Microgrid Interactive Use Case #IA-4

Updates of capability curves of the microgrid’s reactive power sources

Version 2

July 7, 2015

This is one of the eight (8) use cases related to interactions between advanced microgrids in connected mode and Electric Power Systems (EPS). The use cases are described in terms of information exchange requirements between the Distribution Management System (DMS)/ Distribution System Operator (DSO) and the EMS/Controllers of advanced microgrids.

The Microgrid Interactive Use Cases are

1. Information Support for Coordination of EPS and Microgrid Load Shedding Schemes
2. Coordination of Volt/var control in Connected Mode under Normal Operating Conditions
3. Update aggregated at PCC real and reactive load-to-voltage dependencies under normal operating conditions
4. Updates of capability curves of the microgrid’s reactive power sources
5. Updating information on microgrid dispatchable load
6. Updates of the information on overlaps of different load management means within microgrids
7. Updating dependencies of the microgrid operational model on external conditions
8. Update aggregated at PCC real and reactive load-to-frequency and load-to-voltage dependencies in the emergency ranges

These use cases were developed by Smart Grid Operations Consulting (SGOC) on behalf of National Institute of Standards and Technology (NIST)

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1.1 Name of Use Case

Updates of capability curves of the microgrid's reactive power sources

1.2 Scope and Objectives

Scope: The Function a) performs periodic and event-driven updates of the EPS operator/DMS about the aggregated at the μGrid PCC nominal and operational capabilities of generating and absorbing reactive power by the reactive power sources of the microgrid and b) provides the EPS operator with relevant data for post-factum analyses, when needed. The information exchanges are performed through direct interfaces between EPS DMS and μEMS. Interfaces between the μEMS and Aggregators may be used to meet the objective of the Function. It is assumed here that the μGrid var capabilities aggregated at the PCC will be derived by the μEMS for near-real-time and short-term look ahead timeframes.

Objective: The objective of the function under consideration is to provide aggregated at the PCC near-real-time and short-term look-ahead reactive power generating and absorbing capabilities of the μGrid reactive sources for the use by the EPS operator for the coordination of the EPS and microgrid operations.
The objective of the use case is to determine the requirements for information exchange between the microgrid and EPS operators (μEMS-DMS) of the microgrid capabilities of generating and absorbing reactive power for the use by EMS/DMS applications, including

- The contents of the information
- The timing of information exchange
- The structure of data

Rationale: The aggregated at the microgrid PCC DER and other reactive sources capability curves depend on a number of changing in the near-real-time operational conditions, such as the composition of the connected reactive sources, DER real loads, and the voltages at their and customers' terminals.

The microgrid operator/μEMS needs to know the capability curves of individual reactive power sources in the P-Q-V (local) coordinates, which are based on rated data (see Figure 1-1for DER). This is the basic information that the microgrid operator/ μEMS uses for managing the kW and kvar of individual DERs.

The EPS operator/DMS needs to know the capabilities of the microgrid in providing vars under given watts under the near-real-time and short-term look-ahead conditions in the P-Q-V-at-PCC coordinate.

The voltages at the terminals of reactive power sources typically are different from the voltages at the PCC. Also, the actual capabilities of the reactive power sources are limited not just by the rated parameters and local voltages (nominal capability), but also by the operational parameters in μGrid circuits (voltage limits at the customer terminals, current limits in the circuit segments, over-voltages in some circuit nodes, volt/var control functions of the DERs, etc.) This capability is defined here as operational capability

All these and other operational parameters are changing in near-real time, consequently changing the total μGrid var capabilities. Hence, a function for updating the capabilities of the μGrid var sources is required.

Status: The integration of μGrid operations into DMS advanced applications is in its early stages. It will become critically important under the high penetration of advanced microgrids and other Smart Grid technologies.

1.3 Narrative

1.3.1 General Description

A microgrid [1] is considered here as a sub-power system comprising distributed generation/storage and load. In addition, an advanced microgrid may use internal controlling devices, such as different step-wise and/or continuous voltage and var regulators (including advanced inverters [1]-[6]), Remedial Action Schemes (RAS), such as Under-frequency/voltage Load Shedding, and elements of Information Communications Technology (ICT). An advanced microgrid can provide a number of ancillary services. It can operate either in an island mode, or in a connected to the Area Electric Power System (EPS) mode. It is also assumed that there is a microgrid EMS, which is a major actor interacting with the EPS operator (DMS and possibly EPS EMS). Some microgrids may serve comparatively large consumer base and may comprise substantial medium and low voltage circuits (see e.g., [7]-[10]).

[1] DOE Definition of a MicroGrid: “A group of interconnected loads and distributed energy resources (DER) with clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid [and can] connect and disconnect from the grid to enable it to operate in both grid-connected or island mode.”

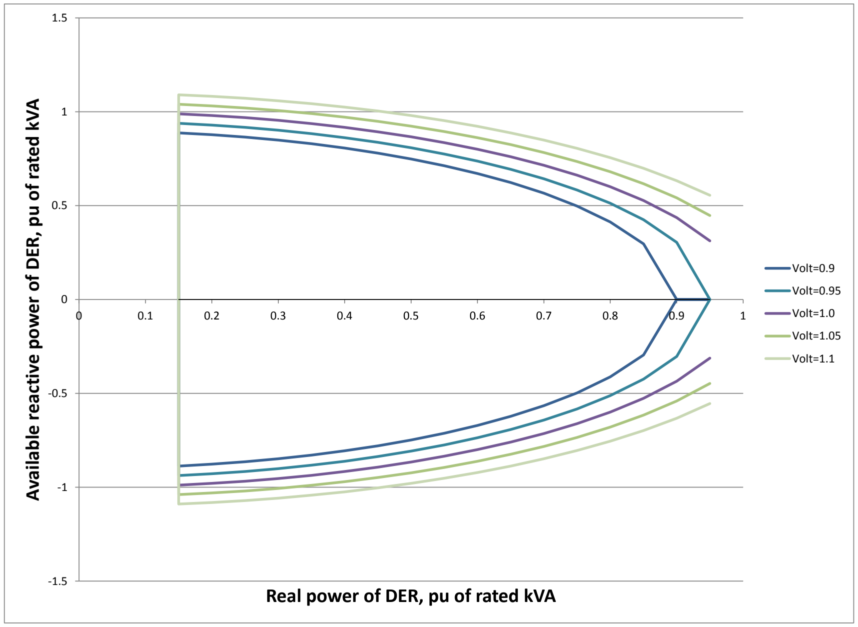

Figure 1-1. Nominal (rated) Capability curves of a DER

Though there may be different types of reactive power sources in a microgrid, in this use case, we will focus mostly focus on DERs with advanced invertors as a sufficiently general case. As seen in Figure 1-1, the voltage at the DER terminals may significantly impact the capability of the DER in providing vars. For instance, a drop in voltage by 10%, when P=0.9, reduces the available Q from 0.5 to 0. This is very important in contingency analyses and in emergency situations. It's also significant, when P= 0.7-0.8. When there are many DERs or large DERS, the loss of available kvars due to voltage reduction, even when P< 0.7, may be significant for the EPS. The voltage at the DER terminals may significantly change in short time periods, due to many factors, such as voltage management in the EPS circuits, changes of the power flow in the EPS and in the microgrid circuits. On the other hand, the voltages at the DER terminals can be changed due to different volt/var controlling actions within the microgrid. Consequently, the near-real time capability of the DERs will be correspondingly changed. In addition, the capability of the DER in providing vars (either generating, or absorbing) and sometimes Watts may be constrained either by the voltage limits at the DER or other voltage –critical terminals, or by loading limits of load-critical circuit segments.

The EPS operator deals with the aggregated at the PCC capability curve of the microgrid DERs and other var sources, which is a function of the voltages at the PCC and total DER kWs. If the voltage is changed at the PCC, all voltages are also changed at the terminals of the individual reactive power sources . These changes are different from the changes due to the voltage-controlling devices within the microgrid. The aggregated capability of reactive power also depends on the allocation of the components of the combined kWs of the DER's due to its impact on the power flow and local voltages. The same total DER kW combined in different ways can result in different kvar capabilities at the PCC. It means that the aggregated capability curves for the use by the EPS should be derived as a function of the voltage at the PCC for the relevant combinations and modes of operations of DERs and other var sources in the microgrid.

Unser different modes of operations of the var controlling devices, the aggregated operational capability may be different. For instance, if the objective of the μGrid's operator is to follow a CVR objective, the var controlling devices may try to keep the voltage lower and reduce the generation of the vars. If the μGrid's operator is just concerned with keeping the voltage within standard voltage limits, the var sources may generate more vars. It means that there may be a conflict between the objective of the μGrid's volt/var control and the EPS requirements for the μGrid var capability. Hence, the provision of required by the EPS different var capabilities may be associate with different costs for the μGrid.

1.3.2 Summary of requirements

- The objective of the use case is to determine the requirements for information exchange between the microgrid and EPS operators (μEMS-DMS) on the microgrid var capability curves for the use by EMS/DMS applications, including

  - The contents of the information
  - The timing of information exchange
  - The structure of data
- The suggested contents of the information exchange include the following data:
  - The μEMS should provide the DSO/DMS with the near-real time and short-term look-ahead aggregated at the PCC maximum and minimum operational var capabilities as a function of the PCC voltage. These limits are defined by the setups of the Volt/var control functions of the var sources and other voltage and current limits in the μGrid circuits.
  - The μEMS should provide the DSO/DMS with the near-real time and short-term look-ahead aggregated at the PCC maximum and minimum nominal capability limits – defined as functions of the reactive power limits vs voltages at the DER terminals regardless of the operational voltage requirements defined by the settings of the Volt/var control functions of the DERs.
  - The μEMS should provide the DSO/DMS with the information on the conditions under which the capability curves were derived (e.g., under which volt/var control objective the capability is determined)
  - The DSO/DMS may request that the μEMS change the volt/var control setups of the μGRID var sources to meet the EPS var support requirements
  - The μEMS should provide the DSO/DMS with the impacts of the change of the volt/var control setup, e.g., the impact on the μGrid net kW, or on the customer power factor due to change in voltage levels at the μGrid buses, etc.
- The conditions for operational var capabilities of the μGrid DERs are changing in near-real time. Hence, the μEMS should update the aggregated at the PCC capability curves on by exception basis.
- The structure of the exchanged data should support multi-dimensional, non-monotonous dependencies, command/request formats, and metrics of data uncertainty. The dependencies should cover practical ranges of the independent variables.
- The EMS/DMS applications will use these data in their "what-if" studies of the EPS operations to derive the near-real time and short-term look-ahead solutions

1.3.3 Illustrative examples

A number of illustrations are presented below to clarify some of the requirements for information exchange between the microgrid controller/EMS and EPS in regards to the aggregated at the PCC var capabilities of the µGrid var sources. These illustrations are based on a specific simple model including inverter-based DERs as reactive power sources (Figure 1-2). The requirements suggested in Section 1.3.2 are based on a generalized consideration of advanced microgrids as it is defined in the first paragraph of Section 1.3.1.

In this example, the DERs are connected close to the customer service terminals.

It is assumed here that the total nodal real load of the microgrid is 1. The three DERs connected to the microgrid can provide 0.9 p.u. real power to the microgrid. The rated power factor of the DERs is 0.9. The nodal real load dependency on nodal voltage (the LTV-factor) is 1 %kW/%Volt. The reactive nodal load dependency on nodal voltage is presented by the following polynomial:

$$Q = Q_{nom} (9 – 19.4 \mathbf{V/V_{nom}} + \mathbf{11.4\ V2/V_{nom}^2})$$

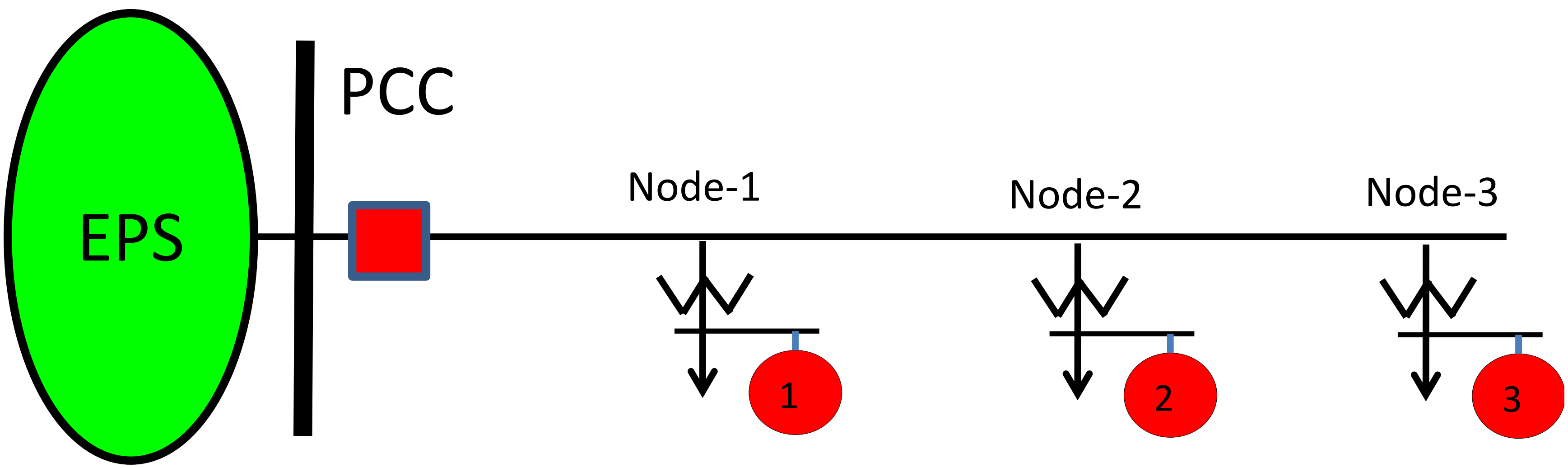

Figure 1-2. Sample diagram of microgrid

It is also assumed that the DERs in the microgrid perform autonomous Volt/var control. The following three scenarios of the Volt/var control are considered:

- Conservation voltage reduction (CVR) with maximum reactive power support of the EPS.
- Super Power Quality (PQ) with maximum reactive power support of the EPS – keeping the voltages at the customer terminals close to the nominal.
- Standard Voltage Quality with maximum reactive power support of the EPS.

The volt/var functions of the µGrid's DER for the CVR objective are presented in Figure 1-3 and Figure 1-4. As seen in the figures, the minimum voltage setting is 0.96 p.u., and the maximum voltage setting is 0.98 p.u. Note that the voltages in these functions are the voltages at the DER terminals, not at the PCC. The initial settings of the reactive power are set either to the maximum, or to the minimum available within the voltage settings. When the voltage deviates beyond the setting, the kvars change according to the set var/volt droop. The initial var settings are different for the different kW loading of the DERs due to different DER kW injections and therefore different var capabilities.

The volt/var functions of the µGrid's DER for the Power Quality (PQ) objective are presented in Figure 1-5. As seen in the figures, in this case, the minimum voltage setting is 0.99 p.u., and the maximum voltage setting is 1.01 p.u. The initial settings of the reactive power are set either to the maximum, or to the minimum available within these voltage settings. When the voltage deviates beyond the setting, the kvars change according to the set var/volt droop.

The volt/var functions of the µGrid's DER for the Standard Voltage objective are presented in Figure 1-6**Error! Reference source not found.**. As seen in the figures, in this case, the minimum voltage setting is 0.96 p.u., and the maximum voltage setting is 1.04 p.u. of the voltage at the DER terminals. The initial settings of the reactive power are set either to the maximum, or to the minimum available within these voltage settings. When the voltage deviates beyond the setting, the kvars change according to the set var/volt droop.

Two kW levels of the DER injections are considered in this illustrations: 100% and 20% of nominal DER kW.

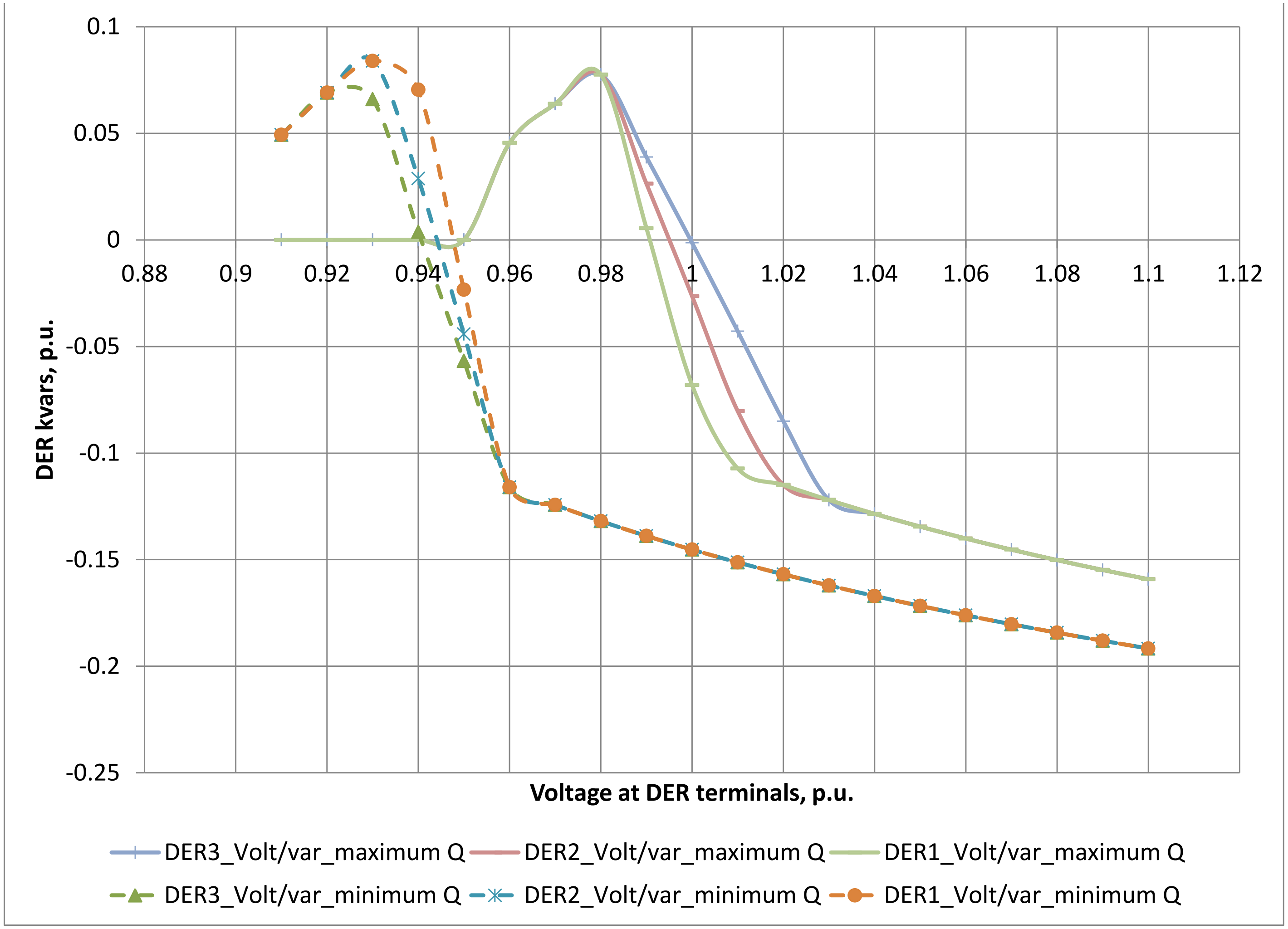

Figure 1-3. DER volt/var function for CVR and maximum/minimum var support (DER kW=100%)

