2016 CIGRÉ USNC International Colloquium
Evolution of power system planning to support connection of generation, distributed resources and alternative technologies

EUROPEAN NETWORK CODES FOR GRID CONNECTION

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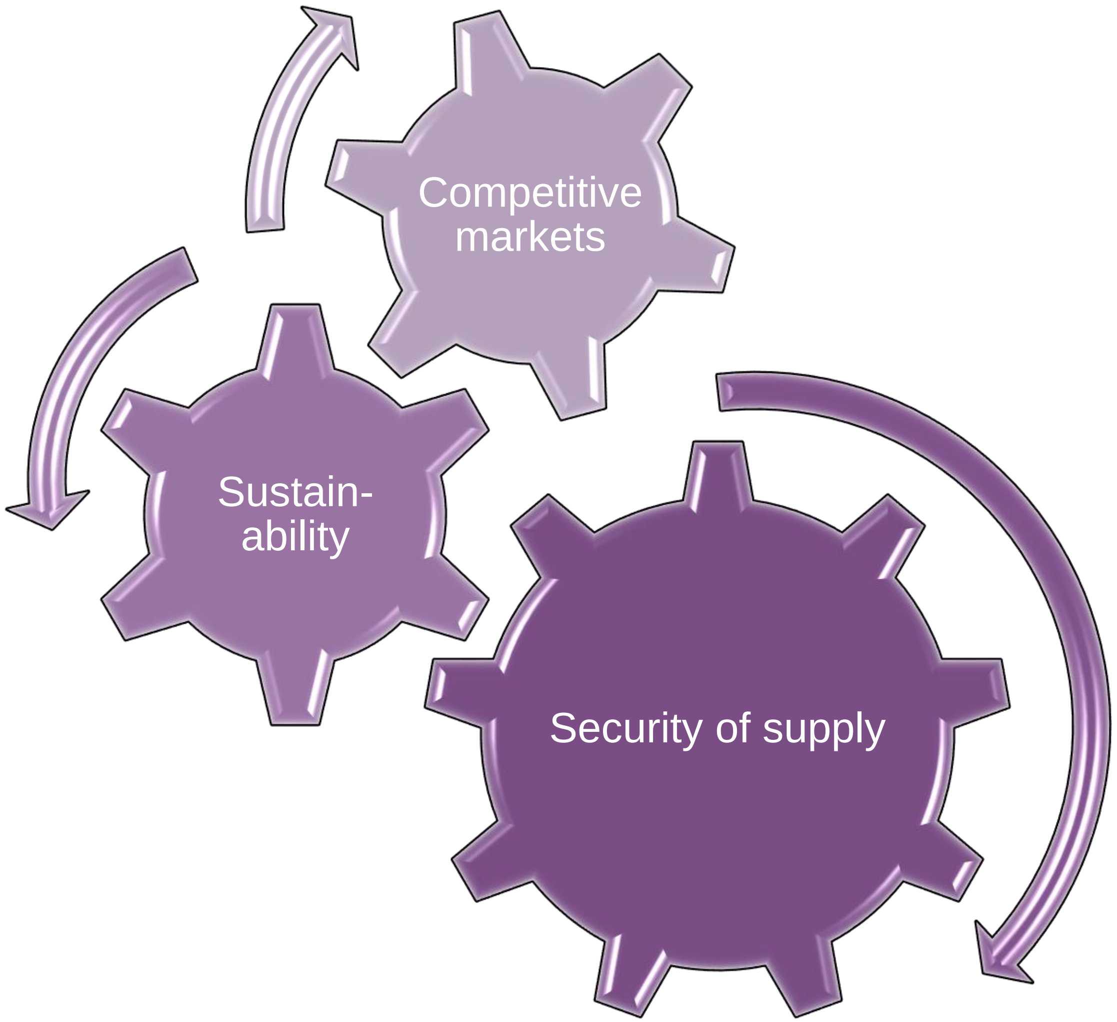
European energy policy objectives

In 2009 “Third package” of the European Commission determined the legislative framework of the European energy supply business:

- Facilitation of a competitive European internal market at all levels of the electrical energy supply chain - generation, transmission, distribution, wholesale and retail.
- Sustainable integration of renewable energy sources (RES) at large scale to decarbonise the electricity sector and to meet ambitious targets of climate protection.
- Ensuring security of supply to all customers at a high level.



