Technical Analysis:
Energy Supply Related to Exton Ferrochrome Refinery Siting

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Imperium Energy Inc. was asked to identify and evaluate from both a technical and an economic perspective a number of proposed electricity supply options in Northwestern Ontario. The most immediate priority was to provide a reliable cost-effective electricity supply for a proposed ferrochrome production facility in Greenstone (Exton), Ontario. Cliffs' current target date for placing the facility in service is 2015.

Our analysis determined that not only is it possible to provide a cost-effective power supply to Greenstone by 2015, it is possible to do so in a manner that, if incorporated into a larger power system enhancement plan, would provide and/or facilitate a number of other longer term economic development and power system objectives, namely:

- providing a grid connection to a number of First Nation communities currently supplied solely by diesel generation;
- enabling the development of significant new renewable (e.g. hydroelectric, wind) and clean (e.g. natural gas) generation in Northwestern Ontario;
- facilitating the cost-effective development of natural resources in the area (e.g. Goldcorp Musselwhite); and
- improving both the reliability and capacity of the overall bulk electrical transmission system in Northwestern Ontario.

The primary electrical load at the ferrochrome production facility will consist of four to six electric arc furnaces that are expected to operate on a continuous basis throughout the year. The facility is forecast to have a maximum electrical load of approximately 300 MW and a total annual consumption projected to be in the range of 2.4 - 2.6 TWh.

The operation of large electric arc furnaces can result in significant power quality issues for other electricity customers connected to the transmission system in the immediate area unless suitable mitigation measures are taken. The primary power quality concerns related to the operation of arc furnaces are voltage flicker, harmonics and power factor fluctuation.

Earlier this year, the Ontario Power Authority (OPA) undertook a preliminary technical assessment of the Northwest power system and determined that such a facility could be accommodated by 2015. As a consequence of their assessment, the OPA identified a need for the following new transmission facilities:

1. Establishing a 230 kV switching station along the 230 kV two circuit line between Lakehead TS and Marathon TS. A minimum of two 230 kV breakers and related protection / control and ancillary equipment would be needed at this switching station.

2. Building a new 230 kV two circuit line from this new switching station to the customer's site (Greenstone – Exton).

3. Providing a step-down transformer station that converts the 230 kV transmission voltage to a distribution voltage level needed for the customer's process. Based on the customer reliability requirements it is assumed that two step-down transformers would be needed within this step-down transformer station.

The OPA further stated that:

“An industrial processes of this nature may impose significant power quality problems for other customers connected to the transmission system in the area. Provided the short circuit capability in the area is sufficient, a static VAR compensator, or equivalent device, would be required to mitigate the associated power quality problems.”

Typically the cost as well as the actual construction of the transmission enhancements identified by the OPA plus any required power quality mitigation measures (e.g. static VAR compensators) are the responsibility of the industrial load customer (i.e. Cliffs Natural Resources Inc.).

However, in this particular case there are significant opportunities to both share the costs of the transmission enhancements with other parties and to reduce the degree of mitigation required. It could even be argued that a significant portion of the costs could and should be included in the overall system rate base given that they are also bulk transmission system enhancements rather than simply a means of supplying a new load.

Previously, most of the transmission enhancements identified by the OPA as required to supply the ferrochrome facility were also identified by the Province, OPA and/or Hydro One as necessary system enhancements to supply the Pickle Lake area of the Province.

In fact the 230 kV transmission route identified in 2009 by Hydro One as its “Northwestern Transmission Expansion Project Reference Corridor” is for the most part the same route that would be required to connect the Greenstone site with the power system in the Nipigon area.

Currently, Ontario Power Generation (OPG) is two years into a three year environmental approval process aimed at developing a 73 MW hydroelectric generation facility on the Little Jackfish River north of Lake Nipigon. As part of this development OPG is proposing to construct a 180 km 230 kV single circuit transmission line along almost identical route necessary to supply the ferrochrome facility. OPG has estimated the cost of the transmission line as approximately $100-150 Million.

If this planned transmission line could be converted to a double circuit 230 kV not only would both OPG and Cliffs Natural Resources significantly reduce their individual costs of construction, the power system would realize a significant reduction in line losses worth millions over the lifetime of these two facilities.

The construction of a double circuit 230 kV transmission line to the Greenstone area would also facilitate the construction of a new natural gas generation facility in Greenstone along the TransCanada main gas pipeline. Currently this pipeline is significantly underutilized.

Hydroelectric generation currently accounts for over half of the existing installed capacity in the Northwest. These facilities are for the most part run-of-river plants with limited storage capacity. This inability to store water results in large variations in annual production. With the closure of the coal plants in 2014, the OPA has identified the need for further non-hydroelectric generation in the Northwest for system reasons . As a result OPG has been directed to convert its coal–fired Thunder Bay generation facility to

natural gas. Unfortunately the conversion of such a station will result in a facility with sub-optimal conversion efficiency. As a result the Thunder Bay facility will only be suited for peaking operation.

A properly designed combined cycle gas facility located in Greenstone would not only significantly strengthen the power system in this part of the transmission system, it would do so with far greater overall efficiency than a converted Thunder Bay facility. A typical GE combined cycle gas facility of the same size would require 30 per cent less natural gas and produce 40 per cent less CO2 per MWh compared to a converted Thunder Bay unit.

