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Alternative Natural Gas Applications Workshop:

Creating a Prosperous Demand Market

Stationary Power Gen Roundtable Discussion

October 9, 2014

NG as a Stationary Power Gen Fuel

1. What are the *current uses* for NG in Stationary Power and what are the current estimated sizes of these markets?
2. What are *potential areas for expansion* for NG in stationary power gen and what is the future potential of these new markets?
3. Who are the *current major players* and leads for NG stationary power gen applications?
4. What are the major *technical and regulatory barriers* or roadblocks that prevent growth of NG as a stationary power gen fuel?
5. What are the primary *technical gaps* inhibiting wider NG utilization and in what areas?
6. What is the magnitude or the *level of impact of the technology gaps*? i.e. How do they compare with other political, social or environmental barriers?
7. What *role should the Government play* in addressing potential technology gaps? (i.e. What role can the National Laboratories play in addressing the technical gaps?)
8. To *prioritize the efforts*, what are the top three technical gaps which need to be addressed first?

1. What are *potential areas for expansion* for NG in stationary energy generation and what is the future potential of these new markets?

For NG Turbines

- Improved efficiency for combined cycles as pointed out in the Tonko Bill
- The major variable in this is whether US government support of increased R&D funding materializes. If it doesn't happen, the share of the NGCC market filled by US-based manufacturers is projected to drop to 42% from 84% today by 2037 (Exhibit ES-1) and 36,000 fewer US jobs by 2035 (Exhibit ES-2).

For Fuel Cells

- Reliable and resilient distributed power generation is an emerging market where NG has the demonstrated advantage for use as clean fuel. Technologies such as SOFC can efficiently utilize NG in CHP and electricity generation in scales ranging from small commercial to large distributed generation (hundreds of kWe to MWe).

Cross-cutting Areas

- CHP
- Polygen, where products in addition to electric power are produced.
  Oxygen + Power
  CO_2 for Enhanced oil recovery + power
  H_2 + power + CO_2

2. Who are the *current major players* and leads for NG in stationary energy generation applications?

For NG Turbines:

- The major players in NGCCs are US-based manufacturers GE, Siemens and Alstom; and Japanese supplier Mitsubishi Heavy Industries (MHI). For smaller gas turbines (< 5-10 MW_{th}) which are often used in simple cycle or combined heat & power applications the major players are GE, Rolls-Royce, Solar Turbines (part of Caterpillar) and PW Power Systems (part of MHI).

For Fuel Cells:

- Bloom Energy, FuelCell Energy, LG Fuel Cell and GE Fuel Cells

CCS:

- Mitsubishi and Cansolv

Polygen suppliers

- Air Products; Praxair

3. What are the major *regulatory, or other barriers* or roadblocks that prevent growth of NG in stationary energy generation?

GHG Mitigation is an Uncertain factor -

- Current proposed regulations exempt NG generation, but if GHG mitigation goals are to be reached, eventually regulations will require mitigation from NG-fired sources. The interim period where NG is not subject to GHG regulations provides an ideal time for R&D targeted at reducing costs for carbon capture utilization and storage so that when regulations are put into place, industry will be ready to comply. The problem will only cost more if we wait to address; will not just go away.

Difficulty in connecting CHP to the Utility Grid

- High charges for back-up power; low prices for produced power

4. What are the major *technical barriers* or roadblocks that prevent growth of NG in stationary energy generation?

For NG Turbines:

- Major technical areas are combustion, heat transfer, materials – thermal barrier coatings). It's very much the overall efficiency goal that includes the 3 barriers.

For Fuel Cells:

- Technical gaps include (1) deployment of clean and efficient energy conversion system such as SOFC, (b) development and deployment of OTM, (c) reclamation of water used during NG extraction. Technology development areas include functional ceramics and membranes, catalysts, robust filtration processes.

For CCS:

- DOE is actively funding coal focused CCS R&D but should consider funding gas focused CCS R&D to overcome the differences in flue gas content. Demonstration would alleviate some of the risks associated with the technology.

5. What science or engineering research and development programs should be expanded to address these gaps?

For NG Turbines:

- The Tonko Bill would provide sufficient funding to enable US-based NGCCs of 64% to go on line by 2022 and 67% by 2027. It was introduced in November 2013 in the House. Bill will be reintroduced with next congress. $50M/yr for 7 years ($350M total). Does not fund a demonstration plan as could be too expensive for government input. This would support major component testing.

For Fuel Cells:

- Viable solution to extending the lifetime of fuel cells and reducing the materials and manufacturing costs

Cross-cutting R&D:

- Across the board integrated basic science programs to understand thermal barrier coatings and high temperature materials (these technologies are complimentary in nature so an integrated research is required)

For CCS:

- An R&D program to develop capture technologies specific to NG-fired systems is needed. This program should be focused on accelerating the development of technologies tailored to the unique characteristics of NG-derived flue gases such as lower CO_2 concentrations as well as lower contaminant concentrations.

6. What is the magnitude or the *level of impact of the technology gaps*? i.e., How do they compare with other political, social or environmental barriers?

For Gas Turbines

- the impact of the technology gaps are significant. As pointed out in Question #1, the gaps equate to the loss of 42 percent loss of market share of US-based manufacturers and 36,000 US jobs by 2035.

For Fuel Cells:

- Commercialization of the technology is currently in sync with the national focus on enhancing the manufacturing ability and increasing the employment

Energy-water nexus – need to show how NG utilization for stationary power gen impacts water utilization. The need to extend life-cycle analyses for NG utilization technologies is critical.

7. What *role should the Government (i.e., federal and state) play* in addressing potential technology or policy gaps? (i.e., What role can the National Laboratories play in addressing the technical gaps?)

For NG Turbines:
The National Energy Technology Laboratory (NETL) would be the major government player in the proposed Tonko Bill which would address this issue for Gas Turbines. Presumably NETL would manage the program, as they did for the quite successful Advanced Gas Turbine Systems Research (AGTSR) Program which ran from about 1992 to 2000 to demonstrate major components.

For Fuel Cells:

- Developing programs to attack the key technical problems associated with implementing the fuel cell technology in next generation systems; fund the R&D that is beyond near term vision (i.e., 5 years horizon) along with demonstration projects efficient and cost effective NG utilization for stationary applications, for example in polygen, to gain market confidence and acceptance and De-carbonized fuel demonstration projects

Public–private partnership under the guidance of federal/ state government ; university research and industrial participation at the R&D and demonstration level should be examined. National labs will play key role in developing big science and engineered systems development of accelerating the deployment.

8. To *prioritize the efforts*, what are the top three technical gaps which need to be addressed first?

Develop and demonstrate cost effective GHG reduction strategies related to NG Stationary Power Gen (all technologies gas turbines, fuel cells and CCS) with parallel targets for reduction over time. A goal could be to demonstrate a 20% improvement CAPEX and OPEX over current state of the art which will enable further investment.