Legislative framework for network code development

Three areas of Network Codes shall facilitate the achievement of the energy policy objectives:

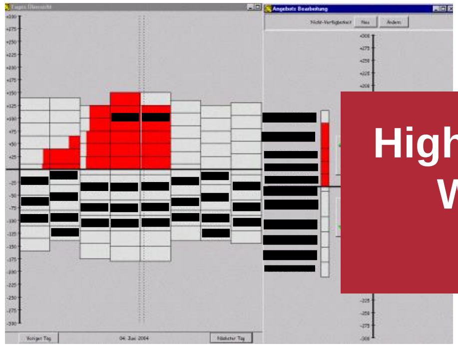
- Grid connection of system users
- System operation
- Market rules

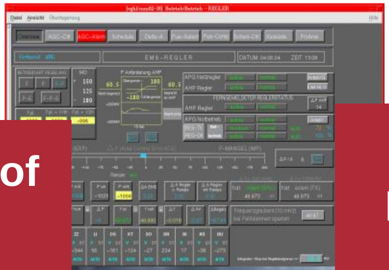
Development of Framework Guidelines (FWGL) — Development of network code — Assessment agreement & entry into force

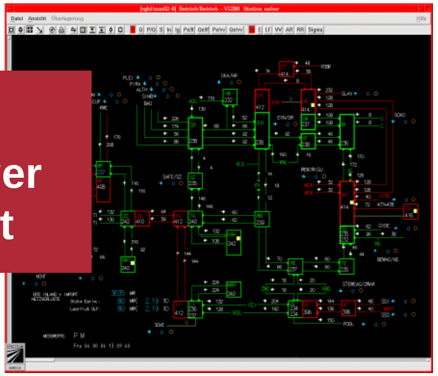
Request to draft a FWGL	Development of the FWGL (6 months)	Request for ENTSO-E to draft a network code	ENTSO-E to develop a network code (12 months)	Assessment of network code	Comitology process
On a topic identified in art. 8 (6) of Regulation 714/ 2009/EC	In consultation with ENTSO-E, stakeholders and ExpertGroup	According to FWGL submitted by ACER	In consultation with stakeholders according to FWGL	Recommendation of network code to the European Commision	In consultation with all stakeholders resulting in a legally binding network code
EC	ACER	EC	ENTSO-E	ACER	EC

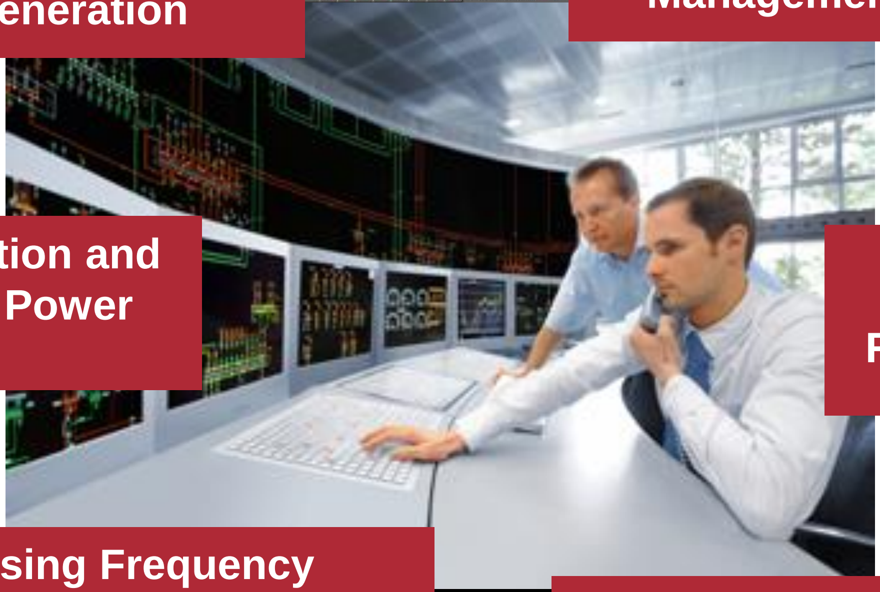
ACER: Agency for the Cooperation of Energy Regulators
EC: European Commission
ENTSO-E: European Network of Transmission System Operators for Electricity

