Danish Energy Agency

ERAV
Electricity Regulatory Authority of Vietnam

Grid Codes: Recommendations for Closing Gaps in Current Grid Codes

October 2020

EVNNLDC

ENERGINET
ASSOCIATED ACTIVITIES

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Document history

Rev.	Date	Author	Reviewer	Description
0.0	2020.06.28	Knud Johansen	ERAV, DEA	Draft document released for comments
0.1	2020.07.06	Knud Johansen	ERAV, DEA	Section 1: clarification on application of certificates Section 6.6: Interconnector Code added Section 6.9.3: KPI for NLDC / ISO added Section 7: Recommendations for gap closing - added
0.2	2020.10.02	Knud Johansen	ERAV, DEA	Language review and corrections – all sections. Section 4.2 C55 added to the list of applicable documents Section 6.1.5 moved to section 10 – Annex 1 Section 6.4 added details and reference to the VN C55 Section 6.5 added details on grid planning code activities Section 7 corrected to the adjustments of report D3.2 and ranked in priority in each of the recommended steps.
0.3	2020.10.05	Knud Johansen	ERAV, DEA	Section 5.3 added from report D3.2, section 6.2. Section 7 corrected accordingly.
1.0	2020.10.08	Knud Johansen	ERAV	Document released for final comments.

1. Acronyms

The table includes acronyms used in this document.

AS	Ancillary Services
C21	Circular 21 - On regulating the pricing method for electric power system's ancillary services and the procedure for scrutinizing a contract for provision of electric power system’s ancillary services.
C25	Circular 25 – The regulations on electricity transmission system
C28	Circular 28 – The document states operational procedures for handling incidents
C39	Circular 39 – The regulations on electricity distribution system
C40	Circular 40 – The procedure for dispatching of national power system
C55	Circular 55 – Technical requirements and management and operation of the SCADA system
CGM	ENTSO-E Common Grid Model
DSO	Distribution System Operator
Dx	Distribution system
EAPP	Eastern Africa Power Pool
EMT	Electromagnetic Transient
GC	Grid Code
GL	European - Guideline
ISO	Independent System Operator (NLDC)
NC	European - Network Code
NC ER	Network Code for Emergency and system Restoration
NC HVDC	Network Code for HVDC systems
NC RfG	Network Code for connecting all kinds of generators
NLDC	National Load Dispatch Centre
RMS	Root Mean Square
RSO	Relevant System Operator – could be a TSO, DSO depending on the specific grid
RTO	Regional Transmission System Operator
SAOA	Synchronous Area Operational Agreement
SCR	Short Circuit Ratio
SO GL	EU System Operational Guideline
TSO	Transmission System Operator
Tx	Transmission system
TYNDP	ENTSO-E Ten Years Network Development Plan
VN	Vietnamese

2. Introduction

Based on a review of the current VN grid code documents, this document highlights some weak and missing specifications in the connection and operational grid code specifications. Any other grid codes are not the focus of this report. It should also be emphasized that there might be more missing elements than observed in this first review so it might be proposed to perform such reviews on a regular basis or at least for each maintenance cycle of the VN GC.

This document provides a comparison of current grid code regulation in VN to international regulation, especially European/Danish rules, looking primarily at the content of these grid codes. A more detailed analysis of the structure can be found in the report for delivery 3.1 according to the VN DEEP DE2 ToR agreement.

The purpose is to compare existing VN grid codes with the referenced documents and point out differences related to the content of each one at article level.

Based on the resulting list of content differences, this document includes recommendations for revisions of specific points in future releases of the VN GC documents.

3. Scope of document

With knowledge of international regulation, especially European/Danish rules, focus on the content of the VN regulations and identify content lacking in existing VN grid codes.

Based on identified gaps, propose a structure, requirements, and basic content for each gap.

Based on industry needs and legal circumstance of VN, ERAV will determine which gaps to close and the order of closing the selected gaps.

This document is provided as deliverable 3.3 according to the VN DEPP DE2 ToR agreement.

4. Grid codes in Vietnam

VN regulation for the power sector consists of the following documents.

- Regulation on licensing of power producers, transmission system operators, regional transmission system operators, distribution system operators, wholesale, and retailers
- Regulation on grid connection - minimum technical requirements, responsibilities of relevant parties involved in the connection process
- Regulation on system operation - transmission system, distribution system
- Regulation on operational procedures for system security, system balancing (generation and demand) in real time, dimensioning of ancillary services and reserve dimensioning, incident classification
- Market regulation on generation: market rules; market procedures; capacity calculation, capacity pricing; metering code; settlement of disputes
- Regulation on tariffs for generation, transmission, distribution, and end-users
- Regulation on PPA contracts

The grid code documents of relevance for this report on grid connection and system operation are listed in the following section.

4.1 Grid connection codes

C25 Circular 25 – "The regulations on electricity transmission system"
The document states a mix of requirements among others some of the requirements to be met in order to be granted a grid connection, some other requirements to the transmission grid system operator as well as requirements for grid system operation and providers of ancillary services. The document also includes a description of some of the responsibilities of the various parties involved.

C30 Circular 30 – "Amendments to some articles of C25"
The document states corrective amendments to C25 and C39.

C39 Circular 39 – "The regulations on electricity distribution system"
The document states a mix of requirements among others some of the requirements to be met to be granted a grid connection, some requirements to the distribution grid system operator as well as requirements for distribution system operation and demand facility obligations.

4.2 System operation codes

C40 Circular 40 – "The procedure for dispatching of national power system"
The document states operational procedures for dispatching power generating facilities.

C55 Circular 55 – "Technical requirements and management and operation of the SCADA system"
The document states requirements for the SCADA systems applied by the various parties.

C31 Circular 31 – "Amending and supplementing a number of articles of C28, C40 and C44"
The document states corrective amendments to C40.

C28 Circular 28/2014/TT-BCT – The procedures for troubleshooting in nation power system in Vietnam.
The document states operational procedures for handling incidents in order to quickly eliminate incidents and restore the national power system to its normal state. Handling incidents includes outages at power plants and substations, and curtailment/reduction of electricity users in an area.

QD106 Decision 106 – "The procedure of identifying and operating ancillary services"
The document states operational procedures for identifying, verifying compliance of and activating power generating facilities.

4.3 Market codes

Not relevant to this report.

5. Missing content identified in current grid codes

5.1 Connection code – gaps identified

5.1.1 What is required of type/unit certificates?

Certificates for generation type / units issued by international accredited laboratories are frequently used as a part of compliance documentation to demonstrate compliance with connection code requirements.

An international unit certificate is a certificate issued on conformity to international standards by an accredited laboratory which is accredited according to ISO/IEC 17065 and 17025 – examples of a unit certificate and accredited laboratories can be found on the website of IECRE for wind turbines and PV systems – link: https://www.iecre.org/
Globally, several test laboratories are accredited to issue type / unit certificates, but the question is which of these certificates is required or can be used for compliance demonstration when installing generation facilities in VN? Will type / unit certificates issued by accredited laboratories be accepted in VN?

In addition to the type / unit certificate, safety certificates could be required in various countries. Which safety certificates are required in VN? One example: "CE" marking is required for selling products in Europe, which means that the product manufacturers declare which quality standards their products have been manufactured under. This also implies that the European legislation for human safety have been considered in the product design, product development and manufacturing process.

5.1.2 Active power control capability

Current specifications are very vague and low compared to the global available active power control capability of generation facilities and must be much more specific as the VN grid could harvest a lot of benefits by applying the distributed units for distributed dynamic stabilisation. The addition of functionalities such as absolute power constraint, delta power constraint and system protection are recommended in current active power control functionality requirements. Commercially available active power control capability requirements must be specified in more details to support the grid system with stabilizing services.

5.1.3 Reactive power control capability

The current specifications are very vague and low compared to the global available capability of generation facilities and must be much more specific as the VN grid could harvest a lot of benefits by applying the distributed units for distributed voltage stabilisation. Commercially available reactive power control capability requirements must be specified in more details to support the grid system with stabilizing services. The missing functional capability is recommended to address a wide range for Q control and Power Factor control. Adding the missing requirement on automatic Power Factor control could be useful in weak Dx grid systems to stabilize voltage.

5.1.4 Power quality – complete set of parameters

1. Rapid voltage variations
2. Harmonic headroom – only planning level parameters are specified in current requirements
3. Interharmonics
4. High-frequency disturbance

The current specification on power quality only addresses planning level parameters, which means that the specific headroom for the specific generation / demand facility must be defined. Otherwise, the first facility to be connected will be allowed to use all of the planning level, meaning that there will be no headroom left for other facilities to be connected on the radial. Several international studies have been performed on this subject and it is recommended to follow the best global practice illustrated in references [18] and [19].

5.1.5 Electrical simulation model

Requirements for providing a representative electrical simulation model is missing in the current connection code.

Specific requirements for the electrical simulation model to be provided as part of the documentation must be specified as this will be used to create a national electrical simulation model used for dynamic stability analyses and grid system adequacy studies under the umbrella of the operational code.

