Reactive Power Management and Voltage Control

First experts group session

Brussels, 25/02/2016
Koen Vandermot
Agenda

1. Context and Related network codes
2. Requirements for Generators
3. Demand Connection Code
4. Agenda next Experts Group meeting

* Reactive Power Management and Voltage Control (RPM & VC)
Context and Related network codes
Facing new challenges in RPM & VC

- Switch centralized production → decentralized production
  - moments with VERY LOW loading of TSO lines/cables AND almost NO centralized production (summer/interseason)
  - Reactive absorption needs ↑, while absorption capabilities ↓

- Higher interconnectivity with other TSO grids
  - Moments with VERY HIGH loading of lines/cables AND almost NO centralized production (winter/interseason)
  - Reactive injection needs ↑, while injection capabilities ↓

Reactive power management becomes 2 times more complex
Future use of reactive capabilities for reactive needs

Future available reactive capabilities

Future reactive needs and reactive capabilities

Network Codes related to RPM & VC

Experts Group - Network codes on Reactive Power Management and Voltage Control - Brussels - 25/02/2016
RPM & VC is a shared responsibility

1. Comparison between FTR-C10/11 and NC RfG + first interpretation + detection of possible quick wins (Today’s discussion)

2. See what additional possibilities this gives @ TSO-DSO level on short term and on long term (Synergrid study/Expert View)

3. Discussion of first results and on extra requirements for
   1. PGM owners (with FB on quick-wins)
   2. Demand facilities
   3. Distribution System Operators (DSOs + CDSOs)
   4. Transmission System Operators (Next Experts Groups)

4. How to use the available reactive capabilities to ensure secure operation (Next Experts Groups)
Requirements for Generators

1. Hypotheses
2. “As Is” (FTR/RTF and C10/11)
3. “To Be” (NC RfG)
4. Interpretation & Implementation Goal
**Approach**

- **Hypothesis:** A/B/C/D classification start point as discussed in previous Experts Groups
- **FTR/RTF vs NC RfG**
- **Interpretation/Goal**
- **Action points**

### 2025 – expected/constrained progress

- Type D - PPM
  - 14% Type D - PPM
- Type D - SPGM
  - 21% Type D - SPGM
- Type B DSO connected
  - 28% Type B DSO connected
- Type C
  - 14% Type C
- Type B TSO connected
  - 6% Type B TSO connected
- Type A
  - 17% Type A

### Iterative process (expected end 2016)

- Draft thresholds for BE-implementation of Network Codes
- Topics for BE-implementation of Network Codes (Frequency, Voltage, Information Exchanges, …)
## Type A

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>FTR/RTF</th>
<th>C10/11</th>
<th>NC RfG</th>
<th>Interpretation/Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P_{\text{installed}} )</td>
<td>Voltage stability</td>
<td>Defined by <strong>DeltaV-frequency profile</strong> (-7.5% to +7.5% @ generator terminal)</td>
<td>Must be capable to permanently operate at ( U_{\text{r}}/_{\text{i}} - 10% ) (at connection point)</td>
<td>Nothing specified</td>
</tr>
<tr>
<td>800W - 250kW</td>
<td>Reactive power capabilities</td>
<td>Nothing specified → to be discussed with SO</td>
<td>Cos ( \phi &gt; 0.95 )</td>
<td>Nothing specified</td>
</tr>
<tr>
<td></td>
<td>Voltage/reactive power control</td>
<td>• At least 2 set points (agreement between owner and SO) • Specific requirements on Qref control (fast-slow)</td>
<td>Nothing specified</td>
<td>Nothing specified</td>
</tr>
</tbody>
</table>

