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A Caterpillar Company

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Massachusetts Department of Energy Resources
100 Cambridge Street, Suite 1020
Boston, MA 02114

Attention: ***Ms. Samantha Meserve***
Deputy Director, Renewable and Alternative Energy Division

Reference: ***2020 APS Minimum Standard Review Comment***

Dear Ms. Meserve,

We respectfully submit this letter for your consideration which contains the comments from Solar Turbines Incorporated (Solar) on the 2020 Alternative Energy Portfolio Standard (APS) Minimum Standard Review pursuant to 225 CMR 15.07(3).

Solar is an American manufacturer of power generation equipment founded in 1927 and is a world leader in industrial combustion gas turbines from 1 MW to 23 MW. Solar has sold more than 16,000 combustions gas turbine systems with over 3 billion operating hours experience. These systems provide clean, efficient, and reliable power for base-load electricity, combined heat & power (CHP), standby power, and mechanical drive applications. Solar has over 4,000 combustion gas turbine packages installed for electrical power generation and CHP in North America; all of which were manufactured in the USA. In 1981 Solar was purchased by Caterpillar Tractor Co. (now Caterpillar Inc.) from International Harvester Company. Solar is a wholly owned subsidiary of Caterpillar Inc.

Since the 2009 implementation of the Massachusetts APS program Solar has supplied and/or installed the following combustion gas turbine based CHP or power generation plants in the Commonwealth of Massachusetts:

- 8 MW CHP - public university medical center in Worchester MA
- 5 MW CHP - paper plant in western MA
- 3.5 MW CHP – paper plant in north central MA
- 16 MW CHP – district energy plant for multiple medical facilities in Boston MA
- 8MW CHP – private university in Cambridge MA
- 4.5 MW CHP – public university medical center in Springfield MA

- 4.5 MW CHP – manufacturing facility in Worchester MA (in progress)
- 8 MW CHP – manufacturing facility in Boston MA
- 44 MW CHP – private university in Cambridge MA
- 16 MW Power Plant – utility in Nantucket MA

Based on the information provided above we believe that Solar is a valid stakeholder to the APS review process, as such we have respectfully provided the enclosed comments for your review and consideration.

We have reviewed the Alternative Energy Portfolio Standard Review dated October 30, 2020 (Daymark Report) prepared by Daymark Energy Advisors (Daymark) for the Massachusetts Department of Energy Resources (DOER) and have provided our comments herein for your consideration. Due to the nature of our business and interest, our comments will primarily be limited to CHP.

Based on our review we believe there are some basic issues in the Daymark Report that will have a fundamental impact on the Daymark Report conclusions and recommendations. These issues are summarized in our comments immediately below. These comments are also applicable as our response to Stakeholder Question 12.

<u>Comments on Daymark Report</u>

1. CHP Prime Mover Technology

   On page 44 (Appendix A Section I Financial Analysis Assumptions) it states that Daymark has only evaluated reciprocating engine based CHP. As a result, the Daymark Report fails to fully examine the common CHP designs and prime mover technology options, and only focuses on a subset of the market.

   Since the inception of the APS Solar has provided more than 115 MW of power generation equipment in MA. The evaluated model is not applicable to large university, hospital, and industrial campuses which currently use CHP in MA. As a result, their conclusions are not indicative of the majority of the CHP installed in MA.

2. CHP Project Size

   On page 44 (Appendix A Section I Financial Analysis Assumptions) it states that Daymark has only evaluated three (3) CHP models; 100 kW, 633 kW, and 3,326 kW. As a result, the Daymark Report on examines smaller CHP and fails to full examine the full range of CHP currently installed in MA.

Since the inception of the APS Solar has provided CHP equipment from 3,500 kW to more than 40,000 kW to various MA based businesses. The evaluated small CHP model is not applicable to large university, hospital, and industrial campuses which currently use CHP in MA. As a result, their conclusions are not indicative of the majority of the CHP installed in MA.

3. CHP Equipment Vendor Selected for Analysis

   On page 44 (Appendix A Section I Financial Analysis Assumptions) it states that Daymark has only evaluated three (3) reciprocating engine based CHP models with two (2) of them being 633 kW and 3,326 kW. It is clear to anyone with experience and knowledge of the common power island equipment in the US CHP market that the majority of the Daymark CHP evaluation is based on a single technology and equipment supplier. CHP design, performance, and costs will vary based on the power island equipment and will have a major impact on the total lifecycle costs. The Daymark Report fails to fully examine a proper cross section of the commercially available CHP power island designs and technology options which are currently being used in MA, and only focuses on a subset of the market. As a result, their conclusions are not indicative of the majority of the CHP installed in MA.

4. CHP System Installed Cost Assumptions

   In Table 17 on page 44 (Appendix A Section I Financial Analysis Assumptions) Daymark provides installed cost assumption which appear to be much lower than the actual average current complete costs for CHP in MA. Footnote 14 of the Daymark Report states that the installed costs we derived from the EPA Catalog of CHP Technologies. The EPA numbers are a national average and do not take into account the higher construction cost in the US Northeast or the higher cost of CHP installation in congested urban centers.

