining and classifying *petroleum* resources (Society of Petroleum Engineers 2018). Its principles are commonly applied to oil and gas assets around the world. Not only is the PRMS framework widespread, but many technical experts and other energy stakeholders are already highly familiar with its principles and application, having utilized it for decades. Furthermore, other standards for hydrocarbons, such as COGEH and the SEC guidelines, make reference to the PRMS. This high degree of acceptance and familiarity is important and may help position the PRMS to be a natural bridge to a geothermal classification system, especially for stakeholders that already have some background in oil and gas.

In August of 2022, SPE issued a statement recognizing that the PRMS principles were being applied to non-hydrocarbons, including geothermal resources. SPE did not object "as long as it is made clear that while such application is outside of the PRMS, PRMS principles have been followed, while involving other subject matter expert parties as appropriate, and applied as though the extracted resources were considered as petroleum (Society of Petroleum Engineers 2022)." This statement opens the door for the acceptance and application of the principles of the PRMS for geothermal resources classification.

The technical estimation of petroleum or geothermal resources involves the assessment of quantities that have an inherent degree of uncertainty. The uncertainty in the estimates of recoverable volumes is represented by the *category* assigned to the estimates. Furthermore, these quantities are associated with exploration, appraisal, and development projects at various stages of design and implementation. The commercial aspects considered (e.g., technical, economical, regulatory, and legal) will relate the project's maturity status, or *classification*, to the chance that a technically viable project will actually be implemented. The PRMS classification framework provides a methodical approach to classify a given project according to its commercial maturity and to categorize the range of estimates according to the associated uncertainty of those estimates, for a project outcome. Since the PRMS is principles-based instead of rules-based, it inherently allows for adaptability to geothermal applications. In addition, petroleum and geothermal projects share many similarities, such as geologic and fluid flow characteristics, exploration and extraction technologies, and economic modeling. On the other hand, there are also important differences, including recovery of heat versus hydrocarbons, capital requirements and infrastructure, saleable products, and market drivers. We recognize that situations may arise requiring a departure from the PRMS as a guideline; however, our initial work has made it apparent that many reserves-related questions for geothermal energy become more straightforward by first looking for an analogy in the handling of hydrocarbon reserves. Finally, for the purposes of our discussion here, the adapted classification framework will be referred to as the Geothermal Resources Management System, or GRMS.

3.3 Important Terms and Definitions

As mentioned earlier, it is first important to distinguish between the terms *resources* and *reserves* in the context of geothermal energy. Leveraging language from the PRMS and adapting it to geothermal, the term *resources* comprises all quantities of geothermal energy, discovered and undiscovered, recoverable and unrecoverable, already produced as well as remaining, that are naturally occurring within the earth. Furthermore, Heat Initially-in-Place (HIIP) is a term that refers to a geothermal resource before any production has occurred. Again leveraging language from the PRMS, *reserves* are the portion of resources that are "commercially recoverable by application of development projects to known [sources] from a given date forward under defined conditions." Furthermore, reserves must satisfy four criteria: they must be "discovered, recoverable, commercial, and remaining based on the development project(s) applied." The exergy, or the useable portion of total energy in a system, of a geothermal project depends upon differences in temperature between the source heat and the reject, or waste, heat. Thus, the amount of geothermal reserves of a project can be different depending upon factors such as the type of geothermal power plant, the reject temperature of the plant, or in the case of a direct heat application, whatever the minimum temperature is of the particular application.

Since geothermal reserves and resources as defined above are energy, their unit of measurement is joules, or more commonly, megawatt-hours (MWh) after the conversion to electrical energy. In the case where geothermal energy is used as direct heat, the British thermal unit (BTU) is another appropriate unit of measurement. We note that a megawatt (MW, 1 million joules per second) is a rate and is suitable to measure instantaneous energy production, such as the electrical power output from a geothermal plant, but it is not the appropriate measure for our definitions of reserves and resources. Furthermore, although geothermal energy is typically carried as heat by steam or water, which are measured in mass units such as kg or pounds-mass (lbm), the mass itself of steam or water does not represent an amount of energy nor would it qualify as geothermal reserves.

