DC Electricity Distribution in the European Union: An Opportunity for Energy Efficiency in Europe

An IEEE European Public Policy Initiative Position Statement

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The IEEE European Public Policy Initiative (IEEE EPPI) calls on European Union policy makers to take actions that will lead to greater efficiency in the supply of Direct Current (DC) electric power for the rapidly growing range of products and equipment that require DC power, commonly found in private homes and businesses.

Ubiquitous electronics (including computers, communications, and entertainment systems), the adoption of LED lighting, and the emergence of electric vehicles are prominent among trends that are increasing the demand for DC power. In homes and businesses, this demand is usually met using AC to DC converters for each product or application; typically, these converters are inefficient while operating, and often consume power when not in service. Reducing these inefficiencies in supply, while taking advantage of the fact that most of the electric power provided by renewable sources is generated as DC power, represents a major opportunity to address European goals and aspirations.

Appropriate policy decisions related to the use of DC Power in homes and businesses, taken soon, can:

- reduce Europe's dependence on fossil fuels;
- slow the growth in electricity costs;
- strengthen the European power industry and its suppliers; and
- help position Europe as a leader in what can be one of the most important technology advances of the next few decades.

Specifically, European policy makers should:

1. Invest in research and development aimed at efficient and low cost DC power components and systems.
2. Support research aimed at understanding DC grid-related safety and reliability issues and means to address them, anticipating and overcoming any issues before the large-scale deployment of these distribution systems.
3. Stimulate and support the development of new standards for DC power components in the home and businesses, as a way of ensuring that all stakeholders' efforts in the development of those components are fruitful.
4. Require the establishment of national and local building construction requirements that include DC power distribution in new homes and office buildings, as a way of achieving the ambitious energy efficiency targets in buildings.

5. Establish mechanisms that promote and provide financial support to the cooperation between public and private entities, researchers and industry, allowing the development of DC-compatible equipment that is not yet available, namely directly DC-fed household appliances, and suitable protection devices.

With nearly two thousand electrical and electronics engineers, and over one thousand power engineers among its members in Europe, IEEE is well positioned to assist in the development of the proposed policies and to contribute to the work required.

The IEEE Power & Energy Society (IEEE PES), an organizational unit within IEEE, has been working on strategies that foster the reliable and efficient use of DC power in homes and businesses, under the name "DC@Home". The work of that group is directly relevant to the policy development recommendations proposed above. Other IEEE Societies, like IEEE Power Electronics Society, IEEE Industry Applications Society, and IEEE Industrial Electronics Society, are also contributing effectively to the implementation of such solution, with advanced know-how about enabling technologies on DC power, vital on DC distribution systems.

Standards will be an essential part of the solution. The IEEE Standards Association, another IEEE organizational unit, has already developed some of the most important standards required to consolidate the large-scale deployment of DC power, and has launched an initiative called the Indian Low Voltage DC Forum, which is conducting research in India to "evaluate LVDC impacts for emerging and developed markets and recommend appropriate global standards."

Background

Since the late 19th century, AC (Alternating Current) technologies have dominated electric generation, transmission, and distribution systems. AC technology provides easy transformation from the typical voltages produced by generators to higher voltages, for more efficient transmission, and to lower voltages again, needed by customers. However, over time, customers' uses of electricity have evolved from primarily incandescent lighting and electric motors that generally use AC electricity, to products that require DC electricity for operation and, often, the charging of batteries. Most electronic products require DC electricity and either contain AC-DC converters within the product or, typically in the case of small products, utilize an external converter. LED lights, designed to directly replace incandescent bulbs, typically have an AC-DC converter in the base of each bulb. Along with market growth in these and other areas, the charging of batteries in electric and hybrid vehicles is driving demand for DC power and AC-DC converters.

The majority of the electricity use of EU households concerns electrical appliances. [1] Electrical appliances can be classified into two groups: small appliances, where most state-of-the-art DC-powered products are framed, and large appliances, consisting of refrigerators, freezers, washing machines, dish washers, dryers, and TVs. The same report [1] stated a notorious growth of the electricity consumption associated to small appliances between the year 2000 and the year 2012, surpassing the electricity consumption related to the power-hungry large appliances in the end of the period under analysis. The replacement of the traditional lighting systems by LED lights and the spread

of the electric vehicle, whose sales doubled between 2014 and 2015 in Europe [2], will certainly leverage the energy consumption made by DC-compatible devices in our homes.

Significant changes also occurred in the energy generation: distributed generation of energy, supported mainly by private microgeneration systems, has increased. The generators of these systems, which take advantage of some renewable sources of energy, are generally photovoltaic cells, wind turbines and cogeneration systems. Again, a great percentage of these generators operate in DC, namely the photovoltaic cells and some variable speed wind turbines. These systems have grown exponentially in the last few years, specially driven by environment-friendly policies encouraging the installation of such systems.

What are the next steps?

To walk towards the adoption of a DC solution, some steps need to be followed. Standardization should be promoted, following successful experiences already available in industrial applications, such as data centers [3]. It is important to clearly define the DC voltage levels that show the best relation between efficiency and safety [3]. Legislation concerning energy efficiency of household and office appliances should be updated, to promote the production of more efficient DC appliances [4].

The behaviour of DC powered systems is different from AC powered systems. Because of that, a transition to a DC grid solution will imply the complete understanding of minor safety issues, in order to suppress them. These safety issues range from protection circuitry implementation, or fault detection in specific cases, to proper insulation of conductors or electric arc extinction. Some initial projects recently started to investigate and propose solutions for these issues [5-8], but a bigger R&D effort will certainly boost the resolution of issues related to DC grids safety and, at the same time, banish some uncertainty and doubts related with the real advantages of DC grids.

The Power Converters field, mainly the DC/DC converters required in DC grids to create several voltage levels, is another topic that requires further development. The following points should be addressed:

- increase the efficiency and power density of these converters, with special focus on the devices with large step in voltage, which will be essential for the DC grids deployment;
- investigate/develop new fault detection and avoidance/tolerance techniques;
- ensure the same level of safety of equipment and people than current AC system;
- determine the best solution for power conversion (a centralized conversion in the building, or conversion close to the DC load - distributed conversion); and
- develop or improve equipment for AC and DC grid interconnection.

References:

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