Building the Case for Global DC Power Standards

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ABSTRACT

Direct current (DC) power systems have historically been found almost exclusively in telephone systems and garden lighting. But today there are many efforts around the world to take advantage of DC power systems' efficiency, flexibility and their natural compatibility with renewable energy and battery storage. Calls for standards relating thereto are coming from diverse stakeholders from around the world. We therefore have an opportunity to go global with the effort.

Keywords: direct current, energy efficiency, global warming, green products, green buildings

1 INTRODUCTION

Not since the unconnected power grids and telephone systems of 100 years ago have there been such pressing reasons to promote new standards for electricity use. Just as the isolated systems of a century ago needed standards development to improve and grow their service capability, the electricity grid today needs new standards that reflect the requirements of the devices we have today, which is radically different than the uses of electricity conceived by the grid's originators. This shift began with the introduction of semiconductors into electrical devices about 50 years ago, and semiconductors consume direct current (DC) power.

The original electric appliance, the common light bulb, has been one of the last end-use electricity consumers to transform into a DC load. It has migrated from its incandescent beginnings, as a resistive load that literally glowed when heated, to today's DC-consuming electronically ballasted fluorescent lamps and Light Emitting Diodes (LEDs). This switch is going on in buildings of all types, and the move has prompted legislation at the national level in the US and heated debates about consumers' choices, technology costs and the environment. Whole countries have now begun to limit or ban the use of inefficient incandescent lamps, including the US, the EU, Brazil, Russia, India and China.

Television set-top boxes, common in developed economies, can draw more kilowatt hours over a year than the former champion in home power consumption, the refrigerator [1]. These sit atop televisions that are increasingly DC devices, many having external power supplies today, just like the brick on a laptop. While television sets have generally risen in efficiency since the cathode ray tubes that started the market, the plasma, LED and LCD sets sold today are generally bigger consumers of DC power.

Similarly, our telecommunication power needs have exploded in the last 25 years with the rise of cell phone handsets (4.6 billion subscribed for in 2010), which now account for about 23 gigawatt hours of power consumption each day [2]. These ubiquitous loads illustrate the fast growth in the use of electronics, all of which use DC. Conventionally this DC power input has been taken as required from the grid to fill the phone's batteries by switching mode power supplies. Lights, televisions and telephones are not alone in this shift to greater DC power consumption, however.

Computers in homes and offices, and dense collections of them in data centers, are also large and growing consumers of DC, currently accounting for about 2% of all electrical consumption [3]. Despite a recent pause, forecasted growth of data centers is expected to outpace overall economic growth. This trend is partly driven by the growth in the Internet and its dependencies, which in turn consume more DC.

Analysts predict electric vehicles will account for 2.5% of the global automobile market by 2020 and between 2% and 5% of the US market [4]. While this represents a relatively small market share in percentage terms, the global automobile market is huge, at about 50 million units sold annually. America's Big 3 and Japanese and Chinese vehicle manufacturers are gearing up, prodded by the state-run electric companies, to make more electric vehicles [5]. These global efforts will prompt growth in vehicle charging infrastructure from a near-zero base to over $200 billion by 2022 [6]. Batteries on board the vehicles are, of course, DC storage devices.

These diverse developments in the ways we use power speak to the rise of semiconductors found in all of them, and their essential DC nature. Each application has been a significant driver in the growth of the world economy since the 1970s. So, what is wrong with the status quo?

2 BILLIONS OF COMPROMISES

Each of these devices outlined (phones, displays, modems, computers, vehicles and lights) have historically required an AC to DC converter, typically designed for low cost. This has been the adaptor that devices require to get power from the grid. How can we flip the problem over, and ask what adaptor the grid could employ to give the devices of today what they require, with dramatically lower losses? The answer to this question is DC power standards. A prior paper focusing on the United States exclusively concluded that the country could improve the integrated electrical efficiency of addressable electronic loads by over 20%, which equated to a net reduction in the national load by over 8% through energy efficiency improvements that would follow DC power standards in the form of DC microgrids[1] [7]. This large benefit would in turn cultivate further improvements in renewable energy penetration and better energy storage integration. By promulgating standards to which the market can build products with confidence of a broad participation, these improvements will also create less waste due to the fewer number of electronic power supplies that will be discarded.

The introduction of DC power standards brings multiple benefits and should therefore garner support from those who benefit. Governments should revisit the historical AC standards that have not kept up with the changing load. Nongovernment organizations, corporations, foundations, and non-profit organizations whose mission statements include the goals of promoting energy efficiency and renewable energy must also engage in this effort. Due to the size of the electricity market today compared to when AC standards were first formulated, it is an immense undertaking.

3 AWESOME IN SCOPE, BUT STILL POSSIBLE

The global market changes quickly, and the moment to act is now, for several reasons. First, this undertaking is possible in the DC domain in part because there is **no significant installed base** of grid-connected DC microgrids today (aside from Plain Old Telephone service). Compared to the world's AC domains and its heterogeneous standards and customs, the DC domain is a relatively blank slate.

But it won't stay that way for long.

Second, there is a universally understood need to conserve resources and limit pollutants, both of which benefit from **increased energy efficiency.** While the debate about energy choice and the environment is contentious, most can agree that efficiency is good and waste is bad. DC power standards will promote fewer power conversions of AC to DC electricity, resulting in more work performed for each unit of electricity delivered by the grid, and better efficiency still when DC-ready appliances are at the end of the line[2]. In the developed world we can see the twin trends of growth in solar PV deployment and the growing electronic load in buildings—both intrinsically DC—as evidence of the opportunity to rationalize the system to which they both connect.

