EKS Technology Development Program
EKR-DT Process
Process Optimisation Program

COSIA Presentation

Questions and Answers

May 30, 2017

This document addresses some of outstanding questions that are related to the EKS presentation to COSIA's Tailings Table on May 25, 2017. Each question is followed by an answer. EKS will provide further details if requested to do so.

Technical Questions

1. ***EKS has been testing their technology since 2010. How have you all of a sudden been able to achieve such large improvements in energy efficiency?***
   Answer: EKS has been able to continually improve the energy efficiency of the EKR-DT process throughout the course of its technology development program. Over the last 24 months, EKS has made major advances in the design and operation of the process. Many of these advances have been driven by the EKR-DT commercial deployment strategy. The results of the C-FER tests also have provided important insights that played a key role in new innovations.

   These technological advances have been validated by the results of the commissioning test. Further improvements in energy efficiency are expected over the course of the process optimisation testing program that is currently underway. In summary, these improvements in energy efficiency are not sudden but rather are the result of an intensive and informed technology development process.

2. ***Why were you able to achieve over 60% solids in the commissioning test but were not able to do so with the much larger scale test at C-FER?***
   Answer: The C-FER test was designed to dewater to 50-55% solids. The C-FER test successfully achieved this dewatering target. Dewatering to 50-55% solids was the key dewatering target at the time the C-FER test was being designed.

   Midway through the C-FER test, EKS was asked to run the test longer. The idea was to see if >60% solids could be achieved. The results demonstrated clearly that this higher level of dewatering was not possible with the design of the C-FER test. This finding was important for modifying and advancing the design and operation of the EKR-DT process.

If the C-FER test was being designed today and the dewatering target was >60%, the design and operation of that test would be quite different and achieving this target could be assured. The design and operation of the electrodes and power supply system with the C-FER test were not capable of achieving >60% solids.

3. ***The final densification pattern is perplexing and is contrary to the basic physics governing the EKR-DT process. The highest density should be present around the anodes. How do you explain this unusual pattern?***

   Answer: Anode conservation (i.e. ensuring that the anodes remain fully function over the course of the dewatering process) has been a major focus of the EKS technology development program. The applied power schedule for the commissioning test was designed to reduce the rate of consolidation around the anodes and to slow the rate of dehydration; critical requirements for anode conservation.

   As well, the design of the EKS test apparatus is unique. A considerable volume of FFT lies below the anodes. The presence of this material provides a much more realistic test environment. When the EKR-DT process is deployed in a tailings pond, FFT will be lying below the suspended anodes tethered below the floating cathodes. Water from below the anodes will flow upward during the dewatering process into the zone between the electrodes. Indeed, EKS is developing efficient means to optimise this upward flow of water. This upward flow of water is not simulated with other test apparatus designs nor is this simulated with standard consolidation models. This upward flow of water is a key consideration in the modelling and operation of EKR-DT systems. This upward flow of water is partially the reason for the observed densification gradient.

   The results of the commissioning test confirm the results of the EKS modelling and demonstrate that prudent application of the applied power over the course of the dewatering process can affect significantly the density gradients that form during the dewatering process. The results of the ongoing process optimisation program will provide EKS with a detailed understanding of the best way to design and operate EKR-DT systems to eliminate the risk of anode failure, to optimise the dewatering of FFT below the anodes and to achieve a desired final density gradient.

4. ***The energy consumption rates you are reporting are based on one test only. Do you expect future tests will be able to achieve this level of dewatering with this little energy being consumed?***

   Answer: Yes. The commissioning test was the first test that has been run as part of the ongoing process optimisation program. Preliminary analyses of the commissioning test results have revealed points in the dewatering process where significant improvements in the applied power were possible. For that reason, the results of the commissioning test do not reflect the maximum energy efficiency that can be achieved with a fully optimised and informed operating schedule.

5. ***Has your work been subjected to third party peer review?***
   Answer: Yes. EKS has retained external peer reviewers throughout its technology development program. EKS intends to continue this valuable process as the process optimisation program progresses.

6. ***What are the major sources of error and imprecision in the results that you have presented?***
   Answer: As noted during the presentation, the commissioning test was not fully instrumented. Not having data pertaining to how the electric field and pore pressure changed over the course of the dewatering process limits the precision with which the detailed dewatering dynamics can be explained. This imprecision will be eliminated in future tests that are fully instrumented.

