Incentive Scheme for Advanced Combined Cycle Gas Turbines (CCGTs)

CALL FOR PROPOSALS

31 MAR 2020

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INCENTIVE SCHEME FOR ADVANCED COMBINED CYCLE GAS TURBINES (CCGTS)

1. BACKGROUND

Over the last 50 years, Singapore has switched from using oil to natural gas for cleaner power generation. As Singapore transitions towards a low-carbon economy, Singapore will harness the “4 Switches” (Natural Gas, Solar, Regional Power Grids and Emerging Low-Carbon Alternatives) to ensure sustainable, reliable and affordable energy supplies.

Combined Cycle Gas Turbines (“CCGTs”) that run on natural gas, and potentially with hydrogen blend in the future, will continue to play an important role in the power sector. CCGTs provide stable and secure baseload generation and will complement the other “switches” in meeting our growing demand.

While natural gas is one of the cleanest fossil fuels, more can be done to improve the efficient use of natural gas for power generation to further reduce emissions. The Energy Market Authority (“EMA”) had launched an Energy Efficiency Grant Call for Power Generation Companies (“Genco EE Grant Call”) in 2018 to improve the overall generation efficiency of the existing CCGTs in the system.

For older generation units that are reaching the end of life, power generation companies (“Gencos”) can take this opportunity to invest in new and more efficient advanced CCGTs to further reduce their carbon emissions. EMA received feedback that advanced CCGTs would face an early mover disadvantage due to their larger capacity (i.e. 600MW or larger) as compared to the current installed base (i.e. ~400MW F-class) and would incur significant reserve cost disadvantage[1]. The high reserve cost would likely offset any efficiency savings that advanced CCGTs have over F-class, thus discouraging Gencos from investing in advanced CCGTs.

To encourage the adoption of efficient advanced CCGT in Singapore’s market, EMA is launching an incentive scheme for advanced CCGTs of at least 600MW to help mitigate the early mover disadvantage face by the first two advanced CCGTs. With the entry of the third[2] and subsequent advanced CCGTs, it is estimated that the share of reserve cost allocated to each advanced CCGT will be reduced such that the early mover disadvantage ceases to exist.

[1] In Singapore’s electricity market, the amount of reserve procured is based on the largest scheduled output from a single CCGT. Based on the modified runway model under the Market Rules, the total reserve cost will be recovered from each scheduled CCGT such that the larger scheduled CCGTs will bear a larger share.

[2] EMA notes that under certain market conditions, the entry of the second advanced CCGT may be sufficient to remove the early mover disadvantage.

2. OBJECTIVE OF INCENTIVE SCHEME FOR ADVANCED CCGTs

The objective of the incentive scheme is to encourage the adoption of advanced CCGTs in Singapore to improve power sector's generation efficiency and reduce carbon emissions. The scheme will help to offset the early mover disadvantage faced by the first two advanced CCGTs and aims to spur a system-wide technology shift towards more efficient advanced CCGTs.

3. GRANT QUANTUM AND SUPPORT RATE

Grant quantum will be subject to a cap of $44 million[3] for a transitional period of up to 4 years from the deployment of the first advanced CCGT. Grant will be disbursed to the first two advanced CCGTs that incur a net disadvantage within the 4-year transitional period.

Grant support will be computed based on the net disadvantage that an advanced CCGT will incur as compared to F-class CCGT.

Annual Grant Quantum ($)	=	max **(**Incremental Reserve Cost Disadvantage – LRMC Savings, 0**)** * Actual net output of advanced CCGT in MWh

a. **Long Run Marginal Cost ("LRMC") savings** incurred by the advanced CCGT (i.e. the difference in LRMC of F-class and Advanced CCGT) ($/MWh)
   i. F-class LRMC is determined from the final determination paper of the Review of the Long Run Marginal Cost Parameters for Setting the Vesting Contract Price for 2019 and 2020[4]
   ii. Advanced CCGT LRMC is determined using similar methodology as the F-class LRMC, adjusted to reflect the advanced CCGT performance and cost parameters. Advanced CCGT LRMC will take into account actual fuel cost incurred by the advanced CCGT.