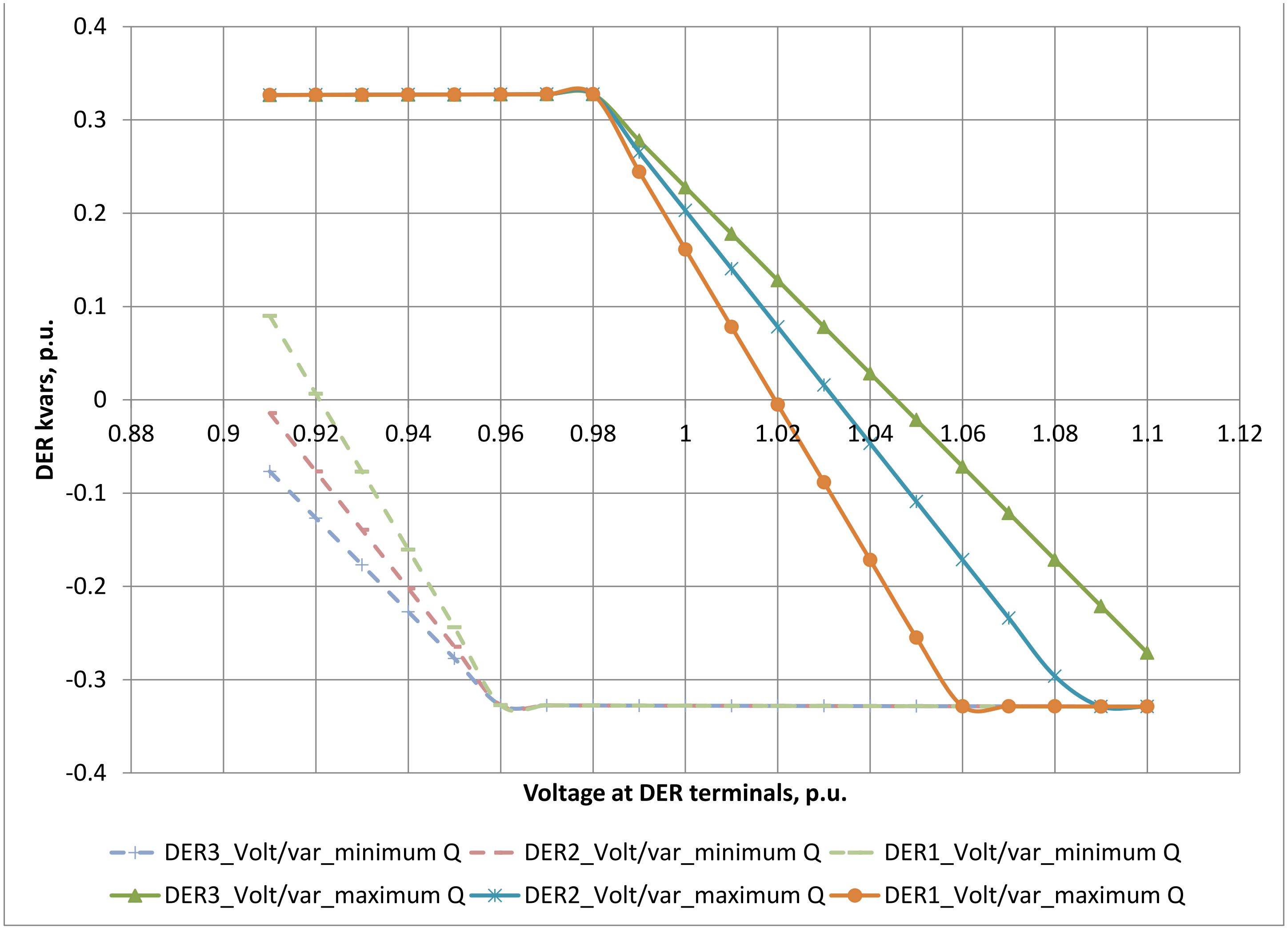

Figure 1-4. DER volt/var function for CVR and maximum/minimum var support (Cloudy Day)

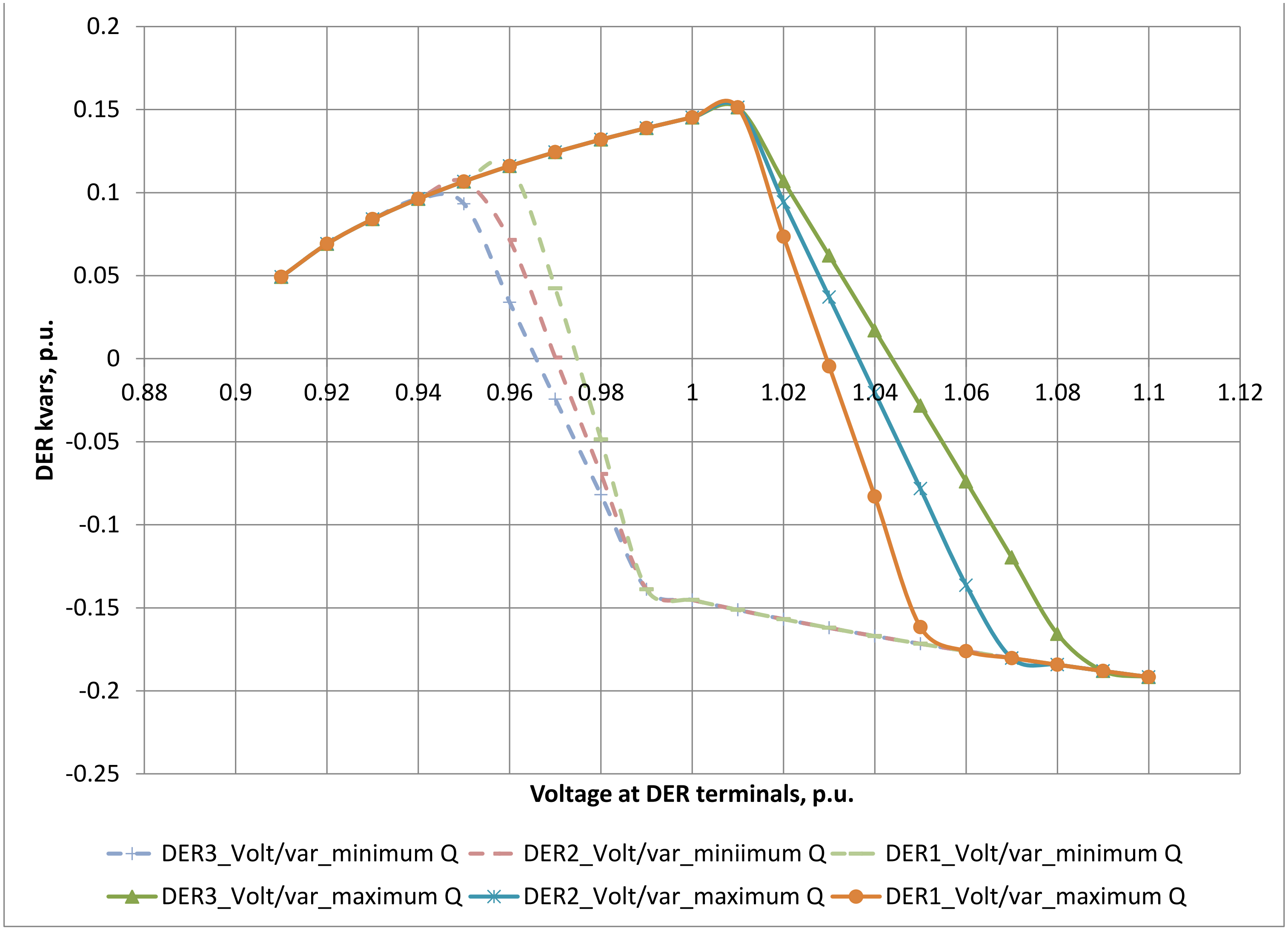

Figure 1-5. DER volt/var function for PQ and maximum/minimum var support (DER kW=100%)

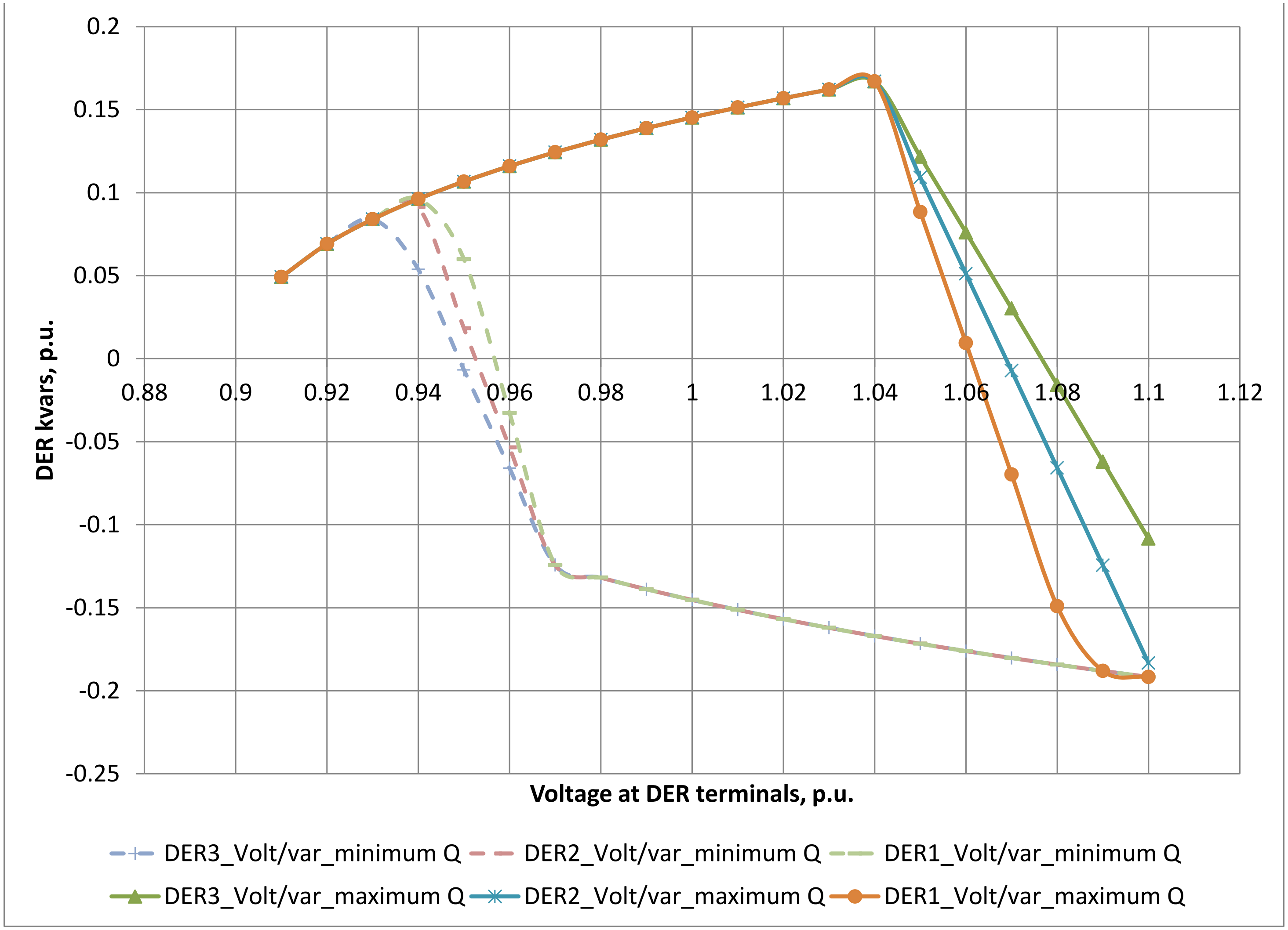

Figure 1-6. DER volt/var function for SQ and maximum/minimum var support (DER kW=100%)

The var capability curves for the two levels of kW injections are defined as functions of the voltage at the PCC for the three modes of volt/var control and for two levels of reactive power requirements: a) maximum generation of reactive power by the DERs and b) maximum absorption of the reactive power by the DERs.

Two kinds of limits of the DER reactive power are defined in the examples:

- Nominal capability limits – defined as functions of the reactive power limits vs voltages at the DER terminals regardless of the operational voltage requirements defined by the settings of the Volt/var control functions of the DERs.
- Operational capability limits – defined by the setups of the Volt/var control functions of the DERs and other voltage and current limits in the μGrid circuits.

Both of these capabilities should be presented in an aggregated manner at the PCC as functions of the PCC voltage for the use by DSO/DMS.

Figure 1-7 through Figure 1-12 present the aggregated at the PCC maximum and minimum var capabilities of the μGrid DERs for the three modes of volt/var control and for the high and low levels of DER kW generation.

Figure 1-7 presents the nominal and operational var capabilities for the 100% kW generation by the DERs and for the CVR objective. As seen in the figure, the operational capabilities significantly differ from the nominal ones, because the DER inverters are changing the reactive power to meet the CVR objective. This is the maximum or minimum reactive power the μGrid can provide, while keeping the CVR objective.

Figure 1-8 and Figure 1-9 present the var capabilities for the PQ and SQ objectives for the high level of kW injections, and Figure 1-10 through Figure 1-12 present the var capabilities for all objectives for low level of kW injections.

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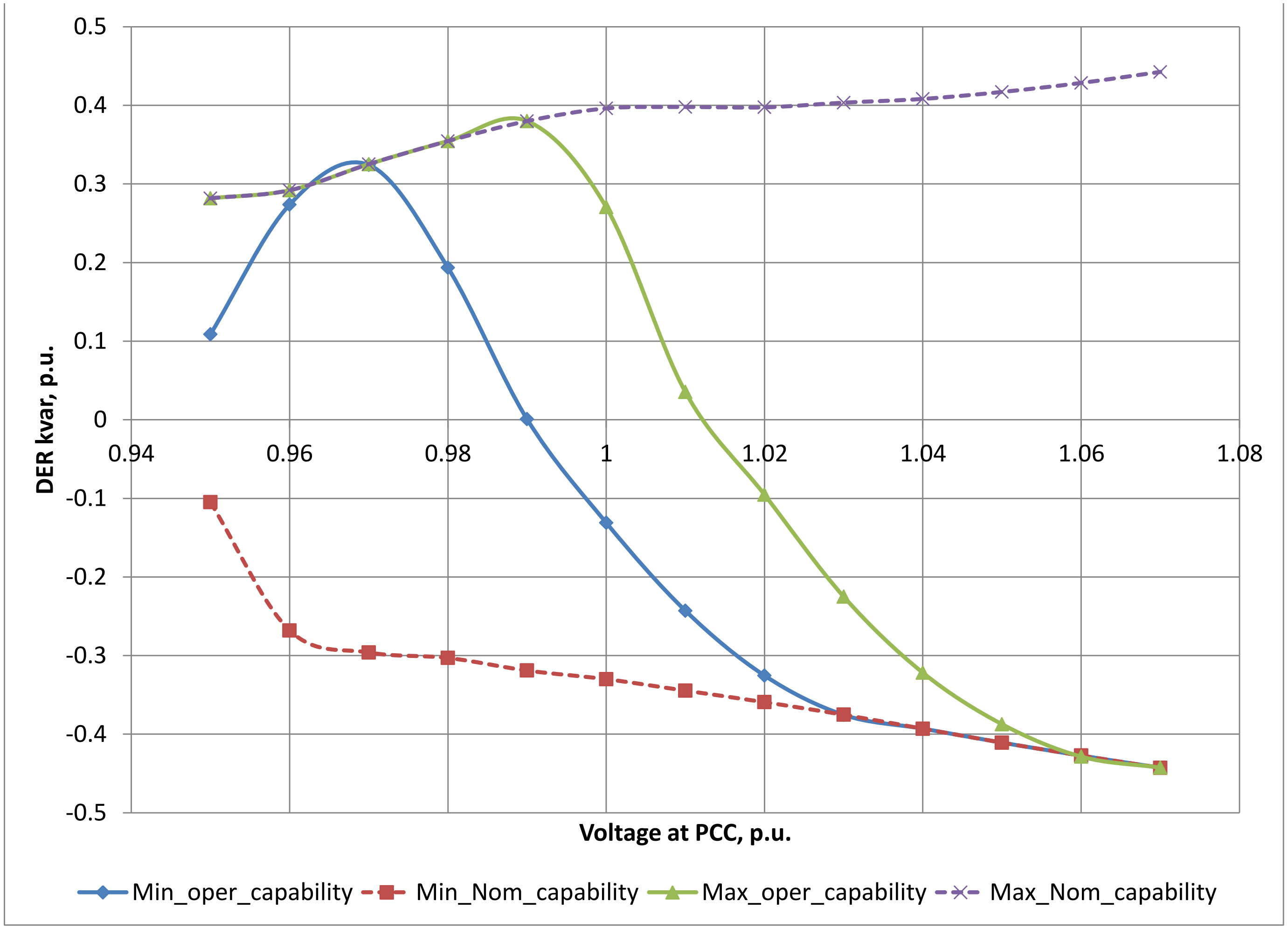

Figure 1-7. Reactive power capability curves under the CVR objective. DER kW=100%.

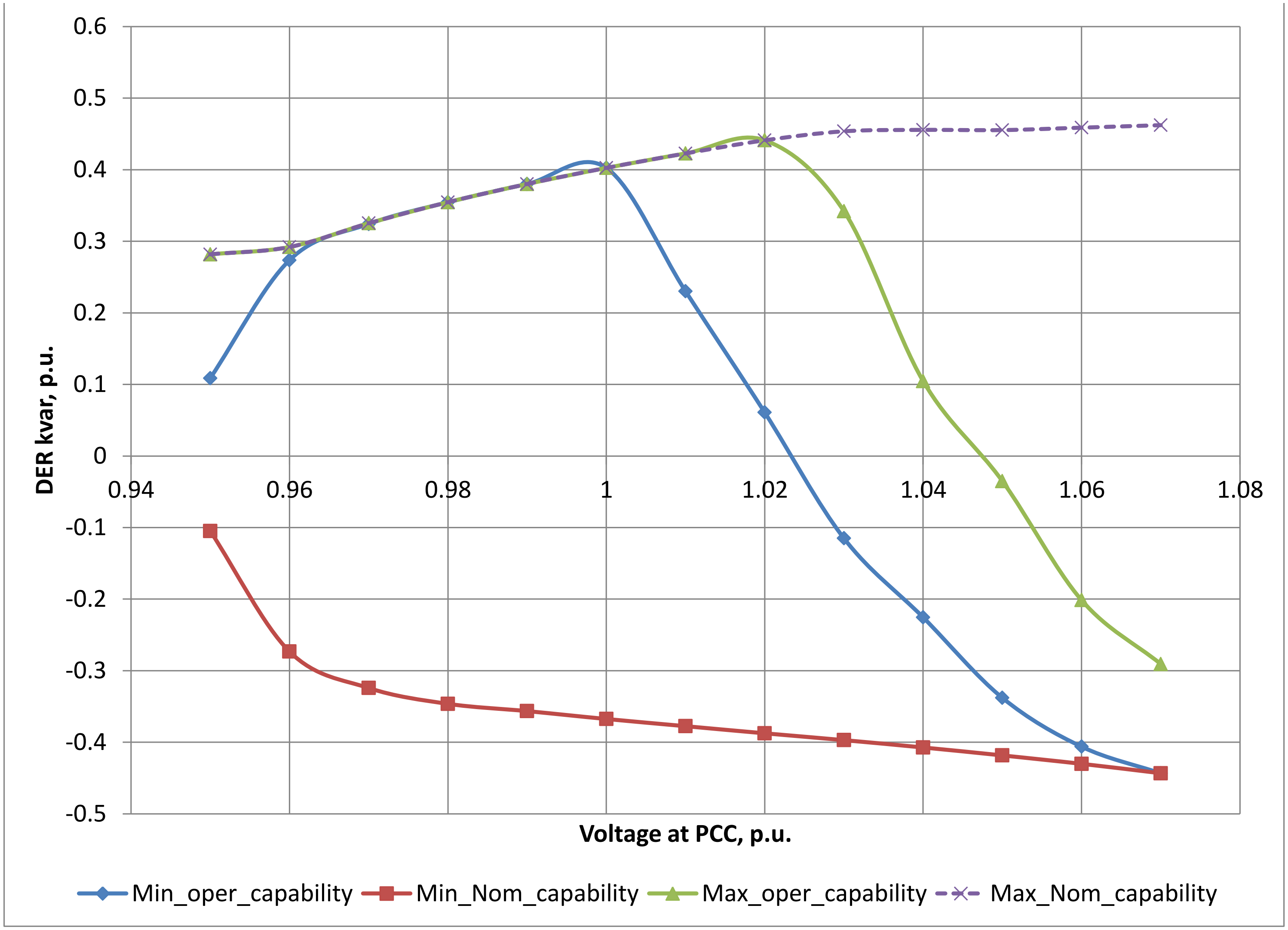

Figure 1-8. Reactive power capability curves under the PQ objective. DER kW=100%.

