Proposal to Test the Randle Reef Deposits for Permanent Removal

Prepared for:
The Public Works Committee of Hamilton City Council

by:
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Executive Summary

EnQuest Power Corporation (EnQuest) is a private company, based in Niagara, that provides a technological solution for converting waste material into usable energy through a process of steam reformation.

Steam reformation is a non-incineration technology that takes place in a non-pressurized atmosphere of high-temperature steam and no additional oxygen (where ‘burning’ or ‘incineration’ would be impossible). Heat is applied only to the outer layer of the kiln, and since no burning of feedstock takes place, the hazards, complications, and expenses arising from incineration are almost completely avoided.

EnQuest believes that the Randle Reef deposits are excellent feedstock for the EnQuest system, and that they could be safely turned into usable energy with a corresponding substantial reduction of the overall net cost of the project to all parties involved. Furthermore, such a process would represent a real cleanup and permanent solution.

EnQuest Power Corporation (EnQuest) is requesting that the City of Hamilton give its non-financial support to EnQuest in our efforts to: a) secure a grant from Environment Canada to test a sample of the toxic deposits from Randle Reef for testing in the SR system; b) assist EnQuest in securing permits and completing applications necessary for the tests; and, c) assist EnQuest in developing the business case as required. If the tests are successful, EnQuest will submit a fully costed proposal for removal of the deposits and their conversion into usable energy for use within the city.

The company’s management and technical team (almost half of whom live in Hamilton) have extensive practical and academic credentials in waste management, recycling, engineering, construction and renewable energy, including first-hand experience with remediation of the Sydney Tar Ponds. They are backed by business and technology alliances with professional service firms, investors and major energy and industrial companies.

EnQuest has just completed a pilot plant at the City’s landfill in Sault Ste Marie, Ontario, to test and fine-tune the process for converting municipal solid waste, sewage sludge and other materials to usable energy. EnQuest is one of only two companies in Ontario to be granted a Certificate of Approval by the Ontario Minister of the Environment for non-incineration, thermal treatment of municipal waste and other carbonaceous materials.
Details of EC Study Request

EnQuest has made a formal request to Environment Canada for a grant of up to $500,000 that will enable the company to have a 30 tonne (30 m³) sample of material removed from the Randle Reef deposits (by an approved environmental contractor) and shipped (by an approved carrier) to EnQuest’s pilot steam reformation plant located at the landfill of the City of Sault Ste Marie, Ontario. In the Sault Ste Marie (“SSM”) facility, the sample will be tested in the company’s double-hulled, rotary kiln under the auspices of scientists from CANMET, the University of Toronto, and possibly other interested institutions, for:

1. the effectiveness of the EnQuest steam reformation system in extracting energy from the samples; and,

2. for the composition and safety of any residue or gases coming from the project.

Approximately half of the estimated amount of a grant will be budgeted towards obtaining, transporting, testing and analysing samples of the Randle Reef material.

If independent scientific review determines that the tests were successful, the other half of the grant will be used to prepare a fully costed proposal for the removal and treatment of material from Randle Reef.

The expense involved with the thermal destruction of toxic wastes from Randle Reef and other Great Lakes “hot spots” has been a significant impediment to this form of remediation. The company expects to demonstrate the ability of the EnQuest system to convert the toxic materials into usable energy and, consequently, to save the City and others substantial money.

EnQuest is aware that, because of the time and money spent to date and the lack of other satisfactory solutions before now, momentum has built towards the current plan to cap the Randle Reef deposits at a cost of $90 million. However, EnQuest asks that any preference to drive ahead with the current plan not interfere with the decision to support this proposed testing program. Successful results of tests conducted on Randle Reef deposits will have beneficial consequences for the complete clean-up of toxic sediments at other spots in the Great Lakes and elsewhere, and Hamilton’s contribution to this technology will be appreciated by other host municipalities and agencies.
General Description of the EnQuest Steam Reformation System

Steam Reformation

Steam Reformation ("SR") is an advanced thermal treatment process that converts carbonaceous materials through a procedure involving partial oxidation of the feedstock in a reducing atmosphere in the presence of steam at very high temperatures. The feedstock is converted to synthesis gas ("syngas"), with inorganic matter turned into a glassy, inert, solid residue known as "vitreous frit" or "slag." The steam reformation reaction initiates at around 350ºC and accelerates as the temperature is raised to over 1,200ºC.

