ANNEX C

HEAT RATE STANDARD FOR POWER GENERATION

Closing date for submissions of comments and feedback:

25 JUN 2020

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HEAT RATE STANDARD FOR POWER GENERATION

1 Background

1.1 Over the past decades, Energy Market Authority ("EMA") had liberalised the electricity market to promote the efficient and competitive supply of electricity. This had resulted in the shift in our power generation mix from older steam plants that run on fuel oil to the more cost efficient combined-cycle gas turbines ("CCGTs") that run on natural gas. Aside from the lower cost of generation as compared to steam plants, an added benefit is that CCGTs are also cleaner and emit less carbon dioxide, thus contributing to our environmental sustainability.

1.2 While the dominant and most efficient power generation technology in Singapore's market today is the "F-class" CCGT, more needs to be done to further improve the efficiency of the power sector especially as more efficient and flexible forms of power generation technologies are made available with technology advancement. Companies with power plants that are due for retirement should consider adopting the best-in-class technology with high efficiency/flexibility.

1.3 To improve the overall energy efficiency and flexibility of the power generation fleet, EMA is proposing to adopt a Heat Rate Standard for all new, repowered and refurbished fossil fuel power plants.

2 Heat Rate Standard

2.1 Setting heat rate standard for new, repowered and refurbished fossil fuel power plants

2.1.1 To encourage the adoption of more efficient power plants, all new, repowered or refurbished fossil fuel generation units will be required to meet a net higher heating value ("HHV") heat rate requirement of 6.920 GJ/MWh or lower. This is based on the expected heat rate of advanced CCGTs running at 75% Plant Load Factor ("PLF"), taking into account the effects of degradation, local air temperature and conditions, start-up gas usage, and adjustments for gas compression.

2.1.2 The heat rate of each unit will be measured on an annual basis, calculated by dividing the total fuel input (GJ) by the total net electricity generation and useful heat generation, if any (MWh).

2.1.3 EMA reserves the right to update the Heat Rate Standard for new, repowered and refurbished power plants over time taking into consideration developments in power generation technologies and the power sector's efficiency levels.

2.2 Administration (monitoring and reporting arrangement)

2.2.1 Companies will continue to submit relevant data on fuel inputs, electricity generation and heat generation (if any) to EMA as part of the monthly Generation Returns.

2.3 Exemptions

2.3.1 For avoidance of doubt, all new and repowered fossil-fuel power plants that use fossil fuel (i.e. natural gas, diesel, fuel oil etc.) for power generation will be subject to the Heat Rate Standard.

2.3.2 The following groups will be exempted from the Heat Rate Standard, including when performing routine testing:

a. Existing fossil-fuel power plants (i.e. operational as of today). This recognises that the existing plants were installed prior to the adoption of standard. The exemption will no longer apply if the existing plants are repowered, refurbished, or undergo life extension[1];

b. Power plants that use non-fossil fuel inputs (e.g. biomass);

c. Zero carbon power plants (e.g. hydrogen, power plants with Carbon Capture, Utilisation and Storage);

[1] Repowering refers to an existing power plant which performs a major replacement work and is considered as a new power plant with an economic end of life of at least 25 years. Refurbishment refers to an existing power plant which performs a service/repair work to extend its economic end of life of 10-15 years.

d. Waste-to-energy incineration plants;

e. Electricity imports where the generation units are not based in Singapore;

f. Standby generators installed solely for buildings' own back-up purposes. However, if such generators wish to provide reserves and/or energy to the electricity market, they would be subject to the Heat Rate Standard;

g. Emergency generators and small diesel generators in power stations for start-up of a power plant during a Black Start scenario.

2.3.3 EMA may lift the Heat Rate Standard where necessary to maintain energy security (e.g. allow certain plants to operate beyond the heat rate requirement due to crisis events).

2.3.4 Other exemptions (e.g. power plants which are part of industrial processes) may be granted by EMA on a case-by-case basis.

