Technical Connection Requirements and Compliance Assessment in Hybrid Power Systems

Theofilos Xanthos, FGH GmbH

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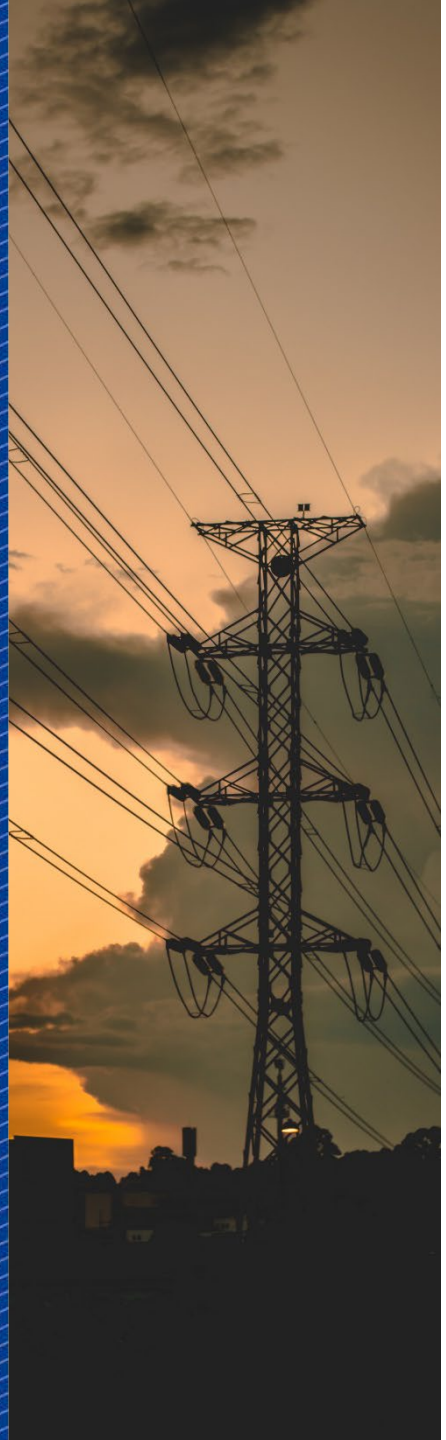


FGH Overview

FGH e.V.

Non-profit research institute with the objective of developing practice-oriented expertise with their members and implementing specialist knowledge in economy, science and training.

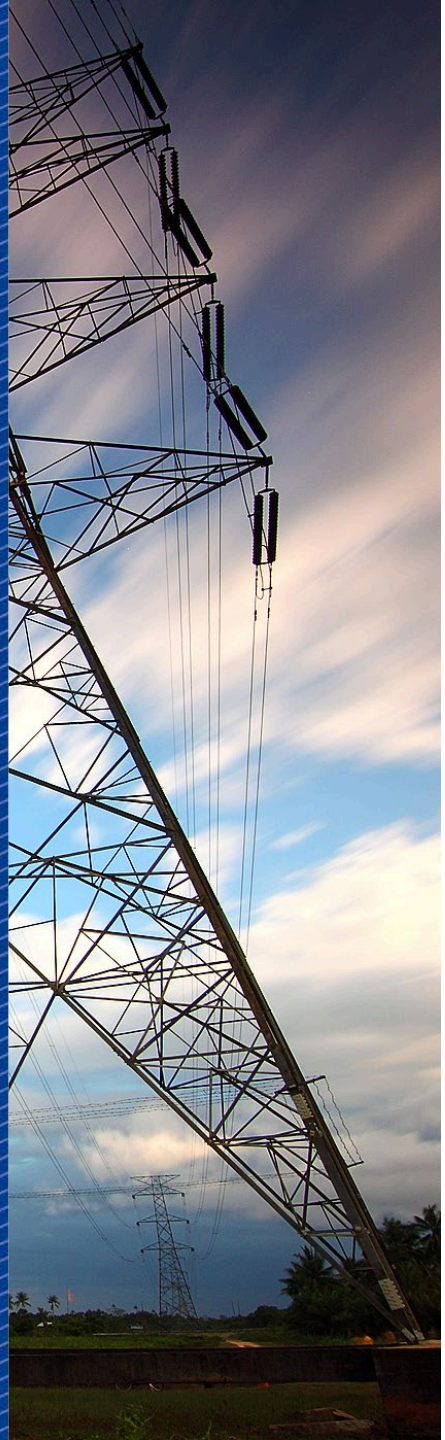
Engineering services provider in the fields of grid planning and one of the leading German companies concerning grid integration of renewable energies and software development, modeling, compliance monitoring.