Future system challenges







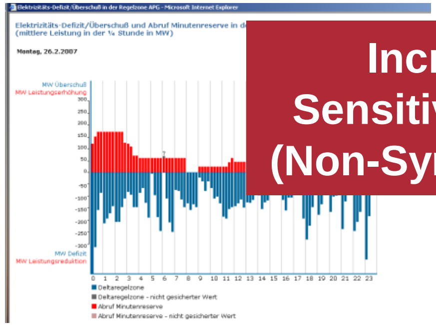


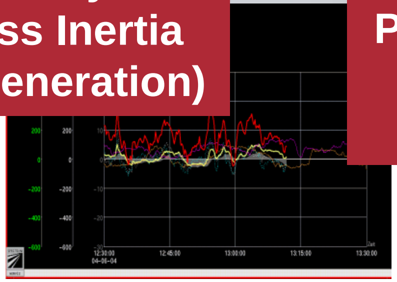
High Penetration of Wind & Solar Generation

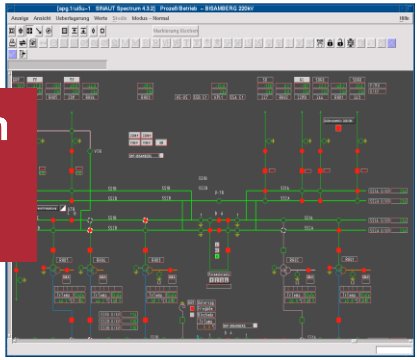
Voltage & Reactive Power Management

Remote Generation and Market-Driven Power Flows

Delays in Grid Reinforcements







Increasing Frequency Sensitivity due to less Inertia (Non-Synchronous Generation)

Priority Dispatch of Renewable Generation

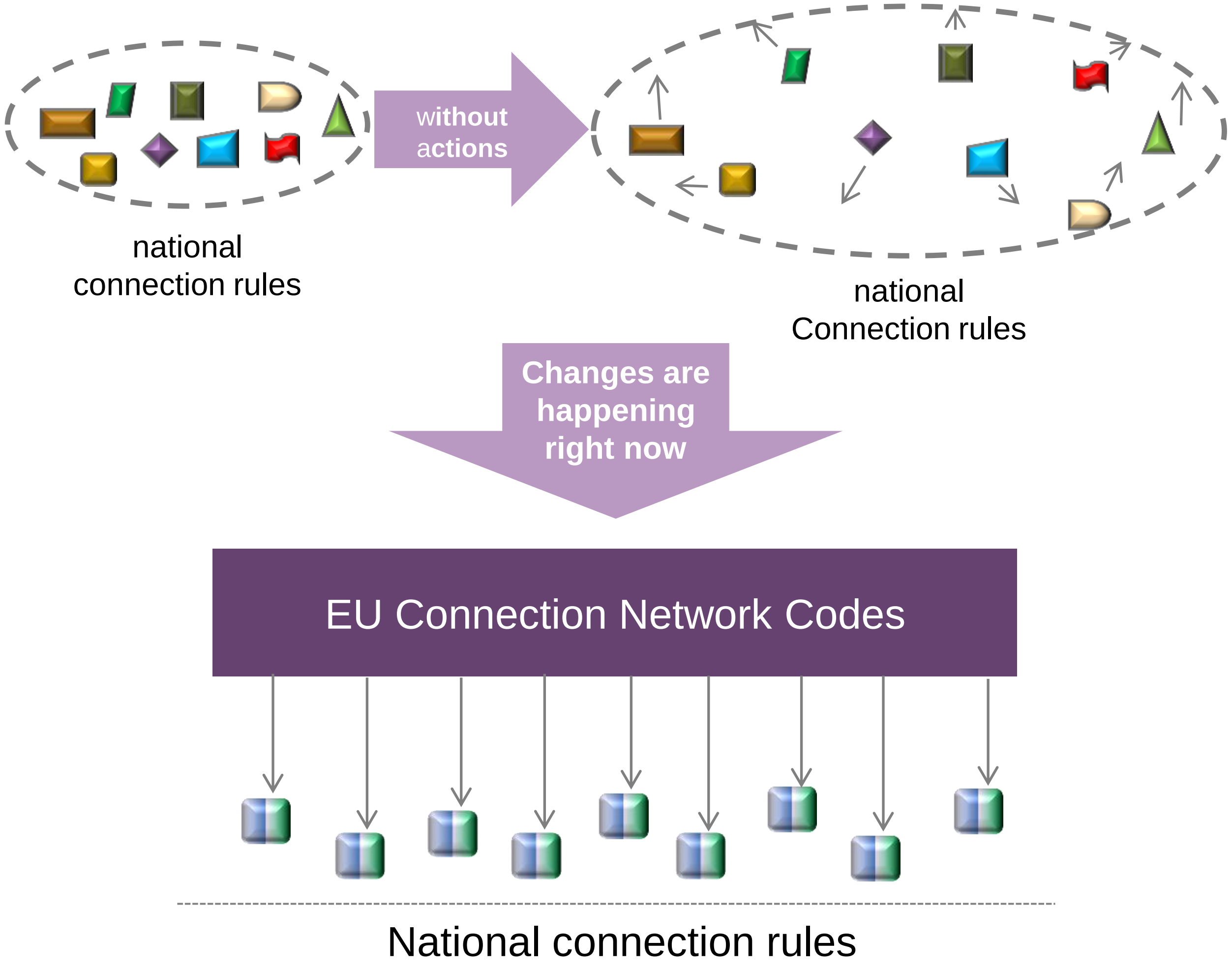
The objective of connection network codes