7. ***What do you see as the primary potential points of failure if this process is applied at a commercial scale?***
   Answer: EKS has conducted a comprehensive technology gaps assessment in support of its commercial deployment strategy and generic commercial conceptual design. This gaps assessment focussed on key uncertainties that could lead to process failures. The results of this assessment informed the design of the ongoing process optimisation testing program.

   Additionally, EKS has prepared a comprehensive and detailed research plan for the field demonstration. That document is also based largely on the technology gaps assessment work. Similar to what has been produced to guide the process optimisation testing program, the field demonstration research plan is built around key research questions with detailed descriptions of the specific testing that will be conducted to address each question.

   When these two testing programs are complete, EKS will have a detailed understanding of the potential points of failure and effective engineering design measures to avoid these failures.

   At this point, EKS is not aware of any potential point of failure that would cause the technology to fail totally. Those potential points of failure that have been identified can be eliminated with informed engineering design.

   One of the advantages of the current commercial conceptual design is that having a large number of parallel electrodes is that if an electrode does fail, the effect will be local. The electric field at a given point is the product of all of the electrodes in an EKR-DT installation. In other words, removing one electrode would not change greatly the electric field pattern or strength. As well if an electrode did fail, the applied power to adjacent electrodes could be adjusted so that the effect in terms of the electric field would be minor and would not affect the overall dewatering success of the installation.

8. ***How long was the commissioning run? How did you decide when the test was complete?***
   Answer: The total time that power was applied to the apparatus was about 21 days.

   EKS monitored the water release rate over the course of the test. As well, cores were extracted and the measured density of the cores reflected the average % solids in that location. A target of 60-65 % solids had been set for the commissioning test. This threshold was determined to be adequate to demonstrate the capability of the EKR-DT process to dewater FFT during both Stage 1 (i.e. a slurry) and Stage 2 (a soil).

   Additionally, the date for the COSIA presentation was a determining consideration. The applied power schedule for the commissioning test was based on the forecast dewatering rate, the time required to reach 65% solids and the time required to analyse the final results and to prepare them for the COSIA presentation. If this deadline had not been pending, the dewatering rate likely would have been slowed to achieve greater energy efficiency and a more uniform density gradient. As well, the test would likely have been run longer so that an overall average density in the range of 65-70% solids was achieved.

9. ***Is an average of 63% solids the maximum density that your technology can achieve?***
   Answer: No. As noted, the treatment time for this test was largely driven by the timing of the COSIA meeting. The test was terminated May 16 to provide us with adequate time to produce the results for the COSIA meeting.

   Based on our current understanding of the physics of the process, the maximum dewatering threshold is much higher. However to reach the maximum threshold, the amount of applied power would be much greater.

   The theoretically maximum dewatering potential can be derived from basic consolidation physics. The ultimate limiting factor is the physically maximum compression of the clay matrix. This level of dewatering however has little practical relevance and is far beyond what is needed to permit final reclamation to be undertaken.

10. ***What is the impact of the EKR-DT process on GHG emissions?***
    Answer: The EKR-DT process offers major advantages over current dewatering practices when it comes to minimising GHG emissions. These advantages include:

    1. The EKR-DT process occurs in situ. No disturbance of the FFT is required. A significant source of GHG with current practices is off-gassing of fugitive emissions when the FFT is disturbed during the extraction process and moved to a dewatering facility and then moved again to a final disposal site. With some

processes, the material is exposed to the air for a period of time for drying allowing further GHG emissions.

2. No material handling is required with in situ dewatering. GHG emissions associated with the energy consumed moving material are totally avoided.
3. The EKR-DT process can be designed to create an impermeable cap over FFT deposits. Capping prevents any future GHG emissions escaping from a dewatered FFT deposit. Current practices result in the lowest consolidation at the surface of partially dewatered FFT. GHG emissions can be expected to continue from these deposits as long as seepage continues which is often decades.
4. The EKR-DT process can be designed to consolidate the top layer of the sediment in end-pit lakes. In the absence of some means to consolidate this layer, GHG emissions can be expected to continue indefinitely from these sediments.
5. The major consumable with the EKR-DT process is electricity. GHG emissions associated with electricity generation can be totally avoided by running EKR-DT installations using just renewable energy. The EKR-DT process does not require a constant reliable flow of electricity. As a result, the variability in renewable energy supplies has no negative effect on the process.