The facility developer needs to know how to provide the simulation model to be compliant with this grid system requirement. The specific requirements for an electrical simulation model must be specified. Otherwise, the TSO / RTO / DSO / Market Operator might not be able to use the simulation model provided.

Specific requirements could be, but are not limited to, the following issues:

1. Must the simulation be an RMS and/or an EMT model?
2. Is the model required to fit into PowerFactory, PSS/E or other applications?
3. Can the simulation model simply be provided as functional blocks in a paper document?
4. Can the model have black-box subparts or must all parts be white-box models?
5. …

The grid connection code must specify these details to make up a complete requirements specification on the required electrical simulation model.

Example of specifications for a simulation model from the Danish BESS connection code, section 9, is inserted on the following pages.

must be sent to the *electricity supply undertaking*. The required documentation appears from Table 23.

8.1.13 Category D battery plants

The documentation form must be filled in with preliminary data for the *battery plant* and sent to the *electricity supply undertaking* no later than twelve months **before** the date of commissioning.

From the design phase to the verification phase, the *plant owner* must inform the *transmission system operator* if the preliminary plant data can no longer be regarded as representative of the final commissioned *battery plant*.

No later than three months **after** the date of commissioning, documentation must be provided in the form of specific data for the entire *battery plant,* which must be sent to the *electricity supply undertaking*. The required documentation appears from Table 23.

9. Simulation model

For the purpose of analysing the *public electricity supply grid*, the *transmission system operator* must maintain and expand the simulation models continuously as new *battery plants* are connected to the grid.

The simulation models are used to analyse the static and dynamic properties of the transmission and distribution grids, including stability.

From the design phase to the verification phase, the *plant owner* must inform the *transmission system operator* if the preliminary data can no longer be regarded as representative of the final commissioned plant.

The *plant owner* must provide the *transmission system operator* with the simulation models specified. In pursuance of Section 84 a of the Danish Electricity Supply Act, the *transmission system operator* is bound by a duty of confidentiality where commercially sensitive information is concerned.

Simulation models may be sent directly from the manufacturer of the *battery plant* to the *transmission system operator*.

The *plant owner* is responsible for ensuring that the correct set of data is submitted at the right time.

9.1 Simulation model requirements

The simulation model for the entire *battery plant* must describe the plant's fixed and dynamic electrical properties, as seen from the *public electricity supply grid*.

The simulation model must:

- Be supported by model descriptions which contain, as a minimum, Laplace domain transfer functions, function descriptions of the model's main modules and detailed descriptions of the various model components and associated model parameters, including set-up and initialisation of the simulation model and any limitations on its application.

- Contain all control functions required in section 5, models for voltage regulators etc.

- Include all protective functions that can be activated during all relevant incidents and faults in the *public electricity supply grid* as required in section 6.

- Allow simulation of root-mean-square (RMS) values in the synchronous system (positive sequence).

- Allow simulation of root-mean-square (RMS) values in the individual phases during asymmetrical incidents and faults in the *public electricity supply grid*.

- As a minimum, cover the 47.00-52.00 Hz frequency range and the 0.0-1.4 pu voltage range.

- Be able to describe the dynamic response from *a* plant for at least 30 seconds after incidents or faults in the *public electricity supply grid*.

- Be numerically stable and capable of utilising numerical equation solvers with variable sample lengths.

- Not use sample lengths less than 1 ms.

9.2 Verification of simulation model

The simulation model for the entire *battery plant*, including all control methods, must be verified by the *plant owner*, as required in section 5.

The *plant owner* is responsible for performing all verification tests and is also responsible for measuring equipment, data loggers and staff.

No later than three months before the final commissioning of the *battery plant*, the practical performance of verification tests must be determined on the basis of the *plant owner's* proposal and in collaboration with the *transmission system operator*.

Measurements used to verify the simulation model for the entire *battery plant* must be documented by the *plant owner* in a report containing detailed descriptions of each test. Measurement results must be compared with the corresponding simulated results and documented in a verification report.

The time series measurements used to verify the simulation model must be enclosed with the verification report in IEEE *COMTRADE* format.

The time resolution for the measuring signals used must be 1 ms or higher.

9.2.1.1 Category A1, A2 and B plants:

No simulation model is required for *category* A1, A2 and B *battery plants*.

9.2.1.2 Category C and D plants:

A dynamic simulation model for the entire *category* C and D *battery plant* must be submitted to the *transmission system operator*. Category C *battery plants* with a rated power of less than 10 MW are excluded.

The *plant owner* must submit a simulation model for the *battery plants* used, including the *plant controller*, if any, no later than three months after commissioning.

The content and level of detail of the simulation models for the *plant controller* and the individual *battery plant* must be such that they can be readily integrated and subsequently appear as a single fully functional simulation model as required in section 9.1.

The simulation model must be verified as specified in section 9.2.

The *plant owner* must supply data for the *plant infrastructure* upon request.

5.1.6 Documentation for compliance approval

Requirements for providing documentation must be specified more precisely in the connection requirements. What are the minimum requirements for the provided documentation to be considered sufficient to obtain a grid connection? One recommendation is to provide a template for the documentation to be provided as an annex to the grid connection code. A template similar to the one for the Danish BESS code could be used to illustrate the details to be specified – see annex

5.1.7 Prototype systems – accepted in VN?

The connection code must specify how prototype systems are handled in VN. If not allowed, this must be clearly specified in the connection code. If accepted, such systems could be accepted with a limited approval period or specific compliance monitoring program. It is recommended to allow prototype systems as local developers might learn from international developers how renewable systems can be integrated into large systems, but they might need a time window for the learning process. Working with prototype systems is also valuable for global developers to learn about how to enter the VN market and, as such, create an attractive investment climate in VN.

5.1.8 Off-grid systems

The connection code must specify the requirements to be fulfilled for off-grid and island systems. As off-grid and island systems will be connected to the grid in the future, it is recommended to apply the same requirements as for the interconnected system. Otherwise, it could be very costly to integrate such systems in the future, making it problematic in to ensure a stable grid system.

5.2 Connection code procedure – new section recommended in the grid code

A new section in the grid code is recommended to distinguish between connection requirements and connection procedures which would ease the understanding of the document.

Procedures of relevance to a grid connection process could consist of the following:

1. Procedure for granting a grid connection
    a. step-by-step guidance on obtaining a grid connection
    b. grid connection agreement template
    c. how to terminate a grid connection agreement
2. Procedure for compliance testing / simulation
    a. what is tested and what can be demonstrated in a simulation model
3. Procedure for operational notification
    1. includes energization operational notification, interim operational notification, limited operational notification and final operational notification
4. Procedure for derogation / exemption requests.

5.2.1 Operational notification procedures

The reader must be able to understand the procedural steps to complete, from request for grid connection to final operation.

1. energization operational notification (EON)
2. interim operational notification (IOM)
3. limited operational notification (LON)

4. final operational notification (FON)

The operational notification procedures could be based on the procedural part in the European grid connection code for generators, see reference [9], articles 30-37.

5.2.2 Procedure for compliance testing / simulation

Minimum requirements for compliance verification, testing and simulation must be specified in the procedure or in a guideline, allowing the party requesting connection to create a risk assessment of the compliance process.

5.2.3 Derogation procedures

How does a developer request a derogation if some specific circumstances support the granting of this? This procedure is missing in the current grid code. In addition, it must also be specified how the outcome of the process will become public to ensure transparency in the procedure.

ERAV hold the overall responsibility for securing that the VN legislation supports a stable grid, including the tools and methods that the TSO, RTO and DSO need to manage the grid system in a safe and secure manner with the technical quality stipulated in the operator license, i.e. the KPIs. Typically, no exemptions need to be issued if requirements are correct for the purpose but there might be specific cases where an exemption could be needed as the VN grid is quite extensive with great diversity from the smallest unit to the largest unit.

The list of exemptions is typically used in a maintenance cycle report to pinpoint which requirements might need to be changed or further specified as an exemption has been issued. If some exemptions are observed that are generic, the respective requirements need to be reviewed and/or updated.

5.3 Recommended structure of the final generator connection code

The recommended generator connection code structure and placement of the current articles within this structure are illustrated in the table below.

An overview of the proposed distribution of the content of the C25 (Tx) and C39 (Dx) connection codes is presented in the D3.1 report, sections 9.1 and 9.2, respectively. The overview has the following generic header:

Current VN grid code document – C25 / C39	**Recommendation for a sectional structure of a complete VN grid code document. Proposed sections in a new document.**									
	Connection Code - Generators	Connection Code - Demand	Connection Procedures	Operational Code	Operational Procedures	Market Code - Ancillary Services	Grid Planning Code	TSO Licensee	DSO Licensee	Performance assessment (KPI)
Chapter I, GENERAL PROVISIONS										

Article 1. Governing scope	X	X	X							
…										

The recommended structure and content of a final generator grid connection code (highlighted in yellow above) are as stated in the table below. The step from the combined circular recommended in report D3.2 to the final code needs a deeper analysis when the combined circular have been released.

