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THE LONG LAKE INTEGRATED UPGRADING PROJECT: STATUS REPORT and DISCUSSION OF SOOT PROCESSING

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ABSTRACT

The Long Lake integrated bitumen and upgrading project, now under construction by OPTI Canada Inc. and Nexen Inc., is the first application of large-scale gasification in Canada and will be the first gasification project operated in conjunction with a heavy oil recovery and upgrading project. The gasifier component of the project is scheduled to begin operations in the second half of 2007.

The Long Lake Project uses a unique combination of technologies to provide a solution to the natural gas supply and cost issue associated with in-situ bitumen recovery and upgrading. A key component is a gasification facility using the Shell Gasification Process (SGP) which converts the liquid asphaltene by-product of the primary upgrader into hydrogen and syngas fuel. The combination of technologies at Long Lake, including the proprietary OrCrude™ primary upgrading process licensed from ORMAT, results in a unique project that will produce premium synthetic crude at a low operating cost.

The bitumen in the Canadian oil sands contains Vanadium, Nickel, and other metals in significantly larger quantities than occur in most other oils. Through the upgrading and gasification processes that convert the heavy bitumen hydrocarbons to more useful forms, the metals in the crude become concentrated in the gasifier feed and subsequently in the gasifier soot. The Long Lake project will employ a patent-pending process developed using Zimpro® wet air oxidation by Siemens Water Technologies, to process the soot into more valuable forms by destruction of residual carbon, reduction in moisture content, and further concentration of the valuable and recoverable metals.

THE LONG LAKE PROJECT - OVERVIEW

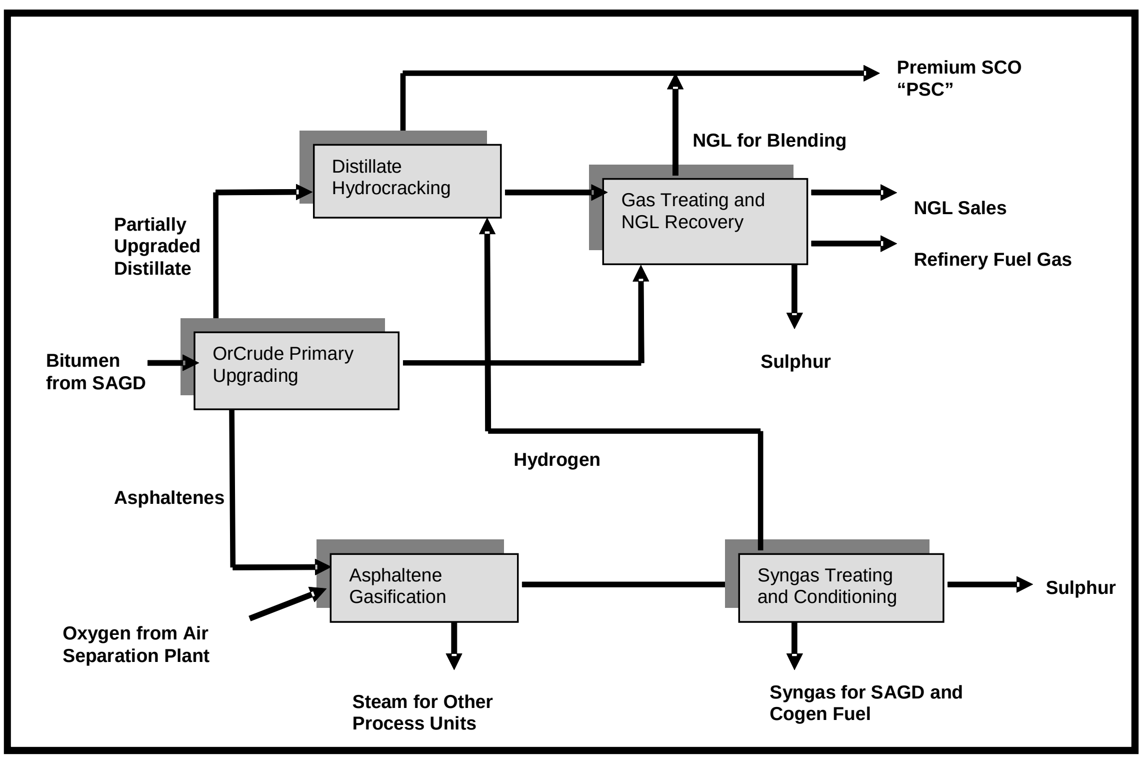
The Long Lake Project was previously described in papers presented by OPTI Canada Inc. (OPTI) and co-authors at the 2002 and 2004 Gasification Technology Conferences.

