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Constant Terminal Voltage

Industry Workshop
1st November 2013

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Covering;

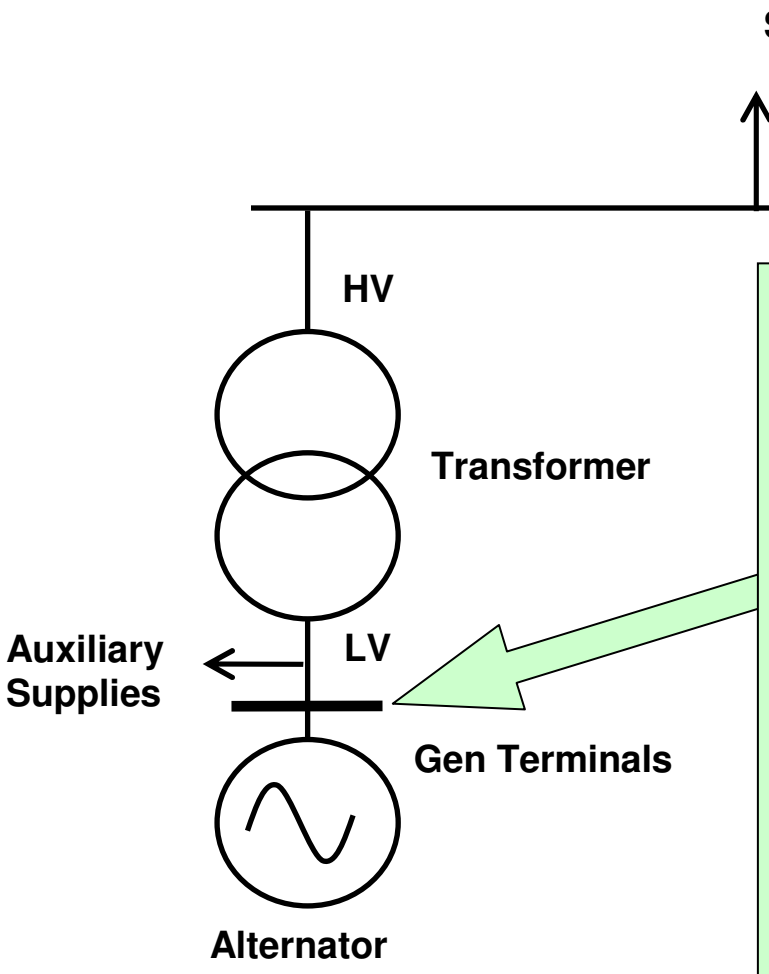
- Reactive Power & Voltage Requirements for **Synchronous Generators** and how the requirements are delivered
- Other countries - A different approach
- Current Issues with meeting the requirement
- What does ENTSO-E RfG say?
- Discussion

Reactive Power & Voltage Requirements for Synchronous Generators

Background:

- Transmission Owner (TO) is responsible for the design of the network and its safety.
- It is the Transmission System Operators (SO) responsibility to maintain a voltage profile across the network.
- Provision of this permits the flow of Active Power across the network.
- The Grid Code specifies reactive capability requirements for Synchronous Generating Units

CC.6.3.2



CC6.3.2 (a)

When supplying **Rated MW** all **Onshore Synchronous Generating Units** must be capable of continuous operation at any point between the limits 0.85 **Power Factor** lagging and 0.95 **Power Factor** leading at the **Onshore Synchronous Generating Unit** terminals. At **Active Power** output levels other than **Rated MW**, all **Onshore Synchronous Generating Units** must be capable of continuous operation at any point between the **Reactive Power** capability limits identified on the **Generator Performance Chart.**

Additionally, CC6.3.2 (a) (i)-(ii) apply where Synchronous Generating units are capable of operating above Rated MW**.**

