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LEGISLATION ASSESSMENT FOR VARIABLE RENEWABLE ENERGY FORECASTING

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ACRONYMS

USAID	United States Agency for International Development
UTM WGS	Universal Transverse Mercator World Geodetic System
VRE	Variable Renewable Energy
WASP	Wind Atlas Analysis and Application Program
ADB	Asian Development Bank
AEMO	Australian Energy Market Operator
ASL	Meters Above Sea Level
AWEFS	Australian Wind Energy Forecasting System
CAISO	California Independent System Operator
DEM	Digital Elevation Model
DUID	Dispatchable Unit ID
GoG	Government of Georgia
GPS	Global Positioning System
GSE	Georgian State Electrosystem
IEC	International Electrical Commission
kW	Kilowatt
MoU	Memorandum of Understanding
MW	Megawatt
QWF	Qartli Wind Farm
SCADA	Supervisory Control and Data Acquisition System

CONTENTS

EXECUTIVE SUMMARY

It is common that Variable Renewable Energy (VRE) Forecasting accuracy is dependent on an optimal combination of Static Data – mostly the design and actual parameters of Wind or Solar Power Plant and Dynamic Data consistent of measurement of meteorological parameters and power generation derived from VRE power plant Supervisory Control and Data Acquisition System (SCADA).

The most important piece of information from wind generation facilities SCADA is the generation, wind speed, wind direction, availability and curtailment of data. The availability and quality of this information tend to have the greatest impact on the forecast performance. Although, in general, the air temperature, relative humidity, and pressure data are less critical, in certain situations their influence might be bigger.

According to the current practice of California Independent System Operator (CAISO) and Australian Electricity Market System Operator, to ensure the proper data input of VRE forecasting System, either the supply of certain data is set as a mandatory (the case of Australian Energy Market Operator AEMO) or both the delivery of certain data and existence of meteorological parameters measurement equipment are set as a mandatory at the VRE power plant (the case of CAISO).

As stated, in the case of AEMO only the supply of static and dynamic data is obligatory. The technical specifications of solar and wind farm, together with geographical and topographical data are considered under the static, whereas the delivery of the real-time data on instantaneous measurement of power generation and measurement of certain meteorological parameters are obligatory under the dynamic data requirement.

Commonly, data required for the AEMO forecasting system Australian Wind Energy Forecasting System (AWEFS)[1] could be grouped as listed below:

Table 1: Data Required for Australia Wind Energy Forecasting System

Static Data	Data for wind farm identification
Static Data	Data for wind farm Status
Static Data	Wind farm nominal data
Static Data	Wind farm location & terrain data
Dynamic Data	Wind Farm SCADA Data

A significant portion of data, similar to data required by the AEMO as an input of AWEFS, might be obtained under the existing data requirement of Network Rules if the VRE project is at the test mode considered by the Connection Agreement, or already connected to the Transmission Network, commissioned and operational. Respectively it might be noted that, data requirement for fulfilment of the forecasting system is dependent on the stage of VRE project development

Moreover, even under the provisions of the existing Network Rules, the performance of the next day generation scheduling is a must. For the said purposes, it is mandatory for each generator with installed capacity above the 5 MW to fill and submit to Dispatch Licensee a Readiness Application. The Readiness Application proposed for the day is starting at 00:00 of next day of scheduling and continues for 24 hours, including 24:00 of the next day and it is the day for which the relevant readiness schedules are prepared. Under the Readiness Application, the hourly data (forecast) of working capacity (MW) for next day should be submitted to Dispatch Licensee.

Under the current version of the Network Rules it might be challenging to oblige VRE project operator of a developer to perform real time meteorological data measurement and share it to Dispatch Licensee.

[1] Australian Wind Energy Forecasting System (AWEFS) https://www.aemo.com.au/-/media/Files/PDF/Australian-Wind-Energy-Forecasting-System-AWEFS.pdf

INTRODUCTION

With the VRE forecast in place, system operators, in advance, have access to detailed information on where, when, and approximately how much electricity will be produced by each large wind or solar plant. This will enable operators to efficiently commit resources to meet demand.

More specifically, it allows operators to have greater confidence in the amount of electricity each wind or solar facility is likely to generate at a given time, which will decrease the need to commit more generation from other types of power plants. This should also help limit the number of times, when there is not enough generation available and ready to produce electricity when wind speed is low and, therefore, wind energy output, is lower than the VRE plant offered to provide.