FGH GmbH

FGH Zertifizierungs-gesellschaft mbH

Testing institute and independent accredited institution for the certification of electrical properties of decetralized power generating plants, units and their components.

FGH



Our Services

Agenda

- Technical requirements for generators
- Specifications related to energy storage systems
- Compliance assessment schemes
- Similarities drawn for non-interconnected systems

Agenda

- **Technical requirements for generators**
- Specifications related to energy storage systems
- Compliance assessment schemes
- Similarities drawn for non-interconnected systems

Technical requirements for generators

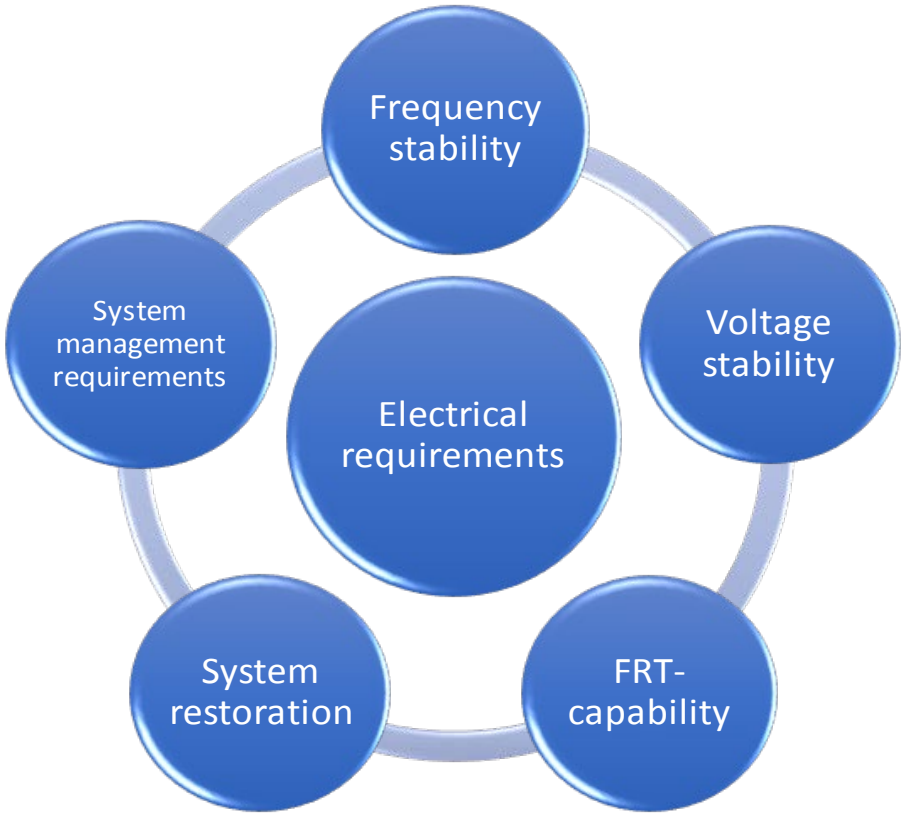
- National implementation of the 2016/631 Commission Regulation (RFG)
- Technical requirements regarding
  - Normal operation
  - Behavior during faults
  - Grid synchronisation requirements
- Requirements set at the level of *Power Generating Module (PGM)*
- Categorization of PGMs based on technology and installed capacity
- Requirements become more complex for each Type

PGM Type	Maximum capacity thresholds
Type A	Voltage at the connection point < 110kV and maximum capacity, 0,8 kW ≤ Pmax < 1MW
Type B	Voltage at the connection point < 110kV and maximum capacity, 1MW ≤ Pmax < 20MW
Type C	Voltage at the connection point < 110kV and maximum capacity, 20MW ≤ Pmax
Type D	Voltage at the connection point ≥ 110kV or maximum capacity, 75MW ≤ Pmax

Source: Greek TSO (IPTO)

Technical requirements for generators

- National implementation of the 2016/631 Commission Regulation (RFG)
- European Standards EN 50549-1/-2: Requirements for generating plants to be connected in parallel with distribution networks (for Types A & B)

