Should the next standby power target be 0-watt?

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(& Introducing the Standzero Approach)

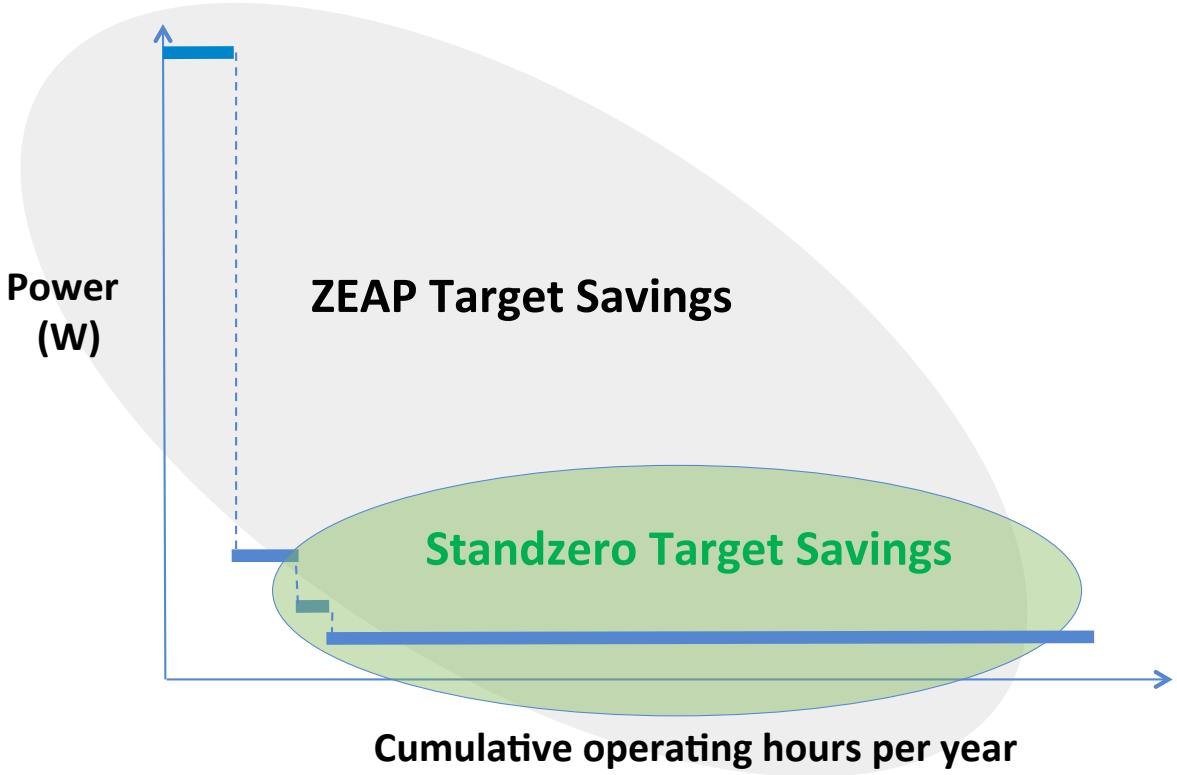
Background

- Rising amount of energy use in the “miscellaneous”, ”plug loads”, or “other” category
  - much of that usage is some sort of continuous/standby
- Future limits on standby power will become more complicated because:
  - Additional power requirements for network connectivity and interfaces
  - Native-DC products – unclear how to treat them
  - Proliferation of mobile products
  - Increasing ambiguity in definition of standby
- So we are looking for comprehensive ways to lower energy use in this broad area
  - Hans-Paul’s ZEAP approach