### Action points:

Shall be included in next Synergrid C10/11

Goal: **enlarge RPM & VC possibilities in DS**
## Type B

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>FTR/RTF</th>
<th>C10/11</th>
<th>NC RfG</th>
<th>Interpretation/Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{\text{installed}}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage stability</td>
<td>As in type A</td>
<td>Must be capable to permanently operate at $U+/\text{-10%}$ (at connection point)</td>
<td>Nothing specified</td>
<td></td>
</tr>
<tr>
<td>Reactive power capabilities</td>
<td>$\rightarrow$ to be discussed with SO</td>
<td>$\geq 1\text{MVA}$: Q-capability range $-0.1 \text{ Pnom} \ldots 0.33 \text{ Pnom}$</td>
<td>To be specified by the relevant SO</td>
<td></td>
</tr>
<tr>
<td>250kW – 25MW</td>
<td>Voltage/reactive power control</td>
<td>$\geq 1\text{MVA}$: multiple setpoints (Q or cos phi) possible</td>
<td>Constant V (alternator terminal) @ a selectable setpoint over the entire operation range</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• At least 2 set points (agreement between owner and SO)</td>
<td>$\geq 2.5 \text{ MVA}$: Real time tele-operation possible, for more dynamic voltage control</td>
<td>Nothing specified</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Specific requirements on $Q_{\text{ref}}$ control (fast-slow)</td>
<td></td>
<td></td>
<td>TSO grid user: Constant V (alternator terminal) @ a selectable set point over the entire operation range</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DSO grid user: Dynamic Q- or cosphi setpoint (remote control above given kVA threshold)</td>
</tr>
</tbody>
</table>

### Action points:

Shall be included in next Synergrid C10/11

Goal: enlarge RPM & VC possibilities in DS
### Type C

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>FTR/RTF</th>
<th>NC RfG</th>
<th>Interpretation/Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{\text{installed}}$</td>
<td>Voltage stability</td>
<td>As in type B</td>
<td>Auto disconnection for V-levels (SO specified)</td>
</tr>
<tr>
<td>Reactive power capabilities</td>
<td>-10% and +45% of $P_{\text{nom}}$ (for each voltage between 0.9 and 1.05 $V_{\text{expl}}$)</td>
<td>SO specifies compensation for HV lines or cables</td>
<td>Compensation of the no-load-losses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>@ max. capacity:</td>
<td>Make the U-Q/Pmax-profile more symmetric:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• SO/TSO specifies U-Q/Pmax-profile (SO/TSO specified)</td>
<td>• To solve future problems for RPM &amp; VC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Within specific boundaries (Q/Pmax=0.95)</td>
<td>• To align more with the available technology (e.g., rotated frame)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• @ connection point</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Capable of moving to any point in U-Q/Pmax</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Below max. capacity:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• SO/TSO specifies P-Q/Pmax profile</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Within specific boundaries</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Capable of moving to any point in P-Q/Pmax</td>
<td></td>
</tr>
</tbody>
</table>

**Goal:** symmetrize reactive power capabilities by win-win
## Type C

<table>
<thead>
<tr>
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<th>Interpretation/Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>P&lt;sub&gt;installed&lt;/sub&gt;</td>
<td>Capability to adapt Q on demand of SO (AVR - voltage @ connection point with selectable constant droop)</td>
<td>Specific requirements on reactive power control modes: V-control, Q-control, cos phi control</td>
<td>automatic voltage regulation within U-Q/Pmax profile (i.e. AVR, OEL, UEL, PSS) → voltage @ connection point with selectable constant droop</td>
</tr>
<tr>
<td>Voltage/reactive power control</td>
<td>Equipped with OEL, UEL and PSS</td>
<td>As in type B</td>
<td>No position yet</td>
</tr>
<tr>
<td>25MW – 75MW</td>
<td>Auto Q&lt;sub&gt;net&lt;/sub&gt; adaptation so that relative sensitivity coefficient is within 18 and 25</td>
<td>Specified by the relevant TSO</td>
<td>Specified by the relevant TSO</td>
</tr>
<tr>
<td>Priority between active or reactive power</td>
<td>Nothing specified</td>
<td>Nothing specified</td>
<td>Nothing specified</td>
</tr>
</tbody>
</table>

### Action points?

To be discussed
## Type D

<table>
<thead>
<tr>
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<th>FTR/RTF</th>
<th>NC RfG</th>
<th>Interpretation/Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;p&lt;/sub&gt;&lt;sub&gt;inst&lt;/sub&gt;</td>
<td>As in type C</td>
<td>As in type C</td>
<td>As in type C</td>
</tr>
<tr>
<td>Voltage stability</td>
<td>As in type C</td>
<td>As in type C</td>
<td>As in type C</td>
</tr>
<tr>
<td>Reactive power capabilities</td>
<td>As in type C</td>
<td>As in type C</td>
<td>As in type C</td>
</tr>
<tr>
<td>Voltage/reactive power control</td>
<td>As in type C</td>
<td>As in type C</td>
<td>automatic voltage regulation within U-Q/Pmax profile (i.e AVR + OEL, UEL, PSS) → voltage @ connection point with selectable constant droop</td>
</tr>
<tr>
<td>Priority between active or reactive power</td>
<td>-</td>
<td>As in type C</td>
<td>As in type C</td>
</tr>
</tbody>
</table>

