



Smart Energy, Sustainable Future

**CONSULTATION PAPER ON
EMISSION STANDARDS FOR POWER GENERATION UNITS**

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EMISSION STANDARDS

1 Background

- 1.1 Singapore has committed to a 2030 Nationally Determined Contribution (NDC) to reduce greenhouse gas (GHG) emissions to 60 million tonnes (Mt) of carbon dioxide equivalent around 2030 after peaking our emissions earlier. It has also recently committed to achieving net zero emissions by 2050.
- 1.2 The government released [Singapore's National Hydrogen Strategy](#) in October 2022. It recognises the potential of low-carbon hydrogen to be a major decarbonisation pathway, enabling a gradual transition from the use of natural gas in CCGTs over time.
- 1.3 Today, the power sector contributes around 40% of Singapore's total carbon emissions, with 95% of our electricity generated from natural gas. Combined cycle gas turbines (CCGTs) have the potential to remain the backbone of Singapore's electricity generation for many years. Enhanced energy efficiency and replacement of fossil fuels with hydrogen can contribute to a reduction of emissions from electricity generation using CCGTs.
- 1.4 As the economic lifespan of CCGTs is around 25 years, each new plant that enters the power system would have an impact on our ability to meet Singapore's 2030 and 2050 emission targets. To ensure that the power sector would be able to gradually reduce its emissions over time, the emissions intensity of new generation units (including advanced CCGTs for baseload generation and smaller generation units providing other services like fast response) running on fossil fuels will need to be managed to facilitate the transition to low-carbon alternatives in electricity generation.
- 1.5 To facilitate advance planning, deployment and operation of clean power generation units in Singapore over time, EMA plans to introduce emission standards for new and repowered¹ fossil fuel-fired generation units.

¹ 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.

2 Emission Standards Framework

- 2.1 Following an earlier [industry consultation on heat rate standards](#) to encourage CCGTs to run as efficiently as possible, EMA will introduce emission standards to directly manage the emissions for power sector. Taking in the industry's earlier feedback on the heat rate standards, EMA has developed a regulatory framework to regulate the unit-level emission standards for new and repowered power generation units from 2023 onwards.
- 2.2 With effect from the date of publishing this consultation paper, **all new and repowered fossil fuel-fired generation units in Singapore whose date of licence application submission, and/or addition to Schedule A falls on or after the launch of this industry consultation²**, will be liable for compliance to the emission standards. All existing generation units, including life-extended units, are grandfathered from this emission standards framework.
- 2.3 Emission standards will enter into force when a new Code of Practice on carbon emissions from electricity generation is published in 2023. A subsequent consultation will follow in 1H 2023 prior to implementing the new Code of Practice for compliance by all generation licensees.
- 2.4 The proposed framework for emission standards takes into account the following key considerations:
- (i) The emission standards will need to be sufficiently stringent to ensure that the power sector can meet its decarbonisation targets, whilst not deterring generation plantings or neglecting operational needs.
 - (ii) The emission standards will need to be achievable and reasonable. EMA will peg the standards to those of best-in-class technology (e.g. H-class CCGTs or equivalent) for new units based on what is already available in the market. This ensures that the new and repowered generation plants are the most energy- and emissions-efficient.
 - (iii) The power generation fleet should be future-proofed, i.e. ready to adopt low-carbon fuels.
- 2.5 To meet Singapore's climate goals, EMA will 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 and provide advance notice before doing so to ensure sufficient lead time for planning.

² Gencos who had submitted their licence application in 2022 prior to the launch of this consultation will also be subject to compliance with the emission standards, as separately informed by EMA.

Setting emissions intensity limit for new and repowered fossil fuel-fired generation units

- 2.6 The emission standards will be in the form of an emissions intensity limit (measured in tonnes of carbon dioxide equivalent per megawatt hour, or tCO₂e/MWh). This will allow EMA to measure the emissions efficiency of electricity generation. The emissions intensity of the plant shall include all GHG (i.e. CO₂, CH₄, N₂O) emitted. The approach will be two-tiered to cater to generation units which provide different primary plant functions. Baseload plants will be subject to more stringent emissions standards, compared to non-baseload plants that are designed to provide other services to the system (e.g. fast-start generation units, diesel generators), as the latter are inherently less efficient but still needed for the system.
- 2.7 By default, all new and repowered fossil fuel-fired generation units will be held to Tier 1 under emission standards. Power generation companies (“gencos”) who wish for their new plant to be held under Tier 2 instead as it is designed to provide other services should indicate so during licence application and/or addition to Schedule A, which sets out the generation units which a genco is licenced to operate with details such as plant capacity and commercial operation date. EMA will assess the application and determine if the new plant should fall under Tier 2 for compliance.
- 2.8 The proposed two-tiered approach for emission standards is outlined as follows:

