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POTENTIAL OF ADVANCED HEAVY-OIL RECOVERY TECHNOLOGIES FOR FUTURE DEVELOPMENT IN UKRAINE: A BRIEF GLOBAL REVIEW

Heavy oil constitutes one of the most technically challenging categories of hydrocarbon resources due to its extremely poor mobility, elevated viscosity, and high content of resins, asphaltenes, and heavy fractions. These properties significantly limit the efficiency of conventional production techniques and lead to very low natural recovery factors. Nevertheless, heavy oil represents a strategically important component of global energy portfolios, especially in regions where conventional light crude reserves have already reached maturity. For this reason, studying global experiences in heavy-oil extraction and identifying technologies that may be applicable in countries such as Ukraine remain highly relevant and timely directions of scientific inquiry [1].

At the global level, heavy-oil resources are widely distributed across several major sedimentary basins. The largest accumulations are located in Canada's Athabasca region, Venezuela's Orinoco Belt, and selected basins in China and the Middle East [5]. These regions have become centers of technological innovation, where thermal, solvent-based, and hybrid recovery methods have been tested, improved, and adapted over several decades. The global distribution of these resources is illustrated in **Figure 1**, which highlights the scale and geographic concentration of heavy-oil deposits.

Figure 1: Heavy oil global view showing reserves and production strategy being used (Dusseault, 2024).

The sustained development of these regions has led to significant technological progress. Classical thermal methods such as cyclic steam stimulation (CSS) and steam-assisted gravity drainage (SAGD) remain the most widely applied techniques [2]. CSS relies on cyclic injection of steam into the same wellbore, enabling temporary viscosity reduction and improved mobility during the production phase. SAGD, on the other hand, uses a pair of horizontal wells positioned vertically one above another, in which continuous steam injection into the upper well forms a steam chamber, allowing the heated oil to drain into the lower well. Although these approaches have proven effective, they are highly energy- and water-intensive, which has motivated the development of more sustainable alternatives [3].

In recent years, attention has increasingly shifted toward environmentally optimized and low-carbon technologies. Solvent-based processes, such as VAPEX (vapor extraction), aim to reduce energy consumption by relying on injected solvents rather than high-temperature steam. Hybrid processes that combine light solvents with steam or controlled in-situ combustion have shown promise in reducing water use while maintaining acceptable recovery factors. Other emerging approaches include nano-enhanced fluids, low-temperature heating strategies, and techniques enabling improved reservoir contact while minimizing operational footprint [2-4]. Collectively, these innovations reflect the global transition toward more efficient and cleaner heavy-oil extraction methods.

While Ukraine currently lacks industrial heavy-oil projects, geological assessments indicate the presence of viscous hydrocarbons within the Dnipro-Donets Basin and several adjacent regions [5]. These resources have historically remained underdeveloped due to a combination of technological, economic, and infrastructural constraints. However, the accumulated global knowledge provides an opportunity to rethink the potential of such deposits within Ukraine's long-term energy strategy. Instead of replicating large-scale foreign projects, Ukraine may benefit from targeted pilot trials, which would evaluate the adaptability of selected methods to local conditions - such as heterogeneous lithology, moderate reservoir thickness, and varying thermal stability.

Furthermore, integrating global experiences into Ukrainian research practice could support the formation of an effective scientific and technological foundation for future development. This may include laboratory screening of viscosity-reducing agents, numerical simulations of simplified recovery scenarios, and comparative assessment of energy and water requirements for different methods under Ukrainian geological constraints [1, 3]. Such an approach aligns with the broader international shift toward environmentally responsible extraction, where reducing emissions, optimizing energy consumption, and minimizing surface impact have become central priorities [4].

In the long term, the development of heavy-oil resources in Ukraine - if based on well-chosen, scientifically justified, and economically reasonable technologies – could contribute to improving national energy resilience. Rather than viewing heavy oil solely as a technological challenge, it may be considered a potential strategic reserve whose utilization depends on the country's ability to select the appropriate, low-risk recovery schemes. Therefore, systematic analysis, careful method selection, and small-scale pilot implementation are essential first steps toward evaluating the real feasibility of heavy-oil development in Ukraine.

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