- ≥ 75MW

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Belgian completion

- NC RfG: art. 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24 & 25
- NC RfG specifies only the requirements, doesn’t indicate how this requirements should be used operationally and doesn’t specify how ancillary services should be rewarded
- FTR/RTF & C10/11 requirements are a minimum on top of the minimal requirements set by the NC RfG.

- **Goal:**
  - **Symmetrize the reactive power capabilities** if technical possibilities allow to and without expensive additional cost
  - **Enlarge reactive power control possibilities** if technical possibilities allow to especially on distribution system connected PGMs
Demand Connection Code

1. Hypotheses
2. “As Is” (FTR/RTF)
3. “To Be” (NC DCC)
4. Interpretation & Implementation Goal
## NC DCC

<table>
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<th>NC DCC</th>
<th>Interpretation /Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transmission grid connected demand facilities</strong></td>
<td>• No specific requirements</td>
<td>• <strong>Reactive power range specified by TSO is not larger than 48% of the larger of the maximum import/export capacity</strong> → cos φ 0.9 exception: techno-economical optimization to be proven by <strong>demand facility owner</strong></td>
<td>No position yet</td>
</tr>
<tr>
<td>• The demand facility owner has the right to have a reactive load (cap. or ind.) of 32.90% Pload for each time interval (min. 3.29% P\textsubscript{onderschreven}) → cos φ 0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transmission grid connected distribution systems</strong></td>
<td>• Possibilities on generators as determined by RfG</td>
<td>• Reactive power range specified by TSO is not larger than 48% of the larger of the maximum import/export capacity → cos φ 0.9 exception: techno-economical optimization to be proven by <strong>joint analysis</strong></td>
<td>Joint analysis to be started with relevant Distribution System Operators (DSOs, CDSOs)</td>
</tr>
<tr>
<td>• No specific requirements</td>
<td></td>
<td>• <strong>Reactive power range specified by TSO is not larger than 48% of the larger of the maximum import/export capacity</strong> → cos φ 0.9 exception: techno-economical optimization to be proven by <strong>joint analysis</strong></td>
<td></td>
</tr>
<tr>
<td>• The demand facility owner has the right to have a reactive load (cap. or ind.) of 32.90% Pload for each time interval (min. 3.29% P\textsubscript{onderschreven}) → cos φ 0.95</td>
<td></td>
<td>• TSO may require to actively control Q. Control method shall been agreed between TSO and DSO.</td>
<td></td>
</tr>
</tbody>
</table>
**NC DCC – art 15.1**

\[
\cos \phi = 0.95
\]

3.29\% \( P_{\text{ond.}} \)

\[
\cos \phi = 0.9
\]

100\% max. import/export capacity

Actual FTR Specified by TSO

\[(\text{*) Exceptions are possible but should be proven by demand facility owner or by a joint-analysis for transmission system connected distribution systems.}\]
Belgian completion

- NC DCC: art. 15
- NC DCC specifies only the requirements, doesn’t indicate how this requirements should be used operationally and doesn’t specify how tariffs should be set.
- FTR/RTF requirements as a start point
- Joint analysis in Synergrid to determine requirements with DSOs
- Joint analysis with relevant CDS Operators to determine requirements for CDS
- Goal: reduce reactive power requirements by demand facilities and to enlarge reactive power control capabilities of distribution systems and demand facilities
Agenda Experts Group April 2016
Agenda Experts Group April 2016

- NC RfG
  - Follow-up action points
  - First proposal of NC RfG Belgian completion

- NC DCC
  - Follow-up action points
  - First results on high-level joint-analyses

- NC OS
  - Overview of NC OS articles related to RPM & VC
Thank you for your attention!

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