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Maltaâ€™s Comments on CECâ€™s Grid Modernization Research Concepts

Additional submitted attachment is included below.

August 25, 2023

Agency: California Energy Commission (CEC)
Docket No.: 23-ERDD-01
Subject: Grid Modernization Research Concepts
Email: docket@energy.ca.gov

Re: Malta's comments on CEC's Grid Modernization Research Concepts in response to CEC Grid Modernization Research Scoping Workshop

Dear California Energy Commission (CEC) staff and leaders,

Malta, Inc. (Malta) appreciates the opportunity to submit these comments following the Grid Modernization Research Scoping Workshop held on July 21, 2023. In these comments, Malta provides our recommendations on how to maximize and target this research initiative in ways to address various grid services that are currently provided by traditional synchronous generation and pose grid stability challenges as more inverter-based and intermittent resources come online and replace these synchronous resources. Specifically, these include services such as synchronous inertia, voltage regulation, black start, and multi-day generation and storage, among others.

Formed in August 2018, Malta is a privately held company that was spun out from X (Alphabet's "moonshot factory", formerly known as Google X) and that offers a long-duration pumped heat energy storage (PHES) system, providing energy storage capacity from 8 hours to 8 days. Malta's PHES system consists of commercially-available and proven technologies and equipment, with the innovation coming from the integration of these components. Malta's PHES technology combines and integrates various technologies commercially available today with a high degree of maturity from the power plant as well as the oil and gas industry and integrates them into a new high temperature heat pump storage system. Importantly, Malta's PHES systems represent one of the few synchronous long-duration energy storage (LDES) technologies commercially available today. By deploying synchronous LDES, system owners can replace the grid services lost with fossil-fueled generation retirements and ensure a stable, reliable, and resilient grid as the penetration of variable renewable energy increases both in the near and long term.

I. <u>INTRODUCTION & SUMMARY</u>.

Malta was pleased to see the various grid modernization research funding concepts included in the CEC's 2021-2025 Electric Program Investment Charge (EPIC) 4 Investment Plan. The CEC, along with the many expert presenters at the workshop, underscored the current and future challenges of ensuring a reliable grid with the increasing penetration of inverter-based resources (IBRs) and intermittent renewables. Malta agrees with the attention paid to the issues around maintaining grid stability, particularly as California is already advanced in its renewable and battery storage penetration and have aggressive and deep decarbonization goals in the long term, pursuant to Senate Bill (SB) 100.

As the California Independent System Operator (CAISO) presented, the operational challenges are only growing with increased penetrations of intermittent renewables and inverter-based resources (IBRs). The three-hour net load ramps and 10-minute variability is only expected to increase, and during spring months, the inability to commit enough gas units on governor controls make it challenging to meet primary frequency response (PFR) obligations.[1] Further, forecasting solar and wind on rainy and cloudy days has also proved challenging.[2] To these ends, the CAISO recommends better utilization of IBR resources, including battery storage, to provide essential grid services, such as voltage control, frequency response, and active power management, potentially through requiring sufficient headroom and posed the question of how to incentivize IBRs to provide essential grid services.[3] Similarly, the National Renewable Energy Laboratory (NREL) presented on the need for grid-forming (GFM) inverters, pointing to the case study of South Australia already operating at 100% IBR penetration. NREL discussed the various benefits of GFM IBRs and shared how the UNIFI Consortium is working toward a standardized set of specifications for GFM IBRs.[4]

However, Malta has some concerns about the overemphasis on IBRs and GFM inverters to serve many of the functions provided today by synchronous generation in a high-IBR future. Further research is needed on whether "mimicking" synchronous machines will provide the same benefits as synchronous generation and storage resources. Malta also respectfully challenges the assumption that the grid of the future will inherently (need to) be inverter-centric. Underpinning this assumption is that only fossil assets provide inertia, when in fact, modern, deployable, inertia-providing LDES like Malta can be deployed to integrate renewables and, in the process, prevent the grid from becoming so inverter-centric that grid stability suffers. It is not clear that there is a consensus on this inverter-centric pathway, including but not limited to questions around:

