Microgrid Interactive Use Case #IA-7

Updating dependencies of the microgrid operational model on external conditions

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

Updating dependencies of the microgrid operational model on external conditions

1.2 Scope and Objectives

Scope: The Function a) performs periodic and event-driven information exchanges between the EPS operator/DMS and Microgrid operator/EMS about the aggregated at the PCC dependencies of the operational model of µGrid on external conditions; b) periodic and event-driven updating of the external conditions by the EPS operator and other parties and c) 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 with parties will be used by the Function to meet the objective of the Function. The information should cover the normal and the emergency situations.

The following external conditions are considered:

- Weather conditions
- Real-time (dynamic) pricing
- Volt/var support requests from EPS
- Very Large Scale Events

Objectives: The objectives of the function are as follows:

- Provide near-real time and short-term look ahead aggregated at the PCC dependencies of the µGrid operational model on the signals from external information sources
- This information should be submitted to the EPS management systems (e.g., DMS) for the coordination of the EPS and microgrid operations in the near-real time and in short-term look-ahead times. It is also needed for the microgrid EMS to assess the impact of the actions due to the external conditions on the µGrid power quality and economics

Rationale: The EPS operator needs to know the dependencies of the attributes of the µGrid operational model aggregated at the microgrid PCCs on the external conditions to execute its volt/var optimization, contingency analysis, service restoration, and other functions, and to support the Transmission Bus Load Model. The use case is to analyze the requirements for the exchange of the near-real-time and short-term look-ahead information aggregated at the PCC that should be delivered to the EPS operator by the microgrid EMS.

Status: The integration of advanced µGrid operations into DMS advanced applications is in its early stages. It will become critically important under the high penetration of the 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]).

Transmission EMS needs to know the dependencies under normal conditions for its Wide Area Situational Awareness and Optimal Power Flow applications. EMS also needs to know the dependencies under emergency conditions for its Contingency Analysis Applications.

The discussions above suggests that a composite model of the microgrid operations aggregated at the PCC needs to be developed and timely updated in the microgrid EMS. This model includes the following sensitive to the external conditions components (it is not an exhaustive list):

- The natural load

[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."

- The real power generation by distributed generation
- The reactive power generation/absorption by reactive power sources including distributed generation/storage
- The charging and discharging of energy storage
- The demand response
- The protection schemes setups, including Remedial Action Schemes and Ride-through functions.
- Volt/var control setups
- Load-to-voltage and load-to-frequency dependencies
- Aggregated reactive power capability curves
- Dispatchable loads
- Other operational parameters associated with the above dependencies, such as net power flow, losses, and load power factor.

There is a number of external conditions that affects the above-mentioned components of the microgrid operational model, such as weather, prices of the energy and ancillary service markets, and other very large scale events. The forecasts of these external conditions are available to the EPS and to the microgrid management systems. In order to predict the behavior of the microgrid components under the forecast conditions and to take it into account by the EPS applications, the dependencies of the components on the external conditions should be known.

The determining of some of the component dependencies is straightforward, e.g., the natural load dependency on time and ambient temperature and the clear-sky photovoltaic generation dependency on time can be presented as schedules in time domain. Other dependencies are more complicated, e.g., the dependency of the demand response capability on the ambient temperature can be different in the first day of a heat wave from the one in the third day, and it can be different due to different contractual conditions, and can be presented as arrays or tables.

The dependencies of the solar and wind distributed generation on the weather and time have a greater degree of uncertainty and may be presented in a probabilistic manner to be used by DMS and EMS applications including risk analysis.

The setup of RAS, in turn, depends on the load-generation balance within the microgrid and thus becomes dependent on the external factors and can be presented in forms of dependent tables (see Use Case # 6).

The price signals for kW may affect the load and the real power generation and consequently may affect the DER var capabilities, which, in turn, may affect the behavior of the Volt/var control in the microgrid, which, in turn, may affect the aggregated load dependencies on the PCC voltage. In this case, the non-monotonous dependencies should be presented with an additional independent price dimension.

Very Large Scale Events are major natural disasters like Superstore Sandy and wide area blackout like the 2003 blackout in the Northeastern USA [12].

The following three stages of VLSE can be suggested:

1. Warning (based on forecast of a natural disaster or on contingency analyses of major grid disturbances)
2. Happening of the VLSE
3. Aftermath of the VLSE – restoration stage

When a warning of VLSEs is issued by EPS or a third party, the operator of the µGrid may implement preventive measures and forecast the aggregated operations of the µGrid during the VLSE. The preventive measures may include the following:

- Charging and keeping charged the Electric Storage
- Changing the settings of the Ride-Through function
- Changing the mode and settings of the Volt/var controlling functions
- Changing the amount and settings of the load-shedding Remedial Action Schemes (RAS)
- Other

At this stage of the VLSE, the µGrid operator should inform about planned/expected actions of the µGrid during the VLSE, such as conditions for disconnecting from the grid, changes regarding the µGrid load, generation, and dispatchable load, availability of backup sources, etc.