Build and maintain transmission networks for long-distance power flows

Implementation of market mechanisms to facilitate a single European electricity market

Continuous evolution and coordination of system operation

Stable operation, robustness of and provision of ancillary services by system users



The family of Connection Network Codes

ACER
Agency for the Cooperation of Energy Regulators

Framework Guidelines On Electricity Grid Connections

FG-2011-E-001
20 July 2011

Agency for the Cooperation of Energy Regulators
Trg Republike 3
Ljubljana - Slovenia

European Commission

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Network Codes

Grid connection requirements for generators (RfG)

Grid connection requirements for Demand Connection (DCC)

Grid connection requirements for HVDC systems and DC-connected power park modules (HVDC)

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Coverage of connection network codes

- **General provisions**
  - Definitions
  - Scope of application
  - Regulatory aspects
  - Stakeholder involvement
- **Technical Requirements for Grid Connection**
  - Frequency stability issues
  - Voltage stability issues
  - Robustness of system users
  - System restoration
  - General system management
- **Operational Notification Procedure for Connection**
  - Energisation
  - Interim operation
  - Final operation
- **Compliance**
  - Compliance monitoring
  - Compliance testing
  - Compliance simulations
- **Derogations**
  - Application
  - Approval
  - Revocation
- **Final Provisions**
  - Entry into force and applicability

Principle of non-exhaustive requirements

- To consider adequately regionally varying system characteristics to avoid unreasonably onerous requirements
- A non-exhaustive requirement at European level does not contain all the information or parameters necessary to apply the requirement.
- It needs to be further specified when implementing the Network Code.
- **Site-specific non-exhaustive requirements** to be considered on a case by case basis.
- **Non-exhaustive requirements of general application** to be specified at either a synchronous area or national level through an established process, e.g. grid code review panel, user group, public consultation, regulatory or ministry approval

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RfG features - significant power generating modules (I)

