REGULATED INDUSTRIES COMMISSION

Quality of Service Scheme for Electricity Generating Entities in Trinidad and Tobago

August 2018

Consultative Document

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1. Introduction

The Regulated Industries Commission (RIC) is the economic regulator for the electricity and water sectors in Trinidad and Tobago. In the conduct of its regulatory functions, the RIC is guided by the legislative and regulatory framework set out in the RIC Act No. 26 of 1998. Section 6(1) of the RIC Act expressly empowers the RIC to prescribe standards of service; to monitor service providers to assess performance with the established standards; and to impose sanctions for non-compliance. Accordingly, the RIC is publishing this Quality of Service Standards (QSS) Scheme for Electricity Generating Entities in Trinidad and Tobago with focus on the **efficiency of generating plants**. Section 6(2) of the Act also mandates the RIC to consult with all parties it considers as having an interest in matters before it.

1.1 Purpose of this Document

The purpose of this document is to engage in consultation with key stakeholders to develop an appropriate Quality of Service Scheme for the Generation Sector in Trinidad and Tobago that can be used to promote the economic and operational efficiencies of non-renewable electricity generation[1]. A previous version was issued for pre-consultation, and consideration was given to the feedback obtained, in preparing this document.

1.2 Structure of this Document

This document is divided into six sections. Section two provides a brief overview of the electricity sector in Trinidad and Tobago. Section three discusses the need for quality of service standards in electricity generation. Section four outlines performance mechanisms for power generation. In Section five, Standards for Power Generation in Trinidad and Tobago are discussed. In Section six, parameters for performance monitoring and reporting are identified.

1.3 Responding to this Document

As part of the consultative process, the RIC invites feedback from stakeholders on the proposals in this document. Responses, and any other issues which respondents believe should be considered

[1] Renewable Energy will not fall under this Scheme

by the RIC in developing quality of service standards for electricity generating entities, should be sent in writing by **September 10, 2018** to:

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Copies of this document are available from the RIC Information Centre or from our website at www.ric.org.tt.

The RIC reserves the right to make all responses available to the public by posting responses on its website at www.ric.org.tt/consultations. If a response is marked confidential, reasons should be given to facilitate the evaluation of the request for confidentiality. The RIC will be guided by Section 62(b) of the RIC Act when evaluating any request for confidentiality.

2. Overview of the Electricity Sector in Trinidad and Tobago

The electricity sector in Trinidad and Tobago consists of a government-owned monopoly electricity transmission and distribution utility, the Trinidad and Tobago Electricity Commission (T&TEC), and three independent power producers (IPPs) – Power Generation Company of Trinidad and Tobago Limited (PowerGen), Trinity Power Limited and Trinidad Generation Unlimited (TGU). T&TEC owns and operates the transmission and distribution grid and purchases electricity from the IPPs which is sold to its 470,000 customers. The relationships between the IPPs and T&TEC are governed by Power Purchase Agreements (PPAs). These are long-term contracts that specify the amount of electricity that is to be supplied to T&TEC, the price to be paid by T&TEC and the conditions of service. Under these contracts T&TEC is responsible for procuring the fuel used to generate the electricity. Total nameplate installed capacity of the generating entities is 2,104 MW, as of 2017, with a net derated capacity of 2,019 MW. Natural gas is the primary fuel used for generation.

2.1 PowerGen

PowerGen was established in 1994 as the first IPP, which resulted from a divestment of the generating assets of T&TEC, with T&TEC retaining 51% ownership and the remaining 49% privately-owned. The company has an installed nameplate capacity of 1,074 MW, with a net derated capacity of 1,003 MW - distributed between two stations in Point Lisas and Penal, of which 624 MW is available to T&TEC under the PPA. The Penal station is primarily a combined cycle plant with a capacity of 236 MW. The Point Lisas plant accounts for the remaining capacity using simple cycle gas turbines. These were commissioned between 1984 and 2007.

2.2 Trinity Power

Trinity Power was the second IPP to come on stream. It is a privately held entity with three (3) 75 MW natural gas fired generating units with a total installed capacity of 225 MW of which 210 MW is contracted to T&TEC under the PPA. The company is located in Brechin Castle, Couva, and was commissioned in 1999.

2.3 T&TEC

T&TEC has a 22 MW diesel plant in Scarborough, Tobago, consisting of eight units, and four 16 MW natural gas/diesel dual fuel reciprocating generators at the Cove Estate in Tobago. However, only 11 MW is available operationally from Scarborough. Therefore, T&TEC has a generating capacity of 75 MW.

