CANADIAN OIL SANDS: DEVELOPMENT AND FUTURE OUTLOOK

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I. UNCONVENTIONAL OIL SUPPLIES

The worldwide global demand for oil has grown by 150% since 1965 and 20% in the past 20 years to the current 80 million barrels per day, and is projected to grow by 50% more in the next 20 years [1]. The growth in global demand for oil comes at a time when the supply from relatively cheap conventional sources is declining, and reserves are not being replaced with new discoveries [2]. However, the world has over twice as much supply of heavy oil and bitumen than it does conventional oil. Not including hydrocarbons in oil shale, it is estimated that there are 8-9 trillion barrels of heavy oil and bitumen in place worldwide, of which potentially 900 billion barrels of oil are commercially exploitable with today's technology [3].

Canada alone has, by some estimates, 175 billion barrels of bitumen reserves that can be processed with today's technology, making it second only to Saudi Arabia in proven oil reserves in the world [4]. This figure remains controversial; a more cautious estimate has been of the order of 17 billion barrels as recoverable [5]. Regardless of the 'true' number, it is most important to assess what impact unconventional oil will have on the world oil supply and in what time frame, given the financial, economic, environmental, engineering and technological constraints. In this regard, the Western Canadian Sedimentary Basin, with its declining conventional oil and gas resources and its replacement requiring large investments in higher-risk but vast oil sands resources, provides a vital case study.

II. "TECHNOLOGY OIL"

It is important to consider that the definition of "conventional oil" is not constant. As has been pointed out by Jaccard [6], offshore oil was not considered conventional 40 years ago, and technological development shifts using enhanced recovery techniques, including thermal production, have moved unconventional sources to the conventional category. For example, in the Faja del Orinoco of Venezuela, 10^0API crude can be produced at economically attractive rates using long horizontal well technology, because of the high native reservoir temperatures (60 – 80^0C). In Canada, progressive cavity pumps have made it possible for Cold Production Technology (co-production of oil and sand with foamy oil drive) to produce heavy oil at 10 times higher rates than is possible by conventional means. In California, thermal heavy-oil projects are already mature, having been produced since the 1960's; oil production peaked in 1986 at 480,000 and declined to the current 340,000 barrels per day [7].

While the Canadian oil sands industry should still be considered "unconventional", the past 20 years have witnessed several major successes, all triggered by technological innovations [8]. The Athabasca is the single largest oil sands deposit, occurring from the surface to a depth of 750 m. In surface mining applications at depth of up to 100 m, new technologies include truck and shovel mining, cold-water extraction, slurry pipelining, mechanical separation and the potential recovery of by-products. In *in situ* operations in the Athabasca, Cold Lake, Peace River and Lloydminister deposits, commercial operations have emerged using cyclic steam stimulation, cold production, and steam assisted gravity drainage (SAGD). VAPEX, the solvent analogue to SAGD, is in the piloting phase. Significant advances have also been made in 'enabling' technologies such as horizontal well drilling, multilateral well technology, instrumentation, automation and telemetry, 3-D and 4-D seismic, pumping systems for sand and fluids, and reservoir simulation and prediction techniques.

These breakthroughs have been the culmination of aggressive public and private investments in research and development and field trials, and have led to a heavy oil and oil sands industry on the verge of a major growth period.

The current production of bitumen and synthetic crude oil from the Canadian Province of Alberta averages 1 million barrels a day and, by 2005, oil sands production is expected to represent 50% of Canada's total crude oil output, and 10% of North American production [9]. Given existing and announced investments (over $50 billion U.S.) as well as projects under development, production is expected to triple to 3 million barrels per day by 2020.

III. CONSTRAINTS ON OIL SANDS GROWTH

The oil sands and heavy oil industry in Canada is facing severe constraints that, without new technology, could jeopardize the above growth scenario [10].

There is an increasing cost for natural gas, currently the fuel of choice for steam generation, upgrading, heat, and power. This comes at a time when natural gas supplies have reached their peak and are expected to decline. Currently oil sands operations consume 5% of Canada's natural gas supply. With growth in production and without fuel substitution, it is expected that oil sands operation will be using approximately 1 billion cubic feet of gas per day, or the major part of the Arctic gas expected to come to market over the next 10 years.