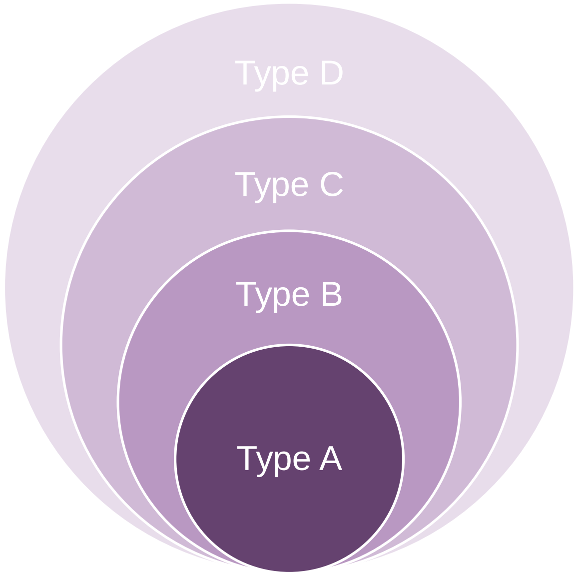
- Generator capabilities are defined from a system performance perspective and are therefore largely independent from technology
- Need to be sustainable to cope with evolutions in generation mix
- Significance is regarded per requirement

Wide-scale network operation and stability including European-wide balancing services

Stable and controllable dynamic response capabilities covering all operational network states

Automated dynamic response and resilience to operational events including system operator control

Basic capabilities to withstand wide-scale critical events; limited automated response/operator control



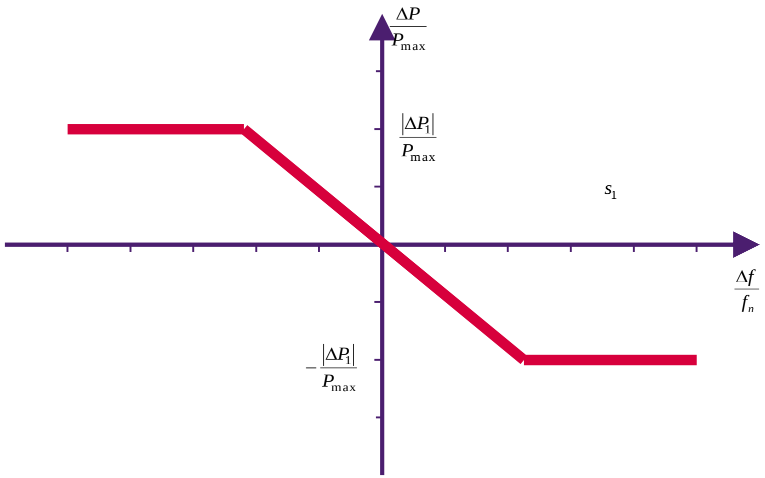
RfG features - significant power generating modules (II)

Synchronous area	Lower threshold for Type A	Maximum lower threshold for Type B	Maximum lower threshold for Type C	Maximum lower threshold for Type D
Continental Europe	0.8 kW	1 MW	50 MW	75 MW
Nordic	0.8 kW	1.5 MW	10 MW	30 MW
Great Britain	0.8 kW	1 MW	50 MW	75 MW
Ireland and NI	0.8 kW	0.1 MW	5 MW	10 MW
Baltic	0.8 kW	0.5 MW	10 MW	15 MW
	and	and	and	or
Voltage level	< 110 kV	< 110 kV	< 110 kV	≥ 110 kV

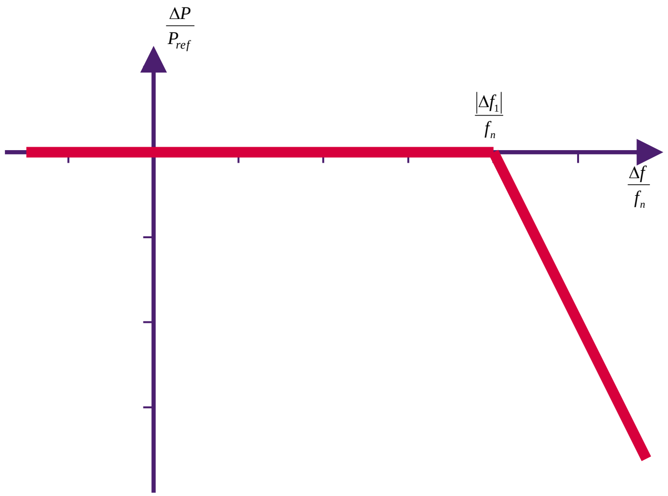
RfG features - frequency stability criteria