EKS has prepared a detailed analysis of the amount of GHG emissions that could be avoided with large-scale application of the EKR-DT process in the oil sands.

Project Development Questions

1. ***What are the expected capital costs on a per m^3 of FFT basis?***

Answer: EKS has produced capital cost estimates for the commercial deployment of the EKR-DT process. The capital costs of an EKR-DT installation are highly scale dependent. The larger the scale, the lower are the per m^3 of FFT treated capital costs.

A hypothetical tailings pond has been assumed for the derivation of consistent capital cost estimates. Specifically, following are the assumed features of this hypothetical pond:

- 2 km X 2 km X 35 m (assuming a 5 m water cap over 30 m of FFT)
- Access to adequate electrical transmission capacity within 2 km.
- Existing access for equipment around the entire perimeter of the pond

Given the preliminary nature of the unit cost data, a 50% contingency was added (consistent with an AACE Class 4 estimate).
The capital cost estimate for the current commercial conceptual design is in the range of \$3-4 per m^3 of FFT including a 50% contingency. Additional design improvements are expected to lower the unit capital costs further.

The capital costs for this hypothetical pond have been regularly revised as improvements to the commercial conceptual design have evolved. The initial capital costs for this commercial application was $1.4 billion. This estimate was based on a conceptual design with:

- Vertical electrodes with a 5 m horizontal spacing, and
- All equipment was assumed to be new.

As noted, this first estimate produced in early 2016 was based on a totally different commercial conceptual design. This initial capital cost estimate converts to about $12 per m^3 of FFT (or about $35/dry tonne).

Many of the capital components are reusable. For example, the power supply and process control units are designed to be modular and mobile. When a tailings deposit is adequately dewatered, these units are moved to the next site. For this reason, the capital cost of these units is spread over multiple applications. The initial $1.4 billion estimate did not make this adjustment.

The primary consumable capital asset is the electrodes. In the case of this hypothetical pond, the electrodes comprise about 70% of the total consumable capital cost of the installation excluding labour costs. EKS is anticipating that the results of the ongoing process optimisation program will lead to further improvements in the design of the electrodes yielding further capital cost efficiencies. Any gains of this nature will be significant given the large portion of the capital cost accounted for by the electrodes.

EKS has developed a detailed capital cost estimating system that can be used to derive quickly, accurately and consistently, the capital cost for different engineering designs for different sites and applications. This cost estimating system is integral to designing commercial-scale EKR-DT installations.

2. ***What do you see as being the best commercial deployment option for your technology?***

Answer: The EKR-DT technology is highly adaptable and suitable for diverse applications in the oil sands. Some of the applications that EKS has examined include:

- In situ volumetric dewatering of legacy "virgin" FFT,
- In situ accelerated dewatering of deep deposits of centrifuge cake or flocculated FFT,
- Progressive dewatering in active tailings ponds, and
- Densification of the upper sediment layer in end-pit lakes.

EKS is designing its technology for all of these applications and others. The best option will depend on the specific local situation and the treatment objectives of the operator.

3. ***What remains to be done before the EKR-DT process will be available for commercial application?***

   Answer: EKS has produced most of the key elements needed to apply the EKR-DT process commercially including:
   - A commercial deployment strategy
   - A generic conceptual design
   - A systematic cost estimating system, and
   - A predictive model to support engineering design optimisation and process control.

   The last remaining step is to conduct a field demonstration.

4. ***If a company was interested in supporting a field demonstration, what would be the expected cost?***

   Answer: EKS has estimated that the all-in costs for a field demonstration are in the range of $6-8 million. EKS has secured over $4 million in government funding to support a field demonstration so the industry contribution would be in the order of $2-4 million.

   The industry portion would include financial and in-kind contributions.

5. ***If the testing program and field demonstration results are positive, when do you expect your technology would be available for commercial deployment?***

   Answer: Our current schedule for large-scale commercial deployment is 2019.