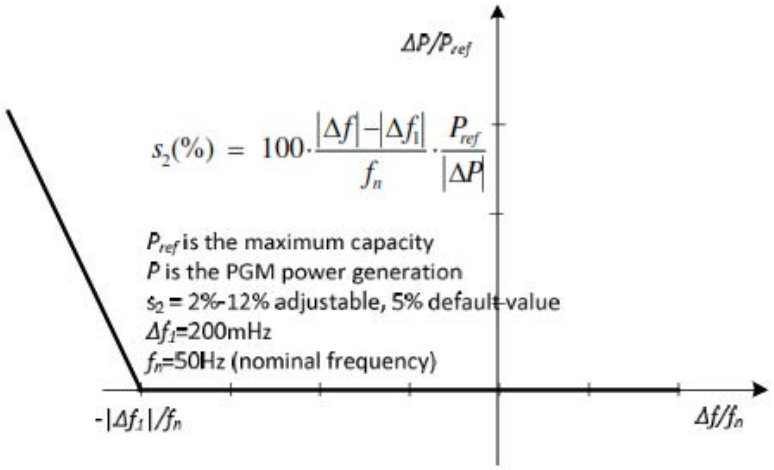


Technical requirements for generators

Frequency stability

- Operational frequency range
- Rate of change of frequency (ROCOF)
- Limited frequency sensitive mode – overfrequency
- Limited frequency sensitive mode – underfrequency (Type C & D)
- Frequency sensitive mode – (Type C & D)

System frequency	Minimum operating time
47,5 Hz – 48,5 Hz	30 min
48,5 Hz – 49,0 Hz	30 min
49,0 Hz – 51,0 Hz	unlimited
51,0 Hz – 51,5 Hz	30 min

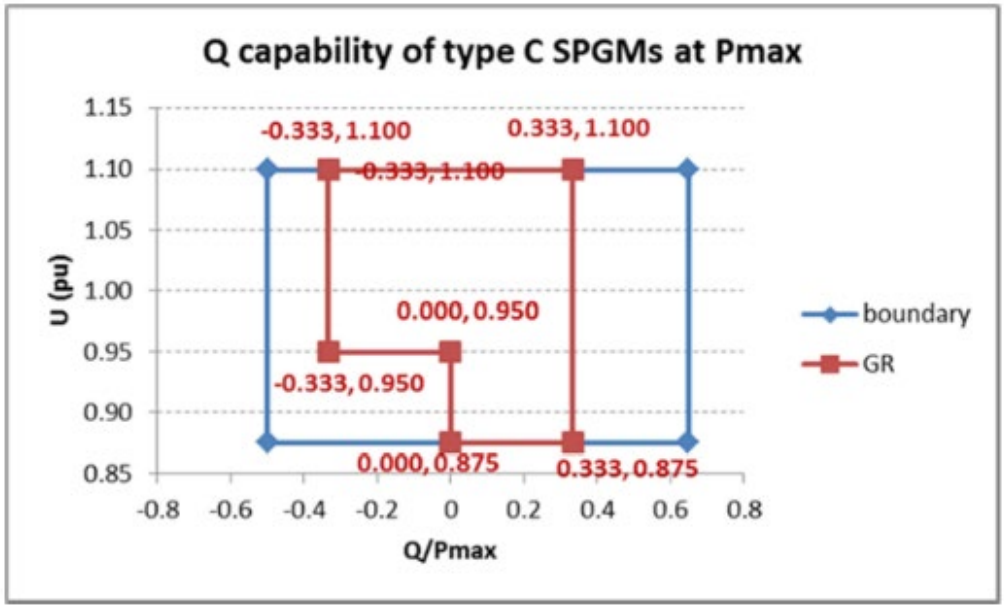


Source: Greek TSO (IPTO)

Technical requirements for generators

Voltage stability

- No operational voltage ranges are defined for PGMs (apart from Type D)
- Contribution of Type B PGMs to be defined by the network operator
- Requirements for Type C and D PGMs defined separately based on the U-Q-P_{max} „envelope graphs“
- Requirements also applicable for $P_{mom} < P_{max}$

