Panel session 2: nano electronics & smart systems components – target areas: grid automation, DC homes, IoT

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MicroDERLab group @ UPB

- [Faculty of Electrical Engineering]
- [Faculty of Automation and Control]
- [Faculty of Power Engineering]

- Team
- Expertise
- Projects

- **DCNextEve**
- **H2020 Flexmeter**
- **H2020 Storage4Grid**
- **H2020 NobelGrid**
- **ITCity (ERA Net LAC 2016), 2017-2020**
- **FISMEP (ERA Net Smart Grids Plus), 2017-2020**

- **Instrumentation for power systems**; synchronized measurements; WAMCS
- Grid integration of renewable energy sources; active distribution grids
- **Microgrids** (including DC and hybrid architectures)
- **Emerging Power Quality concepts**
- Work on standardization (various IEC bodies)

Microgrids today

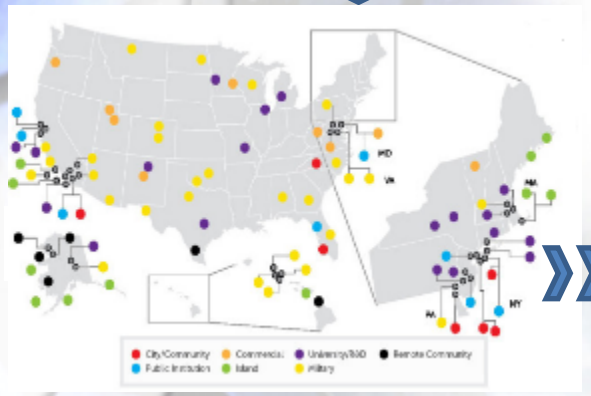
critical cells in a smart grid context → increasing **grid resilience**.

Majority of LV demonstrations are AC MGs

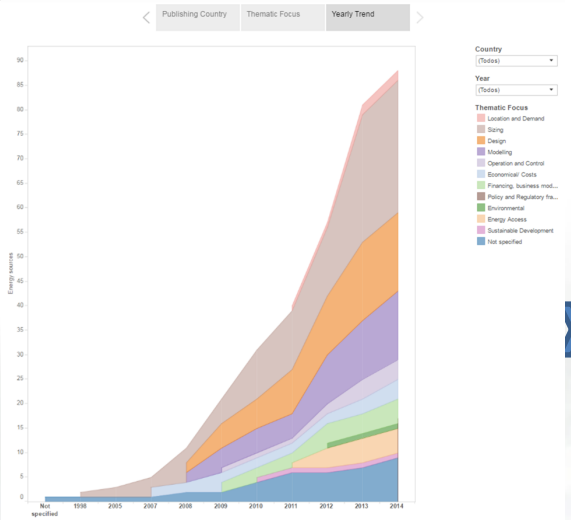
Data centers leaders in deploying DC MG solutions and LV – **commercial building** –household applications [prosumers]

yearly overview: http://microgrid-symposiums.org/

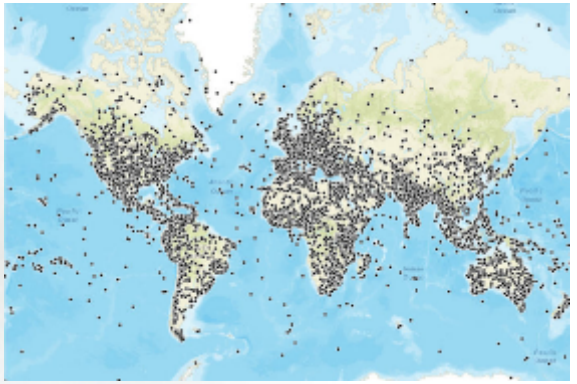
Source: http://smartgrid.ieee.org/ieee-smart-grid/smart-grid-conceptual-model



