HTAC Subcommittee Report on Competitiveness and Competition

Introduction

At the Hydrogen and Fuel Cell Technical Advisory Committee (HTAC) meeting in February 2018, Mr. Gary Flood presented to the Committee on his "Hydrogen and Fuel Cells Perspectives in China." During the ensuing discussion, several members expressed their concerns that the United States was at risk for losing some or all of its competitive leadership in the areas of hydrogen and fuel cells. This concern was evidenced by several economically and politically significant countries focusing national strategies and policies in these areas as a means to address domestic energy security and emissions issues. These countries have also committed to investing large amounts of capital to develop and implement hydrogen and fuel cell technologies. Moreover, some countries, such as China, were reported to have established goals to lead in these technologies, like they have in solar, batteries, and battery electric vehicle technologies. Because of the level of concern voiced by members, Chairman Freese formed a subcommittee, led by Mr. Harol Koyama, to conduct a high-level assessment of United States competitiveness in these areas and make recommendations for further studies.

More specifically, this subcommittee was tasked by the HTAC to evaluate the current competitive position of the United States in hydrogen and fuel cells, focused narrowly on polymer electrolyte membrane (PEM) fuel cells and related hydrogen fueling infrastructure, across multiple regions of the world, assess technology, investment and markets, and then make recommendations to the HTAC on potential options for U.S. Department of Energy (DOE) focus and actions with regard to funding, considering these regional capabilities and competitiveness and the increasing and ongoing developments in these international regions. While there are a range of fuel cell types and applications, this report focuses on low-temperature PEM, hydrogen generation, and infrastructure. The activity of this subcommittee was meant to build upon information and research resulting from the ***U.S. Clean Energy Hydrogen and Fuel Cell Technologies: A Competitiveness Analysis*** Document DE-EE-0006935, and other references as noted in this report.

1.0 Subcommittee members

Levi T. Thompson Ph.D., Harol Koyama, Morry Markowitz, Frank J. Novachek, Charlie Freese, John F. Mizroch, Kathy Ayers Ph.D., Gary Flood, Andy Marsh, and Henry Aszklar.

2.0 Conclusions

Based on patents, advanced research, system and component demonstrations, and commercial products, North America, Japan, and Europe currently hold significant technical leadership in core areas of PEM fuel cell stack, electrolyzer, and systems integration, with Europe holding a leading position in hydrogen fueling infrastructure technology. However, this could shift very quickly and may not be a reliable indicator of future, sustainable competitive advantage.

The fuel cell industry has undergone a very long period of heavy technology development and investment with steady but gradual commercialization. This slow growth but heavy investment has resulted in companies in need of cash and ready markets to continue to fuel their growth, keep investors motivated and involved, and in some cases, ensure their survival.

After many years of investment, the industry is in the critical period of transitioning from research and development and initial commercialization, to large-scale commercialization and related research and

investment in manufacturing. As stated by the Hydrogen Council 2017 report *Hydrogen scaling up: A sustainable pathway for the global energy transition*, it is "about scaling existing technologies and considering the beneficial linkages and virtuous cycles of deploying hydrogen technology across the energy system." What is at stake for the United States are the jobs and economic benefits of manufacturing the more than 400 million cars, 15 to 20 million trucks, and 5 million buses by 2050, as well as the supporting hydrogen infrastructure, envisioned by the Hydrogen Council study. It would be a tragedy for the United States to have made the early-stage investments in the industry only to see the bulk of the 30 million jobs and $2.5 trillion per year of revenues forecasted by the Hydrogen Council shift offshore to countries such as China.

China is a proverbial "elephant in the room," in that it is the only country with both the means and the motivation to pursue fuel cells and electrolysis at a top national level, and it is leveraging these capabilities to rapidly absorb the best technologies and commercial capabilities in the hydrogen and fuel cell industry.

China starts from a relatively rudimentary technical basis. However, while it has taken the rest of the world decades to develop the current technological base in fuel cells and hydrogen infrastructure, China, through its concerted efforts, could acquire or control the bulk of this know-how in a few years. Further, using its home markets, China can build the volume to drive manufacturing costs lower than any other country. Ballard Power Systems is an industry pioneer and has leading-edge fuel cell technology. The recent large-scale investment by Weichai and Broad-Ocean Motors in Ballard Power Systems (http://www.ballard.com/about-ballard/newsroom/news-releases/2018/08/29/ballard-signs-historic-strategic-collaboration-with-weichai-power-advancing-china-strategy) makes possible the wholesale transfer of Ballard's capabilities to China and eventual control of the company. While most visible, Ballard is not the only fuel cell company to have already taken advantage of Chinese investments into their companies.

The year 2020, months from now, represents an important convergence of events in Japan and China. Japanese car companies will be making production component decisions for their fuel cell electric vehicles (FCEVs), catalyzed by the 2020 Tokyo Olympics. Meanwhile, China will be concluding their 13th Five Year Plan mandating thousands of FCEVs, and initiating their 14th Five Year Plan, which will likely include a massive increase in FCEVs.