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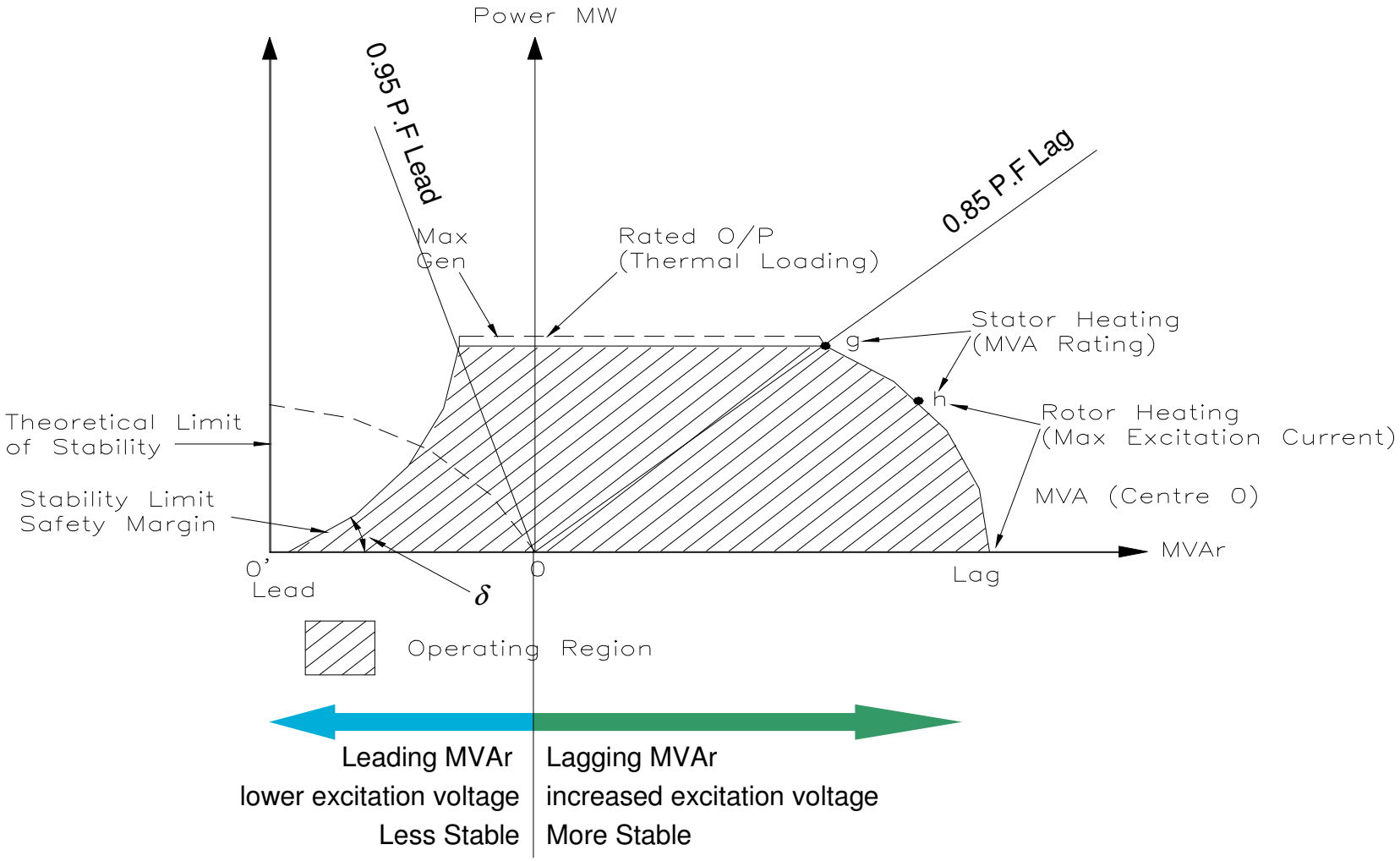
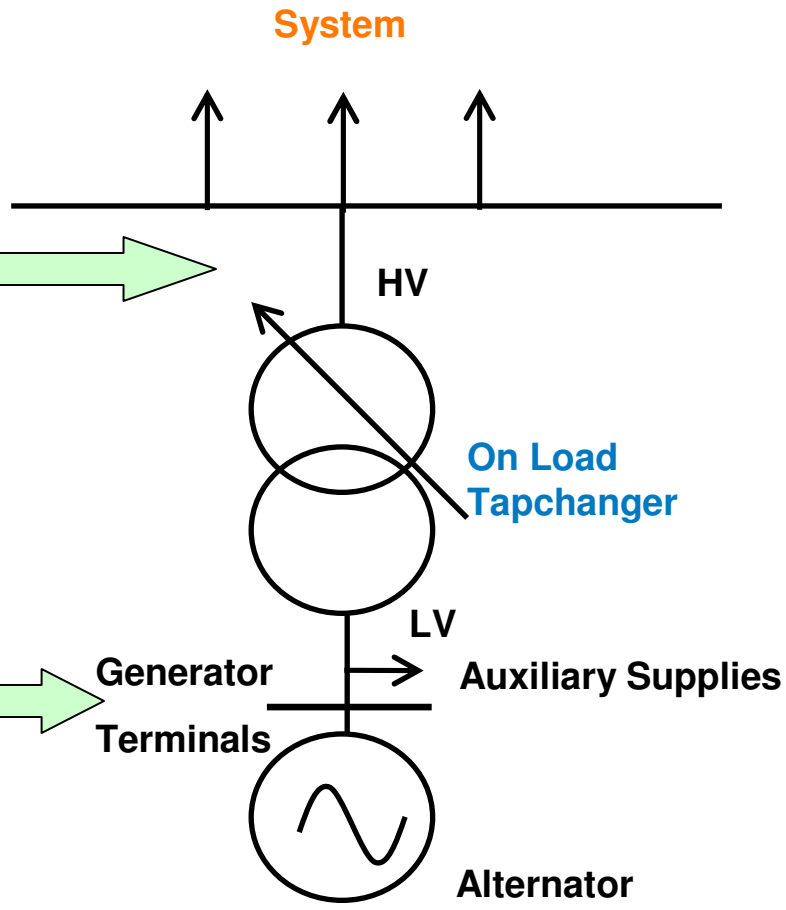
Generator Performance Chart