Source: GTM Research North American Microgrids 2015

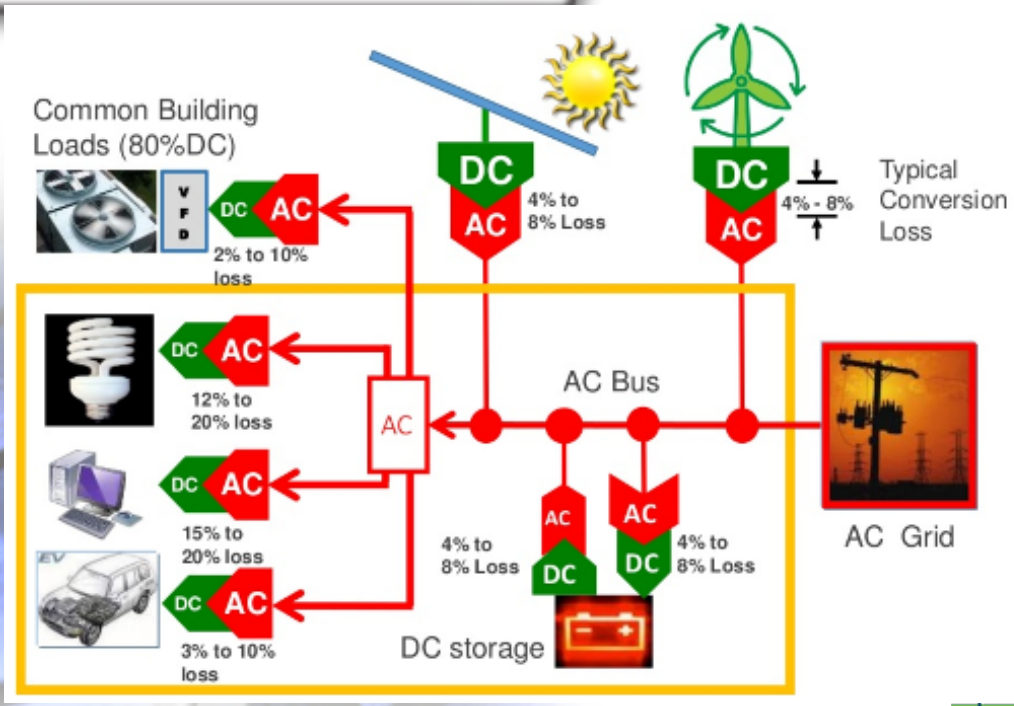


Source: Mar Martinez, PhD thesis, UPC/KUL, July 2017; http://electrifyme.org/



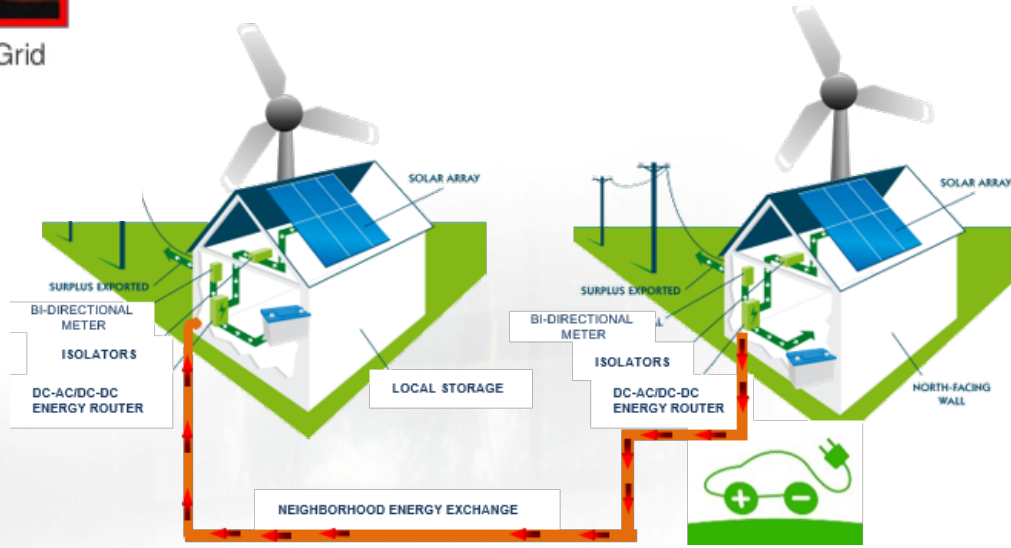
Source: www.microgrids.com

DC microgrids



The LVDC power supply solutions for buildings

- *more and more site based **energy harvesting***
- ***office appliances** are DC native loads or DC compatible;*