In general, wind and solar power forecasting systems, whether they are based on a physical or statistical approach, beyond the static information which derives from design data and technical specifications of the plant, requires real-time information from the VRE units to calculate precise forecasts. The experience of countries in VRE installations in their electricity generation portfolio is that these requirements are integrated into the Network Rules (Grid Code) or relevant business practice manuals and guidelines.

Mandatory under the legislation, the delivery of data required for the proper functioning of VRE forecasting system seems to be a good solution to guarantee a standardized and reliable data supply to grid or system operators, utilizing centralized VRE forecasting system. The important aspect is to define the data requirements as precisely as possible in terms of contents, format, quality, granularity and data delivery periodicity.

The VRE Forecasting System is underdeveloped in Georgia. Respectively, the examination of how the provisions of the existing Network Rules will contribute to the presence of the VRE forecasting system and / or data supply required for forecasting would be the valuable step for facilitating the VRE Forecasting System development and implementation.

METHODOLOGY

With the purpose to check the way in which data requirement, set by the existing Network Rules, could be utilized to ensure the proper input for the proposed system of VRE forecasting, USAID Energy Program applied the AEMO VRE forecasting data requirement and the existing Network Rules.

Respectively for the comparative analysis, it was assumed that Network Rules represent the main legislative document on ensuring the proper input for the proposed VRE forecasting system similar to the forecasting system AWEFS, operated by the AEMO (assumption). Also, it was assumed that in case of Georgia more practical aspect would be the best approach where the type of data, required for the forecasting system, is set as a mandatory.

For the comparative analysis, to each line item from data requirement, set by AEMO through its Energy Conversion Model, the articles and subparagraphs from the existing Network Rules were assigned. The assigned articles and subparagraphs from our point of view should ensure the delivery of required input to the forecasting system.

COMPARATIVE ANALYSIS

WIND FARM IDENTIFICATION

Table 2: Wind Farm Identification[2]

Data Type	Description
Name	Name of the wind farm. To be same as specified in the Registration process
DUID	Dispatchable Unit ID (DUID) of the wind farm to be proposed by the participant. Maximum 8 characters allowed. Example – QWFWIND - (Qartlli Wind Farm). *Note: DUID to be same as specified in the Registration process.*
Region	Name of the Region where the wind farm is installed. Needs to be the same as specified in the Registration process.

NETWORK RULES ARTICLES RELATED TO THE WIND FARM STATUS DATA

Article 7. Basic Requirements for Network Connection Paragraph 1, 2, 5a, 5b, 9, and 10.

Article 8. Connection Application Paragraph 1, 2, and 3.

JUSTIFICATION ON THE AVAILABILITY OF DATA FOR WIND FARM IDENTIFICATION

Due to information, requested from wind projects for submitting the connection application, it's possible to obtain information on wind farm requisites and its location and the first stage of the connection. For each wind farm, its mandatory to provide annually different type of technical information which should be supplemented with the requisites of wind farm.

According the first paragraph of the Article 7, "The rules and requirements for connection to electricity Transmission Network" shall encompass the connection of only those units that are not connected to electricity Transmission Network and are not supplied with electricity as envisaged in the legislation, as for power station – electricity is not supplied in the network".

Referring to the Article 2 definition from Network Rules, the Connection Application is a written request prepared in compliance with the Network Rules regarding the connection to the network or modification of the existing connection.

Respectively, through the provisions of the above provided article 7 and Article 8 subparagraphs, it is possible to obtain data on new connection as well as on the modification of the existing connection of power plant.

Furthermore, according to the Article 7 Paragraph 2 - A declarant seeking new connection to the Transmission Network shall apply to the respective Transmission Licensee and enter into Connection Agreement with Dispatch and Transmission Licensees.

Before entering the Connection Agreement, under the requirement of the Article 8 Paragraph 2, the Connection Application should be filled and submitted to the Transmission Licensee:

The Connection Application shall include the following information:

a) Name of a declarant, organizational form, bank details, address, telephone number and e-mail;
b) Contact person responsible for receiving technical information;
c) Name, location and Global Positioning System (GPS) details of a unit to be connected;
d) Field of activity of a unit to be connected;
e) Types of equipment-installation of a new connection;
f) Presumable date for the connection of a declarant's unit to the electricity Transmission Network;
g) Presumable level of nominal voltage of a facility to be connected;
h) The following data of a facility to be connected:

    h. a) Designed capacity – in case of a producer;

[2] Reference: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Dispatch/Policy_and_Process/2016/Energy_Conversion_Model_Guidelines_Wind_20161209.xlsx

h. b) Active capacity – in case of a different user;
h. c) Reactive capacity or coefficient of active capacity.

i) Upon the request of a user – the necessity of alternative electricity supply in order to the prevent interruption of electricity supply;

Moreover, under the Article 8 Subparagraph 5a) the submission of the cadastral map with the indication of generators location is required.

