Rate of Change of Frequency Immunity & Advanced Capabilities for Converters – A Balanced Scorecard

ACER Workshop in the context of the amendment of electricity grid connection network codes

Ljubljana, Wed 2023-05-10
Agenda

- Self-introduction
- AGPPM issues regarding micro-CHP
- Spill-over effects of ROCOF immunities and remedies
Our Vision

Towards an efficient, integrated and cost-effective net-zero energy system in 2050

Resilient, decentralised and carbon neutral European energy system with cogeneration as its backbone

2050
Our Mission

Cross-sectoral voice of the cogeneration industry

Work with EU Institutions and stakeholders to shape better policies by:

- Building a robust evidence-base, demonstrating the benefits of cogeneration.
- Using the expertise of our membership.
- Establishing strong coalitions and partnerships.
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Asynchronous Generator = PPM

- Asynchronous Generators (ASG) are classified as Power Park Modules (PPM)
- Many micro-CHP units use (water-cooled) ASG
- Further requirements for PPMs such as grid-forming and inertial response are automatically requested by RfG 2.0
- The wrong legal impression is created that converter based generators and ASGs are the same

- Clarification needed for RfG 2.0 requirements in the micro-CHP range (up to 50 kW).
Inverters for Fuel Cells

- Fuell cell inverters are specifically designed to serve a FC stack (AC/DC converter)
- Inverters for “electronic gears” in variable speed drives with improved ICE efficiency
- Low sales figures meaning high specific fixed costs for possible hardware update
- RfG 2.0 requirements (referring to inverters) exception needed for emerging niche market (proportionality)
- See also: GC-ESC, EG ACPPPM, Draft Final Report, Version 0.9, page 55f.
# Niche Market of micro-CHP

## Statistical Data from Germany (BAFA 2022)

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<th>In MW</th>
<th>≤ 2 kW</th>
<th>&lt; 2 kW ≤ 10 kW</th>
<th>&lt; 10 kW ≤ 20 kW</th>
<th>&lt; 20 kW ≤ 50 kW</th>
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<td>11.03</td>
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<td>2013</td>
<td>2.10</td>
<td>12.93</td>
<td>18.28</td>
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</tbody>
</table>

- 50 kW according to Article 2(39), Energy Efficiency Directive
- EU installation of FC heatings ~25,000 units (2012-2024)
- Barrier: still high system costs

Source: [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/kwk_statistik_zulassungen_kwk_anlagen.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/kwk_statistik_zulassungen_kwk_anlagen.html)
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General requirements for type A power-generating modules NC RfG, Article 13 1(b)(i):

- ±4,0 Hz/s over a period of 0,25 s,
- ±2,0 Hz/s over a period of 0,5 s,
- ±1,5 Hz/s over a period of 1 s, and
- ±1,25 Hz/s over a period of 2 s;

Source: ACER draft amendments to NC RfG, 2023-05-10/11
ROCOF requirements

• ROCOF immunity to be tested or maximum frequency?
  52,5 Hz in Fig. XX.a vs. 51,5 Hz (CE), 51,5 Hz (Nordic), 52,0 Hz (GB), 51,5 Hz (IE+N-IE), 51,5 Hz (Baltic) according to NC RfG Article 13 1(a), Table 2.

• 3 upwards steps in the graph vs. 4 in the text
  – 0,25 s + 0,5 s ≠ t + 1 s; 0,5 Hz / 1,5 s = 0,33 Hz/s ≠ 1,25 Hz/s
  test curve is unrelated to requirements
  – Bumpless control vs. kinks

• If power generating modules fulfil the most stringent requirements, can we assume that also the other less demanding requirements are fulfilled? What is the requirements’ objective?
  See NERC report on the Blue Cut Fire: Southern California Event on 2016-08-16 – 1,200 MW Fault Induced Loss, July 2017
EN 50549-1/-2 (Requirements for generating plants, LV/MV)

- The generating modules in a generating plant shall have ROCOF immunity to ROCOF equal or exceeding the value specified by the responsible party. If no ROCOF immunity value is specified, at least 2 Hz/s shall apply.
- The ROCOF immunity is defined with a sliding measurement window of 500 ms.

EN 50549-10:2022

- Tests for conformity assessment of generating units
- 5.3 Immunity to disturbances
- 5.3.1 Rate of change of frequency
- Figure 4 – ROCOF Test

Source: EN 50549-10:2022, p. 35
Global severe system splits

To be prepared for:
• Larger transits / electricity trading
• Lower levels of inertia

\[ ROCOF = \frac{df}{dt} = \frac{\Delta P(t)}{P_{sys}(t)} \cdot \frac{f_n}{T_A} \]

• \( T_A \): network time constant (2 H); aka mechanical starting time
• Discussion about high immunity levels for ROCOF, but not about strategies how to keep \( T_A \) at current levels

Global severe system splits (both parts with ROCOF>1)
Scenario Global Climate Action 2040

Source: ENTSOE, Webinar on ROCOF, 2022-02-01
Coping with frequency issues

What is the problem?
• Nadir or peak?
• Fast frequency response helps, incl. selective load shedding and generator dropping

Mitigate high ROCOF values
• Keep time constant $T_A$ at adequate level
• It’s balancing power of 0th order
• Incentives to provide inertial response
  – Mechanical flywheel: synchronous condensers, synchronous generators
  – Synthetic inertia: converters with batteries

Source: ENTSOE, Webinar on Stability Management, 2022-11-01

Source: TEIAS & ENTSOE, Final Report on Blackout, 2015-09-21

Source: TEIAS & ENTSOE, Final Report on Blackout, 2015-09-21

Turkish Blackout, 2015-03-31

ROCOF and frequency nadir

1 s
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