2.4 TGU

TGU is the newest IPP to establish a PPA with T&TEC. The company has six gas turbines which provide a total maximum simple cycle output of 450 MW. The exhaust gases from these are fed into 6 waste heat boilers powering two steam generators which provide an additional output of up to 270 MW at no additional fuel consumption, for a total installed capacity of 720 MW. The plant was commissioned in 2011, and is owned by the Government of Trinidad and Tobago.

2.5 Jurisdiction

T&TEC falls under the Ministry with responsibility for Public Utilities, while the IPPs fall under the Ministry with responsibility for Energy. The economic regulator of the sector is the Regulated Industries Commission. TGU does not fall under the RIC’s remit at this time.

3. The Need for Quality of Service Standards in Electricity Generation

3.1 The Nature of the Power Market in Trinidad and Tobago

3.1.1 Limited Competition

The dynamics in a competitive market encourages efficiency which is typically reflected in the price and quality of goods and services provided. In Trinidad and Tobago, electricity generation is unbundled from transmission and distribution, as it is in many jurisdictions around the world. This arrangement allows for some level of competition in the procurement of generation[2], however, the terms and conditions of operation is limited to what is negotiated in the PPA contracts. The generators are not subject to the pressures of a highly competitive market, and consequently the buyer or off-taker, in this case T&TEC, does not benefit from the accompanying efficiencies. Economic regulation is intended to address the situation that results from the lack of competition, and thereby promote economic efficiency of the sector.

3.1.2 Generation Procurement

Power generation plants are classified by how they are dispatched in the generation portfolio; either as baseload, peaking or load following power plants. Baseload power plants provide continuous generation of electricity throughout the year and are only turned off for maintenance. Typically, plants with the lowest operating costs are used for this application. Peaking power plants, on the other hand, are brought into service during periods of high electricity demand. These are typically less efficient plants, but their lower capital expenditure requirements (Capex) and quick dispatchability make them the most economical choice for the application[3]. Load following plants operate in the service region between baseload and peaking power plants. For a generation portfolio that is made up totally of natural gas fired power generation, combined cycle power plants are typically used for baseload applications, because of their relatively high efficiency and consequent low per unit operating cost. In Trinidad and Tobago, prior to the commissioning of TGU, a large percentage of T&TEC's baseload was being serviced by simple cycle combustion gas turbine. Although a combined cycle plant was commissioned in 1984 in Penal, subsequent generation procurement was for simple cycle combustion turbines.

[2] This is generally referred to as competition for the market rather than in the market.

[3] Typically, with respect to generating plants there is a trade-off between capital and operating costs, plants that have higher capital costs tend to have lower operating costs.

The economics of generation procurement is dependent on the price of the fuel used. In Trinidad and Tobago, natural gas is supplied at below market price for the generation of electricity. This artificially low price of fuel tends to favour the use of cheaper, less efficient technology as operating expenditure (Opex) is reduced. The incentive to do this could be reduced at the generation procurement stage, if proper consideration is given to the opportunity cost of acquiring fuel for generation.

In Trinidad and Tobago, the Ministry of Energy and Energy Industries has the responsibility for generation procurement, which is essentially relegated to T&TEC. However, since T&TEC is also a generator and has a 51% holding in one of the IPPs, the entity may not be best placed to assume this responsibility. Also, having the utility drive the process could result in the operational need for additional generating capacity in the shortest possible time competing with the benefit of procuring the most efficient option.

3.1.3 Fuel Procurement

In jurisdictions where generation is unbundled from transmission/distribution, contracts with IPPs are typically established through a bidding process and awarded to the entity that offers the most competitive net price for electricity. The successful generator is normally responsible for purchasing fuel and bears all the costs associated with generation. However, in Trinidad and Tobago, the fuel is locally sourced and paid for by T&TEC. The price of fuel is set by the government and has been stable over the years, and not subject to the typical price volatility and other risks associated with procurement on the open market. The arrangement removes the natural incentive for the IPPs to operate at optimum efficiency to minimize fuel cost. To circumvent this shortcoming, the PPAs specify efficiency targets, along with incentives and penalties. The targets are based on the capability of the selected generating technology, and therefore applies only to operational efficiency, which is limited by choices made at the procurement stage. This does not preclude the acquisition of generation that is primarily driven by the provision of additional generating capacity within the shortest time and least capital cost, and without proper consideration for optimal efficiency.

