Codes and Standards Enhancement (CASE) Initiative
For PY2011: Title 20 Standards Development

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Comment Letter in Response
To May 19, 2011 Committee Workshop
For Battery Charger System Energy Efficiency Standards
(Docket Number Docket 09-AAER-2)

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California Energy Commission
Dockets Office, MS-4
1516 Ninth Street, MS-25
Sacramento, CA 95814-5512

May 31, 2011

RE: Battery Charger System Energy Efficiency Standards (Docket Number Docket 09-AAER-2)

Dear Commissioners:

California's investor-owned utilities (IOUs) strongly support the California Energy Commission's proposed battery charger systems standards. This standard is an important next step to address the battery charger system efficiency of hundreds of plug load products that would be difficult and costly for the Commission to address with individual measures. In order to increase battery run time, product designers have long focused on energy efficiency when a product is operating with stored energy from the battery, but less attention has been paid to the efficiency of the battery charger system used to refuel that battery when it is plugged into a wall outlet. The energy savings opportunity for all chargers is nearly one power plant worth of energy (0.9 Rosenfeld). The net present value of consumer battery charger energy savings from the first year of sales alone is $250 Million, orders of magnitude greater than the cost of regulation.

The IOUs have a number of suggestions to the Energy Commission as it moves forward to the next phase of the rulemaking. These include responses to stakeholder concerns expressed at the workshop, further support for IOU suggested changes at the workshop, as well as detailed suggestions to further refine the express terms published May 10, 2011. These are submitted to supplement the comments given in the IOU presentation Efficiency Committee workshop on May 19, 2011, the IOU presentation given at the staff workshop March 3, 2011, as well as the IOU CASE report published in October 2010.

Part 1: Responses to stakeholder concerns at workshop

STAKEHOLDER CONCERN: Extra functionality in some more complex battery chargers warrants changes to the CEC proposal.

IOU RESPONSE: Current data suggest additional energy allowances for non battery charger functions are not required.

The original Codes and Standards Enhancement (CASE) proposal was written to encourage manufacturers to reduce the standby power of products that contain battery chargers by requiring power reductions in no-battery mode. In this mode, the battery is removed from the charger, the charger is plugged in, and all extra functions are switched off via software or hardware. This is a mode of operation that persists for long durations for many battery chargers, so it is important to reduce the energy use in this mode.

Manufacturer-reported laptop data from HP suggests that there are products on the market today that can easily meet the CEC low power mode limits proposed in the express terms. In the table below, the combined battery maintenance and no battery mode power[1] is all less than one watt for 5 separate laptop models, representing a wide range of performance parameters and configurations within the laptop product line. Laptops include many functions also incorporated into other complex battery chargers, including LED indicators and communication functions such as Ethernet and USB ports. Manufacturers have another 12 months to meet the standard, suggesting that even tighter limits on low power mode suggested in the IOU presentation May 19, 2011 could be appropriate to garner additional energy savings.

Laptop description	Battery Maintenance Power (W) [f]		No Battery Mode (W) [c]	Battery capacity (Wh)	CEC-proposed limit (W) [d]	Expected low power value under test procedure (W) [e]
	Load for non-battery charger functions [a]	Load for "smart" battery circuitry [b]				
High-end commercial HP EliteBook 8560p Notebook PC	0.56	0.1	0.20	83	1.17	0.86
Mid-range commercial HP ProBook 6560b Notebook PC	0.56	0.1	0.20	55	1.12	0.86
Entry-level commercial HP ProBook 4431s	0.57	0.1	0.09	47	1.10	0.76

[1] This includes generous allowances for "smart" battery circuitry not captured in the manufacturer's reports.

Notebook PC						
High-end consumer HP Pavilion dv7 Entertainment PC	0.61	0.1	0.20	47	1.10	0.91
Entry-level consumer Compaq Presario CQ43 Notebook PC	0.69	0.1	0.20	47	1.10	0.99

Notes: Dates of HP reports are in March or April 2011. Unless otherwise indicated, data are measured by the manufacturer. Data from: http://www.hp.com/hpinfo/globalcitizenship/environment/productdata/iteconotebook-o.html

[a] S5 state with wake on LAN enabled at 115 V input

[b] Value estimated by PG&E's technical consultant Ecos to be 4.1 mW, or 0.0041 W. This includes 12 μW/cell for protection plus 4 mW for charge control for the whole battery. 9 cells is 4.1 mW total). This value was increased a factor of 25 to 0.1 W to account for ac to dc power conversion losses and other non-quantified uncertainties. Dates of HP reports are in March or April 2011.