There is a significant dependence on water used for separation of oil from the sand in surface mined operations and for *in situ* steam generation. To produce a barrel of bitumen or synthetic oil requires some 10 barrels of water for mining operations and 3 barrels of water for *in situ* operations. Although most of the water is recycled, there is still about 20% of potable make-up water that is required, and this creates concerns over the need for conservation and sustainability.

The amount of energy required to produce a barrel of synthetic crude oil is about a third of the energy in a barrel of bitumen. This makes oil sands operations large single source emitters of greenhouse gases. The need to reduce CO_2 emissions, as concern about climate change grows and reduction targets come into effect; add considerable additional risks to oil sands investments.

The investment costs and time to bring typical oil sands projects into production is also a major risk. Typical mining, extraction and upgrading projects require about $3 billion U.S. investment to produce 100,000 barrels/day of high quality refinery ready synthetic crude oil. The operating cost is typically $10 U.S. per barrel. The time to bring mining projects into production is approximately six years, including engineering feasibility, regulatory approval, equipment purchases, construction and start up. *In situ* operations have the advantage that they can be designed to come on stream in modular fashion; however, the per barrel supply costs are similar to that of surface mined operations.

As production of upgraded oil increases, there is a strong potential for market limitations for exported synthetic crude oil. This is because of the high aromatic content of the synthetic crude oil produced from bitumen, and U.S. refineries are currently not designed to mix more than 10 to 15% into their conventional crude supply to meet end product quality specification.

Despite these challenges, several factors have made investments in oil sands very attractive given world oil prices above about $25 U.S. per barrel WTI. There are no "finding costs" since the oil sands are well delineated. There is ready access to the largest market in the world, the U.S., via established pipelines. New technology has reduced operating costs by at least a factor of two.

IV TECHNOLOGY INTEGRATION – THE KEY TO THE FUTURE

While non-conventional oil is emerging as a new major source of oil, even an aggressive worldwide development scenario can only capture some 10 – 15% of the required new oil supply in the next 20 years. In addition, non-conventional oil by itself cannot make up for the decline in world conventional oil production. Thus, there is a growing recognition that solutions to the pressing global energy needs and the challenges described above emerge when we understand the energy industry as one interconnected system, integrated horizontally along the various energy sources and vertically along the value chain [11].

This integrated energy approach resists the temptation to argue for any one type of solution and assumes that no one single source of energy will be sufficient to meet world demand. Canada, being well endowed with primary energy sources, has one of the largest supplies of hydrocarbons in the world. The country is currently the 5th largest energy producer in the world (considering hydroelectric and nuclear along with fossil fuel production) and is a net exporter of energy. Most of the energy consumed in Canada comes from fossil fuels (oil: 32%, gas: 24% and coal: 13%). Canada also has huge coal resources.

A good example, of technology integration in the oil sands is the Opti-Nexen Long Lake project, which represents the future of Canadian oil sands expansion. This project uses SAGD technology to produce the bitumen, with the interesting feature that no natural gas is consumed to supply the high energy demand for steam injection and upgrading. Instead, the bitumen is deasphalted and the bottoms gasified to produce hydrogen for upgrading the deasphalted crude, steam for SAGD production, along with power and heat sufficient for all operations.

V. THE ENERGY INNOVATION NETWORK

To address the challenges of ensuring an abundant supply of environmentally responsible energy, a process is well underway in Canada to construct a network organization and facilitate a long-term (20- to 25-year) effort to implement an integrated energy innovation strategy.

This collaborative initiative (known as Energy-INet) is being built on the premise that strategic investment in a balanced portfolio of energy innovation – with a focus on common technology platforms and points of leverage across the portfolio – has the greatest potential for returns in economic, environmental, and social terms.

Given the rich diversity of resources available in Canada and in other parts of the world, and the need to maintain a competitive energy supply while ensuring environmental protection, the best investment strategy appears to be at the forefront of shifts in energy systems:

- From a reliance on conventional oil and gas recovery, to emerging unconventional sources such as oil sands and coal bed methane
- From conventional coal burning to near-emission-free clean coal technology
- From a relatively low to a much higher proportion of renewable and hydrogen energy options in the mix of energy production
- From a focus on separate energy sources to an integrated energy system.

The transformative strategy that is being implemented through EnergyINet speaks to an important scenario for the world's future energy economy. The goal is to highlight the innovation needed together with government policies and actions to stimulate such a transition and establish scenarios to inform priority areas for technology development.

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