The countries that developed the bulk of this technology are at an inflection point. They can either take urgent action to moderate this process and secure long-term competitive advantage or allow it to follow a similar path to that of the photovoltaic and lithium ion battery industries. The subcommittee recommends specific focus on the fiscal year (FY) 2019 and FY 2020 budgets of DOE's Fuel Cell Technologies Office (FCTO) to emphasize addressing the competitive threat.

3.0 Recommendations regarding options for DOE to address the threat to U.S. competitiveness

3.1 DOE to launch an effort to identify the top handful of large-scale commercialization demonstration and deployment initiatives, comparable in scale to the most significant offshore deployment initiatives, which will lead to significant investment in manufacturing and job creation in the United States. This study should focus on the already identified leading hydrogen and fuel cell applications including hydrogen for industrial use and fueling infrastructure for FCEVs, FCEV transit buses, FCEV material handling, and commercial-scale cell stack and membrane electrode assembly (MEA) production. The study should clearly identify what is required to (a) elevate the focused segment to a sustainable commercial level and (b) attract the type of investments to build and retain U.S. technology and manufacturing know-how onshore in support of target market segments.

3.2 DOE to determine what "tools" or approaches are available to the U.S. government, states, and public-private organizations to provide financial incentives and market stimulus to encourage investments in domestic large-scale manufacturing of fuel cell/electrolyzer stacks and MEAs for both domestic and export markets. As part of this analysis, DOE should consider the evolution and experiences of similar technologies such as solar photovoltaic, wind, and battery that were developed principally in the United States and Europe, only to eventually be manufactured in large scale in China.

3.3 DOE to conduct an initial competitiveness review and assessment to include progress on commercial demonstration and deployment initiatives; the development of intellectual property as well as the movement and transfer of intellectual property and manufacturing capacity; and the level of commercial and government investment rate to measure the effectiveness of this initiative. The initial review would recommend ongoing metrics and "dashboard" assessment and recommendations for frequency and involvement of other agencies and stakeholders.

3.4 Codes and standards are recognized as an important part of ensuring a level competitive playing field, especially in a developing industry. DOE should play an active role to ensure that appropriate international codes and standards are developed to avoid jeopardizing domestic manufacturers and to foster a global market and robust supply chain.

3.5 FCTO should restore the *Fuel Cell Technologies Market Report*, an annual status report that provides a comprehensive snapshot of activity is imperative to reinforce the status, relevance, and benefits of the fuel cell and hydrogen industry in the U.S. and around the world. The Fuel Cell Technologies Market Report, last issued in 2016, detailed trends in the United States and international fuel cell and hydrogen technologies market and highlighted continued growth in fuel cell commercial deployments in all applications and sectors. The report also provided detailed overviews and analysis of military funding/projects, DOE funding, patents, venture capital investments, sales, and shipments.

4.0 Fuel cell industry activities and references

4.1 http://www.hydrogenics.com/2017/04/28/hydrogenics-announces-us21-million-private-placement/

4.2 https://www.prnewswire.com/news-releases/china-leads-electric-vehicle-market-bev-phev-2020-forecasts-say-new-research-reports-592318931.html

4.3 http://kraneshares.com/resources/2013_10_kfyp_fan_gang_white_paper.pdf

4.4 http://ballard.com/about-ballard/newsroom/news-releases/2016/07/26/ballard-announces-strategic-collaboration-and-equity-investment-deal-with-broad-ocean

4.5 http://www.kwm.com/en/uk/knowledge/insights/china-13th-5-year-plan-key-points-summary-new-normal-innovation-20160414

4.6 http://www.chfca.ca/resources/chfca-blog/canadian-fuel-cell-sector-on-fire

4.7 PowerCell Sweden AB (publ) has received yet another order from a Chinese customer who will test the PowerCell S2 in commercial vehicles. The order value amounts to MSEK 2.3.

4.8 US Hybrid Announces China Fuel Cell Joint Venture and Unveils Class 8 Fuel Cell Port Drayage Truck for San Pedro Ports. http://ushybrid.com/us-hybrid-announces-china-fuel-cell-joint-venture-and-unveils-class-8-fuel-cell-port-drayage-truck-for-san-pedro-ports/

4.9 AFCC Vancouver to close operations in June 2018.

4.10 Standardization of PEM Fuel Cell Balance of Plant Components Report 7-23-2018.

4.11 Carmo M, Fritz DL, Mergel J, Stolten D. 2013. A comprehensive review on PEM water electrolysis. Int. J. Hydrog. Energy 38 (12): 4901–34.

4.12 Babic U, Suermann M, Büchi FN, Gubler L, Schmidt TJ. 2017. Critical Review—Identifying Critical Gaps for Polymer Electrolyte Water Electrolysis Development. J. Electrochem. Soc. 164 (4): F387–99.