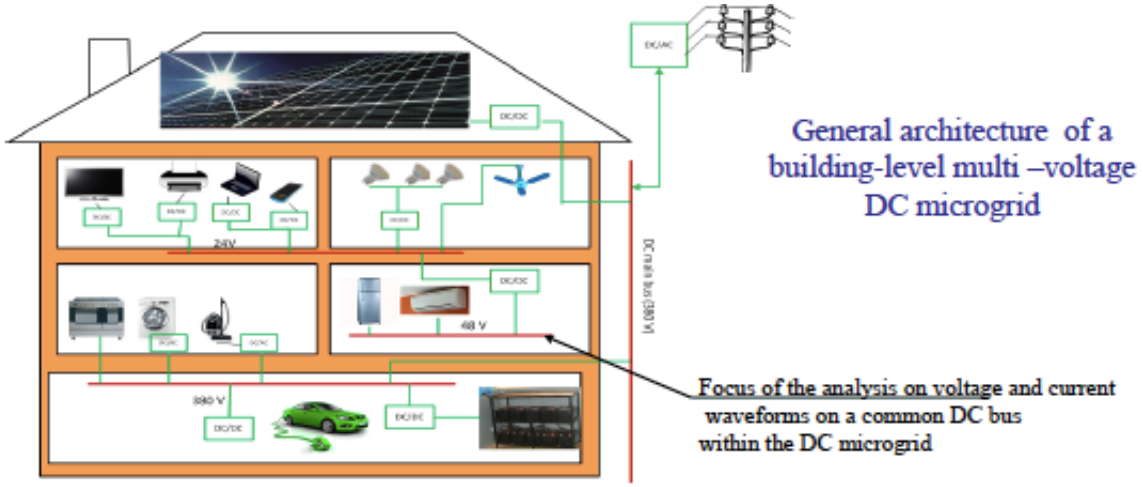
- *Deployment of storage for LV domestic and commercial prosumers (e.g. resilience measure against regulatory framework for RES connection)*
- *No reactive power allocation in the capacity of the line*

Power Quality – voltage acceptability

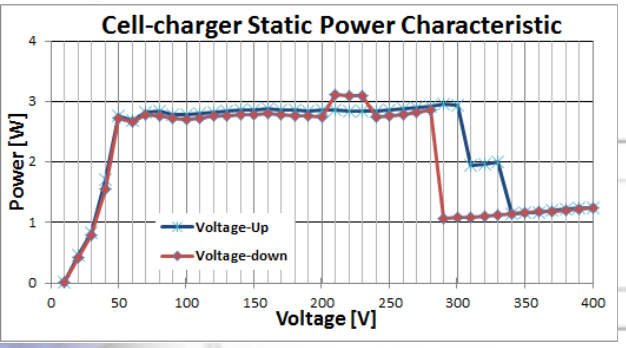
EMerge Alliance dc standard as implemented for building interiors: 24 V

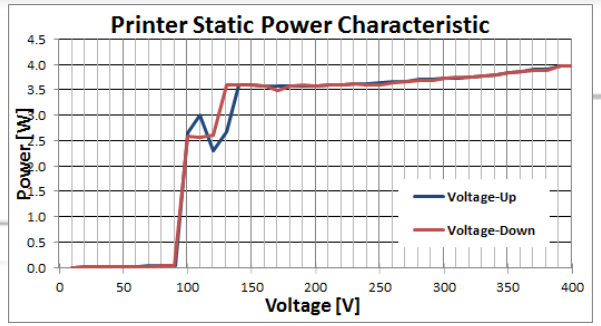
IEC Standard 61000-4-30:2015 “Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods” → **IEC SC77A WG9 - Power Quality Measurement Methods (2017--)**

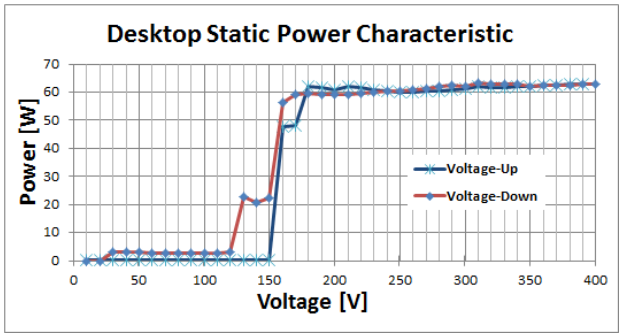
Technical Report in cooperation with TC 8, SC8B, SyC LVDC on “Assessment of Standard Voltages, PQ parameters, PQ requirements and related measurement methods for LVDC supply systems” is envisaged