CC.6.3.4 & CC.6.3.8

CC.6.3.4(a) of the Grid Code requires the **Reactive Power Output** of a Generating Unit under **steady state conditions** should be fully available within the voltage range of **+/-5%** at 400, 275 and 132kV and below.

CC.6.3.8 (a) (i) of the Grid Code requires a **continuously–acting automatic Excitation control system** to provide **Constant Terminal Voltage** control of the **Synchronous Generating Unit** without instability over the entire operating range



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Other countries - A different approach

	GB	North America	Mainland Europe
Historic Position	AVR + Transformer Tapchanger	AVR with adjusted setpoint	AVR with adjusted setpoint
Current Position	AVR + Transformer Tapchanger	AVR with adjusted setpoint	AVR + Transformer Tapchanger

These Grids have:

Different security and operational standards to the GB.

Different Power station design approach with respect to auxiliary supplies

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Issues with meeting the requirement

- Pre-vesting derogations exist for CC.6.3.4.
- Some Generating Units operate permanently at above nominal terminal voltage to achieve full compliance with CC.6.3.4.
- Transformer impedance can greatly affect output seen at HV.
- Manufacturers desire to apply standard products globally.
- Limited transformer tap positions limits system MVAr reserves and could reduce the ability of the Transmission System to recover post fault.

- Generic study:
  - Generating unit with the generator transformer set to fixed nominal tap.
  - Shows it requires a terminal voltage change in excess of +/- 10% to achieve the required reactive range.
  - Problems could arise with Auxiliary Supplies within the station.

