EMISSION STANDARDS FRAMEWORK FOR POWER GENERATION UNITS

FINAL DETERMINATION PAPER

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ENERGY MARKET AUTHORITY
991G ALEXANDRA ROAD
#01-29
SINGAPORE 119975
www.ema.gov.sg

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1. Executive Summary

1.1. The Energy Market Authority (EMA) is introducing emission standards for new and repowered fossil fuel-fired generation units to facilitate advance planning, deployment and operation of clean power generation units in Singapore over time. The standards are set based on what is theoretically achievable by the best-in-class technologies available in the market today. New generation units (including advanced combined cycle gas turbines (CCGTs) for baseload generation and smaller generation units providing other services like fast response) would need to be at least 30% volume hydrogen-ready to facilitate the transition to low-carbon alternatives in electricity generation.

1.2. Today, the power sector contributes around 40% of Singapore's total carbon emissions, where 95% of our electricity is generated from natural gas. CCGTs have the potential to remain the backbone of Singapore's electricity generation for many years. As such, enhanced carbon efficiency and the replacement of natural gas with low-carbon fuels such as hydrogen can contribute to a reduction of emissions from electricity generated by CCGTs.

1.3. Following an earlier industry consultation on heat rate standards to encourage CCGTs to run more efficiently, EMA launched an industry consultation from 9 Jan to 16 Feb 2023 to seek industry feedback on the proposed emission standards framework. Feedback received from the consultation process recognised the need for emissions standards. There were some clarifications on how the standards were set and how it would be enforced. Taking into consideration the comments received, the final emission standards on new and repowered fossil fuel-fired generation units are set out in this Final Determination Paper.

1.4. EMA will continue to review and gradually tighten the emission standards over time to ensure the power sector is on track to facilitate the transition to net zero emissions by 2050. EMA will consult the industry before doing so.

2. Feedback from the Industry Consultation Paper

2.1. EMA received written feedback from 9 stakeholders which consisted of a mix of generation companies ("gencos"), Original Equipment Manufacturers (OEMs), industry operators of Embedded Generation (EG) units and renewable developers. In general, respondents were supportive of EMA's introduction of emission standards for fossil fuel-fired generation units. The respondents also proposed refinements to the emission standards framework outlined in the consultation paper published on 9 Jan 2023.

2.1.1. **Emissions intensity limit (i.e. emission factor limit) under Tier 1 emission standards** – There were no concerns raised regarding the proposed 0.355 tCO_{2e}/MWh emission standard under Tier 1. Clarifications were sought for the definitions of what were considered as repowered and life-extended units.

2.1.2. **Hydrogen-ready requirements for Tier 1 and Tier 2 emission standards** – Respondents sought clarity on whether existing plants undergoing upgrades for hydrogen-readiness were considered repowered units.

2.1.3. **Embedded Generation (EG)** – EG operators proposed that EG units could meet an emissions intensity limit, albeit likely a higher one compared to that for advanced CCGTs. At the same time, there were proposals for EG units, that rely on recovered steam/heat generated from industrial process to generate electricity (i.e. do not rely directly on the combustion of fossil fuel for electricity generation), should not be expected to be 30% hydrogen-ready. Beyond hydrogen, it was suggested that other low carbon fuels such as biogas and biomass should also be accepted. In addition, there were requests to exempt generation units with carbon capture technologies from hydrogen-readiness requirements.

2.1.4. **Exemptions** – Respondents asked if all diesel-related activities required by EMA such as quarterly fuel changeover tests and Directed Supply Scheme (DSS) could be exempted from compliance with emission standards.

2.1.5. **Enforcement through Monitoring, Reporting and Verification (MRV)** – Some respondents have requested that the annual emissions report to be submitted to EMA not require an independent third-party verification given that the emissions reports submitted to NEA for carbon tax are already verified.

2.1.6. **Financial Penalty** – Whilst acknowledging the maximum penalty which could be imposed if a generation unit subject to the emission

standards framework exceeds the limit, some respondents requested for the formula used to determine the financial penalty.

2.2. EMA's responses to the feedback can be found in the Annex.

3. EMA's Final Determination on Emission Standards Framework for New and Repowered Fossil Fuel-fired Generation Units

3.1. The emission standards will be implemented at the unit-level on all new and repowered fossil fuel-fired generation units whose date of licence application submission, and/or addition to Schedule A fell on or after 9 Jan 2023, the launch date of the industry consultation. These generation units will need to start complying with the emission standards from the Commercial Operation Date of the Generation Registered Facility, after completing the commissioning tests.

3.2. Repowered units refer to existing generation units which perform major replacement works. Such repowering works involve the use of some existing infrastructure but could result in a 'good as new' plant lifespan. Under the emission standards framework, generation units that undergo a replacement and/or addition of one or more gas turbines and/or steam turbines will be considered a repowered unit as these are critical components of the generation unit. For avoidance of doubt, this definition of repowered units does not include incremental efficiency improvement works, routine maintenance or upgrading works which are part of common practice. Power generation companies (gencos) may write to EMA (ema_policy@ema.gov.sg) for any further clarification regarding their plans to repower their existing generation units.

3.3. The emission standards will apply to new and repowered fossil fuel-fired generation units as follows in Table 1. By default, all new and repowered fossil fuel-fired plants should meet the Tier 1 emission standard of 0.355 tCO_{2e}/MWh[1] on an annual basis. For avoidance of doubt, plants under both Tier 1 and Tier 2 will not be held to a fixed Plant Load Factor (PLF). Gencos have the flexibility to adjust their operations in order to meet the standards.