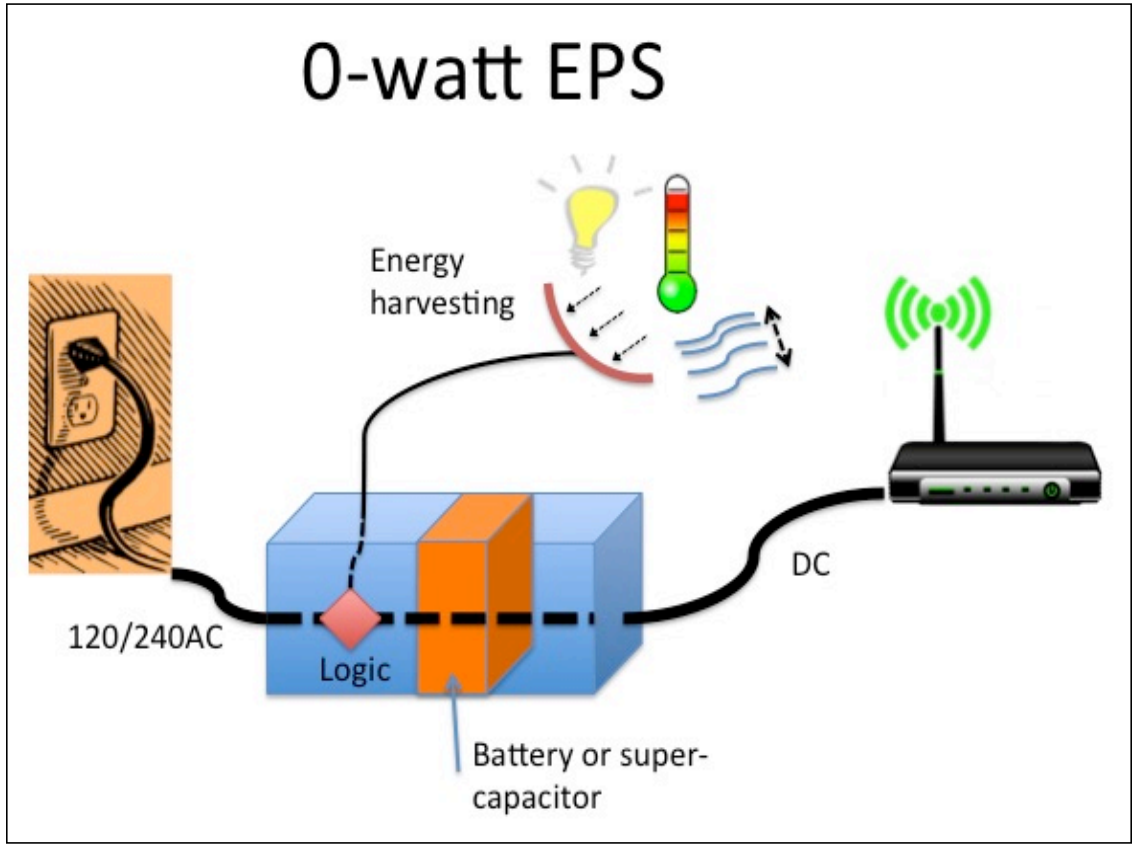
The Standzero Concept

- Short for "*standby zero*"
- Standzero requires a product to be disconnected from the mains and continue operating at a minimal level of functionality for, say, one hour.
- Focuses on the length of time a product can operate without mains power. The target is operation with no mains-power for a specified time period.
- Standzero focuses on standby consumption because the minimum level of functionality will typically be a standby mode.
- Standzero is a new metric of performance: the duration of time a product can operate without mains power.
  - Standzero might be measured in hours.

Targeted Energy Use and Modes by Standzero and ZEAP Approaches



A Standzero External Power Supply

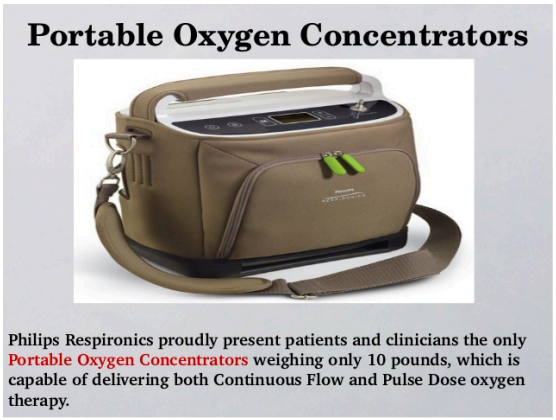


Schematic illustrating how Standzero would be applied to an external power supply (EPS).

Some products already have Standzero features

Keyboard and garden lights energy harvesting and storage

Smartphones and portable oxygen concentrators have energy storage but no harvesting.



What is a technically feasible length of 0-watt operation?

The length of 0-watt (mains power) operation depends on three characteristics:

- power consumption of the product while in standby (load),
- energy stored in the battery, and
- energy supplied through ambient energy harvesting.

Our approach: Perform a sensitivity analysis with a reasonable range of values for each characteristic

Step 1: Estimate Standzero Operating Time

Operating time when only a battery is present

$$Operating\ time\ (hours) = Energy\ stored\ (watt\text{–}hours)\ /Operating\ load\ (watts)$$

Operating time when a battery and energy harvesting is present

$$Operating\ time\ (hours) = Energy\ stored\ /Operating\ load - Harvested\ power$$

Note: If harvested power exceeds load, then operating time is negative.

