FUEL EFFICIENCY IN GENERATION AND COST IMPLICATIONS

A Trinidad and Tobago Perspective

Structure of Presentation

- Overview of the Electricity Sector
- Fuel efficiency and factors that affect it
- The Trinidad and Tobago Experience
- RIC's proposals for handling fuel efficiency

Overview of the Electricity Sector

- One T&D utility, the Trinidad and Tobago Electricity Commission (T&TEC)
- Two independent power producers (IPPs) were introduced:
  - The Power Generation Company of Trinidad and Tobago (PowerGen); and
  - Trinity Power Management Limited (formerly InnCogen Ltd.)
- Both are governed by PPAs.
- One regulator, the RIC.

Overview of the Electricity Sector

- The RIC is conducting its first regulatory review of tariffs for the electricity transmission and distribution sectors.
- As part of the exercise, the RIC closely examined uncontrollable costs which constitutes 70% of T&TEC's costs.
- Uncontrollable costs in our case are PPA costs (conversion and fuel costs).
- Fuel costs accounting for 25% of the costs.

Fuel Efficiency

- Fuel efficiency is examined with reduction in fuel costs as the objective.
- Technical aspects considered:
  - Age of equipment;
  - Plant design;
  - Heat rate;
  - Plant operation;
  - Demand- side management.

Trinidad and Tobago Experience

- There are five power producing stations in Trinidad and Tobago (32 gen sets)
  - Port of Spain - Steam turbine, Gas turbine
  - Penal - Gas turbine, Combined cycle HRSG
  - Point Lisas - Gas turbine
  - Couva - Gas turbine
  - Tobago - Diesel engine
- Natural gas is the fuel of choice used for over 90% of the power produced.
- The other 10% is diesel and jet A fuel.

Trinidad and Tobago Experience.

- Most (78%) of the generating units are over 20 years.
- They are approaching the end of their useful lives, therefore performance is on the decline and fuel efficiency is compromised.
- Decisions to be made:
  - Upgrade;
  - Refurbish; or
  - Replace

Trinidad and Tobago Experience

Age is one aspect for declining performance.

Other critical factors that affect fuel efficiency :

- Terms of the PPAs with respect to:
  - procurement of fuel; and
  - heat rate.
- Plant operation.
- Plant design: simple cycle versus combined cycle HRSG.

T&T Exp. - PPA

- What is a PPA?
  - Take or pay contract
  - Govern bulk purchase of power
  - Contain many standard clauses and schedules depending on existing conditions at the time

T&T Exp. - PPA

- Shortcomings of present PPAs
  - They were negotiated without the involvement of the regulator.
  - Even though the current power producers fall under the remit of the RIC, the nature of the PPAs imposes constraints on the RIC and does not allow for them to be regulated in any significant manner.
  - Future PPAs must be negotiated with the involvement of the regulator

T&T Exp. - PPA

- Two areas of concern that directly affect fuel efficiency are:
  - Fuel procurement
  - Heat Rate

T&T Exp.:PPA - Fuel Procurement

- T&TEC buys natural gas for the generation companies, and then buys the bulk power from the generation companies.
- believed to be the best arrangement at the time, because of pre-existing contract between T&TEC and the NGC, at a preferred price that was not available to the IPPs.
- Since 1995 to present, there has been no new contract and fuel price has increased by 4% annually.
- No risk to IPPs where fuel is concerned, raises issues about efficient use.

T&T Exp.:PPA - Fuel Procurement

- RIC's views on fuel procurement

  There are two options are available.

  – 1. Procurement should be done by the IPPs at a preferred price.

  – 2. Only the fuel cost associated with the most efficient methods of generation will be considered in the revenue requirement.

- The RIC has recommended to government that a new long-term gas contract be renegotiated.

T&T Exp.: Heat Rate

- The Heat Rate measures the thermal efficiency of the conversion process.
- A lower heat rate means that the conversion process is more efficient and may lead to reductions in fuel consumption.
- A plant's heat rate is determined by
  - the plant's design,
  - fuel used and
  - the patterns and levels of operation.

T&T Exp.:PPA – Heat Rate

- Heat Rate
  - Specified for PowerGen (14,000kJ/kWh ±5%)
    - Range 13,300 to 14,737 kJ/kWh
    - This range did not encourage heat rate improvement since prior to divestment the plants were operating within this range
  - Not specified for Trinity Power
    - Heat rates from the Trinity Power station are lower than the 14,000kJ/kWh.
    - Average was 13,438 kJ/kWh in 2004.