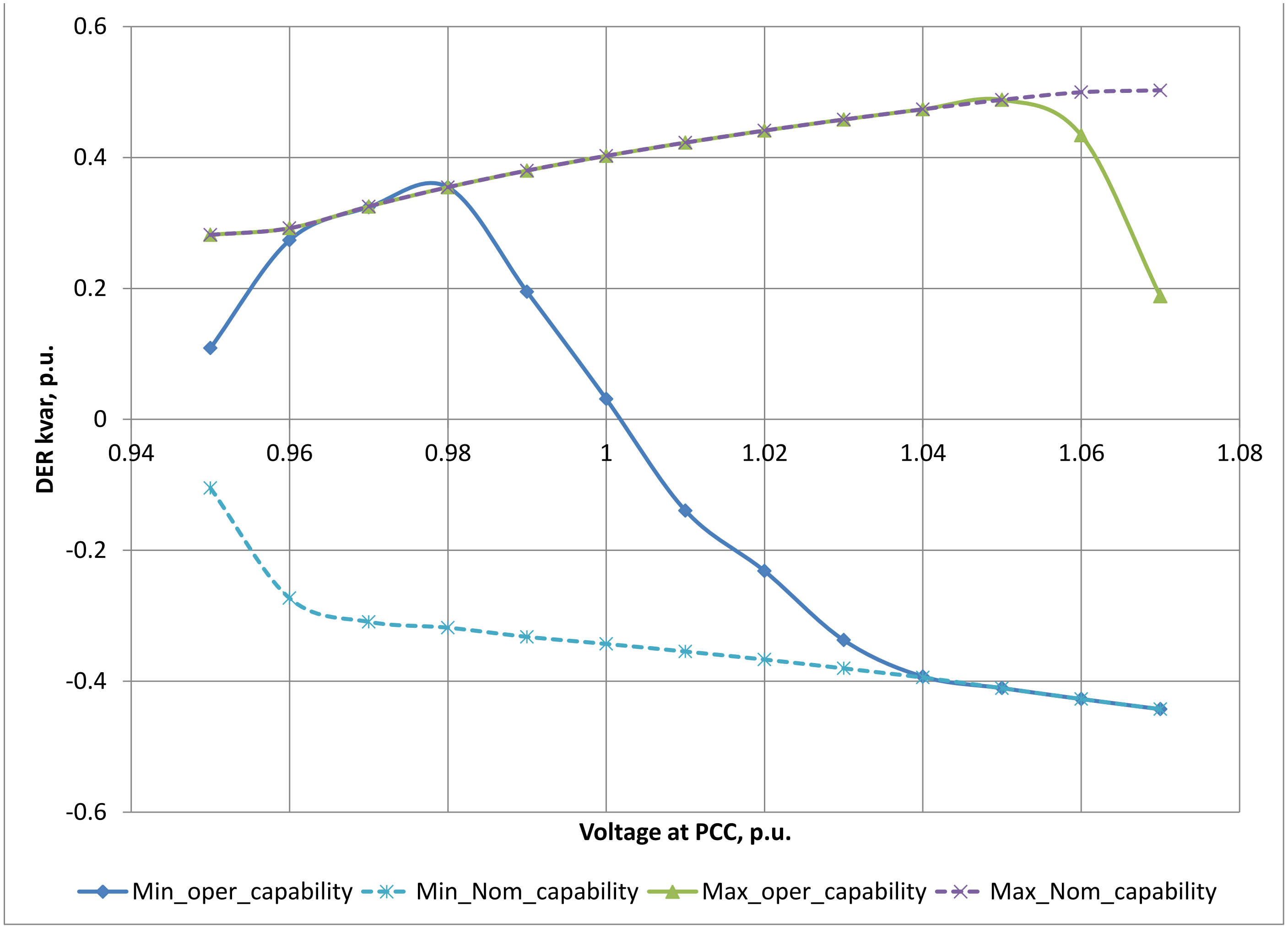

Figure 1-9. Reactive power capability curves under the SQ objective. DER kW=100%.

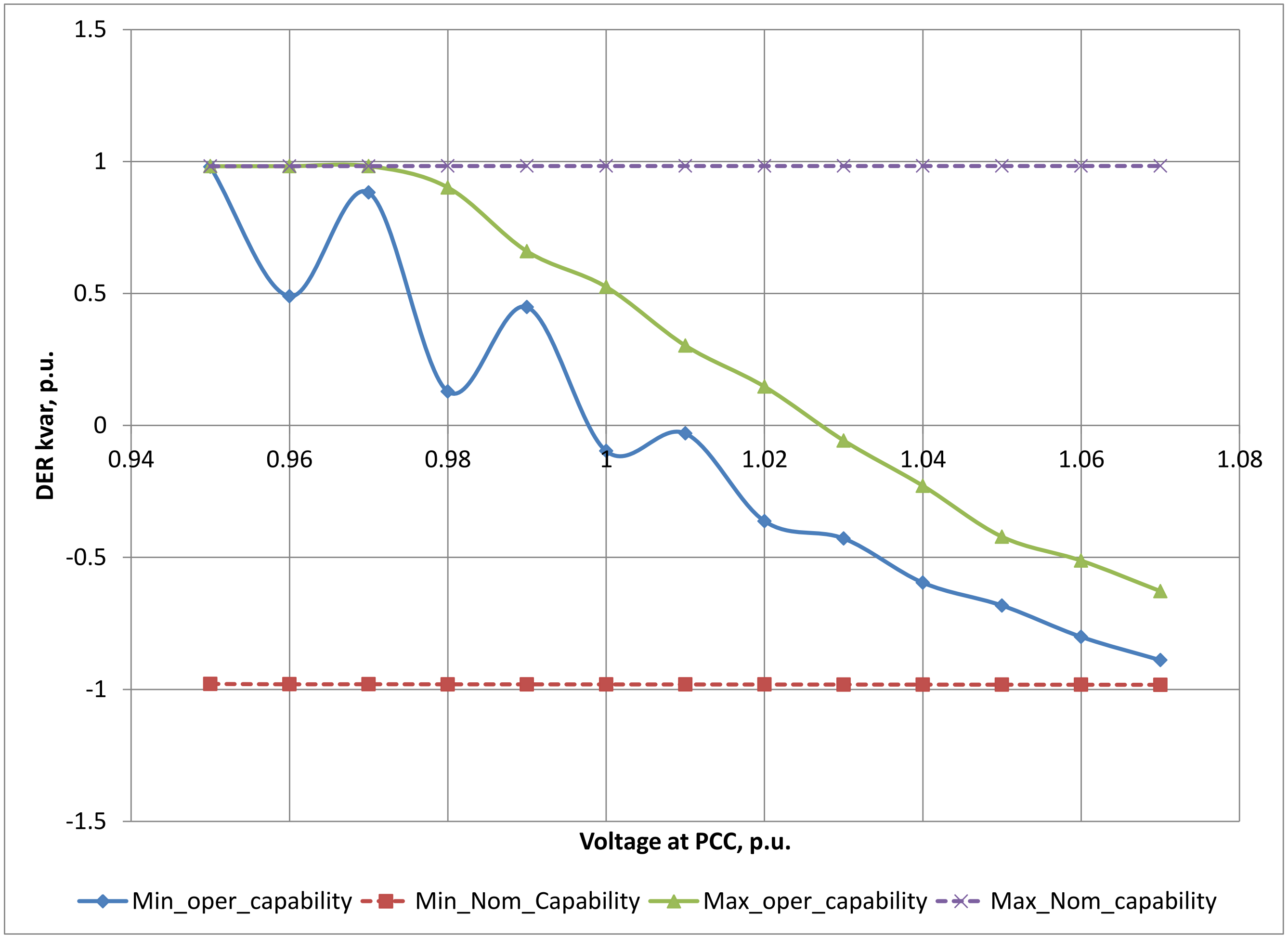

Figure 1-10. Reactive power capability curves under the CVR objective. DER kW=20%

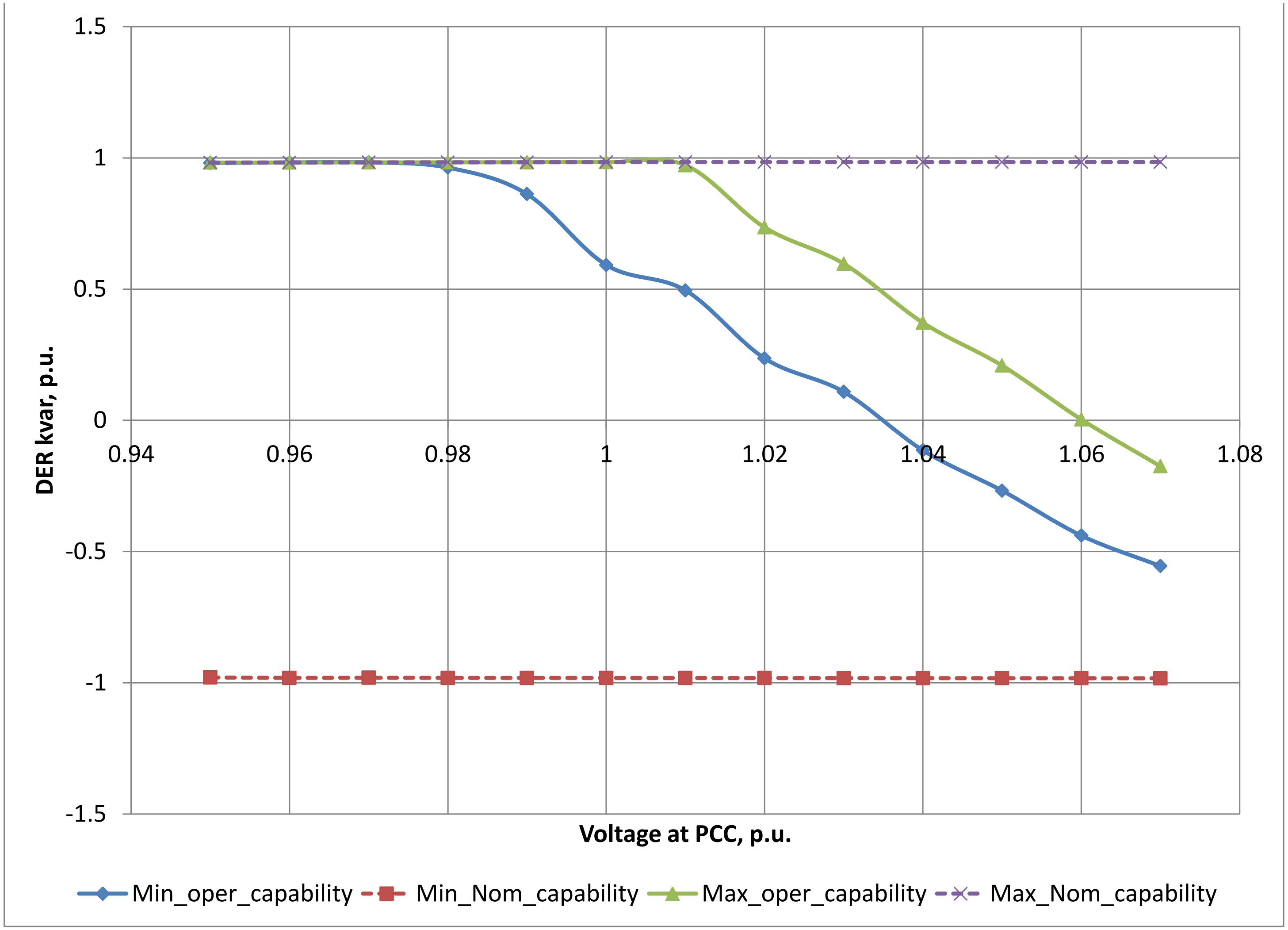

Figure 1-11. Reactive power capability curves under the PQ objective. DER kW=20%

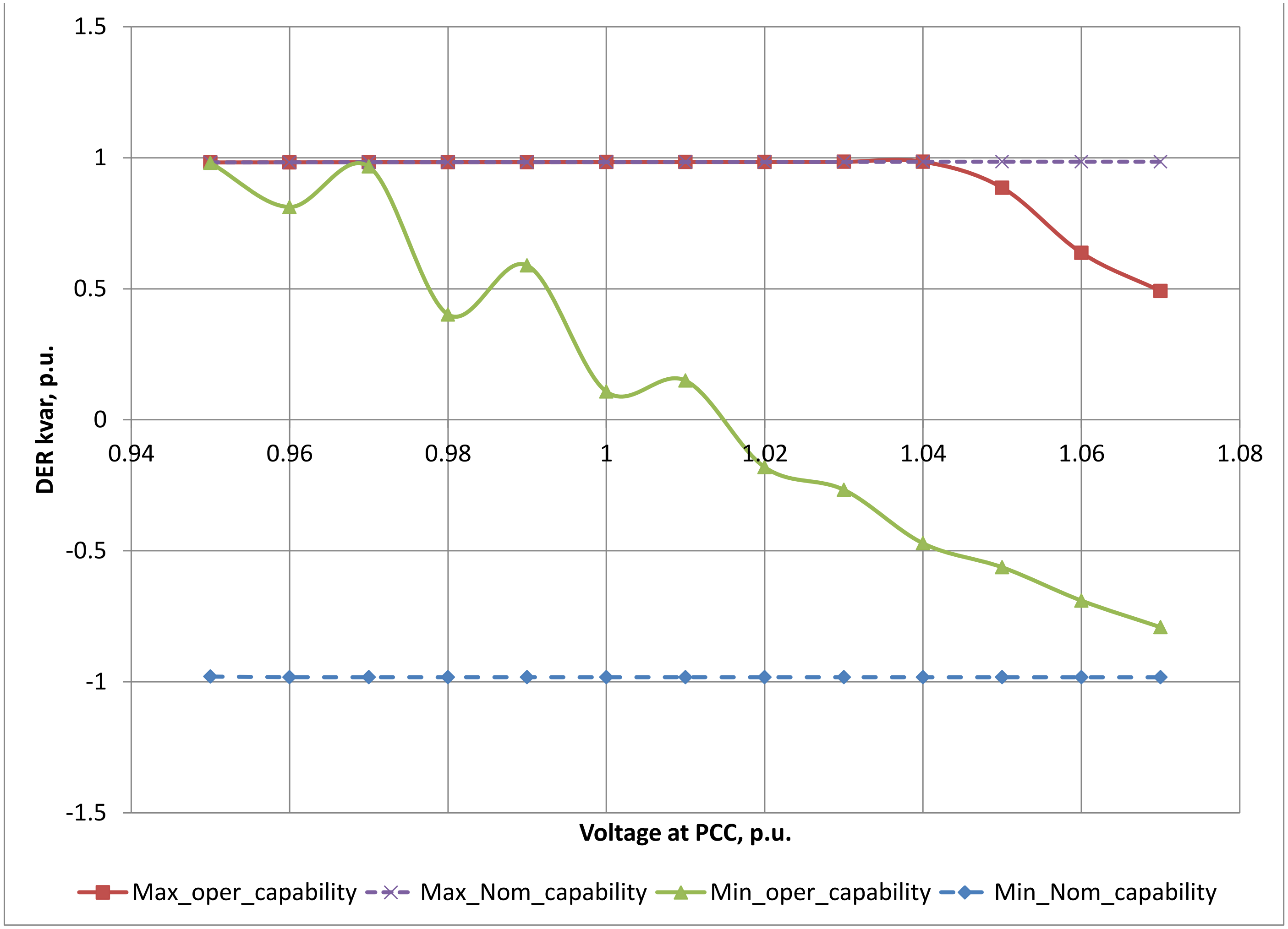

Figure 1-12. Reactive power capability curves under the SQ objective. DER kW=20%

Each of the conditions presented above result in different var capabilities. The comparison of the var limits under different conditions is presented in Figure 1-13 and Figure 1-14.