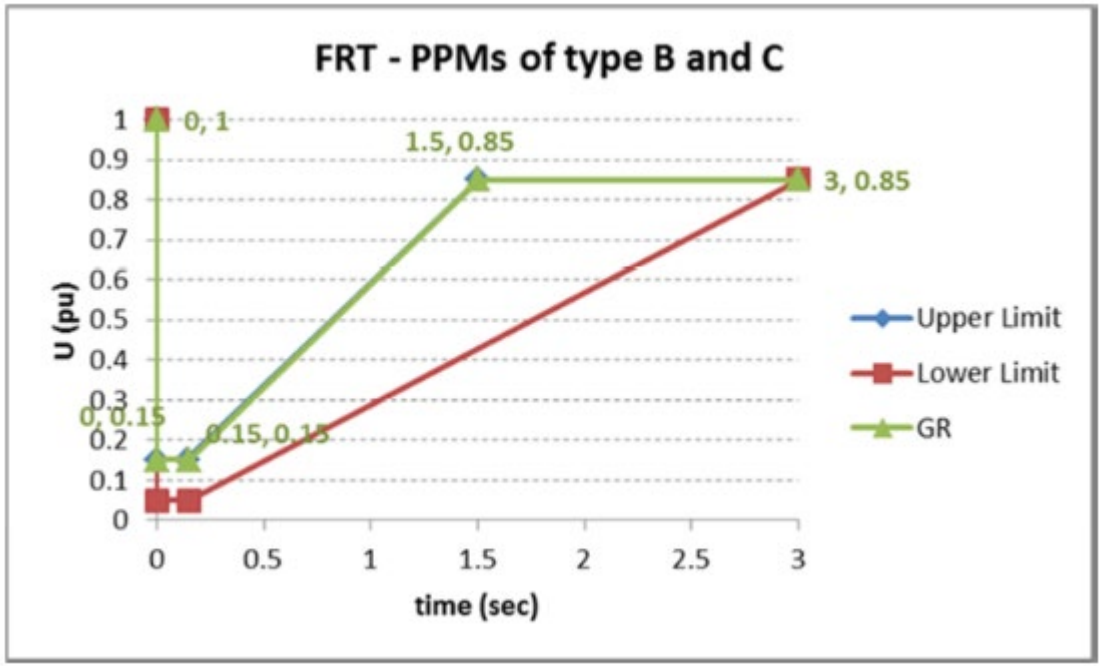


Source: Greek TSO (IPTO)

Technical requirements for generators

Robustness – FRT Capability

- The 2016/631 RFG Regulation only generally defines the LVRT requirement
- Relevant to Type B, C and D PGMs
- The exact form of the FRT diagrams is to be defined by the TSO