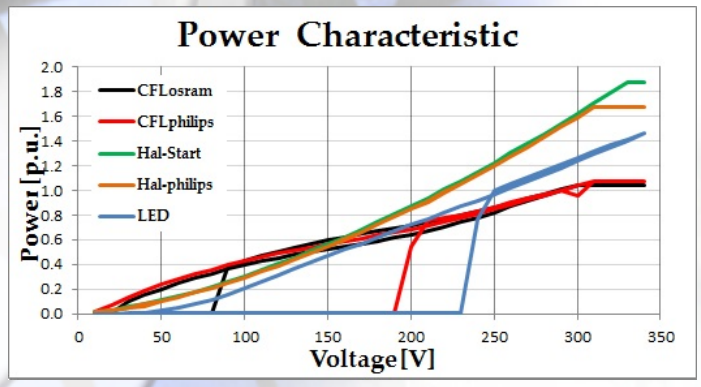
Power Quality – direct voltage acceptability

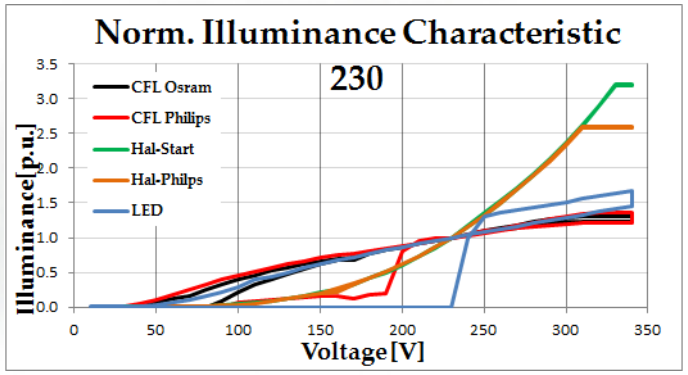






- Voltage level flexibility?
- Inherent droop control P(U) ?
- Models for appliances?
- Acceptability curves – CBEMA / ITIC/ SEMI / IEC Class 3 / EMerge A. / ?





Andrés F. Martínez P., "Studio di Dispositivi Alimentati da una Microrete in Corrente Continua", MSc Thesis, Politecnico di Torino / UPB 2015