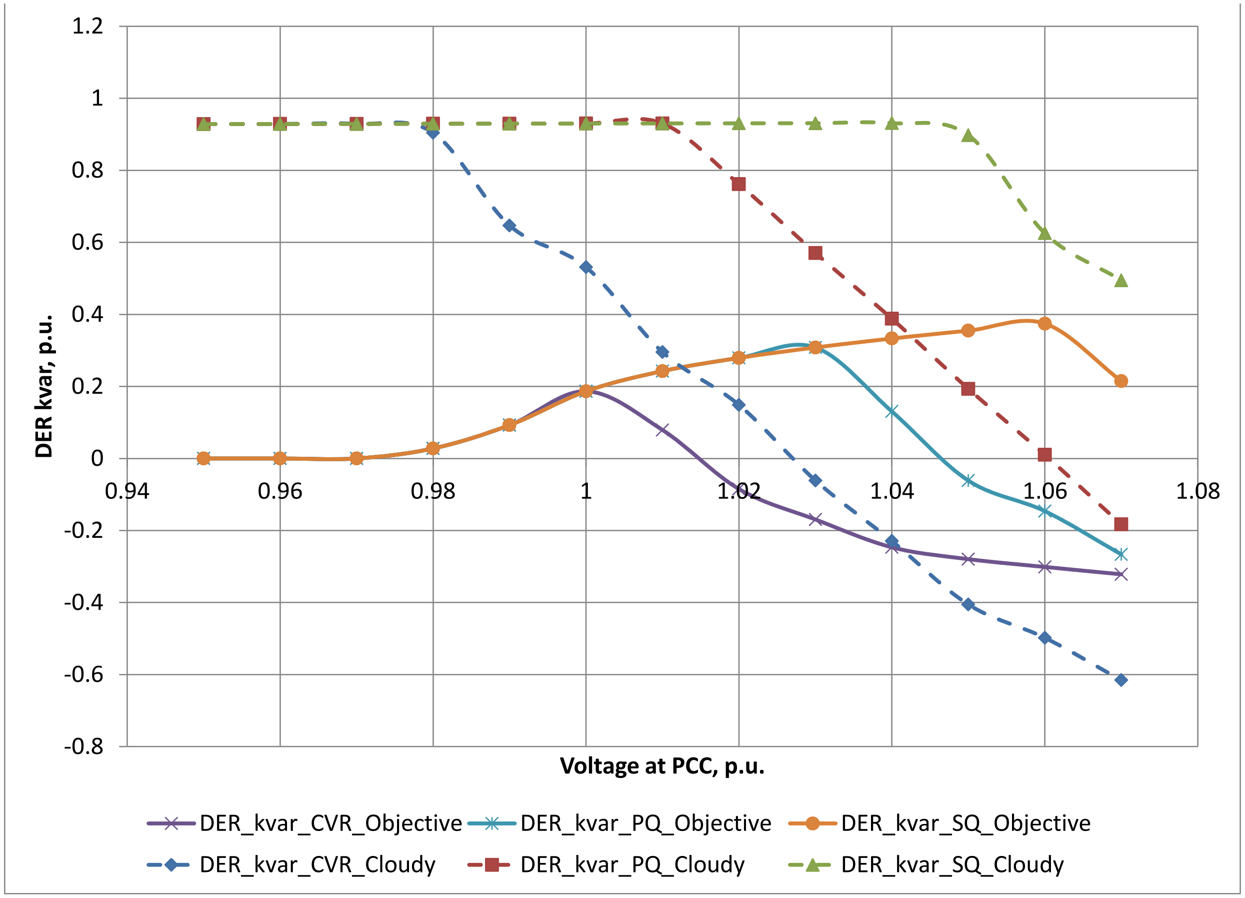

Figure 1-13. Comparison of maximum var operational limits under different operating conditions

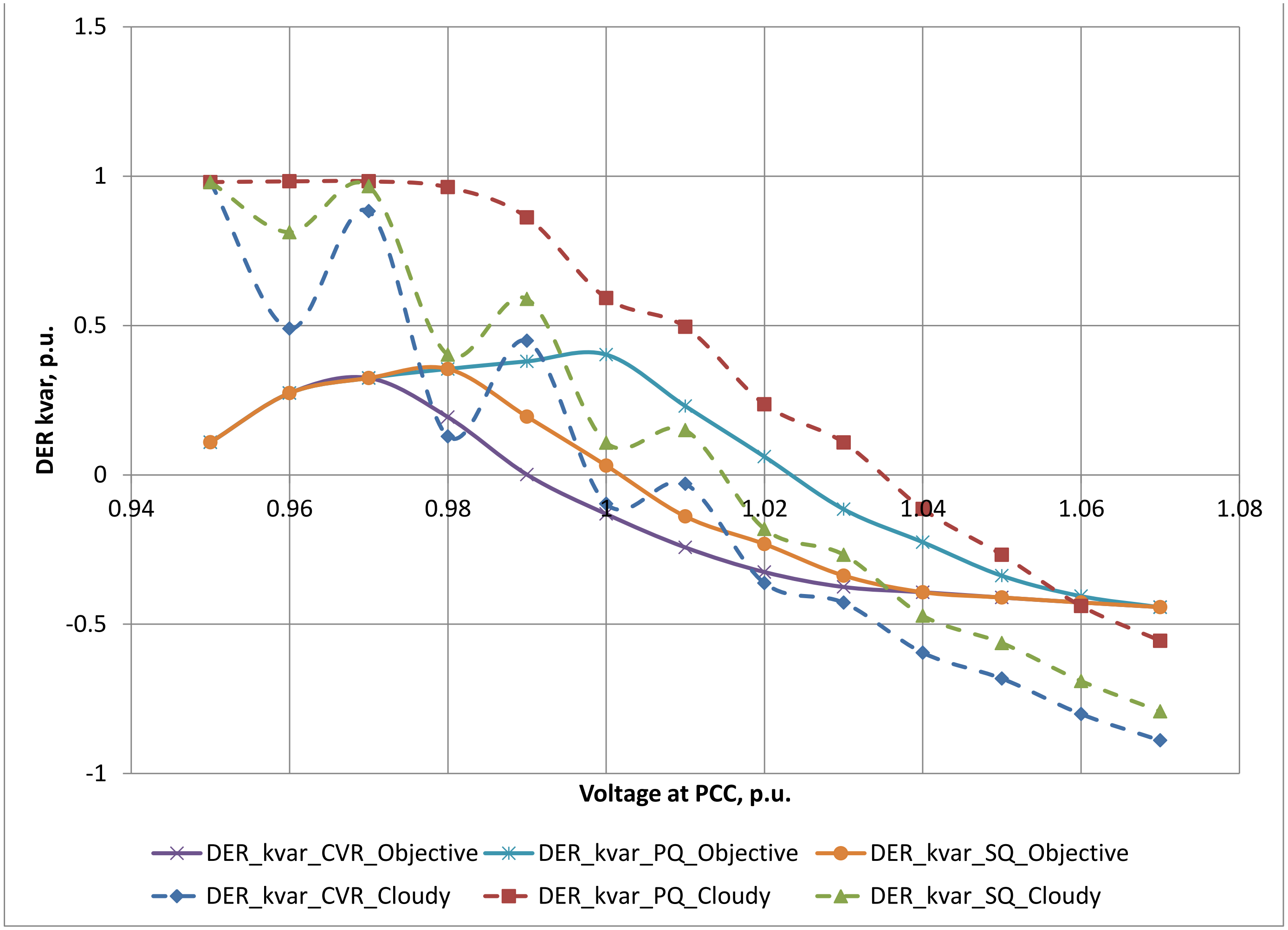

Figure 1-14 Comparison of minimum var operational limits under different operating conditions

As follows from the comparison of the var limits under different conditions, if the reactive power support of EPS under a particular objective of the volt/var control in the μGrid does not meet the DSO/DMS requirements, the μGrid can be requested to change the volt/var control objective to another more favorable for the EPS objective. For instance, if the μGrid runs the CVR objective, but the DSO/DMS requires more var support, the DSO may request the μEMS to switch either to the PQ, or to SQ objective, which are able to provide more vars to the EPS (see Figure 1-13). The additional cost to the μGrid for such a change will be the increased intake of kW from the EPS (see Figure 1-15 and Figure 1-16) and greater bills for the μGrid customers.

Under the conditions of absorbing vars, the objective with the largest kW intake is the PQ objective (see Figure 1-17 and Figure 1-18).

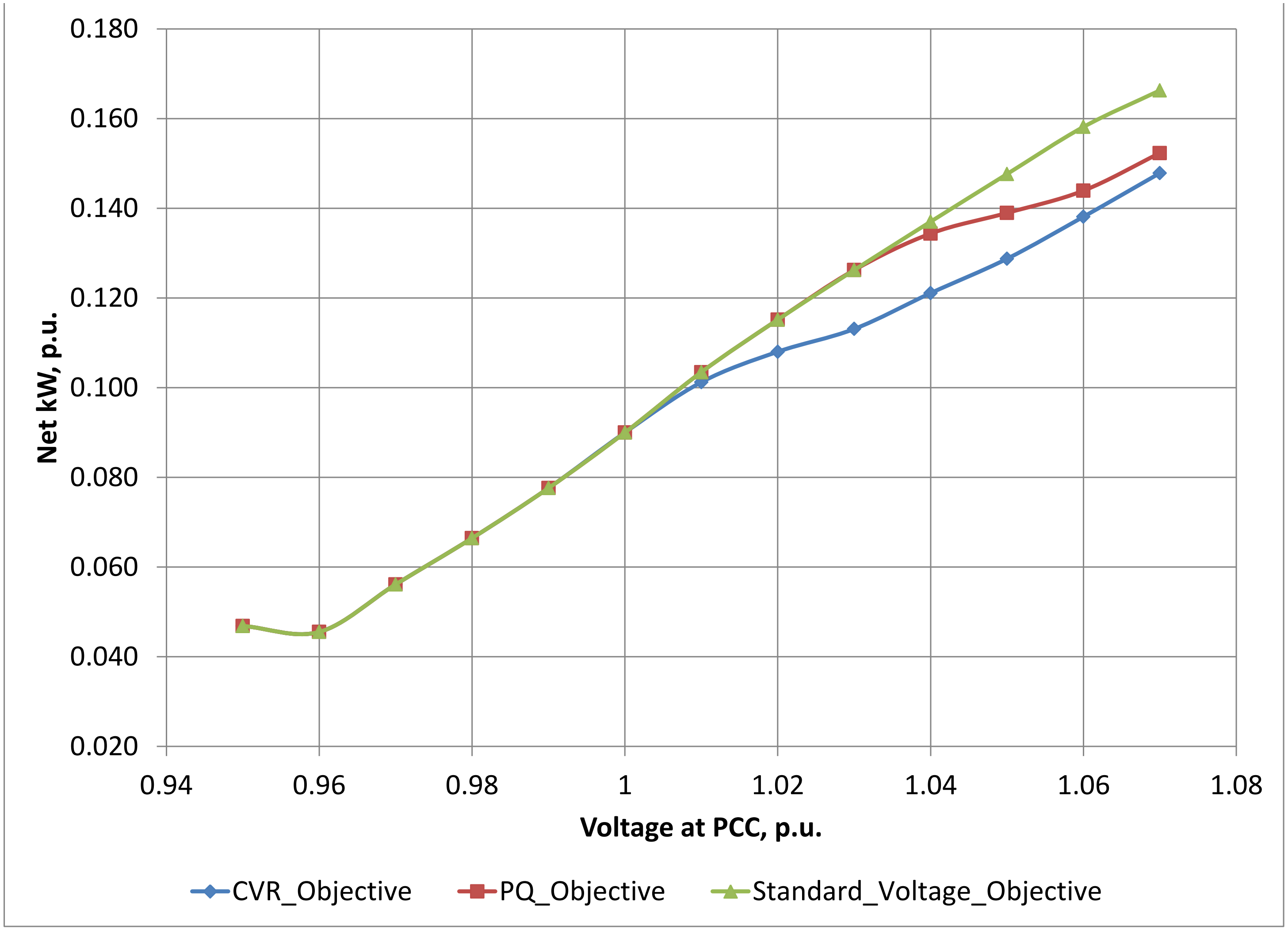

Figure 1-15. Net KW under the maximum var generation requirements. DER kW=100%.

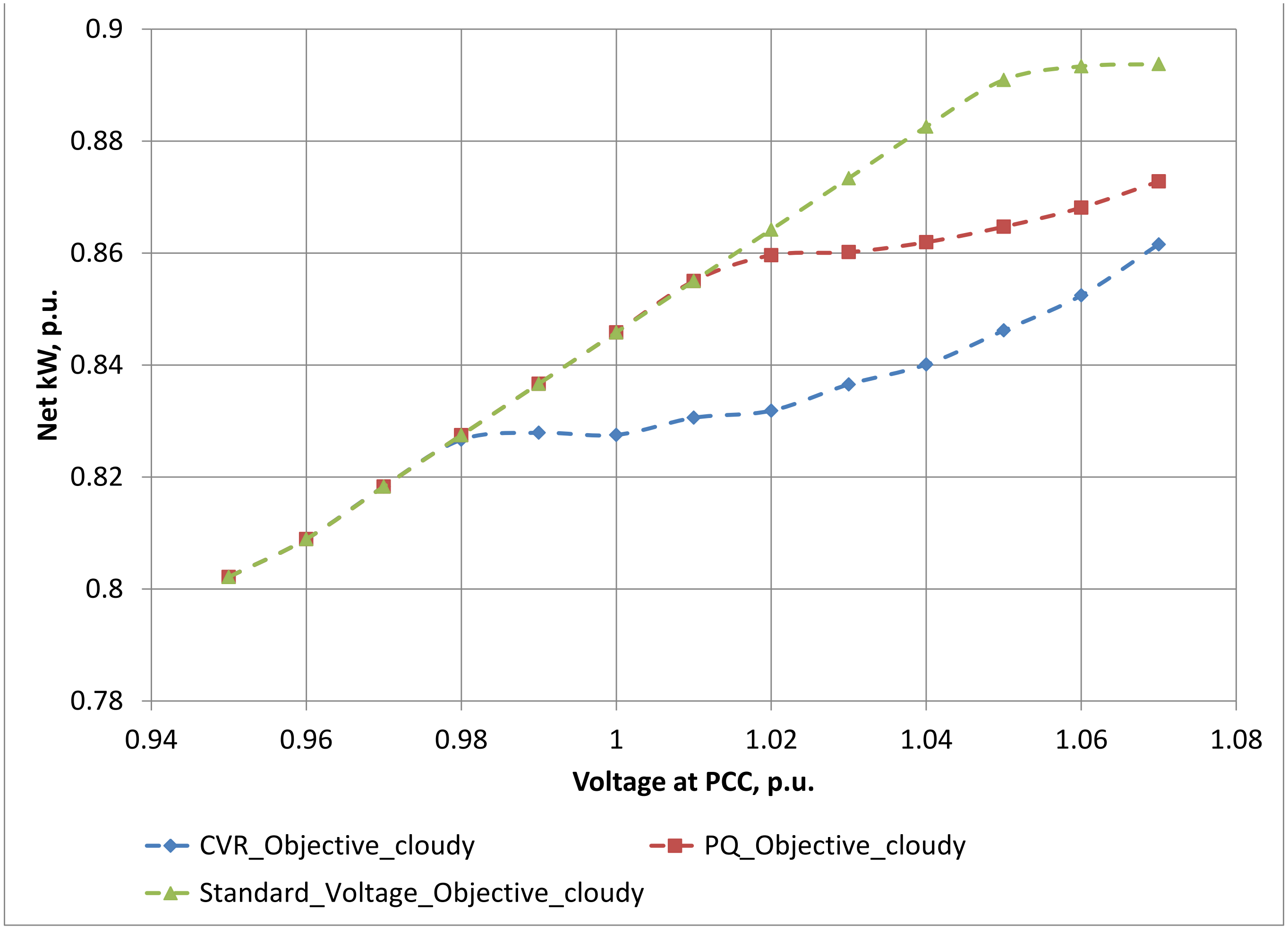

Figure 1-16. Net KW under the maximum var generation requirements. DER kW=20%.

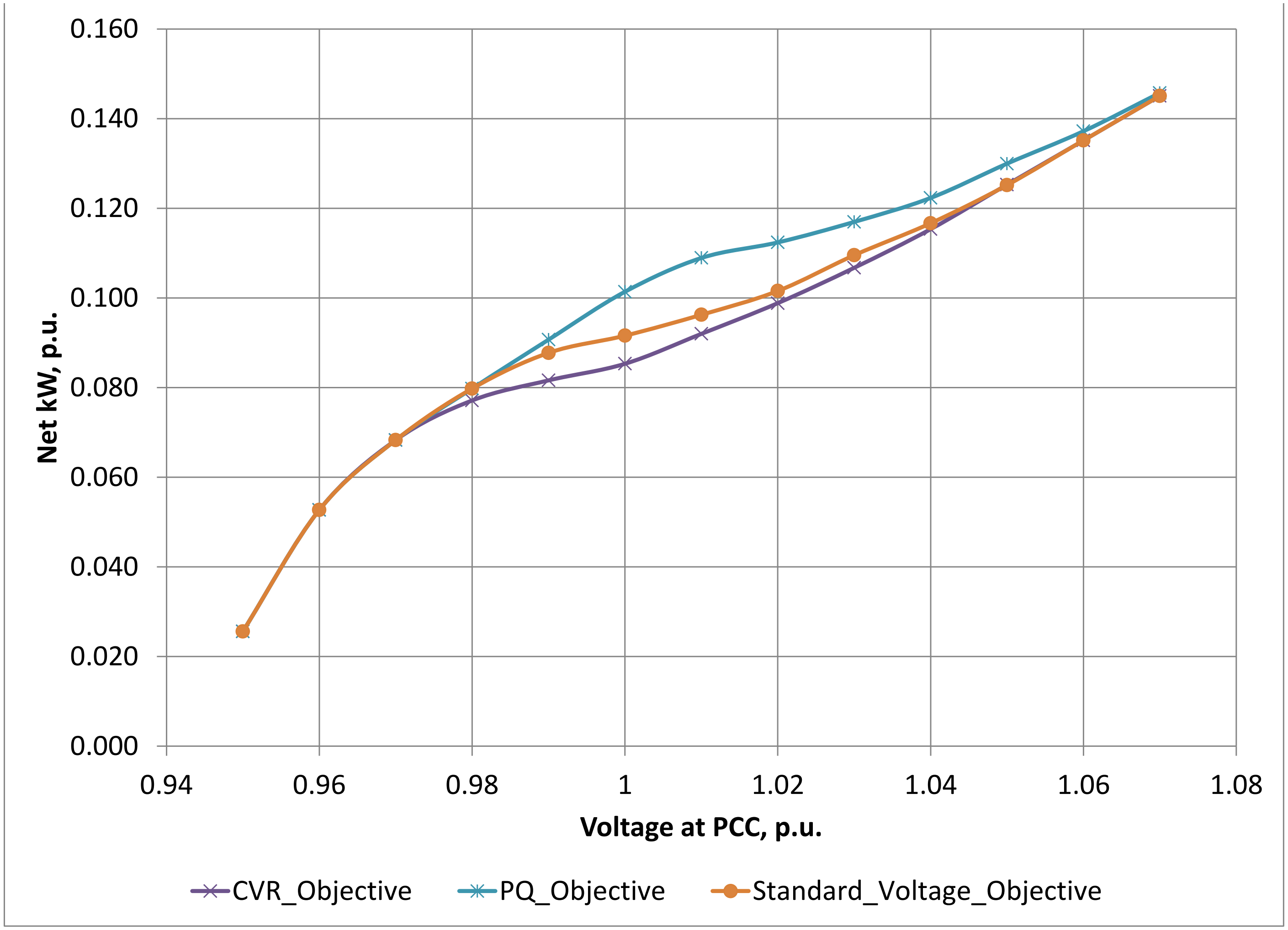

Figure 1-17. Net KW under the minimum var generation requirements. DER kW=100%.

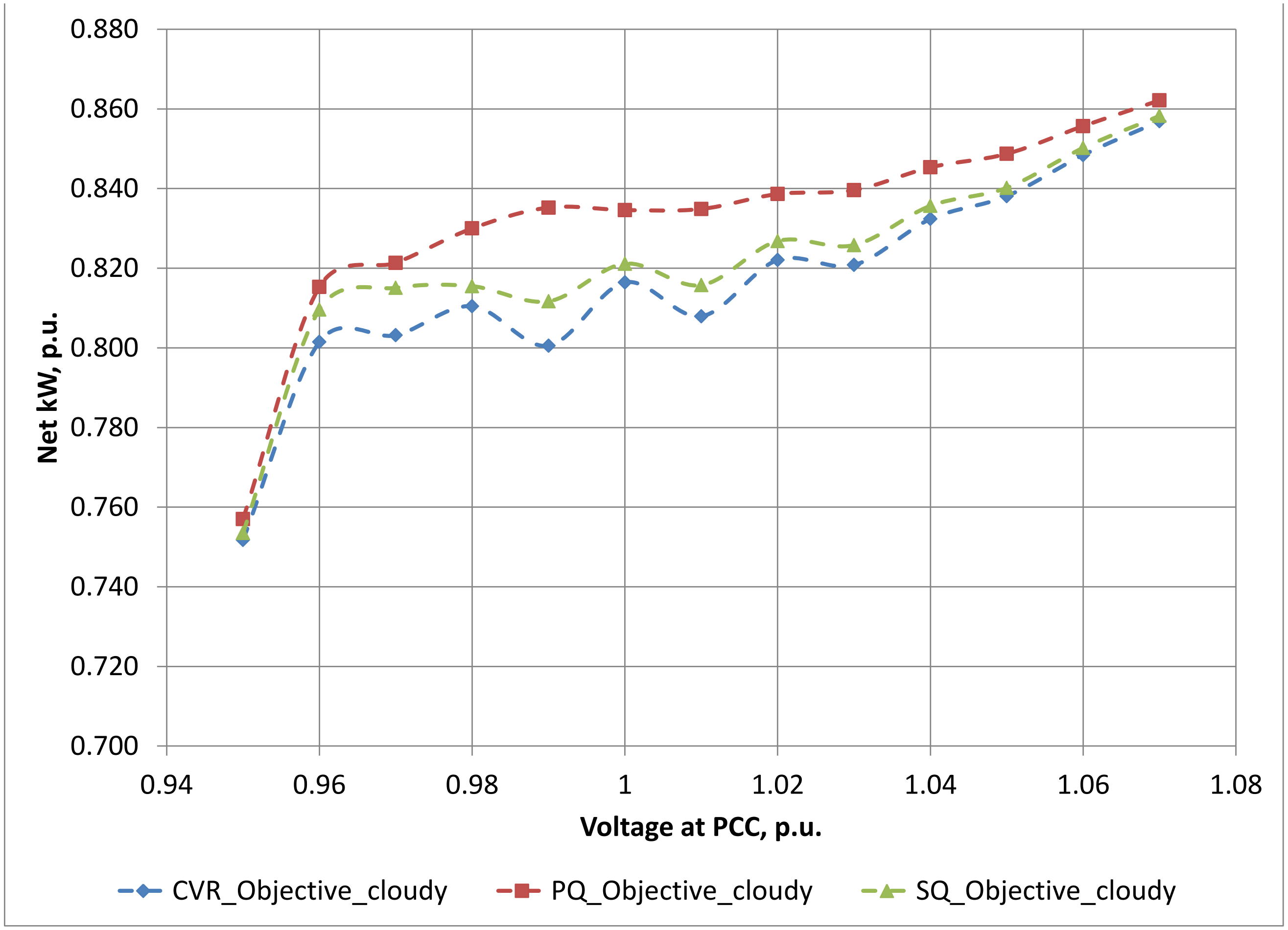

Figure 1-18. Net KW under the minimum var generation requirements. DER kW=20%.