[3] If two advanced CCGTs are found to face a net disadvantage, the grant quantum will be shared between the two units.

[4] EMA conducts a review of the Long Run Marginal Cost (LRMC) Parameters for setting the vesting contract price every 2 years. EMA will adopt the LRMC parameters of F-class as defined in the final determination paper for the computation of the incentive scheme. More information can be found here: https://www.ema.gov.sg/cmsmedia/Final%20Determination%20Paper_Review%20of%20Vesting%20Parameters%20for%202019%20and%202020.pdf

b. **Incremental Reserve Cost Disadvantage** incurred by advanced CCGT (i.e. the difference in \$/MWh reserve cost of F-class and Advanced CCGT) (\$/MWh)
   i. \$/MWh is based on actual reserve cost incurred divided by actual output (MWh) per year. Reserve cost will depend on prevailing wholesale market price of reserve.

Please refer to Annex A for more details on the computation of grant quantum.

All disbursements of grants are made on a reimbursement basis annually upon achieving a carbon abatement of at least 0.2 million tonnes (Mt) per year through the efficient operation of the advanced CCGT.

4. QUALIFYING PERIOD

The incentive scheme is open with immediate effect. The final deadline for submission of application is 31 December 2023.

Gencos can apply for the incentive scheme at any point in time when the incentive scheme is open. The advanced CCGT must be deployed and begin generating electricity no later than December 2026 to qualify for the incentive scheme.

5. ELIGIBILITY CRITERIA

To qualify for the incentive scheme, the Genco must meet the following criteria:

- Genco must deploy the advanced CCGT in Singapore and begin operation of the advanced CCGT by December 2026
- The advanced CCGT to be deployed should meet the following requirements:
  - International Organisation of Standardisation (“ISO”) nameplate capacity of at least 600MW[5]
  - Net Lower Heating Value (“LHV”) heat rate of 6050 kJ/kWh or lower (at reference conditions)
- The advanced CCGT to be deployed should have a proven track record that can achieve measurable and verifiable carbon abatement of at least 0.2 million tonnes (Mt) per annum. Refer to Measurement and Verification Requirement for more details.

[5] While installed nameplate capacity needs to be at least 600MW, due to our power system dynamics today, the system can only allow a maximum loss of 600 MW of gross electricity output from a generating unit outage.

- The incentive scheme is not applicable to Genco(s) who have awarded the Engineering, Procurement and Construction (EPC) contract to proceed with the purchase of advanced CCGT prior to application of grant.
- Genco should only apply for the incentive scheme no earlier than 4 years before intended year of the advanced CCGT deployment and operation.

6. MEASUREMENT AND VERIFICATION REQUIREMENT

The abatement will be computed based on the carbon savings when the same amount of electricity generated by the advanced CCGT was generated by existing F-class CCGT instead. The formula below will be used to determine the carbon abatement that each advanced CCGT achieves at the end of the calendar year, prior to the disbursement of any grant.

Abatement (Mt)	=	(Emission factor of advanced CCGT - Emission factor of existing F-class CCGT) * Actual net output of advanced CCGT in MWh

Gencos will provide fuel consumption and electricity generation data to EMA as part of the monthly Generation Returns. EMA will compute the greenhouse gas emissions of CCGTs based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The emission factor (tCO_2e/MWh) for each advanced CCGT will be calculated by taking the total greenhouse gas (tCO_2e) divided by the net electricity generated (MWh).

For the emission factor of existing F-class CCGT, EMA will take reference to the 2018 build margin GEF (0.4035 tCO_2e/MWh). Build Margin GEF represents the emission factor of the five newest generation units in the system which are F-class CCGTs.