- The proportion of collective GFM IBRs required to provide synthetic inertia and operate as virtual synchronous machines
- The effectiveness of grid formation capabilities when IBRs operate at or near their maximum current and power limits, especially as most IBRs are intermittent or energy limited
- The physical changes required of GFM inverters and associated costs
- The incremental costs associated with GFM inverters versus grid-following (GFL) inverters or sufficient headroom requirements for non-GFM IBRs
- The impact of any time lag, even in milliseconds, in detection of grid anomalies and providing the support impact grid stability
- Whether GFM inverters have proven its ability to fix frequency issues in real-world grid failure scenarios without synchronous machines present
- The ability of GFM inverters to provide reactive power regulation at every generation point like synchronous machines, not just at P = PMax

[1] "EPIC 4 Grid Modernization Research Scoping Workshop," CAISO presentation on July 21, 2023 at Slide 4.
[2] *Ibid* at Slides 7 and 9.
[3] *Ibid* at Slides 8 and 10.
[4] "The Need for Grid-forming (GFM) Inverters in Future Power Systems," NREL presentation on July 21, 2023 at Slides 3 and 6-7.

- How state-of-charge dependent GFM batteries reliably respond and perform to consecutive grid-stability events
- Whether GFM inverters better represent a complementary solution to some minimum amount of rotational inertia

The very purpose of an EPIC research initiative is to investigate these technical and economic questions, but the CEC should avoid a narrow focus of the research and demonstrations funded through the EPIC Program on this one IBR-centric pathway, where clean non-IBR alternatives exist, including from synchronous turbomachinery used in thermal energy storage systems, synchronous condensers with flywheels, supercapacitors, and small modular nuclear, to name a few. From a portfolio-wide perspective as the state builds new resources to meet SB 100 goals, notwithstanding the outstanding technical questions above, there would be significant inefficiencies in either: (1) requiring all IBRs to have a minimum amount of headroom to serve the reliability functions currently provided by synchronous generation; or (2) requiring all IBRs to have GFM inverters. Considering the vast majority of lithium-ion battery storage resources are four hours in duration, it would further constrain their already limited duration, reducing their value to provide daily capacity and energy shifting and perhaps leading to oversizing of short-duration batteries or overbuilding the lithium-ion battery portfolio – all imposing significant costs to California ratepayers. Meanwhile, the addition of GFM inverters to all IBRs would also impose significant costs across the board for the clean generation and storage capacity representing a sizable portion of the future grid mix.

Rather, Malta recommends that the CEC ensure that the research initiative is broadened to assess a wide range of solutions, including their relative technical capabilities as well as the economic costs of pursuing each path, thus **identifying the most cost-effective portfolio of resources to collectively address these grid-service needs** (*e.g.*, inertia, black start, voltage regulation), as well as in identifying optimal capacity expansion decisions. This could be achieved by assessing the various technologies and their relative effectiveness of delivering the full range of grid services, as well as their relative cost competitiveness in doing so.

In addition to these grid services provided by currently operational synchronous generation, the CEC research scope should seek to **understand the solutions that can also address the multi-day reliability needs**, as mentioned by the CAISO in its presentation. Though not a grid service provided by the synchronous nature of traditional generation resources, it is another operational need tied to the challenges of solving for grid stability in a high-IBR future. These multi-day events of low solar and wind production will have pronounced effects on grid stability with their increasing penetration, not only for expected variability (*i.e.*, regular rainy and cloudy days), but also for extreme events such as wildfire smoke that impacts, for example, solar irradiation.[5] As part of broader efforts to identify the technologies and resource types that can provide the desired attributes, the ability to provide this resiliency in a high-IBR future as part of the "value stack" should be identified, understood, and valued. Rather than a patchwork of solutions, the state should be

[5] Cai, Mengmeng, Chin-An Lin, Vikram Ravi, Yimin Zhang, Sarah Lu, and Manajit Sengupta. 2023. *Final Technical Report: Impact of Wildfires on Solar Generation, Reserves, and Energy Prices*. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5D00-86640. https://www.nrel.gov/docs/fy23osti/86640.pdf.

optimizing resource investments to ensure all-in-one solutions are appropriately valued and procured.