Loads caused by typical components of products in standby

Component	Load (milliwatts)	Representative Citation
Radio	0.004	(Moss et al. 2015)
LCD Display (~6 square centimetres [cm^2])	0.015	http://www.mouser.com/
Digital microcontroller unit (MCU)	0.1	(Moss et al. 2015)
Personal sensors	1	(Niu et al. 2015)
Power consumption sensors	3.75	(Tsunoda et al. 2016)
LED indicator light	130	(Cree Inc. 2016)
PC control (S3 state)	210	(Te Huang, Bai, Ying-Wen, and Hsu 2015)
Ground fault interrupt circuit	500	Lawrence Berkeley National Laboratory measurements

Energy Harvesting

Technology	Peak Performance (mW)	Representative Citation
Ambient radio	0.001	(Ferdous, Reza, and Siddiqui 2016)
Thermoelectric	0.06	(Ferdous, Reza, and Siddiqui 2016)
Ambient indoor light	0.1	(Ferdous, Reza, and Siddiqui 2016)
Ambient airflow	1	(Ferdous, Reza, and Siddiqui 2016)
Biomechanical	1	(Niu et al. 2015)
Vibration	7	(Moss et al. 2015)

Energy Storage (normalized to 1g)

Technology	Energy Stored (mWh)	Representative Citation
Hybrid battery ultracapacitor with graphene	39	(El-Kady, Shao, and Kaner 2016)
Ultracapacitor (0.5 kilograms [kg])	57	http://www.skeletontech.com/
1 g of a lithium-ion (Li-ion) battery @ 120 Wh/kg	120	(Bruce et al. 2012)
Li-ion battery	200	(Lee et al. 2016)
Advanced Li-ion battery	600	(Bruce et al. 2012)

Sensitivity Analysis of Operating Time

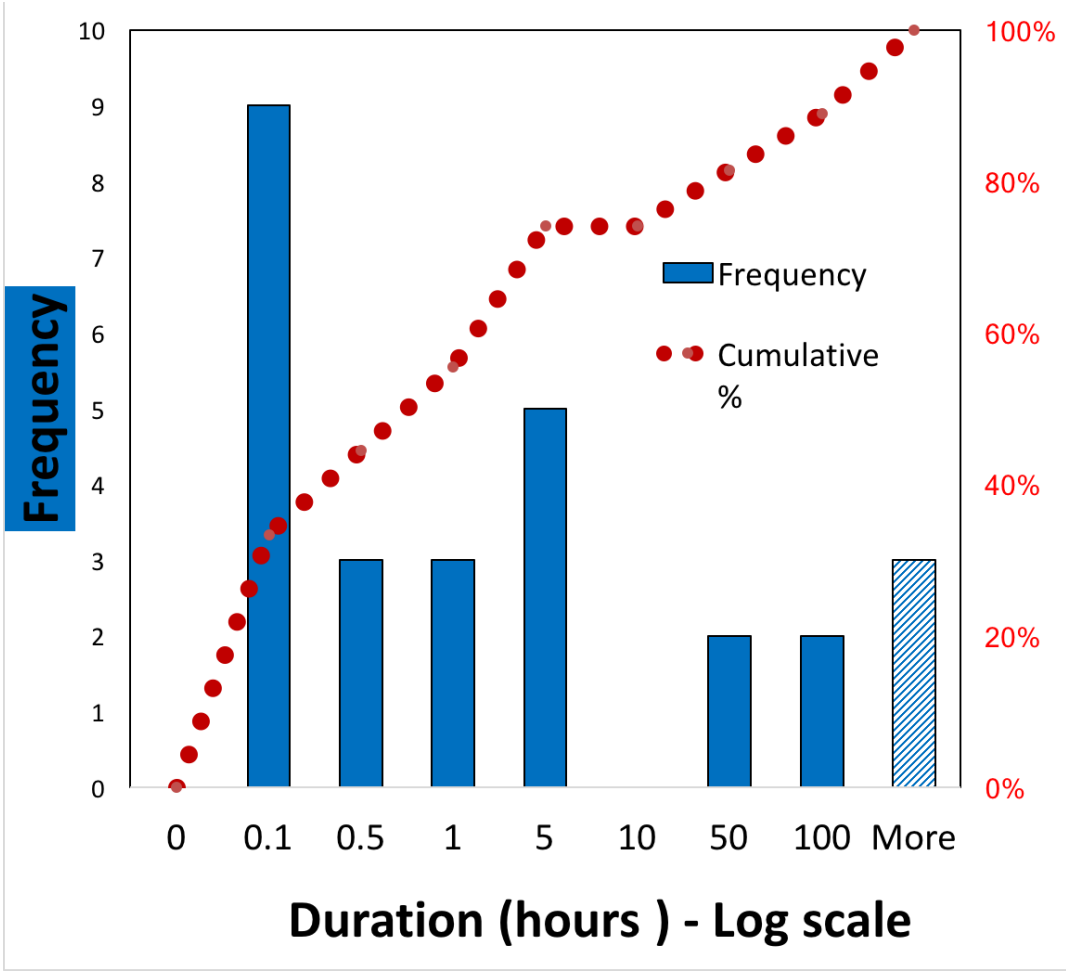
- Sensitivity analysis of operating time without grid-supplied power based on ranges of loads, energy harvesting, and storage.
- There were 27 possible combinations (3 variables, 3 levels).

