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External Reviewer Form

Proponent Name:	**JETRO/METI**
Proposal Title	**Feasibility Study for the "Phase I ABL Project"**
Date Reviewed:	**21-Aug-2009**

SECTION ONE: TECHNOLOGY OPPORTUNITY & COMPETITIVE ANALYSIS

External Reviewer Comments:

1. Technology Gaps:

- The ABL proposal used a mix of hydrocarbons and heavy oil in agglomeration technology to produce coal agglomerates from low rank coal, heat the coal agglomerates from 350 - 450°C to synergistically produce quality distillates from the deposited asphaltene.
- It was also claimed that significantly more distillate can be produced in coal-oil co-processing. There is no technical data to substantiate such claim. Neither is there any scientific data to claim that asphaltene deposited on agglomerated coal can be converted to distillate because coal acts as a hydrogen donor. In the first place, coal has much less hydrogen content than asphaltene and even if it can donate hydrogen, the amount of hydrogen donated is far less than what is needed to stabilize the "de-polymerized" asphaltene.
- The project proponent also claimed in one of the US patents that the coal mineral may catalyze the de-polymerization of the asphaltene. But there is no analytical data to support that the distillate is from asphaltene. Depolymerization of asphaltene, if there is such a possibility, will require very strong acid. Moreover, the agglomeration process has removed much of the mineral matters from the coal.
- This ABL co-processing concept has a similar technical misunderstanding as the Gulf Donor Solvent process previously demonstrated and failed completely at the facility in IFP France back in the late 1980s. The Gulf Donor Solvent process used hydrogenated hydrocarbon to donate hydrogen during the upgrading of heavy oil. Even with 2/3 of solvent and 1/3 of heavy oil, the Gulf process coked badly at less than 50% resid conversion. There simply is just not enough hydrogen to stabilize the cracked molecules.
- The ABL proponent also provided two reports: (1) **Benchscale Development of Coal Oil Co-processing Technology: Effect of Coal Concentration on Reactivity** and (2) **Section 4 - Coal-Oil Co-processing**. These reports are

credible as the tests were done in relatively large continuous flow pilot plant tests operated for 30 days or longer. However, the results contradict the theory that the ABL coal-oil co-processing can produce distillate from deposited asphaltene. Distillates were produced from coal oil processing in the HRI pilot plant reports because of the 3 to 5.3 wt% of hydrogen (on dry ash free basis) consumed in the process. This amounts to between 2500 to 5000 standard cubic feet of hydrogen for each barrel of distillate generated. It did not include the hydrogen required in secondary hydrotreating. Moreover, the conversion of coal to distillate in these reports needed 3000psig hydrogen pressure, >420°C, highly active supported catalyst in ebullated reactor (some used two reactors in series), and hydrogen flowrate >5000 standard cubic feet per barrel of hydrocarbon feed and long reaction time. All of the distillates generated from coal-oil co-processing have lower quality than distillate from heavy oil upgrading alone. Coal-oil co-processing distillates all have higher liquid density, lower hydrogen content than distillates from heavy oil alone. The only rationale that can lead to the distillate yield observed by the various cited patents and agglomeration tests is potential experimental error. This is simple to explain. No proper account of material balance, very small sample size and crude experimental setup, improper measurement of actual agglomerate temperature during heating. The actual temperature in a reactor can be very different from one measured by just a single thermocouple in an oven.

- The ABL project aims to develop a technology that claim to significantly reduce the cost of producing quality liquid fuels from oil sands ore by using technically advanced and environmentally-friendly energy conversion process. In Figure 1 and the text, the application indicated "*up-grading hydro-treatment*", but did not identify what technology will be used to separate the asphaltene from the heavy oil, what technology will be used to produce synthetic crude oil (SCO) from the de-asphalted oil (DAO). DAO cannot be easily hydro-treated or hydro-cracked because it still contains significant amount of 525°C+ liquid. The same technical challenge applies to co-processed oil (CPO) since it has very low hydrogen content and significant aromatic and naphthenic compounds. The infrastructure cost of upgrading heavy oil is high and well documented by cost overrun reports issued by OPTI, Shell Scotford refinery, PetroCanada, North West Upgrading.