Using the PRMS as a model, we define proved, or P1, geothermal reserves as those quantities of geothermal resources that, by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be commercially recoverable from a given data forward from known reservoirs and under defined economic conditions, operating methods, and government regulations. The term *reasonable certainty* means a high degree of confidence that quantities will be recovered (i.e., at least 90% probability, if probabilistic methods are used). We define probable, or P2, geothermal reserves with the same definition from the PRMS as for oil and gas: those additional reserves that analysis of geoscience and engineering data indicates are less likely to be recovered than proved reserves but more certain to be recovered than possible reserves (i.e., in a probabilistic context, there is at least 50% probability that the sum of proved plus probable (2P) reserves will be recovered). Lastly, we define possible, or P3, reserves with the same definition from the PRMS for oil and gas: those additional reserves that analysis of geoscience and engineering data indicates are less likely to be recoverable than probable reserves (i.e., in a probabilistic context, there is at least 10% probability that the sum of proved plus probable plus possible (3P) reserves will be recovered).

Beyond reserves, additional quantities of geothermal resources may be classified as contingent or prospective. Again using the PRMS as a model, we define contingent geothermal resources as those quantities estimated, as of a given date, to be potentially recoverable from known sources by application of development projects, but which are not currently considered to be commercially recoverable owing to one or more contingencies. Contingencies may include various issues, such as no available market, an operator's commitment or financial ability to proceed with development, uneconomic costs or prices, regulatory barriers, environmental opposition, etc. Similar to how the categories of reserves (i.e., proved/P1, probable/P2, and possible/P3) represent different ranges of uncertainty, contingent resources are categorized into C1, C2, and C3, where C1 corresponds to the same technical certainty as P1, C2 corresponds to P2, and C3 corresponds to P3. It is important to note that, similar to P1, P2, and P3 reserves, the terms C1, C2, and C3 are also representative of incremental quantities.

We define prospective geothermal resources as those quantities that are estimated, as of a given date, to be potentially recoverable from undiscovered sources. Prospective resources are sub-classified with the same nomenclature as the PRMS: 1U, 2U, and 3U. These categories are cumulative quantities and represent low, best, and high estimates, respectively.

As our scope with this paper is limited and the application of reserves and resources concepts to geothermal is still developing, we refer the interested reader to the current PRMS document, where additional terms and guidance are given for hydrocarbons that we believe in many instances are readily analogous to geothermal.

3.3 GRMS Classification Framework and Flowchart

As mentioned earlier, a focus of this work was to examine the suitability of adapting the PRMS to geothermal energy. The complete PRMS document is available from the Society of Petroleum Engineers. While it is beyond the scope of this paper to present every detail of our GRMS adaptation, the two figures below convey some key messages. We remind the reader that this initial GRMS may continue to evolve as more geothermal projects are encountered and evaluated.

Figure 2 below has been adapted for geothermal energy from the PRMS classification framework for hydrocarbons. The matrix shows the geothermal resource classifications and categories as were previously defined in section 3.2, the progression of commercial maturity along the y-axis, and the range of uncertainty in estimates along the x-axis. The figure allows a user to characterize where a particular project lies in terms of development maturity while simultaneously designating the uncertainty in a given estimate.