	Purpose	Type A	Type B	Type C	Type D
FSM	provision of frequency containment reserve (FCR)			x	x
LFSM-O	provision of additional support in case of over-frequency when FCR is fully deployed	x	x	x	x
LFSM-U	provision of additional support in case of under-frequency when FCR is fully deployed and before load shedding			x	x
Synthetic Inertia*	non-synchronous generators emulating the inertia effect of synchronous generators			x	x

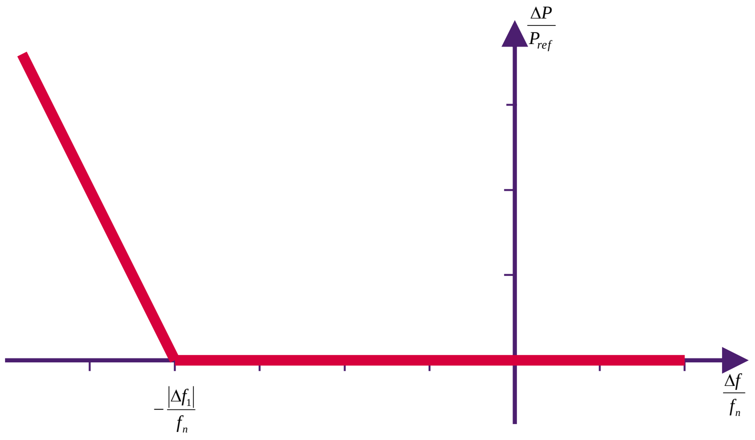
*) optionally required exclusively from power park modules



FSM



LFSM-O



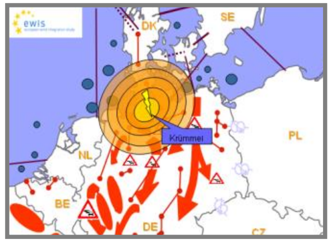
LFSM-U

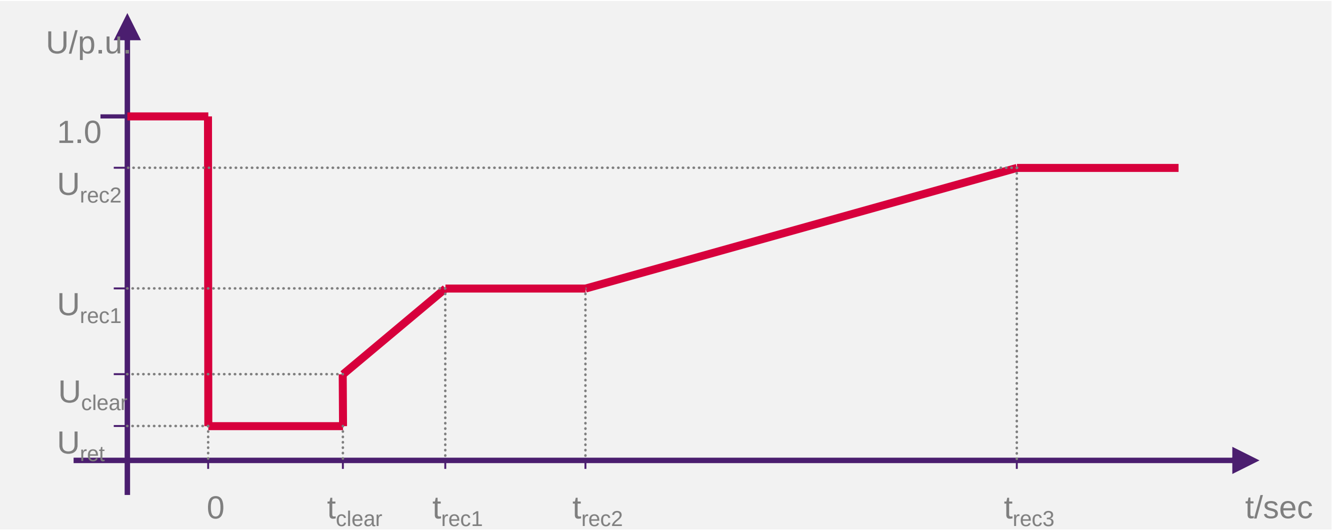
FSM: Frequency sensitive mode LFSM-O: Limited frequency sensitive mode - overfrequency LFSM-U: Limited frequency sensitive mode - underfrequency