[c] This is the equivalent to EPS no load at 115 V input

[d] This is the value shown in the May 10, 2011 express terms and is equivalent to 1 W +0.0021*E_b, where E_b is the energy capacity of the battery in watt-hours.

[e] Sum of battery maintenance mode and no battery mode (watts). Green indicates pass with both IOU and CEC proposed limits. Orange indicates passing of CEC proposal only. Note that one of three notebooks with battery capacity of 47 watt hours, released in March of this year already meets proposed standard.

[f] Battery Maintenance is the sum of the load associated with non battery charger functions and the smart circuitry of non-battery charger functions.

STAKEHOLDER CONCERN: Standard will eliminate nickel based chemistries from the market because nickel-based chemistries require higher levels of constant trickle current to counteract self-discharge. Stakeholders claim this higher trickle current justifies a lower 24 hour efficiency standard for nickel as well as a higher power level for in battery maintenance.

IOU RESPONSE: Larger nickel-based chemistries can meet the standard with hysteresis charging or other charge control mechanisms. The CEC should not consider changes to the standard that address different battery chemistries with different standards.

CEC PIER research concludes that nickel-based chemistries can be maintained with hysteresis charge profiles, which have lower overall energy use than constant trickle charge configurations currently used. Motorola mentioned this as a possible solution to increasing efficiency in the May 19 workshop. Below is a description of hysteresis charging from page 26 of Designing Battery Charger Systems for Improved Energy Efficiency, A Technical Primer, Geist et. all 2006.

> *"Hysteresis charging is a form of maintenance charge that keeps batteries near a fully charged state while maintaining a relatively high efficiency. During hysteresis charge, the battery voltage is allowed to float between a high and low set point. When the high set point is reached during charge, the charge current is*

shut off. After a period of time the battery voltage will fall due to self-discharge until the low set point is reached. At this time the charger turns back on, but instead of charging with a small current, a relatively large current is used to quickly bring the battery voltage and state-of-charge back to the high set point. Because charging occurs at a higher power level, the conversion efficiency of the power supply circuitry is relatively high.

The use of hysteresis charge does not adversely affect the performance or life of most batteries and actually may help enhance product life over traditional float charging. The efficiency improvement feasible with hysteresis charging is heavily dependent on the percentage of time that the product spends in maintenance mode. For a 24-hour full cycle charging operation, efficiency improvement may be as high as 25 percentage points."

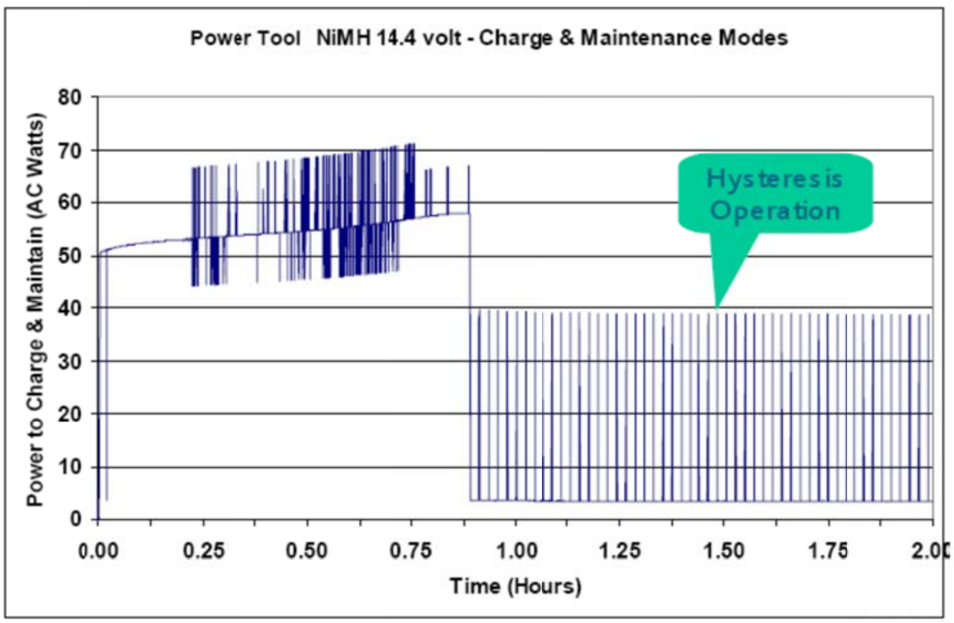

Figure 1: Example of hysteresis operation of a NiMH power tool charger

Figure source: page 26 of Designing Battery Charger Systems for Improved Energy Efficiency, A Technical Primer, Geist et. all 2006. Available at http://www.efficientproducts.org/reports/bchargers/1270_BatteryChargerTechincalPrimer_FINAL_29Sep2006.pdf