Table 1: Summary of two-tiered approach for emission standards

	Tier 1	Tier 2
Description	By default, all new and repowered fossil fuel-fired plants should meet the Tier 1 emission standard.	Plants that are unable to meet Tier 1 standard can opt to be subject to an emissions limit under Tier 2.

[1]The emissions intensity limit of 0.355 tCO_{2e}/MWh is based on a technical study commissioned by EMA on the emissions intensity performance of power plants, derived from the average emissions intensity performance of advanced CCGT models across three major OEMs in Singapore covered in the study (see Annex to the industry consultation paper published on 9 Jan 2023). The study is based on the parameters from EMA's *Review of Vesting Contract Technical Parameters 2021-2022*. This will be tightened accordingly over time to ensure alignment with emissions reduction trajectory.

Emission standards requirements	Emissions intensity limit of 0.355 tCO_2e/MWh.	Emissions allowance limit ($MtCO_2e$ cap) that is equivalent to a Tier 1 advanced CCGT but running at a PLF of 50% on an annual basis.
Hydrogen-readiness requirement	New and repowered plants to be at least 30% volume hydrogen-ready with the ability to be retrofitted to become operationally 100% hydrogen-ready in the future to the extent possible.	

New and repowered Tier 1 generation units

3.4. Today, the power sector contributes around 40% of Singapore's total carbon emissions. Most of the electricity, and hence emissions, is generated by generation units providing baseload energy which run at high load factors and across prolonged periods. In the coming years, EMA expects several new generation plants of this form to enter the system to meet growing demand and to replace retiring units. To encourage the adoption of cleaner and more efficient power plants, all new and repowered generation units will be required to meet an annual emission factor of 0.355 tonnes of carbon dioxide equivalent per megawatt hour of net electrical output (i.e. 0.355 tCO_2e/MWh). This could be in the form of more efficient units such as advanced CCGTs (i.e. H-class or equivalent).

3.5. The emission factor of each generation unit will be measured on an annual basis, calculated by dividing the total annual CO_2e emissions for the calendar year (i.e. 1 Jan to 31 Dec) over the total annual net electricity generation[2] (MWh). The total emissions of each unit will include all greenhouse gases (GHG) emitted from the combustion of fossil fuels for electricity generation (e.g. natural gas, diesel etc.).

New and repowered Tier 2 generation units

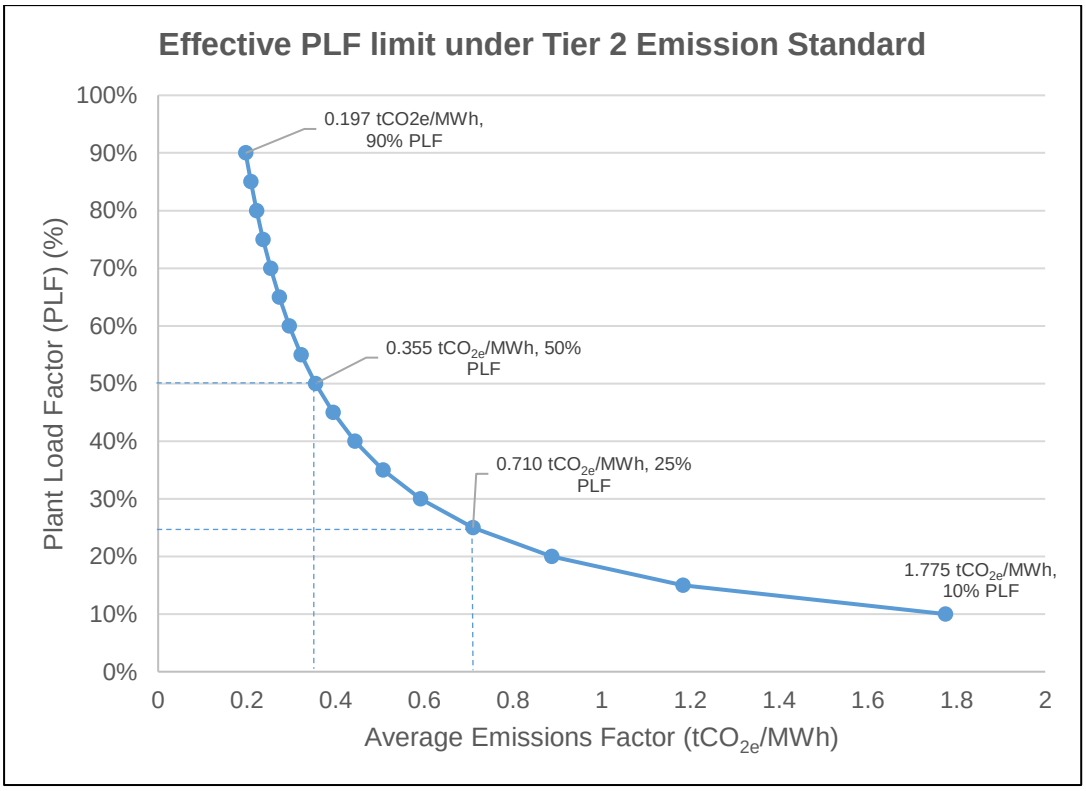
3.6. As we integrate different energy sources (e.g. solar and electricity imports) into our system for decarbonisation, we will also need to ensure that we have generation technologies that can provide greater flexibility and security to the grid. This may include fast response services and backup generation. These units may be older and/or less efficient and may emit higher emissions for every unit of electricity generated, compared to advanced CCGTs. Examples of such units may include Open Cycle Gas Turbines (OCGTs), new gas engines and new diesel generators. While such generation units can improve the flexibility and security of the grid, these units will need to comply with the

[2] Net electrical output is the electricity injected into the grid after accounting for auxiliary load consumption from the generating unit.

annual emissions allowance limit to minimise the impact on Singapore's overall emissions (see Table 1).