Syngas is a combustible gas that is composed almost entirely of hydrogen (H₂) and carbon monoxide (CO). Syngas is similar to natural gas, and can be converted into electrical and thermal energy, or cleaned and conditioned for use as a feedstock for the production of methanol.

Steam Reformation vs. Incineration

Steam reformation has a number of inherent advantages over incineration.

1. Incineration burns waste where 100% of the ensuing energy is totally contained in the exhaust plume/smoke. To recover this energy for useful purposes requires heat recovery systems that use this energy for generating steam that is then fed into steam turbines to generate electricity. The maximum electrical conversion efficiency obtainable by extracting heat, generating steam and then generating electricity is 20% to 25%. Using an SR system, the product is a Syngas, very equivalent to Natural Gas in its utility and cleanliness of conversion to electrical energy in Gas Turbine engines. Using a combination of Gas Turbines and Steam Turbines the electrical energy conversion efficiency can be increased to 60% or higher. This means that the EnQuest SR system will generate up to three (3) times the electrical power available from incineration.

2. The net result of a process that has three (3) times the effectiveness in generating electricity also means that the volume of CO₂ produced per MW of power produced is only 1/3 that of incineration and consequently the EnQuest system can also contribute effectively and positively to reducing green house gases.

3. The EnQuest system generates only about 10% of the volume of product gas as generated by incineration. This means a much smaller plant footprint, hence lower operating and lower capital costs.

4. With lower volumes, SR is relatively quiescent compared to the “tornado”-like velocities and turbulence of incineration. This turbulence is the root cause of the large volumes of fly ash generated by incineration, leading to further major costs. This is largely avoided by the quiescent SR process that generates microscopic quantities of fly ash in comparison.

5. SR gasification uses high temperature steam to break down waste materials into a syngas and specifically and deliberately excludes oxygen, which, consequently, precludes the formation of some of the more toxic substances that are endemic to incineration, including dioxins, furans and NOx and SOx pollutants.
6. The only residues from an SR system are non-carbonaceous materials. For the Randle deposit, the residues will be heavy metals, which are contained in liquid or solid (not gaseous) form. It is common in combustion processes to have ash remaining, which is toxic and needs to be disposed of.

7. Unlike combustion systems, there is usually no need to dry the feedstock for an SR plant because some water content is necessary. Depending on the outcome of the tests, some dewatering may be necessary, but we do not foresee this being a costly process.

**Position and Size of the Proposed Plant**
Details of the size of the SR plant will have to be worked out as part of the output of the study, and will depend on the required rate of processing and storage. In general, SR plants can be relatively small and have smaller stacks (compared to incinerators) because they process a much smaller volume of atmospheric oxygen.

We expect that the processing plant will be as close as possible to the Randle Reef deposits – perhaps on Harbour Commission or steel company dock property.

**Nature of the Equipment Used in an SR Plant**
Our SR process is centred around a rotary kiln. These are well-known, proven and robust. Energy Solutions, of Salt Lake City, Utah, a technology partner, uses SR for the destruction of hazardous waste – including low-level nuclear waste.

The SR kilns are, essentially, ‘off-the-shelf’ pieces of equipment modified to accept the high temperatures used in SR (figure 2). They can be acquired and assembled relatively quickly. If all permits and other pre-conditions were now in place, we could have an SR system up and running in 2008.

An EnQuest SR system installed in Hamilton for the purpose of processing material from Randle Reef can also be used to process sewage sludge and MSW when the Randle Reef cleanup is complete.
Uses of the Syngas

The syngas may have potential as a blast furnace gas, or possibly as a process gas or heat source for some other area industry. The SR plant can also be configured to generate electricity for a local business or institution.

Odours and Residuals

The containment of odours will be one of the parameters studied and evaluated in the proposed test at Sault Ste Marie.

The residuals from the process will be almost entirely heavy metals. Since our business is the safe conversion of wastes to fuel, we work with systems that can remove leads, arsenic, mercury, cadmium and other toxic materials. The containment and extraction of the residuals will also be studied and evaluated in the proposed test.