Load, harvesting, and storage values used in sensitivity analysis

	Low	Mid-Range	High
Load (mW)	0.004	1.0	500
Harvesting (average mW)	0.001	0.006	0.1
Storage (mWh)	0.01	0.5	2.0

Results – Operating Time Without Mains-Supplied Power

- Operating times ranged from 0.0002 – 58 hours
- One-third of the combinations resulted in operating times less than 0.1 hour
- One-third had operating times longer than one hour
- All of the shortest standzero times occur when the load is 500 mW → shows importance of reducing loads



Should the next standby power target be 0-watt (with Standzero)?

…. Perhaps

No. An across-the-board 0-watt target is not feasible → instead, lower to 0.25W (or keep existing targets).

No. It will inconvenience consumers.

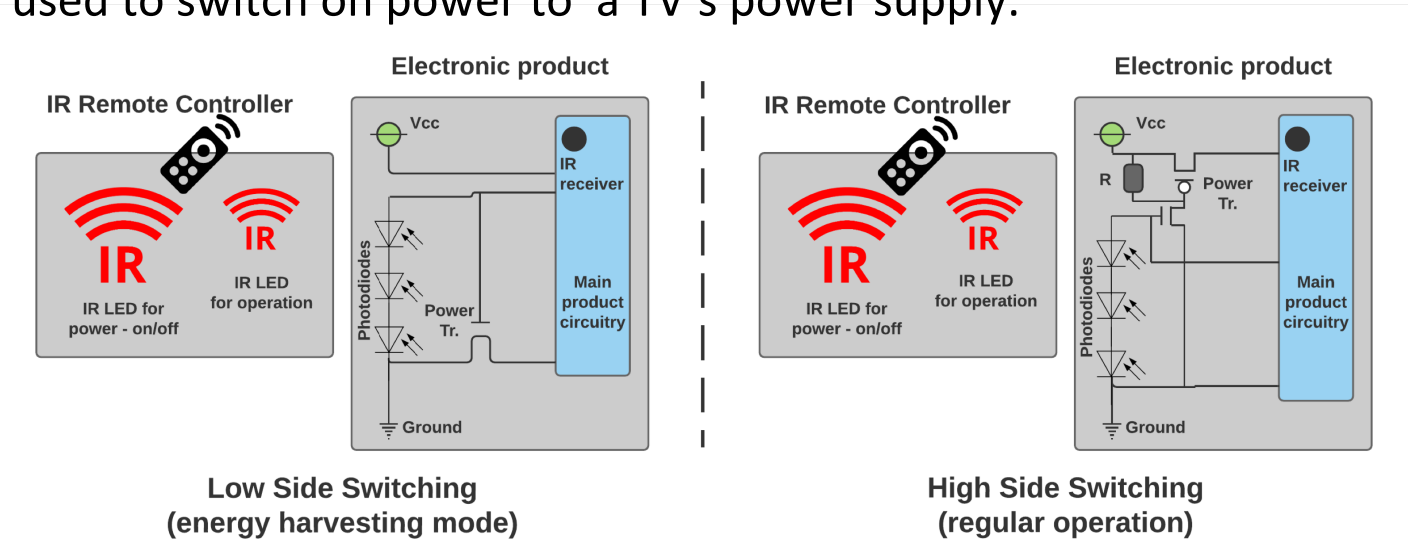
No. Energy storage and harvesting technologies need further development.

Perhaps, because a standzero approach will be feasible for a significant fraction of devices

Yes. It is already happening, beginning with high-value or special situations

A remote control's IR signal to switch on a TV's power supply using energy harvesting

Energy harvesting of the energy in the remote control's IR signal is used to switch on power to a TV's power supply.



This solution applies to all products with remote controls. Standzero time = ∞

Next Steps for Standzero

Industry, Government, Standards Associations	Me
Create definition and scope	Build simulation model
Establish test procedure	Design and fabricate prototypes on breadboard
Establish categories and labels (like power supplies)	Create reference designs for others