Under-achievement of the abatement target will be assessed on a case-by-case basis. If the deviation is substantial, EMA may pro-rate the grant quantum based on actual carbon abatement achieved or ceased disbursement. EMA will work closely with the Genco to understand the reasons for its inability to meet the abatement target and jointly identify solutions to help it achieve the target.

7. APPLICATION

Gencos can submit the application at any point in time when the incentive scheme is open. Companies interested to apply the grant should complete all sections of the Proposal Template Form in Annex B. EMA will assess each proposal individually based on the Eligibility Criteria stated above.

Note that the award of grant does not constitute as approval for any other relevant application that the genco will need to seek to deploy an advanced CCGT.

Proposals may be submitted via email to: EMA_Policy@ema.gov.sg

Annex A – Computation of Grant Quantum Based on Net Disadvantage Faced By Advanced CCGTs

Grant support will be computed based on net disadvantage that an advanced CCGT will incur as compared to F-class CCGT.

Annual Grant Quantum ($) =	max (Incremental Reserve Cost Disadvantage – LRMC Savings, 0) * Actual output of advanced CCGT in MWh

Long Run Marginal Cost (LRMC) savings

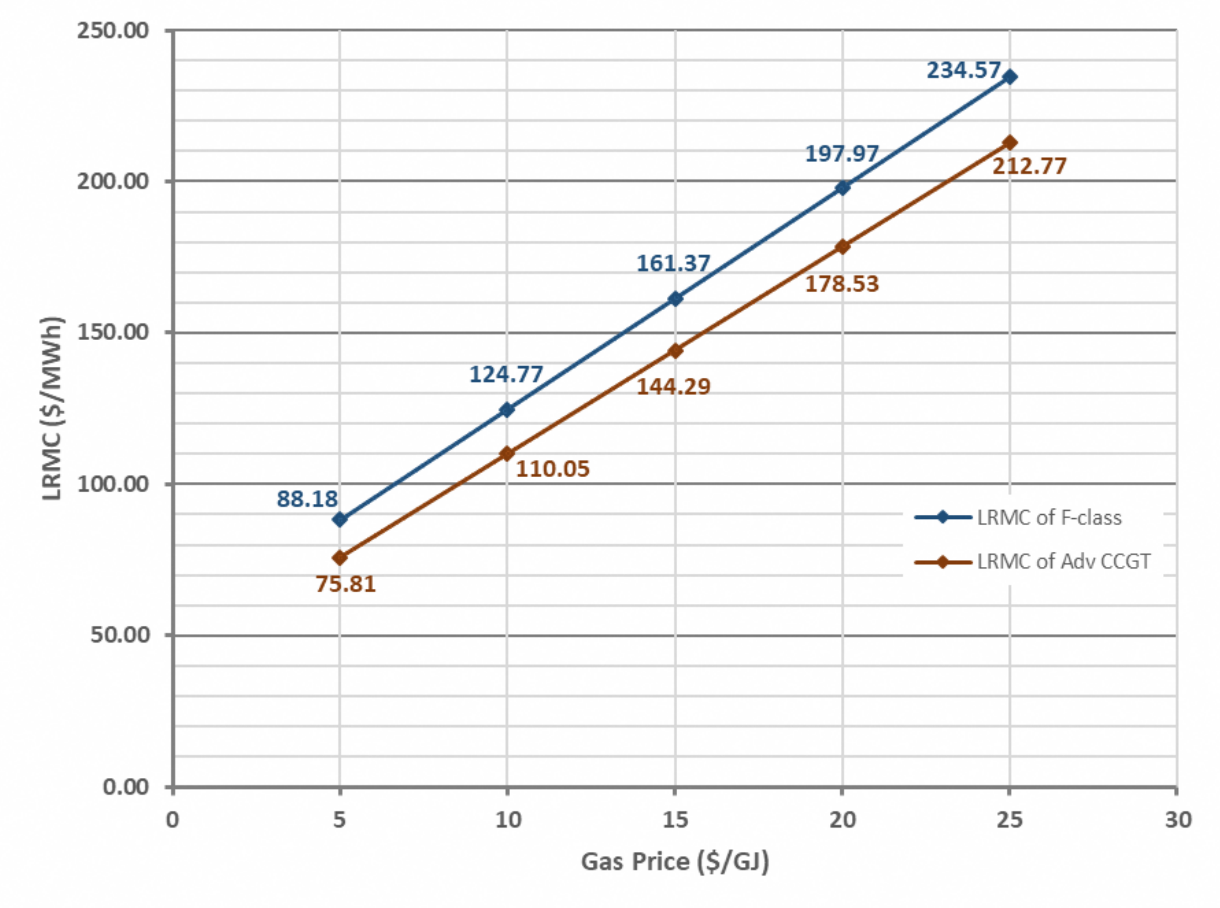
The LRMC savings will be computed based on the difference in the LRMC of F-class and advanced CCGT.