WIND FARM STATUS

Table 3: Wind Farm Status

Data Type	Description
Status of the wind farm	New future wind farm or extension of an existing wind farm?
From which date is or will the wind farm be fully operational?	Provide the plan for progressive commissioning of the wind farm with expected dates of commissioning per wind turbine - as per Rules Cl 5.8.4
From which date will the wind farm be first connected to the grid or energized?	Provide the date when the wind farm is expected to commence generation.

NETWORK RULES ARTICLES RELATED TO THE WIND FARM STATUS DATA

Article 7. Basic Requirements for Network Connection Paragraph 1 and 5b.

Article 2. Definitions o) and z53.

Article 2. Definitions.

Article 11^2 Connection Fee paragraph 7.

Article 13 Connection of Declarant's Unit (putting into operation).

Article 32 Classification of Required Data for Transmission Network Planning.

JUSTIFICATION ON THE AVAILABILITY OF DATA ON WIND FARM STATUS

Under the Connection Application, the Applicant - VRE project Developer should indicate the proposed connection dates, whereas the actual connection proposed in the period equals the period of validity of Connection Agreement. Furthermore, to ensure the compliance with the conditions prescribed in Connection Agreement, the preliminary testing should be performed on electrical equipment and power generation units of VRE project developer, requesting the connection, should ensure readiness for operation and connection to the Transmission Network.

With the consideration of the above mentioned, it might be assumed that Dispatch and Transmission Licensee, at all the stages of wind farm development after the request of connection, is capable of obtaining information on units' commencement and possible dates of connection.

Moreover, Dispatch Licensee is responsible for the Network planning. To fulfill its responsibilities, it is authorized to obtain "Detailed Data" annually.

Referring to the Article 2, Definition of Terms, here the Connection Application is a written request prepared in compliance with Network Rules regarding the connection to the network or modification of the existing connection; In case of Wind Farm Extension, the modification of connection might be required. Respectively the developer of Wind Farm would apply the Connection Application to transmission licensee and this information would become known to the Dispatch Licensee which is involved in the connection process.

In Connection Application, only the connection dates are requested and not the progressive connection of the turbines. The date of commencement would be clarified in the Connection Agreement which would be signed by the developer and Dispatch and Transmission Licensee.

According to the article 2 definition of terms z53) (ȝ47 in Georgian version of Network Rules), Period to Ensure Connection to Transmission Network represents the following – in case of the first stage, it refers to connection determined as a period between the submission of an application requesting connection to the Transmission Network and receipt of connection offer; in case of the second stage it implies connection – period from contract signing to successful testing of equipment and preparation for operation;

Furthermore, according to the Article 11[2] Connection Fee Subparagraph 7, the connection of a declarant to the electricity Transmission Network, including testing and preparation for operation of equipment, shall be carried out within the term of validity of the Connection Agreement.

According to the Article 13, Connection of Declarant's Unit (Putting into Operation), before putting Declarant's electrical equipment/ installations into the operation it is mandatory to undertake preliminary testing in compliance with instructions of Dispatch Licensee. After testing, the Declarant is obliged to submit written notification to the respective Transmission Licensee on readiness for connection. Written notification should be supplemented by reports of testing readiness of electrical equipment/installations for connecting to the Transmission Network.

Also, according to the Article 32 The data for Transmission Network planning is classified into 4 main categories:

a. Preliminary design data;
b. Design data;
c. Standard data;
d. Detailed (additional) data.

Design data shall be presented by Declarants in case of requesting the new connection or modification of the existing one after receiving the connection offer. Standard data shall be presented annually by all existing Users of the Transmission Network. Detailed (additional) data may be additionally requested by the Dispatch Licensee in addition to the design and standard data.

Generators are obliged to annually fill the Standard Data template and Detailed Data template, approved by the JSC Georgian State Electrosystem (GSE). Both forms consider line item which if filled indicates the generation capacity year by year for the next 5 year from the submission of the forms.