Extraction of Toxic Material

Extraction of toxic deposits is a part of the current plan to cap the site as excavation of materials is required for placement of steel retaining walls, and deposits are to removed from various other contaminated areas of the harbour and taken to the containment area. EnQuest is open to discussions on the method of extraction used (both for the purposes of a taking a test sample and for the eventual clean-up). We have individuals within EnQuest with the appropriate experience to safely handle materials extraction.
Atmospheric Emissions

The EnQuest system uses much less atmospheric oxygen and does not produce most of the toxic substances created by incineration. Consequently, output from EnQuest steam reformation exceeds, and in most cases, easily surpasses the strictest atmospheric emissions guidelines on the continent. The following table compares test results of our process with Canadian emissions guidelines:

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Regulated Limits</th>
<th>EnQuest System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter (PM)</td>
<td>17 mg/Nm³</td>
<td>3.050E-04 mg/Nm³</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.014 mg/Nm³</td>
<td>3.000E-07 mg/Nm³</td>
</tr>
<tr>
<td>Lead</td>
<td>0.142 mg/Nm³</td>
<td>2.100E-06 mg/Nm³</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.02 mg/Nm³</td>
<td>1.450E-07 mg/Nm³</td>
</tr>
<tr>
<td>Dioxins and furans</td>
<td>0.08 ng/Nm³</td>
<td>6.500E-05 ng/Nm³</td>
</tr>
<tr>
<td>Hydrochloric acid (HCl)</td>
<td>27 mg/Nm³</td>
<td>2.1905 mg/Nm³</td>
</tr>
<tr>
<td>Sulphur dioxide (SO₂)</td>
<td>56 mg/Nm³</td>
<td>1.2542 mg/Nm³</td>
</tr>
<tr>
<td>Nitrogen oxides (NOₓ)</td>
<td>110 ppmv</td>
<td>0.0000 mg/Nm³</td>
</tr>
<tr>
<td>Organic matter</td>
<td>100 ppmv</td>
<td>3.050E-04 mg/Nm³</td>
</tr>
</tbody>
</table>

Costs

The plant itself is less costly than an incinerator that could process similar volumes of material. Costs of completing a full facility to process Randle Reef waste cannot be properly determined until tests on the material are completed and the full business case is developed. However, we expect that recovery of the energy value of the deposits will help to reduce the overall cost to the City by a significant amount.
Alliances

Technology

- Energy Solutions (formerly Duratek, a Division of Westinghouse – destruction of nuclear wastes using steam reformation.)

Advisory & Research

- Giffels Associates Ltd (engineers)
- Clean 16 Environmental Technologies Corporation (engineers)
- University of Toronto; Sault College; Niagara College (research)
- Deloitte & Touche LLP (financial/Accounting)
- Aird & Berlis LLP (legal)
- Baker & McKenzie LLP (legal)

Investment

- Shaw Group (NYSE-listed energy & construction)

Equipment

- GE Energy (gas and steam turbines)
- Metso Minerals (rotary kilns)
- Solar Turbines (small to medium gas turbines)

Personnel\(^1\)

Management

- Jayson Zwierschke (Fonthill, Ontario) – President and Chief Executive Officer
- Leonard Zwierschke (Fonthill, Ontario) – Executive Vice President
- Ernie Dueck, P. Eng. (Fort Erie) – Vice President of Operations and Engineering

Technical Advisory Board

- Henry Miyamoto, P.Eng. (Chemical), FCIC (Hamilton, Ontario)
- Professor Donald W. Kirk, Ph.D. (Chemical), Faculty of Chemical Engineering and Applied Chemistry, University of Toronto (Caledon, Ontario)
- Dr. Craig Simpson, Ph.D (Metallurgy) (Hamilton, Ontario)

\(^1\) See Appendix D for curriculum vitae
Sault Ste Marie Demonstration Plant

On February 10, 2005, EnQuest entered into an agreement with the City of Sault Ste. Marie (Ontario) for the supply of municipal solid waste (“MSW”) and a land lease agreement in response to the Company’s proposal to construct and operate a “proof of technology” demonstration plant. The plant is intended to demonstrate the effectiveness of the EnQuest system for the beneficial conversion of feedstock materials, e.g., MSW, wood products (including various biomass species and hog fuels), paper by-products and bio-solids (sludge), sewage sludge, and coal. Successful operation of the plant will prove, in a commercial setting, that the chemistry of SR produces a clean syngas, composed primarily of hydrogen and carbon monoxide gases.