Acronyms applied in table below:

X: specify minimum design requirements

C: recommended to be defined in contractual terms, specify minimum requirements and conditions for offering the system service

na: not applicable

Section #	Section header	Synchronous	Non-synchronous
1.	Terminology, abbreviations, and definitions	X	X
1.1	Abbreviations	X	X
1.2	Definitions	X	X
2.	Objective, scope of application and regulatory provisions	X	X
2.1	Objective	X	X
2.2	Scope of application	X	X
2.2.1	New plants	X	X
2.2.2	Existing plants	X	X
2.2.3	Modifications to existing plants	X	X
2.3	Delimitation	X	X
2.3.1	Exemptions from minimum requirements	X	X
2.4	Statutory authority	X	X
2.5	Effective date	X	X
2.6	Complaints	X	X
2.7	Breaches	X	X
2.8	Sanctions	X	X
2.9	Exemptions and unforeseen events	X	X
2.10	References	X	X
2.10.1	Normative references	X	X
2.10.2	Informative references	X	X
3.	Tolerance to frequency and voltage deviations	X	X
3.1	Frequency ranges	X	X
3.2	Voltage ranges	X	X
3.3	Normal operating conditions	X	X
3.4	Abnormal operating conditions	X	X
3.3.1	Tolerance to frequency deviations	X	X
3.3.2	Voltage dip tolerance	X	X

3.3.2.1	Category A plants	X	X
3.3.2.2	Category B plants	X	X
3.3.2.3	Category C plants	X	X
3.3.2.3	Category D plants	X	X
3.3.3	Voltage support during voltage dips / swells	X	X
3.3.3.1	Category A plants	X	X
3.3.3.2	Category B plants	X	X
3.3.3.3	Category C plants	X	X
3.3.3.4	Category D plants	X	X
3.3.4	Recurring voltage dips in the public electricity supply grid	X	X
3.3.4.1	Category A plants	X	X
3.3.4.2	Category B plants	X	X
3.3.4.3	Category C plants	X	X
3.3.4.4	Category D plants	X	X
3.3.5	Island operation	X	X
3.3.5.1	House-load operation	C	C
3.3.5.2	Island operation	X	X
3.3.6	Start-up from black-out	C	C
4.	Power quality	X	X
4.1	General	X	X
4.2	DC content		X
4.2.1	Category A plants		X
4.2.2	Category B plants		X
4.2.3	Category C plants		X
4.2.4	Category D plants		X
4.3	Asymmetry		X
4.3.1	Category A plants		X
4.3.2	Category B plants		X
4.3.3	Category C plants		X
4.3.4	Category D plants		X
4.4	Rapid voltage changes	X	X
4.4.1	Category A plants	X	X
4.4.2	Category B plants	X	X
4.4.3	Category C plants	X	X
4.4.4	Category D plants	X	X
4.5	Flicker		X
4.5.1	Category A plants		X
4.5.2	Category B plants		X
4.3.3	Category C plants		X
4.4.4	Category D plants		X
4.6	Harmonic distortions		X
4.6.1	Category A plants		X
4.6.2	Category B plants		X
4.6.3	Category C plants		X

4.6.4	Category D plants		X
4.7	Interharmonic distortions		X
4.7.1	Category A plants		X
4.7.2	Category B plants		X
4.7.3	Category C plants		X
4.7.4	Category D plants		X
4.8	Distortions 2-9 kHz		X
4.8.1	Category A plants		X
4.8.2	Category B plants		X
4.8.3	Category C plants		X
4.8.4	Category D plants		X
5.	Active and reactive power control	X	X
5.1	Active power control functions	X	X
5.1.1	Frequency response (LFSM-U and LFSM-O)	X	X
5.1.1.1	Category A plants	X	X
5.1.1.2	Category B plants	X	X
5.1.1.3	Category C plants	X	X
5.1.1.4	Category D plants	X	X
5.1.2	Frequency control (FSM)	X	X
5.1.2.1	Category A plants	X	X
5.1.2.1	Category B plants	X	X
5.1.2.2	Category C plants	X	X
5.1.2.2	Category D plants	X	X
5.1.3	Active power control – power limiters	X	X
5.1.3.1	Absolute power limiter	X	X
5.1.3.1.1	Category A plants	X	X
5.1.3.1.2	Category B plants	X	X
5.1.3.1.3	Category C plants	X	X
5.1.3.1.4	Category D plants	X	X
5.1.3.2	Ramp rate limiter	X	X
5.1.3.2.1	Category A plants	X	X
5.1.3.2.2	Category B plants	X	X
5.1.3.2.3	Category C plants	X	X
5.1.3.2.4	Category D plants	X	X
5.1.3.3	Delta limiter	X	X
5.1.3.3	Category A plants	X	X
5.1.3.3	Category B plants	X	X
5.1.3.3	Category C plants	X	X
5.1.3.3	Category D plants	X	X
5.2	Reactive power control functions	X	X
5.2.1	Q control	X	X
5.2.1.1	Category A plants	X	X
5.2.1.2	Category B plants	X	X
5.2.1.3	Category C plants	X	X

5.2.1.4	Category D plants	X	X
5.2.2	Power Factor control	X	X
5.2.2.1	Category A plants	X	X
5.2.2.2	Category B plants	X	X
5.2.2.3	Category C plants	X	X
5.2.2.4	Category D plants	X	X
5.2.3	Voltage control	X	X
5.2.3.1	Category A plants	X	X
5.2.3.1	Category B plants	X	X
5.2.3.2	Category C plants	X	X
5.2.3.3	Category D plants	X	X
5.3	Requirements for U-PQ characteristics	X	X
5.3.1	Category A plants	X	X
5.3.2	Category B plants	X	X
5.3.3	Category C plants	X	X
5.3.4	Category D plants	X	X
5.3.4	System protection	X	X
5.3.4.1	Category A plants	X	X
5.3.4.2	Category B plants	X	X
5.3.4.3	Category C plants	X	X
5.3.4.4	Category D plants	X	X
5.4	Priorities for protection and control functions for active power	X	X
5.5	Plant components	X	X
5.5.1	Generator	X	X
5.5.1.1	Category A plants	X	X
5.5.1.2	Category B plants	X	X
5.5.1.3	Category C plants	X	X
5.5.1.4	Category D plants	X	X
5.5.2	Generator transformer	X	X
5.5.2.1	Category A plants	X	X
5.5.2.2	Category B plants	X	X
5.5.2.3	Category C plants	X	X
5.5.2.4	Category D plants	X	X
5.5.3	Excitation system		X
5.5.3.1	Category A plants		X
5.5.3.2	Category B plants		X
5.5.3.3	Category C plants		X
5.5.3.4	Category D plants		X
5.5.3.3	PSS function	X	X
5.5.3.4	Category A plants	na	na
5.5.3.5	Category B plants	na	na
5.5.3.6	Category C plants	na	na
5.5.3.7	Category D plants	X	X
6.	Protection	X	X

6.1	Protective setting requirements	X	X
6.1.1	Category A plants	X	X
6.1.2	Category B plants	X	X
6.1.3	Category C plants	X	X
6.1.4	Category D plants	X	X
7.	Exchange of signals and data communication	X	X
7.1	Measurement requirements	X	X
7.2	Data communication	X	X
7.2.1	Category A plants	X	X
7.2.2	Category B plants	X	X
7.2.3	Category C plants	X	X
7.2.4	Category D plants	X	X
7.3	Fault incident recording	X	X
7.4	Requesting metered data and documentation	X	X
8.	Verification and documentation	X	X
8.1	Requirements for plant documentation	X	X
8.1.1	Category A plants	X	X
8.1.2	Category B plants	X	X
8.1.3	Category C plants	X	X
8.1.4	Category D plants	X	X
9.	Electrical simulation model	X	X
9.1	Simulation model requirements	X	X
9.2	Verification of simulation model	X	X
9.3	Category A plants	X	X
9.4	Category B plants	X	X
9.5	Category C plants	X	X
9.6	Category D plants	X	X

5.4 Operational code – gaps identified

5.4.1 Outage coordination

1. TSO / RTO
2. DSO

The current specifications of outage coordination are very limited and read more like a wish list than actual requirements. Documenting the current practice on outage coordination, involving all parties in the grid system (TSO, RTO and DSO), could be a first step in outage coordination requirements and related procedures.

5.4.2 Security coordination

1. TSO / RTO
2. DSO

The current specification of coordination of system security parameters between regions and distribution areas are described to a limited degree, but current practice might include some details that would be valuable to state in the security coordination requirements. Especially on the boundaries between Tx and Dx grid systems, a maximum allowable range for reactive power exchange should be included as such export / import of reactive power could endanger voltage stability, causing grid system collapse.