Not only is hysteresis charging already employed in some nickel chargers today (Figure 1, above), but the IOU teardown and redesign of a NiCd charger detailed in the March 3, 2011 IOU presentation demonstrated the technical potential of hysteresis charging in the laboratory. The original design as-shipped incorporated approximately a 0.05C constant or "float" trickle to maintain charge. This level agrees with industry rule of thumb to counteract self-discharge cited in the May workshop. "Float" charge is relatively inefficient because much of the useful energy is lost as heat in the battery to keep the voltage very high and at these charge levels, the ac-dc power supply operates at a less efficient partial load. This results in high battery maintenance and low 24 hour efficiencies (Figure 2). The IOU technical team modified this product to employ a hysteresis charging algorithm as an alternative. This algorithm, coupled with more efficient ac-dc power conversion, improved the 24 hour efficiency by nearly 20 percentage points. Battery maintenance was reduced, and the no-battery mode was maintained at 0.3 watts (table below). When the battery was discharged after the 24 hour charge cycle, it was confirmed within equipment confidence intervals that the battery was at the same state of charge as observed in the as-shipped configuration, which used “float” charge.

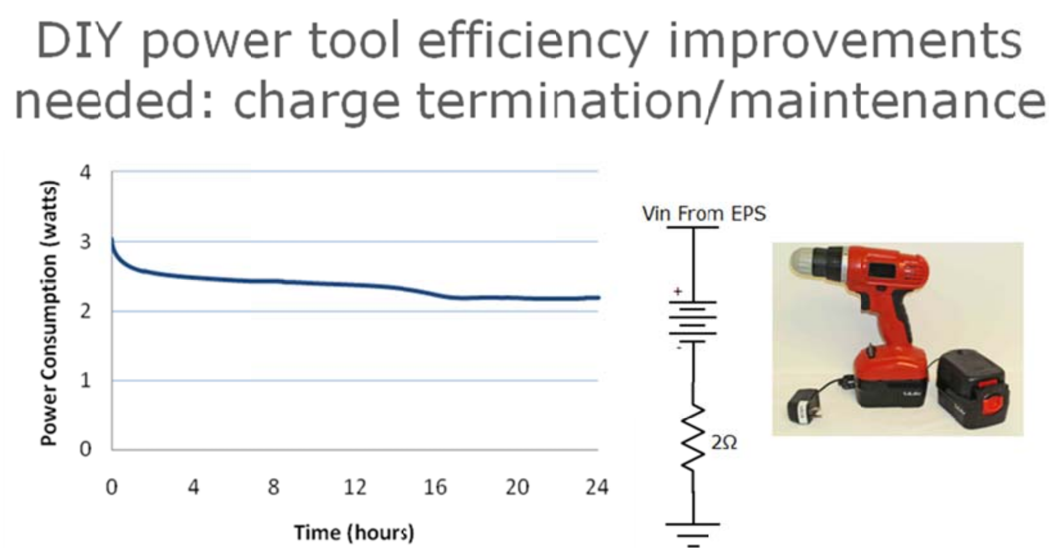

Figure 2: As-shipped DIY power tool with constant current charge solution

Source: March 3, 2011 IOUs workshop presentation, available at
http://www.energy.ca.gov/appliances/battery_chargers/documents/2011-03-03_workshop/presentations/Proposed_Standards_for_Battery_Chargers-Suzanne_Foster_Porter_and_Philip_Walters.pdf

Mode	24-hour efficiency	Maintenance	No-battery
Proposed Title 20	45%	0.5 W	0.3 W
As shipped	35%	2.2 W	0.25 W
Modified: charge term. +V EPS	54%	0.40 W	0.30 W

The CEC has an opportunity to accelerate the market-adoption of high efficiency battery charger technology for nickel based systems. Manufacturers can employ charge control integrated circuits available from a number of manufacturers (see March 3, 2011 IOU workshop presentation). These ICs facilitate known charge control techniques, such as hysteresis charging, to reduce losses in battery charger systems. The IOUs have confirmed CEC's own PIER research in the laboratory, and the standard is an opportunity to apply this savings opportunity to the market.