3.1.4 Transparency

The price that T&TEC pays for electricity and the condition of service are negotiated upfront with the generator and locked in a long-term contract, spanning as much as 30 years. The associated costs are considered to be generally uncontrollable by T&TEC after signing of PPA and are therefore passed through by the RIC when setting the rates that T&TEC charges to customers. Generation costs, which consist of conversion cost paid to IPPs and fuel costs, accounts for more than half of the cost that T&TEC incurs in providing service to customers. Hence, the resulting costs passed on to customers by T&TEC represent a significant portion of the price that customers pay for electricity. In keeping with the principle of transparency and accountability, there should be some level of public reporting on the agreement and the performance of the arrangements between T&TEC and the IPPs to allow for public scrutiny of what is a significant contributor to the rates that customers are required to pay for service.

3.2 Reliability of Power Generation

There have been a number of major blackouts in recent years in Trinidad and Tobago which affected a large portion of the country across all customer classes. On May 11, 2016, a problem with the pneumatic control system at the TGU plant resulted in widespread load shedding across Trinidad, which lasted for several hours. There was an island wide blackout on March 29, 2013 due to disruption in the natural gas supply caused by a malfunctioning valve at Phoenix Park Gas Processors Ltd. While the disruption in natural gas supply lasted for about 30 minutes, the power outage lasted for several hours because the generator had difficulties restarting their machines (black start) after the gas supply was restored. In December 2012, a blackout along the entire north-west of Trinidad forced dozens of businesses in downtown Port- of-Spain to halt business operations. On August 30, 2011, Port-of-Spain was without electricity for more than two hours after lightning struck the T&TEC's Bamboo sub-station, Valsayn. Power outages also were reported in north, central and east Trinidad. In July 2010, lightning struck a PowerGen station during heavy rains, causing blackouts in several parts of the country. That incident also caused several generators to trip at the Point Lisas facility, affecting areas in Point Fortin, Fyzabad, Santa Flora and surrounding areas. Investigation of these seems to indicate that the electricity sector in Trinidad and Tobago could benefit from some kind of reliability oversight, including electricity generation.

It is not uncommon to have an independent body responsible for ensuring the reliability of the electricity grid. For example, The North American Electric Reliability Corporation (NERC) is a regulatory authority whose mission is to assure the reliability and security of the bulk power system in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the bulk power system through system awareness; and educates, trains, and certifies industry personnel. NERC’s area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the electric reliability organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the bulk power system, which serves more than 334 million people. At the state level, there is the Electric Reliability Council of Texas (ERCOT) which manages the flow of electric power on the Texas Interconnection that supplies power to 24 million Texas customers – representing 85 percent of the state's electric load. ERCOT is subject to oversight by the economic regulator of the state – Public Utility Commission of Texas – and the Texas Legislature. In Trinidad and Tobago, there is no body with explicit responsibility for regulating the reliability of the electric grid.

Mechanisms should be instituted to ensure reliability of the electricity supply; promote maximum efficiency; protect against cybersecurity threats; foster transparency and public accountability; and safeguard the public interest and national welfare.

3.3 Tightening Natural Gas Supply and Energy Security

Trinidad and Tobago is experiencing a curtailment of natural gas from local production to meet current demand. Average gas production has been declining over recent years, falling from 4.1 billion cubic feet/day in 2013 to under 3.3 billion cubic feet/day in 2016. While there was a boost in gas production during 2017 due to the Juniper project and other activities, the long-term projection is that net gas production will continue to decline. Electricity generation is the most immediately important use of natural gas in Trinidad and Tobago, and is given priority access to current supply. Given that a significant amount of the electricity is generated using inefficient technology, there is a significant opportunity to reduce natural gas demand by improving conversion efficiency within the electricity generation sector. Optimization of natural gas consumption for electricity generation is expected to result in significant gas savings, and generate foreign exchange through additional petrochemical production.

These challenges of energy security and optimal value creation are recognized by other oil and gas producing countries. The United Arab Emirates and Saudi Arabia, which are known for their vast oil reserves, have within recent years sought to diversify their energy portfolios and reduce dependence on fossil fuels by investing heavily in nuclear power and renewable energy. Several Middle Eastern and North African countries have also announced plans to include nuclear power and renewable energy within their electricity supply matrix to meet rapidly rising demand for electricity, as well as safeguard oil exports, support economic growth, achieve greater security of energy supplies, and reduce their carbon footprint.