5.4.3 Communication requirements - new information exchange code?

1. Roles and responsibilities of parties involved
2. Structural information – information on rated capacity, electrical characteristics, possible limitations, etc.
3. Scheduled information – dispatching, outage, availability, etc.
4. Real-time information – measured values, status, grid element status, alarms, etc
5. Protocols applied
   a. Devices – e.g. IEC 61850 with Secure MMS stack
   b. Control centre – IEC 69870-6 ICCP, TASE2 – with secure communication
6. Information security
   a. Which standards to apply as a minimum – e.g. ISO/IEC 27002, 27019, IEC 62351
   b. Specific security monitoring requirements
7. Redundancy – e.g. doubling of triple redundant network system?
8. Requirements for data storage – e.g. how long must data be stored by which parties?

5.4.4 Short circuit current management

The TSO / RTO / DSO must secure a reasonable level of short circuit ratio (SCR) thorughout the grid system. Consequently, a regular task for the TSO / RTO / DSO is to coordinate SCR on a regular basis. Typically, such coordination activities take place twice a year as the grid system might evolve very rapidly. It could also be reasonable to coordinate SCR more frequently in specific regions if the integration of renewables moves very fast there.

The Tx or Dx system operator is always responsible for securing a certain level of short circuit ratio, so the protection systems of connected facilities can operate properly. Grid operators must specify minimum and maximum real-time SCR by doing the appropriate coupling in their grids. One example: in Denmark, a map of short circuit ratios is issued at least four times a year by the TSO to the DSOs as the DSOs need to secure a certain level of SCR in their grid system and inform those who want to be connected in the DSO grid system.

The reason for regularly calculating short circuit impedance is that grid protection and individual protection settings are dependent on a certain level of SCR to be able to provide the necessary protection functions.

The fundamental SCR and short circuit currents calculations are based on the IEC 60909 series of standards globally, and the recommendation is to follow these specifications in VN as well.

5.4.5 Dynamic stability assessment

1. Roles and responsibilities of TSO / RTO / DSO
2. Dynamic Stability Assessment (DSA)
    a. Regional coordination
    b. Distribution coordination
    c. System adequacy monitoring
3. DSA management concerns
    a. Inertia monitoring
    b. Rotor angle stability monitoring
    c. Small signal stability monitoring

It is recommended to establish a specific system dynamic simulation team that reports to the TSO / RTO / DSO if this does not exist already.

Electrical simulation models provided for generator and demand facilities connected must be merged into regional and national simulation models to provide near real-time stability analyses for the system's dispatching operators, outage coordinators and grid coupling responsible operators.

Simulation models are normally also used for system adequacy studies in different time frames as discussed in the next subsection.

5.4.6 System adequacy – assessment

System Adequacy is defined as the ability of the electric system to always supply the aggregate electrical demand and energy requirements of the end-use customers, considering scheduled and reasonably expected unscheduled outages in system elements. System adequacy is used globally to issue warnings on problems in the system in the following time frames:

1. Short-term: focuses on generation adequacy for intra-day, day ahead, week ahead, month ahead and seasonal variations, typically from time of operation and up to 1 year
2. Mid-term: focuses on energy adequacy, demand evolution, typically from 1 to 7 years. Focus is on grid reinforcement needs and announcements of limitations in the grid systems in due time
3. Long-term: focuses on long-term demand evolution and energy adequacy and is meant to motivate developers to build needed generation facilities and the TSO / RTO / DSO to secure the needed infrastructure.

These studies must be performed regularly within each time frame and published accordingly to motivate the relevant parties or inform the public of any grid constraints or any risk of limited access to electricity. Public dependency on access to electricity is growing rapidly and using blackouts is not an acceptable way to handle electricity shortages that could have been predicted with reasonable system simulations.

5.5 Operational procedures – recommended new grid code section

A new section in the grid code is recommended to distinguish between connection requirements and connection procedures which would ease the understanding of the document.

Procedures relevant to the operational process could include the following recommended content.

1. Procedure for granting an operational notification
    1. step-by-step guidance on obtaining an operational notification
    2. operational notification templates, e.g.
        a. energization operational notification
        b. interim operational notification
        c. limited operational notification
        d. final operational notification
2. Procedure for compliance testing / simulation and monitoring
    1. what is tested and what can be demonstrated in a simulation model before granting the respective operational notifications
    2. What must be checked on a regular basis?
    3. Additional compliance test procedures in case of agreement as an AS provider?
3. Procedure for operational notification from an operational point of view
    1. Includes energization operational notification, interim operational notification, limited operational notification and final operational notification – what are the system operator's role and responsibilities?
4. Procedure for a derogation request in relation to operational requirements

6. Missing grid codes identified

6.1 Grid connection code for HVDC systems

A new section in the grid code is recommended to specify requirements for HVDC systems, making it easier to understand the requirements to comply with when requesting an HVDC system connection.

The HVDC code could include requirements for the following systems:

1. HVDC systems for transmission of active power over long distances
2. HVDC systems for connection of offshore facilities or isolated systems

The recommended minimum content of a HVDC connection code could be as the following European network code [12]:

NC HVDC CONTENT- OVERVIEW

TITLE I - General provisions

TITLE II - General requirements for HVDC connections

- CHAPTER 1 - Requirements for active power control and frequency support

- CHAPTER 2 - Requirements for reactive power control and voltage support
- CHAPTER 3 - Requirements for fault ride through capability
- CHAPTER 4 - Requirements for control
- CHAPTER 5 - Requirements for protection devices and settings
- CHAPTER 6 - Requirements for power system restoration

TITLE III - Requirements for DC-connected power park modules and remote-end HVDC converter stations

- CHAPTER 1 - Requirements for DC-connected power park modules (PPM)
- CHAPTER 2 - Requirements for remote-end HVDC converter stations

TITLE IV - Information exchange and coordination

TITLE V - Operational notification procedure for connection

- CHAPTER 1 - Connection of new HVDC systems
- CHAPTER 2 - Connection of new DC-connected power park modules
- CHAPTER 3 - Cost benefit analysis

TITLE VI – Compliance

- CHAPTER 1 - Compliance monitoring
- CHAPTER 2 - Compliance testing
- CHAPTER 3 - Compliance simulations
- CHAPTER 4 - Non-binding guidance and monitoring of implementation

TITLE VII – Derogations

TITLE VIII - Final provisions

As discussed earlier in the operational section of present document, the procedural part could be removed, leaving the document to merely address connection procedures.

6.2 Grid connection code for storage systems

A new section in the grid code is recommended to specify requirements for storage systems and ease the understanding of what to comply with when requesting a connection for a storage system.
The storage code could include requirements for the following systems:

3. Battery energy storage systems
4. Pumped hydro storage systems

Grid connection of storage systems could be developed in steps, with the first step focusing on VN's existing battery storage systems and hydro pump storage systems. The next step for the storage system connection code could be to focus on other kind of storage, like carbon capture and storage (CCS) systems. The final report of the Identification of European Storage Devices Expert Group (EG STORAGE), established by the European Stakeholder Committee (GC ESC) in late 2018, details various storage devices. See reference [17] for the final report.

Pump storage systems in hydro power plants could be included as part of the generator facility, but a separate control functionality could offer ancillary services, making it recommendable to specify separate requirements for pump storage systems. Inspiration for specific requirements can be found in the European expert group report on pump storage systems – see reference [16].

The recommended minimum content of a battery energy storage system (BESS) connection code could be similar to the Danish BESS code [15]:

As very few examples of BESS grid connection codes exist globally, a VN specific approach is recommended. Concerning the specific BESS requirements, specifications should be as close as possible to the requirements for generator and demand facilities as a BESS can act as both a generator and a demand facility and can change characteristics very quickly.

6.3 Grid connection code for demand facilities

The proposal for a new VN grid connection code for all types of demand facilities fits the generation facility specifications, and it would be useful to apply the same content and structure.

Modern demand facilities use power electronics comparable to those of generators and thus impact the stability of the grid system in a similar manner.

As the stability of the grid is impacted by the size of the demand and generation facilities, it is recommended to sort requirements into the same size-based categories.

6.4 Information exchange code

A separate code should be prepared for information exchange as communication aspects span the connection, operational and market codes. Such a cross-code function should be regulated in a separate code, an information exchange code. The VN circular C55 specifications could be applied for some of the proposed requirements in a new code, but the completeness of an information exchange code is not secured by using C55 unaccompanied.