Voltage Quality – time and frequency domain

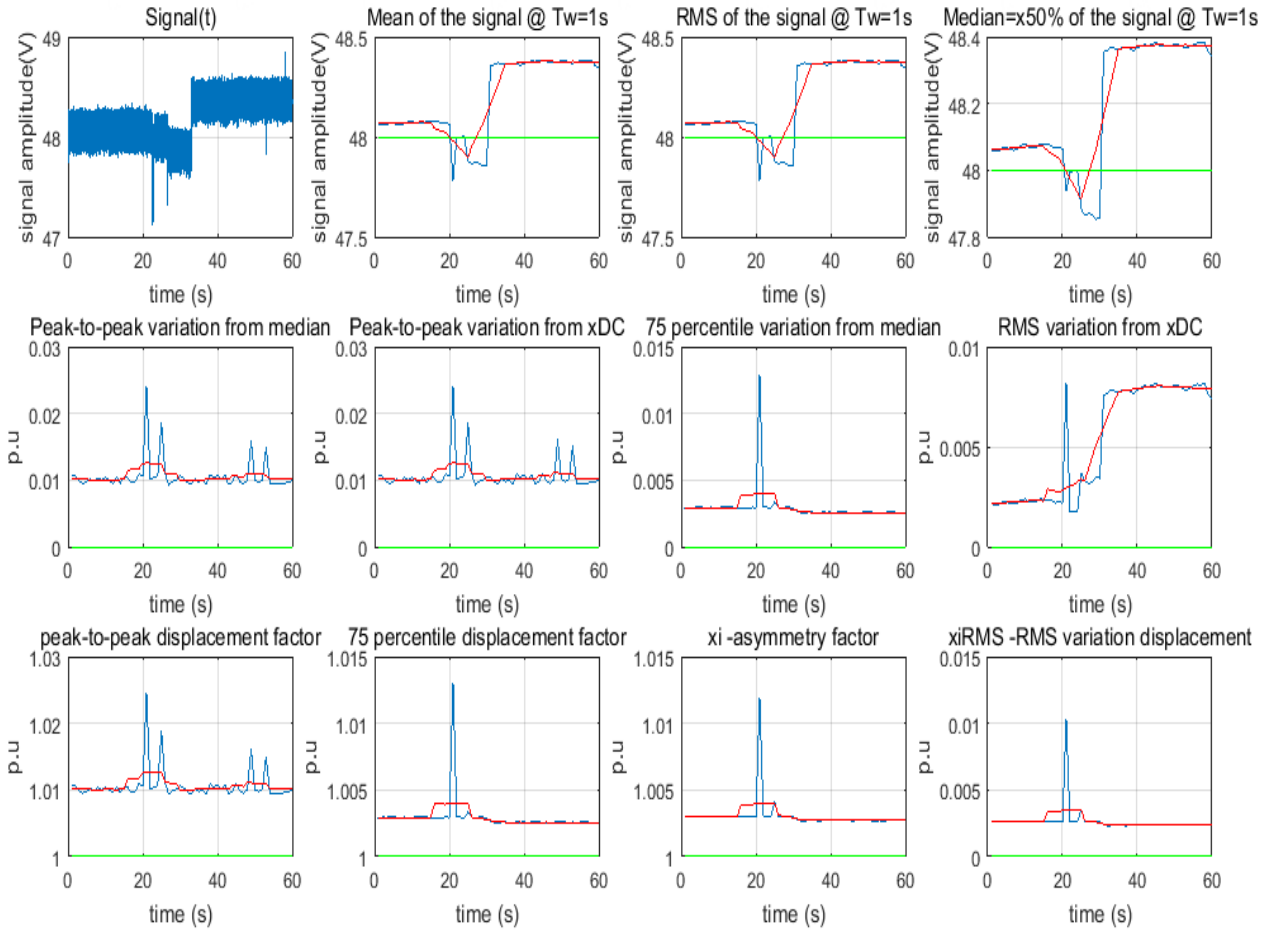
Example: time domain indices for u(t) in a dc/dc converter

$$\xi_{y\%} = (x^{+}_{y\%}/x^{-}_{y\%})$$

$$\xi^{*}_{RMS} = \xi_{RMS} * x_E$$

$$\xi = \frac{\sqrt{\frac{1}{N}\sum_{x_i > X_{DC}} (x_i/X_{DC})^2}}{\sqrt{\frac{1}{M}\sum_{x_j < X_{DC}} (x_j/X_{DC})^2}}$$

$$\xi_{RMS} = \left| 10l\, g\left(\frac{\sum_{x_i > X_{DC}} (x_i/X_{DC})^2}{\sum_{x_i < X_{DC}} (x_i/X_{DC})^2}\right)\right|$$