The demonstration plant, which is now complete and in the process of being commissioned, will process about 1,000 tonnes of waste material per year — the maximum allowable under the Certificate of Approval issued by the Ontario Ministry of the Environment (although the plant is capable of greater volume). The complete test program is designed to provide engineering and design optimization data for purposes of a commercial plant design.

EnQuest has Certificates of Approval for Air, and Waste Disposal, for a variety of materials, but will require an amendment to these certificates to test samples of the Randle Reef deposits.
Appendix A: Executive Summary from Application for Certificates of Approval

EnQuest Power Corporation (EnQuest), in conjunction with The City of Sault Ste. Marie (SSM), Sault Ste. Marie Economic Development Corporation (SSM EDC), Sault College, Niagara College, University of Toronto Department of Chemical Engineering and Applied Chemistry (U of T), Shaw Group and Clean 16 Environmental Technologies Corporation (Clean 16) propose the construction and operation of a proof-of-technology pilot plant. This pilot plant will be located at the City of Sault Ste. Marie landfill site using Municipal Solid Waste (MSW), and other suitable test carbonaceous materials to produce syngas, which in a commercial plant setting would be used to generate various forms of energy and commodities. The demonstration project will begin operations in the fall of 2007, and is currently, now under construction.

The demonstration project will prove that the chemistry of steam reformation under optimum process conditions will produce a clean and valuable syngas (a mixture of hydrogen and carbon monoxide gases) from a wide variety of carbonaceous materials. The focus is to optimize the process in order to efficiently and reliably affect the conversion of said materials and produce a useful syngas for commercial applications. It is intended that process operating conditions be determined to optimize control of the plant for various types of feed stocks, determine and prove out all necessary gas cleaning systems (such as the removal of halogens, sulphur and other unwanted compounds) and provide a product that is suitable for interfacing with the various technologies and equipment integration, e.g., power production, steam generation, renewable hydrogen creation, natural gas replacement, pure gas separation or syngas-to-fuel cells.

Stack gas sampling and analyses will be conducted to demonstrate that the potential for producing dioxins and furans when this syngas is temporarily burned has been virtually eliminated. (Note: alternate technologies that deal with MSW, such as incineration, pyrolysis and two-staged gasification processes, will produce dioxins and furans).

Mass and Energy balances will be conducted to demonstrate the efficiency and viability of the overall process. Methods for cleaning the syngas to various clients’ specifications will be developed. Process control strategies will be modified as required and monitoring parameters will be refined. The study will provide sufficient information to design full-scale commercial plants. Once commercialized, the EnQuest technology will meet the obvious needs of the marketplace and plans are in place for rapid dissemination.
You have applied in accordance with Section 27 of the Environmental Protection Act for approval of:

a pilot plant, consisting of a natural gas fired, indirectly heated kiln and an electrically heated kiln together with all auxiliary equipment, a gas treatment system and an enclosed flare, as described in the attached Schedule 1.

to be used for the transfer, processing and thermal degradation of the following types of waste:

solid non-hazardous waste, limited to woodwaste, sewage sludge, paper waste and domestic waste, all originating from within The Corporation of The City of Sault Ste. Marie, The Township of Prince and The Rankin Indian Reserve, all in accordance with the plans and specifications as listed in Schedule “A” which is attached to and forms part of this Provisional Certificate of Approval, except as specified in the Conditions contained herein

Note: Use of the site for any other type of waste is not approved under this Certificate, and requires obtaining a separate approval amending this Certificate.

For the purpose of this Provisional Certificate of Approval and the terms and conditions specified below, the following definitions apply:

Definitions

For the purpose of this Certificate the following definitions apply:

“Air Certificate” means the certificate of approval (air) issued in accordance with section 9 of the EPA for the same equipment and for the same experiments as the ones covered by this Certificate, and includes any schedules to it;

“Certificate” means this entire certificate of approval document, issued in accordance with
You have applied in accordance with Section 9 of the Environmental Protection Act for approval of:

a pilot plant for experiments involving gasification of coal and thermal degradation of woodwaste, sewage sludge, paper waste and domestic waste, consisting of:

1. Receiving room for materials receiving and preprocessing including a manual waste sorting area together with a shredder for domestic waste and a waterproof storage bin for recyclables, having a capacity of approximately 220 litres or 0.5 metric tonne, measuring one metre by one metre by 1.5 metres, and a storage bin for incidental subject wastes, having a capacity of approximately 220 litres or 0.5 tonne, measuring one metre by one metre by 1.5 metres, with incoming waste, sorted incoming waste and shredded waste placed in piles on the receiving room floor with no more than two piles at a time, and with the receiving room being maintained under negative pressure by directing the room air for use as combustion air;