3.4 Environmental Impact

It is well established that the generation of electricity by the combustion of hydrocarbons such as natural gas, is a major factor in the anthropogenic emission of carbon dioxide, which is believed to contribute to harmful environmental effects such as global warming. Trinidad and Tobago has a high CO_2 emission per capita because of the relative size of its industrial sector, with power generation producing 19% of the country's greenhouse gas emissions. As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol and Paris Agreement, Trinidad and Tobago is committed to conditionally reducing its cumulative carbon emissions by 15% in the power generation, transport and industrial sectors by 2030. Improvement in the thermal efficiency of natural gas powered electricity generation will help to reduce the country's greenhouse gas emissions.

1. ***Do you agree with the rationale for quality of service standards for electricity generation in Trinidad and Tobago?***

4. Approaches for Regulating Service Quality

There are several mechanisms that can be used for regulating the quality of service provided by utilities. These include:

- Minimum/Indicative Standards;
- Performance Reporting;
- Guaranteed Standard Scheme;
- Performance Incentive Mechanism (S-Factor); and
- Legal Compensation and/or Application of Statutory Penalties.

4.1 Minimum/Indicative Standards

Minimum service standards are typically specified for a range of quality attributes, and are often part of a licensing condition. However, these provisions impose little pressure on the service provider to move towards an optimal level of service quality. Minimum standards can have a role in improving service quality but only in conjunction with other measures that either incentivize good performance or penalize poor performance.

4.2 Performance Reporting

Under this scheme, specific performance indicators are identified that the generator would be required to report on to the regulator and the public. The reporting may also include past performance as well as benchmarks from utilities in other jurisdiction. This allows for public scrutiny of the performance of the utility which in turn exerts pressure on the service provider to improve performance. This type of scheme is flexible and can be easily tailored to suit any sector. It can also be used in conjunction with other schemes or as a precursor to introducing other schemes.

4.3 Guaranteed Standards Scheme

A guaranteed standard scheme is one in which standards of performance are set for specific outputs of the utility. The utility is required to meet these minimum standards in its service delivery to individual customers or a group of customers. Failure to comply with these standards is recorded as a breach and the utility may be required to make a pre-defined compensatory payment to customers. The compensatory payment is meant to incentivise the service provider to improve performance rather than to compensate the customer for any loss or inconvenience suffered. The scheme is best suited where there is a monopoly service provider serving many customers with little market power. Hence, the payout by the service provider can be very significant in cases where a large group of customers is affected. The generators have one customer, T&TEC, which, it can be argued, wields significant market power through its position as a single buyer. Therefore, a guaranteed standards scheme may not be appropriate.

4.4 Performance Incentive Mechanism (S-Factor)

In this type of scheme, the allowed revenue of the utility is adjusted in relation to the difference between the target level of performance and the actual level achieved. This type of scheme incentivizes performance improvement and penalizes under-performance. However, it is more difficult to set up and administer. It involves complex mechanisms for assessing performance and incentives/penalties and requires an elaborate and robust data collection system. As the RIC does not at this time set prices for the sub-sector it is not possible to institute such a scheme.

4.5 Legal Compensation and/or Application of Statutory Penalties

Under this approach, service providers have an incentive to provide good service due to the possibility of having the courts award compensatory payments to customers affected by poor service or the application of statutory penalties by the regulator. This approach carries high transaction costs, and is also ad hoc, but can be an effective incentive of last resort.

2. ***On balance the RIC considers Performance Reporting mechanism as the most appropriate scheme for power generation at this time. Do you agree with this position?***

5. Proposed Performance Standards for Power Generation in Trinidad and Tobago

An integral tool in evaluating the performance of any service provider is the identification, determination and monitoring of appropriate performance indicators. In considering standards for electricity generation, certain key performance indicators that are used internationally for power generating plants in benchmarking factors such as economic efficiency, quality of service, commercial viability and operational efficiency were considered. At this time, the RIC has chosen to confine this scheme to quality of service indicators and operational efficiency. The performance characteristics of similar plants operating under comparable conditions were also taken into account as the basis for benchmark targets for the local power generating plants. Moreover, specific attention was paid to indicators that impacted on key areas of concern to the RIC; given the impact of fuel costs on tariffs paid by electricity customers.