STAKEHOLDER CONCERN: Standard will eliminate nickel based chemistries from the market because nickel-based chemistries have a lower charge acceptance than lithium based chemistries. Nickel should have a less stringent 24 hour efficiency requirement. Specifically, the coefficient in front of battery energy should be 1.9 instead of 1.6 (e.g., Motorola presentation, May 19, 2011, slide 14).

IOU RESPONSE: The slow battery discharge rates required by the test procedure are appropriately matched with the CEC proposed 24 efficiency requirements. The CEC should not consider changes to the standard that address different battery chemistries with different standards.

For nickel chemistries, the rate of discharge of the battery has a significant effect on the measured capacity of the battery. If a battery is discharged in an hour or two (employing rates of 1C or 0.5C) then the measured capacity will be much lower than if the battery is discharged in 5 hours (0.2 C), as required by the test procedure. The test procedure's 5-hour discharge helps reduce the differences observed among battery chemistries. A 5 hour discharge provides a very favorable measurement of battery capacity, and matches the battery industry's published recommendations for capacity measurement.

Motorola's assertion that nickel chemistries need a higher 24 efficiency level is based on 1 to 2 hour discharge rates not consistent with the test procedure. In Figure 3 below taken from the Motorola workshop presentation, the NiMH is discharged with a 1C rate (approximately 60 minute discharge) and the Li-Ion battery is discharged with a 0.5 C rate (approximately a 120 minute discharge). Employing the fastest acceptable discharge rate for NiMH (1C) and comparing that capacity measurement to a slower discharge rate of the Li-Ion (0.5C) over-emphasizes the differences between these two chemistries. Furthermore, the actual 24-hour test requires a much slower discharge of 0.2 C.

Motorola and other stakeholders are correct that nickel-based batteries have different characteristics than Li-Ion batteries. The CEC-proposed value for 24 hour efficiency is based solely on the 0.2C discharge energy of the battery ($12+1.6\ E_b$, where E_b is the battery energy measured by the test procedure). This slow discharge helps reduce difference among battery chemistries, and is appropriate when compared to the test procedure discharge rates.

There are many examples of fast charging NiMH systems that can meet the proposed CEC 24 hour efficiency requirements. Under a fast charge algorithm, the efficiency of the ac-dc power conversion is higher than at slow charge, and hysteresis charging can be employed to reduce battery maintenance mode (as discussed in other response). We strongly encourage the CEC to retain the current CEC 24 hour efficiency proposal for all chemistries.

