THE PRINCE EDWARD ISLAND ENERGY-FROM-WASTE PLANT

PAUL E. DAVIDSON
Burlington, Ontario, Canada

ABSTRACT

Under the terms of a five year full service contract, TricU Limited has provided to the Prince Edward Island Energy Corporation the design, construction and operation of an energy-from-waste plant employing a modular Two-Stage Combustion (TSC) incineration process with heat recovery. Contractual arrangements are discussed together with TricU's improvements to the technology and the plant's performance to date.

Prince Edward Island, located in the Gulf of St. Lawrence, is the smallest province in Canada. The energy-from-waste plant services the City of Charlottetown and surrounding area which have a combined population of 42,000.

Prince Edward Island relies heavily on expensive oil imports for its energy needs. To reduce this dependency, the Provincial Government is developing new energy sources and promoting energy conservation through the Prince Edward Island Energy Corporation. One of the mandates of this agency is the development of local energy sources. There are also concerns for the consumption of valuable agricultural land and contamination of this land by landfilling of municipal solid waste.

In 1980 TricU Limited assisted the Prince Edward Island Energy Corporation in a feasibility study and proposal development for the design, construction and operation of an energy-from-waste plant.

As a result of the study, TricU and the Energy Corporation entered into a five-year full service contract in May, 1981. Under the terms of the contract, the nominal 108 TPD (100 t/day) energy-from-waste plant was designed and constructed and is now operated by TricU. Plant design began in June, 1981 and construction was completed in January, 1983, nineteen months later. Acceptance testing was completed in March, 1983 and normal operations began the following month.

Steam generated from the plant is sold to nearby Riverside and Queen Elizabeth Hospitals for both heating and cooling purposes. The hospitals are located approximately three-quarters of a mile from the plant.

FULL SERVICE CONTRACT

The Prince Edward Island Energy Corporation had specific needs and the full service contract with TricU was structured to meet them. The unique features of this contract are:

- Maximum local input into the project. The incinerators were fabricated on the Island by Georgetown Shipyard, Inc., a local marine fabricator and shipyard. To the extent possible, subcontractors from Prince Edward Island were selected for the project execution.
- Performance guarantees were provided by TricU to ensure that the plant would operate as designed.
- The majority of the project cost was guaranteed by TricU, but those project costs relating to the local fabrication of the incinerator system were passed through to the Prince Edward Island Energy Corporation on a cost-reimbursable basis.
- TricU provided operating know-how and management expertise for the plant's operation. After five years, the Energy Corporation may choose to operate the plant themselves.

TricU contracted with an American modular controlled air equipment manufacturer to supply drawings and engineering services during plant design, construction and
start-up. After reviewing several operating plants and holding discussions with the manufacturer, Tricil developed its own Two-Stage Combustion (TSC) process design for the P.E.I. project. The design modifications incorporated were required to ensure that the long-term operation of the plant would be reliable, and that the guaranteed performance standards would be achieved.

**PLANT DESIGN FEATURES**

Tricil is a waste management service company and the design of the energy-from-waste plant was strongly influenced by operational experience. Operating personnel participated on the project team and a unique approach was taken to ensure safe, reliable operation.

The plant design was subjected to a rigorous hazard and operability (HAZOP) review in which the project team carried out a systematic, but imaginative, search for deviations from the intent of the design in order to expose potential hazards and equipment operability problems. This review was coordinated by an experienced chairman, who was not part of the project team, and involved intensive discussions resulting in over sixty design modifications and operational changes. The benefits of this review are evident in:

- A more professional design, leading to an industrial grade plant.
- A faster start-up: a total of five weeks elapsed from construction completion to the start of the performance test.
- A minimum of operational difficulties.