Terminal Voltage, tap position and Transformer HV voltage relationship

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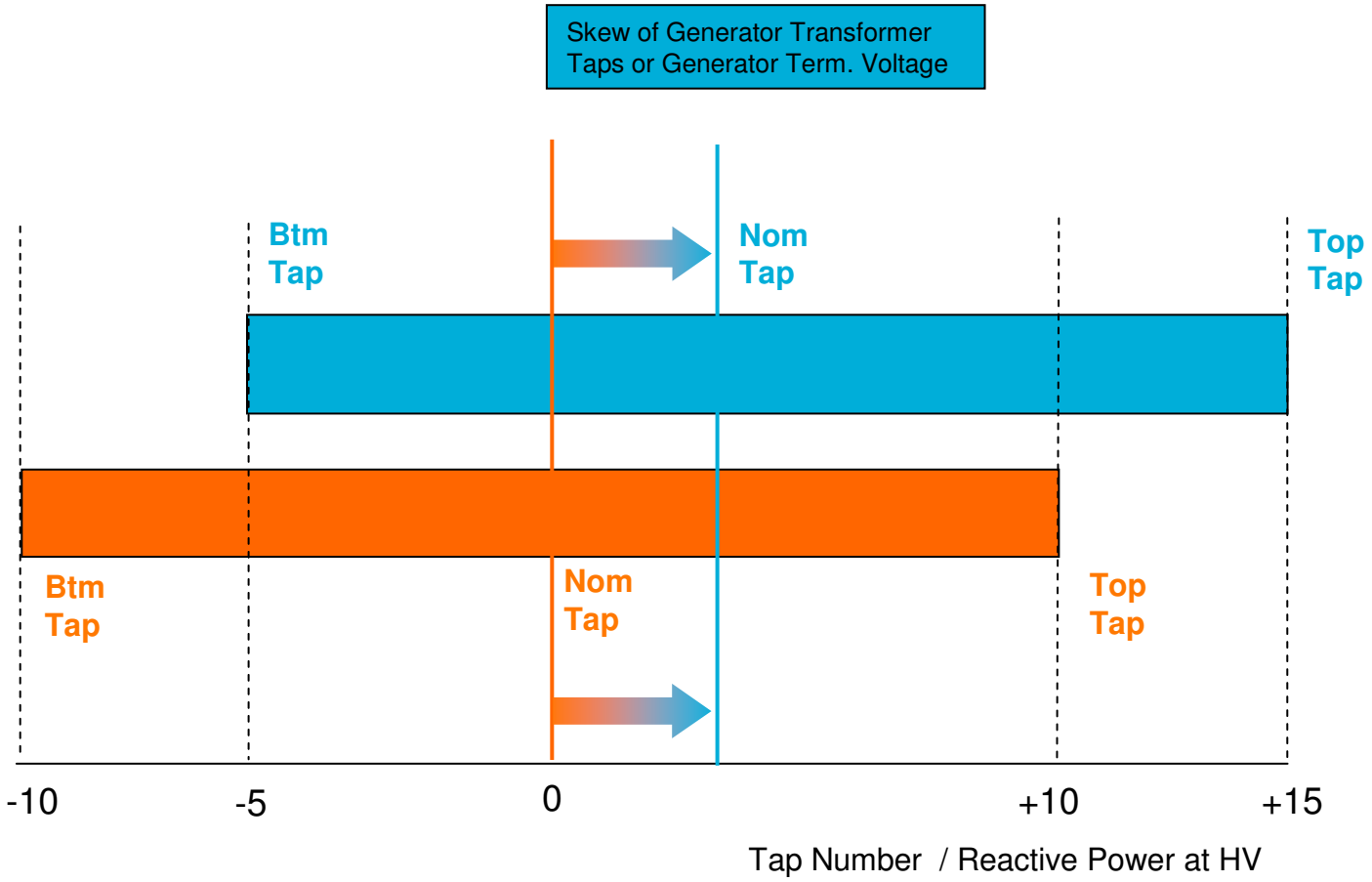
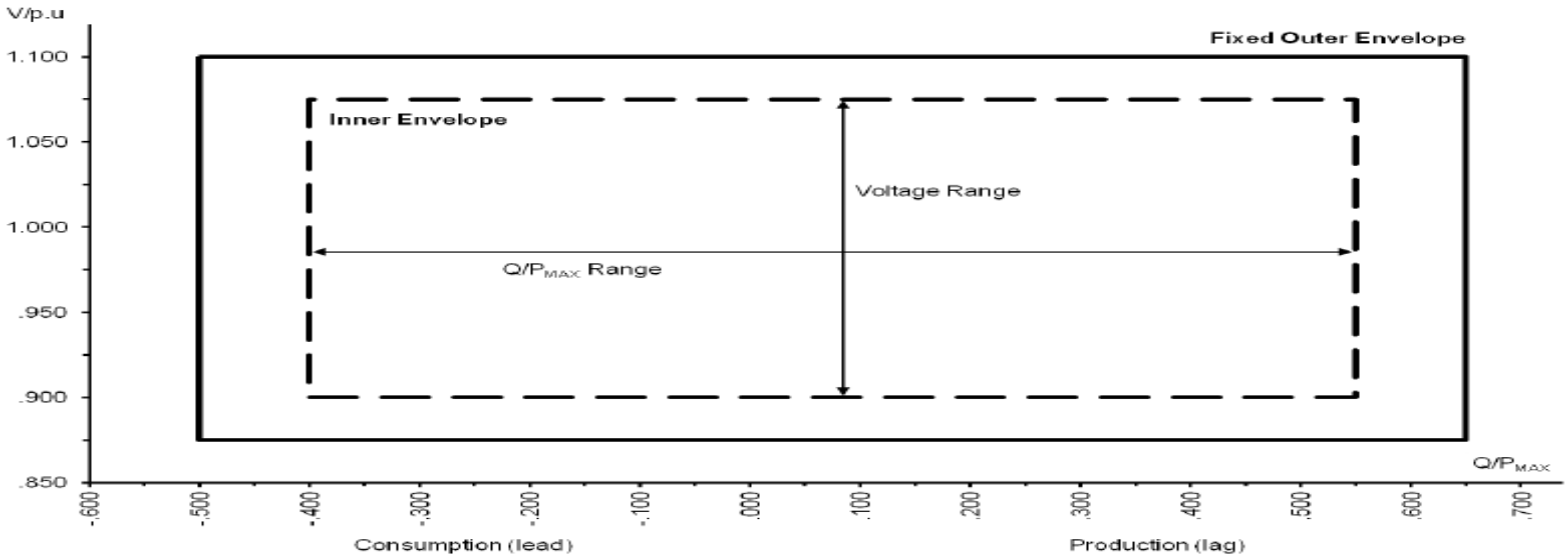