5.1 Thermal Efficiency

Improved energy efficiency is often the most economic and readily available means of improving energy security and reducing greenhouse gas emissions[4]. Both energy efficiency and greenhouse gas emissions are affected by the technology and type of fuel used. Electricity production is responsible for 32 percent of total global fossil fuel use[5]. Therefore, the efficiency of converting fuel to electric power is a natural area of attention for continuous improvement in energy use. The fuel matrix for world electricity generation in 2015 was made up of 39.3 percent coal, 22.9 percent natural gas, 16.0 percent hydro, 10.6 percent nuclear and 11.2 percent from oil and non-hydro renewables[6]. In countries where coal, nuclear or hydro is used to supply most of the electricity load, natural gas, if used, supplies peak loads, using mainly simple cycle gas turbines. They can be brought into service quickly, and the power output ramped up in minutes. However, the corresponding cost of the electricity produced, is relatively expensive. In countries where natural gas is the dominant fuel used for the generation of electricity, combined cycle power plants are also used to supply intermediate loads or base loads because of their efficiency and reduced greenhouse gas emissions. In the United States of America, where natural gas accounted for 33.8

[4] *Energy Efficiency Indicators for Public Electricity Production from Fossil Fuels*, International Energy Agency, July 2008

[5] Ibid

[6] International Energy Agency. (2017). Key World Energy Statistics 2017. International Energy Agency.

percent of the electricity generated in 2016, the average capacity factor[7] for combined cycle plants was 55.5 percent, and that of simple cycle natural gas-fired generation was 8.3 percent. Average efficiency of electricity produced from natural gas was 46.5 percent in 2015. In Trinidad and Tobago, practically all electricity generation is fueled by natural gas. However, unlike the rest of the world, 53 percentage of the generating capacity is supplied by simple gas turbines. These units have a lower capital cost than a combined cycle unit of the same capacity, and requires approximately fifty percent less time from inception to commissioning. This is further compounded by the fact that natural gas was once considered to be abundantly available locally, and supplied for electricity production at below international market price. Therefore, the electricity generation profile of Trinidad and Tobago is unique in terms of fuel supply matrix and type of generating units used to supply the various types of load.

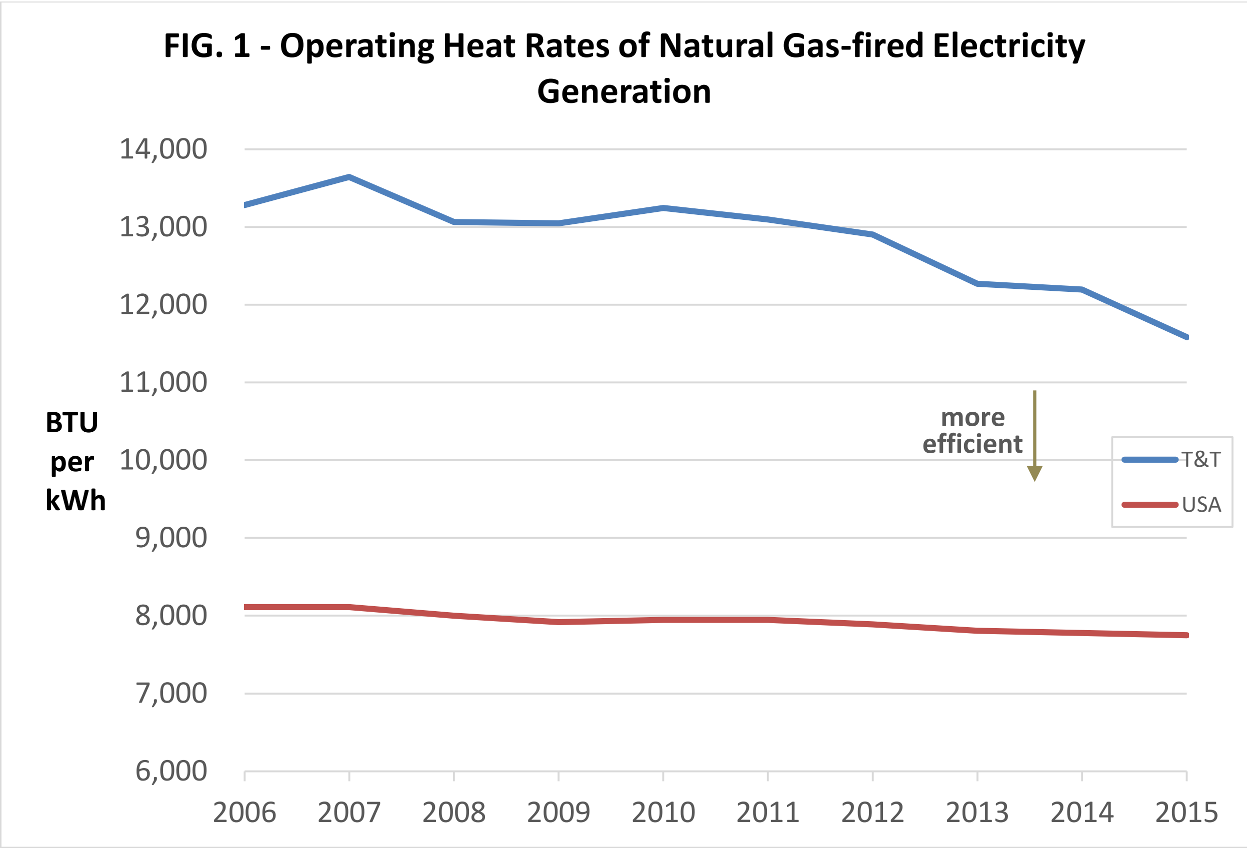
A measure that is widely used to assess the efficiency of a generating plant is its thermal efficiency. Thermal efficiency is a measure of how effectively the heat content of a fuel is converted to electricity. Since fuel accounts for a significant portion of the cost of producing electricity, the thermal efficiency can be considered to be one of the indicators of how efficient a generating plant operates. There are several ways to assess and represent thermal efficiency. All involve comparing the electric power produced to the calorific value of the fuel consumed in producing the electricity. The quantity derived, depends on whether the gross or net power output, or the gross or net calorific value, is used. However, there is no unique international standardized and acceptable methodology available to report thermal efficiency[8]. One metric that is used is the heat rate of the generating plant. This is the amount of heat supplied (from the fuel source) per kilo-watt of energy produced. The heat rate is a measure of the thermal efficiency of a generating unit, commonly expressed in Btu per kilowatt-hour (or KJ per kilowatt-hour). Heat rate can be expressed as either gross or net heat rate, depending whether the gross or net electricity generation output is used to calculate the heat rate, but is typically expressed as net heat rate[9]. Figure 1 shows the average operating heat rate for natural gas-fired electricity generation in the United States and Trinidad