Features of the plant design include:

- Tricil-specified heat recovery boiler complete with bottom ash hoppers, economizer, and rotary steam sootblowers.
- Tricil-designed controls incorporating comprehensive supervisory instrumentation which generates reliable data and operating information. Programmable logic controls allow rapid flexibility in adjusting operating parameters.
- Tricil-designed wet ash handling system.
- Separate emergency by-pass stacks with individual control and damper systems.
- Visitors gallery with a view of the plant and receiving area.
- Large waste receiving and storage area with high curved scrub walls and high ceilings.

**PERFORMANCE STANDARDS**

The plant design and performance standards are based upon analysis of acceptable waste as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>moisture</td>
<td>30 percent</td>
</tr>
<tr>
<td>ash</td>
<td>26 percent</td>
</tr>
<tr>
<td>combustibles</td>
<td>44 percent</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100 percent</strong></td>
</tr>
</tbody>
</table>

This table represents the composition of waste with an average higher heating value of 4500 Btu/lb.

The plant is designed to receive and process a minimum of 500 tons/week (450 t/week) or approximately 72 tons/day (65 t/day) on a reliable 7 days/week basis.

The performance standards provide that the concentration of unoxidized organic material and free carbon in the ash shall not exceed 8 percent by weight of the total dry combustibles in the refuse.

In addition, the standards provide for an opacity limit. The stack emission (water vapour excluded) shall not obstruct more than 20 percent of the light passing through the plume except for occasional periods of not more than 2 min in duration to allow for corrective measures to be taken.

The boiler system was designed to produce at least 15,000 lb/hr (6800 kg/h) saturated steam at 300 psig (2070 kPa) pressure.

**PROCESS DESCRIPTION**

Waste received at the plant is discharged directly onto a large concrete floor inside an enclosed receiving area. The waste is mixed by a front-end loader and moved as required to one of three hydraulically operated incinerator loaders. The loaders feed the waste into the primary chambers of the three incinerator units. Transfer rams move the material slowly through the primary chamber, which has a stepped bottom design with three horizontal hydraulic rams. These rams, with individual strokes of 3 to 4 ft (1 to 1.3 m), have steel faces with areas of approximately 4 ft² (0.4 m²).

In the primary chamber, air is introduced at low velocity below the refuse bed through a total of eight 2 in. (6.4 cm) diameter water-cooled tubes which extend through the ram faces. The air flow is controlled to permit sufficient combustion of the lower portion of the bed to generate a controlled amount of heat which dries and pyrolyzes the remaining refuse. In effect, the organics in the refuse are converted into combustible gases which pass into the secondary chamber where preheated air at 140°F (60°C) and 30 to 50 percent excess air conditions is introduced through radial openings and mixed with the gases to complete combustion. Temperatures are controlled at approximately 1150°F (620°C) in the primary chamber and 1830°F (1000°C) in the secondary chamber. Under normal operation, no auxiliary fuel is required. Number 2 fuel oil is used only to start-up the incinerators.
The fully combusted gases are drawn from the secondary chambers of the incinerator units through a common refractory lined manifold to a water-tube boiler. The induced draft fan vents the cooled gases at 430°F (220°C), through the stack. Each incinerator unit also employs an emergency stack which directly vents hot combustion gases ahead of the boiler when required by conditions such as power failure.

Steam is produced at 300 psig (2070 kPa) saturated and is transferred to the boiler house at the hospital complex via a 3700 ft (1130 m) 6 in. (15 cm) steam line. Boiler feedwater is supplied from the hospital, via a parallel line, to the energy-from-waste plant. The hospital boilers are fired with No. 2 fuel oil and provide stand-by and peak loading capability. The hospital steam load varies from 4000 lb/hr (1800 kg/h) to 25000 lb/hr (11,400 kg/h) and averages 13,000 lb/hr (5900 kg/h).

Ash from the primary chambers is discharged by the final transfer ram into a wet ash tank and conveyed by a drag conveyor to a storage bin for removal and ultimate landfill disposal.

**OPERATING EXPERIENCE**

The plant operates 24 hr/day, 7 days/week with a total plant staff of 12 which includes the following personnel:

- Plant Manager 1
- Secretary 1
- Operating Engineers 4
- Maintenance Technician 1
- Labourers/Operators 5
- **TOTAL 12**

The following operating statistics are based on six months of operation, including an initial 7-day performance test.