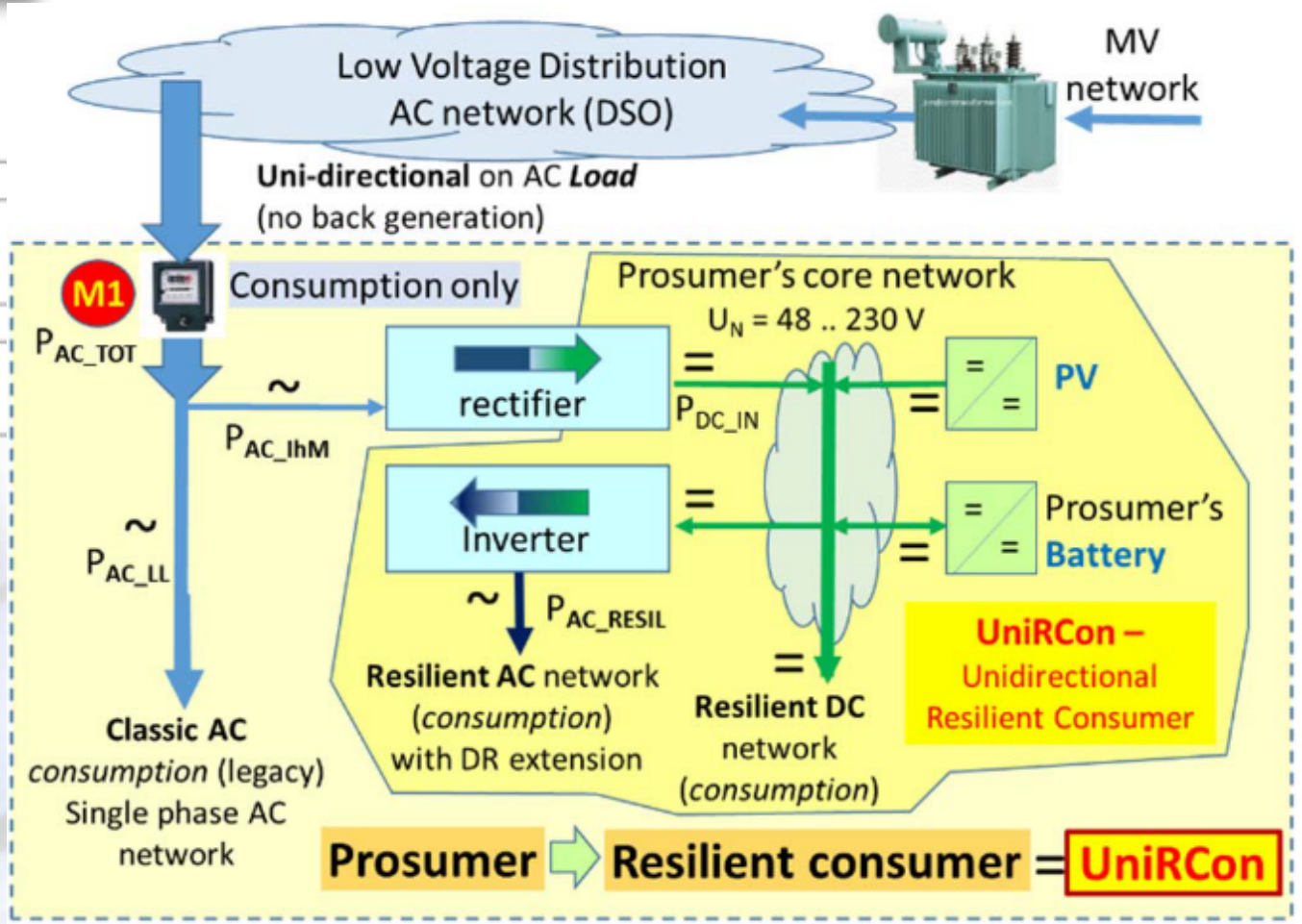


Irina Ciornei, Mihaela Albu, Mihai Sanduleac, Lenos Hadjidemetriou, Elias Kyriakides, **2017**, *Analytical derivation of PQ indicators compatible with control strategies for DC microgrids*, Proc. of 2017 IEEE Manchester PowerTech

System solutions

Key element for control:

Energy Meter
USM = SMM & SMX



Source: *Mihai Sanduleac, Mihaela Albu, Lucian Toma, João Martins, Anabela Gonçalves Pronto, Vasco Delgado-Gomes - Hybrid AC and DC Smart home resilient Architecture Transforming prosumers in UniRCons* – ICE 2017 IEEE TMC Europe Conference, *July 2017*

Open issues

- *Nominal voltage level[s] (**standardization**!)*
- ***Compatibility** with existing appliances / energy end-user set-up ?*
- *[new!] **voltage acceptability curves**;*
- ***New models** (start collecting information! load curves, high time granularity, P(U), etc.)*
- ***Power quality/ quality of service** (design and operation of PE interfacing sources, loads and storage with the common DC bus);*
- ***Efficiency studies** conducted in the application environment*
- ***Prosumers local architectures**, as extensions in the legacy AC form and their potential to be fully in DC;*
- *Storage as new grid element*
- ***Static transformers** (with accessible DC bus)*
- ***Measurement** (including **energy metering**), definitions, data (with context) availability*
- ***Dialogue with regulators***

Example: Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network *code* on *requirements for grid* connection of generators