RfG features - fault-ride-through capability

	Purpose	Type A	Type B	Type C	Type D
Fault-ride-through (FRT)	power generating modules connected at transmission and distribution level exposed to a single incident to withstand the propagation of voltage dips from faults at transmission level by being capable of remaining connected to the network and continuing stable operation		x	x	x
Fast fault current injection*	fault detection, location and clearance, and maintaining voltage stability		x	x	x
Active power recovery	maintaining frequency stability by restoring load balance		x	x	x

*) optionally required exclusively from power park modules, which in contrast to synchronous power generating modules do not have this capability inherently





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DCC features – reactive power capability at T/D-interface

Consequences of high instantaneous penetration level of renewable energy sources

- Loss of a key source of reactive power for voltage stability by displacement of synchronous generators
- Each system operator needs to take care of reactive power balance in its responsibility area
- Reactive power management needed for transmission connected-distribution systems and demand facilities

Requirements for transmission-connected demand facilities and distribution systems

- Reactive power capability at the connection point to be $1 \geq \cos \varphi > 0{,}9$ of the larger of the maximum active power import or export capacity for both reactive power import and export
- Capability to not export reactive power from the distribution to the transmission system at an active power flow of less than 25% of the maximum import capacity
- Reactive power exchange with the transmission system to be controlled by the distribution system operator (optional requirement)

DCC features – demand response services

Autonomously controlled services to support frequency stability

- Demand response system frequency control
  - Triggered by frequency deviation
  - Effective for temperature controlled demand units
- Demand response very fast active power control
  - Comparable with synthetic inertia
  - Decelerate rate of change of frequency

Remotely controlled services to manage power flows on the network

- Demand response active power control
- Demand response reactive power control
- Demand response transmission constraint management

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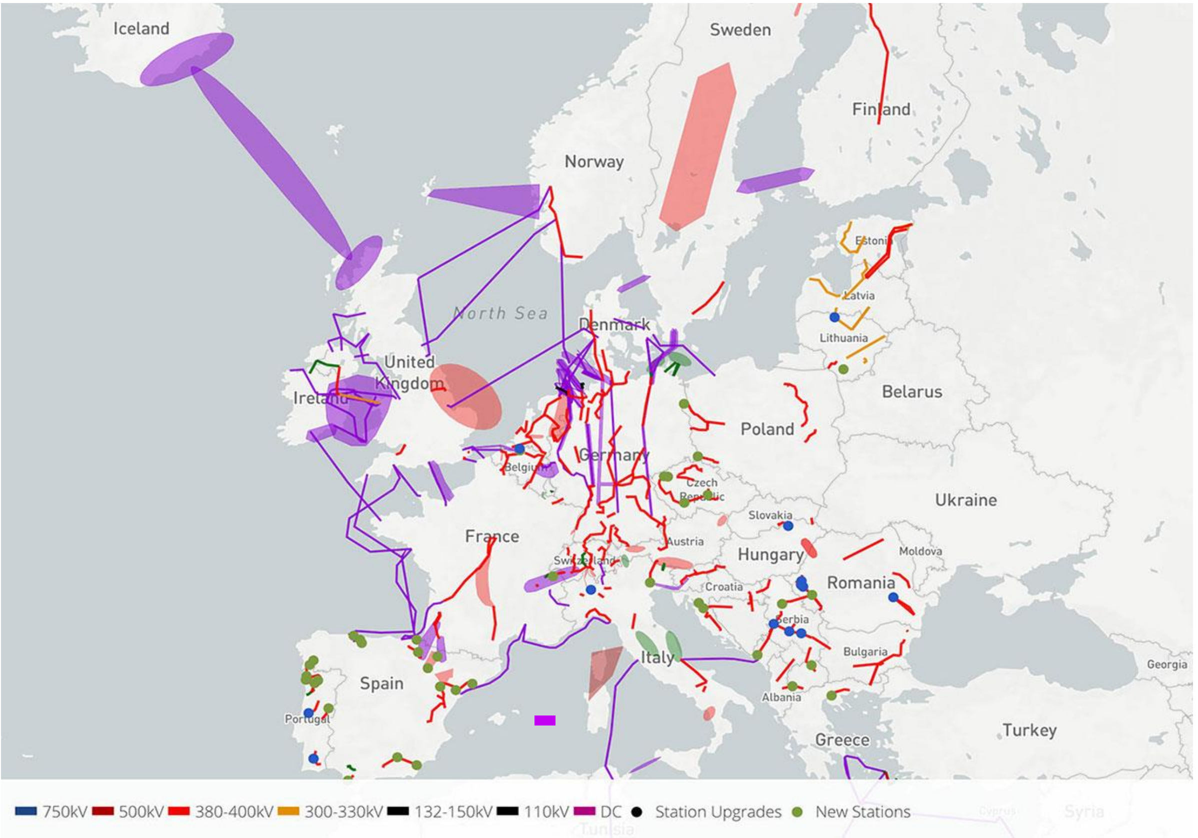
HVDC features - Motivation