WIND FARM NOMINAL DATA

Table 4: Wind Farm Nominal Data

Data Type	Description
Nameplate Rating	The total installed capacity of the Wind Farm (MW). This equals turbine nameplate rating x total number of turbines installed. This Item corresponds to *"Nameplate Rating" in Sections C and I.5 of "Application for Registration as a Generator in the NEM."*
Maximum Capacity	Maximum generation to which the semi-scheduled generating unit may be dispatched. This definition can be found in sections C, I.4 and I.5 of "Application for Registration as a Generator in the NEM",

NETWORK RULES ARTICLES RELATED TO THE WIND FARM NOMINAL DATA

Article 7 Basic Requirements for Network Connection Subparagraph 5b.

Article 8. Connection Application Subparagraphs 1-2-3.

Network Code Annex 1.

Article 10. Offer of Connection.

Article 2. Definition of Term Z55) Technical Project.

Article 2 Definitions of Terms Z44) Working Capacity.

Article 32. Classification of required data for Transmission Network Planning Paragraphs from 1 to 10.

JUSTIFICATION ON THE AVAILABILITY OF DATA ON WIND FARM STATUS

At the first stage, a declarant is submitting the Connection Application. At the second stage a technical project, considering the technical specification of the generators, should be submitted as well. At this stage information on the designed capacity of generators might become available for the Dispatch and Transmission Licensee. Later, at a final stage, the testing procedures would clarify the Working Capacity[3] which might be the same as the maximum dispatchable capacity of the generator.

[3] Network Rules Article 2 Definition z44) Working Capacity – maximum capacity of power plant that can be obtained through possible maximum use of available primary resources (hydro resources, fuel etc.) within 24 hours or several consecutive hours, taking into consideration the technical condition of energy unit/ aggregate (deducting capacity spent during repair process.

Moreover, after the connection to the Transmission Network through the submission of the Standard Data and Detailed Data filled forms for the planning purposes, generator is obliged to update information on the generation capacity.

According to the Article 7, Basic Requirements for Network Connection Subparagraph 5b, there are two stages for the connection. The first stage shall cover the submission of an application and all requested documents, whereas the second stage shall cover the signing of the Connection Agreement among Transmission Licensee, Dispatch Licensee and a declarant seeking connection; the completion of connection works by respective party as it is envisaged in the technical conditions for connection; the agreement of the technical project by the Dispatch Licensee; a successful testing of equipment foreseen in the agreement and preparation for operation.

Referring to the definition of the Technical Project[4] which is a part of connection's second stage, general information on Generators Technical Specification (nameplate rating) would become available for Dispatch and Transmission licensee even at the connection stage. Whilst the maximum capacity, which might be dispatched, would be clarified during the testing stage which is the predecessor of the connection to the network process.

Under the Article 32, generators are obliged to fill the Standard Data template and Detailed Data template approved by the GSE. Both forms consider line item which if filled indicates the generation capacity year by year for the next 5 year from the submission of the forms.

WIND FARM LOCATION AND TERRAIN DATA

Table 5: Wind Farm Location and Terrain Data

Data Type	Description
Geographical coordinates (Universal Transverse Mercator World Geodetic System (UTM WGS)-84)	Geographical coordinates of a representative point of the wind farm, example: UTM WGS 84 Z55 E304898 N5489758
Geographical coordinates	Geographical coordinates of a representative point of the wind farm, example: - 40.72067 / 144.68691
Wind farm altitude	Representative value for the wind farm altitude (given as a unique value in m ASL [meters above sea level]). It should be average of ground altitude for turbine locations.
Wind farm geometry	Given as a map with marked wind turbines position (high resolution image/ PDF file)
Orography information	Given as a map of the wind farm area in numerical format with the highest available spatial resolution (recommended not inferior than 200 m) (e.g. WASP [Wind Atlas Analysis and Application Program] format)
Mesoscale roughness coefficient	Given as a unique representative value for the mesoscale roughness coefficient of the wind farm (meso z0)
Roughness of surrounding area	Given as a map in numerical format (e.g. WASP format) with the highest available spatial resolution (recommended not inferior than 200 m) or paper format (1:50000)
Met mast measuring height	Description: If a met mast available, indicate the measuring height(s) above ground level. Example - Met mast (SCADA wind speed data) height: = met mast A=80m, met mast B=85m, met mast C=92m.
Met mast Geographical coordinates	Description: If a met mast available, indicate the geographical coordinates. Example - Met mast (SCADA wind speed data) coordinates = met mast A: (- 81.15611,122.47823) met mast B: (- 81.15984,122.47159)
Air density	The typical air density at the level of this Wind Farm (yearly average). In case of multiple power curves, the one that corresponds to this density is considered.

