Household DC networks: state-of-the-art and future prospects

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Context

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• The past decade has seen a rapid increase in local electricity generation from solar PV, both globally and in the EU [Solar PV produces DC power]

• Support schemes at the household level for battery storage [batteries are charged and discharged with DC power]

• Several household appliances, such as computers, mobile phones and LED lighting use DC power

Are low voltage DC networks at the household level technoeconomically feasible?
Role of USB C and USB 3.1

Main features:
• reversible
• “flippable”
• twice the theoretical throughput of USB 3.0 (increased from 5 GBps to 10 GBps),
• delivers power of 100 W
Configuration 1: Hybrid AC-DC

A potential solution is a hybrid system where:

- both AC and LVDC networks will operate side-by-side
- high power appliances (such as washing machines and dishwashers) supplied by AC
- Power from solar PV is converted from DC to AC through an inverter.
- Medium and low power appliances supplied by LVDC with voltage levels ranging from 12 to 50 Vdc.
Configuration 1: Hybrid AC-DC
Configuration 2: DC household

Another solution is to power the entire household through a DC system with:

- three LVDC networks installed in parallel
- 400 Vdc can be used for high power appliances,
- 100 Vdc for medium power appliances and
- a few volts (potentially with USB 3.1) for appliances with low power ratings.
Configuration 2: DC household
Market for DC networks

Source: International Electrotechnical Commission, Standardization Management Board, May 2014
Market for DC networks

Main reasons for this potentially delayed market uptake at the household level are:

• Benefits of LVDC networks for households has not been clearly evident
  o due to prevalence of large AC loads
  o relative lack of low-cost appropriate power converters.

• Large stock of households
  o not renovated/refurbished as frequently as data centres and tertiary buildings.
Standardisation

• Standardisation work in the area of data centres has progressed the farthest

• European Telecommunications Standards Institute (ETSI) has developed standards:
  o **EN 300 132-3-1**, which describes the characteristics of a DC bus between 260 and 400 V, and
  o **EN 301 605**, which describes the earthing and bonding of 400 Vdc data and telecom (ICT) equipment.

• Further standards from USA-based Emerge Alliance, the International Telecommunication Union (ITU-T), and the International Electrotechnical Commission (IEC).

• Both IEC and IEEE are very active in this field, but until now there has been little coordination between the two bodies.

• By October 2016, SG 4 of the IEC report will present a first suggested set of standards for LVDC (up to 1500 V) networks.
**Standardisation**

- It is most likely that multiple voltages will be used and apparent that on the highest level, 380-400 V will be used globally.
- Apart from the 400 Vdc level, the standard for the lower voltage level is set by USB 3.1,
Policy recommendations

• Encourage and support standardisation (driven by IEC and IEEE)
• Clearer policy direction on self-consumption of renewables
• Increased support for batteries at the household level
• Mandate USB 3.1 (with Type-C connectors) for power supply to electronics

The key factors in the choice of a transition to DC networks in households will be:
• evolution of electricity consumption of different household devices,
• penetration of residential solar PV
• cost of DC power electronics (such as converters)