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

	Tier 1 New and repowered baseload generation unit	Tier 2 New and repowered non-baseload generation unit
Primary function of plant	By default, all new fossil fuel-fired plants should meet the Tier 1 emission standard.	Plants designed for specific non-baseload purposes that are unable to meet Tier 1 standard can opt to be subject to an emissions limit under Tier 2.
Examples of plant types	Advanced CCGTs (i.e. H-class or equivalent)	Open Combined Gas Turbines (OCGTs), new gas engines, new diesel generators
Emission standards requirements	Emissions intensity standard of 0.355 tCO ₂ e/MWh (based on 75% Plant Load Factor, or PLF).	Emissions allowance limit (MtCO ₂ e cap) that is equivalent to a Tier 1 advanced CCGT but running at a lower PLF of 50%.

	This is based on most efficient CCGT technology today (i.e. advanced CCGT).	
Hydrogen-compatibility requirement	New and repowered plants to be at least 30% vol. hydrogen-compatible with the ability to be retrofitted to become operationally 100% hydrogen-compatible in the future to the extent possible.	

(i) Tier 1: New and repowered baseload generation 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).

- a. **An emissions intensity limit of 0.355 tCO_{2e}/MWh³** is based on the expected heat rate of an advanced CCGT (i.e. H-class or equivalent) that runs fully on natural gas at a plant load factor (PLF) of 75% averaged on an annual basis. This limit also takes into account a maximum degradation factor of 2.08% over a 25-year lifespan. Nevertheless, gencos are expected to make continuous technical improvements to enhance plant efficiency over its lifespan.
- b. **Net electrical output** is the electricity injected into the grid after accounting for auxiliary load consumption from the generating unit.

The emission factor of each 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 (MWh). The total emissions of each unit will include all GHG emitted from the combustion of fossil fuels for electricity generation (e.g. natural gas, diesel etc).

(ii) Tier 2: New and repowered non-baseload generation units

As we integrate different energy sources (e.g. solar and 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. Such units may be less efficient and may emit higher emissions, compared to advanced CCGTs. While we welcome the entry of generation units that can improve the flexibility and security of the grid, we will also need to ensure that

³ 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](#)). 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.

they do not run as frequently as baseload units, to minimise their impact on Singapore's overall emissions.

- 2.9 As such, new and repowered plants designed for specific primary purposes other than providing baseload that are unable to meet Tier 1 standard can opt to comply with an emissions limit under Tier 2 instead, subject to EMA's confirmation. Under Tier 2 standard, new and repowered units will need to comply with an annual emissions allowance limit (Mt CO₂e), calculated based on a plant's installed electrical capacity. This limit will be equivalent to an advanced CCGT under Tier 1 but running at a lower PLF of 50% on an annual basis. The total emissions of each unit will include all GHG emitted from the combustion of fossil fuel (e.g. natural gas, diesel etc).
- 2.10 Examples of plant types subject to Tier 2 include less efficient, but fast response generation units that can provide fast-start services. The examples below show the implication of emission limits on the average PLF of generation units. This is 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). For avoidance of doubt, Tier 2 plants will be subject to an emission limit (Mt CO₂e) 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. Such periods will be excluded from the calculation of the emissions limit.
- 2.11 These calculations are for illustrative purpose only.

$$\text{Emission Limit} = \text{Installed Capacity} \times 0.355 \text{ tCO}_2\text{e/MWh} \times \text{Plant Load Factor (50\%)} \times \text{Hours in a year}$$

Example 1 (500MW Open Cycle Gas Turbine (OCGT) with an emission factor of 0.7 tCO₂e/MWh):

Emission allowance limit = 500 MW x 50% x 0.355 tCO₂e/MWh x 8760 hr = 0.777 Mt CO₂e/year

Effective PLF limit = 0.777 / (500 MW x 8760 hr x 0.7 tCO₂e/MWh) = 25.3% PLF on average in a year

Example 2 (10MW generation unit):

Annual emission limit for 10MW plant:

$$10\text{MW} \times 0.355 \text{ tCO}_2\text{e/MWh} \times 50\% \times 8760\text{hrs} = 15,549 \text{ Mt CO}_2$$

A 10MW gas engine (with an assumed average emission factor of 0.45 tCO₂e/MWh) will have to operate at no more than 39.4% PLF throughout the year to keep within the emission limit.

A 10MW diesel generator (with an assumed average emission factor of 0.76 tCO_{2e}/MWh) will have to operate at no more than 23.3% PLF throughout the year to keep within the emission limit.

A lower PLF could be acceptable for small-scale generation units that mainly operates to provide reserves/peaking capacity.