The EPS should be timely informed about these changes, plans, and expectations to consider them in its preparation procedures. From the EPS side, there may be preventive measures that are of interest of the µGrid operator, and there may be requests to the µGrid for preventive measures based on the EPS needs, which should also be timely submitted to the µEMS.

During the disaster, the μEMS model should be updated based on the changing conditions. The EPS (DMS) may issue commands, requests, and instructions to the μEMS.

In the aftermath of the disaster, the μEMS should reflect the quasi-steady state of the μGrid, the conditions for restoration, the ability to assist in the black start, if needed, etc. The EPS (DMS) updates the μEMS on the conditions for restoration, such as the condition for re-synchronization, if the μGrid was disconnected, the conditions for restoration of loads, etc.

1.3.2 Summary

- The objective of the use case is to determine the requirements for information exchange between the microgrid and EPS operators (μEMS-DMS) on the dependencies of the microgrid operational model on external to the microgrid conditions for the use by EMS/DMS applications, including
  - The contents of the information
  - The timing of information exchange
  - The structure of data
- The external conditions considered in the use case include the following:
  - Weather conditions
  - Real-time (dynamic) pricing
  - Volt/var support requests from EPS (ancillary service)
  - Very Large Scale Events
- The suggested contents of the information exchange include the following data:
  - Dependencies of the μGrid natural real and reactive load on weather, dynamic prices, and EPS request for ancillary services
  - Dependencies of real and reactive load-to-voltage sensitivities on weather , dynamic prices, and EPS request for ancillary services
  - Dependencies of DER/ES real power generation on weather , dynamic prices, and EPS request for ancillary services

   - Dependencies of microgrid reactive power generation/absorption on weather , dynamic prices, and EPS request for ancillary services
   - Dependencies of the μGrid net real and reactive load on weather , dynamic prices, and EPS request for ancillary services (can be derived from the above information)
   - Dependencies of the μGrid reactive power nominal and operational capability on weather , dynamic prices, and EPS request for ancillary services
   - Dependencies of the μGrid dispatchable real and reactive power on weather , dynamic prices, and EPS request for ancillary services
   - Dependencies of the μGrid losses on weather , dynamic prices, and EPS request for ancillary services
   - Dependencies of the load power factors of on weather , dynamic prices, and EPS request for ancillary services
   - Dependencies of the setups of the RAS and Ride-through functions on the weather, dynamic prices, and EPS request for ancillary services
   - Preventive measures implemented by microgrid in response to warning about a VLSE
   - Planned/expected measures to be implemented by microgrid during the VLSE
   - Updates on changes during the disaster
   - Dynamic prices from EPS
   - Requests for ancillary services from EPS
   - Weather conditions from weather sources
   - Commands, requests, and instructions to the μEMS issued by the EPS (DMS) before and during the VLSE,
   - Updates of the microgrid restorative state after the VLSE
   - The EPS (DMS) updates the μEMS on the conditions for restoration, such as the condition for re-synchronization, if the μGrid was disconnected, the conditions for restoration of loads, etc.
- The timing of the information exchange should be consistent with significant changes of the above-listed data. Many of the underlying operatinal condition for these data change in near-real time. Therefore, the updates of the data exchanhges should be in the near-real time –frame, like on by exception basis.

- The structure of the exchanged data should support multi-dimentional, non-monotonous dependencies, command/request formats, and metrics of data uncertainty. The dependecies should cover practical ranges of the independent variables.
- The EMS/DMS applications will use these data in their "what-if" studies 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 influence of the external factors on the aggregated operational model of advanced microgrids. These illustrations are based on a specific simple model and do not cover all addressed-above issues. 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.

Weather related dependencies

The illustrations for weather related dependencies are based on the example microgrid diagram presented in Figure 1-1. In this example, DER 1 and DER 3 are distributed generators, and DER 2 is an Electric Storage.