3.7. To allow the entry of such generation units, these units can opt to be subject to an emissions limit under Tier 2 if they are unable to meet the Tier 1 standard. Under the Tier 2 standard, new and repowered units will need to comply with an annual emissions allowance limit (in Mt CO_2e terms), calculated based on a plant's installed electrical capacity. This limit will be equivalent to an advanced CCGT of the same capacity under Tier 1 but running at a PLF of 50% on an annual basis (see Figure 1). The total emissions of each unit will include all GHG emitted from the combustion of fossil fuels (e.g. natural gas, diesel etc.). For example, generation units under Tier 2 with an average emission factor of 0.71 tCO_2e/MWh should operate within an effective PLF limit of 25% average over a year.

Figure 1: Effective annual PLF limit under Tier 2 Emission Standard at various average emissions factors



3.8. The examples in Para 3.9 show the implication of emission limits on the average PLF of generation units. This refers to the average PLF across the year. Plants may vary their part load at different periods (e.g. to produce at 100% part load when activated to provide reserves, while remaining at near-zero part load during standby periods). Tier 2 plants will be subject to an absolute emission limit (Mt CO_2e) and not a PLF limit. During periods of tight supply, the EMA Power System Operator (PSO) may direct fast-response

units to run up more frequently to provide baseload generation. Such periods will be excluded from the calculation of the emissions limit.

3.9. These calculations are for illustrative purpose only.

Emission Limit = Installed Capacity × 0.355 tCO_2e/MWh × Plant Load Factor (50%) × Number of Hours in a year

Example 1 (200MW Open Cycle Gas Turbine (OCGT) with an average emission factor of 0.57 tCO_2e/MWh):

Emission allowance limit = 200 MW x 50% x 0.355 tCO_2e/MWh x 8760 hr = 310,980 tCO_2e/year (0.311 $MtCO_2e$/year)

Effective PLF limit = 310,980 ÷ (200 MW x 8760 hr x 0.57 tCO_2e/MWh) = 31.1% average PLF over a year

Example 2 (20MW gas engine generation unit with an average emission factor of 0.46 tCO_2e/MWh):

Annual emission limit for 20MW plant:
20MW × 0.355 tCO_2e/MWh × 50% × 8760hrs = 31,098 tCO_2e (0.031 $MtCO_2e$/year)

Effective PLF limit = 31,098 ÷ (20 MW x 8760 hr x 0.46 tCO_2e/MWh) = 38.6% average PLF over a year

Example 3 (20MW diesel generation unit with an average emission factor of 0.72 tCO_2e/MWh):

Annual emission limit for 20MW plant:
20MW × 0.355 tCO_2e/MWh × 50% × 8760hrs = 31,098 tCO_2e (0.031 $MtCO_2e$/year)

Effective PLF limit = 31,098 ÷ (20 MW x 8760 x 0.72 tCO_2e/MWh) = 24.6 % average PLF over a year

Hydrogen-ready requirements for all new and repowered generation units across Tier 1 and Tier 2

3.10. EMA will require all new and repowered fossil fuel-fired generation units going forward to be hydrogen-ready[3] in terms of technical capabilities, at the point of commissioning (i.e. Commercial Operation Date, or COD). As a start, all new and repowered generation units must be technically ready to combust at least 30% volume hydrogen-blend with natural gas without having to undergo any refurbishments to do so at COD.

3.11. Over time, as generation units capable of combusting a higher blend of hydrogen (including 100% hydrogen) become commercially available, EMA may raise the required capabilities for hydrogen-readiness and will consult the industry before doing so.

Accounting for heat generation by cogeneration power plants

3.12. Cogeneration power plants which combine heat and electricity generation production could improve the energy efficiency of the generating unit and reduce carbon emissions, as compared to having a separate power plant for electricity generation and boiler for heat generation.

3.13. To avoid unduly penalising new and repowered cogeneration power plants, the emission factor standard will only be imposed on the electricity generation portion without heat. The standard makes allowance for carbon emissions arising from the production of useful heat as described in the example below. The same approach is adopted today when determining the carbon emissions contribution of a cogeneration plant to our system's Grid Emission Factor (GEF).

Example 1 (New cogeneration power plant):

Maximum emission factor = 0.355 tCO_{2e}/MWh

Assuming in a year, cogeneration power plant produces:

- Electricity generated: 4,500 GWh
- Heat generated: 1,500 GWh
- Total emissions for the year: 2 million tCO_2e ($MtCO_{2e}$)

Emissions arising from electricity generation =
4,500 GWh ÷ (4,500 GWh + 1,500 GWh) × 2 Mt = 1.5 $MtCO_{2e}$

Emission Factor of Cogeneration =
1.5 $MtCO_{2e}$ ÷ 4,500 GWh = **0.333 tCO_{2e}/MWh**

Cogeneration plant is compliant with the emission limit.

[3] Gencos may propose alternative low-carbon fuels for combustion based on available technologies for EMA's consideration.

Embedded Generation

3.14. New and repowered fossil fuel-fired embedded generation (EG) units[4] with generation licences will be required to be at least 30% hydrogen-ready or start combusting low-carbon fuels at the point of commissioning that can achieve emission reductions. Apart from hydrogen and its derivatives, companies may write to EMA (ema_policy@ema.gov.sg) to propose the combustion of other low-carbon fuels to achieve emissions reduction on a case-by-case basis.