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

- 2.12 EMA will require all new and repowered fossil fuel-fired generation units going forward to be hydrogen-compatible⁴ in terms of capabilities, to the extent techno-economically possible when commissioned. Based on the assessment of currently available technologies, all new generation units supplying baseload energy must be able to accommodate at least 30% volume hydrogen-blend with natural gas.
- 2.13 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. Over time, as generation units capable of running on higher volumes of hydrogen (including 100% hydrogen) become commercially and economically available, EMA may raise the required capabilities for hydrogen-compatibility.

Accounting for heat generation by cogeneration power plants

- 2.14 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 separate power plant for electricity generation and boiler for heat generation.
- 2.15 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

⁴ Hydrogen-compatibility refers to both gaseous hydrogen and low-carbon hydrogen derivatives (e.g. ammonia) that may be used directly as a fuel.

- Heat generated: 1,500 GWh
- Total emission for the year: 2 million tCO_{2e} (MtCO_{2e})

Emissions arising from electricity generation =
 $4,500 \div (4,500 + 1,500) \times 2 \text{ MT} = 1.5 \text{ million tCO}_2\text{e}$

Emission Factor of Cogeneration =
 $1.5 \text{ MtCO}_2\text{e} \div 4,500 \text{ GWh} = \mathbf{0.333 \text{ tCO}_2\text{e/MWh}}$

Cogeneration plant is compliant with the emission limit.

3 Embedded Generation

- 3.1 New and repowered Embedded Generation (EGs) units⁵ that are part of industrial processes would not be subject to an emissions intensity limit under the emission standards framework. EMA recognises that subjecting all new and repowered EGs to a uniform emissions intensity limit may not be meaningful given their variance in design (e.g. cogeneration vs. electricity generation only), nameplate capacity and correspondingly, plant efficiency.
- 3.2 However, new and repowered EGs with a nameplate capacity above 10 MW will be subject to a requirement to be at least 30% volume hydrogen-compatible, with the ability to be retrofitted to become operationally 100% hydrogen-compatible in future when it becomes techno-economically feasible to do so. This is to future-proof smaller generation units to facilitate long-term emissions reduction when it becomes technically and commercially viable to switch to hydrogen. Such units capable of combusting 30% volume hydrogen with natural gas are already commercially available in the market today.

4 Exemptions

- 4.1 All existing generation units will be grandfathered from this framework. This refers to fossil-fuel power plants in operation today which were commissioned before emission standards are introduced. Exclusion will no longer apply if existing plants are repowered. Renewable energy power generation (i.e. solar) and imported electricity where generation sources are located outside of Singapore will also be excluded from this framework.
- 4.2 The following categories will be exempted from complying with emission standards:

⁵ 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.

- 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 back-up 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 start-up of a power plant during a Black Start scenario.
- 4.3 EMA may 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).
- 4.4 Other exemptions may be proposed for EMA's consideration on a case-by-case basis.

5 Enforcement through Monitoring, Reporting and Verification (MRV)

- 5.1 The emission standards will be enforced through a new Code of Practice on carbon emissions from 2023 onwards. An industry consultation on this will follow in 1H 2023.
- 5.2 Gencos will need to declare the carbon emission factor⁶ of their new and repowered generation units as well as hydrogen-compatibility at the point of licence application and validate this 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 through a written confirmation endorsed by OEMs during licence application.
- 5.3 In addition, gencos will be required to submit an annual emissions report verified by an accredited third party to EMA by 30 Jun 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 (refer to Para 2.8(i) and (ii)). 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.
- 5.4 Separately, companies with cogeneration plants will continue to submit data on electricity and heat generation to EMA as part of the monthly Generation Returns.

⁶ 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).

6 Financial Penalty

- 6.1 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.
- 6.2 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 \$1 million, whichever is higher.
- 6.3 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.

7 Request for Comments and Feedback

- 7.1 EMA invites written comments and feedback on Sections 2 to 6 of the consultation paper to the EMA Policy and Planning Department (PPD) at the following email address:
- ema_policy@ema.gov.sg
- 7.2 The closing date for feedback submissions is 16 February 2023, 2359 hrs Singapore time. Anonymous submissions will not be considered.
- 7.3 EMA will acknowledge receipt of each submission via email. If you did not receive an acknowledgement of your submission within two business days, please contact ema_policy@ema.gov.sg.
- 7.4 EMA reserves the right to make public all or parts of any written submissions made in response to this consultation paper and to disclose the identity of the source. Any part of the submission, which is considered by respondents to be confidential, should be clearly marked. EMA will take this into account regarding

the disclosure of information submitted. EMA may also approach respondents for clarification while the consultation is ongoing.

~ End ~