DOCKETED	
Docket Number:	21-ESR-01
Project Title:	Energy System Reliability
TN #:	247760
Document Title:	Bosch LLC - Response to CEC's Request for Information Clean Energy Resources for Reliability
Description:	N/A
Filer:	System
Organization:	BOSCH
Submitter Role:	Public
Submission Date:	11/29/2022 7:22:38 AM
Docketed Date:	11/29/2022

Comment Received From: Martin
Submitted On: 11/29/2022
Docket Number: 21-ESR-01

Robert Bosch LLC - Response to CECâ€™s Request for Information Clean Energy Resources for Reliability

Additional submitted attachment is included below.

BOSCH

November 29, 2022

Robert Bosch LLC
38000 Hills Tech Dr.
Farmington Hills, MI 48331
Visitor:
28875 Cabot Dr.
Novi
MI 48377
www.bosch.us

California Energy Commission
715 P Street
Sacramento, California 95814

Robert Bosch LLC
38000 Hills Tech Drive
Farmington Hills, MI 48331
Attn: Martin Hering, PS/PJ-SOFC-NA
Tel +1 248 876-6084
Martin.Hering2@us.bosch.com

Response to California Energy Commission's Request for Information Clean Energy Resources for Reliability – Docket # 21-ESR-01

To whom it may concern,

Robert Bosch LLC appreciates the opportunity to provide responses to the Request for Information Clean Energy Resources for Reliability – Docket # 21-ESR-01. Please see our feedback attached to this letter.

Yours sincerely

Martin Hering

Martin Hering – Technical Business Development Manager

Bosch Group Overview

The Bosch Group is a leading global supplier of technology and services. It employs roughly 402,000 associates worldwide (as of December 31, 2021). The company generated sales of 78.7 billion euro in 2021. Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods and Energy and Building Technology.

As a leading IoT company, Bosch offers innovative solutions for smart homes, Industry 4.0, and connected mobility. Bosch is pursuing a vision of mobility that is sustainable, safe, and exciting. It uses its expertise in sensor technology, software, and services, as well as its own IoT cloud, to offer its customers connected, cross-domain solutions from a single source.

The Bosch Group's strategic objective is to facilitate connected living with products and solutions that either contain artificial intelligence (AI) or have been developed or manufactured with its help. Bosch improves quality of life worldwide with products and services that are innovative and spark enthusiasm. In short, Bosch creates technology that is "Invented for life."

The Bosch Group comprises Robert Bosch GmbH and its roughly 440 subsidiary and regional companies in some 60 countries. Including sales and service partners, Bosch's global manufacturing, engineering and sales network covers nearly every country in the world. With its more than 400 locations worldwide, the Bosch Group has been carbon neutral since the first quarter of 2020. The basis for the company's future growth is its innovative strength.

Having established a regional presence in 1906 in North America, Bosch employs nearly 35,500 associates in more than 100 locations with consolidated sales of $13.5 billion in 2021.

List of Resource types and Evaluation Attributes

1) Are the categories (indicated in Tables 1, 2 and 3) appropriately representing how the CEC should be evaluating resources?

   The CEC may want to consider adding front-of-meter and behind-the-meter (BTM) language to provide additional clarity in the classification of Table 1 and Table 3 (for resource types and categories).

2) Are there resources that should be added to or removed from the preliminary list under each of the categories (shown in Tables 1, 2, and 3)?

   Large-scale multi-MW fuel cell solutions should be included in Table 1. Both low and high temperature fuel cell solutions can fill a role in the front-of-meter utility market. Many stationary fuel cell providers have already proven the applicability of the technology in this space, for example in the Korean market. Even smaller scale modular fuel cell systems with sub 100 kW in output, can be clustered to become valuable front-of-meter assets in the future.

3) Are there other attributes that should be considered, in addition to the ones listed in Table 4? If so, should those be considered for the qualitative and/or quantitative evaluation?

   Space limitations / space usage should be considered as it impacts project siting and land usage constraints. Additionally, noise emissions could be considered as another distinctive criteria or as a part of the "Cleanliness Definition". Both space usage and noise can be evaluated during the qualitative and quantitative study.

4) How should the attributes be weighted relative to each other? Should some attributes be weighted more than others?

5) What data/information sources can help inform characterization and evaluation (both qualitative and quantitative) of the different resources?