3 Administrative cap and PLF limit for other generation technologies

3.1 Background

3.1.1 In some jurisdictions (e.g. UK, Ireland), capacity auctions experienced a surge in the amount of other generation technologies (e.g. small-scale distributed reciprocating gas engines) displacing conventional CCGTs. For the UK, embedded generation received an advantage by (i) not having to pay transmission network use of system charges (leading to "triad avoidance benefits" that was estimated to be worth double the FCM clearing price) and (ii) exemptions from EU emissions trading. This distorted the capacity market and resulted in many of such generation technologies entering the market.

3.1.2 While these generation technologies (e.g. gas engines) have fast ramping capabilities that could provide greater flexibility to the system, they are less energy efficient than conventional CCGTs and may worsen the overall efficiency of the power sector if they provide baseload energy. To ensure continuous improvement in power sector's energy efficiency, an administrative cap would be set to limit the entry of these generation technologies.

3.2 Proposed administrative cap

3.2.1 New generation technologies that do not meet the Heat Rate Standard but can offer greater flexibility for the system (e.g. fast ramping) may be allowed into the system, subject to a system-wide administrative cap of about 400 MW. The administrative cap will be applicable to all newly deployed

generation technologies, and will be reviewed prior to each auction by EMA. Once the administrative cap for other generation technologies is reached, EMA will not accept any new licence application for other generation technologies, regardless of whether it qualifies for and clears the FCM.

3.2.2 The amount of other generation technologies required to provide fast ramping capabilities will depend on several factors such as the (i) size of power system, (ii) size of largest generating unit in the system, (iii) amount of intermittent generation sources in the system. EMA reserves the right to review and update the administrative cap based on system's needs.

3.3 Proposed plant load factor ("PLF") limit

3.3.1 New generation technologies that do not meet the Heat Rate Standard will be held to an average annual PLF limit to mitigate their impact on overall system efficiency, so that such generation technologies are not frequently providing baseload energy. The PLF limit for the generation unit will be computed in relation to the unit's heat rate.

PLF Limit of the unit = Heat Rate Standard ÷ Heat rate of the unit × Plant Load Factor (75%)

3.3.2 The example below shows the computation of the PLF limit of generation units. This is the average PLF limit across the year. Plants may vary their part load at different periods (e.g. to produce at 100% part load when activated to provide energy/regulation/reserves, while remaining at near-zero part load during standby periods). These calculations are for illustrative purposes only.

Example (10MW generation unit):

Assume gas engine has a heat rate of 7.7 GJ/MWh, the PLF limit would be:

6.920 GJ/MWh / 7.7 GJ/MWh × 75% = **67%**

A lower PLF could be acceptable to these generation technologies that mainly operate to provide reserves/regulation/fast start.

3.4 Implications of PLF limit on QCAP for FCM resource qualification

3.4.1 As the PLF limit would affect how often the other generation technologies could operate, companies should factor this in the qualified capacity (QCAP) based on the proposed equation.

$$QCAP_{thermal} = ICAP_{thermal} \times (1 - Maximum(POR, PLFR)) \times (1 - UOR)$$

where: *POR* = declared planned outages in days / total number of days in a year

UOR = one-year historical unplanned outages in days / (total number of days in a year – historical planned outages in days)
PLF Rate (PLFR) = 1 – PLF_L
PLF_L = *Heat Rate Standard / Heat rate of the unit × Plant Load Factor (75%)*

3.4.2 For avoidance of doubt, the proposed QCAP equation above applies only to generation technologies that are subject to the PLF limit.

3.5 Definition of other generation technologies

3.5.1 All new CCGTs/Cogeneration/Trigeneration plants are required to meet the Heat Rate Standard in section 2 and will not be subject to an administrative cap.

3.5.2 Other generation technologies that will be subject to the administrative cap are new generation units that:

a. Do not meet the Heat Rate Standard; and

b. Are deployed solely to provide energy and/or reserve and/or regulation.

3.5.3 Other generation technologies that are planted for other purposes (e.g. buildings' back up power, part of industrial production process, cogeneration for the production of steam) will be excluded from the administrative cap. Other exemptions may be granted by EMA on a case-by-case basis.

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