1. The aim of an information exchange code is to establish a harmonized way of communicating based on a set of requirements for information exchange activities

2. Why establish an information exchange code?
   To have common set of requirements for all level of communication in the electricity sector of Vietnam
   a. To share the most updated information to secure adequate grid stability

3. Who is the typical reader / user of the information exchange code?
   a. Grid investors, system operators (Tx, Dx)
   b. Power plant managers and investors
   c. Grid planners – at transmission and distribution grid level – ISO, TSO, RTO, DSO, CDSO
   d. System adequacy assessment analysers
   e. Grid infrastructure investors

4. What should be included as a minimum?
   a. Specification of the legal basis of the code – e.g. VN Electricity Act
   b. Scope of document
   c. Legal aspects / document validity / confidentiality / entry into force / reference to other regulations of relevance
   d. Transparency of information
   e. Definitions and acronyms
      1. All definitions of relevance to grid system planners, decision makers and politicians
   f. Roles and responsibilities of parties involved – ERAV, TSO, RTO, DSO, Grid users
   g. Information type 1: Structural information – information on rated capacity, electrical characteristics, possible limitations etc.

h. Information type 2: Scheduled information (control center communication) – dispatching, forecasting, outage coordination, availability monitoring, etc.
i. Information type 3: Real-time information – SCADA system values, Access to data base systems, measured values, status of substations, grid element status, alarms, warnings, monitoring of power quality parameters, PMU information processing, Early warning systems, Dynamic Line Monitoring systems, data network monitoring, time management systems, etc
j. Protocols applied – the recommended exchange protocols are the following:
    1. Devices – e.g. IEC 61850 with Secure MMS stack
    2. Control centre – IEC 69870-6 ICCP, TASE2 – with secure communication
k. Information security – recommended standards are the following:
    1. Standards to apply as a minimum? – e.g. ISO/IEC 27002, 27019, IEC 62351
    2. Specific security monitoring requirements are under development in IEC TC57
l. Redundancy strategy – e.g. double or triple redundant data network system?
m. Requirements for data storage and information back-up – e.g. for how long must data be stored by the involved parties? To which security level?

Information exchange is very essential to implement a reliable operation and thereby keep security of supply and maintain a stable grid. If the information provided cannot be trusted, the quality of decisions in system operation is affected.

6.5 Grid planning code

1. The aim of a grid planning code is to establish a common understanding of the methodology and procedures applied in grid planning and grid development activities

2. Why establish a grid planning code?
    a. To have common methodology and procedures
    b. To share the most updated information to secure adequate grid stability

3. Who is the typical reader / user of a planning code?
    a. Politicians, grid investors, system operators (Tx, Dx)
    b. Power plant managers and investors
    c. Grid planners – at transmission and distribution grid level – ISO, TSO, RTO, DSO, CDSO
    d. System adequacy assessment analysers
    e. Grid infrastructure investors
    f. Screening of possible connection points for new grid users

4. What could be included as a minimum?
    a. Specification of the legal basis of the code – e.g. VN Electricity Act
    b. Scope of document
    c. Legal aspects / document validity / confidentiality / entry into force / reference to other regulations of relevance
    d. Transparency of information
    e. Definitions and acronyms
        1. All definitions of relevance to grid system planners, decision makers and politicians
    f. General principle of grid development activities
        1. Methodology applied / business case methodology

2. Public consultations procedures - procedures for preparation, approval and public announcement of transmission and distribution grid development plans
3. Grid Planning Responsibilities and Procedures
    1. Grid Planning Responsibilities
    2. Submission of Planning Data
    3. Consolidation and Maintenance of Planning Data
    4. Evaluation of Grid Expansion Project
    5. Evaluation of Proposed User Development
    6. Preparation of the Tx and Dx Development Plans
4. Grid Planning Studies
    1. Grid Planning Studies to be conducted
    2. Load Flow Studies
    3. Short Circuit Studies
    4. Transient Stability Studies
    5. Steady-State Stability Analysis
    6. Voltage Stability Analysis
    7. Electromagnetic Transient Analysis
    8. Reliability Analysis
    9. System adequacy monitoring/study – short, mid, long term
5. Standard Planning Data
    1. Historical energy and demand
    2. Energy and demand forecast
    3. Generating unit data
    4. Demand system data
6. Detailed Planning Data
    1. Generating unit and generating plant data
    2. Demand unit and demand facility data
    3. Minimum required information to be exchanged with TSO / RTO / DSO on grid development – Tx and Dx

The content of the former chapter 4 which were removed by circular 30, Nov 2019 in circular C25 and C39 is recommended to be included in the planning code as the planning code must be holistic in the content as the grid system is one coherent system independent of where in the governmental system the final decisions are taken. The planning code must address the system needs and secure supply of electricity to the consumers in Vietnam.

6.6 Interconnector code

A code or an interconnector agreement should be specified for interconnectors as a separate section of the VN grid code, targeting future interconnectors to neighbouring countries. As a first step, specific agreements should be made for each interconnector. If such agreements could be converted into a specific interconnector code later on could be beneficial but for the first step an interconnector code is not really needed.

An interconnector code or agreement includes all minimum requirements for the parties involved. Organisational requirements, harmonisation of connection requirements for generator and demand facilities, reserve calculations, reserve activation etc. all depending on the interconnector technology selected.

If an AC interconnector is established, leading to the establishment of a synchronous area, agreements must be made on how to harmonize dynamic stability assessments, how to coordinate system security limits, how to define system states, how to manage power flows in emergency situations, how to coordinate Low Frequency Demand Disconnection (LFDD) criteria and coordinate high frequency generator curtailment, how to specify maximum reactive power flows and specify maximum active power run-back on each interconnector, how to set maximum allowed power quality parameters, etc. All of this needs to be coordinated in the synchronous area and the recommendation is to create a synchronous area operational agreement (SAOA) which specifies all of these details. Please find an example of a SAOA in reference [21].

If the interconnector is a DC connector, the specific parameters for the DC system must be agreed and coordinated. Topics to be coordinated could include how to harmonize dynamic stability assessment, how to coordinate system security limits, how to define system states, how to manage power flows in emergency situations, what are the emergency power activation parameters, what is the maximum active power run-back on each interconnector, what are the maximum allowed power quality parameters, are there special protection schemes, etc

An example of an interconnector code could the EAPP interconnector code:
The Eastern Africa Power Pool (EAPP) member countries continue to plan and build transmission interconnections that will eventually link the electric grids of all member nations and greatly improve the potential for cross border trade, thereby leading to greater energy security and economic prosperity. One of the key components required for the successful integration of the East African region's electricity sector is a framework and set of rules for the coordinated planning and operation of the region's electric transmission systems and generation resources. As a first step, the EAPP and its members directed the development of the EAPP Interconnection Code, which was developed in 2012. The Code sets out the technical rules necessary for the EAPP to ensure the transmission grid is operated in a safe, reliable, secure, and efficient manner. In 2012, Power Africa then augmented the EAPP Interconnection Code to include a set of standards and measures to clearly specify what was required of member countries/utilities and what evidence was needed to determine whether an entity complies with each of the requirements set out in the Code.

To further enhance understanding of the Interconnection Code, its standard requirements and measures, and assist member nations in complying with the Code on a timely basis, the EAPP and the Independent Regulatory Board (IRB), with support from Power Africa plan to implement an Interconnection Code Compliance Program.

OBJECTIVES

- To make the standard requirements of the Interconnection Code mandatory to ensure operational security, reliability of the transmission system and quality of supply.
- To define a plan to phase in the minimum set of Interconnection Code Standards that are to be met over time.
- To assist members in determining if they comply and, if not, what steps to complete to become compliant.
- To assist the Independent Regulatory Board (IRB) in developing a process which assures that all EAPP Members comply with the Interconnection Code on an ongoing basis; and
- To assist Members in identifying areas where external funding will be needed to meet the Interconnection Code requirements and to assist in obtaining such funding.

For further details on the EAPP interconnector code and compliance program, see reference [22].

6.7 Market code – ancillary services

Ancillary services (AS) should be specified in a separate code, dedicating part of the VN grid code to AS providers.

The ancillary services code section should include the following as a minimum.

1. All ancillary service providers must comply with the ancillary service code – existing as well as new grid-connected facilities (generators, demand facilities and grid components).

2. Why establish an ancillary services code?
    a. Ancillary service providers need a clear specification of the minimum technical requirements that they must comply with to provide the various services.
    b. Grid system operators need a clear specification of the minimum operational actions they must perform and their responsibility as grid system operators to purchase ancillary services.

3. Who is the typical reader / user of the AS code?
    a. Power plant operators and managers

4. What should be included as a minimum?
    a. Specification of the legal foundation of the technical code – e.g. VN Electricity Act
    b. Scope of document
    c. Legal aspects / document validity / confidentiality / entry into force / reference to other regulations of relevance
    d. Transparency of information
    e. Definitions and acronyms
        1. All definitions of relevance to service providers, control rooms, compliance evaluation point, system states (normal, alert, emergency, restoration, blackout) etc.
    f. All relevant minimum technical requirements to be met to provide ancillary services, e.g.
        1. Minimum technical capabilities - design requirements
            1. Additional roles and responsibilities of parties involved in providing AS
            2. Additional information exchange, tools and facilities for providing AS
            3. Additional compliance demonstration and review
        2. Dimensioning and activation of AS
            1. Frequency containment reserves
            2. Frequency restoration reserves
            3. Replacement reserves
            4. Balancing and scheduling (dispatching and activation) of AS

6.8 TSO / RTO license

1. The purpose of a TSO license is to formalise the responsibility of the entity granted a TSO /RTO license to secure well-functioning and efficient transmission of electricity from producers to distributors and end users connected to the Tx grid.