3.15. EMA recognises that subjecting all new and repowered EGs to a uniform emissions intensity limit may not be meaningful at this point given their variance in design (e.g. cogeneration vs. electricity generation only), nameplate capacity and correspondingly, plant efficiency. As such, EGs will not be subject to an emission intensity limit.

Exemptions

3.16. All existing generation units will be grandfathered from this framework. This refers to fossil fuel-fired power plants in operation today which were commissioned before emission standards were introduced. Exclusion will no longer apply after existing plants are repowered. Renewable energy power generation (i.e. solar) and imported electricity where low-carbon generation sources are located outside of Singapore will also be excluded from this framework at this point.

3.17. The following categories will be exempted from complying with emission standards:

i. Waste-to-energy (WTE) incineration plants, as their main purpose is to reduce the volume of waste before disposal in landfills, rather than for electricity generation;

ii. Standby generation units installed solely for buildings' own backup purposes. However, if such generation units wish to participate in the wholesale electricity market to provide reserves and/or energy, EMA will review on a case-by-case basis on whether they would be subject to emission standards;

iii. Emergency generators and small diesel units in power stations for the startup of a power plant during a Black Start scenario.

3.18. EMA will exclude emissions for instances where the EMA Power System Operator (PSO) has directed gencos to run to manage gas/power emergency to ensure the security and reliability of the gas/power system,

[4] Embedded Generation (EGs) units are owned by industrial facilities which provide steam and electricity for their own consumption, though they may choose to export the excess electricity generated to the grid.

including when the use of diesel is required. This could include the Directed Supply Scheme (DSS), Fast Start Services or other emergency periods instructed by PSO. During such periods, the exemptions would apply only to the incremental electricity generated resulting from PSO-instructed dispatch. The base volume of electricity generated prior to PSO's issuance of instructions is considered part of its normal operations and will remain subject to the emissions standard. Periods where units have bid into the market and are activated to provide regulation and reserves will not be exempted.

3.19. EMA reserves the right to temporarily suspend the emission standards where necessary to maintain energy security (e.g. requiring certain plants to generate more than the allowed emission standards due to crisis event).

3.20. Other exemptions may be proposed for EMA's consideration on a case-by-case basis.

Enforcement through Monitoring, Reporting and Verification (MRV)

4.1 The emission standards will be enforced through a new Code of Practice on carbon emissions from 2024 onwards. An industry consultation on the new Code of Practice will follow after the publication of this Final Determination Paper.

4.2 Gencos will need to declare the carbon emission factor[5] of their new and repowered generation units as well as hydrogen-readiness at the point of licence application and validate their emission factor during the commissioning test. The technical capability to blend up to 30% volume hydrogen would not need to be demonstrated during commissioning test but instead, would be validated such as providing a performance guarantee from OEMs to EMA during licence application.

4.3 In addition, gencos will be required to submit an annual emissions report verified by an accredited third party to EMA by 30 June every year for their new and repowered generation units. EMA acknowledges that companies already submit an annual Emissions Report to the National Environment Agency (NEA) under the Carbon Pricing Act every June. Hence, EMA would require the same timeline for the reporting cycle to allow companies to tap on their existing MRV process to have an accredited third party verify the data for reporting under the emission standards framework. It is noted that data submission to NEA is done at the facility-level, while that required for emission standards would be at the unit-level.

[5] Computed based on the IPCC 2006 default carbon emission factor for Natural Gas listed in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 Energy, Table 2.2 (as of 26 Oct 2022).

Financial Penalty

4.4 Financial penalties will be imposed on gencos whose plants exceed the annual emission standard under their respective Tiers except for exempted conditions or mitigating factors considered by EMA on a case-by-case basis (e.g. due to energy security needs including fuel disruptions). EMA will also take into account whether gencos had actively taken steps to rectify emissions performance for emissions emitted in excess of the Tier 1 or Tier 2 emission standard during the one-time commissioning test, if gencos' new and repowered plants fail to meet the annual emission standard. This is to encourage gencos to invest in low-carbon solutions and ensure carbon-efficient plant operations as much as possible.

4.5 The maximum possible financial penalty would be in line with the Electricity Act Part 3 Section 14, which states that if a generation licensee contravenes or breaches the Code of Practice, EMA may require the electricity licensee to pay a financial penalty of an amount not exceeding 10% of the annual turnover of that part of the licensee's business in respect of which the licensee holds a licence, ascertained from the licensee's latest audited accounts, or an amount not exceeding S$1 million, whichever is higher.

4.6 In determining the financial penalty amount to be imposed on a genco, EMA will take into consideration:

- The severity of the violation, measured in percentage terms over the emission standard;
- Whether this is a first or repeat violation of the emission standard; and
- Any mitigating factors submitted by the genco.