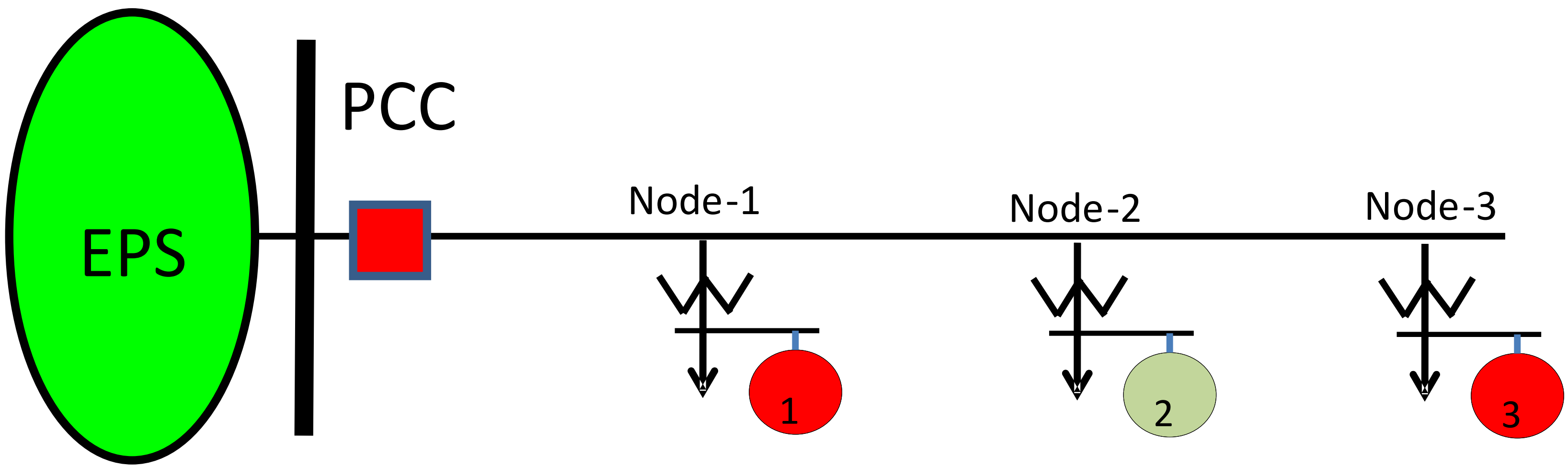

Figure 1-1. Sample diagram of microgrid

It is assumed here that the total nodal real load of the microgrid is 1under the reference external conditions. 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:

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

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

- Conservation voltage reduction (CVR), with maximum generation of reactive power. In our example, the minimum voltage setting is 0.96 p.u., and the maximum voltage setting is 0.98 p.u
- Super Power Quality (PQ) – keeping the voltages at the customer terminals close to the nominal. In our example, the minimum voltage setting is 0.99 p.u., and the maximum voltage setting is 1.01 p.u

- Standard Voltage Quality. In our example, the minimum voltage setting is 0.96 p.u., and the maximum voltage setting is 1.04 p.u

The impact of the weather conditions on the volt/var functions of the DERs for the CVR objective (with maximum var generation) is presented in **Error! Reference source not found.**Figure 1-3. The dashed lines represent the ideal volt/var function, while the solid lines represent the real function limited by the DER capabilities. 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 to the maximum 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 sunny and cloudy days, due to different DER kW injections and therefore different var capabilities. This difference in the volt/var function results in differences in load-to-voltage dependencies for these two weather conditions (see Figure 1-4 through Figure 1-7) in the real and reactive power generation by the DERs of the microgrid (see Figure 1-12 through Figure 1-13), in DER reactive power capability curves (see Figure 1-14 and Figure 1-15), in dispatchable load, and in other operational parameters (e.g., losses – see Figure 1-16).

Figure 1-2. DER volt/var function for CVR and maximum var support (Sunny Day)