The project is now in construction, with start-up of the gasifier scheduled for the second half of 2007. In general, the project scope and configuration have not changed from that described in the 2004 GTC paper.

The first phase of Long Lake will comprise 72,000 bpsd of steam assisted gravity drainage (SAGD) bitumen production and on-site upgrading. The SAGD portion of the project will be operated by Nexen Inc. (Nexen), while the upgrader will be operated by OPTI Canada Inc. The primary upgrading at Long Lake is accomplished using OPTI's proprietary OrCrude™ process, which was previously described in detail in the prior GTC papers. The OrCrude unit converts the raw bitumen into a bottomless, sour synthetic crude and a stream of heavy, liquid asphaltenes. The sour OrCrude product is fed to a hydrocracker (licensed from Chevron Lummus), where it is further upgraded to a sweet synthetic crude with premium properties. The asphaltenes from the OrCrude unit are fed as a liquid into the gasification system (licensed from Shell Global Solutions International BV).

The integration of the three main components of the Long Lake Integrated Upgrader (OrCrude primary upgrading, liquids asphaltene gasification, and hydrocracking of the OrCrude product as shown in Figure 1) is a unique, proprietary and patented advantage of the OPTI / Nexen configuration. A key advantage of the Long Lake Integrated Upgrader configuration is the integration of an asphaltene gasification unit into the upgrader system to provide hydrogen to the hydrocracker and fuel for power and steam generation.

Figure 1: Long Lake Integrated Upgrader – Block Flow Diagram



LONG LAKE GASIFICATION UNIT CONFIGURATION

The Long Lake Project uses a Shell-licensed gasification system with four 1033 tonne/day (each) gasification reactor trains, each with dedicated syngas coolers generating 7700 kPa(a) steam. The steam from the syngas coolers provides steam for the operation of other process units, along with steam from other sources.

Cooled syngas from all four gasification units is combined and treated in a single UOP-licensed Selexol™ gas purification system. After treatment, most of the syngas is directed to a Linde PSA unit for recovery of hydrogen. The Upgrader's hydrogen requirements are lower than the quantity of native hydrogen in the syngas, therefore no CO-shift is required. The tail gas from the PSA flows directly to users (primarily steam generators) without compression. Since no CO-shift is employed, the tail gas has low CO_2 concentrations and thus a BTU/scf content that is approximately the same as unshifted syngas.

The Long Lake Project also incorporates two General Electric (GE) 7EA gas turbine generators in a cogeneration system. The gas turbines will operate on syngas (high pressure syngas, compressed PSA tail gas, or mixtures of both), natural gas, and mixtures of syngas and natural gas. NO_x suppression is provided by steam injection.

The gasification system will normally operate with all four gasifiers running at less than 100% capacity, with the feed rate following the asphaltene production rate from the bitumen being upgraded in the OrCrude unit. During periods when one of the gasification reactors is out of service, such as for burner maintenance, the remaining reactors will increase throughput to their maximum capacity. The syngas from the operating gasifiers will be directed to the PSA unit, which will be able to recover sufficient hydrogen to meet the hydrocracker requirements.

A key advantage of the Long Lake Integrated Upgrader is that the proprietary OrCrude process accomplishes the carbon rejection step by producing a liquid asphaltene stream. This feedstock allows use of a liquid-feed gasifier design, which offers large capital cost advantage over solid-fuel gasification configurations. In addition, the integration with the SAGD operations, the selected severity of hydrocracking, and the amount of cogeneration, all support a material and energy balance that avoids the expense of syngas shifting, CO_2 removal, or significant PSA tail gas compression.

PROJECT SCHEDULE AND STATUS

As of September 2006, the project is on track for a 2007 start-up of the upgrader, including the gasification unit. Some of the key metrics of the project's status are:

- Detailed engineering complete
- Major equipment procurement is complete
- Module delivery (from the extensive off-site module fabrication activity employed for Long Lake construction) is complete for the SAGD and nearing completion for the upgrader.
- On site construction is over 85% complete for the SAGD and over 60% complete for the upgrader.
- SAGD well pair drilling is 100% completed.

The Long Lake lease and additional oil sands leases owned by the Long Lake partners contain sufficient resource for several additional phases of integrated SAGD and upgrader development. OPTI and Nexen Inc. are moving forward on plans to develop three additional 72,000 barrel per day developments utilizing the same configuration as Phase 1. Regulatory approvals for a second upgrader at the Long Lake site are in place and the regulatory process for an additional two phases of SAGD production at Long Lake South are underway. Engineering and procurement activities for the second integrated development have commenced with a planned on-stream date of 2011, with subsequent phases planned to follow at two year intervals..