NETWORK RULES ARTICLES RELATED TO THE WIND FARM LOCATION AND TERRAIN DATA

Article 8. Connection Application Paragraph 5 Subparagraph a).

Article 23. Subparagraph 18.

JUSTIFICATION ON THE AVAILABILITY OF DATA ON WIND FARM STATUS

If the cadastral map is available in electronic format, a representative point and altitude of wind farm might be estimated. It is possible to obtain the map on the disposition of wind generators which might

[4] Network Rules Article 2 Definition z55) Technical Project a document or a combination of documents that in compliance to technical conditions and Connection Agreement issued for the existing electrical (transmission or distribution) network, encompasses key data about a new connection (electricity transmission line, substation, power station) - electricity transmission trace line, material of cable conductor/wire and cross section, types of electricity transmission tower, generators, substation scheme (of transformers, communication equipment, secondary communication, technical details of ancillary equipment and so on);

be utilized to determine the geometry of the wind project. Specific to the wind industry maps like Digital Elevation Model (DEM) or Roughness Map are not mentioned in the article regarding the connection neither in the Connection Application form. In case the forecasting service or software vendor request the DEM or Roughness Map, some additional changes will be required to the Connection Application form or respective article of Network Rules to obtain maps in the appropriate format requested by the vendor of forecasting services.

Before the wind project becomes bankable, a project developer must perform the measurement of meteorological parameters at meteorological masts installed in proximity of proposed project[5]. The measurement of meteorological parameters is recommended at the height proximity to wind turbine hub height. The indication of the met mast specification and the location are not considered in the articles related to the connection, neither in the Connection Application form. If after the commissioning of the wind turbines, met-mast remains, and/or installed measurement equipment remains fully operational, this together with the measurement of met parameters on nacelles of wind turbines would provide more reliable and precise input for the forecasting system.

Respectively if the measurement of the meteorological parameter is requested by the vendor of forecasting services, some amendments should be made in the Network Rules regarding the existence of met mast in the proximity of wind project and provision of the information regarding the location and technical specification installed on met mast.

Dispatch Licensee is authorized to acquire metering control and other data of power plant, this might be required for fulfilling the obligations conferred upon it by the legislation. The said might be utilized to obtain information about the meteorological equipment installed on nacelles of wind turbines, however, the met mast is hard to perceive as a part of power plant.

The provision of Orography information[6], Mesoscale roughness[7] coefficient, information on roughness of surrounding area, are not considered in Connection Application, nor in the technical project. Moreover, a clear or detailed requirement which should make the provision of such information or data mandatory, does not exist in Memorandum of Understanding (MoUs) signed between the Government of Georgia (GoG) and developers of the proposed wind projects.

Under the Article 8, Connection Application Subparagraph 5a, the cadastral map and map for disposition of generators are requested. Thus, at some extent, the representative point and altitude of the wind farm might be estimated under the provisions of said article. The provision of Orography information, Mesoscale Roughness Coefficient and information on roughness of surrounding area are not considered in Connection Application, nor in Technical Project.

Under the Article 23 subparagraph 18, Dispatch Licensee is authorized to acquire metering control and other data of power plant, that might be required for fulfilling obligations conferred upon it by the legislation. Orography information, Mesoscale Roughness Coefficient, information on roughness of surrounding area can be perceived as parameters which are difficult to attribute to the plant related data.

[5] Requested under the MoU signed with GoG
Recommended in the Guidelines for Wind Resource Assessment: Best Practices for Countries Initiating Wind Development - Asian Development Bank (ADB)
[6] Map of terrain roughness in numerical format
[7] Map of wind generator area in numerical format (dimensions of land surface)