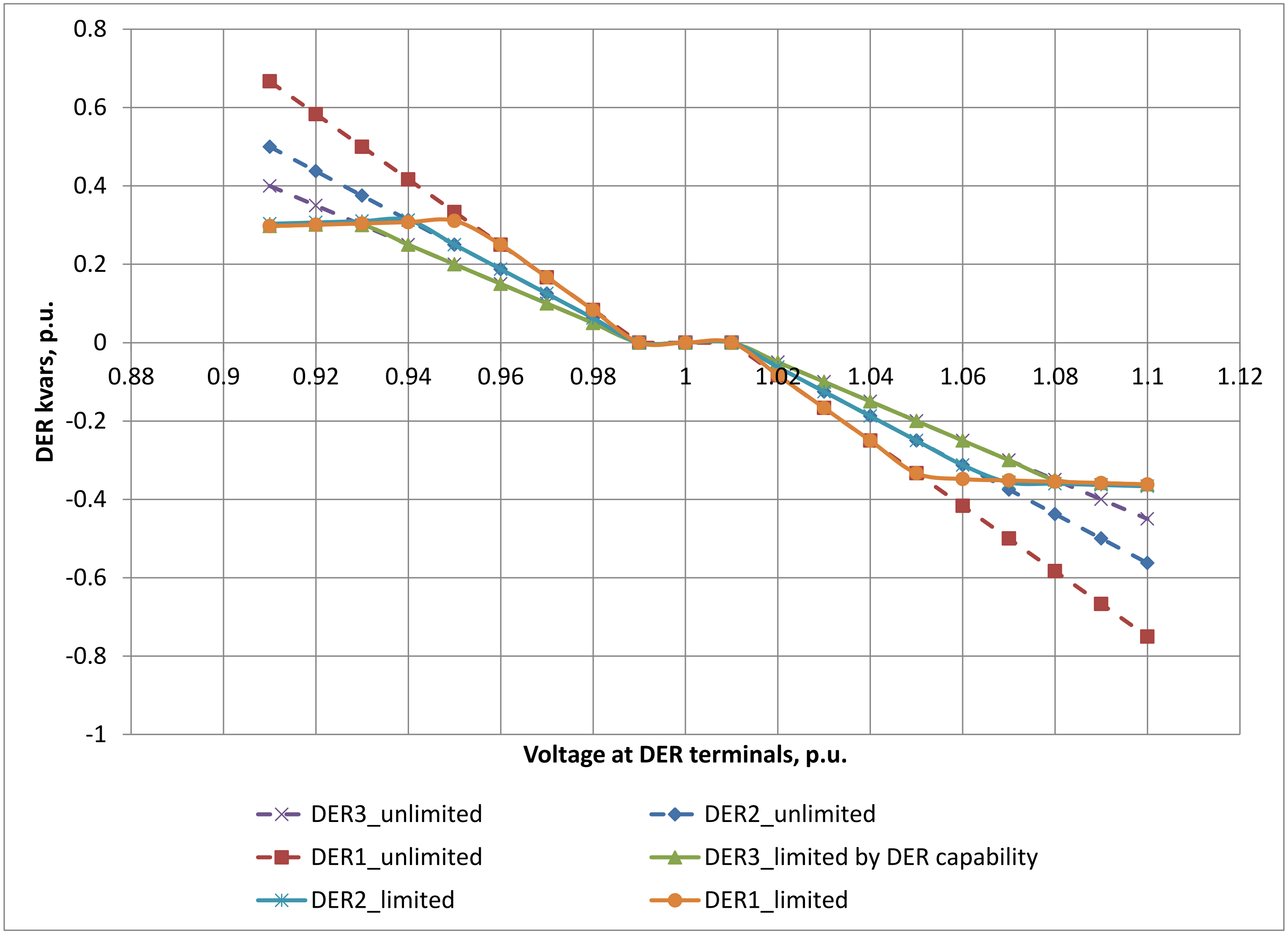

Figure 1-3. DER volt/var function for CVR and maximum var support (Cloudy Day)

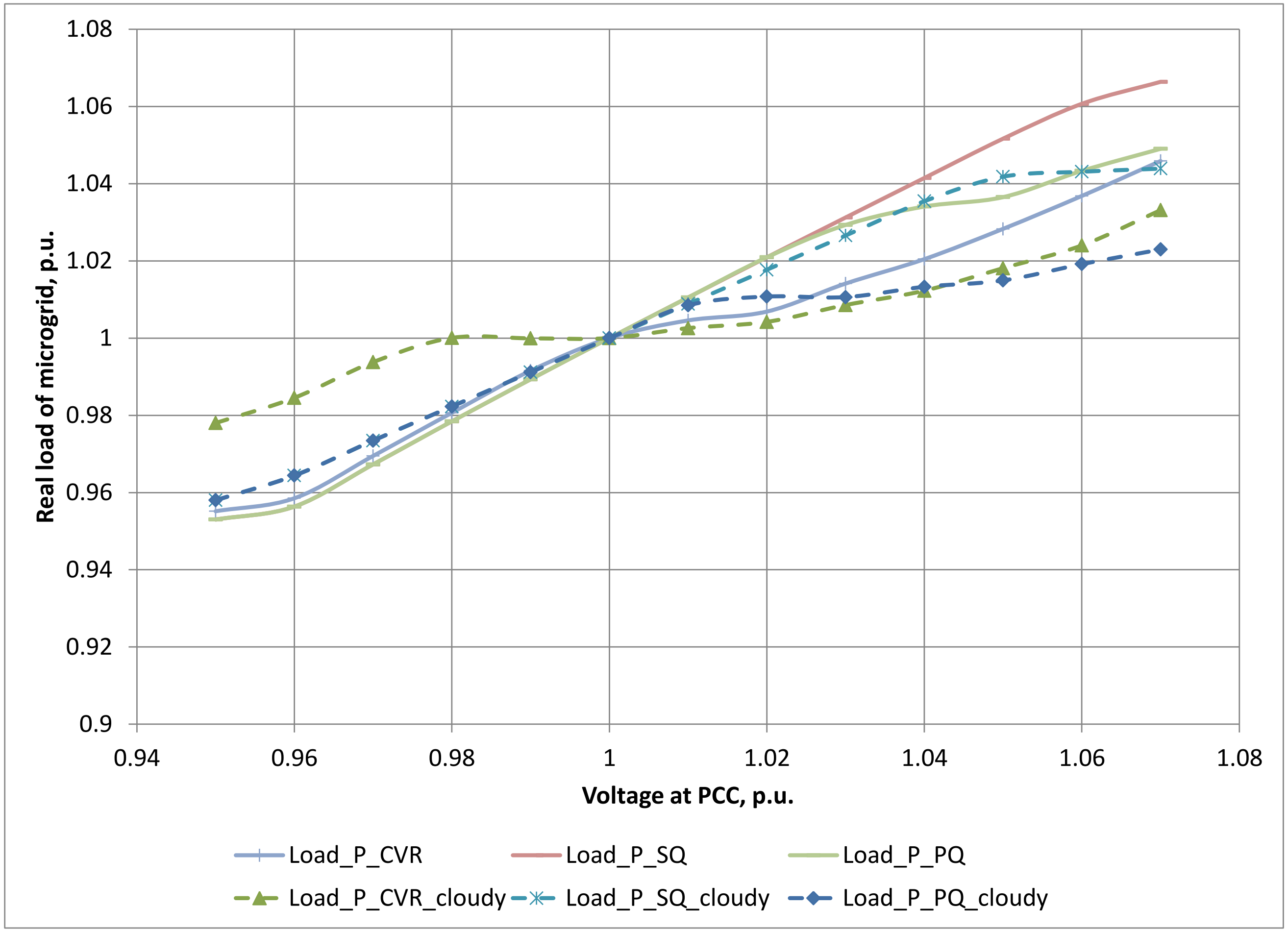

Figure 1-4. Dependencies of the μGrid real load on PCC voltage, p.u for sunny and cloudy days