- Assuming ABL will be using conventional hydrotreating and hydrocracking technologies to produce SCO and CPO, ABL proposal offers no new technology here to address the technology gap needed to cut the cost of upgrading. As the evaluator has consulted for 7 refineries throughout the world that has LC-Finer or H-Oil ebullated bed hydrocracker, even with multiple ebullated bed reactor in series operating at 3000 psig hydrogen pressure and fresh catalyst addition of 0.45 pounds per barrel of black oil feed, hydrocracking DAO is a challenge. The BP Texas City refinery is the only LC-Finer unit (3 trains each with 3 reactors in series) that process DAO. And it has never operated as designed because of severe fouling and high catalyst deactivation rate.

- The ABL proposal and the review completed by Dr. Yousuke Maekawa believe that injecting DME as the solvent will solve the problem of poor

performance reported in steam-solvent SAGD operations. Applying DME in SAGD to recover bitumen and heavy oil will face the same technical challenges experienced in current SAGD demonstration projects. Field SAGD demonstrations performed poorly largely because of poor matching between actual geology and computer model. Issues such as ground water, heterogeneous reservoir, less than anticipated ore thickness, and emulsion in produced water are some of the factors negatively impacting SAGD operation. Aside from the lack of understanding in bitumen and heavy oil recovery challenges, the ABL proposal did not address DME's water solubility issue. DME is a costly chemical because of the high infrastructure capital cost needed to produce syngas and gas clean up, reactors and separators for producing the product. DME is priced as high as commercial diesel. Injecting into a reservoir, much DME will be lost in the reservoir, ground water, and any produced water because of its solubility. The proposal completely ignores the need to remove produced solids in the recovered bitumen and no provision for post production treatment of the produced bitumen and infrastructure needed.

- The ABL proposal used "solid fuel" as feedstock for gasification. This is an unnecessary complication for the purpose of producing syngas. Gasifying the low rank coal alone or with the asphaltene will cost less as additional process is needed to produce the agglomerated coal. This whole concept of gasifying hydrocarbon to produce DME is nothing new. It does not address the technology gap needed to reduce cost or cut greenhouse gas.

2. Understanding of Context & Scope:

- For continuity, much of the discussion in item 2 has been discussed in item 1 under "Technology Gap".
- The ABL application did not demonstrate an understanding of the context and scope of the technical problem. The technical and economic challenges of heavy oil upgrading were not addressed in the document.
- It should be noted that one cannot produce liquid distillate from simply heating asphaltene deposited on coal to generate liquid distillates having higher hydrogen content than both feedstock (coal and asphaltene) without adding significant amount of external hydrogen. This runs contrary to fundamental principles of chemistry and physics. Most distillates observed by the proponent's work have to come from the diesel and lighter components in the heavy oil. Higher than expected distillates was generated because of excessive heating temperature (>450°C) causing thermal cracking in the asphaltene and evolution of coal tar from the coal. Detailed analytical data may show the low hydrogen content and high aromatic concentration in the observed distillates confirming the presence of coal tar.
- The ABL application does not address the challenges facing SAGD and the causes for poor field performances. The proposal on using DME to recover heavy oil or producing DME from solid fuel and the whole train concept is technically and economically unsound.

3. **State-of-the-Art Advancement:**

- In heavy oil upgrading area, upcoming commercial processes such as the ARC (HC)3 – licensed to Headwaters Technology Inc., Snaprogetti's EST (Eni Slurry Technology), Chevron's CASH (Chevron Advanced Slurry Hydrocracking) are built around molecular and nano catalyst, understanding of asphaltene chemistry and how to achieve high conversion with proper transfer of needed hydrogen without forming coke to foul the process units.
- In producing alternate fuel from coal, advances are made in gasification and using advanced Fisher Tropsch technology focusing on catalysis, compact and cost efficient processing equipment with much reduced capital cost to produce higher value chemicals such as alcohols, waxes, paraffins, DME. Research on direct coal liquefaction and coal oil co-processing is focused on nano catalysis and process simplification.
- In SAGD research, operators are learning why field trials perform poorly and what need to be done to better understand and model the geology of reservoirs.
- The ABL proposal has little technical content or new ideas that can help to advance the state of the art and generate economic value.