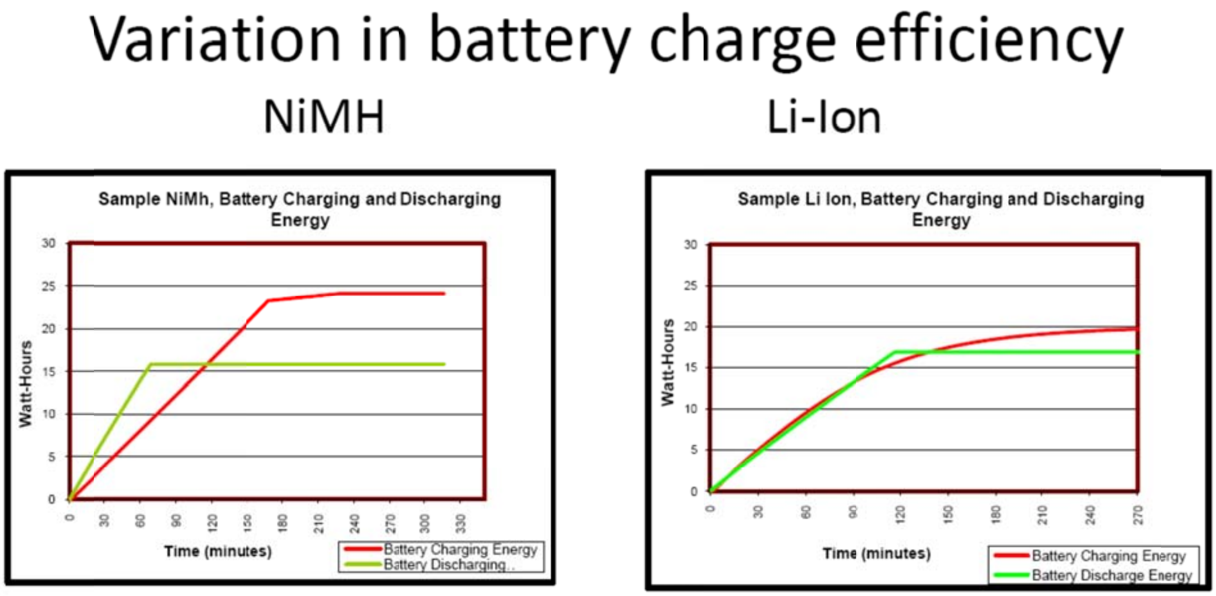

Figure 3: Motorola discharge energy presented at workshop not consistent with test procedure, underestimates extractable battery energy

Source: Motorola Efficiency Committee workshop presentation, slide 12, May 19, 2011

STAKEHOLDER CONCERN: Markups used in CEC and DOE analysis of the battery charger standards do not reflect typical markups for Wahl Clipper trimmer and shaver products.

IOU RESPONSE: Markups in analysis are appropriate for incremental cost associated with an efficiency measure, and should be lower than full product mark ups.

Markups used on incremental cost for efficiency measures are less than markups applied on the total product because many costs associated with bringing a product to the consumer are unaffected by the efficiency standard, and therefore remain constant. Examples of costs unaffected by standard include (but are not limited to):

1) cost of retailing the product, including shelf space, time of stocking and time of checkout
2) cost of distribution, including space for storage, fuel for shipping
3) cost of marketing, including branding, packaging

For further detail on rationale, please see the U.S. DOE Preliminary Analysis for battery charger released October 2010.

Part 2: Suggested changes to draft express terms language

The power factor requirement of >0.90 should be retained for products greater than 100 watts. The table below, also shown in the May 19, 2011 presentation, illustrates the short payback periods. Some of these products are less than the proposed 100 watt requirement, suggesting that this revised proposal on power factor does not capture all cost effective savings in the market.

Application	**Incremental BOM cost**	**Wiring energy savings (kWh/yr)**	**Payback (yr)**
High power laptop	$0.90	13	1.0
Commercial fast charging power tool	$0.90	2.5	5
Auto/marine	$0.90	8	1.6
Personal electric vehicle	$0.90	53	0.2

There are many ICs available for power factor correction, developed in part to enable manufacturers to comply with European total harmonic distortion requirements, ENERGY STAR and 80Plus power factor requirements for computer power supplies, and television power factor requirements in California. These ICs include, but are not limited to, the following:

- Power Integrations PFS704-729 EG HiperPFS family
- Fairchild Semiconductor FAN6982
- Cirrus Logic CS 1500
- GreenChip TEA1742T
- On Semiconductor NCP1653, NCP1653A
- Texas Instruments UCC28070

Part 3: Technical refinements to draft express terms language

We recommend a number of changes to the large charger language in the express terms. This includes:

- Changing the definition of the family to be based on the charger type. There are four charger types: ferroresonant, silicon controlled rectifier (SCR), high frequency, and hybrid. The technology is the most important predictor of efficiency, and therefore should be the characteristic that defines a family of chargers for testing and compliance purposes.
- Changing the definition of a subfamily to be based on the maximum charging voltage. Charging voltage is the second most important predictor of efficiency, and therefore should be the defining characteristic of the subfamily.

- Retaining the family (and subfamily) definitions for certification after 2014, but requiring the testing of all charge profiles. This is a similar test burden to current CEC proposal, but captures greater variation in efficiency associated with charge algorithm.
- Applying the family certification to large battery chargers and golf carts chargers only. These definitions should not apply to all small non-consumer chargers. Small non-consumer products do not have the same high testing burden and therefore should certify all their models to the standard individually.