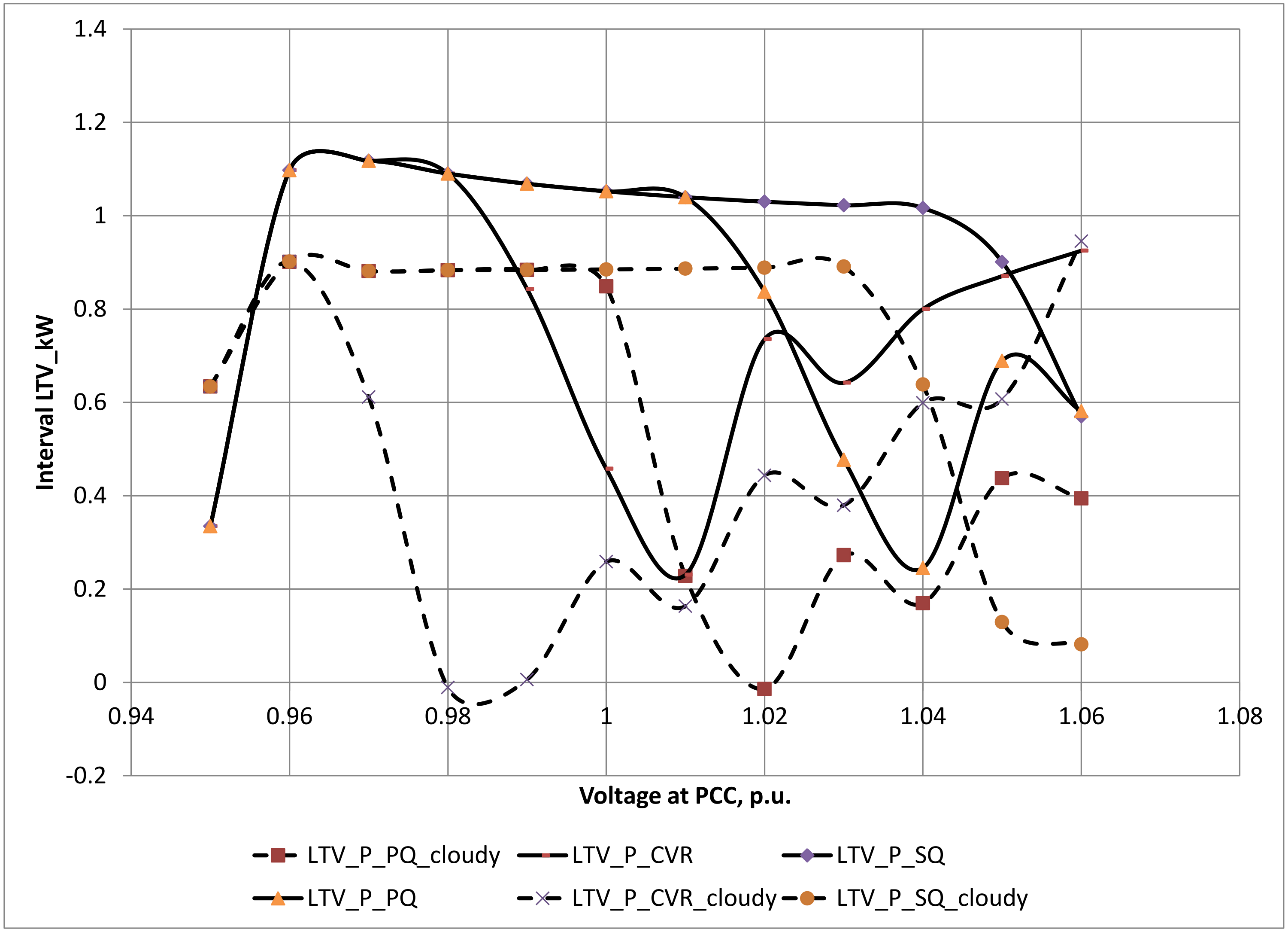

Figure 1-5. Interval real LTV-factors for different modes of DER Volt/var control and different weather conditions

Similar situation is observed for the reactive load-to-voltage dependences (See Figure 1-6 and Figure 1-7)