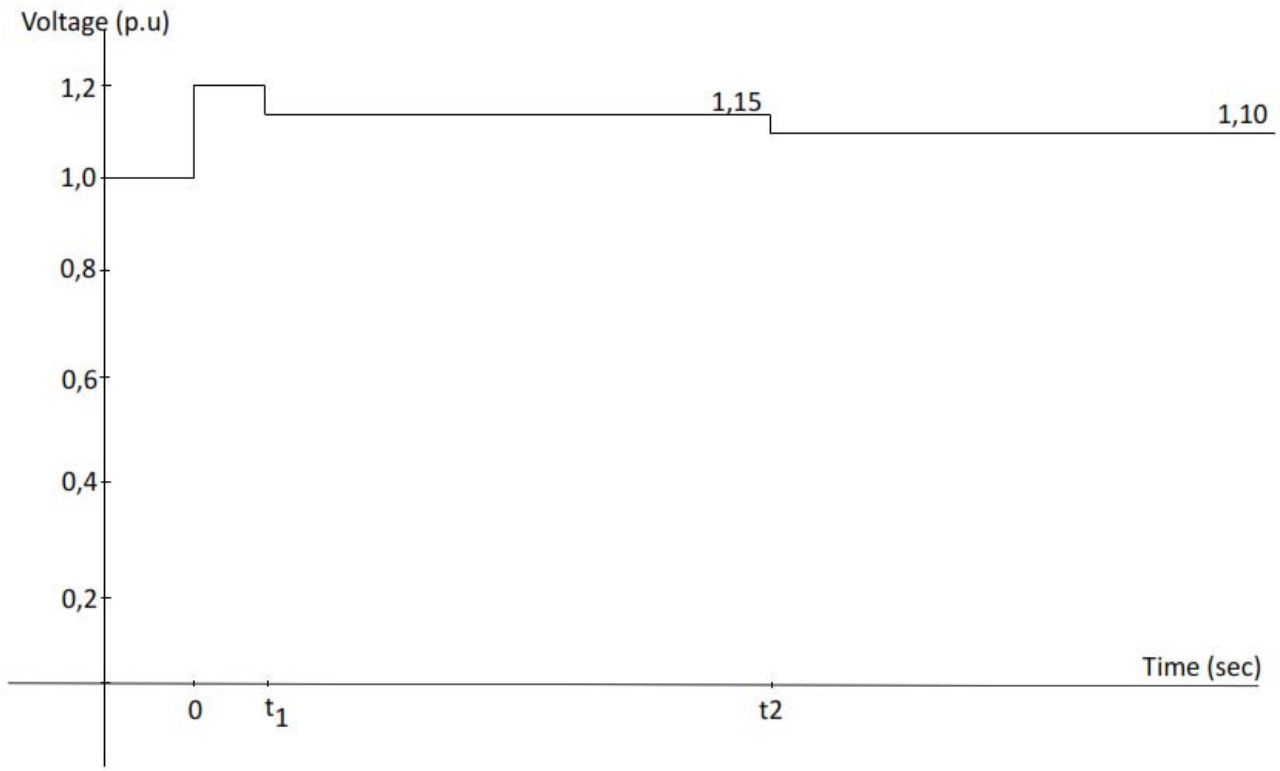


Source: Greek TSO (IPTO)

Technical requirements for generators

Robustness – FRT Capability

- EN 50549-1/-2: Suggest the expansion of LVRT for Type A PGMs
- EN 50549-1/-2: Require the introduction of OVRT for all PGMs
- OVRT is meanwhile state of the art



Technical requirements for generators

Other requirements

- Automated or manual reconnection after grid fault
- Black start capability (Types C and D)
- Islanding mode (Types C and D)
- Participation at system management
- Measured quantities
- Protection schemes
- Validated simulation models (Types C & D)
  - *At the request of the relevant system operator or the relevant TSO, the power-generating facility owner shall provide simulation models which properly reflect the behaviour of the power-generating module in both steady-state and dynamic simulations (50 Hz component) or in electromagnetic transient simulations.*

    Source: Commission Regulation 2016/631

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- Technical requirements for generators
- **Specifications related to energy storage systems**
- Compliance assessment schemes
- Similarities drawn for non-interconnected systems

Specifications related to energy storage systems

- Exclusion of energy storage systems from the RFG Regulation
- Launch of the EG Storage expert group in 2018
- Inclusion of energy storage systems in EN 50549-1/-2
- Differentiation between charging and discharging mode
- A change of mode is allowed
  - LFSM-O
  - LFSM-U

Agenda

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- **Compliance assessment schemes**
- Similarities drawn for non-interconnected systems

Compliance assessment schemes

Background

- Compliance assessment schemes existed before the RFG Regulation
- They target the verification of the compliance to specific requirements
- Methods available
  - Compliance tests
  - Commissioning tests
  - Compliance simulation
  - Compliance monitoring

- **The RFG Regulation introduces a compliance assessment framework, based on installation documents, validated simulation models, equipment certificates and power generating module documents**

Compliance assessment schemes

2016/631 RFG definitions

- Equipment certificate: A document issued by an authorised certifierer for equipment used by a PGM. An equipment certificate may include simulation models, validated against real test results. Equipment certificates are issued through institutes complying to the ISO/IEC 17065 Standard.

- Power generating module document: (PGMD), a document issued by the power generation facility operator (PGFO) including a statement of compliance, detailed technical documentation of the PGM as well as compliance test reports and results of simulation studies assessing steady state and dynamic performance. For Type C and D PGMs, the simulation models discussed are part of the PGMD / operational notification.