Ten Year Network Development Plan (TYNDP) 2016



Projects for the European transmission grid development 2030*

North Sea Offshore Grid Infrastructure 2030

GW	2020	Vision 1	Vision 2	Vision 3	Vision 4
Offshore wind	24.1	30.6	30.8	72.2	79.6
Onshore wind	94.0	110.9	124.7	155.1	154.5

*http://tyndp.entsoe.eu/

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HVDC features – Relevant aspects

REQUIREMENTS

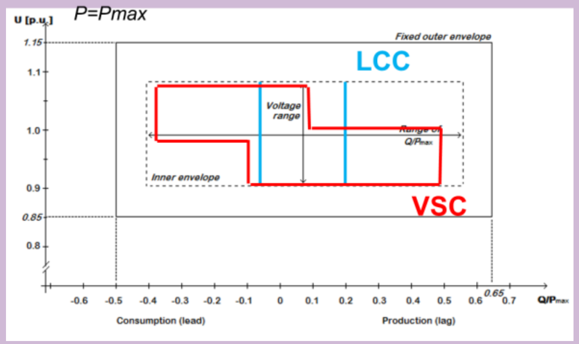
- HVDC systems
- Remote end DC-converters
- DC-connected Power Park Modules

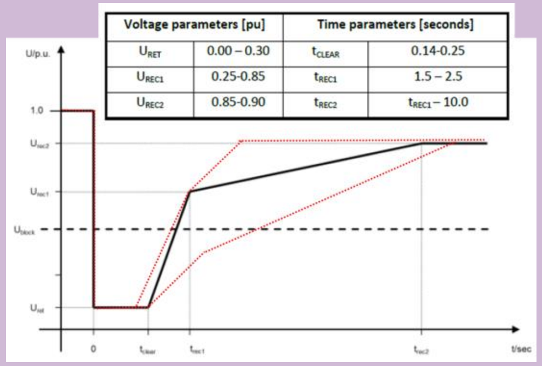
„3 in 1“

Active power and frequency stability	Reactive power and voltage stability	Low voltage fault ride through	Control and protection	System restoration	Information Exchange

All requirements shall apply at the AC-side

Technology neutrality through non-exhaustive requirements: final specifications to be made at national level





Frequency ranges for HVDC system operation are wider than for generators or demand to not disconnect transmission system assets earlier than system users

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Conclusion/Summary

Connection Network Codes …

- … are indispensable to achieve the EU energy policy targets
- … have been developed with a long-term view of evolvement of system characteristics
- … take into account in particular the transition from a electricity supply system based on bulk synchronous generators to a dispersed generation portfolio with high penetration of non-synchronously connected power park modules
- … define sustainable connection requirements for all relevant system users
- … maintain a high level of security of supply

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