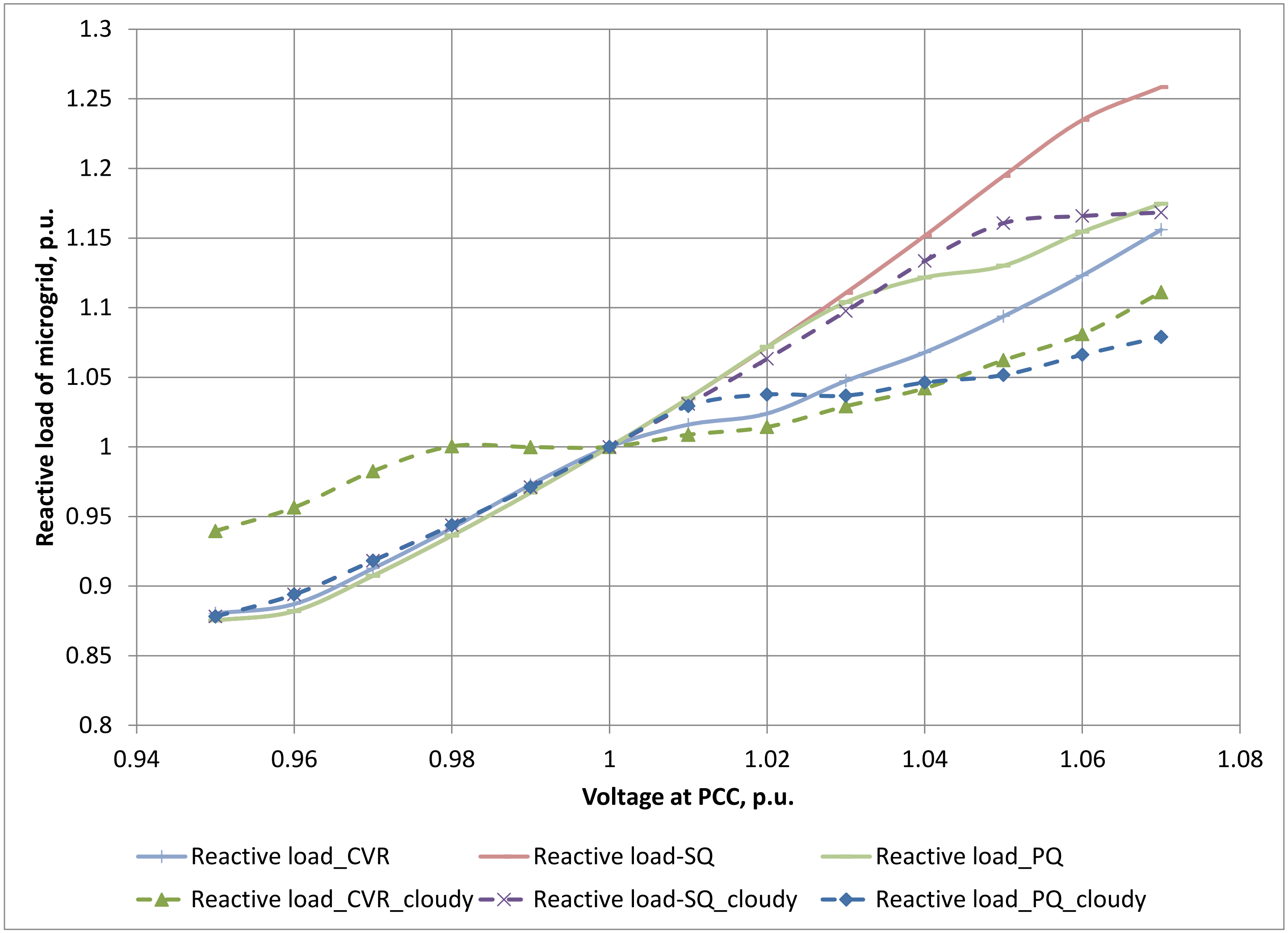

Figure 1-6. Dependencies of the µGrid reactive load on PCC voltage, p.u for different weather conditions