Locating a significant generation source (e.g. 150 -250 MW) close to the new 300 MW load would have the further benefit of significantly reducing transmission system losses. Since the expected lives of both a new natural gas generation facility and the ferrochrome facility are in excess of 25 years and given the projected annual energy demand for the ferrochrome facility, the avoided transmission system line losses of such an arrangement could approach 1TWh or more. Assuming an average energy price over the 25 year period of $0.09/Kwh, these savings alone are worth $90 Million.

That alone could justify the additional cost of double circuiting the 230 kV transmission line OPG is proposing to construct for the Little Jackfish generating station.

As noted earlier, the nature of the electrical load created by the ferrochrome facility can create significant power quality concerns for other customers connected to the transmission system in the immediate area. In Ontario it is the responsibility of the load customer creating the power quality issue to pay for any mitigation required. Given that (at least initially) there would be no other load customers connected to the 230 kV transmission within at least 100 km of the ferrochrome facility, the need for mitigation measures and hence the related costs may be significantly delayed or reduced at the Exton site compared to the other sites (Thunder Bay, Sudbury, Timmins) being considered for the ferrochrome facility. The location of two significant generation facilities (gas generation and the Little Jackfish) in close proximity to the load would further mitigate the power system challenges presented by the arc furnace loads.

Beyond being simply a cost-effective source of supply to the ferrochrome facility, the construction of a double circuit 230 kV transmission line to the identified Greenstone location near Exton would provide a number of other economic and power system benefits. It would, particularly if combined with new natural gas generation and the Little Jackfish, provide a sound basis for extension of the grid system to a large number of the remote diesel sites as well as increasing dramatically the reliability and capacity to the mining sites throughout the North (including Pickle Lake).

If even a single circuit 230 kV transmission line was extended from Exton to the Little Jackfish generating station, then Pickle Lake and eventually on to either Dryden or Ignace, it would dramatically improve the feasibility of establishing a northern grid system.

Once connected to either Dryden or Ignace the transmission line may well increase the opportunity for further electricity purchases from Manitoba.

Currently the OPA is investigating the reinforcement of the transmission system between the Northwest and the southern system by means of the addition of a 400 km 230 kV double circuit transmission line running from Wawa to Thunder Bay at a total projected cost of approximately $600 Million. (Note – Included in this projected cost is between $50-100 Million in station modifications and additional static VAR compensators and other reactive devices). The addition of new generation and a new 230 kV switching station into the system near Nipigon may benefit the power system significantly from both a technical and an economic perspective. It could well reduce the size and hence cost of the required reactive devices.

Furthermore, completing the transmission loop north and west of Lake Nipigon to either Dryden or Ignace would greatly improve the power system ability to extend the grid to the remote communities and the new mining developments in the far North.

The OPA has estimated that the 21 communities north of Pickle Lake currently supplied solely by diesel generation could be economically connected to the grid. The total 2010 load of these communities is only 15 MW but is projected to double over the next 20 years.

In addition, the OPA has identified new demand related to the Ring of Fire and other mining developments in the order of 50 to 60 MW by 2017 and growing to 90 MW by 2025. The OPA's analysis of the mining load alone during its first decade of operation indicates that grid connection is economically justified. Without a continuous 230 kV connection between the bulk transmission system near Nipigon and either Dryden or Ignace, all these loads would be exposed to very long radial feeds with poor reliability, increased line losses and significant voltage control issues.

Conclusions

1. It is practical to supply the proposed Cliffs Natural Resources ferrochrome facility at Exton in a cost-effective, reliable and timely manner.

2. A significant portion of the costs for enhancements to the power supply to the Greenstone area can be shared among a number of other parties as well as Cliffs Natural Resources.

3. A 230 kV transmission connection that extended from near Nipigon to the Greenstone area and on to the Little Jackfish, Pickle Lake and either Dryden or Ignace would provide a number of power system benefits, including facilitating the extension of the transmission and distribution systems to remote First Nation communities and mining developments.

4. Based on the above, there is strong rationale for including a significant majority of the costs of the discussed transmission enhancements in the rate base given that they represent significant enhancements to the bulk transmission system as a whole. This would further reduce significantly the costs to Cliffs Natural Resources of developing the ferrochrome facility at Exton.

Larry Doran Biography:

Larry Doran is President &CEO of Imperium Energy Inc. Since 2004 Imperium Energy has been providing strategic and technical advice to municipalities, First Nations, local distribution companies and developers related to renewable generation and transmission projects. During his career Larry has successfully lead the development and/or construction of over $3 Billion of generation and transmission projects.

From 2006 to 2011 Larry was President & CEO of the Peterborough Utilities Group (PUG). In 2010 Electric Light & Power magazine named Larry as North American Utility CEO of the Year based on his leadership and achievements at PUG.

Prior to PUG, Larry spent over 30 years with Ontario Hydro and Ontario Power Generation. During his career with these organizations he held numerous leadership positions including Regional Director for Northwestern Ontario, VP – Aboriginal & Northern Affairs, VP & GM – Ontario Hydro Retail System, VP & GM – Ontario Transmission System, VP & GM – Hydroelectric Generation and VP – Business Development.

Larry has a BASc (Electric Engineering) from Queen's University, a MBA from the University of Toronto as well as graduate training from Harvard, MIT, Stanford and the University of Chicago. In addition he has achieved his ICD designation from the Institute of Corporate Directors.