[7] Capacity factor is the ratio of the net electricity generated for the time considered, to the energy that could have been generated at continuous full power operation during the same period.

[8] Kaupp, A. (2006). *Article # 29: The complexity of thermal power plant efficiencies reporting in India and Germany*, http://www.energymanagertraining.com/PowerPlantComponent/Output1.1/08.pdf

[9] Energy Information Administration, (May 21, 2009), *Energy Glossary*, US Department of Energy, http://www.eia.doe.gov/glossary/glossary_h.htm

and Tobago for the period 2006 to 2015. The US heat rate averaged at approximately 8,000 Btu/kWh (8,400 kJ/kWh) and declined over the period by 7%. By comparison, heat rate in Trinidad and Tobago averaged at 12,800 Btu/kWh (13,500 kJ/kWh) and declined by approximately 13%.



Sources: - U.S. Energy Information Administration, Form EIA-923, Power Plant Operations Report
- Trinidad and Tobago Electricity Commission

The IPPs in Trinidad and Tobago monitor the heat rate of their power stations as a part of their PPA contracts with T&TEC. As such, the net heat rate will be used as a performance indicator because there is more uniformity in the way it is determined across IPPs, thus making it more likely to obtain suitable benchmarking information. When setting parameters for performance monitoring, it is useful to indicate how the parameters are related to system performance. Thermal efficiency of a generating station is a function of several variables. These include internally controllable factors such as plant design, operation and maintenance, as well as exogenous factors that are beyond the control of the operator, such as ambient temperature, humidity and air density.

To compensate for the variation in ambient conditions, it is usual to consider some standard conditions at which efficiency is measured. The standard conditions used by the gas turbine industry are 15°C, 1.013 bars (atmospheric pressure at sea level) and 60% relative humidity, which are established by the International Organization for Standardization (ISO) and frequently referred to as ISO conditions. A plant that is well managed will be operated in such a way as to maximize output and minimize cost within the existing constraints. While the maximum thermal efficiency attainable is dependent on several factors, the actual efficiency that is sustained over time is an indication of how well the plant is being maintained, and, to some extent, how well it is being managed. Therefore, setting limits of efficiency, as well as long term improvement targets, in light of current technology, will encourage good operational and maintenance management in addition to prudent decision-making and planning to determine when it is better to replace the plant, instead of holding on to worn out equipment and passing on the cost inefficiencies to customers.