Compliance assessment schemes

2016/631 RFG definitions

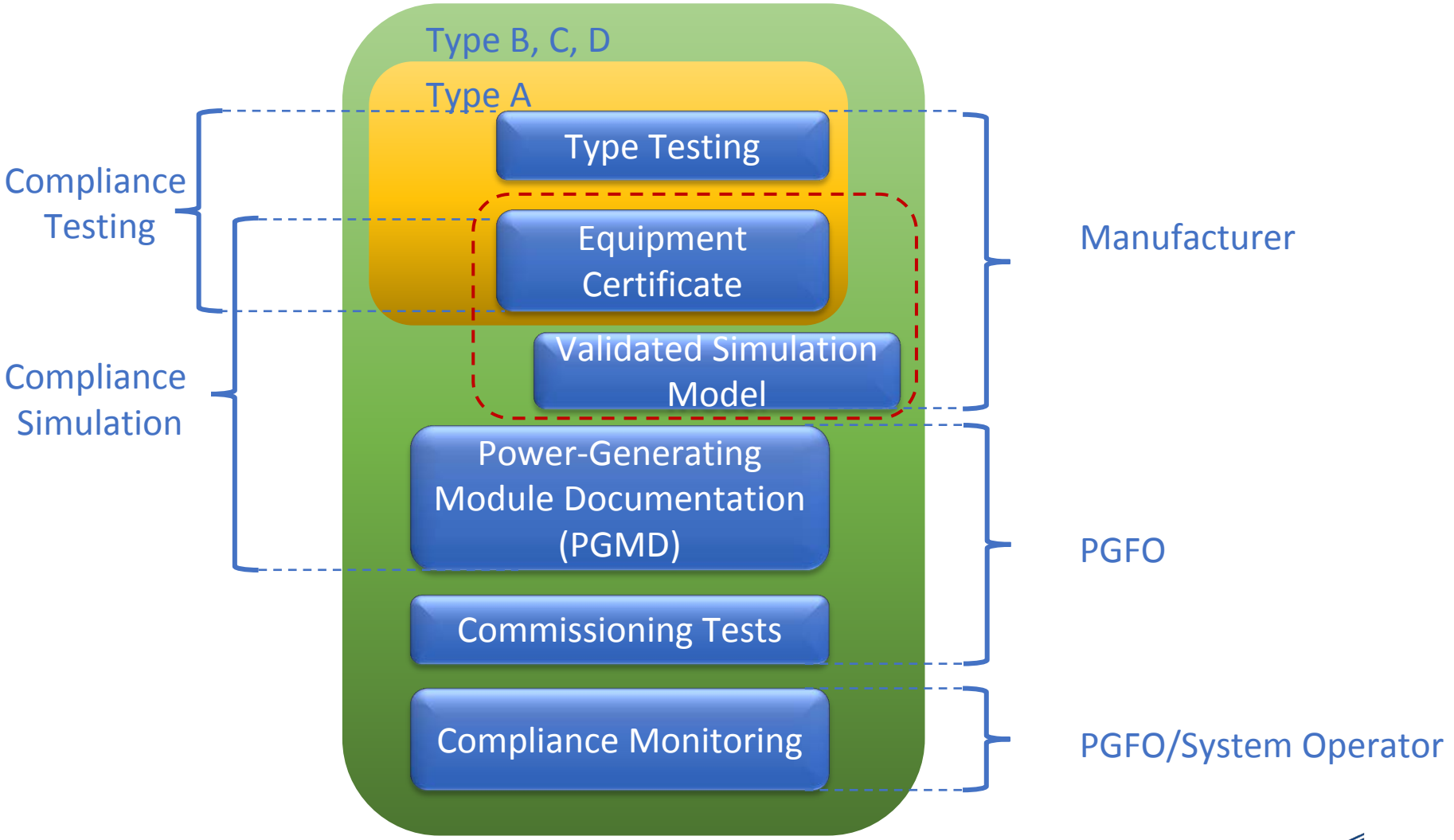
- Example: Requirements for an inverter based Type C PGM:

Compliance tests	Compliance simulations
• LFSM-O response • LFSM-U response • FSM response • Active power control • Frequency restoration control • Reactive power capability • Voltage control mode • Reactive power control mode • Power factor control mode	• LFSM-O response • LFSM-U response • FSM response • Island operation • FRT capability • Post fault active power recovery • Reactive power capability

- Issue: A procedure for accurate, efficient and impartial handling of the PGMD is not clearly defined in the RFG Regulation