WIND FARM SCADA TO SYSTEM OR MARKET OPERATOR

Table 6: Wind Farm SCADA to AEMO

Data Type	Description
Instantaneous measurements are required, unless otherwise agreed by AEMO. Instantaneous means values updated at least every 4-10 seconds, with 4 seconds or faster preferred. If only averages are available, a maximum 15-second average update is required.	
Wind farm active power	Total wind farm active power.
Number of wind turbines available for generation data	Number of turbines available for generation. This definition is the summation of: • Turbines operating; • Turbines available to operate, but not operating due to ambient wind conditions (very low / high wind speeds, extreme direction change); • Turbines available to operate but paused due to down regulation. This definition excludes all the following cases: • Turbines under maintenance or repair; • Turbines with a fault or damage; • Turbines not yet built; • Transmission/distribution network not available. If agreed with AEMO, turbines paused due to ambient temperature may be counted as available in this signal.
Number of wind turbines actively generating	Number of turbines actively generating power
Local Limit	In MW, the SCADA Local Limit for a wind farm is the lower of its plant availability and all technical limits on the capacity of its connection assets to export energy. When implemented in AWEFS, the SCADA Local Limit is used to cap the UIGF for the wind farm in the dispatch timeframe. The SCADA Local Limit excludes limits on a transmission network and distribution network (to ensure AEMO's compliance with clause 3.7B(c)(6) of the Rules) and may exclude other limits managed by AEMO through the central dispatch process. Limits already communicated in the SCADA Turbines Available signal may be excluded from the SCADA Local Limit. Manually-applied transient limits not intended to apply at the end of the next dispatch interval may be excluded from the SCADA Local Limit. The SCADA Local Limit should not exceed the higher of the nameplate rating and the Maximum Capacity of the wind farm.
Wind Farm Control System Set-Point	MW set-point applied in the wind farm's control system to limit (down regulate) its output. At other times when no limit applies, the set-point to be set to above the wind farm's Nameplate Rating, but below 250% of it.
Pressure or humidity data	Also provide the height at which this is measured.
SCADA data available from this wind farm	SCADA readings not listed above, if any, to be provided as per National Electricity Rules S5.2.6.

NETWORK RULES ARTICLES RELATED TO WIND FARM SCADA

Article 2 Definitions.

Article 45. Operational Communication Between the Dispatch Licensee, the Transmission Licensee and Electricity System Participants.

Article 52. Scheduling Electricity Generation.

Article 53. Electricity Producer's Readiness Application.

JUSTIFICATION ON THE AVAILABILITY OF DATA ON WIND FARM STATUS

Referring to the definition of III Level SCADA, it is designated to control the regime parameters of generator and doesn't consider the meteorological parameters measurement data acquisition.

One of the biggest innovations — which goes back to 2006, however being widely implemented now— is the International Electrical Commission (IEC) 61400-25 standard for wind turbines. The IEC and the wind industry worked to create the communications standard for monitoring and controlling the wind power plants.[8]

[8] SCADA 2014 systems for wind Exploring the latest developments in supervisory control and data acquisition software, and trends to enhance the commercial viability of wind

The scope of the IEC 61400 25 - is addressing all communication means among wind power plant components such as wind turbines and actors such as SCADA systems and dispatch centers. Its application area covers all components required for the operation of wind power plants including the meteorological subsystem, the electrical subsystem and the wind power plant management system.

Even more, there are companies offering SCADA services and those services consider a supervisory wind-farm control, automated and staggered turbine shutdown and startup meteorological data acquisition system.

With the consideration of the above mentioned, it might be assumed that the Wind Farm modern SCADA System, beyond the power regime data control and acquisition, considers the meteorological subsystem for the acquisition of real time meteorological measurement data.

Also, it might be assumed as well, that it is not possible to obtain real time meteorological data (Wind speed, Wind direction, Temperature data, Pressure and/or humidity data) under the current provisions of Network Rules and some amendment are required for the definition of III Level SCADA to ensure the provision of such kind of data to VRE forecasting system. It means that the supply of real time meteorological data to the VRE forecasting system is challenging and can't be ensured without the willingness of wind farm operators to cooperate.

Dispatch intervals considered in AEMO system views dispatch 5 and 30 minute intervals and next day dispatch[9].Under the Estimated Power line item, a generator is obliged to supply SCADA estimated power generation with the same intervals as it is utilized for the dispatch i.e. 5 and 30 minute intervals and next day dispatch. SCADA Estimated Power is the Generator's forecast in MW of active power at the end of the next dispatch interval, subject only to technical factors affecting the operation of its generation and connection assets.

Power plants are submitting applications to Dispatch Licensee on the readiness of energy units/aggregates and dispatch parameters daily. Readiness Application includes hourly data on: working capacity (MW), available capacity (MW) and technical restrictions of energy for unit / aggregate (power plant) on schedule day.

Schedule day is a calendar day starting at 00:00 of the next day of scheduling and continuing for 24 hours, including 24:00 of the next day and it is the day for which relevant readiness schedules are prepared.