2 Diagrams of Use Case

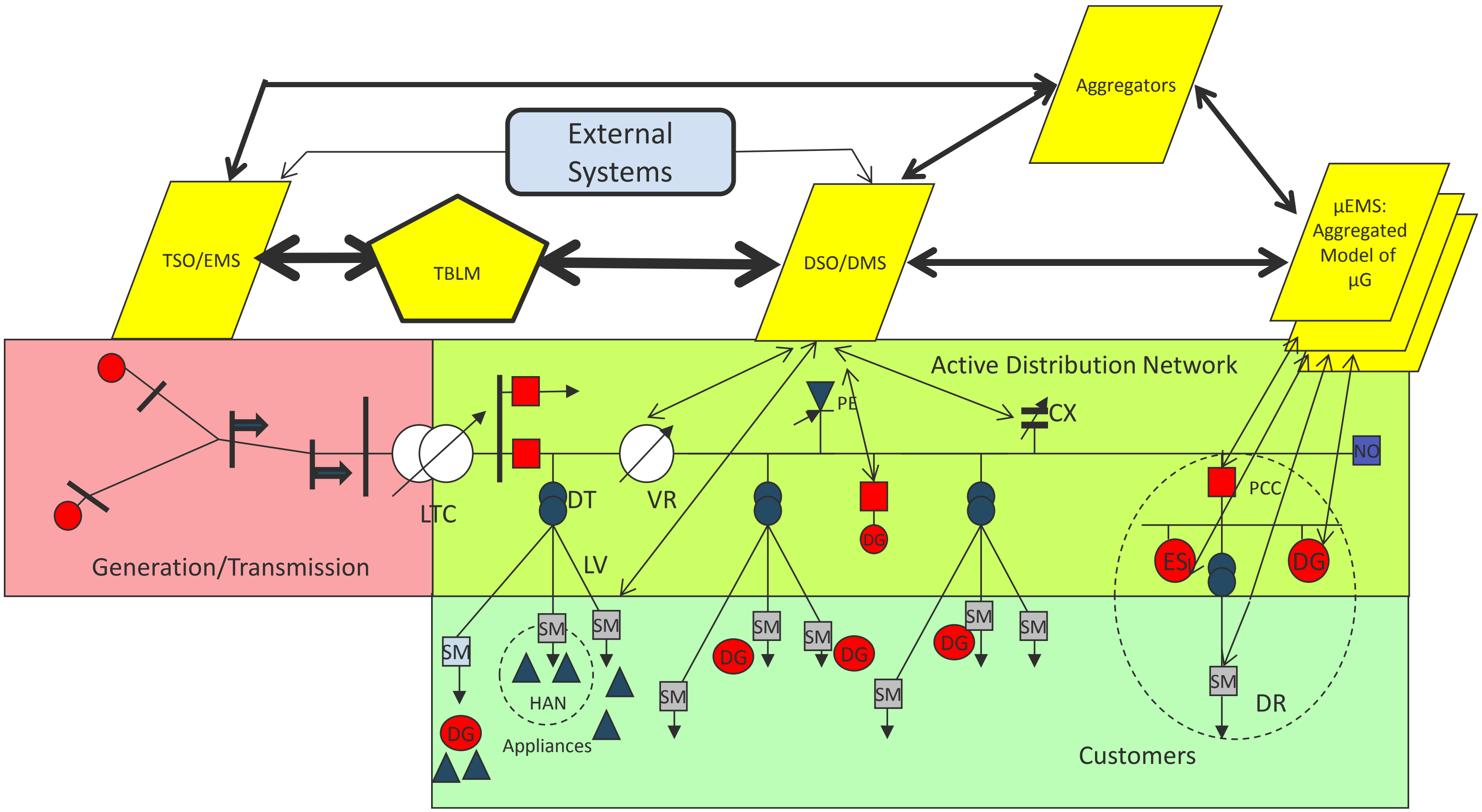

Figure 2-1. Conceptual information exchange between µEMS, other distribution active components, DMS, and EMS

Error! Reference source not found. through **Error! Reference source not found.** present the activity diagram for the major actors involved in transmission and distribution operations. The highlighted actors and activities represent the ones directly or indirectly associated with the operations of microgrids.

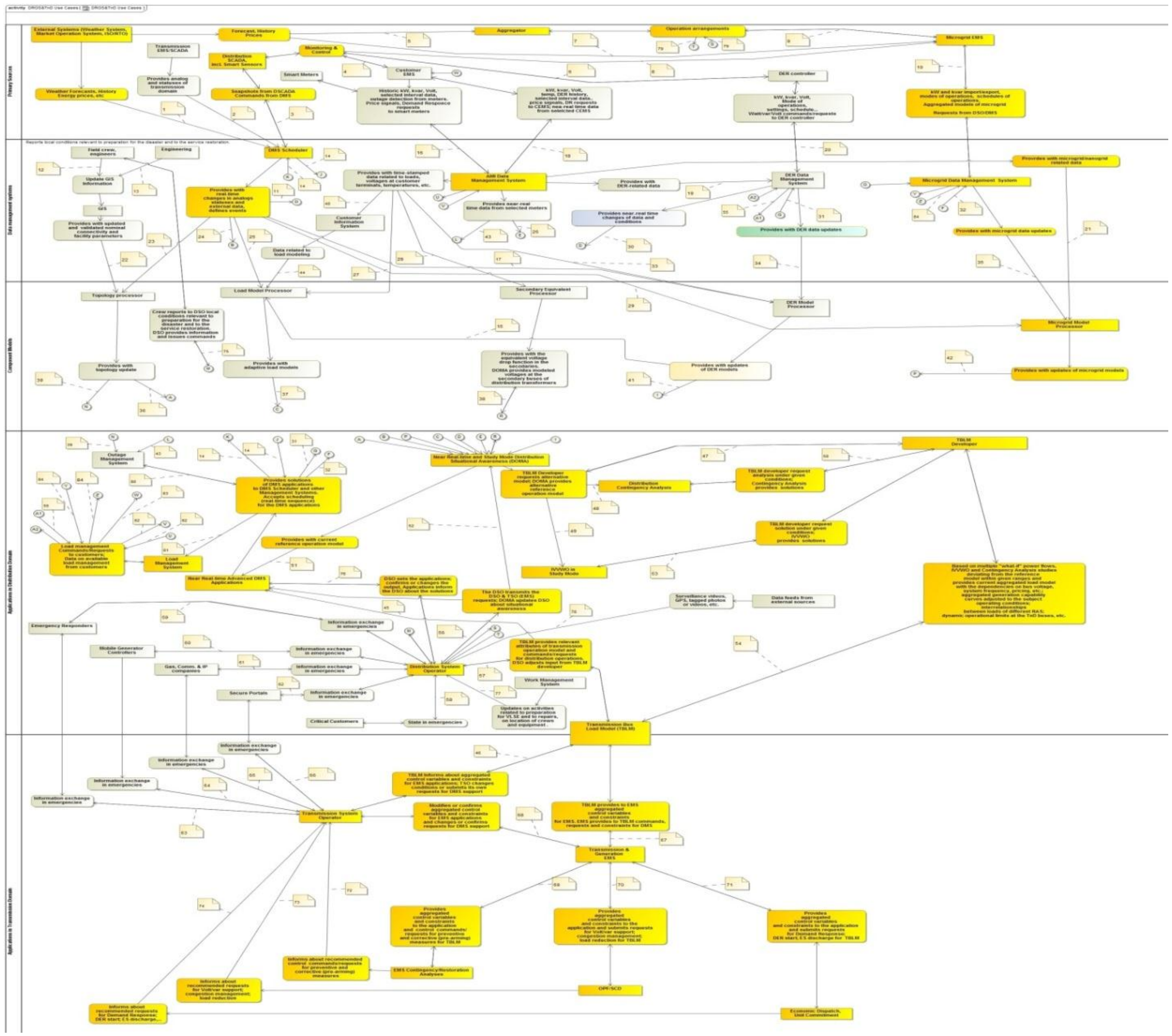

Figure 2-2. Activity diagram for use cases on interactions between customer, distribution and transmission domains

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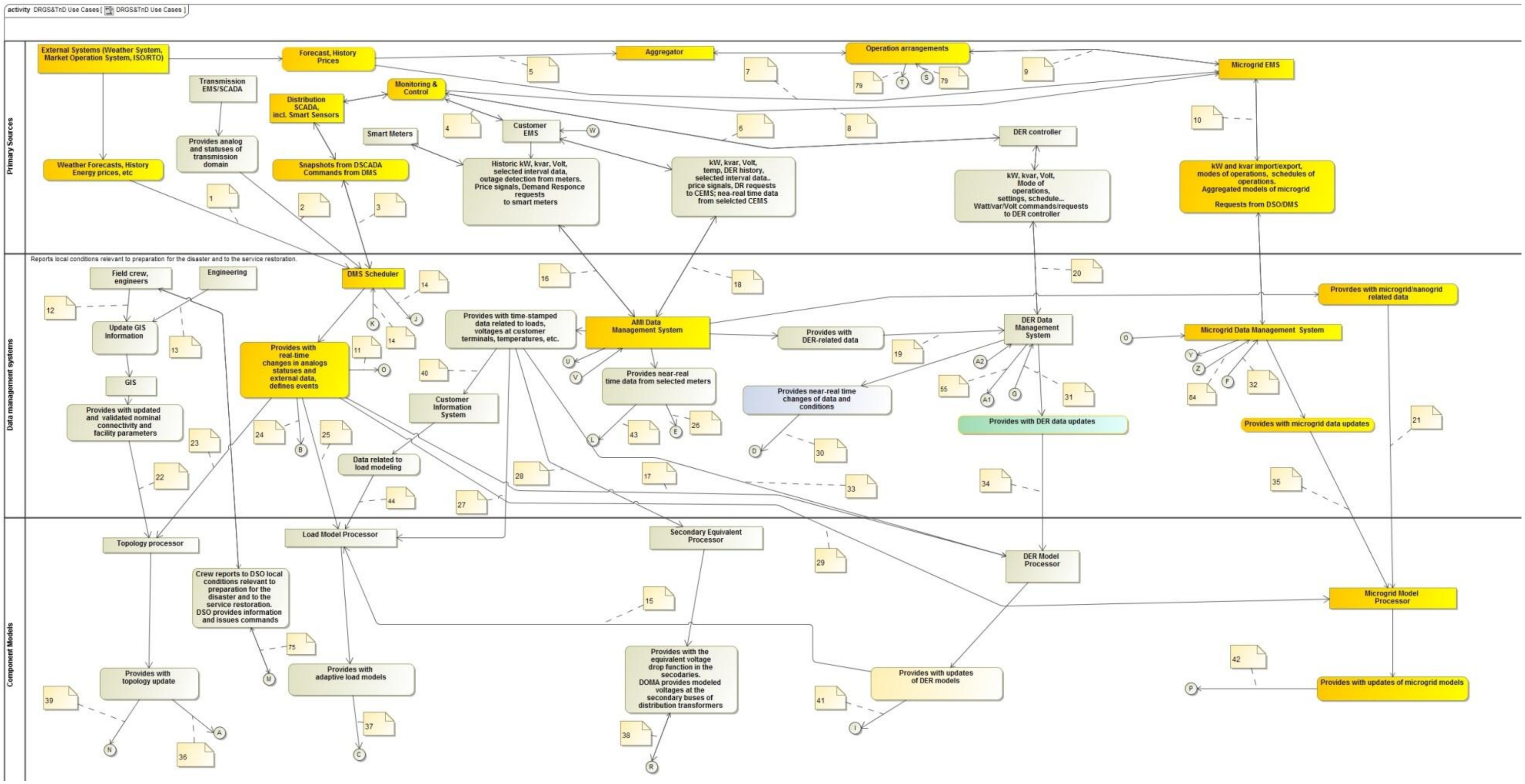

Figure 2-3. Portion of activity diagram for primary information sources and back office systems

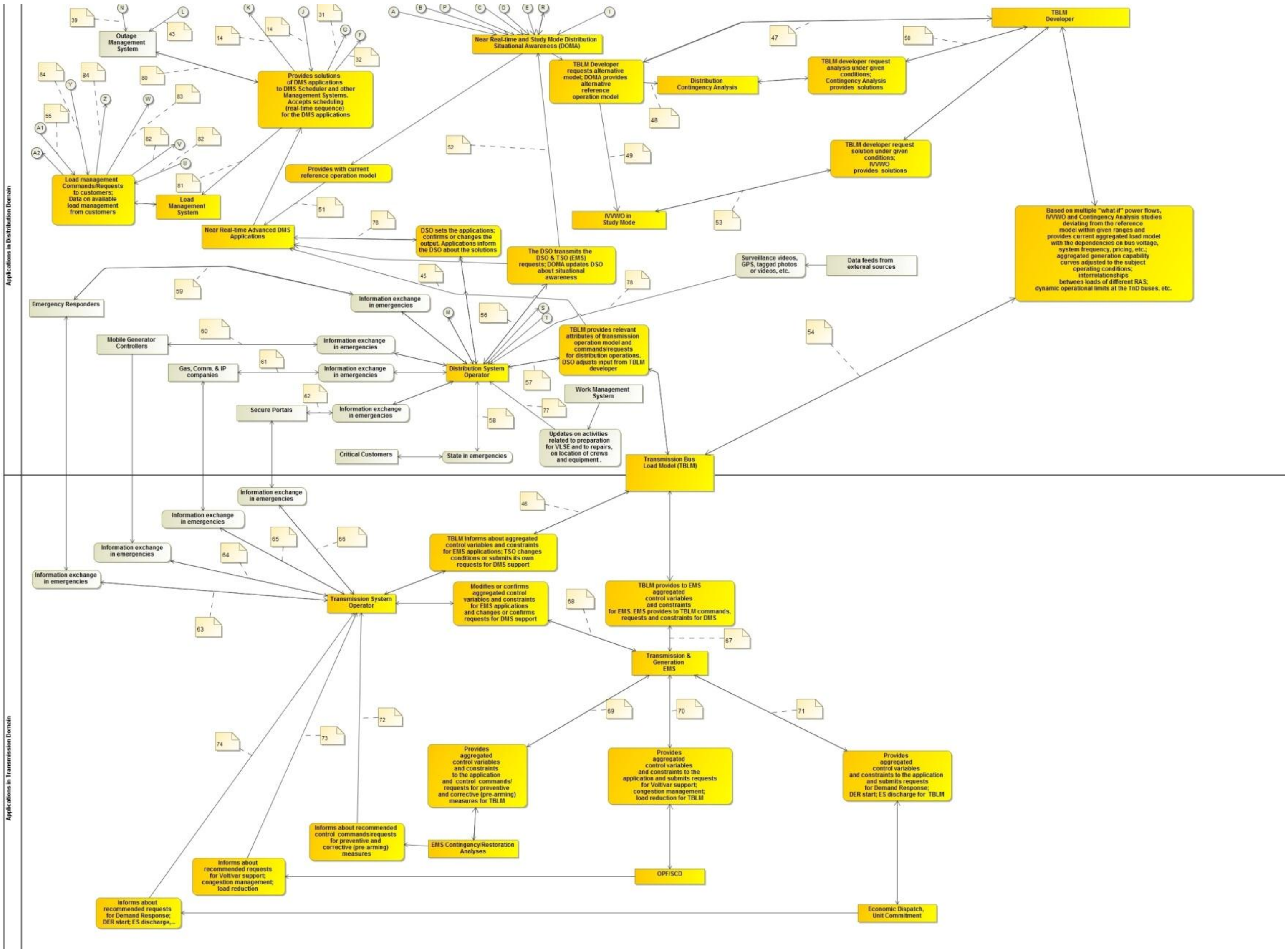

Figure 2-4. Portion of activity diagram for DMS and EMS applications and TBLM

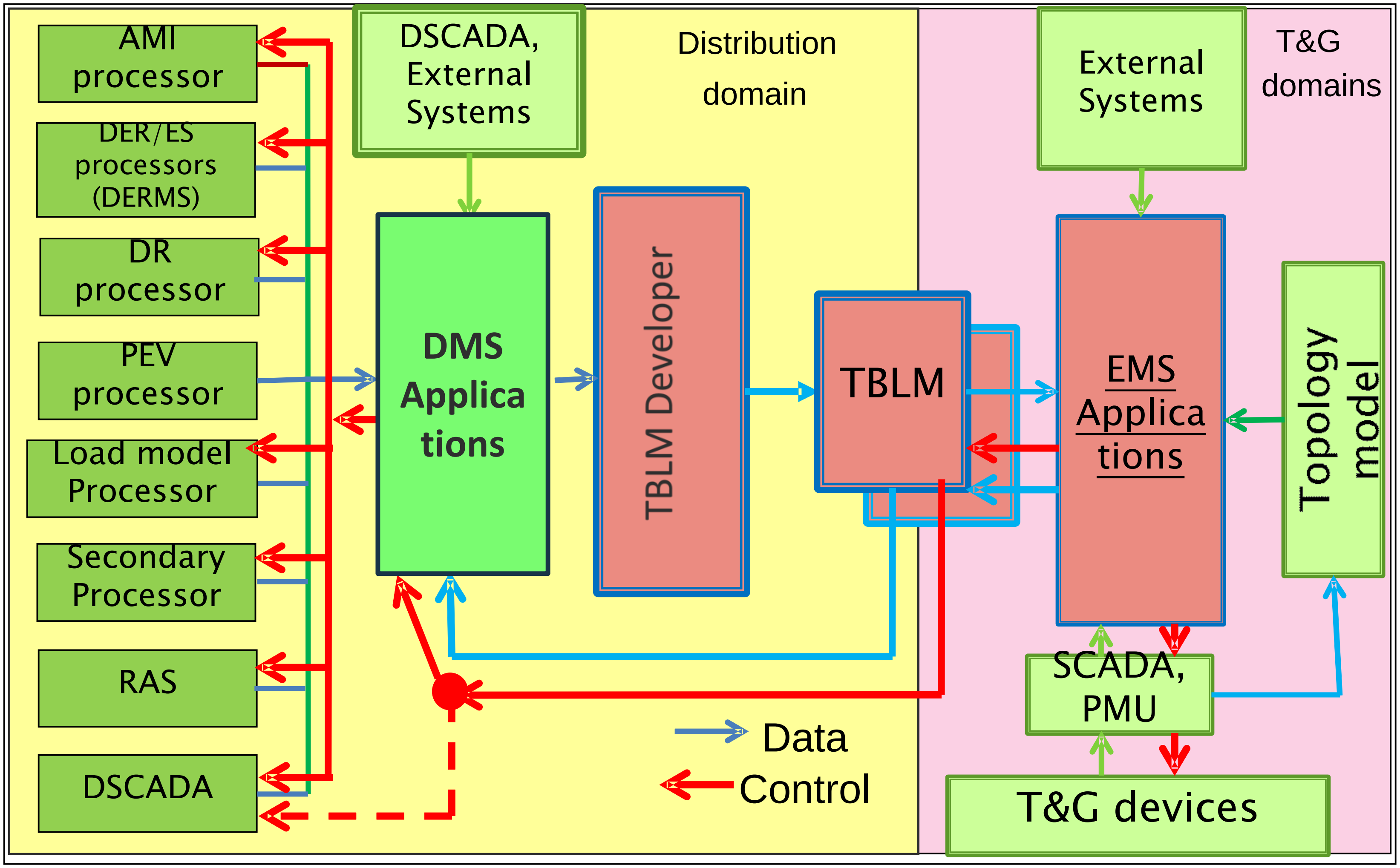

Figure 2-5. Conceptual information exchange between the DMS and EMS through TBLM

3 Technical Details

3.2 Actors

Table 3-1. List of major actors involved in interactions between a microgrid and EPS