2. one skid steer for material transfers within the building;

3. spent filter storage room measuring 1.2 metres by 1.2 metres by 2.4 metres for Spent Activated Carbon Filters and Spent HEPA Filters as shown on the Layout Drawing dated November 24, 2006 with reference to Filter Room;

4. eight leak-proof storage bins for kiln residue, each having a capacity of 0.75 metric tonne or 0.62 cubic metre, stacked two-high in a row of four containers, located in the main process room as shown on the Layout Drawing dated November 24, 2006 with reference to Residue Containers;

5. two leak-proof barrels, each having a capacity of 225 litres, located within a dyked area measuring approximately 1.5 metres by 3 metres complete with a concrete barrier of at least 10 centimetres in height, with the dyked area treated with an impervious coating.
Appendix D (continued): Personnel – Curriculum Vitae

Management

Jayson Zwierschke – President and Chief Executive Officer. Jayson is the founder of EnQuest Power Corporation. Jayson has extensive experience in the environmental and waste management industries in the development of large-scale and niche recycling and environmental operations.

Leonard Zwierschke – Executive Vice President. Leonard has more than 30 years experience in the as an owner in the construction and transportation industries. He is experienced in budget and project management, estimating, and logistics management.

Ernie Dueck, P. Eng. – Vice President of Operations and Engineering. Ernie has over 30 years of experience in various engineering roles and executive management positions in the aerospace industry, including 25 years with Pratt & Whitney. From 1993 to 1999 he served as Vice President and General Manager of Fleet Industries Inc. Ernie’s key role and function has been to provide engineering support for the development of EnQuest’s proprietary SR technology.

Mark Mullins, B.A., M.B.A., C.F.A. – Vice President. Mark has experience as a financial analyst, portfolio manager and investment counsellor. He has been on the staff of the McMaster Institute for Energy Studies, and has been a developer and operator of renewable energy facilities for almost 20 years.

George C.M. Banks, B.A., L.L.B. – Chair of the Board of Directors and Corporate Counsel. George is a practising member of the Law Society of Upper Canada (Ontario) with over 45 years experience. He is currently Municipal Solicitor for several municipalities, including the City of Welland.

Technical Advisory Board

Henry Miyamoto, P.Eng. (Chemical), FCIC. Henry is a professional engineer and fellow of the Chemical Institute of Canada; he has over 25 years of experience in process development and optimization with a specialization in gas purification systems. Henry has managed the design, installation, optimization, and modification of numerous international environmental applications and has published over 30 papers on the subject of environmental solutions. He has been an industrial design advisor at the University of Toronto Department of Chemical Engineering and Applied Chemistry for the past 14 years. Mr. Miyamoto first designed a system to substitute landfill gas for natural gas in 1994, and currently oversees Clean 16’s engineering team.

Professor Donald W. Kirk, Ph.D. (Chemical). Dr. Kirk is a fully tenured professor with more than 25 years experience as a professor and inventor. Dr. Kirk is currently a co-ordinator of the Collaborative Environmental Engineering Program for Chemical Engineering at the University of Toronto. He has 15 patents to his credit and has published over 50 papers in refereed journals related to solid waste, hydrogen, and green energy with a unique and long history of dedicated focus on the treatment and beneficial use of synthetic gases.
Dr. Craig Simpson, Ph.D (Metallurgy). Dr. Simpson has been involved in the research and development of advanced thermal conversion EFW technologies for approximately 20 years. In the late 1980s, he participated in the research and development in plasma arc processing of MSW. In the 90s, on behalf Enbridge Gas Distribution, he directed a research program at Queen’s University on gas-assisted combustion of MSW. In 2003/4, Dr. Simpson was an Expert Consultant and Member of the City of Toronto’s Advisory Group on New & Emerging Technologies for dealing with waste issues.

Robert Henderson, P.Eng. (Mechanical). Robert Henderson is a professional engineer with over 25 years of experience in the Pulp and Paper Industry, in both Canada and New Zealand. Robert has worked at various levels within the Pulp and Paper industry while gaining knowledge and understanding of the critical and relevant issues that are the current and practical to modern, profitable mills.