- **For F-class**, the LRMC will be based on the final determination paper of the Review of the Long Run Marginal Cost Parameters for Setting the Vesting Contract Price for 2019 and 2020, with plant load factor of 61.9%. For the purpose of the incentive grant computation, EMA will use the system weighted average gas price (PNG & LNG) to set the LRMC to more accurately reflect the average F-class units operating in the system.

- **For advanced CCGT**, the LRMC is computed using similar methodology as that used in the vesting paper (adjusted to reflect the advanced CCGT cost and performance) and the genco's specific weighted average gas price (PNG & LNG) will be used to better reflect the LRMC of the advanced CCGT incur by the Genco. As advanced CCGTs are more efficient and can bid in more competitively in the market, the LRMC of advanced CCGTs will be based on a higher plant load factor of 75%.

The graph below shows the how LRMC will be determined at varying gas price. The graph will be used to compute the LRMC savings on an annual basis using the actual fuel cost incurred in the year. The graph will be held constant throughout the disbursement period once the letter of award has been issued to the company. For new application, EMA reserves the right to update the graph based on market conditions, such as a change in advanced CCGT technology.

Graph 1: LRMC at different gas price

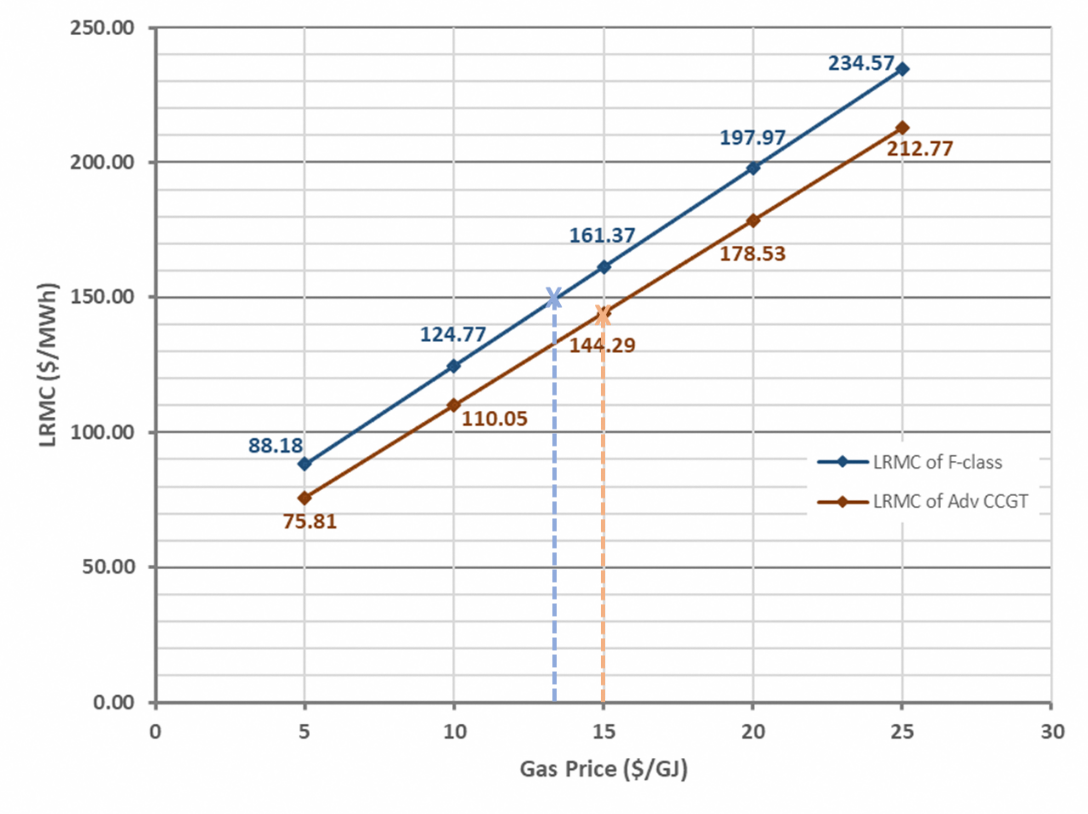


Comparison of LRMC of F-class and Advanced CCGTs

	F-class ($/MWh)	Advanced CCGTs ($/MWh)
LRMC	**159.84**	**142.85**
Capital Cost Component	31.14	24.43
Non-fuel Operating Cost Component	17.53	14.35
Carbon Price	1.85	1.73
Fuel Component*	109.32	102.34

* Based on the weighted average gas price of S$14.79/GJ from March 2018 to May 2018

<u>Worked Example to compute LRMC savings*</u>



Average system gas price: $13.45/GJ
LRMC of F-class: $150/MWh

Genco specific gas price (for advanced CCGT): $15/GJ
LRMC of advanced CCGT: $144.29/MWh

LRMC savings: $150/MWh - $144.29/MWh = **<u>$5.71/MWh</u>**

*Note: Numbers for illustration only. Actual gas price will be used to determine LRMC savings.