The efficiency of thermal power plants varies significantly depending on type of fuel (coal, natural gas, oil), type of generating unit (steam turbine, gas turbine, steam & gas combined cycle, diesel) and the technology (advanced technology large combined cycle gas turbine (CCGT) can attain over 60 percent efficiency, compared with conventional technology at 45-50 percent). Standards will be set with an understanding of the capability of the current installation, and with the aim of encouraging efficiency improvements over time towards what is technologically and economically feasible, so that prudent decisions will be made at the end of the economic service life of generating units. The average heat rates for the IPPs are shown in **Table 5.1**[10]. The generating assets of each service provider consist of a variety of electricity generating units (EGU), with each unit at a different stage of its life cycle. It is therefore best to at least monitor EGUs individually. The average heat rate over the period was approximately 12,000 kJ/kWh.

[10] Heat rate obtained by RIC from the Trinidad and Tobago Electricity Commission (T&TEC)

TABLE 5.1 - SYSTEM HEAT RATES 2013 - 2017

YEAR	HEAT RATE (kJ/kWh)								
	PORT*** OF SPAIN	PENAL	PT. LISAS*	PT. LISAS** (NEW)	TRINITY	TOBAGO SCARBOROUGH	TOBAGO COVE	TGU	SYSTEM
2013	15,161	10,651	17,071	13,051	13,099	8,954	8,615	9,071	12,948
2014	14,912	10,611	17,091	12,927	13,259	9,486	9,877	8,929	12,639
2015	14,996	10,028	17,066	13,185	13,417	11,120	9,861	8,798	12,222
2016	14,263	9,735	16,931	13,029	13,632	9,542	9,674	8,712	11,497
2017	-	9,240	17,402	13,271	13,889	8,917	9,514	8,622	10,797

*Does not include the heat rates for PowerGen's two 105 MW gas turbines.
**Heat rates for PowerGen's two 105 MW gas turbines. These are reported under a separate PPA.
***Port of Spain power station was decommissioned in 2016.

The thermal efficiency of the generating stations, as well as the overall efficiency of the system can be calculated for 2013 to 2017 using the data in Table 5.1. The result is shown in **Table 5.2**.

TABLE 5.2 - SYSTEM EFFICIENCIES 2013 – 2017

YEAR	EFFICIENCY (%)								
	PORT OF SPAIN	PENAL	PT. LISAS*	PT. LISAS** (NEW)	TRINITY	TOBAGO SCARBOROUGH	TOBAGO COVE	TGU	SYSTEM
2013	24	34	21	28	27	40	42	40	28
2014	24	34	21	28	27	38	36	40	28
2015	24	36	21	27	27	32	37	41	29
2016	25	37	21	28	26	38	37	41	31
2017	-	39	21	27	26	40	38	42	33
AVERAGE	**24**	**36**	**21**	**27**	**27**	**38**	**38**	**41**	**30**

*Efficiency for PowerGen's Pt Lisas operation, except the two 105 MW gas turbines installed in 2007.
**Efficiency for PowerGen's two 105 MW gas turbines only.

It can be seen that the lower efficiencies were associated with the older plants located in Point Lisas and Port of Spain. Higher efficiency is associated with the combined cycle plants at the TGU and Penal stations, and the newer power plants at the Cove station. It can also be seen that there was gradual improvement in the overall efficiency of the system as plants with newer, more efficient technology were added to the system. There was a further increase in overall efficiency coinciding with the retiring of the Port of Spain station. Trinidad and Tobago had an average thermal efficiency of 30% over the period 2013 to 2017.

As part of the PPA contracts, most of the IPPs are required to guarantee an overall system heat rate for delivery of power to T&TEC as follows:

- PowerGen: 14,000 kJ/kWh (included POS, which is now decommissioned);
- PowerGen (2005): 12,526 kJ/kWh;
- Trinity Power: None specified; and
- TGU: 8,290 kJ/kWh.

The IPPs are required to pay a penalty if they exceed the heat rate by 5% and are rewarded if it falls more than 5% below the contracted value.

Simple cycle units can be upgraded to combined cycle but this has significant cost implications and will increase generating capacity, in a situation where the network currently has excess capacity. To balance the capacity, some generation machines may no longer be needed, and in essence may become stranded assets[11] that T&TEC will have to pay for under the PPA arrangements. The overall thermal efficiency of a power plant can also be improved by utilizing the waste heat in other applications such as the generation of process steam. While this does not increase the output of electrical energy, it can result in significant improvement in the use of the fuel, and therefore, can be considered when assessing the efficiency of the plant. This option could be attractive for some of the plants that are situated close to industrial processes requiring steam, such as in the Point Lisas Industrial Estate. Given the complexity of the situation, it is recommended that thermal efficiency be initially set for each existing generating station for defined ambient conditions, using the contracted heat rate values as a basis and adding an efficiency improvement target over a specified period to be negotiated with the generators on a case by case basis. Progressive performance improvement targets should be set to incentivise improvement of efficiency over time by

[11] Stranded assets in terms of generation typically occur where there is excess capacity and the market price may be relatively low and thus insufficient to support the historical capital costs of the existing power plants.

encouraging service providers to refurbish/upgrade or replace legacy units. A minimum thermal efficiency level should be set for new natural gas-fired generation based on the heat rate of TGU or higher to ensure that the most efficient technology available at the time of procurement is used.