T&T Exp.:PPA – Heat Rate

- Reducing the heat rate can lead to significant savings in the volume of fuel used and consequently in fuel costs.
- Various scenarios were examined in order to assess the possible cost savings from reducing the heat rate.

T&T Exp.:PPA – Heat Rate

Scenario	Stations	Heat Rate Reduction	Annual Savings (US$)	Savings over Review Period (US$)
1.a)	All stations that supply T&TEC	From: 14,433 kJ/kWh To: 13,300 kJ/kWh	6,031,732	30,158,664
1.b)	All stations that supply T&TEC	From: 14,433 kJ/kWh To: 12,000 kJ/kWh	12,949,339	64,746,695
2	PowerGen Stations	From: 14,752 kJ/kWh To: 13,300 kJ/kWh	5,872,689	29,363,445
3	Point Lisas Station	From: 16,557 kJ/kWh To: 13,300 kJ/kWh	6,617,013	33,085,068

T&T Exp.: PPA – Heat Rate

- From the 1st Scenario, at least **7.8%** of saving on annual fuel costs is possible, approximately US$6.03 million.
- The RIC is mindful of the operational difficulties and cost implications to reduce the heat rate since some of the equipment needs to be upgraded or completely replaced based on their age.
- However, the cost must be weighed against the savings to the consumers.
- As such, the RIC feels that T&TEC must insist that the power generators make every effort to reduce the system heat rate to the lower end of the range proposed in the PPA with PowerGen

T&T Exp.: PPA – Heat Rate

However in the interim, possibilities for improvement include:

- Improving the availability of the Penal combined cycle by installing General Electric's new maintenance-extender kit on the two gas turbines;
- Reducing the large spinning reserve;
- Commissioning the Load Share control system on the 8 large generating units at Point Lisas station;
- Upgrading the older generators; and
- Implementing analytical monitoring tools to change the dispatch of the plants to a more energy efficient arrangement.

T&T Exp. – Plant Operation

- Plants must be able to maintain its efficiency over a wide load range.
- However, plants operated near capacity will experience their most efficient heat rates.
- Most of the generation units are committed to providing base load.
- Designated units at Point Lisas are used to satisfy any increase in load demand.

T&T Exp. – Plant Operation

- These units have to respond to large daily fluctuations in demand because of the large industrial customers. Eg. Steel mill.
- Plant cycling (frequent load change) and low levels of operation will produce higher heat rates.
- This duty cycle makes the heat rates at the Point Lisas station the highest and the most difficult to reduce.(>16,500 kJ/kWh)

T&T Exp. – Plant Operation

- Another factor is plant dispatch.
- In competitive markets, the most efficient plants are dispatched first.
- However, in Trinidad and Tobago, although there are two IPPs, there is no competition in the generation market.
- Peak demand for electricity is almost at the maximum capacity of the generators. Hence, it is not a question of which block of power to be used but rather is the power available.

T&T Exp.: Plant Design

Plant designs currently used in T&T:

- simple cycle natural gas turbines;
- diesel engine driven generators;
- steam turbines; and
- combined cycle heat recovery steam generator (HRSG)

T&T Exp. : Plant Design

- Additional capacity will be required to cater for normal growth by the end of 2006.
- RIC, as part of forecasting the efficient revenue requirement for T&TEC in its review of tariffs for the period 2005-2006, sought to examine the generation options available.
- Simple cycle generation versus combined cycle generation is explored.

T&T Exp. – Plant Design

- Simple Cycle

  Advantages

  – Short time to install & start up;

  – Relatively small Capital Costs (US$360-$440/kW) without emission control.

  – Capacity Factor: 30 to 85% in peaking mode.

  – Availability: >90%

T&T Exp. – Plant Design

- Simple Cycle

  Disadvantages

  – **R**equires natural gas and would increase fuel bill by about US$5 million annually.

  – Relatively large Operating Costs based on 85% capacity factor: US$34 -$44/kW.

  – Maintenance costs are higher because major overhaul is required every three years and parts for gas turbines are very expensive.