Amongst other parameters, considered under the dispatch parameter application, are: information on restrictions of energy unit/aggregate capacity (description of restriction, start and end date and time, volume of restricted capacity (MW) and minimum loading capacity of energy unit / aggregate.

With submission of Readiness Application, the supply of data considered under the line item Estimated Power - Generators Active power[10] might be ensured, but to comply with the definition of the mentioned line item, the time horizon for the forecast should coincide with the dispatch interval. If it is the next day dispatch it might be in compliance with the term but if the GSE dispatch interval is one hour, then the next hour estimation of power is missing.

Normally for wind farm SCADA, at least the followings are required[11]:

- Wind Turbine Generators: status (working, ready, paused, stopped), power (kW), cos j, speed (rotor, generator, wind), temperatures, voltage and current of each phase, active alarms, meteorological parameters from nacelles;
- Met Mast: Wind speed and direction, temperature, pressure, battery status;
- Substation: Line voltage and current, active and reactive power delivered, status of alarms and protections.

Under the Vestas Online™ Business SCADA[12] system for each wind turbine, a detailed online information is available:

- Operating status;
- Temperatures throughout the turbine;

[9] https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Data/Market-Management-System-MMS/Dispatch
[10] z29) ȝ23) Active Power – the time average of the instantaneous power over one period of electrical wave
[11] Windfarm SCADA system characteristics Posted on May 29, 2012 by Francesco Miceli at http://www.windfarmbop.com/tag/scada-system/
[12] https://www.sec.gov/Archives/edgar/data/61339/000006133906000020/ex102d2.htm

- Production counters;
- Detailed grid data.

Information on wind speed, wind direction, pressure and ambient temperature is available for each meteorology station. Information on voltages, currents, active production, reactive production, power factor and much more is available for each grid computer.

It is possible to send a Stop, Pause, Start or Reset command to the turbine. Furthermore, it is possible to turn the turbine nacelle yaw in both clockwise and counter-clockwise direction. However, only users with appropriate access rights can send such commands. Also, the operator must acknowledge the command by entering a confirmation.

The Group control module enables the operator to predefine up to 10 turbine groups that can be launched, stopped or reset simultaneously or with a user-defined delay between the execution of the command on the wind turbines in the group.

The real time information on local limit, wind farm active power, the number of wind turbines available for generation, the number of wind turbines actively generating, Local Limit, and Wind Farm Control System Set-Point represent a data and information derived from form Wind Farm SCADA.

Article 2 Definitions:

s^2) III Level SCADA – a combination of software and technical facilities under the ownership of Distribution Licensee and/or producer that collects, monitors and manages regime parameters of a distribution network and/or concrete units of a producer.

z43) Available Capacity Annex 1 - Information on Available Capacity.

Article 45. Operational Communication Between the Dispatch Licensee, The Transmission Licensee and Electricity System Participants.

7. II and III Level SCADA and data transmission system shall be placed according to the following conditions (7.10.2016):

a) Electricity system participants shall agree on types of II and III Level SCADA and data transmission equipment with Dispatch Licensee;
b) Expenses related to II and III Level SCADA and data transmission system implementation, placement and operation shall be covered by the respective electricity system participant.

Article 52. Scheduling Electricity Generation

1. Power plants are submitting applications to the Dispatch Licensee on the readiness of energy units/aggregates and dispatch parameters with periodicity in a manner established under these Rules.

Article 53. Electricity Producer's Readiness Application

4) Readiness Application shall comprise:

a) Information on readiness period of energy unit (date, time);
b) Following information of energy unit/aggregate (power plant):

b. a) hourly data of working capacity (MW);
b. b) available capacity (MW);
b. c) technical restrictions of energy unit/aggregate (power plant) on scheduled day.

c) Information submitted additionally by hydropower plants:

c. a) on expected water inflow;
c. b) water levels in the water reservoirs (is such).

5) The application on dispatch parameters comprises:

a) Information on restrictions of energy unit/aggregate capacity (description of restriction, start and end date and time, the volume of restricted capacity (MW));
b) Time (min.) necessary from start-up of energy unit to its synchronization;
c) Minimum time from scheduled outages of energy unit to its restart;
d) Minimum loading capacity of energy unit/aggregate;
e) Minimum time of disconnecting energy unit/aggregate from the network;
f) Information on synchronization method of energy unit/aggregate;

g) Data on the speed of capacity increase of energy unit/aggregate;
h) Data on the speed of capacity reduction of the energy unit/aggregate;
i) Data on voltage increase speed (kW/sec);
j) Data on voltage reduction speed (kW/sec);
k) Data on conditions of primary and secondary regulation of energy unit/aggregate;
l) Data on conditions of group regulation of power plant.