   - *Technology / solution / manufacturer data sheets and brochures and / or published operational information.*
   - *Interviews with Manufacturers and subject matter experts on current and future technology portfolios.*
   - *Conversations with / outreach to relevant trade associations (including potential data compilation through their member outreach capabilities).*
   - *Academic / national lab support with preexisting expertise in this segment (e.g. to collect / compile technology portfolio overviews and future application potentials).*

Resource Characterization

1) Please provide a general overview of the resource, including the following:
    a. Resource category (e.g., supply, demand) and type (e.g., solar) and scale (e.g., utility, distributed)?
        - *Resource Category: Supply / Demand,*
        - *Type: Modular stationary high temperature solid oxide fuel cell (SOFC)*
        - *Scale: 10's of kWs to 100's of kWs (modular design, which can be clustered)*
        - *Application: Mainly distributed generation and microgrids (behind-the-meter), solution is scalable to benefit utility (front-of-meter) segment.*

Since 2019, Bosch has been establishing a pre-commercial manufacturing and assembly line for small-scale 10 kW class SOFC systems in Germany. Bosch manufactures individual cells based on Ceres Power SteelCell® technology and assembles them into 5kW-class stacks. Within the final manufacturing step, the stacks and multiple assembly groups from the mechanical, electrical, and thermodynamic system are merged to ultimately form the 10 kW class unit.
The design achieves outstanding electric efficiencies of around 60% (Lower-heating-value-based) at a small-scale power output of around 10 kW packed tightly into a dense industrial design (~6x2x5 ft.). The solution also offers power modulation capabilities to flexibly change its output to enable load following and demand response capabilities. The SOFC units can be operated with desulfurized natural gas or a hydrogen - natural gas blended mixture (with up to 20% hydrogen contents); commercial units will be able to run on pure hydrogen in the future (development objective). Additionally, the technology has near-zero emissions of criteria pollutants, particulates, and noise. The SOFC units can also be used as a combined-heat-and-power (CHP) application by integrating an exhaust gas heat exchanger boosting the overall efficiency beyond 85%.
The small-scale 10 kW class modular SOFC unit design offers a high integration flexibility. The systems can be deployed separately or clustered to deliver a highly resilient Distributed Energy Resource with several hundred kW capacity. The modular units or clusters are integrated into microgrids to provide resilient, scalable, and clean power (alongside other DERs such as solar and

batteries). Multiple SOFC-based microgrids can also be aggregated to form a virtual power plant.

2) How does the resource compare to conventional generation in terms of greenhouse gas and priority pollutant emissions?

SOFC technology has near-zero emissions of criteria pollutants and particulates. Compliance with California Air Resource Board's Distributed Generation Certification Program's emissions limits (NOx < 0.07 lb/MWh, CO < 0.10 lb/MWh and VOCs < 0.02 lb/MWh) is anticipated. Additionally, the SOFC solution achieves lower emissions of CO2 compared to conventional natural gas based technologies due to its significantly higher electric efficiencies. For example, an SOFC with a net electric efficiency of 60% will achieve a 50% CO2 emission reduction compared to a gas engine based technology with a 30% net electric efficiency. Clean hydrogen blending or utilizing a pure clean hydrogen feedstock will reduce CO2 emissions towards zero.

3) How does the resource support reliability (e.g., supply, permanent load reduction, net peak reduction, or emergency asset?) (List all that apply.)

SOFC solution mainly provides behind-the-meter demand side / permanent load / peak reductions. Additionally, a cluster or clusters of small-scale distributed SOFC assets could also provide a supply response due to their ability to adjust their power output, potentially even beyond their nominal 100% capacity point to provide additional ancillary grid support (and complement intermittent renewable generation). Stationary SOFC based microgrid solutions (for example integrated with solar and battery storage behind-the-meter) with islanding capabilities can also provide an additional demand side response by island entire facilities from the grid while continuing to provide reliable power to the facility.

a. How can the resource be used as an incremental on-call resource during emergencies?

Positive load response - maximize fuel cell output or "power-boost" fuel cells (operate beyond maximum load for limited period of time for example 5% or 10% above nominal 100% capacity power output) to provide grid support / ancillary services.

Negative load response - ramp down fuel cells to minimum load or move fuel cells to standby or in microgrid setup island entire demand side / facility from utility grid.

4) How many new MWs and MWhs can the resource provide per year, taking into account resource characteristics and known barriers between now and 2035?

Solution is able to provide firm power 24/7/364 running on natural gas, natural gas / hydrogen blends (or pure H2 in the future). Therefore, assuming a net output power of 10 kW per modular SOFC system, up to 87.6 MWh of electricity can be provided per system. Bosch is investing around $500 million into establishing mass scale production of this solution with initial target scales for commercial volumes around 200 MW/a. The global market introduction is in progress with anticipated market entries in the mid-2020s. Towards 2035, commercial annual output volumes can be significantly increased based upon region & global market demands.

a. How is that different if used incrementally as an emergency asset during an extreme heat event?