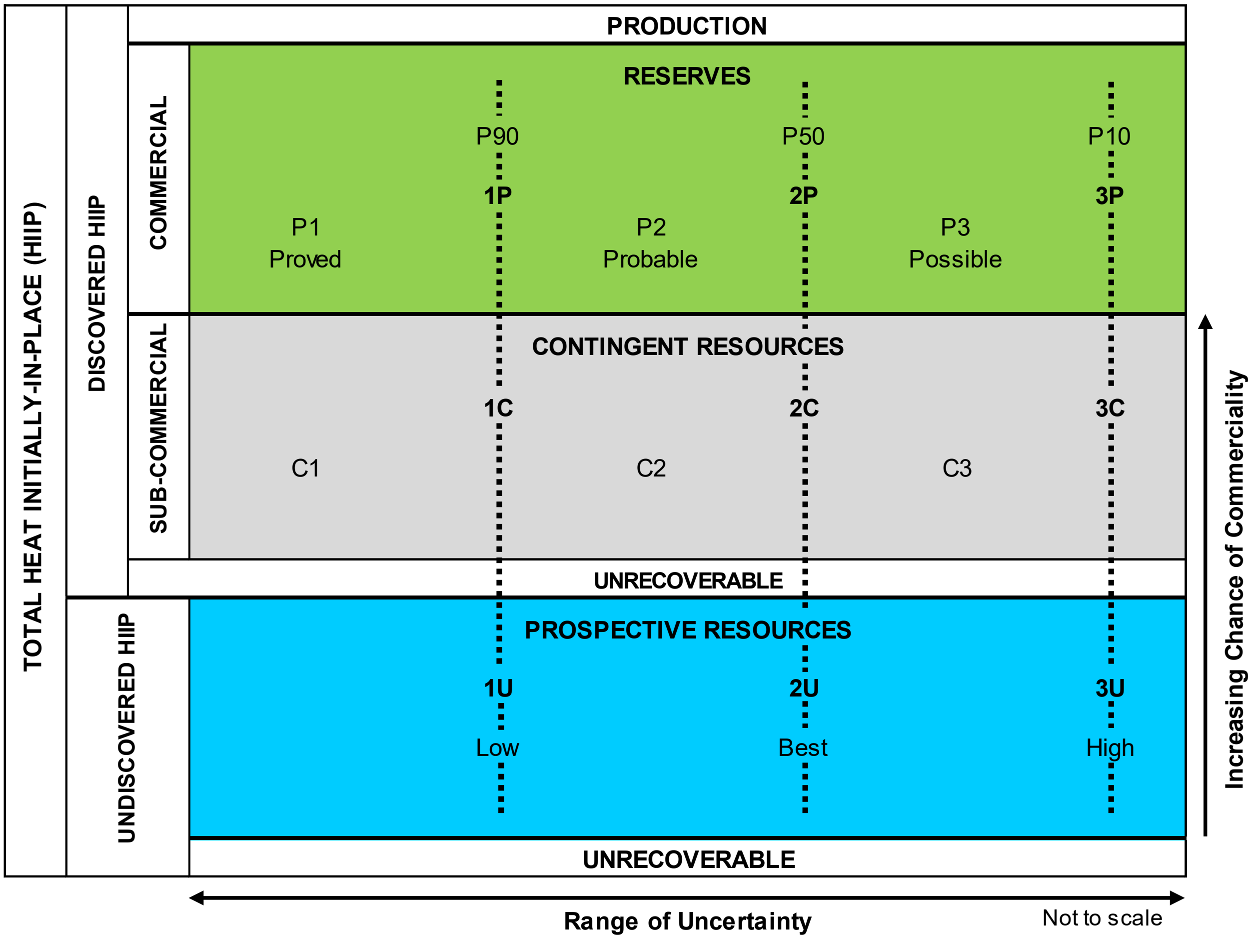

Figure 2: Geothermal resources classification framework (adapted from the SPE-PRMS, page 2).

Figure 3 is adapted for geothermal application from a concept graphic published by the Oil and Gas Climate Initiative, or OGCI (Oil and Gas Climate Initiative 2022). Based on the PRMS structure, the OGCI had originally generated the figure for application to carbon capture and storage. We have further modified it here for use with geothermal resources. The flowchart allows a user to understand and communicate the path that a project follows as it progresses, as well as what hurdles may remain to reach the next level of maturity, all the while utilizing the resource classifications and categories that were given in Figure 2.