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
1	Distribution Operator (DSO)	Person, supported by DMS applications	Person in charge of distribution operations during the shift. The operator sets up the DMS applications, defining the objectives, the modes of operations, the contents of application results presented to the operator, provides certain input data, monitors the results of DMS applications, requests additional information, when needed, authorizes the DMS recommendations, makes decisions based on DMS recommendations, etc. Normally, the operator defines the options for the close-loop control in advance, but does not take a part in the close-loop control	Additional functionalities: Communicates with µEMS, VPP operator/management systems; with community, campuses, military establishment, mobile DER systems, aggregator management systems, first responders, and communication companies; **issues requests and schedules for autonomously controlled DER; issues requests, schedules and/or commands to µEMS**, receives, analyzes and takes into account aggregated data from µEMS and other EMSes
2	Distribution Supervisory Control and Data Acquisition (DSCADA)	System	Distribution SCADA transmits/receives status and controls individual remote devices (IED) and sensors. Manages energy consumption by controlling compliant devices e.g., direct load control), and allows operators to directly control power system equipment. Required scope, speed, and accuracy of real-time measurements are provided, supervisory and closed-loop control is supported. It provides information to a Distributed Management System (DMS), including OMS or Customer Information System (CIS) for outage	Additional functionalities: Communicates with large DER systems, µEMS, and other collective EMS receiving aggregated data and issuing commands/requests. A wider use of DSCADA for communications with smaller DERs, microgrid and other customer EMSes can be expected

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			scenarios.	with the implementation of new interoperability standards (e.g., IEC 61850), which support more types of data and provide higher security.
3	Transmission SCADA/EMS	System	Transmission SCADA/EMS collects data from IEDs within the T&D substation and from the TBLM. It supports remote control of controllable devices in the substation. The EMS runs the applications for analysis and control of the transmission and generation systems.	Transmission SCADA/EMS collects data through the TBLM. EMS **contains the transmission power system model on its side of the TBLM**. It also accepts information from DMS through the TBLM for the use in the EMS applications
4	Aggregator/Energy Services Company (Market Participant-SGAC)	Company	A company combining two or more customers into a single purchasing unit to negotiate the purchase of electricity from retail electric providers, or the sale to these entities. The transaction may include electricity consumption and demand, DER/Micro-grid generation, Demand Response "Nega-watts", and ancillary services. Aggregators also combine smaller participants (as providers or customers or curtailment) to enable distributed resources to play in the larger markets. The agreement between the customers and the Aggregators, if approved by the utility, define the conditions under which the DERs/μG will operate during pre-defined times, and the operational tolerances for control of these devices, if any	The agreement between the customers and the Aggregators, if approved by the utility, define the **conditions under which the DERs/μG will operate during pre-defined times, and the operational tolerances for control of these devices, if any**. A wider use of DSCADA for communications with smaller DERs, microgrid and other customer EMSes can be expected with the implementation of new interoperability standards (e.g., IEC 61850), which support more types of data and provide higher security.

#	Actor	Actor Type	Actor Description	Further information specific to this use case. New functionalities
5	Large Customer EMS	System of a large customer	A customer EMS in typically implemented for large customers, such as large industrial or commercial company. Such customers may comprise multiple loads, distributed generation, energy storage, capacitors, volt/var controllers, load management means for normal and emergency operations, etc. The EMS includes human interface displays for interacting with the system and allows the customer to program functions, control loads, and display energy costs, usage, and related information. It can be programmed to take action based upon price inputs or event messages from the utility, etc. It interfaces with internal monitoring and control systems and with DMS. Customer Energy Management System can receive pricing and other signals for managing customer devices, including appliances, DER, electric storage, and PEVs.	Customer EMS can provide DMS with an aggregated model of the customer operations, including (but not limited to) the following: • **Net kW and kvar and generation kW and kvar** • **Net kWh and generation kWh** • **Net load and generation profiles** • **Critical interval average voltages** • **Critical instantaneous voltages** • **Instantaneous frequency, , if needed or mutually agrreed by the EPS and the customer, e.g., for transition state from island to connected mode or for unintentional islanding detection** • **Weather data** • **Attributes of load shedding schemes** • **Attributes of Demand Response aggregated at the PCC, like near-real time or short-term look-ahead available amount and duration of DER, price-level tolerance, etc. (see UC #7)** • **Attributes of dispatchable load** • **Aggregated at the PCC load-to-voltage dependences in the normal and emergency ranges**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				(Separately for load and generation) • **Aggregated load-to-frequency dependences in the normal and emergency ranges (Separately for load and generation)** **Customer EMS can provide the following services under corresponding contracts:** • **Demand Response** • **Operating Reserve** • **Volt/var control** • **Load/frequency control** • **Load shedding**
6	Smart Meter	Device	A Smart Meter is an advanced electric revenue meter capable of two-way communications with the utility and other parties. . It measures, records, displays, and transmits data such as energy usage, generation, text messages, and event logs to authorized systems and provides other advanced utility functions. The meters serve as gateways for two-way communications between the individual customer and the utility, Customer EMS, Community/Campus EMS, µEMS, and other authorized parties. They also can be used for transmitting prices and other triggering signals for enabling DR, control of customer-side DERs, ES, and PEVs. The meters can be used by the customers for communication to the utility and other parties their choices regarding participation in DR, DER, ES, and PEV controls .	There are multi-functional Smart Meters able to frequently measure, store, and transmit **kW, kvar, high accuracy Volts, voltage sags and swells, "Last Gasps", weather and higher harmonics data.** . Smart Meters can support a number of services, such as: • **Last Gasp/AC Out** • **Demand Response functions** • **Information for customers and third parties** • Communications with HAN

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
7	Community EMS (new actor)	System	A community may comprise multiple loads, distributed generation, energy storage, capacitors, volt/var controllers, load management means for normal and emergency operations, etc. The Community EMS includes man-machine interface for interacting with the system and allows the operator to program functions, control loads, and display energy costs, usage, and related information. It can be programmed to take action based upon price inputs or event messages from the utility, etc. The EMS interfaces with internal monitoring and control systems and with DMS. The community EMS can receive pricing and other signals for managing customer load, DER, electric storage, and PEVs. .	Communicates with Data Management Systems of DMS or other systems dedicated to manage aggregated generation and loads. This communication is for the coordination of the EPS operations with the operations of the composite customer. It may be executed through the aggregator, if it meets the scope and timing requirements of the information exchange.. Supports control of frequency and voltages either in autonomous mode, or controlled by the DMS. The EMS also calculates, stores, and communicates to the DMS **aggregated net load and generation, Demand Response, generation capability data for the community, summarized at the PCC ride-through and RAS settings and settings for frequency and voltage control in centrally controlled or autonomous modes of operations, other data needed for current and predictive model of community operations**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
8	Campus EMS (new actor)	System	A campus may comprise multiple loads, distributed generation, energy storage, capacitors, volt/var controllers, load management means for normal and emergency operations, etc. The Campus EMS includes man-machine interface for interacting with the system and allows the operator to program functions, control loads, and display energy costs, usage, and related information. It can be programmed to take action based upon price inputs or event messages from the utility, etc. The EMS interfaces with internal monitoring and control systems and with DMS. The Campus EMS can receive pricing and other signals for managing customer load, DER, electric storage, and PEVs.	Communicates with Data Management System of DMS or other systems dedicated to manage aggregated generation and loads and with DMS applications. Supports control of frequency and voltages either in autonomous mode, or controlled by the DMS. The EMS also calculates, stores, and communicates to the DMS **aggregated net load and generation, Demand Response, generation capability data for the campus, summarized at the PCC ride-through and RAS settings and settings for frequency and voltage control in centrally controlled or autonomous modes of operations, other data needed for current and predictive model of campus operations (see Use Cases #1, 2,4, and 7)**.
9	DER controller	Device/sub-system	The DER controller supports different functions of DER based on either local, or remote inputs, is able to respond to utility requests, to price signals and other triggers. It controls Watts, vars, voltages and frequency according to either locally or remotely installed settings in both connected and island modes.	Some (under mutual agreement) DER controllers communicate through the DSCADA with DMS Scheduler and back-office systems, like DER Data Management System, DER Model Processor or other back-office systems dedicated to manage DER. The DER controller may contain a portion or entirely **the object model of DER**. It measures, stores and communicates **current**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				generation, generation schedules, capability curves, protection settings, mode of operations and voltage/var and frequency control settings, and other data needed for current and predictive model of DER operations.
10	Microgrid EMS (new actor)	ICT system	µEMS is a system that monitors and controls the operations of the components of advanced microgrid, analyses the operational alternatives in accordance with the EPS and contractual requirements, develops near-real-time and short-term look-ahead aggregated operational models of the microgrid, and interchanges information with the EPS DMS. . Note: An advanced microgrid is comprising distributed generation/storage, and load. It may use internal controlling devices, such as voltage and var regulators, Remedial Action Schemes, such as Under-frequency/voltage Load Shedding, and elements of Information Communications Technology (ICT). A microgrid may provide a number of ancillary services. It can operate either in an island mode, or in a connected to the bulk power system (EPS) mode. Its µEMS is a major actor interacting with the EPS operator (DMS and possibly EPS EMS). A microgrid can belong to a customer and can be a part of a Virtual Power Plant (VPP) µEMS executes different functions of the microgrid in both connected and island modes of operations, such Watts, vars, voltages and frequency control according to either locally or remotely installed settings.	µEMS communicates with µG Data Management System and µG model processor of the DMS, with the DMS scheduler or other systems dedicated to manage microgrids. including market systems The aggregated models of the microgrid contain **measurements of current generation, generation schedules, DER capability curves, load-to-voltage and frequency dependences and generation-to-voltage and frequency dependences for normal and emergency conditions, dispatchable load, setups of protection and remedial action schemes, relationships between load management means, mode of operations and settings of voltage/var and frequency control functions, dependences of model components on external signals,**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				degree of uncertainty and validity of the model components and other data needed for current and predictive model of microgrid operations.
11	VPP Management system (new actor)	System	VPP Management system performs planning and trading an aggregation of generation and load within one control area.	The participation of a microgrid in a VPP should be governed under conditions of the agreements between the microgrid, VPP, and EPS. VPP management system calculates, stores, monitors and communicates **the current and look-ahead aggregations of the Distributed Generation, Demand Response, and Micro-grids** through interfaces with distribution and transmission domains and trades with the market domain. The Commercial VPP system will interface with the market categories after approval of the Technical VPP by the DSO.
12	Distribution Field Crew	Organization /person	Manual operations of field devices, repair and construction work, patrolling facilities, recording changes in facility parameters, connectivity, in mobile computers, transferring data to the operator, and corresponding database administrators. This is a class of actors. (SGAC)	Field crews are able to communicate with the distribution system operator and with GIS management via Field Crew Tools, such as mobile communications and computing, **based on predefined templates**.
13	Distribution Field Crew Tools	Devices	A field engineering and maintenance tool set that includes any mobile computing and hand-held devices.	

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			(SGAC)	
14	Engineering	Person/Department	Includes planning, and DMS maintenance personnel, power quality and reliability engineers, etc.	Performs DER/microgrid impact studies, recommends interconnection requirements, recommends options of setups of ADA applications, periodically inspects performance of ADA applications, troubleshoots applications, reviews report, etc.
15	Controllers/gateways of DER, PEV, and Electric Storage embedded in customer premises	Devices	Equipment and systems monitoring and controlling the DER, PEV, and ES at the customer site. These embedded resources can be just passive components of the prosumer; some may be active components providing demand response and other services.	The results of the performance of the embedded systems, in addition to be included in the net measurements by the AMI, should be also accounted separately. This is needed for the adequate load models for the customers and, consequently, for the microgrid.This may include **profiles of real and reactive power injections and charges, modes of operations and settings**.
16	Smart customer appliances	Devices	Equipment and systems at the customer site that could be controllable and can participate in demand response and other programs. Includes lights, pool pumps, air conditioners, electric air and water heaters, refrigerators, washers, electric dryers, dishwashers, etc.	The **characteristics of the smart customer appliances** can be used in the load management applications and to derive components of adaptive load models that can be used for the aggregated models.
17	External Systems (e.g. Weather, DER provides)	Systems	Information systems outside the utility that provides the utility with information on weather and major event relevant to utility operations. The information obtained from these systems is used by the modeling components of DMS for adjustment of the adaptive	The information obtained from these may contain the following: (see also the requirements developed by PAP 21). • **Temperature**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			models. This information is most important for the development of the models of weather- dependent DER/ µG. Other external sources of information are the providers of the DER (e.g., the PV panel installers). If they collect data on the DER performance, this information can be used by DMS (via DER Data Management System) to determine the DER injetions and separate them from the net load of the customer.	• **Wind parameters at given height** • **Speed** • **Direction** • **Solar irradiance (near-real time and short-term forecast), W/sq.m** • **Cloudiness cover (near-real time and short-term forecast), %** • **Cloud velocity (near-real time and short-term forecast), m/sec** • **Cloud direction (near-real time and short-term forecast)** • **Cloud height** • **Cloud shadow patterns (near-real time and short-term forecast**)
18	ISO/RTO	Systems	ISO: An independent entity that controls the power grid in a designated wide area to coordinate the generation and transmission of electricity and ensure a reliable power supply. RTO: An independent organization that coordinates, controls, and monitors the operation of the electrical power system and supply in a particular geographic area; similar to Independent System Operator.	Issues **aggregated load management requirement to TSO/DSO Operators that are distributed by the TSO and DSO among individual and composite consumers and prosumers**. The µEMS then distributes the requests among its participants.
19	Market Operation System (MOS)	System	Wide-area energy market management system providing high-level market signals for TSO and DSOs	MOS deals with energy products, **including products of the bulk generation, distributed**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				generation, electric storage, electric transportation, and demand response, and composite participants, such as large microgrids. and other customer EMS. It also deals with the products of the ancillary services.
20	Geographic Information System (AM/FM/GIS)	System	Repository of distribution system assets, their relationships (connectivity), ownerships, nominal states, and links to associated objects AM/FM/GIS database should be interfaced with the Outage Management System (OMS), Customer Information System (CIS) for linkage between the customer data and point of connection, with AMI, DER/µG, and DR data management systems for updates of secondary circuit equivalents, and relevant attributes of adaptive load models for the consumer, prosumer, DER/µG, ES, and DR. AM/FM/GIS database is also accessible to field crews via mobile computing for updates on facility connectivity and parameters. The AM/FM/GIS database is updated, proof-tested and corrected in a timely manner to provide a high probability of preparedness for supporting near-real-time DMS applications.	AM/FM/GIS system contains the **geographical information of the distribution power system circuit connectivity, as well as the parameters describing the power system facilities, including all electric characteristics of distribution transformers, as well as circuit connectivity and parameters of secondary circuits between the distribution transformers and customers or their equivalents consistent with voltage drops and power losses. Conceptually, the AM/FM/GIS database can contain transmission connectivity and facility data and relevant to distribution operations customer-related data. GIS should also contain data aggregated at the PCCs of composite prosumers (location, transfer capabilities, voltage limits, transformation ratios, etc.)** How much of internal data from the µGrid should be in the EPS' GIS depends on the contractual agreements between the

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				EPS and the prosumer.
21	Customer Information System (CIS)	System	CIS contains energy consumption and load data for each customer separate, even for the ones, which are included in consolidated accounts, based on measurement interval established for the Smart Meters and also aggregated for established billing periods. CIS interfaces with GIS and other data management systems providing customer information including billing data, customer types, and numbers of customers connected to distribution circuits and distribution transformers	CIS communicates with AMI, DER/microgrid, and DR data management systems. It contains **consumption and demand data on per customer basis for pre-defined time intervals of measurements by the Smart Meters, as well as composite data for billing periods. It also contains information on other customer properties, like customer type, rate schedules, etc.** How much of internal data from the µGrid should be in the EPS' CIS depends on the contractual agreements between the EPS operator, aggregators and the prosumer.
22	DMS	System	A set of integrated IT systems and DA applications supporting the operations, maintenance, and planning of the electric distribution system	The DA applications are the central component of the EPS DMS, being supported by DSCADA, DMS corporate databases, such as AM/FM/GIS, and interfaced with other EPS IT systems, such as OMS. The future DMS should interface for monitoring and control with the EMSes of large and composite consumers and prosumers, including µEMS. (Microgrids' EMS will have similar although scaled-down

#	Actor	Actor Type	Actor Description	Further information specific to this use case. New functionalities
				applications) DMS displays **the summary results to the DSO via a GUI and issues commands and requests to monitored and controlled components of the Active Distribution Network either directly, or through the DMS scheduler.**
23	DMS Scheduler	Sub-system/application	Computer-based sub-system consisting of Graphic User Interface, and an advanced scheduling application that accepts, checks, and organizes information obtained from DSCADA, DSO and other authorized personnel and triggers DA applications according to the given setups. It accepts output information from DA applications and initiates execution of their instructions. . .	The DMS scheduler interfaces with External Systems, DSCADA, DA applications, back-office DMS systems, and other ICT systems including large individual and composite consumer/prosumer EMSs. It transmits the **commands and requests to monitored and controlled components of the Active Distribution Network issued by the DMS applications.**
24	DMS conversion and validation function (processor) - (C&V)	Application	The C&V function uses standard interface between AM/FM/GIS database, converts and validates information about incremental changes implemented in the field. GIS information should be validated on two levels: 1) validation of connectivity and distribution transformer loading, and 2) integrated validation on operational reasonability. The first level of validation can be performed by analyzing the consistency of connectivity (de-energized elements, loops, wrong phasing, etc.)	With the high penetration of DER and microgrids, and other composite DER categories, the C&V function should integrate the specifics of these categories and new Smart Grid technologies. One significant aspect of these categories is the uncertainty of the components of the aggregated models at the PCC. Major causes of the uncertainty are the