SOOT PROCESSING AT LONG LAKE

Gasification processes convert a hydrocarbon feedstock – in the case of Long Lake, a heavy liquid – primarily into syngas. A small amount of carbon, along with all the non-hydrocarbon components in the feed, exit the gasifier as particulates with the syngas. These soot particles are scrubbed from the syngas in a water wash section. The resultant soot slurry is delivered to filter presses for recovery and recycling of the scrubber water, and solids concentration of the soot.

The bitumen in the Canadian oil sands contains Vanadium, Nickel, and other metals in significantly larger quantities than occur in most other oils. Vanadium, for example, is present at a rate of about 2.5 ounces of V2O5 per barrel of bitumen. (As a note, the metal industry standard is to quote Vanadium quantities as the V2O5 oxide form, regardless of the actual form of Vanadium present. The Vanadium compounds present in the bitumen and in the soot are several, and may not actually include the form V2O5.)

Through the upgrading and gasification processes that convert the heavy bitumen hydrocarbons to more useful forms, the metals in the crude become concentrated in the gasifier feed and subsequently in the gasifier soot.

Soot from the SGP process has a small sized, highly porous structure. Soot slurry does not dewater easily, and exhibits very high viscosities at very low (e.g. < 5%) solids concentrations. Typical SGP units exhibit ~15% solids content in soot filter press cake. At Long Lake the resulting filter cake is expected to have approximately the following properties:

Amount:	300 tonnes per day (wet basis)
Solids Content:	~15% solids
Composition (dry basis):	~ 80% C ~ 13% Vanadium (as V2O5) ~ 3% Nickel (as Ni) ~ 0.4% Molybdenum (as Mo) Balance is Fe, Si, and other inerts

The quantity of valuable and recoverable metals in the Long Lake soot is on the order of US$40 million per year at current prices. However, the large amount of carbon and water in unprocessed gasifier soot, and the remote Long Lake location, results in transportation costs to potential buyers that substantially erode the economics of sale of the native soot. Given the plans for additional phases of upgrading, including gasification, by the Long Lake partners, a cost effective means of processing the soot on site was pursued.

SOOT PROCESSING AT LONG LAKE

Past presentations at the Gasification Conference and in other forums have described the variety of methods that have been used or considered for further processing of soot. One option that has been used at SPG installations is drying and combustion of soot in a multi-hearth furnace to produce a dry, low carbon material that is subsequently sold to metal processors. The unique opportunity at Long Lake, including the planned expansions of installed capacity, led OPTI to investigate and subsequently decide to implement a wet air oxidation unit for soot processing.

The Long Lake project will employ a Zimpro® wet air oxidation process, supplied by Siemens Water Technologies, to process the soot into more valuable forms by destruction of residual carbon, reduction in moisture content, and further concentration of the valuable and recoverable metals. The proprietary patent-pending process was jointly developed by OPTI and Siemens Water Technologies (formerly U.S. Filter Zimpro, Inc.).

WET AIR OXIDATION PROCESS

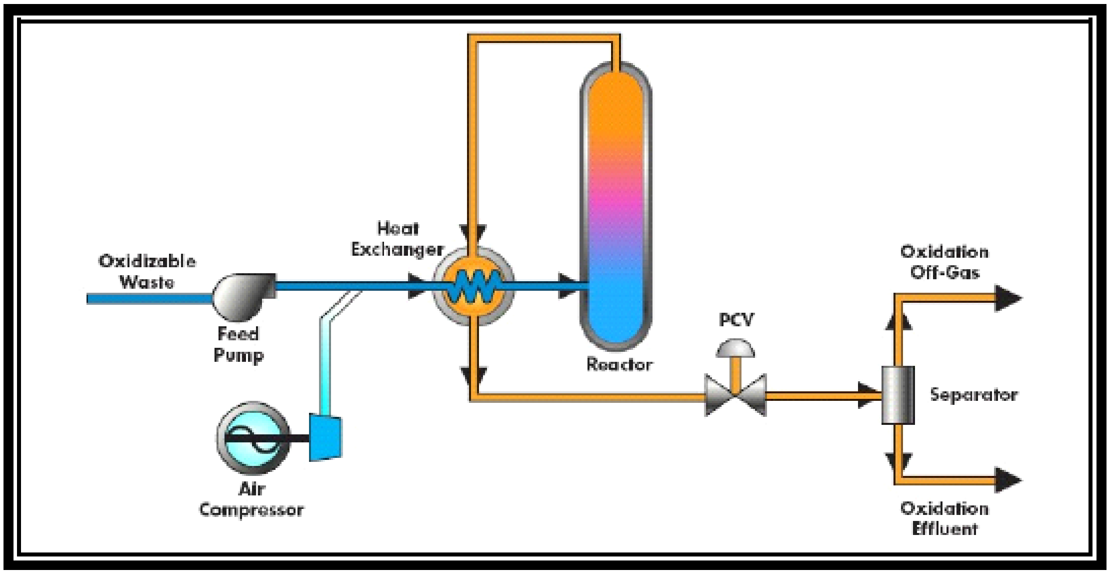
The wet air oxidation ("WAO") process is an aqueous phase oxidation of organic compounds or oxidizable inorganic compounds that is accomplished at elevated temperatures and pressures. This process has been utilized for treatment of a wide variety of wastewaters as a pretreatment step or for subsequent discharge, or for treatment of process liquors for recycle/recovery. Commercial WAO systems have been designed for a wide range of operating temperatures; 150 to 320°C (300 to 608°F) and over a wide range of pressures, 1035 to 22,000 kPa (150 to 3200 psig). Full scale systems have been installed and operated using air or pure oxygen as the oxygen source gas for the oxidation process.