4. **Fine-tuning or Breakthrough:**

- The ABL proposal has little scientific and technical content. The proposal is technically unsound and has no scientific basis.
- As stated earlier, one cannot produce liquid distillate from simply heating asphaltene deposited on coal to generate liquid distillates having higher hydrogen content than both feedstock (coal and asphaltene) without adding significant amount of external hydrogen.
- Please see write up on 'Technology Gap"

5. **Uniqueness & Advantages:**

- The ABL proposal did not describe any competing technologies.
- In Chapter 2, the proposal just superficially cites many established commercial processes it will use (gasification, DME manufacturing, co-generation plant). It never discussed any co-processing technologies.
- In SAGD, it simply proposed to substitute DME for current proposed solvent such as propane or butane. It also failed to understand why SAGD failed to perform in current demonstration projects.

6. **Competing R&D & Synergies:**

- The ABL proposal did not describe similar R&D being done elsewhere. Although it provided a letter from UNICO International Corp that claim confirmation of the Agflotherm process in their test. However, there is no report to substantiate the claims. The letter claimed they converted 90% of the petroleum vacuum residue into distillable oil. It did not provide any

technical data on the composition and boiling point distribution of this distillable oil. As an example, coal tar is considered distillable oil, except it has very high boiling points and full of aromatic and poly-aromatic components that is extremely difficult to upgrade into transportation fuels like diesel.

7. SWOT Analysis:

Strengths: None that can be identified because of the lack of ingenuity and technical content in the proposal.

Weaknesses: No technical merit on proposal. No scientific basis on proposed coal-oil co-processing concept. No understanding on issues facing SAGD. No credible technical idea in the proposal.

Opportunities: No hope of any market opportunities because there is no technology or new or relevant ideas being proposed.

Threats: Extremely weak proposal without technical and economic merit.

SECTION TWO: ECONOMIC, ENVIRONMENTAL & CLIMATE CHANGE BENEFITS

External Reviewer Comments:

8. Markets Needs Identified:

- There is no technology or sound scientific concept in the ABL proposal.

9. Potential Clients Identified:

- The proponent identified some Japanese companies. It is not clear if these clients provided any clear support.

10. Exploitation Strategy:

- Very vague and general statements appear in the proposal. As there is no technology in the proposal, this topic is irrelevant.

11. Potential Benefits:

- In Figure 3.16, a pie chart shows the product values generated by ABL 300,000 BPD plant. This figure is meaningless because there is no technology being proposed here. DME is a commercially operated process. The SCO will never have the value as projected because it uses conventional refining technology and the capital cost will be high and return marginal. The CPO will never come to fruition because there is no technology.

12. Have Benefits been Quantified?

- Some information generated from numerical analysis is provided. The information is not relevant since there is no technology in the proposal. One

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must appreciate that computer modeling information is as good as the data used to do the numerical analysis.

13. Have Pollutant Emissions been Quantified?

- The computer modeling generated information on pollutant emissions. The information is meaningless since there is no technology in the proposal. One must appreciate that computer modeling information is as good as the data used to do the numerical analysis.

14. Have GHG Emissions been Quantified?

- Computer modeling generated information on GHG emissions. The information is meaningless since there is no technology in the proposal. It assumes that the DME will solve the issues of poor performance in SAGD. The reviewer does not believe that DME will perform as anticipated because the proponent lacks the understanding on issues limiting SAGD performance. One must appreciate that computer modeling information is as good as the data used to do the numerical analysis.

15. Your Assessment of Economic, Environmental & Climate Change Benefits:

- There is no economic, environmental & climate change benefits. The ABL project has no technical merits. If the project goes ahead, it will actually cause financial loss, damage the environment and climate.

OVERALL RECOMMENDATIONS

External Reviewer Comments:

- The ABL proposal has no technical merit. The claim that coal can donate sufficient hydrogen to convert asphaltene into distillate at 350°C+ temperature without hydrogen pressure or active catalyst in the ABL coal-oil co-processing concept is not supported by fundamental principles. The proposed coal-oil co-processing concept is in total contradiction to credible data from numerous continuous pilot plant studies on coal oil co-processing. These results showed that very severe processing conditions (high hydrogen pressure, expensive solid catalyst, high reaction temperature, long reaction time) and 2500 to 5000 standard cubic feet per barrel of hydrocarbon feed (3 to 5.3 wt% hydrogen on the basis of hydrocarbon feed) must be used to generate distillates. The ABL proponent provided the reports cited above.
- In relation to SAGD, the issue of simply substituting DME, which is as expensive as diesel, as the solvent for recovery of heavy oil will not improve heavy oil recovery. It will create another set of bigger problems such as loss of DME in reservoir and produced water.