REQUEST FOR INFORMATION

FACILITATING THE DEPLOYMENT OF NEW AND INNOVATIVE GENERATION TECHNOLOGIES

Closing date for submission of comments and feedback:

31 July 2019
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1 Executive Summary

1.1 The Energy Market Authority ("EMA") aims to improve the overall efficiency and flexibility of the power generation fleet, while meeting future electricity demand growth and ensuring system reliability. Technological advancement presents opportunities to facilitate the entry of more efficient, flexible, competitively-priced and cleaner forms of power generation. Against this backdrop, EMA is considering what new and innovative technologies can be introduced to the power system. EMA also wishes to understand any potential new regulatory treatment or market rules that should be considered.

1.2 It is timely to explore such options, given that Power Generation Companies ("Gencos") have indicated interest to retire and repower older generation units. EMA is separately consulting the industry on developing a Forward Capacity Market ("FCM") to enhance the Singapore Wholesale Electricity Market. The FCM aims to maintain resource adequacy by providing adequate incentives to existing resources and new investment and maximise economic efficiency to minimise long-run costs to consumers.\(^1\) As generation plantings tend to be lumpy and have a long technical life-span of around 20 to 30 years, there will be long-term benefits to Singapore if subsequent generation plantings are more efficient, flexible, competitively-priced and cleaner from an emissions perspective.

1.3 EMA continuously strives to ensure that our regulatory framework is able to encourage the adoption of such beneficial generation technologies. Hence, this paper seeks information from the industry on the following matters:
   a. New and innovative solutions that can enhance generation efficiency of the current fleet and new generation plantings; and
   b. Measures that can encourage the adoption of such new and innovative solutions to enhance power sector effectiveness.

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2  Background

2.1 In the liberalisation of the electricity industry over the last two decades, EMA had put in place a competitive market structure to promote the efficient and competitive supply of electricity. Investments in the power system infrastructure are commercially-driven. Investors responded to the competitive market structure, and gradually shifted Singapore’s power generation mix from older steam plants running on fuel oil to the current state dominated by efficient combined-cycle gas turbines (“CCGT”) running on natural gas. This evolution had benefited Singapore in multiple ways: CCGTs have a lower cost of generation compared to steam plants; they are also cleaner and emit less carbon dioxide, thus contributing to our environment sustainability.

2.2 EMA is of the view that there is room to improve the current generation efficiency and reduce the power sector’s carbon output. The dominant and most efficient power generation technology in Singapore’s market today is the “F-class” CCGT, with average size of around 380 Megawatts (MW). The part load of these CCGTs is about 65.4%, resulting in an overall generation efficiency of approximately 48.7%. This is lower than the maximum efficiency that our system can achieve with “F-class” CCGTs, which is around 52% at 100% part load under local conditions, or about 51% at a part load of 90%. EMA thus seeks views on possible solutions to improve the part load of CCGTs.

2.3 EMA also recognises the value of improving flexibility in our power system. Existing conventional land-based generation technologies take three to five years to build and have long economic lifespans of 20 to 30 years. This inflexibility restricts Singapore from (i) introducing newer and more efficient generation technologies to the power system, and (ii) being more responsive to changing electricity demand and market conditions. Introducing deployment flexibility in the power system will (i) better enable Singapore to balance the long-term development of the electricity market, and (ii) allow Singapore to more readily adopt more advanced technologies.

2.4 With this backdrop, it is important for EMA to plan for more innovative, efficient and flexible power generation. While we note that the electricity market is facing an oversupply situation, electricity demand is currently projected to grow at a compounded annual growth rate of 1.4 – 2.0% from 2019 to 2029\(^3\). There is also indication of large loads potentially coming into the system. At the same time, EMA has received indicative interest from Gencos to retire and repower their older generation units. EMA is also consulting the industry on the FCM, and there is scope within the FCM to introduce new forms of capacity which are more innovative, efficient and flexible. As the entry of new planting or repowering is a lumpy investment, each new entry should aim to maximise the

\(^2\) The part load measures the percentage of the maximum capacity at which the plant is operating at any point in time. It determines the typical efficiency of the CCGT when it is in operation.

overall generation efficiency, flexibility and cleanliness of the power system, where viable.