A simplified general flow diagram for the Zimpro® WAO process is shown in Figure 2. In this flow scheme, the influent aqueous stream is brought to the pressure of the WAO system using a high-pressure pump. Compressed air or pure oxygen is added to the pressurized aqueous stream down stream of the high pressure pump. The pressurized aqueous stream and air mixture is heated in a process heat exchanger to a temperature sufficiently high enough to initiate the WAO reactions. The WAO reactions are exothermic and the heat of reaction, which is generated in the reactor, will raise the temperature of the mixture to a desired value. The aqueous stream is retained in the reactor for a sufficient period of time to achieve the desired degree of oxidation.

The WAO effluent from the reactor is cooled in the process heat exchanger, or a heat exchanger supplied with a cooling medium, before it is discharged through a pressure control valve into a separator. The off gas is separated from the WAO liquid stream in the separator. Treatment of the off gas may be required in a downstream off gas treatment unit depending on its composition and the requirements for discharge to the atmosphere. For wastewater applications, the wet oxidized effluent is commonly discharged into a biological wastewater treatment plant. When WAO is applied to process liquors, the oxidized liquor is typically recycled back into production processes.

In the case of Long Lake, the effluent is partially recycled with the balance initially diverted to deep disposal wells. Alternatively, the effluent can be processed for additional metals recovery and water recycling.

Figure 2: Zimpro® WAO process – Basic Flow Diagram



SUMARY OF TEST RESULTS

The Zimpro® WAO process routinely uses bench scale and pilot scale demonstration units for developing and demonstrating new applications of this technology. For the Long Lake application, the testing program included over 350 different test conditions in bench and continuous pilot plant tests. Since the gasifiers at Long Lake will not be in service until 2007, the pilot tests were conducted with SGP soot from other gasifiers, with metal compounds added to reflect the higher metal concentrations of the Long Lake feedstock.

Both bench scale autoclave testing and continuous flow pilot testing demonstrated that very high volatile solids (primarily carbon in the case of SGP soot) destruction can be achieved in the soot slurry using WAO. The pilot program also defined potential problematic operating regimes to avoid, and provided key data for detailed design of the Long Lake WAO units.

Among the results of the extensive testing program are the following:

- Carbon destruction rates as high as 98% could be achieved under commercially reasonable operating conditions

- Residence time and temperature options could have material impacts on carbon destruction rates.

- The use of either air or oxygen were evaluated, with air being selected as the oxidant

- The existence of the metals in the soot contributed to catalytic activity that improved the oxidation reaction

- The addition of pH adjusters (such as nitric acid or soda ash) could have an impact on the carbon destruction rate as well as the amount of metal that would go into solution in the WAO effluent. The ability to manipulate the amount of soluble metals is important since some have catalytic activity and can greatly enhance the performance of WAO. In addition, solubilizing metals may be beneficial in downstream metal recovery processes.

- Severe corrosion could result from improper operating conditions

- WAO effluent exhibited greatly improved settling and filterability relative to SGP soot, with filter cake demonstrating solids concentrations greater than 25%.

- A portion of the WAO effluent filtrate could be effectively recycled to the WAO feed preparation system, thereby reducing water consumption in process.