   While the Daymark Report costs may be indicative of the modeled power island equipment and simple rural green field installation costs, they clearly do not include the complete costs that are commonly required for a CHP project in MA. These common costs include:

   a. Demolition and/or removal of existing plant
   b. Electrical and mechanical balance of plant equipment
   c. Black start generation equipment
   d. Electrical utility interconnection

e. Logistics for confined urban installation
f. Owner soft costs (permitting, taxes, project management)
g. Startup and commissioning

Based on our recent experience we would expect CHP projects in the evaluated size range to be between $3,000 and $6,000 for projects in MA. Combustion gas turbine based CHP can be more expensive due to the large amount of steam generation equipment required for exhaust heat recovery.

5. CHP System Fixed O&M Cost Assumptions

In Table 17 on page 44 (Appendix A Section I Financial Analysis Assumptions) Daymark provides fixed O&M cost assumptions ($8 to $20 per kW per year) installed cost assumption which appear to be an order of magnitude lower than the actual average current complete costs for CHP in MA.

For reciprocating engine generator sets the cost for a long term service agreement (excluding lube oil replacement and accrual for engine overhaul) is about $12 per MWhr. With lube oil replacement and accrual for engine overhaul this cost can be $25 per MWhr. Based on an average 92% availability this equates to a maintenance cost of about $200 per kW per year for the reciprocating engine generator sets alone. This cost would be about $80 per kW per year for a combustion turbine under a standard long term service agreement.

Note that the equipment maintenance cost above does not include maintenance of the CHP heat recovery and balance of plant equipment, and do not include plant operations. It is important to note that CHP with steam generation will require full time steam operators. As a result, with balance of plant maintenance and full time steam operators (5 shifts per week) the O&M costs could exceed $500 per kW per year for a new reciprocating engine based CHP installation. The Daymark Report O&M cost assumption appears to be an error which will have a large impact on the financial results of this model.

With respect to the DOER APS review and request for stakeholder feedback to the questions being put forward by the DOER we have the following general comments immediately below.

<u>Comments on DOER Stakeholder Questions</u>

1. Question 3 Technology Prioritization

We believe that the APS program should prioritize technologies based on their proven benefits. Our concern is that the APS program prioritization may be polarized on a single benefit, such as greenhouse gas emissions, rather than looking at a range of benefits. Our other concern is that the APS program prioritization be overtly influenced by potential benefits rather than proven benefits.

While efficiency, emission reduction, and energy costs savings are primary benefits of CHP which need to remain a core prioritization of the APS program, other benefits need to be considered. With the huge community and business impact of utility grid power failures due to severe weather energy resiliency should be a primary focus of the technologies being considered by the APS program. Critical facilities require reliable resilient power to maintain services and prevent the loss of life support or other critical infrastructure. CHP is one of the APS technologies that can reliably provide micro grid or island mode (grid separated) operation to maintain heating, cooling, and electric power to critical infrastructure and places of refuge during a utility power gird outage. As such resiliency is an important benefit that needs to be considered by the APS program.

We believe that the APS program should continue to prioritize technologies such as CHP that show a proven ability to reduce greenhouse gas emissions. We also recommend that the APS program full recognize that greenhouse gas reduction must include the ability to offset and reduce the marginal emissions produced by the utility grid.

The 2018 ISO New England Electric Generator Air Emissions Report states that the 2018 annual CO2 emission rate for emitting generators is 1,005 lbs/MWhr. A CHP system with standard efficiency emits between 700 – 750 lbs/MWhr, which is more than 25% less that the published grid CO2 emission rate.

The US EPA Fuel and Carbon Dioxide Emissions Savings Calculation Methodology for Combined Heat and Power Systems report dated February 2015 states "*Because the CHP capacity operates continuously (or near continuously), the load duration curve shifts downward. The additional CHP capacity displaces an equal amount of generation each hour that it runs, shifting the load curve down while it runs. The CHP system therefore displaces power from the last unit of generation that would have been dispatched in each of these hours. Generators with a lower dispatch order, such as nuclear, hydro, and certain renewables, are unaffected. These resources operate whenever they are available so are unaffected by changes in power demand that result from CHP additions.*"

It is clear that CHP is a valid carbon reduction strategy which should continue to be a prioritized technology in the APS program. As an additional point we strongly

recommend that the MA DOER prioritize American developed, manufactured, and maintained technologies.

We believe that reciprocating engine and combustion gas turbine based CHP is an important technology that is critical to many businesses and institutions in MA and needs to continue to be supported under the APS program. CHP provides energy resiliency and reliability, low energy costs, higher efficiency with incrementally low emissions. CHP will continue to be a very important element to maintain existing and attract new business to MA.

Your thoughtful review and consideration of our comments above is greatly appreciated. Should you require any further information, please contact the undersigned.

Very truly yours,

Solar Turbines Incorporated

Johnathan Coleman, P.Eng.
Principal Engineer and
Senior Account Manager Power Generation