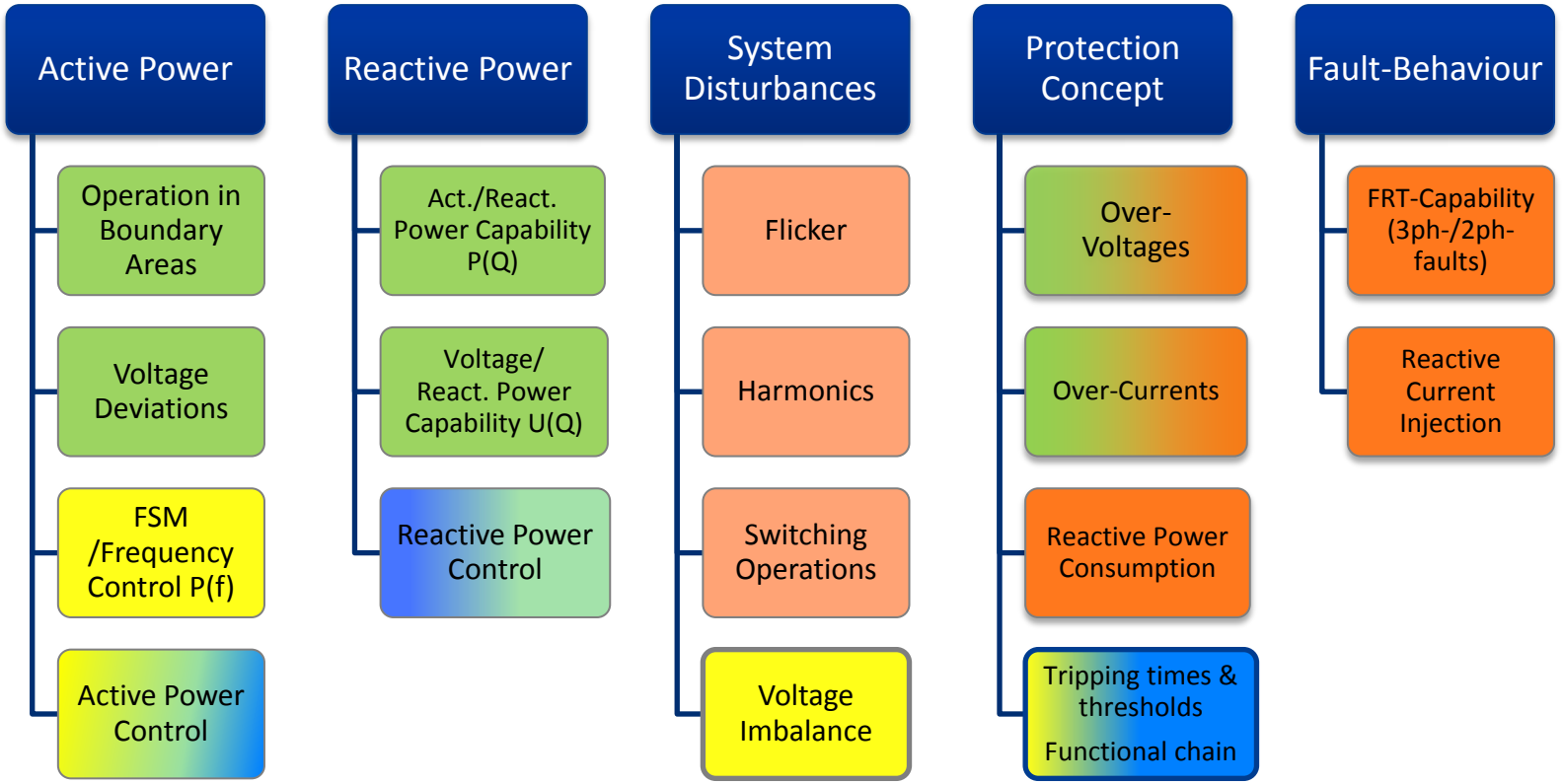
Compliance assessment schemes

An optimized approach



Compliance assessment schemes

An optimized approach



Compliance assessment schemes

An optimized approach

- Independent und impartial third party assessment
- Transparent evaluation scheme embedded in international standards
- High and comparable quality of certification bodies continuously checked by national accreditation authorities vs. non-monitored services
- Efficient, especially for mass PGU production
- No conflict of interests
- Minimizing risks for manufacturer, plant developers/operators & power system operation
- Can provide a compliance monitoring system as requested by the RFG Regulation