#	Actor	Actor Type	Actor Description	Further information specific to this use case. New functionalities
			and by analyzing the consistency of customer association with the distribution transformers and of its loading. The second level of validation is based on the consistency of the power flow and contingency analysis results with the utility expectations (e.g., if the utility expects that it can to back up 50% of maximum load of any faulted feeder, and the contingency analysis shows that it cannot be done, then it is likely, with a certain degree of uncertainty that the input data is wrong and need double-checking). .	intermittency of renewables, the autonomous not monitored operations of the DERs, and the performance of the enabled demand response. These uncertainties are propagated to the uncertainty of the overall validation in level 2. Also, if significant inconsistencies are determined within the sub-system of the composite prosumer, the validity of the aggregated models is compromised, and a corresponding message should be delivered to the C&V processor. The C&V **processor submits its results** to the personnel in charge for the GIS and relevant data management systems.
25	AMI Data Management System		AMI Data Management System communicates with AMI Headends, collects, stores, and processes measurements from the Smart Meters. It is interfaced with CIS, GIS and other data management system and model processors, such as DER/µG, DR, and EV, and with the DMS applications. It gathers, validates, estimates, and permits editing of meter data such as energy usage, real and reactive loads and generation interval measurements, voltages, meter logs, and other data of multifunctional meters. It stores this data for a limited amount of time before it goes to the Meter Data Warehouse and makes the data	AMI Data Management System derives **aggregated at the distribution transformer load profiles** based on the link between the distribution transformers and the customer IDs stored in GIS; For prosumers, microgrids, and other composite customers, AMI Data Management System should collect the **net real and reactive load information and the generation components of it**. If the generation component is not available, the net load patterns

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			available to authorized systems.	should be analyzed involving additional information from the DER/µG Data Management System and or model processors to derive the component of the natural microgrid loads and the component of generation. This analysis can be done in the Load Model Processor.
26	DER data management system	DMS database/application	A specific database for DER attributes, contracts, and performance associated with the owner. DER data management system is able of controlling DER and ES charging/discharging; storing and processing **data on DER attributes, operations, contracts, relevant historic information, collecting, processing, and storing power quality and reliability characteristics, etc.,** according to the designs of the object models and DMS applications	DER data management system is interfaced with AMI data management system, Aggregators, with the Load Management System, with DER model processor, and with the DA applications.
27	DER model processor	DMS Application	DER model processor is able of creating **adaptive near-real-time and short-term look-ahead models of DER.** It provides DMS applications with full object model of DER. Derives the object model from the data obtainable from the DER controller, if monitored, from the DER Data Management System, GIS, AMI Data Management System, historic measurements and external data.	Develops adaptive models of DER based on new data obtained from the snapshots of the DMS scheduler, from the attributes from the Data Management System and from DER controllers, including the setups of ancillary services provided by the DER, current protection settings, etc.
28	Microgrid Data Management System		µG data management system is able of storing and processing data on microgrid attributes, operations, contracts, relevant historic information, of collecting, processing, and storing power quality and reliability characteristics, etc. according to the designs of the object models and DMS applications	The µG data management system can issue requests and commands to the corresponding microgrid EMS based on DSO and/or DMS application input, if so designed. These messages may include the following:

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				• **Real-time prices** • **Demand response triggers and amount** • **Disconnection/reconnection command for intentional islanding** • **Desired kW and kvar (power factor) setpoints at PCC and/or volt/var control curves** • **Desired setups of Remedial Action Schemes (RAS)** • **Desired setups of DER ride-through functions** • **Data requests** • **Other**
29	Microgrid Model Processor	DMS Application	Accumulates and updates the aggregated at PCC operational models of µG. Interfaces with µEMS, EPS' DMS, and TBLM developer.	Develops **adaptive models of µG** based on new data obtained from the snapshots of the DMS scheduler and attributes from the Data Management System and from µEMS, including the **setups of ancillary services provided by the µG, current RAS and protection settings, etc.**
30	Load /Demand Response Management System	Database/Application	Controls DR and other load management means based on input from the operator and DMS applications, processes and stores **data on load management programs, contracts, relevant historic information, for creating adaptive models of DR, collects, processes, and stores customer-specific data according to the designs of the object models and**	Distributes the DSO/DA commands for aggregated load control among individual/group participants. It interfaces with the Load model processor, aggregators, customer EMS, µG Model Processor and Data Management

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			DMS applications.	System, µEMS, AMI Data Management System, and DMS applications.
31	Load Model Processor	Application	The Load Model Processor develops **daily load models** based on information available from CIS and GIS (currently – typical load profiles and typical load-to-voltage dependences)) and engineering input. interfaces with AMI Data Management System, DER and µG Data Management Systems and Model processors, customer and µG EMSes, different sources of operational triggers, such as real-time pricing sources, reliability trigger sources, weather sensors and systems, with DMS applications and TBLM Developer	The Smart Grid Load Model Processor develops **adaptive individual and aggregated load model of consumers and prosumers taking into account the variety of possible load components and their dependences on a number of factors, such as embedded distributed generators, electric storage devices, and plug-in electric vehicles, and demand response means. The real and reactive load models, individual or aggregated, reflect the behavior of these composite loads depending on the known weather, prices, voltage, time of day, and other factors. It normalizes the models to the nominal conditions and derives the dependences of the load on the changes of these conditions.**
32	PEV data management system and model processor	Application	PEV data management system is processing and storing **data on PEV programs, contracts, relevant historic information, creating adaptive models, collecting, processing, and storing customer-specific data according to the designs of the object models**	Such application may be needed in the µEMS, and other EMS of composite prosumers.

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			and DMS applications.	
33	Secondary Equivalent processor	Application	The secondary equivalent processor provides DMS with **equivalents of the voltage drops and power loses in the secondary circuits** fed from distribution transformers It derives the voltage drop and the power loss equivalents in the secondaries as functions of the available near-real time data, based on the historic AMI data and modeled or measured voltages at the LV bus of the distribution transformers.	Such application may be needed in the µEMS, and other EMS of composite prosumers
34	Topology processor, including topology validation processor	Software program	The topology processor provides DMS with near-real time connectivity model. It derives and validates the connectivity model based on GIS, DSCADA data and on power flow analysis	Such application may be needed in the µEMS, and other EMS of composite prosumers
35	Energy Services Interface (ESI)	Application	ESI is a network communications application device which provides a gateway from the utility (or other energy service provider) to the customer site. Provides cyber security and coordinates functions that enable secure interactions between relevant Home Area Network (HAN) devices, meters and the Utility/ESP. Permits applications such as remote load control/Demand response, monitoring and control of distributed generation, in-home display of customer usage, reading of non-energy meters, and integration with building management systems. Provides auditing /logging functions that record transactions to and from Home Area Networking Devices. This service is also a specialized class of services potentially included in HAN gateways. Also commonly referred to as a Home-Area Network Gateway.	May be a part of µEMS, and other EMS of composite prosumers, or may interface with these EMSes.

#	Actor	Actor Type	Actor Description	Further information specific to this use case. New functionalities
36	Transmission Bus Load Model (TBLM)	Data model	The TBLM is a composite model of the distribution system operations aggregated at the demarcation bus between the transmission and distribution domains. It consists of the following components: • **Net real and reactive load at the bus** • **Real and reactive generation components** • **Load management components** • **RAS load components and attributes** • **Aggregated DER/µGrid capability curves** • **Aggregated real and reactive load-to-voltage/frequency dependencies** • **Aggregated real and reactive load dependencies on other external factors** • **Technical and economic functions and attributes of composite prosumers** • **Aggregated dispatchable real and reactive loads** • **Overlaps of different load management functions, which use the same load under different conditions.** • **Degree of uncertainty of the distribution model** • **Other**	The operational models of the µG and other composite prosumers should be aggregated in the TBLM
37	Distribution Situational Awareness	DMS application	The Distribution Situational Awareness is based on two major DMS applications: Distribution Operation Modeling and Analysis (DOMA) and Distribution Contingency Analysis (DCA). DOMA is an advanced DMS application. It runs periodically and by event, or in study mode for given conditions, including short-term look-ahead analysis. It models and analyzes unbalanced power flow; it analyzes the operations of	The Distribution Situational Awareness utilizes **adaptive nodal load, DER/Micro-grid, and PV models and secondary equivalents**. It communicates with AMI, DER/microgrid, and DR data management systems. Supports TBLM developer.

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			the distribution system from the standpoints of **adequacy, power quality, and economic efficiency;** provides situational awareness of distribution operations under normal and contingency conditions; provides background models for other DMS applications. The DCA performs an N-m contingency analysis in the relevant portion of distribution and provides situational awareness on the status of real-time distribution system reliability. For each contingency, the application returns optimum restoration solution based on the short-term forecast of the operating conditions covering the expected time of repair, thus providing dynamically optimal fault isolation and service restoration.	The new functionalities of the DCA are as follows: Handling of the Distributed Energy Resources, Demand Response, Electric Storage, and Electric Transportation as generation resources available for backup of the load, when needed Using the capability for intentionally created Microgrids to maximize the amount of energized loads With significant penetration of DER and microgrids, there will be a new kind of contingencies associated with a loss of a significant generation by the DER generation due to the disturbances in the bulk EPS. The DCA will need to include optimal distribution of the EMS requests for coordination of the EPS' emergency actions and the emergency actions of the composite prosumers. Thus the new DCA will include the Relay Protection and Remedial Action Schemes Re-coordination
38	Fault Location Isolation and Service Restoration (FLISR)	DMS application	Fault Location, Isolation, and Service Restoration identifies and locates the fault, isolates the faulted element from healthy sections and restores services to	The application should include the modeling and control of the operations of DER, μGs, and DR.

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			the customers connected to the healthy sections. It assesses, for the duration of repair, the situation with loads, DER, Demand response and Micro-grids.	The application issues **advice to the DSO and/or commands to switching devices in the EPS circuits, to Demand Response installations, to µGrid EMS, and to other relevant components of the Active Distribution Network.**
39	Multi-level Feeder Reconfiguration (MFR)	DMS application	MFR performs a multi-level feeder reconfiguration to meet one of the following objectives or a weighted combination of these objectives: • Optimally restore service to customers utilizing multiple alternative sources. The application meets this objective by operating as part of FLISR • Optimally unload an overloaded segment • Minimize losses • Minimize exposure to faults • Equalize voltages. • Swap loads to reduce LMPs and assist in congestion management	The application should include the modeling and control of the operations of DER, µGs, and DR. The application issues **advice to the DSO and/or commands to switching devices in the EPS circuits, to Demand Response installations, to µGrid EMS, and to other relevant components of the Active Distribution Network**
40	Integrated Voltage, Var, and Watt Optimization (IVVWO)	DMS application	IVVWO is a multi-objective DMS application. It runs periodically and by event, as well as in the study mode for given conditions. It optimizes states of voltage and var controlling devices of the EPS and takes into account the states of the DER, µG, and DR. IVVWO communicates with DOMA, Demand Response/Load Management System, field IEDs and adjusts voltages and vars during and after the operations of FLISR.	It should **model the behavior of the autonomously controlled DER systems and composite prosumers, as well as DR means in the course of volt/var optimization**. It should also optimize **the modes of operations and settings of the centrally controlled DER and composite prosumer systems, as well as the DR associated with IVVWO**.

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				It should communicate with the composite prosumer EMS/Controllers either directly, or through the corresponding data management systems and model processors.
42	Pre-arming of Remedial Action Schemes (RAS)	DMS Application	The applications will receive **pre-arming signals** from the EMS Contingency/Security analyses through the TBLM and DMS scheduler and will change **the setups of distribution-side remedial action schemes.**	The EMS Contingency/Security Analyses applications will take into account the **protection (ride-through) and RAS settings of the DERs and µGs, as well as the generation-load balances of microgrids and other composite prosumers. The existing contractual agreements between the EPS and prosumers of different categories should be respected**. The relevant information on the RAS of the composite prosumers will reside in their EMSes, which will be interfaced with the DMS. The input information for the EMS applications will be aggregated by the DMS and will reside in the TBLM. This application can be a part of the Distribution Contingency Analysis.
43	Coordination of emergency actions (CEA)	DMS application	CEA will receive critical statuses, measurements, and requests for preventive and corrective actions needed for the coordinated self-healing management of bulk power system contingencies. CEA will coordinate the	The application should include the modeling and control of the operations of DER, µGs, DR, and relevant DMS applications under

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			objectives, modes of operation, and constraints of other advanced DMS applications in concert with the RAS in distribution. For instance, the function can change the mode of operation of the IVVWO from normal to emergency, change its settings, or trigger the use of dispatchable real and/or reactive load, etc.	the emergency conditions. **The models should include the aggregated at the microgrid PCCs load-to-voltage/frequency dependences, the generation-to-voltage/frequency dependences, and the overlaps of different load management means. The models should be adapted to other external conditions, like weather and prices,** at the corresponding time The **existing contractual agreements between the EPS and prosumers of different categories should be respected**.
44	Coordination of restorative actions (CRA)	DMS application	CRA coordinates the restoration of services and normal operations based on the availabilities in distribution, transmission, and generation domains after the emergency conditions are fully or partially eliminated. The availabilities of restoration in transmission and generation domains are submitted to the DMS by the transmission/generation EMS.	The application determines the sequence of restoration based on the **available control of the DER, µG, DR, and IVVWO within the transmission, generation, and distribution constraints and in accordance with the contractual agreements between the EPS and other parties involved**.
45	DMS application: TBLM developer	DMS Application	The application provides the aggregated transmission bus model, including: **Load components; VPP technical and economic functions and attributes, including prices; Aggregated capability curves; Aggregated real and reactive load-to-voltage dependencies; Aggregated real and reactive load-to-frequency dependencies; Aggregated real and reactive load dependencies on**	The application aggregates the attributes of the models of the DER. µGrid, and other composite prosumers in the normal and emergency ranges taking into account the specifics of different DER categories

#	Actor	Actor Type	Actor Description	Further information specific to this use case. New functionalities
			Demand response control signals, Dynamic prices, Weather, etc.; Aggregated dispatchable load; Model forecast; Overlaps of different load management functions; Degree of uncertainty. It derives the aggregated current states and the dependences of the model attributes on the impacting factors retrieved from the real-time measurements and from the DMS applications in near-real time and study modes.	

Note: The bold letters emphasize the probable gaps in object/data models to be represented in the interoperability standards. The importance of these models may be different for different states of the Active Distribution Network and for different applications.

3.2 Information exchange

The list of interfaces presented in **Error! Reference source not found.** is consistent with the activity diagram presented in **Error! Reference source not found.** through **Error! Reference source not found.**.

Table 3-2. . List of logical interfaces for information support of the transmission and distribution operations

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
1	External Systems	DMS Scheduler	Environmental data by locations; Other information affecting the behavior of the customer loads.	Medium to Large	Periodically and by significant changes.	
2	Transmission SCADA/EMS	DMS Scheduler	Analog and statuses from the transmission domain;	Medium	Periodically and by significant changes.	
3	DMS Scheduler	DSCADA	Control commands from ADA applications executable by DSCADA	Small to Medium	Minimum exchange times	
3	DSCADA	DMS Scheduler	Near real-time analog and	Medium to	Minimum	According to

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			status information from the observable portions of the distribution power system Protection and Remedial Action Schemes data	Large	exchange times	efficient utilization
4	Customer EMS	Distribution SCADA	Monitoring data	Small to Medium	Near real-time	
4	Distribution SCADA	Customer EMS	Control commands and requests	Small	Near real-time	
5	External Systems	Aggregator	Weather and Market data	Small	As needed due to significant changes	
6	DER controller	Distribution SCADA	Monitoring data	Small to Medium	Near real-time	
6	Distribution SCADA	DER controller	Control commands and requests	Small	Near real-time	
7	External Systems	Microgrid EMS	Weather and Market data	Small	As needed due to significant changes	
8	Distribution SCADA	Microgrid EMS	Control commands and requests	Small	Near real-time	
8	Microgrid EMS	Distribution SCADA	Monitoring data	Small to Medium	Near real-time	
9	Aggregator	Microgrid EMS	Suggested operation arrangements	Small	By schedules	
9	Microgrid EMS	Aggregator	Accepted and executed operation arrangements	Small to Medium	Up to near real-time	
10	Microgrid Data Management System	Microgrid EMS	Real-time prices Demand response triggers and amount Disconnection command for intentional islanding Desired kW and kvar setpoints Desired voltage setpoints Data requests	Small to average	Immediately after change	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
10	Microgrid EMS	Microgrid Data Management System	Aggregated for Microgrid net load and generation of kW and kvar Net, load and generation kWh Net, load and generation load profiles Interval average voltages from selected Smart Meters Weather data. Demand response triggers received with timestamps; Commands issued for Demand Response (customers' Smart Meters, thermostat, appliances, DER, Storage) Protection settings and settings for frequency and voltage control for connected and for autonomous modes of operations, Operational limits O&M cost functions Other data needed for current and predictive model of Microgrid operations, e.g., electric storage parameters, load-shedding RAS parameters.	Small to average	Once a day	Revenue accuracy for kW and kvar; 0.5%-0.2% accuracy for Voltages
10	Microgrid EMS	Microgrid Data Management System	Lowest instantaneous voltages from included Smart Meters Instantaneous frequency Last Gasp/AC Out from selected Smart Meters Changes in relay protection and RAS settings, volt/var control modes and settings,	Small to average	Last gasp - immediately from selected first-reporters; Instantaneous voltages within minutes after fault;	0.5%-0.2% for Volt; 0.1% for Hz

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			ride-trough settings, and electric storage parameters.		Instantaneous frequency – report by exception in autonomous mode of operations. Changes - immediately	
11	DMS Scheduler	Microgrid Data Management System	Provides with real-time changes in analogs statuses and external data, defines events	Small	As needed due to significant changes	
12	Field Crew	GIS	States and parameters of the corresponding equipment observed in the field according to pre-defined instructions (template)	Small	During the presence at the subject in the field	Verified information
13	Engineering	GIS	Updates of GIS data	Small	As needed	
14	DMS Applications	DMS Scheduler	Provides solution of DMS applications to DMS Scheduler and other Management Systems.	Small	After DMS applications run and determine a need in control (periodically and by event)	Verified information
14	DMS Scheduler	DMS Applications	Provides scheduling (real-time sequence) for the DMS applications, defines events	Small	As needed	
15	DER Model processor	Load management system	Updates the information on load management means	Small	Provides with updates of DER models	
16	AMI Data Management System	Smart Meter/AMI	Real-time prices Demand response triggers and amount	Small to average	Immediately after change	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			Data requests			
16	Bellwether Smart Meter/AMI	AMI Data Management System	Instantaneous kW and kvar Weather data Instantaneous voltages Instantaneous frequency from dedicated meters in autonomous mode of Microgrid Last Gasp/AC Out	Small to average	Last gasp - immediately from selected first-reporters; Instantaneous voltages within minutes after fault; Instantaneous frequency from dedicated meters – report by exception	0.5%-0.2% for Volt; 0.1% for Hz
16	Smart Meter/AMI	AMI Data Management System (including Last Gasp service)	kW and kvar kWh Load profiles Interval average voltages Weather data Demand response triggers received with timestamps; Commands issued for Demand Response (thermostat, appliances, DER, Storage).	Large	Once a day	Revenue accuracy for kW and kvar; 0.5%-0.2% accuracy for Voltages
17	DMS Scheduler	DER model processor	Provides analogs and external data relevant to DER operation modeling, e.g., weather parameters, prices, DR requests, etc.	Average	Periodically and by events	Verified data
18	AMI Data Management System (including Last Gasp service)	Customer EMS	Real-time prices Demand response triggers and amount (Demand response can be executed via load reduction, or DER/ES generation	Small to average	Immediately after change	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			increase, or both) Data requests			
18	Customer EMS	AMI Data Management System	Aggregated from Smart Meters: kW and kvar kWh Load profiles Interval average voltages Weather data. Demand response triggers received with timestamps; Commands issued for Demand Response (customers' Smart Meters, thermostat, appliances, DER, Storage). Protection and Remedial Action Schemes data	Small to average	Once a day	Revenue accuracy for kW and kvar; 0.5%-0.2% accuracy for Voltages
18	Customer EMS	AMI Data Management System (including Last Gasp service)	Lowest instantaneous voltages from included Smart Meters Instantaneous frequency Last Gasp/AC Out from selected Smart Meters	Small to average	Last gasp - immediately from selected first-reporters; Instantaneous voltages within minutes after fault; Instantaneous frequency – report by exception	0.5%-0.2% for Volt; 0.1% for Hz
19	AMI Data Management System	DER Data Management System	Provides the DER Data Management System with relevant data on customer owned/embedded DER	Average to large	Once a day and by defined events	
20	DER Controller	DER Data Management	Generation kW and kvar	Small to average	Once a day	Revenue