Proposed language is below:

> EXCEPTION 4 to Section 1606(a)(3)(D) : Before July 1, 2014 manufacturers of large battery charger systems and golf carts ~~and of small battery charger systems that are not consumer products~~ may certify multiple battery chargers using the testing results of two or more representative battery charger models from each subfamily. A family is defined as having the same charging technology (silicon controlled rectifier, ferroresonant, hybrid, or high-frequency), and a subfamily is defined as having the same maximum voltage. Also, any charger that can charge chemistries other than lead acid should be tested.~~, provided that all models so certified are designed to charge batteries of the same chemistry and design.~~ All models certified in this manner must meet the requirements of Section 1606(a)(3)(D), in that untested models must have performance characteristics equal to or better than what is certified. For this reason the models selected for testing by the manufacturer must be those that the manufacturer expects to have the lowest performance out of the set to be certified, and manufacturers must report the lowest values generated by the performed tests.
>
> After July 1, 2014, manufacturers of large battery charger systems and golf carts may certify multiple battery chargers using the testing results of two or more representative battery charger models from each subfamily, but all charge profiles must be tested.
>
> Manufacturers certifying their models using this alternate method shall, as part of the declaration required in Section 1606(a)(4), make a statement under penalty of perjury that all certified models meet all applicable standards and have performance characteristics equal to or better than the reported results

We recommend that the CEC correct the test procedure reference to the revision marked by "November 12, 2008 with typographical errors corrected" test procedure version. This version is available on www.efficientproducts.org and was the last version adopted by the CEC. (See http://www.efficientproducts.org/reports/bchargers/1413_Battery%20Charger%20System%20Test%20Procedure_V2_2_2_FINAL.pdf). No changes have been made to this procedure since the rulemaking date.

We recommend changing the exemption of large battery chargers to "greater than 300 V three-phase line-to-line RMS input" (removing the reference to transmission and distribution). This ensures that the standard does not include large data center uninterruptible power supplies (UPSs), which are much different than the battery charger systems proposed under this standard. Although data center UPSs use substantial amounts of energy, they are not appropriate to include in this proposal. (See detailed proposed language below.)

> (4) ~~designed exclusively to be connected to distribution and transmission lines of peak~~ which take input voltage that is three phase of line-to-line 300 volts (V) RMS or more and is designed for a stationary power application.

We recommend that the maintenance mode power allowance for large battery chargers scale with battery size, similar to the small battery charger proposal. Assuming 2.5% self-discharge per day and 85% charge efficiency (power conversion plus internal resistance plus coulombic losses), the allowance would be 0.0012*Eb plus the 10 W no-battery allowance (see proposed language below).

> Battery Maintenance power less than or equal to: ~~20 W~~ 10 + 0.0012*Eb (Watts)

We recommend incorporating the definition of a batch charger from the test procedure and indicating that batch chargers are subject to the regular standard, and propose that only multiport (multiple charge control circuits) have the extra energy allowance under the standard (see proposed changes in language below). Batch chargers do not need the extra power allowance because they do not have multiple charge control circuits and indicator systems that would draw extra power.

> ~~"Multi-port charger" means a battery charger that is capable of simultaneously charging two or more batteries independently or charges multiple batteries at simultaneously with a single charge control circuitry. These chargers also may have multi-voltage capability, allowing two or more batteries of different voltages to charge simultaneously.~~
>
> Batch Charger
>
> A batch charger is a battery charger that charges two or more identical batteries simultaneously in a series, parallel, series-parallel, or parallel-series configuration. A batch charger does not have separate voltage or current regulation nor does it have any separate indicators for each battery in the batch. When testing a batch charger, the term

"battery" is understood to mean, collectively, all the batteries in the batch that are charged together. A charger can be both a batch charger and a multi-port charger or multi-voltage charger.

Multi-port Charger

A multi-port charger is a battery charger which charges two or more batteries (which may be identical or different) simultaneously. The batteries are not connected in series or in parallel. Rather, each port has separate voltage and/or current regulation. If the charger has status indicators, each port has its own indicator(s). A charger can be both a batch charger and a multi-port charger if it is capable of charging two or more batches of batteries simultaneously and each batch has separate regulation and/or indicator(s).

We support the CEC proposal presented at the May 19 workshop for the FDA exemption only applying to class II and class III. Class I FDA products, like toothbrushes, should not be exempted, and are intentionally covered by this standard.

We support correcting the "24-hour" energy allowance for toothbrushes to be the number of hours of the test in watt-hours. This enables the test to operate longer than 24 hours for longer charge times often characteristic of these types of products.

Thank you for the opportunity to provide comment on this important initiative. Additionally, we continue to work with CEC staff to address stakeholder concerns and seek collaboration with industry whenever possible.

Sincerely,

Pacific Gas and Electric Company
San Diego Gas & Electric
Southern California Edison
Southern California Gas Company