2.5 EMA has therefore published this Request for Information ("RFI") to seek information on possible ways to improve the overall generation efficiency and deployment flexibility from current levels, as well as facilitate the entry of new and innovative power generation technologies or other innovative solutions. EMA welcomes views from industry players and technology providers on the options available, relevant case studies from other jurisdictions if available, and any potential implications on existing regulatory framework.
3 Understanding New and Innovative Technologies that Benefit the Power System

3.1 Potential new and innovative technologies

3.1.1 EMA is interested to understand potential new and innovative technology options that can be introduced into the market. Technologies that have higher efficiencies than the existing “F-class” CCGTs will enhance market competition and reduce carbon emissions for Singapore. Some examples include advanced “F-class”, “H-class” and “J-class” CCGTs, which have higher nameplate capacities and higher maximum generation efficiency. Smaller sized CCGTs, such as modular-CCGTs\(^4\), can also achieve comparatively high efficiencies and flexibility over a wider range of part load. They can be more efficient than competing technologies operated at lower part load. Some alternative solutions which have been introduced in overseas markets include power generation based on oxy-combustion technology. Though in their nascent stage, such technologies can also enable power plants to operate more flexibly and efficiently, while being cleaner when applied with carbon capture technologies.

3.1.2 EMA is also interested in generation technologies that can improve the overall flexibility of the power system. This is especially when electricity demand over the lifespan of a plant will be harder to predict going forward. While conventional forms of generation such as land-based CCGTs remain important in meeting overall demand today, the lumpy nature of each new planting or repowering encompasses significant uptake of land. Once planted, the investment also locks Singapore in the particular generation technology, capacity and land use for the next two to three decades. Solutions such as Floating Power Plants (“FPPs”) can potentially enhance the flexibility of the power system and save land. The FPPs' mobility and speed-to-deployment allows them to not only be deployed quicker than land-based power plants, but also be disconnected and re-deployed in response to changing market conditions or from a desire to replace them with FPPs equipped with more advanced generation technologies. Thus technologies that allow capacity flexibility will be of value to the power system.

3.1.3 Virtual Power Plants (“VPPs”) are also a potential option. They have the benefit of connecting multiple small and distributed generation, and feed power back to the grid. This can complement the growth of solar PV installations in Singapore. Solar is a space-intensive energy resource, has associated intermittency issues and can only generate electricity during the day. Pairing solar with energy storage systems (“ESS”) may overcome the intermittency issue. A VPP model can aggregate such systems to increase availability and flexibility of more energy sources to the power system, such as the ability to better meet fluctuations in demand and supply compared to conventional large power plants. A key consideration is the level at which VPPs can be integrated with the power system to realise the benefits.

\(^4\) Modular CCGTs refer to smaller scale generating units that can be operated in parallel and deployed as needed to match the changing power requirements. Such units can also achieve higher overall part-load efficiencies, as individual sub-units can run at optimum output while other sub-units are not running.
Feedback sought for Section 3.1

**Current Market Conditions**

**3.1A.** Do new or existing industry players have indicative plans for new builds and repowering within the next 5-10 years? What are the top few technologies being considered?

**Introduce New and Innovative Generation Technologies**

**3.1B.** What are the new and innovative generation technologies that can be introduced to meet Singapore’s market needs, while being more efficient, flexible and/or quick-to-deploy?

**3.1C.** What is the performance of the technologies identified in terms of (and in comparison with the existing generation technologies):

i. Fuel efficiency;
ii. Fuel flexibility;
iii. Heat rate curve;
iv. Ramp rate curve;
v. Emission factor;
vi. Frequency response capability;
vii. Fuel changeover capability;
viii. Unit size;
ix. Inertia;
x. Capital cost (CAPEX) and operating cost (OPEX);
xi. Land, water and other siting requirements;
xii. Manpower requirements;
xiii. Maintenance requirements;
xiv. Deployment timeline and flexibility;
xv. Level of technology maturity;
xvi. Current state of deployment in other power systems;
xvii. Whether it is commercially viable in Singapore, and if not, when might it be commercially viable?

**3.1D.** What are the key risks? For example, will there be sufficient manufacturers/ providers that can provide maintenance and service support?

**3.1E.** What is the expected implementation lead-time (i.e. construction time, commissioning and decommissioning time, etc.) required to bring these technologies into the market?

**3.1F.** What are the barriers that may inhibit the entry of such technologies into Singapore’s power system? What regulatory enhancements can better support their entry?

**3.1G.** What degree of flexibility in generation capacity should be introduced into the system? What are these and how much should we design this into our system?
3.1H. FPPs. What are some of the specific siting, market and/or regulatory requirements that need to be addressed in order to facilitate the deployment of FPPs in Singapore?

3.1I. VPPs. How can they be catalysed to support distributed energy resources like solar and batteries? To what extent should VPPs be used to complement baseload energy generation?

3.1J. Carbon capture technologies. Do they have a strong and viable role to play in reducing carbon output from the power sector? What generation technologies coupled with carbon capture can be introduced to the Singapore market? Are there any potential barriers?

3.2 Technical Challenges with Large Generation Units

3.2.1 As we facilitate the entry of new and innovative technologies, we also want to carefully balance our energy trilemma – energy security, economic competitiveness and environmental sustainability. Such technologies may be more economically efficient and cleaner, but they should not affect the stability of the power system.