Annex: Feedback from Industry Consultation

S/N	Feedback	EMA's Response
Emission Standards Framework		
1	The MSCP supports the introduction of emission standards for power generation units as it is in line with Singapore's commitment to achieving net zero emissions by 2050. The emission standards should apply as and when new and repowered generation units enter the market. Nevertheless, the emission standards may affect genco's decisions to repowering their existing fossil fuel-fired generation units, which require costly retrofit. Therefore, it is important to ensure the orderly exit of retiring generation units as well as the entry of new generation units in order to maintain market stability and efficiency.	Emission standards will apply when gencos submit their licence applications and/or additions to Schedule A after 9 Jan 2023, which is the date of publication date. To ensure that there is sufficient generation capacity to serve demand in a secure and reliable manner, EMA has introduced a Centralised Process to coordinate the planting of new generation capacity in Singapore by the private sector.
2	We support EMA's current proposed emission standards to only be applicable to all new and repowered fossil fuel-fired generation units. This will allow existing grandfathered units to go through life extension and provide the required reserve margin in a cost effective and efficient manner instead of having to retire prematurely. We would also like to confirm in writing that the heat rate standards as per the consultation paper titled "Annex C: Heat Rate Standard For Power Generation" published in 2020 would not be applied going forward.	EMA confirms that the heat rate standards as per the consultation paper "Annex C: Heat Rate Standard For Power Generation" published in 2020 would not be applied. Instead, the emission standards framework will apply to all new and repowered fossil fuel-fired generation units going forward.

3	In 2020 EMA Consultation Paper on FCM, ANNEX C: HEAT RATE STANDARD FOR POWER GENERATION has a clear distinction between repowering vs. refurbishment/life extension. **2020 Heat rate standard paper:** "Refurbishment refers to an existing power plant which performs a service/repair work to extend its economic end of life of 10-15 years." **Current consultation paper:** "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." For the avoidance of doubt, we are seeking confirmation in writing that refurbished or life-extended units will not be subjected to these new emission standards.	Units that undergo regular maintenance, upgrading, refurbishment works such as incremental efficiency improvements, will not be subject to the emissions standards. For the purposes of emission standards, repowering refers to existing generation units which perform major replacement works. Such repowering works involve the use of some existing infrastructure but could result in a 'good as new' plant lifespan. Refer to Section 3 of the paper for more details on the definition of repowering units which would be subject to the emission standards.
4	Can we confirm that this emission standard applies only to generating unit under the Generation Licence issued by EMA?	EMA confirms that emission standards apply to new and repowered fossil fuel-fired generation units under the Generation Licence, for which gencos had submitted their application on or after 9 Jan 2023.
5	Is biomass generator subjected to such compliance? Or such technology will be considered as waste to energy and exempted?	The emission standards apply to fossil fuel-fired generation units. Units running on 100% biomass are excluded from the Emission Standards framework. For avoidance of doubt, the biomass plant in question should ensure compliance with the relevant regulations/requirements (e.g. Measurement and

		Reporting Requirements for Greenhouse Gas Emissions under NEA's Carbon Pricing Act). In addition, all emissions from power generation units, including biomass generation units, are required to comply with the parameters listed under The Schedule stipulated within the Environmental Protection and Management (Air Impurities) Regulations under NEA. This includes NO_x emissions.
6	Another area that EMA can consider is the overall emissions, including for items such as NOx. As a minimum, we believe that the CO_2 values should be normalized or based upon a set value such as NO_x as NO_2 of 50 mg/Nm 3, dry,@15% O_2. This is to ensure that all technologies are treated the same in regards to total emissions to the environment and measured at the correct baseline (Note: in general, increasing firing temperature will increase efficiency and lower CO_2 intensity as measured in the draft document, but also increase NO_x).	The emission standards framework requires the calculation of GHG emissions (i.e. CO_2, CH_4, N_2O) and does not include NO_x emissions which is not a GHG. Separately, all industrial facilities including power generation units are required to comply with the Environmental Protection and Management (Air Impurities) Regulations under NEA, which includes oxides of nitrogen (NO_x, which is the sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2)) limit of 400 mg/Nm^3 (expressed as NO_2).
Repowering		
7	Gas Turbine (GT) upgrades is a common practice that power plant owners perform to achieve incremental improvement on existing efficiency and emissions level, when opportunity arises, it should not be classified as repowering. Other schemes and incentives such as grants to improve the existing systems, will help to reduce emissions of existing power plants.	Regular refurbishment, maintenance and upgrades that do not significantly increase the overall plant lifespan would not be considered as repowering. We have refined the definition of major replacement work to include a replacement and/or addition of one or more gas turbines and/or steam turbines will be

8	What constitutes “major replacement work”? For example, we would not consider a unit that has a change in hot gas path components as a result of typical maintenance cycle to be a “repowered unit”.	considered a repowered unit as these are critical components of the generation unit. See definition of repowering in Para 3.2.
9	For avoidance of doubt, if an existing Unit undergoes H2 compatibility upgrade/refurbishment, can EMA confirm it will not be considered a repowered Unit and hence will not come under proposed emission standards?	
10	Would an existing unit that refurbished its heat recovery steam generator (HRSG) be considered a repowered unit?	An existing unit that refurbished its heat recovery steam generator (HRSG) alone would not be considered a repowered unit under the emission standards framework. See definition of repowering in Para 3.2.
Two-Tiered Approach for Emission Standards (Table 1)		
11	Could EMA please further define baseload plants? How would a multi-shaft configured plant be treated? I.E., the ability to operate on open-cycle and/or combined-cycle mode?	EMA has removed the term “baseload plants” from Table 1 to provide flexibility to generation units (baseload or non-baseload) to opt for the Tier that best meets their operating conditions. To respond to the feedback, in general, baseload plants refer to those which run frequently in order to meet the minimum amount of electricity needed by the system at any given point in time (i.e. to provide baseload generation). By default, Tier 1 emission standards would apply to all new and repowered fossil fuel-fired generation units, regardless of mode of operation (i.e. single- or