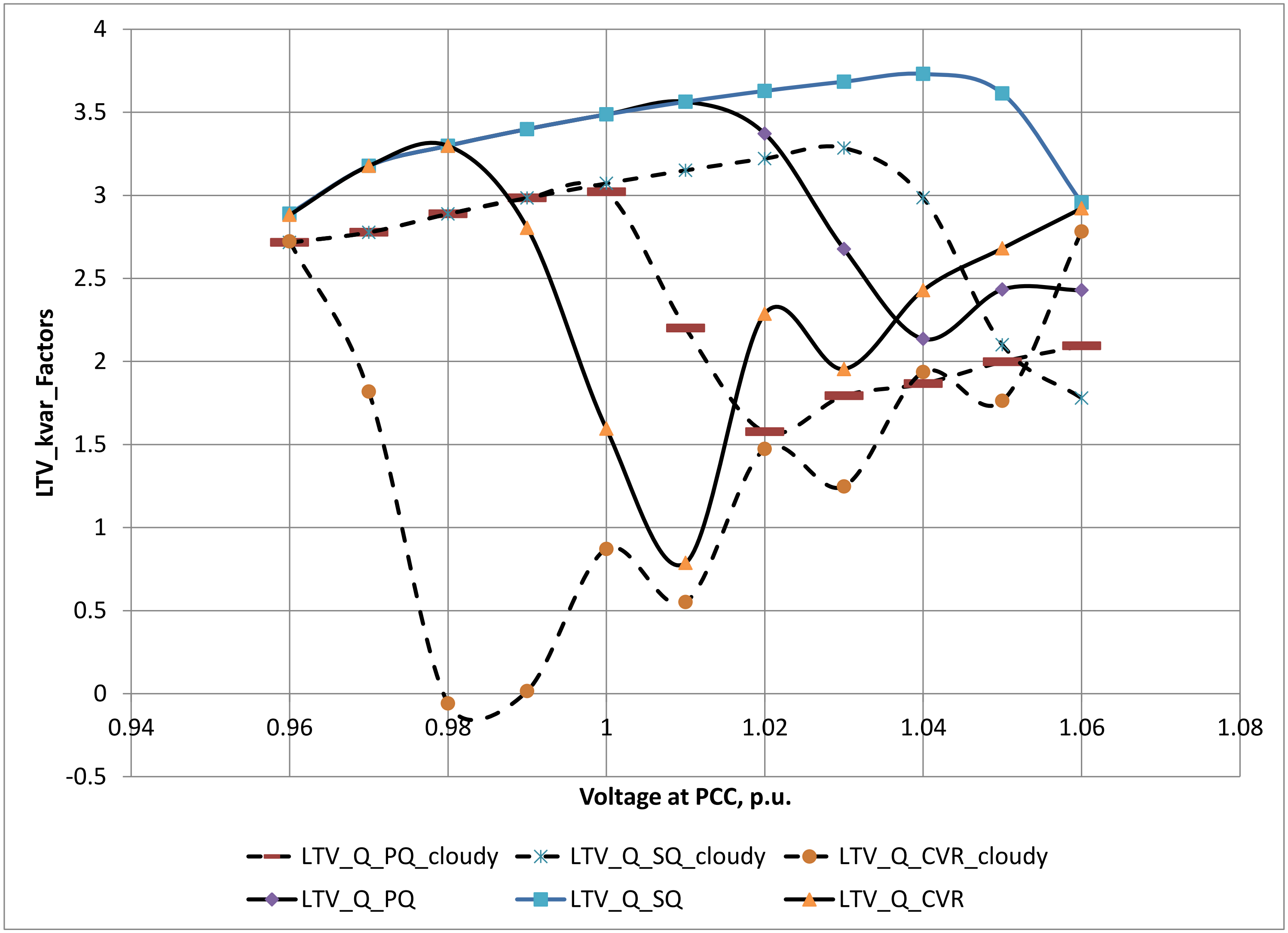

Figure 1-7. Interval reactive LTV-factors for different modes of DER Volt/var control and different weather conditions