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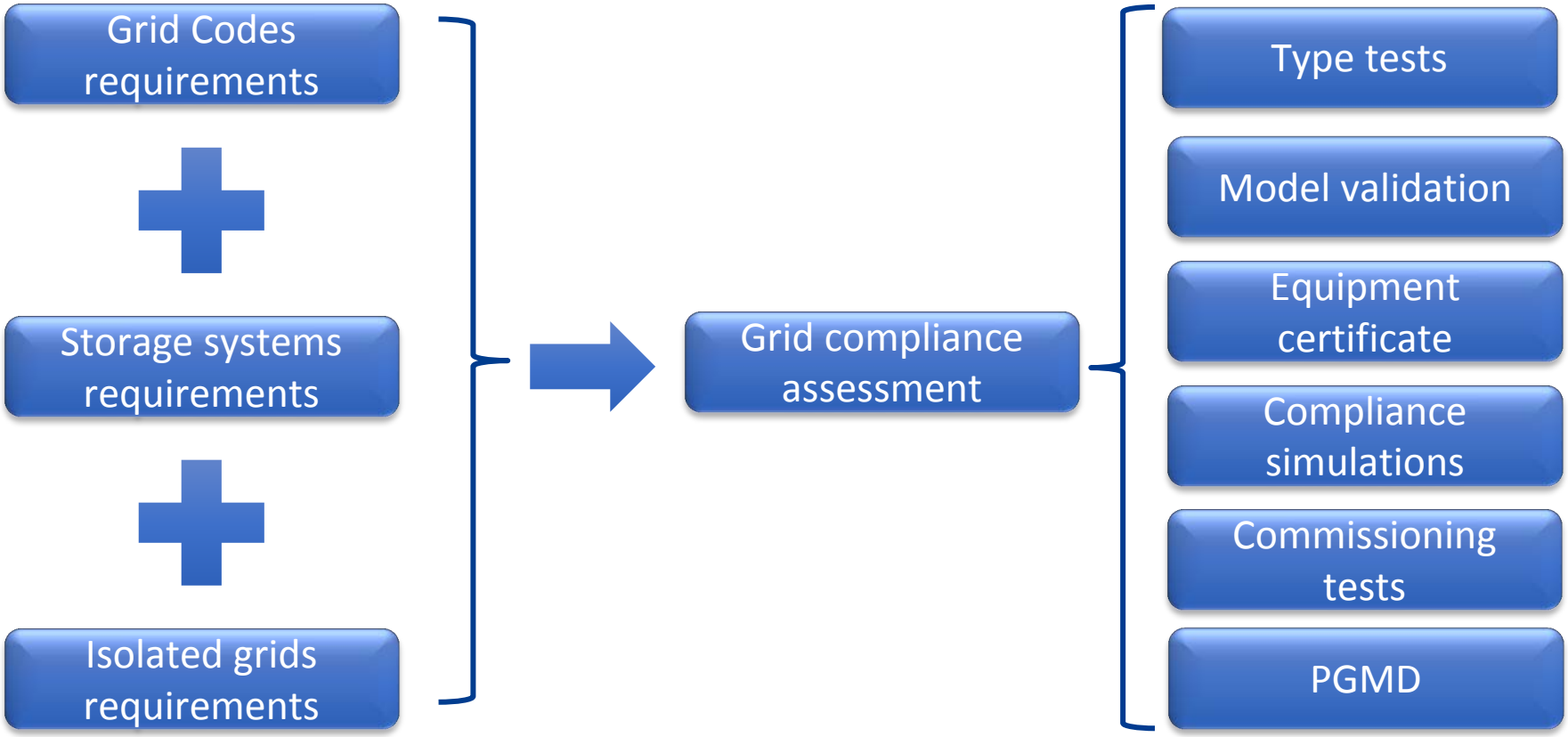
- **Similarities drawn for non-interconnected systems**

Similarities drawn for non-interconnected systems

- Exclusion of non-interconnected systems from the RFG Regulation
- Inclusion of non-interconnected systems in EN 50549-1/-2
  - *„For small isolated distribution networks (typically on islands), even more stringent time periods and frequency ranges may be required“*
  - *„For small isolated distribution networks (typically on islands), higher ROCOF immunity values may be needed“*
- Through the national implementation of the standards, this framework may become binding for non-interconnected systems
- As there is a trend of interconnection of islanded systems, early adaptation to the confirmity assessment schemes offers a uniform approach
- No barriers where identified in the Greek non-interconnected islands code regarding the introduction of such a compliance assessment process
- In fact there are already references to **equipment certificates** for PV and wind issued through an **accredited institute**

Source: EN 50549-2 Standard

Summary


Grid Codes requirements
Storage systems requirements
Isolated grids requirements
Grid compliance assessment
Type tests
Model validation
Equipment certificate
Compliance simulations
Commissioning tests
PGMD

Thank you for your attention !

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