		multi-shaft). Generation units that cannot meet Tier 1 emission standards, may opt to be subject to Tier 2.
12	It is stated that the proposed emission limit of 0.355 tCO_{2e}/MWh is derived from the **<u>average</u>** emissions intensity performance of advanced CCGT models across three major OEMs in Singapore. The use of average would result in favouring the OEM that has a lower emissions intensity performance compared to the average. As emission factor is not the only criteria in the choice of the OEM to work with for a new or repowered generating units, to ensure level playing field, this approach of determining a uniform emission standards is not appropriate. It is stated that the proposed emission intensity limit will be tightened over time to ensure alignment with emission reduction trajectory. We would like to seek confirmation that new or repowered baseload generation units would not be subject to future lower emission intensity limit after licence registration and/or addition to Schedule A.	There is no restriction to any OEM which gencos can work with. All three major OEMs in Singapore can meet the 0.355 tCO_{2e}/MWh emissions intensity limit at slightly varying PLF levels. All new and repowered fossil-fuel fired generation units will be subject to the emission standards framework which will be tightened over time to ensure that Singapore can meet our goal of reaching net zero emissions by 2050. To meet the tightened standards, generation units that are subject to the emission standards can consider options to reduce the emissions intensity by improving the energy efficiency or using low-carbon technologies or low-carbon fuels when they become available. Before tightening the standard, EMA will review and consult the industry in advance before doing so to ensure that gencos with generation units under the emission standards or are applying for licence and/or addition to Schedule A are duly engaged ahead of time.
13	While standards are based on 75% PLF, each Unit's emissions will be assessed based on its actual prevailing annual PLF for each year of its operational life (which may be higher or lower than 75% PLF)	EMA does not dictate a specific PLF for generation units. Gencos have the flexibility to adjust their operations to ensure that they can meet the emission

	For fair comparison against emissions standards, can EMA consider incorporating correction/adjustment factors to normalize actual emissions to 75% PLF (since actual PLF attained may be impacted by commercial dispatch considerations as well)? We propose not to set the emissions intensity standard at a specific PLF level. We would recommend measuring Tier 1 CCGTs actual emissions against a pre-determined emissions intensity curve at various PLF levels.	standards of 0.355 tCO_2e/MWh on an annual basis by investing in a more efficient model, performing technical improvements and adopting low-carbon fuels such as hydrogen when they become available. To keep the emission standard framework straightforward for compliance, EMA will not be using an emissions intensity curve based on varying PLF.
14	It is not reasonable to assume that new or repowered fossil fuel fired generation would be able to maintain at 75% Plant Load Factor for the entire economic life of 25 years. We would like to propose that a unique emission standard be set for each unit based on actual commissioning result with maximum degradation applied and also the possibility to reclassify to Tier 2.	See above response. EMA does not require generation units to maintain a 75% PLF for the entire economic life of 25 years. In setting the emissions intensity limit under Tier 1, EMA had already taken into account an assumed maximum degradation rate of 2.08% over a 25-year plant lifespan (see Annex published with the industry consultation paper on 9 Jan 2023). In view of maintaining an industry standard for all new and repowered generation units, EMA will not be implementing a unique emission standard for each generation unit. On requests to reclassify plants subject to Tier 1 to Tier 2 in future, gencos may write to EMA with clear justifications for EMA's consideration on a case-by-case basis.

15	Para 2.8 The computation for the annual emission factor should be aligned based on the Carbon Price Act (CPA) and use the default IPCC 2006 conversion factors for HHV natural gas combustion. Para 2.8 (i) a 1. Has EMA consulted the OEMs if repowered baseload units can meet the proposed 0.355 tCO_{2e}/MWh limit? Existing CCGTs undergoing life extension will not be able to meet the new emission requirements as it is not technically feasible. Propose that for life extension units, in particular units that are commissioned and operational for more than 15 years to be either exempted from the new requirements or have a more realistic threshold.	The computation for the annual carbon emission factor will need to be consistent with the methodology for reporting under the Carbon Pricing Act. It will also be based on the IPCC 2006 emission factors. The 0.355 tCO_{2e}/MWh standard was derived from a consultancy study based on the average emissions performance of advanced CCGTs across 3 major OEMs in Singapore. EMA had engaged OEMs in Singapore and there were no concerns raised over the ability of repowered units to meet the 0.355 tCO_{2e}/MWh. Gencos need to ensure that their existing units to be repowered can meet the limit before proceeding with repowering works. Existing units and life-extended units are excluded from the emission standards framework.
16	In Table A of Jacobs' report, Jacob has shown the emission intensity at 100% load ranging from 0.335 to 0.344 tCO_{2e}/MWh. Would EMA be able to share what is the corresponding emission intensity range at the proposed Plant Load Factor of 75% and 50%.	Refer to Table 5.1 in Jacobs' report *Technical Consultancy for Emissions Intensity of Power Plants* (see Annex published with the industry consultation paper on 9 Jan 2023).
17	Can EMA explain what is the rationale for setting the Tier 2 emission allowance limit at Tier 1 advanced CCGT running at 50% Plant Load Factor and not a lower Plant Load Factor?	Tier 2 recognises other types of plants needed in the system such as those providing fast start. These plants are likely to be less efficient and their operating duration is likely lower than the more efficient plants such as CCGTs. The emission standard is set based on a Tier 1 advanced CCGT running at 50% PLF. This is to manage the overall emissions of the generation