5.2 Reliability of Supply

It is imperative that the electricity being delivered to consumer meet minimum standards of quality and reliability, even as the service provider seeks to maintain economic and operational efficiencies. Voltages and frequency must be kept within acceptable limits so that equipment may function properly and safely. Electricity supply must be consistent in order to be a dependable source of power for industrial, commercial and residential users, as the usefulness of a power source is directly related to its reliability. Tight tolerance is maintained on the frequency and voltage of supply produced by the electricity generator, as this is necessary for synchronization with the rest of the network and failure to adhere to the existing guidelines could lead to equipment damage. The RIC considers it useful for the generators to report on the reliability of the machines used to generate electricity as this will have possible implications for the reliability of supply.

5.2.1 Mean Time between Failure (MTBF)

One metric used for assessing reliability is the mean-time-between-failure (MTBF). This is a measure of the arithmetic mean (average) time between failures of a system.

5.2.2 Mean Time to Recovery (MTTR)

Mean time to recover (MTTR) is the arithmetic mean (average) time taken to restore a system to operational status after failure.

5.2.3 Capacity Factor

Capacity factor for a power plant is the ratio of the actual kilowatt-hours of electricity produced in a given period, to the maximum possible, i.e. running full time at rated power. It is influenced by plant utilization, operational and maintenance efficiency, type of power plant (whether base-load, load-following or peaking), and may reflect excess capacity relative to load requirements. A measure of capacity factor by itself is inadequate to assess the operational efficiency of a power plant, because it is influenced by the function of the plant within the generating matrix. For example, a plant that is used primarily to meet peaking demand will have a lower capacity factor than a plant that is used to supply base load. Where a plant is positioned in the generating matrix is dependent on how quickly it can be brought into service as well as its generating cost per unit output (cost/kWh). Capacity factor standards should therefore take into account the type of plant and its use. Capacity factor is considered to be important in the Trinidad and Tobago context for the additional reason that T&TEC takes as much power as is practical from TGU to save on fuel cost, given that TGU has the lowest heat rate of the IPPs, and that the PPA contracts are all ***take-or-pay***[12]. Therefore, plants may be idle while T&TEC pays for power it cannot take. To encourage prudent decision making in this area, the extent to which electricity is being paid for but not taken should be publicly known, as this affects the operating cost of the utility that is passed on to customers.

5.2.4 Availability

A plant may be out of service (unavailable) for maintenance or because of a breakdown. Good operation and maintenance management will keep these occurrences to a minimum. One way of keeping tabs on this is to track the availability of the plant. Availability is the fraction of the total time that a plant is able to produce. A higher fraction is an indication of a better availability. A reliable supply of electricity depends on the plant being available when needed. Hence availability is an indication of plant reliability as well as the quality of its operation and maintenance management, when benchmarked against similar plants.

5.2.5 Equivalent Forced Outage Factor

The ***equivalent forced outage factor*** represents the fraction of a given period in which a generating unit is not available due to forced outages and forced deratings. This metric is useful in assessing the performance of power plants for which the total capacity is not contracted to supply the grid.

> ***3. Do you agree with the choice of the proposed performance indicators for electricity generation in Trinidad and Tobago?***

[12] "Take-or-pay" is an agreement between buyer and seller where the buyer is obliged to pay for goods or services irrespective of whether they are delivered or taken.

6. Performance Monitoring and Reporting

Under the proposed scheme, the service providers will be required to collect data pertaining to the identified performance parameters and report it to the RIC on a quarterly basis. The RIC will also provide the relevant templates to ensure that the data is reported in the format required by the RIC and which also help ensure that the data submitted is reliable and valid.

The RIC will use the information reported to prepare annual performance reports on the electricity generation sector that will be published for public information in various media.

4. ***Do you agree with the list of parameters that are identified for performance monitoring and reporting?***
5. ***Are there other parameters that you believe should be monitored and reported?***
6. ***Do you agree with the frequency with which the information should be reported to the regulator?***
7. ***Do you agree that performance reports should be published annually for public information?***