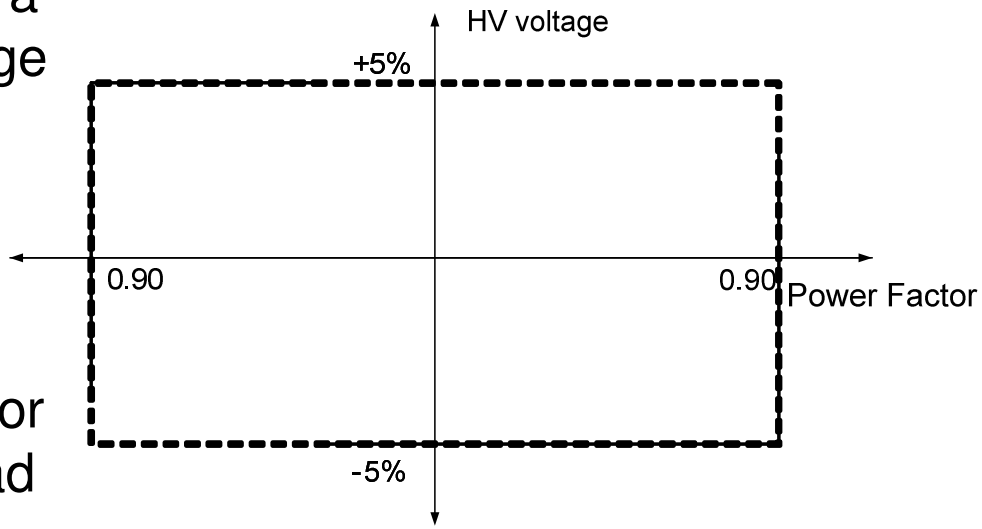
What does ENTSO-E RfG say?