		unit while still providing some flexibility for such generation unit to respond to market conditions.
Hydrogen-readiness		
18	As the 30% H2 mix fuel ready already seems ambitious at this stage based on our own discussions with OEMs, we propose to reduce it to 20% for repowered units.	Based on EMA's discussions with major OEMs, advanced CCGTs with 30% volume hydrogen-readiness are already available on the market. For avoidance of doubt, this is not a requirement for generation units to combust hydrogen fuel, but a requirement for the generation unit to be technically capable of doing so at the point of commissioning. Blended hydrogen combustion could be possible when hydrogen fuel becomes available.
19	It should be noted that there is a threshold point of H2 mix fuel (~ 50-70%) beyond which GT may not be able to go back to firing 100% NG or Diesel without re-tuning the GT, and for some GT it might be impossible as the GT combustion hardware may have changed irrevocably especially for GT designed for 100% Hydrogen firing.	EMA notes the feedback on the threshold point of hydrogen mix fuel and will take it into consideration for future review of the emission standards requirements.
Embedded Generation (EGs)		
20	Emissions limit may be implemented as well for embedded generation, though likely at a higher emission limit than that of a H-class CCGT, to avoid economic decisions to be made to invest in less efficient power generation technologies instead due to low costs. Such emissions limits can be set suitably in relation to each type of generation technologies or to assume the highest emissions amongst most efficient technologies of EGs available in the market as a blanket limit for all the EGs.	Embedded Generation (EG) units in operation today vary in size, such as from 10 – 110 MW. Setting a set of standards that is fair for new and repowered EG units with a similar variance in size may not be meaningful at this point. Nevertheless, EMA notes this feedback and may consider for future reviews of the emission standards.

21	Based on the variability of power generation technologies, requiring all EGs with nameplate capacity above 10MW to be subject to be at least 30% volume hydrogen compatible in future may not be viable. For example, in a process where steam for driving steam turbine generators is generated from heat exchange recovery systems instead of fuel-fired systems, it is not practically nor economically feasible for these systems to be hydrogen ready. Therefore, this requirement should not apply for processes which generate steam from heat recovery systems. Instead of limiting to Hydrogen, we suggest also to accept biogas, biomass or other non-reckonable emission feedbacks complying to the Carbon Pricing Act, to be accepted to be fulfilling this requirement as an alternative to Hydrogen. Furthermore, this requirement should also be exempted for generators that are capturing its CO_2 emission for CCU or CCUS applications.	Embedded generation that relies on the recovered steam/heat generated from industrial process (i.e. steam/heat is not generated directly through the combustion of fossil fuel) will not be subject to the Emission Standards Framework. Apart from ensuring new and repowered embedded generation units are at least 30% volume hydrogen-ready, companies can rely on other low-carbon fuels (e.g. biomethane etc) to reduce the carbon intensity of the generation unit. EMA is open to considering cases where companies are able to take immediate action that can reduce their plant's emissions, such as combusting other low-carbon fuels at the point of commissioning. Companies may write to EMA (ema_policy@ema.gov.sg) to propose the combustion of other low-carbon fuels to achieve emissions reduction on a case-by-case basis. Companies that are considering carbon capture utilisation and/or storage (CCU or CCUS) for the electricity generation unit should engage EMA further to discuss the requirements.
22	Seek clarification on the definition of "repowered" EGs, especially given the implications set out in Paragraph 3.2 of the Consultation Paper. Footnote 1 states that "*repowered units refer to existing generation units which perform a major replacement work, which then effectively extends their economic life by 25 years or more*". We would like confirmation that this means, any unit that undergoes replacement work that results in an extended economic life of ***less***	On "repowered" EGs, please refer to Para 3.2 on the updated definition.

	than 25 years would ***not*** be subject to the conditions set out in Paragraph 3.2.	
23	For level playing field, new and repowered embedded generator units, in particularly those that are also exporting to the grid, shall be subject to the same emission standards that EMA is introducing because they are contributing to the grid emission factor of Singapore. While individual EGs may be small in terms of capacity, their total generation capacity is still significant. In 2022, EGs captured about 6% of the total generation market share. We advocate the imposition of certain emissions standards requirements to new and repowered EGs for the country to meet its carbon emissions targets. We would like to highlight that new and repowered non-embedded generator units face the same challenges as the plant efficiency may varies throughout the economic life due to changing ambient temperature, lower plant load factor, cogeneration vs electrical generation only, amongst others.	EGs in operation today vary in capacity, such as from 10 – 110 MW. Setting a set of standards that is fair for new and repowered EG units with a similar variance in capacity may not be meaningful at this point. However, new and repowered EGs are required to be 30% hydrogen-ready so that they are able to switch to low-carbon hydrogen when available. Nevertheless, EMA notes this feedback and may consider for future reviews of the emission standards.
Cogeneration		
24	Could EMA please elaborate further on the definition of useful heat and share how steam generated will be converted into a GWh equivalent as per your example in page 8/9 in the industry consultation paper. Can we confirm that the steam output will be based on the enthalpy method?	Useful heat refers to heat/steam produced in a cogeneration/tri-generation plant that can be used/sold for a variety of industrial applications.