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
		System	Generation kWh Generation profiles Interval average voltages Weather data. Generation change triggers received with timestamps; Active protection settings and mode of operations and settings for volt/var control in the connected mode of operations and voltage and frequency control settings for island mode of operations, settings for ride-through operations Capability curve Electric storage parameters Synchronization settings O&M cost functions			accuracy for kW and kvar; 0.5%-0.2% accuracy for Voltages
20	DER Controller	DER Data Management System	Lowest instantaneous voltages before disconnection Instantaneous frequency in island mode Last Gasp/AC Out or protection actions Changes in relay protection settings, volt/var control modes and settings, ride-trough settings, electric storage parameters	Small	Immediately after change	0.5%-0.2% for Volt; 0.1% for Hz
20	DER Data Management System	DER Controller	Real-time prices Desired kW and kvar setpoints (reference points) Desired volt/var mode of	Small	Immediately after change	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			operation and setpoints Desired ride-through settings Data requests Synchronization commands			
21	AMI Data Management System	Microgrid Model Processor	Provides with microgrid/nanogrid related data	Small to medium	As needed due to significant changes	Statistics
22	GIS	Topology processor	Provides with updated and validated nominal connectivity and facility parameters	Small to average, if incrementally; Large, if globally	One a day, and by significant events	Verified data
23	DMS Scheduler	Topology processor	Provides with real-time changes in topology	Small	Immediately after change	Verified data
24	DMS Scheduler	Distribution Situational Awareness (DOMA)	DSCADA/SCADA/EMS analog and status snapshots;	Medium to Large	1-2 seconds updates	Verified data
25	DMS Scheduler	Load model processor	Provides with real-time changes in analogs and external data related to adaptive load modeling, e.g., weather and prices	Small to Medium	Periodically every 5-15 minutes and by defined events	
26	AMI Data Management System	Distribution Situational Awareness (DOMA)	Provides with near-real time data from selected meters and changes of external conditions	Small	By event. This information is based on the input from bellwether meters monitoring local weather and sunshine conditions	Verified data
27	AMI Data	Load Model Processor	Load impacting factors with	Large	Once a day	Verified

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
	Management System		time stamps, e.g., local weather data, Demand Response requests with start and stop times, other related events with timestamps			historic data
28	AMI Data Management System	Secondary Equivalent processor	Daily kW and kvar load profiles from individual Smart meters and aggregated at the distribution transformer load profiles Daily profiles of interval-average voltages	Large	Once a day	
29	DMS Scheduler	Microgrid Model processor	Provides with real-time changes in external data related to adaptive microgrid modeling, e.g., weather and prices	Small	As needed due to significant changes	
30	DER Data Management System	Distribution Situational Awareness (DOMA)	Provides with near-real time changes of external conditions for DER operations.	Average	By event. This information is based on the input from selected DER monitoring local weather and sunshine conditions	
31	DMS applications	DER Data Management System	Provides solution of DMS applications for execution	Small	After DMS applications run and determine a need in control	Verified information
32	DMS applications	Microgrid Data Management System	Provides solution of DMS applications for execution	Small	After DMS applications run and determine a	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
					need in control	
33	AMI Data Management System	DER Model processor	Provides with time-stamped historic loads aggregated at DT bus, voltages at customer terminals, temperatures, etc.	Medium	As needed due to significant changes	Statistics
34	DER Data Management System	DER model processor	Provides with updates on DER parameters relevant for DER modeling	Small to average	Once a day and by events	Verified data
35	Microgrid Data Management System	Microgrid Model Processor	Provides with updates on microgrid parameters relevant for microgrid modeling	Small to average	Once a day and by events	Verified data
36	Topology processor	Distribution Situational Awareness (DOMA)	Provides with topology updates	Small	By event	Verified data
37	Load model Processor	Distribution Situational Awareness (DOMA)	Provides with adaptive load models	Average	Once a day	
38	Distribution Situational Awareness (DOMA)	Secondary Equivalent processor	Provides modeled voltages at the secondary buses of distribution transformers	Large	On request by Secondary Equivalent processor (once a month or less frequent)	
38	Secondary Equivalent processor	Distribution Situational Awareness (DOMA)	Provides with dependencies of voltage drops and losses in secondaries on nodal loads	Large		
39	Topology processor	Outage Management System	Provides with topology update	Small	By event	Verified data
40	AMI Data Management System	Customer Information System	Provides customer load and consumption data	Large	Daily	
41	DER model processor	Distribution Situational Awareness (DOMA)	Provides with updates of DER models	Average	After significant change	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
42	Microgrid model processor	Distribution Situational Awareness (DOMA)	Provides with updates of microgrid models	Average	After significant change	
43	AMI Data Management System	Outage Management System	Provides near-real time data from selected meters, including outage detections	Small	By event	
44	Customer Information System	Load Model Processor	Load and consumption data aggregated at Distribution Transformer buses	Medium	Daily	
45	TBLM	DMS Advanced Applications	TBLM provides relevant attributes of transmission operation model and commands/requests for distribution operations.			
46	Transmission System Operator	TBLM	TBLM Informs about aggregated control variables and constraints for EMS applications; TSO changes conditions or submits its own requests for DMS support	Small	Periodically and by event	
47	Distribution Situational Awareness (DOMA in study mode)	TBLM Developer	Provides with the current and alternative reference operation models	Large	Every run of State Estimation, e.g., every 5-10 min and by events	Verified information
47	TBLM Developer	Distribution Situational Awareness (DOMA in study mode)	Requests alternative model	Small	By event	
48	Distribution Situational Awareness (DOMA in study mode)	Distribution Contingency Analysis in study mode	Provides the alternative operational model.	Medium	By events, for multiple scenarios	Verified information
49	Distribution Situational Awareness (DOMA in study mode)	Integrated Volt/var/Watt Optimization in study mode	Provides the alternative operational model.	Medium	When there is a change in the requirements	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
50	Distribution Contingency Analysis in study mode	TBLM Developer	Provides solutions under requested conditions	Small to medium	By event	
50	TBLM Developer	Distribution Contingency Analysis in study mode	Request analysis under given conditions	Small	By event	
51	Distribution Situational Awareness (DOMA)	Advanced DMS applications	Provides with the current reference operation model components	Large	Every run of State Estimation and IVVWO, e.g., every 5-10 min and by events	Verified information
52	Distribution Situational Awareness (DOMA)	Distribution System Operator	DOMA updates DSO about situational awareness	Small	Periodically and by event	
52	Distribution System Operator	Distribution Situational Awareness (DOMA)	Transmits the DSO & TSO (EMS) requests;	Small	By event	
53	Integrated Volt/var/Watt Optimization (IVVWO) in study mode	TBLM Developer	Provides solutions under requested conditions	Small to medium	By event	
53	TBLM Developer	IVVWO in study mode	Request solution under given conditions for a series of runs for different operating conditions, e.g., within and beyond the LTC capabilities to adjust distribution bus voltage according to current setting; for load reduction objective,	Small	By event	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			etc.			
54	TBLM Developer	Transmission Bus Load Model	Based on multiple "what-if" power flows, IVVWO and Contingency Analysis studies deviating from the reference model within given ranges and provides current aggregated load model with the dependencies on bus voltage, system frequency, pricing, etc.; aggregated generation capability curves adjusted to the subject operating conditions; interrelationships between loads of different RAS; dynamic operational limits at the TnD buses, etc.	Large	Every update of the State Estimation, e.g., every 5-10 min and by events, for multiple scenarios	Verified information
54	Transmission Bus Load Model	TBLM Developer	Delivers results of steady-state and Dynamic EMS Contingency Analyses	Small	Every run of the EMS CA	
55	Load Management System	DER Data Management System	Triggers of Demand Response for dispatchable DERs (ES)			
55	DER Data Management System	Load Management System	Customer choices, contractual conditions, and DER/ES attributes, available Demand Response			
56	Distribution System Operator	Advanced DMS applications	Transmits Operator’s requests, changes to EMS requests, etc.	Mall	As needed for a portion of EMS requests,	Verified information
57	Distribution System	Transmission Bus Load	Authorizes and/or changes the	Small	By event	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
	Operator	Model `	components in the TBLM			
57	Transmission Bus Load Model	Distribution System Operator	Informs the operator about the changes in TBLM	Small	As needed based on pre-defined criteria	
58	Critical Customers	Distribution System Operator	State and preparedness of the customer for emergencies	Small	By event	
58	Distribution System Operator	Critical Customers	Warning about emergencies	Small	By event	
59	Distribution System Operator	Emergency Responders	Information exchange in emergencies	Small	By event	
59	Emergency Responders	Distribution System Operator	Information exchange in emergencies	Small	By event	
60	Distribution System Operator	Mobile Generator Controllers	Information exchange in emergencies	Small	By event	
60	Mobile Generator Controllers	Distribution System Operator	Information exchange in emergencies	Small	By event	
61	Distribution System Operator	Gas, Communications, Internet Provider companies	Information exchange in emergencies	Small	By event	
61	Gas, Communications, Internet Provider companies	Distribution System Operator	Information exchange in emergencies	Small	By event	
62	Distribution System Operator	Secure portals with officials	Information exchange in emergencies	Small	By event	
62	Secure portals with officials	Distribution System Operator	Information exchange in emergencies	Small	By event	
63	Emergency Responders	Transmission System Operator	Information exchange in emergencies	Small	By event	
63	Transmission System Operator	Emergency Responders	Information exchange in emergencies	Small	By event	
64	Mobile Generator	Transmission System	Information exchange in	Small	By event	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
	Controllers	Operator	emergencies			
64	Transmission System Operator	Mobile Generator Controllers	Information exchange in emergencies	Small	By event	
65	Gas, Communications, Internet Provider companies	Transmission System Operator	Information exchange in emergencies	Small	By event	
65	Transmission System Operator	Gas, Communications, Internet Provider companies	Information exchange in emergencies	Small	By event	
66	Secure portals with officials	Transmission System Operator	Information exchange in emergencies	Small	By event	
66	Transmission System Operator	Secure portals with officials	Information exchange in emergencies	Small	By event	
67	Transmission & Generation EMS	Transmission Bus Load Model	Provides commands and requests to TBLM	Small	As the requirements change, may be up to several times a day	Verified information
67	Transmission Bus Load Model	Transmission & Generation EMS	Provides aggregated control variables and constraints for EMS	Small	After every update of TBLM	Verified information
68	Transmission & Generation EMS	Transmission System Operator	Informs about aggregated control variables and constraints for EMS applications	Small	After every update of TBLM	Verified information
68	Transmission System Operator	Transmission & Generation EMS	Changes conditions or submits its own requests for DMS support	Small	In special cases. Typically, the operator is not in the loop of automated control	
69	EMS Steady-state and dynamic	Transmission & Generation EMS	Submits control commands/ requests for preventive and	Small	When preventive and corrective	Verified information

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
	Contingency Analyses		corrective (pre-arming) measures		measures in distribution are needed	
69	Transmission & Generation EMS	EMS Steady-state and dynamic Contingency Analyses	Provides aggregated control variables and constraints for EMS applications	Small	After every update of TBLM	Verified information
70	Optimal Power flow/ Security Constraint Dispatch	Transmission & Generation EMS	Submits requests for Volt/var support; congestion management; load reduction	Small	When Volt/var support; congestion management in distribution are needed	Verified information
70	Transmission & Generation EMS	Optimal Power flow/ Security Constraint Dispatch	Provides aggregated control variables and constraints for EMS applications	Small	After every update of TBLM	Verified information
71	Economic Dispatch/ Unit commitment (or equivalent)	Transmission & Generation EMS	Submits requests for Demand Response; DER start; ES discharge, etc.	Small	When Demand Response; DER start; ES discharge in distribution are needed	Verified information
71	Transmission & Generation EMS	Economic Dispatch/ Unit commitment (or equivalent)	Provides aggregated control variables and constraints for EMS applications	Small	After every update of TBLM	Verified information
72	EMS Steady-state and dynamic Contingency Analyses	Transmission System Operator	Informs about recommended control commands/requests for preventive and corrective (pre-arming) measures	Small	When preventive and corrective measures in distribution are	Verified information

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
					needed	
73	Optimal Power flow/ Security Constraint Dispatch	Transmission System Operator	Informs about the recommended requests for Volt/var support; congestion management; load reduction	Small	When Volt/var support; congestion management in distribution are needed	Verified information
74	Economic Dispatch/ Unit commitment (or equivalent)	Transmission System Operator	Informs about recommended requests for Demand Response; DER start; ES discharge,	Small	When Demand Response; DER start; ES discharge in distribution are needed	Verified information
75	Field crew	DSO	Crew reports to DSO local conditions relevant to preparation for the disaster and to the service restoration. DSO provides information and issues commands	Small	By event	
76	DSO	DMS Advanced applications	DSO sets the applications; confirms or changes the output. Applications inform the DSO about the solutions	Small	As needed	
77	Work Management System	DSO	Updates on activities related to preparation for VLSE and to repairs, on location of crews and equipment.	Small	As needed	
78	Data feeds from external sources	DSO	Surveillance videos, Global Positioning System (GPS) tagged photos or videos, etc.	Small to medium	By events	
79	Aggregator	DSO	Data on coordination of Aggregator's operational plans with distribution system operations	Small to medium	Periodically and by events	
80	Outage Management	Advanced DMS	Data on outage and restoration	Small to medium	By events	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
	System	applications	management			
81	DMS Advanced Applications	Load Management System	Requests/Commands for Demand Response, other load management means	Small to medium	By events	
82	Load Management System	AMI Data Management System	Triggers of Demand response for selected nodes			
82	AMI Data Management System	Load Management System	Customer choices, contractual conditions, and available Demand Response			
83	Load Management System	Customer EMS	Desired amount of Demand Response in selected nodes			
83	Customer EMS	Load Management System	Customer choices, contractual conditions, and available Demand Response			
84	Load Management System	Microgrid Data Management System	Triggers of Demand Response for aggregated loads of Microgrid			
84	Microgrid Data Management System	Load Management System	Microgrid choices, contractual conditions, and available Demand Response			

3.3 Scenarios

1) Update the aggregated at the PCC var capabilities of the µGrid's DERs for the CVR objective of the µGrid
2) Update the aggregated at the PCC var capabilities of the µGrid's DERs for the super quality objective of the µGrid
3) Update the aggregated at the PCC var capabilities of the µGrid's DERs for the standard voltage objective of the µGrid

3.4 Step-by-step actions

The step-by-step actions presented in

Table 3-3 do not cover all the possible scenarios and conditions. The table is an illustration of possible exchanges of information between the µEMS and DMS.

Table 3-3. Illustrative step-by-step actions

#	Event	Primary Actor [i]	Name of Process/Activity [ii]	Description of Process/Activity [iii]	Information Producer [iv]	Information Receiver [v]	Name of Info Exchanged [vi]	Additional Notes [vii]
1	DMS provides µEMS with the expected range of voltage in the PCC for the short-term look-ahead time interval	DMS applications	Update of voltage range at PCC	DMS runs IVVO for the next short-term interval and informs the µEMs about the expected voltages at the µGrid PCC and desirable range of voltage at the PCC for further network analyses.	DMS applications, DSO	µEMS	Update of voltage range at PCC	In each cycle of the DMS applications, the applications run "what-if" studies, exploring different voltages within an expected range. In each step of these studies, the appropriate reactive power capabilities of the µGrid should be used. Therefore, the µEMs should provide with the dependencies of the capabilities for the expected range of PCC voltages that will be used by the DMS applications.
2	µEMS provides DMS with the adjusted reactive power capabilities for the provided range of PCC voltages.	µEMS	Update of µGrid reactive power capabilities	µEMS provides DMS with reactive power capabilities adjusted for the requested PCC voltage range	µEMS	DMS	Update of µGrid reactive power capabilities	

3	DSO requests greater var support	DMS	Request for the additional reactive power support from the μGrid	In case the reactive power capabilities of the μGrid are insufficient for the EPS needs, EPS may request an increase in the capabilities.	DMS, DSO	μEMS	Request for the additional reactive power support from the μGrid	
3.1	μEMS is able to increase the reactive power capabilities of the μGrid	μEMS	Information about the adjusted reactive power capabilities of the μGrid	μEMS informs DMS about adjusted μGrid reactive power capabilities and about associated consequences for the μGrid in accordance with the agreements between the μGrid and EPS	μEMS	DMS	Information about the adjusted reactive power capabilities of the μGrid	For instance, μEMS runs the CVR objective, and the reactive power of the sources of the μGrid is limited by the lower voltage levels at the service terminals. Based on the DMS request, the μEMS changes the setup of its VVO so that the reactive power sources are not limited by the low voltage limits, These changes result in some drawbacks for the μGrid, which should be dealt with in accordance with the agreements between the EPS and μGrid
3.2	μEMS is unable increase the reactive power capabilities	μEMS	Information about inability of increasing the reactive power capabilities of the μGrid	μEMS informs DMS about its inability of providing greater reactive power capabilities of the μGrid and about the reasons why	μEMS	DMS	Information about inability of increasing the reactive power capabilities of the μGrid	For instance, the capabilities are limited by the voltages at critical points within the μGrid. In this case, the EPS may change the voltage in its circuits, including the voltage at the μGrid PCC, and release a margin for the voltage change in the μGrid providing additional reactive power capabilities

4	The real power generation by the µGrid DERs significantly changed	µEMS	Information about significant change of the reactive power capabilities	µEMS informs DMS about a significant change of the reactive power capabilities due to the change of contribution of real and reactive power generation	µEMS	DMS	Information about significant change of the reactive power capabilities	For instance, a change from a sunny to a cloudy sky may significantly reduce the real power generation by PV DERs and increase the available reactive power generation.
5	DMS runs the next iteration of DMS applications and returns to i.1							

4 Version Management

Version	***Date***	***Author***	***Changes***	***Comments***
1	07/02/2014	Nokhum Markushevich	Draft 1 Narrative of Use Case	
2	09/07/2014	Nokhum Markushevich	Development of the illustrative model	
3	09/26/2014	Nokhum Markushevich	Modification of the use case based on the new model	

4	09/27/2014	Nokhum Markushevich	Added long-term dependencies scenario	
5	10/08/2014	Nokhum Markushevich	Updated the narrative based on the updated illustrative model	
6	10/10/2014	Nokhum Markushevich	Added to the narrative the comparison of scenarios	
7	10/28/2014	Nokhum Markushevich	Edited the narrative	
8	12/07/14	Geza Yoos	Commented on use cases	
9	12/08/14	Nokhum Markushevich	Replied to Geza's comments	
	01/05/15	Frances Cleveland	Commented on the list of actors	
10	01/11/15	Nokhum Markushevich	Updated the use case based on Geza's and Frances' comments	
11	03/23/15	Nokhum Markushevich	Updated to version 2	
12	07/07/15	Jim Reilly and Nokhum Markushevich	Formatting for posting	

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[i] Information receiver corresponds to a Classifier Role having a base Classifier assigned to an existing Actor, Classifier or Interface.

[ii] Name of Activity corresponds to name attribute of an Action.

[iii] Description of Activity corresponds to documentation attribute of an Action.

[iv] Information receiver corresponds to a Classifier Role having a base Classifier assigned to an existing Actor, Classifier or Interface.

[v] Information producer corresponds to a Classifier Role having a base Classifier assigned to an existing Actor, Classifier or Interface.

[vi] Name of Info Exchanged corresponds to the name attribute of a Message.