Incremental Reserve Cost Disadvantage

The incremental reserve cost disadvantage will be based on the difference in $/MWh reserve cost incurred by F-class and advanced CCGT. The $/MWh reserve cost will be computed based on the total annual actual reserve cost incurred by each CCGT divided by the actual net output of each unit (MWh). Reserve cost will depend on the prevailing wholesale market price of reserve. This data will be obtained from EMC.

- For F-class, EMA will consider the average annual reserve cost ($/MWh) incurred by the top 3 F-class with the highest dispatch quantity.

- For advanced CCGT, EMA will look at the annual reserve cost ($/MWh) incurred by the specific advanced CCGT unit.

Annex B – Project Proposal Template

Company Name	
Details of advanced CCGT	Provide technical and operating details of the advanced CGGTs including but not limited to the following: - Capacity of advanced CCGT (ISO and @32ºC nameplate capacity, Gross and Net Capacity based on a clean-as-new condition) - Heat Rate and Efficiency of advanced CCGT (Net Lower Heating Value ("LHV") heat rate at reference conditions and @32ºC) - Original Equipment Manufacturer of advanced CCGT. Provide relevant information on the proven design and technology of advanced CCGT - Plant design parameters (ie. frequency response capability, load ramp up/down rates, fault contribution, inertia constant) - Lifespan of advanced CCGT (based on EOH) - Expected average load factor (%) at peak and off-peak periods and other relevant operating parameters - Specify targeted actual operating efficiency (%), emission factor (tCO_2e/MWh) and carbon abatement (tCO_2e) per annum of the advanced CCGT, with step-by-step calculations of abatement - Maintenance Cycle for major and minor inspection
Project Timeline and Milestones	Provide <u>timeline of the key milestones</u> of the project including but not limited to the following: - Project commencement date - Construction/Installation/commission of advanced CCGT - Expected commercial operation date
Project Leader/ Point-of Contact	Provide contact details of Project Leader/ Point-of Contact managing the project