Exemptions		
25	Propose that all emission for diesel related activities (E.g. quarterly fuel changeover, diesel commissioning activities, DSS) should not be used in the computation. On an annual basis, in the computation of the emission factor of each unit, the following shall be excluded: (i) Gas to Diesel Fuel Change Over Test (ii) Gas to Gas Fuel Change Over Test (iii) Any Generation arising from PSO Dispatch Instructions	EMA will exclude diesel emissions for instances where EMA Power System Operator (PSO) has directed gencos to run on diesel to manage gas/power emergency to ensure the security and reliability of the gas/power system. This could include Directed Supply Scheme (DSS) or other emergency periods instructed by PSO. Emissions arising from fuel changeover tests will be included in the computation for emissions reporting under the emission standards framework. In setting the emission standard, EMA had factored in 1% with diesel firing (similar to parameters in the *Review of Vesting Contract Technical Parameters for the Period of 1 January 2021 to 31 December 2022*) to reflect the typical combustion fuel mix. As part of the MRV, gencos will need to submit the necessary documentation and verification on the incremental amount of diesel that was used due to PSO's requirements. This exclusion from compliance with the emission standards will not apply to commercial decisions by gencos to use diesel.
26	We acknowledge that the EMA may be required to activate the Tier 2 units to run up more frequently during tight supply periods. For clarity, we would suggest defining "tight supply periods" as instances where either a high-risk or emergency operating state notice has been issued.	See above response. EMA agrees to apply exemptions to the incremental volume generated resulting from PSO directions.

	We acknowledge that such situations may warrant exemptions from the emission standard. However, any exemption should only be applicable to the incremental volume generated resulting from such PSO instructions. In other words, the base volume of the unit prior to PSO's issuance of the overriding dispatch instruction should be considered as part of its normal operations and must remain subjected to the emissions standard. Lastly, we would request that overriding information should be socialised and be made publicly available to market participants.	As per the practice today, PSO's dispatch instructions may be on short notice due to the typical emergency nature of such situations.
27	Request that EMA should consult and notify the industry on instances when they intend to temporarily lift the emission standards or establish any other exemptions.	In emergency situations such as natural gas supply disruption, gencos are required to comply with their natural gas standing operating procedure (NGSOP) for an effective and prompt response to ensure the secure operation of the gas and power system. EMA may separately notify the industry for temporary suspension of EMA's emission standards. Such notifications could be on very short notice (pre- or post- event), given the nature of emergency circumstances requiring urgent backup.
28	New and repowered generator that has entered into an ancillary service contract with EMA, such as the fast start service contract and the backup service contract for import, should be exempted from the emission standard since their generation is activated by the PSO all the time.	New and repowered generation units under Ancillary Service Contract (ASC) will fall under Tier 2 emission standards which are catered to less efficient plants such as those providing fast start and backup. EMA will exclude emissions for instances where the EMA Power System Operator (PSO) has directed gencos to run to manage gas/power emergency to

		ensure the security and reliability of the gas/power system, including when the use of diesel is required.
Monitoring, Verification and Reporting (MRV)		
29	Could EMA please confirm that “Grandfathered” units would not be subjected to EMA’s MRV requirements. (I.E., emissions reporting on a unit level As Gencos are already submitting an annual emissions report to NEA. As such, we are hoping that EMA’s MRV requirements would remove any duplication of work. Given that the current emissions report submitted to NEA is already verified by an independent third-party, we are asking that the emissions report to be submitted to EMA will not require such verification requirements.	Existing and life-extended units are grandfathered (i.e. excluded) from emission standards, including MRV requirements. MRV requirements under the emission standards framework are necessary given that some data submitted to NEA and those required by EMA are different. EMA has sought to ensure that the annual reporting cycle is the same as the carbon tax reporting to NEA (i.e. 30 June each year) for synergistic timing. Gencos could consider using the same independent third-party verifier for the annual emissions report to EMA.
30	For the declaration of the carbon emission factor of the new and repowered generation unit, what is the level of plant load factor to be used to perform the carbon emission test during commissioning testing?	There is no fixed PLF for commissioning tests. As long as gencos demonstrate that 0.355 tCO_{2e}/MWh can be achieved during commissioning test, as verified by OEM such as through a performance guarantee, that would suffice to show that the unit is technically capable of performing within this emissions intensity limit.

Financial Penalty		
31	Currently, only the maximum possible financial penalty is stated. Could EMA share the formula used to determine the financial penalty in the event that a Unit exceeds the emissions threshold?	Similar to other penalty frameworks under EMA, EMA will not be sharing the detailed formula for the financial penalty to avoid gaming. The penalty framework for emission standards is tiered based on severity of contravention of the emission standards. For example, ≤ 5% in excess of Tier 1 or Tier 2 limits would be considered under 'Minor', >10% would be considered 'Severe'.
32	Similar to the current treatment of breaches under other Codes of Conduct or Practices, we would propose that any breach to the Code of Practice on Carbon Emissions should be published to market participants.	EMA will consider this in a subsequent industry consultation on the new Code of Practice on emission standards.
33	We would like to recommend an incentive-based approach instead of a penalty approach to encourage generation companies to invest in low-carbon solutions and ensure carbon-efficient plant operations as much as possible. For example, a generation unit that is able to achieve better than the pre-set emission standards determined during commissioning shall be given financial incentive in proportion to the amount of carbon emission that has been reduced. This financial incentive can be funded by the carbon tax that is being collected from the emitters in Singapore. When the new and repowered generating units is no longer be able to operate at baseload, it should be allowed to downgrade itself to Tier 2 or exempted from compliance.	The current emission standards are based on what is reasonable and achievable by advanced CCGTs today. The intent is to ensure that gencos deploy carbon efficient generation units. Given that there are already concrete plans by gencos to plant advanced CCGTs, this indicates that it is commercially realistic to do so. The penalty framework will be structured to deter any contraventions to the emissions limit due to a failure to manage plant operations efficiently. On requests to reclassify plants subject to Tier 1 to Tier 2 in future, gencos may write to EMA with clear justifications for EMA's approval.