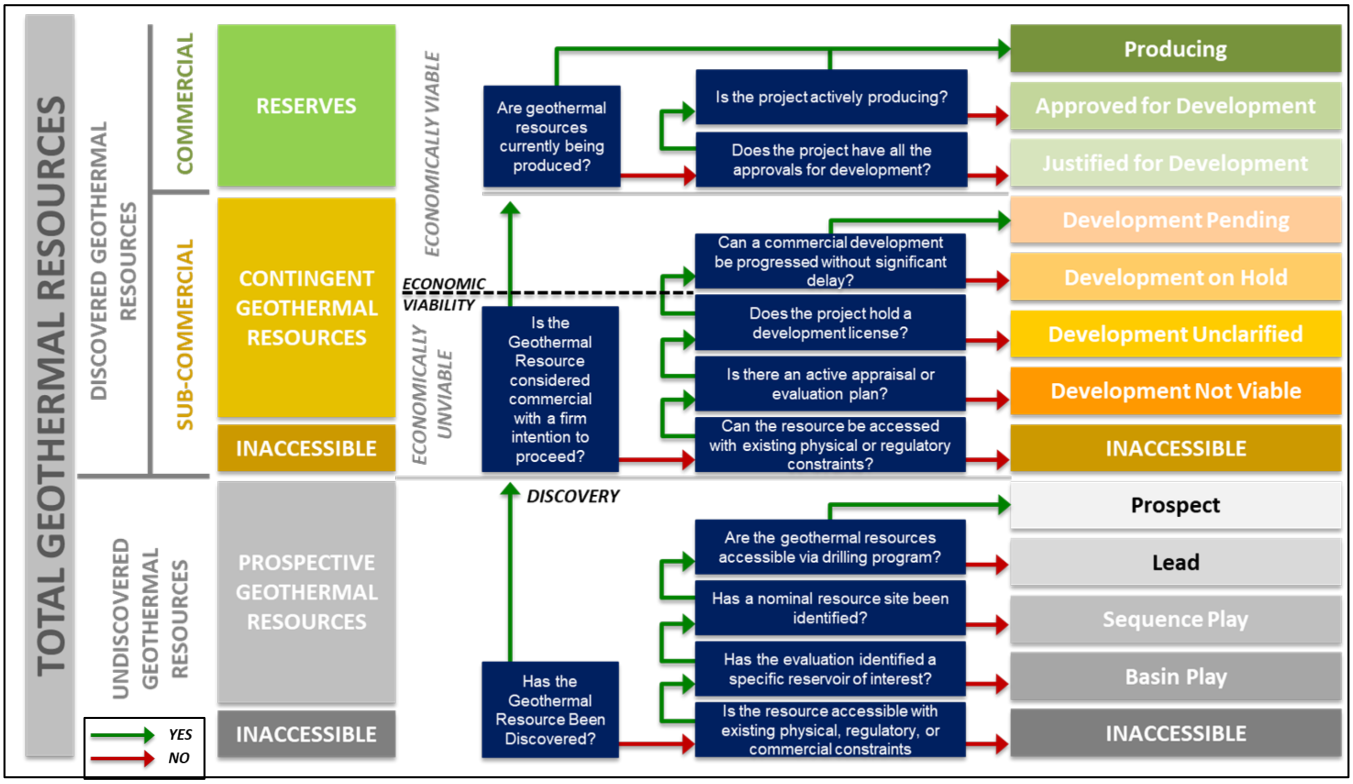

Figure 3: Flowchart for Assigning Project Sub-Classes (adapted from the OGCI CO2 Storage Resource Catalogue Cycle 3 Report, page 16).

4. Conclusions

The U.S. domestic and worldwide geothermal industries have matured with sufficient experience and data to apply formal definitions, methodologies, and protocols for estimating geothermal reserves and resources. Our literature survey and review of existing standards indicated an increasing interest and emphasis over the past two decades in the development of classification standards for geothermal reserves and resources. Yet no single set of standards has become widely accepted throughout the world. The Petroleum Resources Management System (PRMS), the common global standard for hydrocarbons, provides a good analogy for the establishment of a Geothermal Resources Management System (GRMS) and has an important advantage by being familiar to many energy stakeholders. Multiple case studies are ongoing by the authors to test the utility of the suggested GRMS framework. Over time, additional application of the GRMS to geothermal reserves evaluations will help identify and resolve future questions or gaps in the framework.

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