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

An IEEE European Public Policy Committee Position Statement

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The IEEE European Public Policy Committee (EPPC) calls on European Union policy makers to take actions to increase efficiency in the supply of Direct Current (DC) electric power, which is needed for a growing range of products and equipment in private homes and businesses. Moreover, DC power distribution and smart microgrids deployed in industrial plants, data centres, ships and ports are considered appealing as they facilitate the integration of equipment with a prosumer profile, RES or energy harvesting devices, eliminate reactive power flow, while reducing power losses in the distribution network which is reflected to reduced fuel oil consumption.

Appropriate policy decisions related to the use of DC Power in industrial plants, domestic installations and transportation related activities (e.g., electric cars, ship electric energy systems, or even ports where RES and large energy storage units are planned to be deployed) 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.

Recommendations

Specifically, the EPPC recommends that EU policy makers:

1. Increase the level of investments 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 as a way of achieving the ambitious energy efficiency targets;
5. Establish mechanisms that promote and provide financial support for 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 a solution, with advanced know-how about enabling technologies on DC power, vital on DC distribution systems.

Moreover, 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”. In the marine sector, there is the IEEE 1709 for MVDC (1-33 kVDC) [1], while under discussion is to update LVDC standards in IEEE 45 (up to 1kV).

Background

Since the late 19^{th} century, Alternating Current (AC) 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 in EU households concerns electrical appliances that 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 [2]. The same report states 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, the sales of which doubled between 2014 and 2015 in Europe [3], 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. Moreover, DC power distribution has evolved in the case of data centres in an attempt to reduce losses especially due to the circulation; for similar reasons, DC distribution has been exploited in ships and industrial plants.

What are the next steps?

The adoption of DC solutions requires a number of actions. First, standardization should be promoted, following successful experiences already available in industrial applications, such as data centres [4] and ships [1]. It is important to clearly define the DC voltage levels that show the best relation between efficiency and safety [4]. Some indicative voltage levels depending on the power capacity of the installation are the following:

- 375 VDC for 0-1 MW installed power capacity
- 650 VDC for 1-3 MW installed power capacity
- 1000 VDC >4 MW installed power capacity

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 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 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 to the real advantages of DC grids, as explained for instance in [9-10].

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 [11-13]:

- 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);
- develop or improve equipment for AC and DC grid interconnection;
- develop standards to calculate short circuit fault calculations in DC circuits;
- Resolve stability problems developed in DC circuits.

References:

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