- peak waste throughput: 120 TPD (109 t/day)
- average waste throughput: 72 TPD (65 t/day)
- annual waste throughput: 1984 annual estimate — 26000 tons (23,600 t)
- peak steam production: 20,500 lb/hr (9300 kg/h) at 300 psig (2070 kPa) saturated
- average steam production: 15,000 lb/hr (6800 kg/h)
- tons of steam/ton of waste: 2.5 (avg.)
- auxiliary fuel oil (start-up conditions only): Approximately 60 U.S. gallons (230 L) of fuel are required per start-up from a cold start
- electricity consumption: 50 kWh/ton (55 kWh/t) (avg.)
- concentration of unoxidized organic material and free carbon in the ash: 3.5 percent by weight of the total dry combustibles in the refuse
- opacity of the total emission: clean stack less than 5 percent avg.
- Shutdowns: the plant has not had an unscheduled outage during the first six months of operation. The plant does schedule one shutdown every 2 months for a 36 hr duration to clean and check the boiler and steam systems
- fluctuations in steam production: 5 to 10 percent

Source air pollution testing was conducted by Environment Canada during a two-week period in April. Total suspended particulate levels in the stack were 0.086 gr/scf (200 mg/m³). Processed through the Ministry of Environment (Ontario) dispersion model, ground level particulate concentrations would be approximately 25 ug/m³ against a Provincial standard of 100 ug/m³.

**BUILDING AND SITE DETAILS**

- Land Area: 2.6 acres (1.1 ha)
- Building Plan Area: 17,160 ft² (1600 m²)
- Receiving Floor Area: 9,700 ft² (900 m²)
- Process Deck Area: 6,600 ft² (610 m²)
- Office Area: 860 ft² (80 m²) (offices are on second floor. Employee facilities and locker room are on first floor)
- Stack Heights (above grade): 70 ft (21 m) (main stack) 50 ft (15 m) (emergency stack)
- Building Height: 50 ft (15 m)

**PROJECT ECONOMICS**

The Energy Corporation financed the project with loans and with various grants from the federal government. The capital cost for the project in Canadian dollars is as follows:

- design, construction and start-up of the plant (Tricil contract) $ 8,000,000
- site servicing, design and construction of steam and feedwater transfer system and project financing costs. This cost excludes land cost. The plant is situated on reclaimed land owned by the P.E.I. Energy Corporation

\[
\text{TOTAL PROJECT COST} \quad 2,000,000 \\
\text{TOTAL PROJECT COST} \quad 10,000,000 \text{ Cdn}
\]

The following are the sources of capital funds employed in the project:

(a) Grants
   - Federal Government \$ 4,000,000
   - Provincial Government \$ 500,000

(b) Long term loans @12 percent interest
   \$ 5,500,000

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\text{TOTAL} \quad 10,000,000 \text{ Cdn}
\]

The 1984 project economics are presented as follows:

**ANNUAL REVENUES**

- Steam \$1,340,000
  130 million lbs (59 million kg) is produced annually. However, steam used by the hospital is projected to be less than that produced. The selling price is \$11.00/1000 lb (454 kg).
- Tipping fees \$ 260,000

\[
\text{TOTAL} \quad 1,600,000
\]

**ANNUAL COSTS**

- Debt Service (20 year amortization) \$ 720,000
- Operating Costs (1984 Budget includes Tricil’s Management Fee) \$ 880,000

\[
\text{TOTAL} \quad 1,600,000
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**CONCLUSION**

The technical success of this plant illustrates that substantial benefits can be gained when a full service contract approach is employed. Specific needs of the client were fully met and the operating know-how and experience of the waste management contractor has resulted in an improved plant design and successful operation.

**Key Words:** Combustion • Disposal • Energy • Incineration • Modular • Operation • Steam