2. Why establish a TSO license?
    a. To have an entity responsible for securing grid access to the grid users connected.

3. Who is the typical reader / user of a TSO license?
    a. Transmission system operators
    b. Grid operators – at transmission grid level –TSO, RTO

4. What is the recommendation on what to include as a minimum?
    a. Specification of the legal basis of the code – e.g. VN Electricity Act
    b. Scope of document
    c. Legal aspects / document validity / confidentiality / entry into force / reference to other regulations of relevance
    d. Transparency of information
    e. Definitions and acronyms
        1. All definitions of relevance to grid system operators
    f. Technical requirements for the Tx grid elements
    g. Minimum technical quality of supply from Tx grid
    h. Minimum technical availability of Tx grid
    i. KPIs for the licensee
    j. Handling of disputes

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6.9 DSO license

1. The purpose of a DSO license is to formalise the responsibility of the entity granted a DSO license to secure well-functioning and efficient transmission of electricity from transmission to end users connected to the Dx grid.

2. Why establish a DSO license?
    a. To have an entity responsible for securing grid access to the grid users connected.

3. Who is the typical reader / user of a DSO license?
    a. Distribution system operators
    b. Grid operators – at distribution grid level –DSO, CDSO

4. What is the recommendation on what to include as a minimum?
    a. Specification of the legal foundation of the license – e.g. VN Electricity Act
    b. Scope of document
    c. Legal aspects / document validity / confidentiality / entry into force / reference to other regulations of relevance
    d. Transparency of information
    e. Definitions and acronyms
        1. All definitions of relevance to grid system operators
    f. Technical requirements for the Dx grid elements
    g. Minimum technical quality of supply from Dx grid
    h. Minimum technical availability for the Dx grid
    i. KPIs for the licensee
    j. Handling of disputes

6.10 Performance assessment code (KPIs)

The primary content of this code is the procedures related to monitoring and regularly reviewing KPIs for the TSO / RTO / DSO

6.10.1 KPI for TSO / RTO

1. What could be included as a minimum?
    a. Specification of the legal basis of the code – e.g. VN Electricity Act
    b. Scope of document
    c. Legal aspects / document validity / confidentiality / entry into force / reference to other regulations of relevance
    d. Transparency of information
    e. Definitions and acronyms
        1. All definitions of relevance to grid system planner and decision makers as well as politicians
    f. Methodology for calculation of defined KPIs
    g. KPIs for a TSO / RTO could be, but are not limited to
        1. Weekly, monthly and yearly amount of energy not served
        2. Technical quality of electricity served
        3. Weekly, monthly and yearly grid availability to generation facilities
        4. Grid loss per MWh served
        5. …
    h. Acceptable level of KPIs for contractual agreements
    i. Benchmark procedures for KPIs
    j. Exemptions from the minimum KPI acceptance level
    k. Handling disputes and contract terminations

6.10.2 KPI for DSO

1. What could be included as a minimum?
    a. Specification of the legal basis of the code – e.g. VN Electricity Act
    b. Scope of document
    c. Legal aspects / document validity / confidentiality / entry into force / reference to other regulations of relevance
    d. Transparency of information
    e. Definitions and acronyms
        1. All definitions of relevance to grid system planner and decision makers as well as politicians
    f. Methodology for calculation of defined KPIs
    g. Acceptable level of KPIs for contractual agreements
    h. KPIs for a DSO could be, but are not limited to
        1. Weekly, monthly, and yearly amount of energy not served
        2. Technical quality of electricity served
        3. Weekly, monthly, and yearly grid availability to generation facilities
        4. Grid loss per MWh served
    i. Benchmark procedures for KPIs
    j. Exemptions from the minimum KPI acceptance level

k. Handling disputes and contract terminations

6.10.3 KPI for NLDC / ISO

2. What could be included as a minimum?
   a. Specification of the legal basis of the code – e.g. VN Electricity Act
   b. Scope of document
   c. Legal aspects / document validity / confidentiality / entry into force / reference to other regulations of relevance
   d. Transparency of information
   e. Definitions and acronyms
      1. All definitions of relevance to grid system planner and decision makers as well as politicians
   f. Methodology for calculation of defined KPIs
   g. KPIs - The frequency quality defining parameters could be, but are not limited to the following:
      1. Maximum instantaneous frequency deviation
      2. Maximum steady-state frequency deviation
      3. Time to restore nominal frequency
      4. Frequency restoration range
   h. Acceptable level of KPIs for contractual agreements
   i. Benchmark procedures for KPIs
   j. Exemptions from the minimum KPI acceptance level
   k. Handling disputes and contract terminations

7. Recommendations for gap closing

The recommended sequence of actions for closing the gaps detailed in this document is listed below in priority order. This sequence is based on the fundamental priority of securing the stability of the grid first and foremost, or, in other words, securing a sufficient supply of electricity in an efficient manner.

Step 1
- Merge C25 (Tx) and C39 (Dx) articles into a new circular with a combined set of articles - report D3.2, section 6.1
- Fix gaps and overlaps in the new combined circular - see section 5.1 and section 5.3 of this report
- Develop connection procedures as recommended in section 5.2 of this report

Step 2
- Fix gaps in current operational code - see section 5.3 of this report
- Develop information exchange code - see section 6.4 of this report
- Develop operational procedures as recommended in section 5.4 of this report

Step 3
- Develop missing demand connection code - see section 6.3 of this report
- Develop missing storage connection code - see section 6.2 of this report
- Develop missing HVDC connection code - see section 6.1 of this report

Step 4
- Develop missing grid planning code - see section 6.5 of this report
- Develop market code - especially a section specifying ancillary services - see section 5.3 of this report

Step 5
- Develop TSO / RTO license code - see section 6.8 of this report
- Develop DSO license code - see section 6.9 of this report
- Develop performance assessment code (KPIs) - see section 6.10 of this report

The first step is to ensure that **new** facilities connected to the grid are compliant with an upgraded grid connection code for safe and reliable system integration of renewables. This might need some organisational adjustments on top of the enhanced grid connection requirements because of a recommended focus on compliance verification, e.g. establishment of a compliance verification team under the scope of TSO / RTO / DSO to ensure compliance with the legislation. The step 1 – action 1 – have to be seen as an interim action with merging the current C25 and C39 articles into a combined circular for smoothing the legal process but are not handling the technical issues raised in section 5.1.1 - 5.1.8 of this report and the overlapping issues raised in section 5.3 of this report.

The second step is to ensure that operational aspects are in place, and that information exchanged is valid and present at the requested time and of the required quality.

The third step is intended to include the missing connection codes for Demand, Storage and HVDC facilities. The connection codes could be developed in parallel as the experts to be involved in the specific codes are typically from different teams with different skills. The benefit of developing these in parallel could be to create a harmonized structure with the purpose of ease the reading and public acceptance of the new connection codes.

The fourth step is to address the market code and especially the ancillary services. These codes are not critical for the security of supply in the short and mid-term aspect, but it will be critical in the long term.

The fifth step is to ensure development of the quality of supply. This makes step 5 critical in the long term only as current regulation seems to be appropriate, focusing on the quality and efficiency of operation and long-term development of the Vietnamese electricity infrastructure.

8. References

The following documents are used as references in the report.

#	Description
1.	Circular 25 – “The regulations on electricity transmission system”
2.	Circular 28 – “Define the process of troubleshooting in the national electricity system”
3.	Circular 30 – “Amendments to some articles of C25”
4.	Circular 39 – “The regulations on electricity distribution system”
5.	Circular 40 – “The procedure for dispatching of national power system”
6.	Circular 31 – “Amending and supplementing a number of articles of C28, C40 and C44”
7.	Circular 42 – “Electricity Price regulations and guidelines”
8.	Circular 44 – “Define the operating procedure in the national electricity system”
9.	Circular 55 – “Technical requirements and management and operation of the SCADA system”
10.	Decision 106 – “The procedure of identifying and operating ancillary services”
11.	COMMISSION REGULATION (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (NC RfG)
12.	COMMISSION REGULATION (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators (NC RfG)
13.	COMMISSION REGULATION (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection NC DCC)
14.	COMMISSION REGULATION (EU) 2016/1447 of 26 August 2016 establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (NC HVDC)
15.	COMMISSION REGULATION (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (SO GL)
16.	COMMISSION REGULATION (EU) 2017/2196 of 24 November 2017 establishing a network code on electricity emergency and restoration (NC ER)
17.	Technical regulation 3.3.1 for battery plants, Danish grid connection code for BESS; published 28.09.2017.
18.	European Stakeholder Committee, Pump Storage Hydro Expert Group: Final Report; released 11,.12.2019.
19.	European Stakeholder Committee, Storage Expert Group: Final Report; released 12.12.2019.
20.	Cigré report 596 - GUIDELINES FOR POWER QUALITY MONITORING, Measurement Locations, Processing and Presentation of Data, Oct 2014.
21.	Cigré Technical Brochure: Network modelling for harmonic studies; Reference: 766; April 2019.