MAIN CONCLUSIONS AND ISSUES FOUND

- Before the commencement of the Wind project and connection to the Transmission Network, it's possible to obtain a significant portion of the static data, whilst the dynamic data derived from the Wind Farm SCADA before the commencement of project and connection to the network, might be limited with the real time data from meteorological mast installed in the proximity of wind project;
- Currently, due to only one Wind farm being operational, it's possible to obtain significant portion of the static and dynamic data required for forecasting system like AWEFS only at Qartli Wind Project level. No other proposed VRE project could supply through the SCADA System Power and Meteorological parameters related dynamic data to the VRE forecasting System;
- Dispatch Licensee is authorized to acquire metering control and other data of power plant, that might be required for fulfilling obligations conferred upon it by the legislation. The said might be utilized to obtain the meteorological data from wind farm. However, meteorological equipment installed on nacelles of wind turbines and meteorological mast are hard to perceive as a part of power plant;
- According to the Network Rules, it's not obligatory to perform the measurement of meteorological parameters at the location or proximity of the wind farm. In such case, the mandatory existence of measurement devices at nacelles of Wind Farm or at the met mast in proximity and/or at location of wind farm is hindering the supply of meteorological data to VRE forecasting system;
- In reference to the definition of III Level SCADA, it is designated to control the regime parameters of a generator and doesn't consider the meteorological parameters measurement data control and acquisition;
- Currently, the Network Rules do not consider the requirement related to the measurement of meteorological parameters and its delivery through the SCADA system, while the application area of International Electrical Commission Standard IEC 61400-25 covers all components required for the operation of wind power plants including the meteorological subsystem, the electrical subsystem and the wind power plant management system;
- The scope of the IEC 61400-25 is addressing all communication means among the wind power plant components, such as wind turbines and actors such as SCADA systems and dispatch centers. Its application area covers all components required for the operation of wind power plants, including the meteorological subsystem, the electrical subsystem and the wind power plant management system. The implementation of the mentioned standard might be useful in the process of III Level SCADA architecture and components agreement with the Dispatch Licensee;
- With the submission of the Readiness Application, the supply of data considered under the Energy Conversion Model line item "Estimated Power" might be ensured, but to comply with the definition of the mentioned line item, "Time Horizon" the forecast should coincide with the dispatch interval. If it's the next day dispatch than it might be in compliance with the term, but if the GSE dispatch interval is one hour, then the next hour estimation of power is missing.

RECOMMENDATIONS

- Modification of network rules should include VRE forecasting requirements. This will facilitate the integration of VRE into the grid. Generation of electric power with the deployment of VRE sources on electricity grid leads to certain problems related to the system stability, voltage flickers, voltage fluctuations overcurrent, overvoltage and variation of frequency. Despite these problems, VRE generators can supply surplus power to the grid but the generation of power requires certain grid code. Network Rules in Georgia can be modified to include integration of VRE into the grid;
- Include the minimum required data in Network Rules to facilitate VRE forecasting. VRE forecasting is a cost-effective way to optimize power system flexibility. For decentralized forecasting, a Network Code can include provisions that require the VRE generator to provide day-ahead generation forecasts with time intervals close or equal to the system operator's dispatch interval (e.g., hourly or 15 minutes). For centralized VRE forecasting, data to be collected from generators should include specific geographic location, installed capacity, historic hourly (or higher resolution) generation, and detailed meteorological data. More advanced forecasting systems may benefit from collecting additional information on real-time generation, wind turbine or solar array availability, and park potential;
- Ancillary services. Network Rules can include opportunities for VRE generators to provide grid services through advanced turbine and inverter capabilities, including synthetic inertial response, primary frequency response, voltage control, and ramp limitations. The inclusion of these provisions as part of a Network Rules can encourage VRE generators to provide ancillary services in jurisdictions where market incentives for these services are not available or adequate;
- III level SCADA parameters required for VRE forecasting significantly improve the system operator ability to monitor VRE power plant performance. While most modern VRE generators employ SCADA systems, the Network Rules may require additional SCADA parameters to significantly improve the system operator's ability to monitor VRE plant performance and respond to system conditions. For example, outage data for individual wind turbines or solar arrays and information about park potential will enable system operators to optimally dispatch reserves and issue curtailment orders as needed to maintain grid stability.

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