**Possible New Coal and Bitumen Transportation Options for the Further Development of the Oil Sands Industry of Alberta**

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The great size of the potential resource of the oil sands of Alberta (traditionally placed at the equivalent of a very large 310 gigabarrels of recoverable oil) has long been a tantalizing option for the energy economy of Canada, especially now that the production of conventional light oil from the mature Western Canada Sedimentary Basin is declining at about four per cent per year. Production from this non-conventional source of oil is increasing at some 100,000 to 150,000 barrels per day per year at present. This output should continue to increase steadily over the coming decades and faster if all announced plans are realized. The new techniques designed to recover that portion of the oil sands resource beyond the range of surface mining methods are in the early stages of production, notably the twin-hole Steam Assisted Gravity Drainage (SAGD) system, and other approaches such as VAPEX, usually involving solvents of one kind or another, continue to be assessed. The SAGD method as presently practiced requires at least one gigajoule of energy in the form of natural gas to produce sufficient steam to allow the recovery of one barrel of bitumen.

The National Energy Board in its most recent study on *Canada's Energy Future: Scenarios for Supply and Demand to 2025* [1] notes that the need for natural gas to extract and process the bitumen will grow with the expansion of the industry. More light hydrocarbon diluent will also be required to facilitate the transport of the recovered bitumen by pipeline from those operations without on-site upgrading facilities. At present, condensates derived from raw natural gas are the main source of this diluent. The Board considers that meeting either of these requirements could well prove a limiting factor in the development of the oil sands in the future.

There are growing indications that the production of natural gas from conventional sources in North America is reaching a drawn-out limiting plateau rather than a sharply defined peak. This production pattern may last for some years before steady decline sets in probably no later than 2010. Major new supply options include gas from known Arctic resources delivered by one or two long pipelines, from gas derived from Coal Bed Methane operations within Alberta and possibly B.C., and from gas imported in liquefied form (LNG) to the existing four receiving facilities in the U.S. There are also proposals to build several new LNG tanker terminals to serve the American market, with some located in Baja California in Mexico and at least one in Canada in New Brunswick. Increased conventional production from anticipated eastern offshore resources is also likely though there have been recent disappointments in the exploration field. While the price of gas on U.S. trading markets may well fall from the high levels of some $US 6/1000 cubic feet experienced in the Spring of 2003, there could now be effectively a floor set by the high costs of these other options which is perhaps as high as $US 4/1000 cubic feet.

In this note, the twin problems of the supply of a cheaper energy supply for steam-raising for in-situ operations and the possible lack of sufficient hydrocarbon diluent for pipeline transport of the recovered bitumen are addressed by consideration of other possible transportation options. In essence, a low-cost transportation system is required which allows the delivery of sub-bituminous coal north-bound for steam-raising at the in-situ recovery sites and at the same time provides a means of transporting the recovered bitumen south-bound to up-grading facilities located in the Edmonton refining district without the need for diluent. The distance from these extraction sites to Edmonton is of the order of 500 km with an additional 150-200 km to reach large coal-mining sites southeast of the city. The coal resources are large enough to support such a new market in addition to serving their growing traditional outlet for electrical generation in that Province.

## Conventional Railway Operations

Conventional railway operations are considered first because of the very large quantities to be moved on a regular basis in both directions. There are very few back-haul situations anywhere that are more favourable for efficient rail operations. Moreover, there is now extensive experience in the operation of trains of this class to Pacific Coast ports by both railway companies. A new line could be built with branches to serve several in-situ production sites as they develop. A new roadbed would no doubt be required because of the poor construction standards on the old existing railway that at one time served Fort McMurray but has now been partly abandoned. Such new trackage would lie entirely within the Province of Alberta and thus train operations could be free of the traditional practices mandated by Federal agencies. There is, for example, an automatic crew-less electrically-powered shuttle train operated under comparable severe winter weather conditions at the Carol Lake Mine of The Iron Ore Company of Canada in Labrador though the distance involved is not great. The poor soil conditions in northern Alberta are, however, a major concern in the provision of a roadbed capable of supporting heavy trains. Nevertheless, the advances in the field of soil mechanics over the last decades may allow a suitable base to be built and there would be little trouble on this score in the winter in any case.

In essence, it is proposed that conventional unit trains of about 100 `bathtub'-type cars equipped with rotary couplers, such as have been in service delivering coal to B.C. ports for many years, would move bitumen in one direction and coal in the other. Assuming a 10,000 tonne total load, one train movement a day would service an in-situ operation recovering about 60,000 barrels per day. The return haul would be at least of the order of 3-4,000 tonnes of coal. Passage time in one direction might be about eight hours. The service life of an individual in-situ site would be expected to be 20-30 years but several such sites might occur in clusters that would in effect extend the life of the track as new near-by facilities come into production to replace those being phased out due to depletion. Back-haul traffic will materially reduce the overall unit costs of such operations.

The bitumen loading problem appears manageable but there are two other difficulties that need to be addressed to allow the use of the low-cost heavy-load bathtub cars as opposed to the traditional slow loading/discharge tank cars. The motion of the train may cause the bitumen to become progressively more fluid in a classical positive feedback mechanism. This effect arises from the non-linear effect of an increase of temperature caused by the kinetic energy of shaking upon viscosity. This motion might be kept within reasonable bounds by welding vertical baffle plates within the cars. Looking down at the car, the steelwork would have the appearance of an egg crate or honeycomb. Such an arrangement should dampen the tendency of the bitumen to slosh yet not unduly impair the ability of the car to carry and unload coal.

As far as the bitumen unloading problem is concerned, it is essential that the discharge step be conducted as quickly and as completely as possible as the continuously coupled cars are rotated (usually in pairs) so as to minimize the time of passage of the train through the unloading station. One possibility might be to spray an insulating material on the outside of the rail car and provide electrical heating elements to keep the steel in contact with the bitumen warm thus allowing it to flow freely.