22.	Nordic synchronous area proposal for the frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127 of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation, 10 September 2018; link: https://consultations.entsoe.eu/markets/nordic-tsos-proposals-for-frequency-quality-and-fc/supporting_documents/Explanatory%20document%20for%20frequency%20quality%20proposal.pdf
23.	Synchronous Area Operational Agreement for Synchronous Area IE/NI, 12.07.2019; link: http://www.eirgridgroup.com/site-files/library/EirGrid/SAOA-for-the-Ireland-and-Northern-Ireland-Synchronous-area-V2.0-(for-consultation-post-RfA).pdf
24.	EAPP interconnector code and compliance program; link: http://eappool.org/interconnection-code-compliance-program/

9. Further reading and self-study on network codes

#	Description & link
1.	Florence school of regulators - Network Codes - self-study programs: https://fsr.eui.eu/tag/network-codes/

10. Annex 1 – Danish BESS GC – compliance documentation

Appendix 1 - Documentation

Technical regulation 3.3.1 for battery plants

This is a translation of the original Danish regulation text. In case of any discrepancies, the Danish version shall prevail.

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Appendix 1 Documentation

Appendix 1 specifies the documentation requirements for the five *plant categories*, see section 1.2.4:

- A1. *Battery plants* up to and including 11 kW
- A2. *Battery plants* above 11 kW up to and including 50 kW
- B. *Battery plants* above 50 kW up to and including 1.5 MW
- C. *Battery plants* above 1.5 MW up to and including 25 MW
- D. *Battery plants* above 25 MW or connected to over 100 kV.

The documentation, as specified in section 8, must be submitted electronically to the *electricity supply undertaking*.

The technical documentation must include the configuration parameters and configuration data applicable to the *battery plant* at the time of commissioning.

All subsections in the appendix must be filled in for the *battery plant* in question.

If information changes after the time of commissioning, updated documentation must be submitted as required in section 2.2.

A template for Appendix 1 for the various *plant categories* is available on Energinet.dk's website www.energinet.dk.

B1.1. Appendix 1 for battery plants

The documentation form must be filled in with data for the *battery plant*, valid at the time of commissioning, and submitted to the *electricity supply undertaking*.

B1.1.1. Identification

(Applicable to category A1, A2, B, C and D battery plants)

Plant	Description of the plant:
GSRN number	
Plant owner name and address:	
Plant owner tel. no.:	
Plant owner email:	
Inverter – make:	
Inverter – model:	
Inverter – rated power:	
Storage medium – make:	
Storage medium – model no.:	
Storage medium - energy storage capacity at rated inverter power in *POC*: [kW/h]	
Energy storage – runtime at rated inverter power in the *POC*: [kW/h]	

B1.1.2. Tolerance of frequency and voltage deviations
(Applicable to category A1, A2, B, C and D battery plants)

The *battery plant* is designed for single-phase connection when neither P_{no} nor P_{nl} exceeds 3.6 kW.	Yes ☐ No ☐
The *battery plant* is designed for three-phase connection if neither P_{no} nor P_{nl} exceeds 3.6 kW.	Yes ☐ No ☐
The *electricity supply undertaking* has determined the voltage level in the *Point of Connection* within the required limits as specified in table 3.1, section 3.1.	Yes ☐ No ☐
Within the *normal operating* range, the *typical operating voltage* is U_c±10%, see section 47,00, and the frequency range is 52.00 to 52.00 Hz. The *battery plant* can be started and operated continuously within this area, restricted by the protective settings.	Yes ☐ No ☐
The plant can withstand transitory (80-100 ms) phase jumps of up to 20° in the *Point of Connection*.	Yes ☐ No ☐
The plant can withstand transient frequency gradients of up to ±2.5 Hz/s in the *Point of Connection*.	Yes ☐ No ☐
After a voltage dip, the plant is able to return to normal operation no later than 5 seconds after the operating conditions have returned to the *normal operating range*.	Yes ☐ No ☐

B1.1.3. Voltage dip tolerances
(Applicable to category C and D battery plants)

Will the *battery plant* remain connected to the public electricity supply grid during voltage dips as specified in section 3.3.1, Figure 5?	Yes ☐ No ☐
Does the *battery plant* deliver additional reactive current during voltage dips as specified in section 3.3.1, Figure 6?	Yes ☐ No ☐
Will the *battery plant* remain connected to the public electricity supply grid during recurring faults as specified in section 3.3.2?	Yes ☐ No ☐
Is a simulation enclosed, documenting that the Low Voltage Fault Ride Through (LVFRT) requirements have been met? If No, how is compliance then documented?	Yes ☐ No ☐

B1.1.4. Power quality

Category / Requirements	A1	A2	B	C	D
DC content (4.2)	X	X	X	X	X
Asymmetry (4.3)	X	X	X	X	X
Flicker (4.4)	X	X	X	X	X
Harmonic distortions (4.5)	X	X	X	X	X
Interharmonic distortions (4.6)			X	X	X
Distortions 2-9 kHz (4.7)			X	X	X

Overview of power quality requirements for plant categories

B1.1.4.1. Voltage quality

For each power quality parameter must be indicated how the result was achieved, either by means of the type test for each of the units of which the *battery plant* is composed, or by means of an emission model developed for the system.

Have the values been calculated/simulated?	Yes ☐ No ☐
Have the values been measured?	Yes ☐ No ☐
Is a report enclosed, documenting that the calculations or measurements comply with emission requirements? If No, how are calculations or measurements then documented?	Yes ☐ No ☐
Has the *electricity supply undertaking* set emission limits in the *Point of Connection*? **(Applicable to category C and D *battery plants* for all power quality parameters)** The requirements for category A1 and A2 *battery plants* are specified in the criteria for inclusion on the *positive list* – for all power quality parameters. The requirements for category B *battery plants* can be found in the regulation.	Yes ☐ No ☐

B1.1.4.2. DC content

Does the DC content at normal operation exceed 0.5% of the *rated current*?	Yes ☐ No ☐

B1.1.4.3. Asymmetry

Does asymmetry at normal operation and during faults exceed 16 A?	Yes ☐ No ☐
If the *battery plant* consists of single-phase electricity-generating units, is it ensured that the above limit is not exceeded?	Yes ☐ No ☐

B1.1.4.4. Flicker

Is the *flicker* contribution for the *battery* plant below the limit value? (See requirements for *category* B *battery plants* in Table 5 in the regulation.)	Yes ☐ No ☐

B1.1.4.5. Harmonic distortions

Are all *harmonic distortions* for the *battery* plant below the limit values? (See requirements for *category* B *battery plants* in Table 6 and Table 7 in the regulation.) (See requirements for *category* C and D *battery plants* in Table 8 in the regulation.)	Yes ☐ No ☐

B1.1.4.6. Interharmonic distortions

Are all *interharmonic distortions* for the *battery plant* below the limit values? (See requirements for *category* B *battery plants* in Table 10 in the regulation.)	Yes ☐ No ☐

B1.1.4.7. Distortions in the 2-9 kHz frequency range

Has the requirement for emission of distortions with frequencies in the 2-9 kHz range been met? (Requirements for *category* B *battery plants*: The emission of currents with frequencies higher than 2 kHz must not exceed 0.2% of the *rated current* in any of the frequency groups measured.)	Yes ☐ No ☐

B1.1.5. Control

Control function	A1	A2	B	C	D
Frequency response – LFSM-O (5.2.1.3)	X	X	X	X	X
Frequency response – LFSM-U (5.2.1.5)	-	-	-	X	X
Frequency control	-	-	-	X	X
Absolute power limit (5.2.3.1)	X	X	X	X	X
Ramp rate limit (5.2.3.2)	X	X	X	X	X
Q control (5.3.1) *)	X	X	X	X	X
Power Factor control (5.3.2) *)	X	X	X	X	X
Automatic Power Factor control (5.3.4) *)	X	X	-	-	-
Voltage control (5.3.3) *)	-	-	-	X	X
System protection (5.4)	-	-	-	(X)	(X)

Control functions for a battery.

All control functions mentioned in the following sections refer to the *Point of Connection.*

In order to ensure security of supply, the *transmission system operator* must be able to activate or deactivate the specified control functions by agreement with the *plant owner.*

Control functions must be for single units or for a plant controller.

Before commissioning, current parameter settings for reactive power and voltage control functions must be determined by the *electricity supply undertaking* in collaboration with the *transmission system operator*.