3.2.2 For example, some newer CCGT models exceed 600 MW, which is currently the largest generation unit size in our system. 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. Loss of a larger gross electricity output can lead to load shed.

3.2.3 However, as Singapore’s electricity demand and power system continue to grow, we will eventually be able to accommodate larger generation units. As such, EMA does not wish to foreclose this option if there is commercial interest. Such plants can bring system benefits and improve the energy trilemma. EMA thus seeks views on potential solutions that can allow the power system to accommodate more than 600 MW of gross electricity output per generating unit. For example, given that ESS can potentially arrest rapid frequency decay due to its unique capability of delivering power much faster than CCGTs\(^5\), proposals to adopt larger CCGTs can also incorporate the use of ESS to ensure system resiliency.

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\(^5\) For example, lithium-ion ESS can respond within 10 to 20 milliseconds, compared to CCGTs which is in the order of several minutes.
**Feedback sought for Section 3.2**

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<th>3.2A.</th>
<th>What are the key benefits of larger generating units? Alternatively, can Singapore’s market need and characteristics be better met by smaller generation units?</th>
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<tr>
<td>3.2B.</td>
<td>How can EMA facilitate an increase in the 600MW gross electricity output limits without compromising system stability?</td>
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<td>3.2C.</td>
<td>How can ESS be optimally incorporated with larger CCGTs and the overall power system to ensure an immediate response to trigger events such as generation plant tripping? Are there other technologies that can support larger CCGTs?</td>
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4 Facilitating Adoption of New and Innovative Technologies and Solutions that Enhance Power Sector Effectiveness

4.1 It is possible that some generation technologies may face challenges in entering the Singapore market. In this section, EMA has identified a few challenges and seek industry feedback on how such challenges can be overcome.

4.2 Reserves costs disadvantage for large advanced CCGT

4.2.1 One challenge faced by large generation units (e.g. at 600MW) is the cost of reserves incurred. In the National Electricity Market of Singapore, spinning reserves are procured on a half-hourly basis to cover the largest scheduled output as back-up against outages. Based on the "Modified Runway Model", the cost will be allocated to the generating units based on their scheduled output in accordance with their Reserve Responsibility Share. Thus, generating units that are larger than the current “F-class" CCGT will bear higher reserve costs.⁶

4.2.2 EMA has received industry feedback that the modified runway methodology creates an early-mover disadvantage that inhibits the entry of large and efficient generation units, as the higher reserve costs may outweigh the efficiency gains. At the same time, the net cost disadvantage may only be temporary as subsequent large units enter our market and share the reserve costs.

4.3 Low part load for CCGTs operating in our market

4.3.1 As discussed in Section 2.2, the derived⁷ part load of our CCGTs is 65.4%, resulting in an overall generation efficiency of approximately 48.7%. EMA views that even without the introduction of new technologies, there is scope to improve the overall part load and generation efficiency from today's levels.

4.3.2 Based on feedback received, the load is typically distributed evenly across each Genco’s fleet of CCGTs in order to avoid incurring higher reserve charges from the modified runway methodology. Gencos are also not running the generation plants at a higher part load to provide spinning reserves into the market. Other factors include the way newer plants are perceived to be less reliable due to their lack of track records, hence incurring a higher reserves cost. Thus, these newer plants may not operate at a higher load relative to the older units.

4.3.3 Another factor is that cogeneration plants are required to be run at a relatively stable or equal part loads in order to produce the amount of steam required to meet their contractual requirements. As such, load balancing across their fleet is influenced by stability concerns.

⁶ Singapore Electricity Market Rules: https://www.emcsg.com/marketrules
Feedback sought for Section 4

**Overcome Reserves Costs Disadvantage**

4A. What is the expected quantum of the net cost disadvantage\(^8\) faced by new large units and prevailing “F-class” CCGTs? Please share the methodology for deriving this quantum.

4B. What kind of regulatory support or rule changes can overcome the early-mover disadvantage for larger generation units?

**Increase Part Load of CCGTs**

4C. What are the key reasons that have led to today’s generation fleet operating at a comparatively low part load and generation efficiency?

4D. What are possible ways to improve the part load and generation efficiency of the existing power generation fleet?

\(^8\) The net cost disadvantage should recognise the higher reserve costs faced by larger units, as well as the cost savings arising from such units if they have higher efficiency.
5 Request for Information

5.1 The EMA invites comments and feedback to Section 3 and Section 4 of this RFI. Please submit your written responses via www.go.gov.sg/ema-rfi by 31 July 2019. Anonymous feedback will not be considered.

QR code link to submit written responses:

![QR code link](image)

5.2 For clarifications, please contact EMA Policy and Planning Department (PPD) at ema_policy@ema.gov.sg.

5.3 EMA reserves the right to make public all or parts of any written submissions made in response to this RFI 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 disclosure of the information submitted. EMA may also approach the respondents for clarification while the RFI is ongoing.

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