- **Article 13 2(b):** Reactive Power capability at Maximum Capacity
- It defines the reactive capability in terms of a Voltage Q/Pmax profile at the Connection Point (ie at the HV connection point) rather than the Generating Unit terminals
- U-Q/Pmax-profile of a Synchronous Power Generating Module



Applying Article 13.2(b) for GB

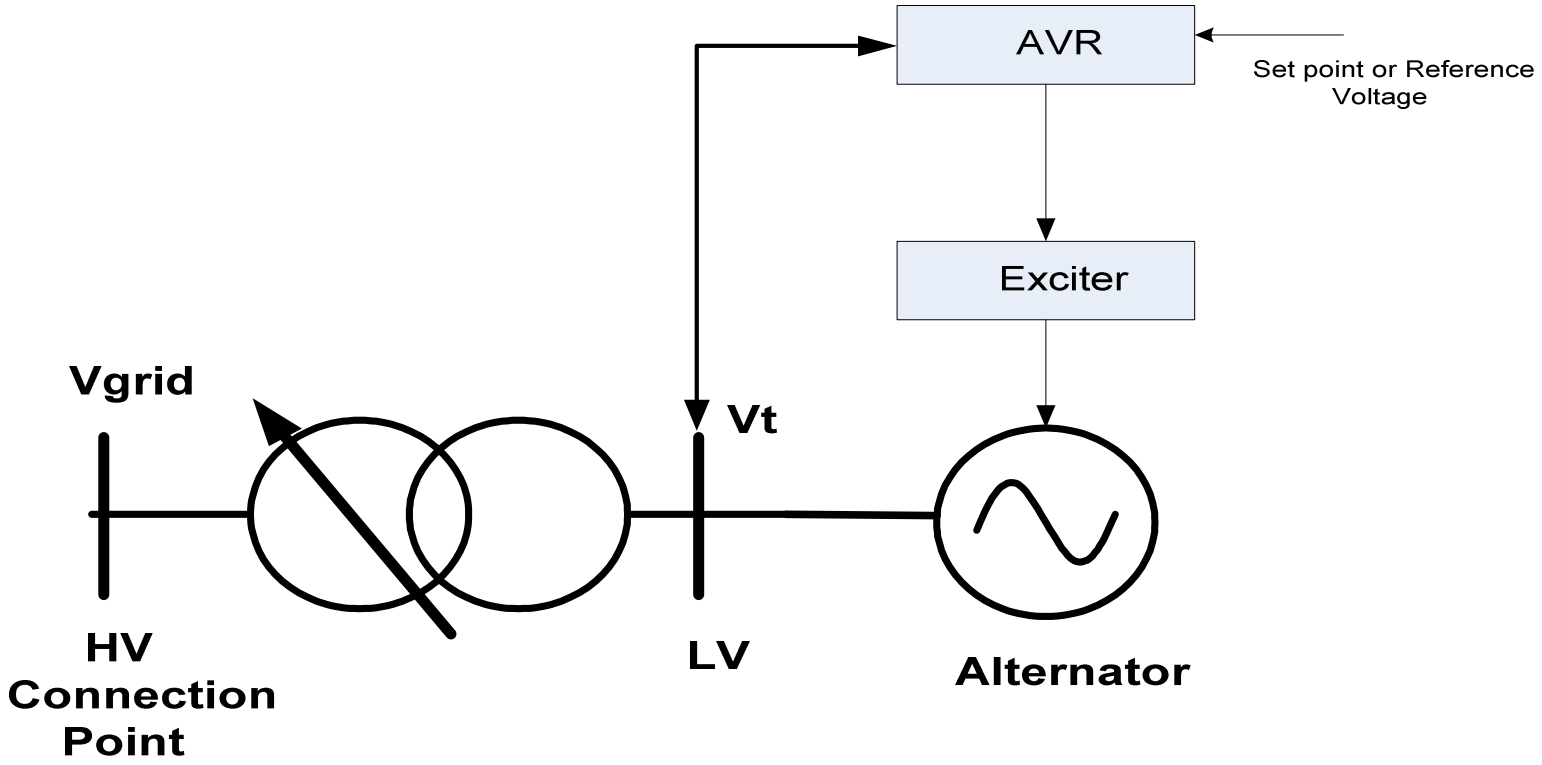
- For GB maximum Q/Pmax range of 0.95 is defined with a maximum steady state voltage range of 0.1 p.u.



- This equates to a power factor range of 0.9 power factor lead to 0.9 power factor lag at the Connection Point (ie HV) over a voltage range of +/-5%.