  – Typical efficiencies range between 35-42%

T&T Exp. – Plant Design

- Combined Cycle HRSG

  Advantages

  – Relatively small Operating Costs based on 85% capacity factor: US$28/kW.
  – No additional fuel required, if steam turbine is used with pre-existing gas turbines.
  – Typical Efficiencies of 50 to 55% .
  – Availability: >90%
  – More energy efficient. (Lower heat rates).
  – Maintenance costs are lower because major overhaul is required every 7 years and parts are not as expensive as those for gas turbines.

T&T Exp. – Plant Design

- Combined Cycle

  Disadvantages

  – Time to have plant up and running is long, approximately 18 – 36 months.

  – Relatively large Capital Costs: US$500-$600/kW without emission control.

  – Water management is crucial, both for steam generation and cooling systems.

T&T Exp. – Plant Design

- RIC firmly believes that a cost-efficient option would be to add HRSG to the existing infrastructure.
- This will lead to lower heat rates and consequently improve fuel efficiency.
- RIC has estimated that over a fifteen (15) year period there will be savings of $28.1 million per annum (US$4.5Mn).

T&T Exp. – Plant Design

This estimation is based on using combined cycle generation for the additional 210MW capacity at PowerGen and the following factors:

- Capital outlay and associated costs;
- Non fuel operations and maintenance costs;
- Fuel purchases from NGC; and
- Heat rate of 12,000 kJ/kWh

RIC's Proposals on Fuel Efficiency

- The RIC is mandated by its Act, to adopt incentive regulation as the way forward for our local utilities
- As such, only the most efficient costs for all areas of the electricity sector will be considered.
- RIC's responsibility is to provide T&TEC with incentives to explore options for improving fuel efficiency, thereby reducing fuel costs.

RIC's Proposals on Fuel Efficiency

- Future PPAs must be negotiated with the involvement of the regulator.
- T&TEC must insist that the power generators, especially PowerGen, reduce their system heat rate to the lower end of the range proposed in the PPA with PowerGen;
- The renegotiation of the Heat Rate with PowerGen with a reduced tolerance (3% instead of 5%) and a shorter heat rate averaging period (quarterly instead of annually);

RIC's Proposals on Fuel Efficiency

- The RIC recognizes that there are cost implications to reducing heat rate, however, the medium to long-term savings to the consumers are significant and must be considered.
  - Accordingly, the RIC is of the view that there should be only 90% pass-through of the fuel costs to the consumers.
  - No regulator can knowingly encourage inefficiencies to be passed through to consumers
- The renegotiation of a long-term gas contract between T&TEC and the National Gas Company (NGC);

RIC's Proposals on Fuel Efficiency

- The establishment of a monitoring system to get baseline information on the performance of the different generating units in order to set targets and establish performance indicators.

Other RIC Proposals - Heat Rate Reduction

- Undertake a plant performance assessment.
- Establishing clear, measurable goals for improved heat rate by management.
- Developing heat rate improvement training programs for plant staff.
- Assignment of a heat rate engineer at each plant.
- Establishing a centralized heat rate-testing group.
- Installation of cost-effective design upgrades including heat rate monitoring systems.

Other RIC Proposals - Benchmarking & Monitoring

- Heat rate is only one indicator of performance.
- Power plants of similar design and operational parameters should be benchmarked.
- Some of these parameters consist of , but are not limited to
  - Age of equipment, Fuel firing system, Boiler Circulation Type, Turbine Manufacturer, Boiler Manufacturer, Unit Size, Generator Manufacturer, Condenser Cooling Water Type, Duty Cycle, Ambient Conditions, Quality of Fuel Supplied- Processed Natural Gas or Jet A 1

Other RIC proposals - DSM

Demand-side management objectives:

- **Energy conservation -** the reduction of overall consumption of electricity by reducing its use in lighting, cooling, cooking, etc.;
- **Energy Efficiency -** encouraging customers to use energy more efficiently through the use of energy-efficient lighting, appliances, etc.; and
- **Load Management -** providing incentives to use electricity during off-peak periods, thereby reducing the quantum of additional capacity required to serve customers during periods of peak demand.

Conclusion

As regulators we must be fair, prudent and seek the interest of all stakeholders.

Shortcomings that impact on fuel efficiency will not be passed on to consumers.

Only efficient cost will be considered and this is reflected in the RIC's decision to allow only 90% of fuel costs to be passed through.

The End