Technology outputs are not affected by extreme heat as long as connected gas infrastructure / or storage remain in operation. Small-scale SOFC technology can be deployed incrementally due to its modular design. Even an already deployed microgrid can add capacity later, enabling scalability and reliability on smaller (behind-the-meter) scales.

5) What is the levelized cost for the resource in $/MW-yr. and $/MWh-yr. from 2023 to 2035?

The levelized cost of electricity of a stationary SOFC system depends on a multitude of variables and factors such as capital expenditures (or cost of capital / financing over lifetime), time-based operating expenses (such as fuel & service cost), available incentives / subsidies, type of deployment (such as combined heat and power versus electric only) and other financial factors (such as internal rate of return considerations). Therefore, rather than providing a generalized figure or a range, Bosch asks the CEC to consider providing / defining various applicable techno-economic scenario constraints (input values) to allow a technology comparison on a defined playing field.

6) What is the average length of time from ordering or purchasing the resource to operation? How long does that typically take in today's market? What conditions must be met to deploy the technology rapidly? (e.g., transmission interconnection, building electrification or upgrades, etc.)

7) For an emerging technology, when will it be ready for deployment, and at what scale?

Bosch has initialized the industrialization of the small-scale fuel cell technology. Currently, a pre-commercial field evaluation is ongoing in Europe, where Bosch has deployed around 60 units in the field to date. Initial target scales for commercial volumes are around 200 MW/a. The global market introduction is in progress with anticipated market entries in the mid-2020s.

8) Is the target customer primarily residential, commercial, agricultural or industrial?

Customers for smaller-scale modular fuel cells are mainly commercial and light industrial in the scope of 10's to 100's of kW. However, "larger" residential customers such as multifamily dwellings or communities can also benefit from the solution. Small-scale modular fuel cells offer a modular and dispatchable solution covering a wide range of the behind-the-meter market while offering a novel take on end-user / facility resiliency.

9) What are the key non-financial barriers to the development and implementation of this resource (including, but not limited to, permitting, interconnection, supply chain, customer acceptance, and alignment with policy goals)?

Long lead times of interconnection permitting is a key barrier to deployment, even for small behind-the-meter assets / microgrids. Additionally, the availability of skilled labor / expertise to design, plan, execute, build, and service a fuel cell based microgrid is limited. From the deployment component angle, the availability of "of-the-shelf" auxiliary components (such as matching bi-directional inverter technology at various output sizes) is currently limited to specialty equipment / solutions.

10) What are the key financial barriers to the development and implementation of this resource?

11) What types of benefits or impacts is the resource anticipated to have on low income and disadvantaged communities, and tribes, if any in terms of development and deployment?

Decentralized modular small-scale SOFC technology can support the quality of life, especially regarding air quality (reduction / elimination of critical pollutants) and energy resiliency in dense urban developments. Novel non-capex-based business models will allow low income & underserved communities to actively participate in the clean technology spectrum by enabling community sourced pay per use models. Decentralized deployed technologies will also bring local / regional job opportunities in the service and maintenance space to communities.

Tribes can especially benefit from decentralized generation of heat and power, and even hydrogen generation, due to their capabilities *to form their own utilities / co-ops. Some of their communities suffer from limited grid capacities, high electricity cost and frequent grid outages which could be overcome by creating a local / tribal microgrid hub with stationary fuel cells providing firm power. Again, novel non-capex-based business models can allow these communities to utilize the benefits of clean generation and storage without extensive upfront capital investments / commitments.*

Input on Distributed Electricity Backup Assets Program Design

1) What size of resource and what types of customers should the program target?

   See answer #3 and #8 in Resource Characterization Section above (focusing on commercial and light industrial space). Objective should include to safeguard / provide resiliency as close to the end-user as possible with distributed / island-able microgrids. Additionally, the Program should be designed to enable utilities to safeguard on community level with substation type microgrids to allow disadvantaged communities to benefit from this program (for example through community type microgrids allowing an entire sub-station level to island in case of a grid event).

2) What types of incentive structures and amounts are needed to accelerate the development and deployment of this resource?

   Upfront $/kW capital expense reduction incentives to overcome initial investment barriers for end-user or investors. These types of incentives will also drive the application of energy-as-a-service / pay per use models, especially to enable participation / access for low-income & disadvantages communities.

3) What types of conditionalities and measurement and verification requirements should the program include to ensure funded resources participate and deliver during emergency events?

   As an on-call resource, technologies should be equipped with state-of-the-art interconnectivity features, reporting availability status and capacities in a continuous manner. In case technologies / solutions are failing to respond to an emergency call (with the agreed upon response and corresponding reported availability status and capacity), operational penalties and / or incentive restrictions should be applied.

4) In general, please provide any specific proposal or recommendation on the design and implementation of the DEBA program.