After bitumen unloading, the train would proceed to a conventional top-loading silo at the mine. Since perhaps only about one half the cars are required to move the coal in a given movement, it is possible that the train could be divided into two lengths after half the cars have been unloaded of bitumen to save time. These emptied cars could be taken for loading at the coal mine separately and then re-connected later to the remainder of the cars once unloading is completed at the upgrader site for the return journey north. Because the existing pipeline systems would stay in service, or even be expanded if more diluent becomes available, the north-bound trains have the spare capacity to carry additional coal for steam-raising at some in-situ operations served by pipeline as well.

Based upon current coal movements to the B.C. coast, even with the heavy investment required for a new heavy-duty roadbed and track, the cost of energy in the delivered coal should be well below that of natural gas at $4/1000 cubic feet. Though the cost of moving bitumen by train is no doubt more costly than by pipeline when sufficient diluent is available, there would be no new capital requirement for pipeline construction. The overall cost of the two-way traffic would appear comparable with natural gas at $4/1000 cubic feet and present pipeline costs.

The extra complexity of the combustion of coal as compared to gas under the conditions at in-situ operations is a major uncertainty and could well add as much as $1/GJ to the fuel cost. Opportunities for co-generation would also be more limited than in the natural gas combined-cycle case. Nevertheless, high pressure steam might be generated and expanded in a turbine before proceeding to the underground in-situ operation. It is also possible that carbon dioxide could be captured in the combustion process and be added to be steam in some way for use in the in-situ operation. This gas could promote the recovery of the bitumen and at the same time be at least partly sequestered. It is now important to assess this possibility.

The successful development of such a transportation option means there would be no effective limit on the expansion of the in-situ industry. Nevertheless, nothing in this proposal changes the hydrogen requirement at the upgrading sites in Edmonton still best provided from natural gas.

### Non-Conventional Transportation Possibilities

It is possible conveyors could be considered for this two-way operation. The longest conveyor system (for only one-way traffic) was a 100 km system built in West Africa that never became fully operational because of terrorist attacks. The generally poor experience with conveyors used in oil sands mining operations over the years under the severe prevailing climatic conditions make the efficacy of their use for this purpose doubtful although it might be useful to have an engineering review of this possibility.

The only other option available known to this writer is a device developed in France in the 1960s known as `canalisation mobile'. Two units were installed in New Caledonian for the movement of lateritic nickel ore. The principle was a virtually continuous miniature railway powered from fixed stations mounted external to the track in such a way that no adherence of the supporting driving wheels was required on the track. In essence, it was a railway system operated in the opposite mode to conventional railways. Instead of the passage of occasional trains that only occupied a given point on the track for only a few minutes a day, a very long small train was used which occupied the track much more of the time. Instead of pulling the train from one end which leads to the requirement of a heavy engine to provide sufficient adhesion of the driving wheels to the track, the small railway was powered from the side by horizontally mounted rotating tires pressing on both sides of the train which was coated with sand held in an epoxy coating to increase the friction. In the preferred arrangement, each two-wheel axle assembly was articulated to the centre of the previous axle assembly in the style of the Spanish `Talgo' train. The result was a long but small train that moved snake-like over the tracks. From the top, the train looked like a conveyor built of flexible steel sections with sides that were mounted on the articulated frame.

The advantage of such a system is the light load it places upon the ground in a region of unstable muskeg-like conditions. With its light weight, the entire track system may be readily moved to new locations as required. Loading is from the top similar to a conveyor, but the device may be discharged by rotation though 180 degrees. To unload bitumen effectively, scrapers could be used while the unit was in the upside-down position.

The largest cross-section that could be envisioned is of the order of one square metre which means a train unit of the order of ten kilometres in length to take the entire day's output of 60,000 barrels of bitumen. With the fastest feasible speed probably about 20 kilometres per hour, the train unit would take 30 minutes to pass a given point given this size of load. Nothing prevents several such train units being employed, one following the other.

It may be that a competition should be established to encourage the search for innovative ways to carry out this unique movement so important to the future development of the oil sands.

## Institutional Change in the Industry

A successful rail-based system could also encourage institutional changes in the industry. If the railway access line were operated as a common carrier serving a number of in-situ sites without discrimination, the investment required of a newcomer to enter the industry as a producer of bitumen is substantially reduced since no pipeline construction is required. The on-site extraction activity, whether involving the SAGD or perhaps other innovative techniques, could well evolve to become the operating domain of a number of independent companies specializing in the development and operation of in-situ recovery technology who supply the separated bitumen to the upgrading industry. Such companies might well be small enough to be financed on Canadian venture capital exchanges. It is to be hoped that progress in developing these extraction techniques may be more rapid in the hands of a larger number of smaller agile operators.

The upgrading and refining stages would continue to be carried out by a few large technologically sophisticated companies with access to major markets. These processing units would probably be owned at the international level due to the large capital requirements, their complexity of operation, and marketing considerations. The long-lasting, predictable, and steady nature of their operations likely because of the great size of the resource suggests that investment trusts of one type or another might be a major source of the large capital requirements.

Dividing the oil sands industry into two distinctly different industries is also attractive on psychological grounds. Conditions for those working at the northern sites would be more similar to those at mining operations than chemical ones. Process engineering operations would be conducted in a more `chemical' background in the settled Edmonton region with its many amenities.

## References


1. *Canada's Energy Future: Scenarios for Supply and Demand to 2025*, National Energy Board, 444 Seventh Avenue SW, Calgary, Alberta, T2P 0X8. Released 3 July 2003. (Web: www.neb-one.gc.ca)


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