LONG LAKE WAO CONFIGURATION

At Long Lake, the WAO system will be configured as shown in Figure 3. The system is comprised of the following major components:

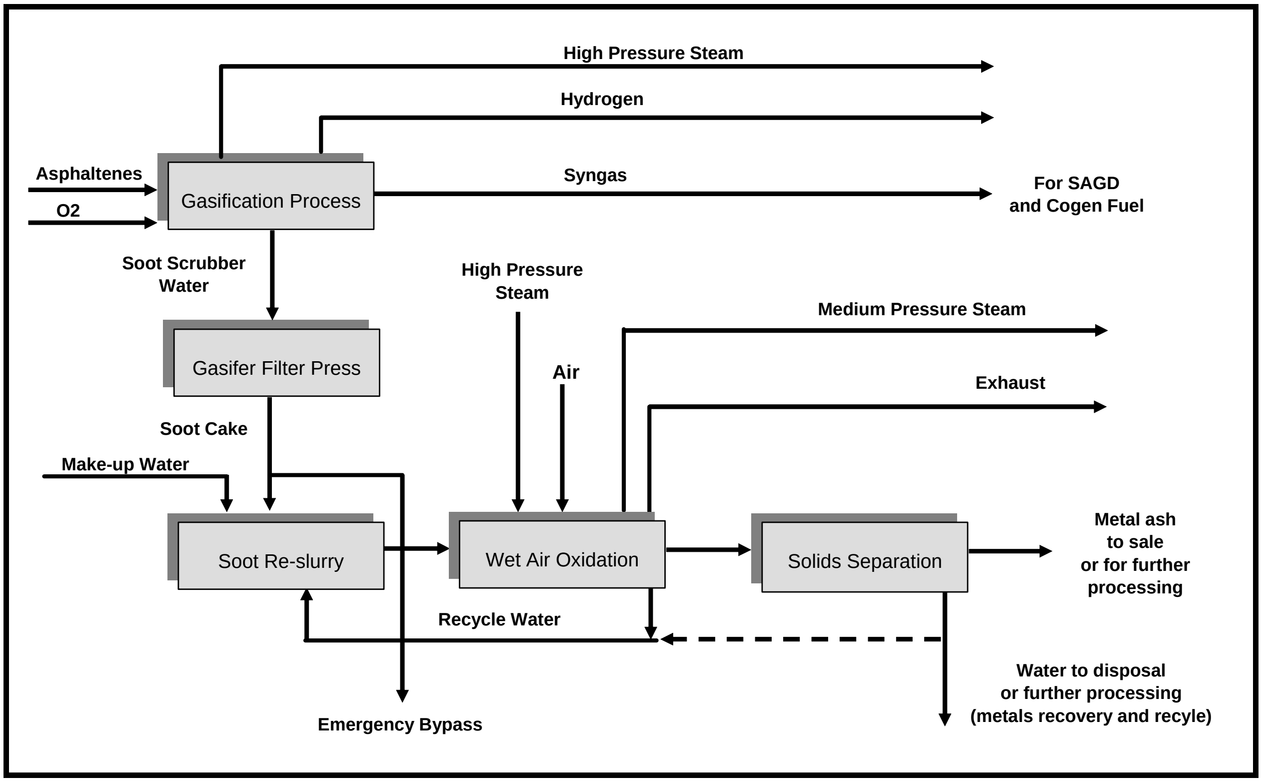
- Feed preparation, including re-slurrying of the gasifier filter press cake to the optimal slurry concentration for the WAO process

- Two WAO reactor systems, with feed-effluent heat exchangers and generation of export steam from the oxidation reaction

- WAO effluent filtration, with bagging of the filter cake, and partial recycling of the filtrate to the initial slurry stem

- Supply of compressed air to the WAO system, with the WAO compressors capable of providing start-up air to the SGP gasifiers

Figure 3: Long Lake WAO Configuration – Block Flow Diagram



During the Long Lake pilot test program, OPTI and Siemens Water Technologies identified several opportunities for further improvement in the application of the WAO process to SGP soot. OPTI plans to further investigate such opportunities following start-up of the Long Lake gasifier and WAO system.

In addition to the testing with Siemens Water Technologies, OPTI undertook additional pilot testing of WAO filter cake and effluent for metals recovery. Those pilot tests demonstrated that the metals in the soot could be recovered using standard hydrometallurgical techniques. Further testing is contemplated following operating of the Long Lake WAO system. Given the large quantity of Vanadium and other metals that will result from the planned additional phases of development by the Long Lake partners, on-site metals recovery to finished grade materials may be cost effective.