Applying Article 12.2(b) for GB

- It also requires a generating unit to be equipped with a permanent automatic excitation control system to provide constant Alternator terminal voltage control at a selectable set-point without instability.



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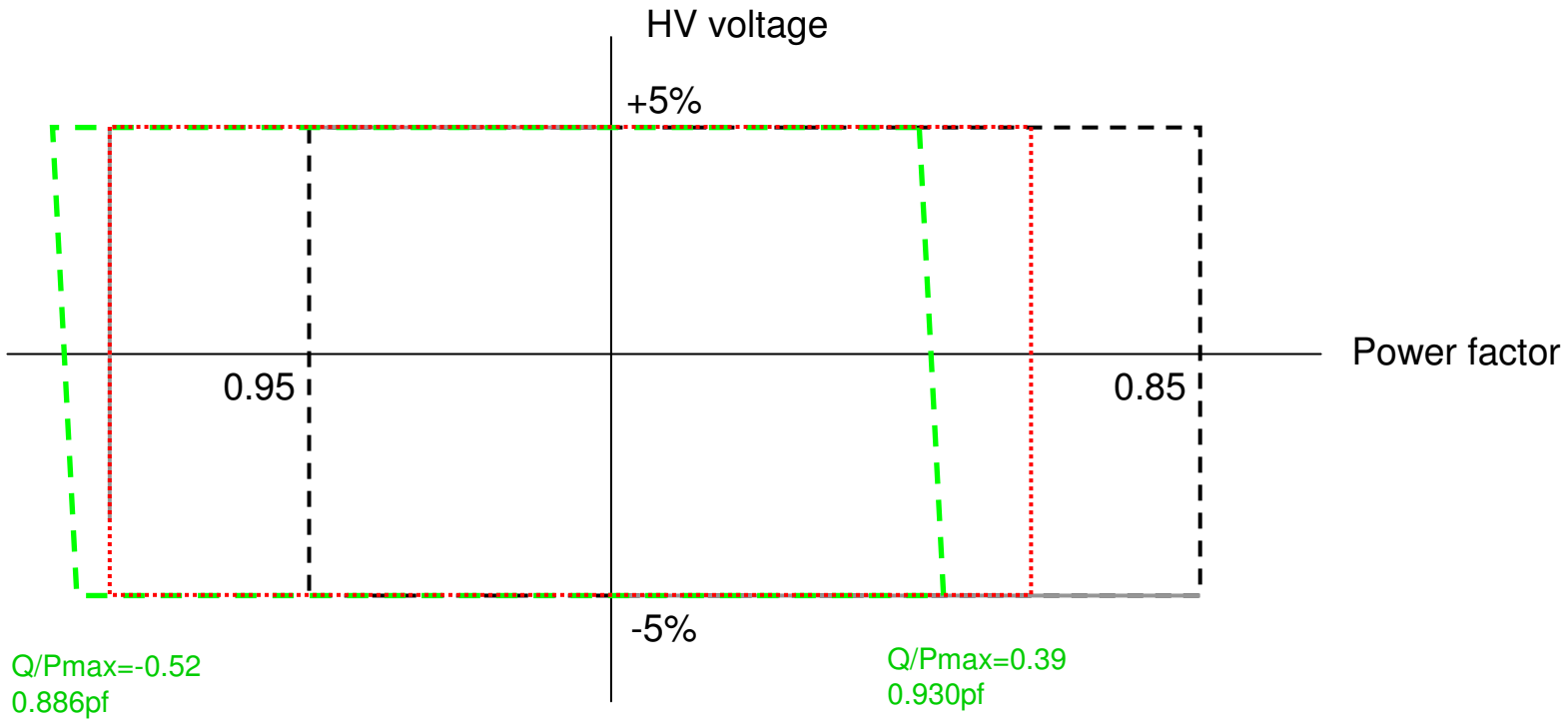
Case: Actual LV / HV Reactive Capability



Current Grid Code requirement (LV)

Translated HV capability

+/-0.9pf position

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Issues

- Clarity required over current GB Grid Code.
- Requirement defined under CC6.3.4 and CC6.3.8 but CC6.3.8 does not indicate at what terminal voltage setpoint the design requirement should be based.
- Manufacturers desire to apply standard products globally.
  - eg. 380kV in Germany vs 400kV in GB.
- Generator Terminal Voltage variation has implications for the data and real time information needed by the System Operator.
- Application of RfG into GB Grid Code.