B1.1.5.1. Connection and synchronisation
(Applicable to category A1, A2, B, C and D battery plants)

Can the *battery plant* be started and operate continuously within the normal range restricted only by the protective settings?	Yes ☐ No ☐
Do connection and synchronisation occur more than 3 minutes after voltage and frequency have come within the normal production range?	Yes ☐ No ☐

B1.1.5.2. Control of active power and frequency
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with a *frequency response* function? Regulation must be commenced no later than 2 seconds after a frequency change is detected and must be completed within 15 seconds. It must be possible to set the *frequency response* function's frequency points (response frequencies are indicated in Table 11 and Table 12 in the regulation), indicated in Figure 9 and Figure 10 in the regulation, to any value in the 10.00-52.00 Hz range with a resolution of maximum 10 mHz. For *category* C and D *plants*, *frequency response* functionality is required for underfrequency, LFSM-U. This is required for all *battery plants* in case of overfrequency, LFSM-O.	Yes ☐ No ☐

B1.1.5.3. Frequency control
(Applicable to category C and D battery plants)

Is the *battery plant* equipped with a *frequency control* function as specified in section 5.2.2?	Yes ☐ No ☐

B1.1.5.4. Absolute power limit
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with an *absolute power limit* function?	Yes ☐ No ☐
Is the function activated?	Yes ☐ No ☐

B1.1.5.5. Ramp rate limiter function
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with a *ramp rate limiter* function?	Yes ☐ No ☐
Is the function activated?	Yes ☐ No ☐

B1.1.5.6. Reactive power control

Reactive power can be controlled by means of:	*Q control*	☐
	Power Factor control	☐
	Voltage control	☐

B1.1.5.7. Q control
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with a *Q control function* as specified in section 5.3.1?	Yes ☐ No ☐
Is the control function activated with a set point of ______ VAr? (Value may not differ from 0 VAr unless agreed with the *electricity supply undertaking*).	Yes ☐ No ☐

B1.1.5.8. Power Factor control
(Applicable to category A1, A2, B, C and D battery plants)

Is the *battery plant* equipped with a *Power Factor control* function as specified in section 5.3.2?	Yes ☐ No ☐

B1.1.5.9. Voltage control
(Applicable to category C and D battery plants)

Is the *battery plant* equipped with a *voltage control* function as specified in section 5.3.3?	Yes ☐ No ☐

B1.1.5.10. Automatic Power Factor control
(Applicable to category A1 and A2 battery plants)

Is the *battery plant* equipped with an automatic *Power Factor control* function as specified in section 5.3.4?	Yes ☐ No ☐
As a starting point, the function must be deactivated and must be activated only by agreement with the *electricity supply undertaking*. Is the function deactivated?	Yes ☐ No ☐

B1.1.5.11. Order of priority for control functions

Has the order of priority for the *battery plant*'s control functions been set as specified in section 5.5?	Yes ☐ No ☐

B1.1.5.12. System protection
(Applicable to category C and D battery plants)

Is the *battery plant* equipped with a *system protection function* as specified in section 5.4?	Yes ☐ No ☐
Is the function activated?	Yes ☐ No ☐

B1.1.5.13. Power Factor interval

Control method and settings must be agreed with the *electricity supply undertaking* for *category* C and D *battery plants*.

Applicable to *plant category* A1, A2 and B Does the *battery plant* lie within the *Power Factor* interval specified in section 5.3.5.1?	Yes ☐ No ☐
Applicable to *plant category* C Does the *battery plant* lie within the *Power Factor* interval specified in section 5.3.5.2, Figure 17?	Yes ☐ No ☐
Can the *battery plant* deliver reactive power in the voltage range as specified in section 5.3.5.2, Figure 18?	Yes ☐ No ☐
Applicable to *plant category* D Does the *battery plant* lie within the *Power Factor* interval specified in section 5.3.5.3, Figure 19?	Yes ☐ No ☐
Can the *battery plant* deliver reactive power in the voltage range as specified in section 5.3.5.3, Figure 20?	Yes ☐ No ☐

B1.1.6. Protection against electricity system faults

All settings are stated as root-mean-square (RMS) values, and settings deviating from these may be used only with the permission of the *electricity supply undertaking*.

Voltage and frequency must be measured for all three phases as line-to-line voltage.

Alternatively, if the measuring point is located on the low-voltage side of the plant transformer, voltage can be measured between the three phases and ground.

Frequency must be measured simultaneously on all three phases.

B1.1.6.1. Protective functions

Applicable to *category* A1 and A2 *battery plants* Are the protective functions with associated operating settings and trip time for the *battery plant* in accordance with the specifications in section 6.3.1, Figure 17?	Yes ☐ No ☐
Applicable to *category* B *battery plants* Are the protective functions with associated operating settings and trip time for the *battery plant* in accordance with the specifications in section 6.3.2, Figure 18?	Yes ☐ No ☐
Applicable to *category* C *battery plants* Are the protective functions with associated operating settings and trip time for the *battery plant* in accordance with the specifications in section 6.3.3, Figure 19?	Yes ☐ No ☐
Applicable to *category* D *battery plants* Are the protective functions with associated operating settings and trip time for the *battery plant* in accordance with the specifications in section 6.3.4?	Yes ☐ No ☐

B1.1.7. Exchange of signals and data communication

Activation of the individual functions in the plants and configuration of the specific parameters must fulfil the requirements stated in Technical Regulation 5.8.1 [ref. 10].

B1.1.7.1. Signal description

Applicable to *category* A1 and A2 *battery plants* Has the requirement for information exchange with the *battery plant* been met as specified in section 7.2.1, Table 20?	Yes ☐ No ☐
Applicable to *category* B *battery plants* Has the requirement for information exchange with the *battery plant* been met as specified in section 7.2.2, Table 21?	Yes ☐ No ☐
Applicable to *category* C *battery plants* Has the requirement for information exchange with the *battery plant* been met as specified in section 7.2.3, Table 22?	Yes ☐ No ☐
Applicable to *category* D *battery plants* Has the requirement for information exchange with the *battery plant* been met as specified in section 7.2.3, Table 22?	Yes ☐ No ☐

B1.1.7.2. Fault incident recording and requesting of metered data and documentation

(Applicable to category D battery plants)

The specific settings for incident-based logging must be agreed with the *transmission system operator* upon commissioning of the *battery plant*.

Has logging equipment which records voltage for each phase for the *battery plant* been installed in the *Point of Connection*?	Yes ☐ No ☐
Has logging equipment which records current for each phase for the *battery plant* been installed in the *Point of Connection*?	Yes ☐ No ☐
Has logging equipment which records active power for the *battery plant* (can be computed values) been installed in the *Point of Connection*?	Yes ☐ No ☐
Has logging equipment which records reactive power for the *battery plant* (can be computed values) been installed in the *Point of Connection*?	Yes ☐ No ☐
Has logging equipment which records frequency for the *battery plant* (can be computed values) been installed in the *Point of Connection*?	Yes ☐ No ☐
The *transmission system operator* can request metered data and fault recorder data collected for the *battery plant* for a period of up to three months back in time.	Yes ☐ No ☐

B1.1.8. Verification and documentation

The *plant owner* is responsible for ensuring that the *battery plant* complies with this technical regulation and for documenting that requirements are met. A documentation package must be submitted to the *electricity supply undertaking*.

Documentation	A1	A2	B	C	D
Supplier statement	X	X	X	X	X
Protective functions	X	X	X	X	X
Single-line representation	X	X	X	X	X
Power quality	X	X	X	X	X
Voltage dip	-		-	X	X
PQ diagram	-		-	X	X
Signal list	-		-	X	X
Dynamic simulation model	-		-	X	X
Verification report	-		-	X	X

Documentation requirements for plant categories

B1.1.8.1. Supplier statement
(Applicable to category A1, A2, B, C and D battery plants)

Is a supplier statement regarding the *battery plant* enclosed with the documentation?	Yes ☐ No ☐

B1.1.8.2. Protective functions
(Applicable to category A1, A2, B, C and D battery plants)

Is documentation of protective functions for the *battery plant* enclosed? This means a list of values for the relay configurations applicable at the time of verification.	Yes ☐ No ☐

B1.1.8.3. Single-line representation
(Applicable to category A1, A2, B, C and D battery plants)

Is a single-line representation for the *battery plant* enclosed with the documentation? If No, when will the final single-line representation be provided?	Yes ☐ No ☐

B1.1.8.4. PQ diagram
(Applicable to category C and D battery plants)

Has the final PQ diagram been submitted to the *electricity supply undertaking*? If No, when will the final PQ diagram be provided?	Yes ☐ No ☐

B1.1.8.5. Signal list
(Applicable to category C and D battery plants)

Has the final signal list been submitted to the *electricity supply undertaking*? If No, when will the final signal list be provided?	Yes ☐ No ☐

B1.1.8.6. Simulation model
(Applicable to category C and D battery plants)

Has the electrical simulation model for the *battery plant* been submitted to the *electricity supply undertaking*? If No, when will the final simulation model be provided?	Yes ☐ No ☐

B1.1.8.7. Verification report
(Applicable to category C and D battery plants)

Has the verification report been submitted to the *electricity supply undertaking*? If No, when will the verification report be provided?	Yes ☐ No ☐

B1.1.9. Signature

Date of commissioning	
Company	
Person responsible for commissioning	
Signature	

KOLOFON

Energinet
Tonne Kjærsvej 65
DK-7000 Fredericia

+45 70 10 22 44
info@energinet.dk
VAT no. 25 94 33 25

Author: KDJ/MDA
Date: July 6, 2020