Finally, Malta encourages the CEC to focus this initiative on **how we can put a value on these various grid-service attributes** to accommodate a high-IBR future. While focused on IBRs, the CAISO asked the essential question of how to *incentivize* the provision of these services, which are overlooked in current capacity planning models. One way to solve these issues would be to set mandatory requirements for the provision of all these grid services, but as discussed above, such a solution would likely impose significant resource buildout costs and represent a highly inefficient and imprecise approach that imposes costs on all resources instead of incentivizing best-fit new-resource build and compensating the best-capable resources to do so. However, in order to do so, a value needs to be put on the provision of these grid services traditionally provided by synchronous generation for "free" and by the inherent nature of rotating turbomachinery. By establishing a value on these grid-service attributes, the CEC would inform procurement of resources with these attributes, valuing these quantified "benefits" in cost-effectiveness assessments in the regulatory review and approval of long-term offtake contracts. Alternatively, or in combination, the valuation of these attributes could inform the development of market products administered by the CAISO, which similarly value resource types that can provide grid services that are priced in forward or real-time organized wholesale markets.

II. RESPONSES TO CEC WORKSHOP QUESTIONS.

In addition to our comments above, Malta offers the following responses to guide the scoping of the CEC's forthcoming grant funding opportunity (GFO).

1. **What specific research gaps or technology advancements should be prioritized to enhance grid reliability, resiliency, and flexibility to meet SB100 goals?**

   In Malta's view, the most significant research gap is around determining the value of the various grid services previously provided by traditional synchronous generation (*e.g.*, gas, coal) in a high-IBR future. Given the fact that these attributes were inherent in nature to these synchronous generation resources, they were never quantified and has thus been taken for granted. Assessing and establishing this value will be the most profound and impactful result of this initiative because it will guide resource procurement or technology deployment decisions and do the very thing that the CAISO asked: "how do we incentivize the provision of these grid services?"

   To illustrate, there may be multiple ways or approaches to ascertain this value, such as the following, but in each case, the first step is establishing the baseline and forward-looking amount of need for these attributes, both in terms of quantity but also in terms of locational specificity:

   - **Setting minimum forward procurement requirements for various attributes:** While not upfront setting a value, it would allow the value to be realized through the sourcing of this attribute via solicitations, auctions, etc. Similar to how capacity is valued today based on the cost competitiveness of different resources to meet outstanding Resource Adequacy (RA) requirements and provide daily availability through its must-offer obligations and deliveries to the CAISO market, the value of a certain attribute (*e.g.*, inertia) would be realized based on the competing and winning bids to meet some minimum procurement quantities. However, this approach would need to be cautious to ensure differentiation of the *quality* of the provision of a particular grid service, in addition to being sure that it precludes fossil-based synchronous generation that run counter to the SB 100 goals. Another challenge with this approach would be the siloed procurement of this attribute, posing barriers to value stacking as compared to a single solicitation that would assess the full range of benefits and costs in making procurement decisions.

- **Establishing forward market products for various attributes:** Valuation of a CAISO market product could also be set in clearing market mechanisms, such as those already run by CAISO for energy, regulation, and spinning/non-spinning reserves. In many ways, the development of market products would follow the same path as setting minimum forward procurement requirements since the amount and location of need must be first determined in order for the CAISO to make a market run and solicit day-ahead or real-time bids for the provision of any particular grid service (*e.g.*, 6% of CAISO load in setting required contingency reserves) in combination with others (*e.g.*, energy, ancillary services). On the one hand, operational wholesale market products would in itself be difficult to drive resource procurement decisions alone, but it would make transparent the market-clearing price and thus imply a market value that can be used in bilateral solicitations (*i.e.*, similar to how current and forecasted energy arbitrage and ancillary service values are incorporated into net present value and resource procurement decisions). In this way, this approach may be superior to just setting minimum forward procurement requirements, where the price discovery would only occur bilaterally and suffer some of the same challenges of the RA market in California.
- **Determining an avoided cost value based on some benchmark:** At minimum, a more readily available approach could be to identify a cost benchmark for the provision of a grid service (*e.g.*, inertia provided by a synchronous condenser) that could be avoided and delivered by a generation or storage resource, or infrastructure solution, as part of its value stack. This is similar to how resiliency is sometimes valued based on the avoided cost and emissions of diesel backup generators as the default solution for most customers. On the other hand, establishing the appropriate cost benchmark or "solution to beat" will be challenging and potentially controversial.
- **Determining an avoided cost value based on an optimal portfolio:** In some cases, certain grid services could be valued by looking at an extreme scenario, such as an SB 100 scenario with little or no synchronous generation and another portfolio that optimizes the grid mix for the desired attributes