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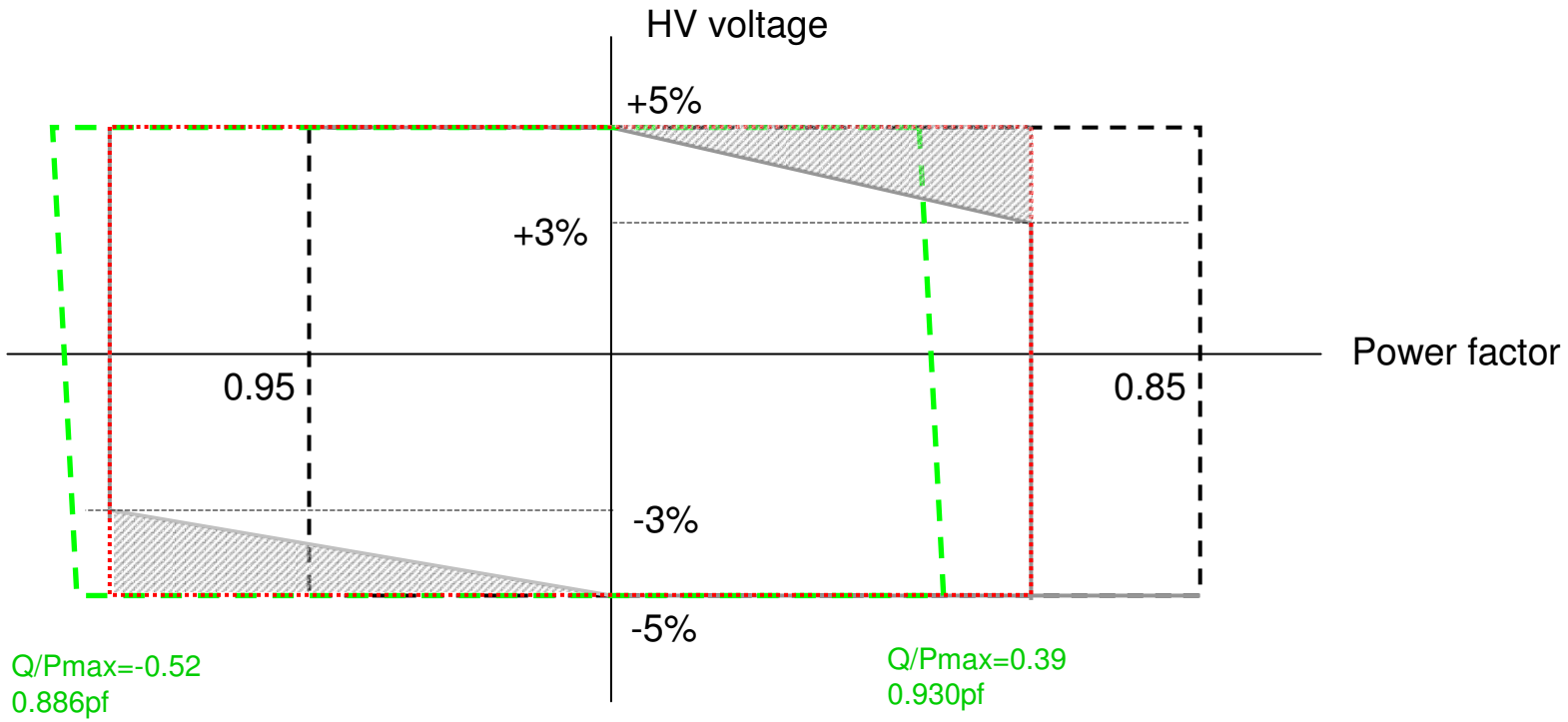

Current Grid Code requirement (LV)

Translated HV capability

+/-0.9pf position

Line for discussion

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Discussion