Third, a reason to act now on DC power standards is to **advance power availability and social stability** for everyone on earth. For this goal we will need global, not just national, standards. According to the UN Foundation, 1.6 billion people have no access to electricity at all, depriving them

[1] e.g. solar photovoltaic and battery outputs

[2] solar photovoltaic and battery outputs

of the "oxygen of commerce and wealth creation." [8] It is an old saw in development circles that, while electricity availability doesn't guarantee development, lack of electricity does indeed guarantee that development will not happen. Power systems in the developing world today are often hodge-podge affairs with cast-off hardware, or otherwise poor quality materials. The great up-front capital expenditure required to install a conventional centralized grid in the developed economy model is generations away for billions of people. Consequently makeshift systems are cobbled together, often involving car batteries, a lamp, a radio or TV, and sometimes solar panels or a fossil fuel generator. A DC microgrid model is more appropriate for the organic nature of developing electrical infrastructure and presents an opportunity to optimize these types of systems.[3]

Parts commonality, a fourth reason to advance DC power standards, would lower the costs of connectors and power systems, all of which would be the same whether you are Los Angeleno, Laotian or a Liberian. It will be an opportunity for existing and new market entrants to build for a larger global market. There is also the possibility that this phenomenon could cross sectors in addition to crossing geographies. With the exception of integrated circuits and flat panel displays, there is essentially no intersection between the parts used in stationary power systems (buildings) and mobile power systems (vehicles) today. However, as the power train of vehicles is becoming increasingly electronic and less mechanical with the introduction of electric, hybrid electric and start/stop sub-systems, those power electronics can increasingly resemble the inverters, drives and battery banks found in stationary systems. Parts commonality lowers costs, because volumes are higher.

Having more parts and connectors in common, along with global DC power standards, would promote **universal power connectivity,** a fifth reason. Connectivity is more than a convenience; it streamlines travel and commerce by cultivating easier connections to electricity for everyone, better democratizing access.

A sixth pressing reason to promote DC power standards is to **decrease electronic waste.** A 2008 industry estimate [9] calculated that 3.2 billion external power supplies were manufactured worldwide, with many different power capacities and operating DC voltages on the output. Of these, 737 million were shipped to the US. In that same time period 434 million external power supplies will be retired from use, of which less than 13% will find their way to recycling. This means that 379 million external power supplies purchased in the US will go into landfills. If device manufacturers had adopted a common operating voltage for these devices' charge input, and this were harmonized with a DC power system operating voltage available, only a connector would be needed, and the one-to-one converter could be avoided altogether. In June of 2009, partly due to the scale of this particular issue for Europe, the European Commission solicited and reached an agreement among the fourteen leading mobile phone producers to harmonize chargers for data-enabled mobile phones (i.e., chargers that can be connected to a computer) sold in the European Union [10]. This move to the mini-USB connector by the European Commission and European industry is illustrative of the need that DC power standards address. Complying handsets started to reach the EU marketplace under this directive in the first quarter of 2011.

This development is not all that has been contributed to the advancement of DC power standards by the European Committee for Electrotechnical Standardisation (CENELEC) and the European Telecommunications Standards Institute (ETSI), however. These groups have been exchanging information in order to harmonize a particular DC standard for data center and telecommunications use with the California-based non-profit industry organization called the EMerge Alliance[4]. This group was founded to define and promote DC power standards and to "lead the rapid adoption of safe DC power distribution in commercial buildings" through the development of DC power standards.

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[3] for more on this phenomenon see http://spectrum.ieee.org/slideshow/green-tech/solar/mobile-solarenergy-units-bring-lights-to-haitian-homes

[4] Author Paul Savage is a founding member of the EMerge Alliance

4 THE START OF A GLOBAL EFFORT IS UNDERWAY

The process in the US first began with a DC standard for the built environment: offices and other commercial buildings, schools, retail establishments and light industrial environments. These locations are typically lit by electronically ballasted lighting, and increasingly LEDs, and are often controlled by Building Management Systems (BMSs) for time of day scheduling, daylight harvesting, occupancy control, and sometimes load shedding. Through collaborative committee work, the EMerge Alliance released an open standard for 24 VDC to the market in late 2009. This operating voltage in 100 volt amp increments has the added attraction of falling under Class 2 power restrictions in the US, meaning that it is intrinsically safe and below the shock and startle hazard for workers and users interacting with it.

In the following year a group called the DC Power Partners, led by the US trade and research organization for utilities Electric Power Research Institute (EPRI) voted to fold itself into the EMerge Alliance to more effectively advance its effort to promote 380 VDC as a standard voltage for use in data centers and telecom applications. The DC Power Partners had met since 2005, at first to investigate and then advocate for DC power use in dense computing environments. This group's international members from Europe, Scandinavia and Japan would foreshadow the EMerge Alliance's strategic plan for international expansion that is beginning with directed efforts in Europe in 2012.

Some threads of a global undertaking can be seen coming together in this move into Europe, where EMerge Alliance members are also active in CENELC and ETSI. Similarly, DC Power Partner NTT Facilities, the giant Japanese communications and data conglomerate, participates in the US's Smart Grid Interoperability Panel (SGIP) convened by National Institute of Standards and Technology (NIST). The CENELEC and NIST organizations' involvement are evidence that governments are in touch with, if not leading, the DC standardization effort.

5 CONCLUSION

What has been put in place must be capitalized upon. The EMerge Alliance effort needs to continue on to the EU with great focus, and then form the partnerships in China, India, Russia and Brazil that will be necessary to create global DC connectivity. This is an opportunity for the Institute of Electrical and Electronics Engineers to exercise its international organization. Building global DC power standards is an opportunity that has not existed before in either the sphere of technology or energy—and it will take a veritable army of enthusiasts with vision to realize it.

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