(*e.g.*, inertia). The difference in these two portfolio costs could determine the value of the specific attribute. This approach, for example, is currently being used by the CPUC to determine the avoided costs of distributed energy resources (DERs) by assessing a "No New DER" scenario and comparing it to one that incorporates DERs. However, current capacity expansion modeling tools are likely incapable of modeling these two scenarios since today's models more simply optimize for capacity and energy investment decisions based on various constraints (*e.g.*, minimum operating reserves, greenhouse gas emissions limit) rather than optimizing for grid services, such as inertia. Many of these grid services may also require power flow modeling, not just capacity expansion or production cost modeling. Unless new tools emerge or novel modeling approaches are identified, this method may pose the most difficult and complex.

Malta does not currently have a view on the best method to quantify these values, as we are still researching this issue ourselves, but the above represents some preliminary thinking undertaken internally. The above is also not intended to be an exhaustive or necessarily the right solution, as there may be other superior methods. Nonetheless, in illustrating some example methods, Malta hoped to kickstart the CEC's thinking on how this research initiative and the results produced could be transformative to more holistically addressing the fundamental challenges of a high-IBR grid, in contrast to the current approach of focusing on a narrow set of technologies. The CEC would also be answering the CAISO's key question of how to incentivize the provision of these necessary and desired services.

2. **What target metrics can be used to assess the efficacy of grid modernization technologies in mitigating grid congestion, ensuring system reliability, and enhancing operational flexibility?**

Among various target metrics, Malta recommends that the CEC study the need for short-circuit current (SCC), using short circuit current ratio (SCR) or weighted short circuit ratio (WSCR) as the metrics to assess the local stability of the grid. Inverters are current limiters devices by definition (*i.e.*, power electronics) and thus can provide only its rated current as SCC, whereas synchronous machines can provide five or six times its rated current. While not raised in the CAISO's presentation, SCR is an important metric for grid reliability and stability since IBRs need a minimum value of SCR to work properly on the grid and avoid sub-transient resonance in their control systems. Most of the HVDC systems in operation today are based on line-commutated converters (LCC), which also need a minimum level of short circuit for the correct operation of the valves. In short, all electric grids need a minimum value of SCC to assure their stable operations and avoid blackout situations when there are insufficient frequency containment reserves (FCRs).

In addition, Malta recommends that the CEC assess "critical inertia" levels at which a system can be reliably operated with current frequency control practices, a benchmark that ERCOT has recently defined and begun to measure.[6] This represents a critical first step in later defining requirements and/or market products, with a focus on resource types that can meet these needs while representing clean and flexible resources that advance the state's decarbonization goals (*i.e.*, not representing a reason to unnecessarily prolong the lifespan of fossil assets). It will also be important to assess these needs across the hours of the day, where solar and/or wind output may be high and low load leads to low economic prices and economic unavailability of synchronous generation, thus reducing the system inertia at these times of the day. Synchronous LDES would offer value in these instances since they would be economically available during these low net load periods.

The assessment of critical inertia levels should also study the minimum of mechanical inertia (*i.e.*, minimum synchronous must-run) needed on a location-specific basis, especially when considering how conventional power plants today are located near customer load centers. With IBRs increasingly located remotely and away from customer load centers, Malta understands that many grid operators are deploying synchronous condensers at specific "weak" grid nodes.

3. **Are there developed technologies or lessons learned and best practices from other regions including internationally that could be applied to grid modernization efforts in California?**

The existing approach to rotational inertia has been to put short-term operational or procurement limits in place. The Irish system operator, EirGrid, has set a System Non-Synchronous Penetration (SNSP) limit at up to 70%.[7] The Electric Reliability Council of Texas (ERCOT) has defined a critical inertia value and will call in additional reserve capacity if this value is violated. These operational approaches, however, are reactionary rather than proactive. To our knowledge, only Britain has been proactive in addressing rotational inertia. In January 2020, UK's National Grid ESO announced a "world-first approach to inertia", allowing entities to provide rotational without having to provide power, and spending £328MM to procure 12.5 GW·s of dedicated rotational inertia.[8]

By creating market structures to allow load-serving entities (LSEs) and system operators to competitively and proactively procure rotational inertia in conjunction with their forward power capacity requirements, the CEC could advance the de-coupling of rotational inertia from carbon-emitting capacity and would prevent rotational inertia from becoming a bottleneck to achieving 100% zero-carbon electricity. In this research initiative, the CEC should examine the potential value of

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[6] *Inertia: Basic Concepts and Impacts on the ERCOT Grid* (2018) at 10 and 12-13. https://www.ercot.com/files/docs/2018/04/04/Inertia_Basic_Concepts_Impacts_On_ERCOT_v0.pdf

[7] "EirGrid hits 70% variable renewable electricity instantaneous target," EirGrid Group, 22 January 2021. https://www.eirgridgroup.com/newsroom/70-snsp-trial/

[8] A. Grundy, "National Grid ESO claims world first approach to inertia, awarding £328m in contracts," Current News, January 2020. https://www.current-news.co.uk/news/national-grid-eso-claims-world-first-approach-to-inertia-awarding-328m-in-contracts

a coupled procurement of capacity and rotational inertia attributes and assess the relative value of various resource mixes based on technical limitations of energy production and rotational inertia. Such a study would be similar to the way markets for Fast Frequency Response have been proposed by others.[9]

4. **What collaboration opportunities exist between stakeholders, utilities, technology providers, research institutions, and government agencies to accelerate grid modernization research and implementation?**

Malta is broadly supportive of collaboration across stakeholders, utilities, technology providers, research institutions, and government agencies. Cross-cutting collaboration in this way will foster interdisciplinary and diverse perspectives on tackling the objectives of this research initiative.

In particular, Malta suggests that the CEC issue Requests for Information (RFI) to solicit a wider range of technologies and solutions that advance and modernize the grid and support the transition to a high-IBR grid. The research concepts for the forthcoming GFO narrowly focus on grid-enhancing technologies (GETs), monitoring, protection, and control capabilities, and GFM inverters, at the exclusion of alternative solutions, including Malta's PHES system that provides the exact attributes of traditional synchronous generation by virtue of its use of same or similar turbomachinery as part of its integrated LDES system. In so doing, the CEC could modify the research concepts to not focus on two or three technology types but instead make this a more comprehensive assessment of the best solutions to solve the various grid-service needs of a high-IBR future. In sum, collaboration and outreach to industry should be an important aspect of this research initiative.[10]

5. **What other considerations or requirements should be incorporated into the future GFO?**

As summarized in the above section, Malta recommends that the CEC also assess the technology solution set that also solves for multi-day reliability issues, which currently are and will increasingly be a grid reliability and stability issue in a high-IBR grid.

Moreover, the CEC should answer questions around how the various grid-service needs could be efficiently addressed and optimized by the significant new resource buildout required to meet SB 100 goals. Rather than looking at these services in a silo, the CEC should seek to inform the California Public Utilities Commission (CPUC), who oversees integrated resource planning, on how the resource buildout

[9] E. Ela, V. Gevorgian, A. Tuohy, B. Kirby, M. Milligan and M. O'Malley, "Market Designs for Primary Frequency Response Ancillary Service—Part I: Motivation and Design," IEEE Transactions on Power Systems, vol. 29, no. 1, pp. 421-431, 2014.
[10] The Electric Power Research Institute (EPRI) is currently in the process of studying the various solutions to address the need for rotational inertia. Upon its completion, the CEC should refer to EPRI's findings as guidance for this initiative.

could be optimized in least-cost ways to select resources that can "stack" these values and thus provide direction (via market products, attribute valuation, and/or resource-specific carveouts with synchronous storage) to LSEs in their procurement activities.

III. CONCLUSION.

Malta thanks the CEC for the opportunity to offer these comments and responses regarding this new research initiative. Please do not hesitate to reach out if you have questions or wish to discuss any of the comments or responses above.

Sincerely,

Jin Noh
Director, Business Development & Policy
August 25, 2023