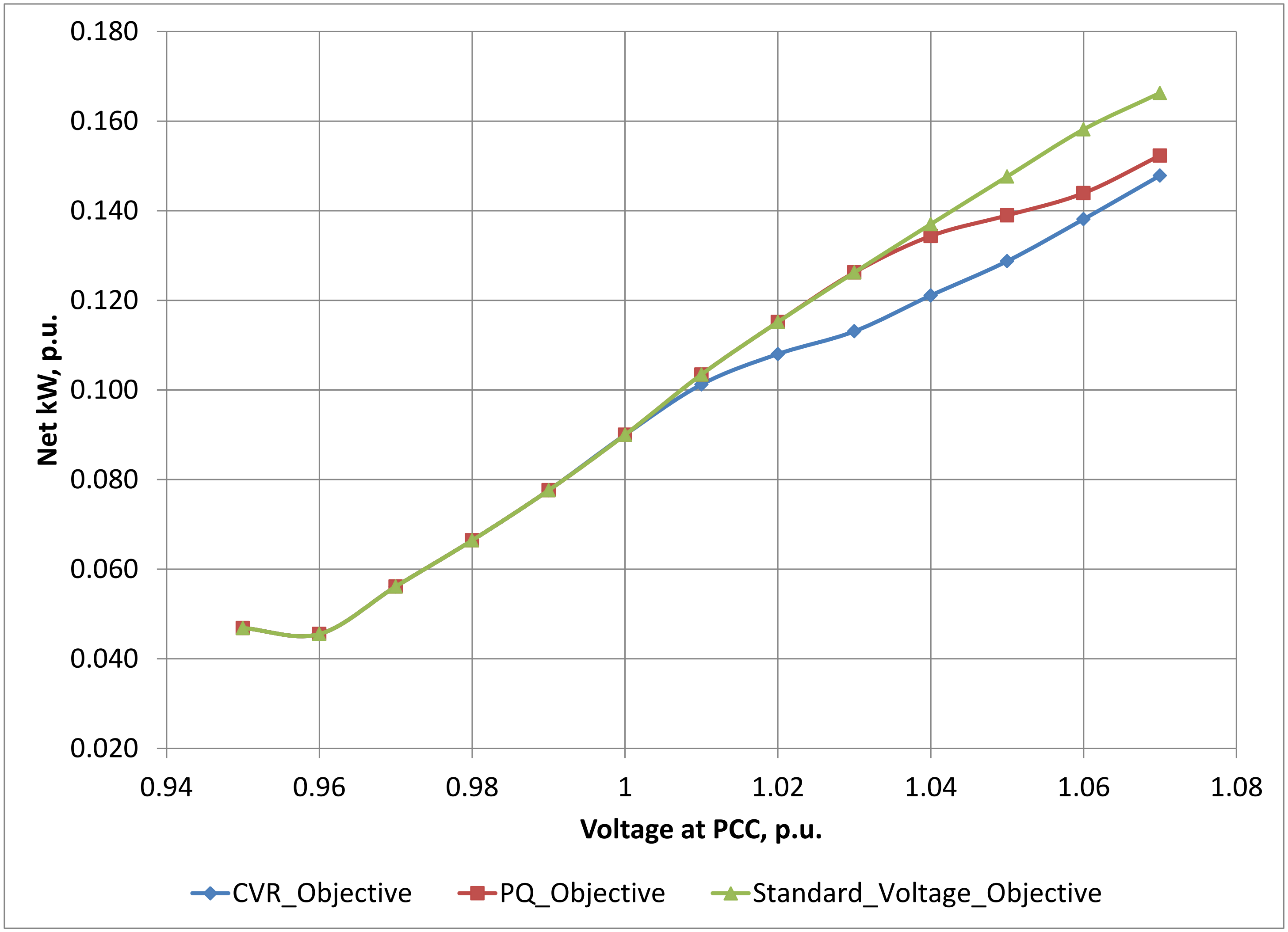

Figure 1-8. Net KW under the maximum var generation requirements. Sunny Day.

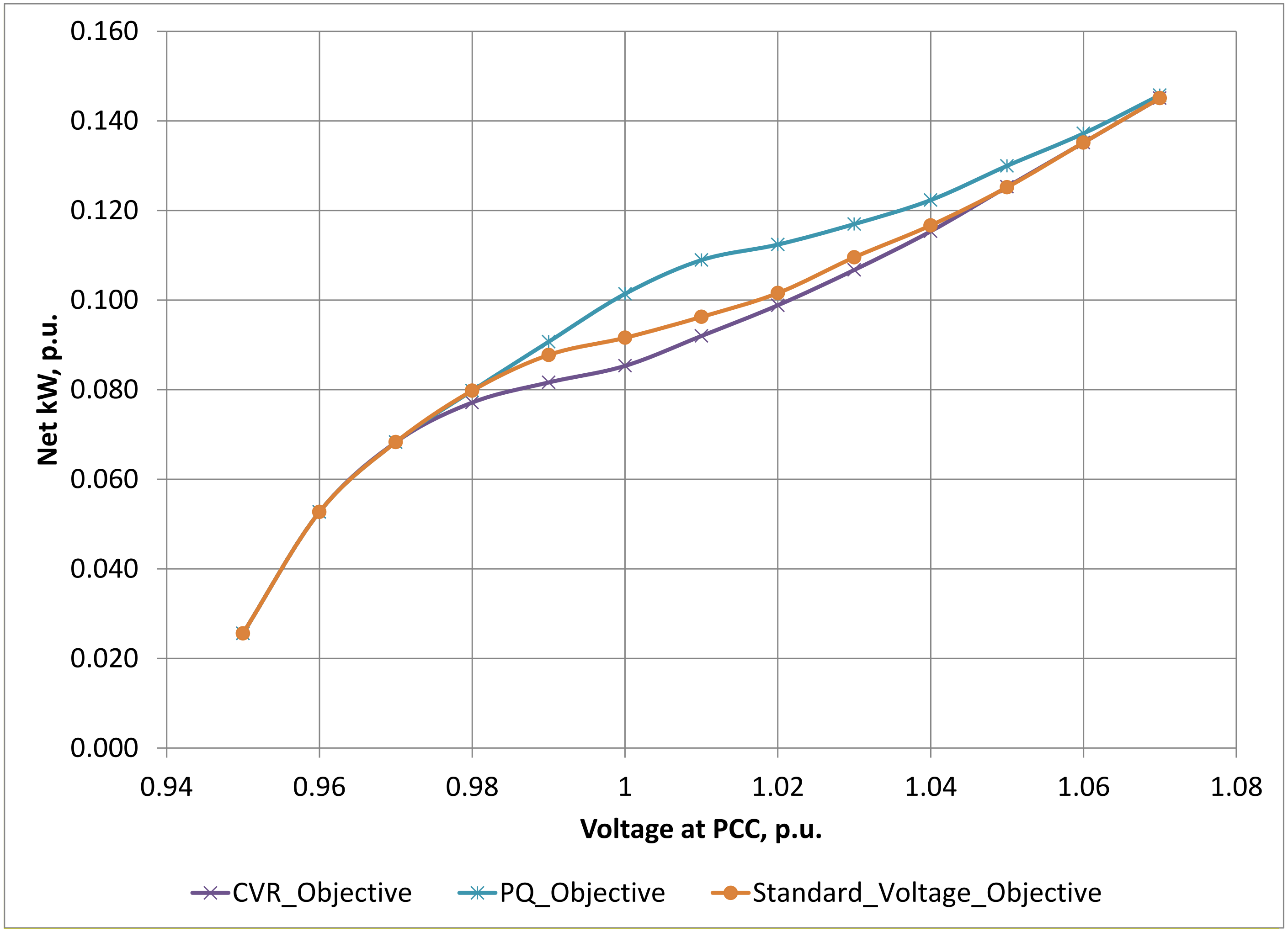

Figure 1-9. Net KW under the minimum var generation requirements. Sunny Day

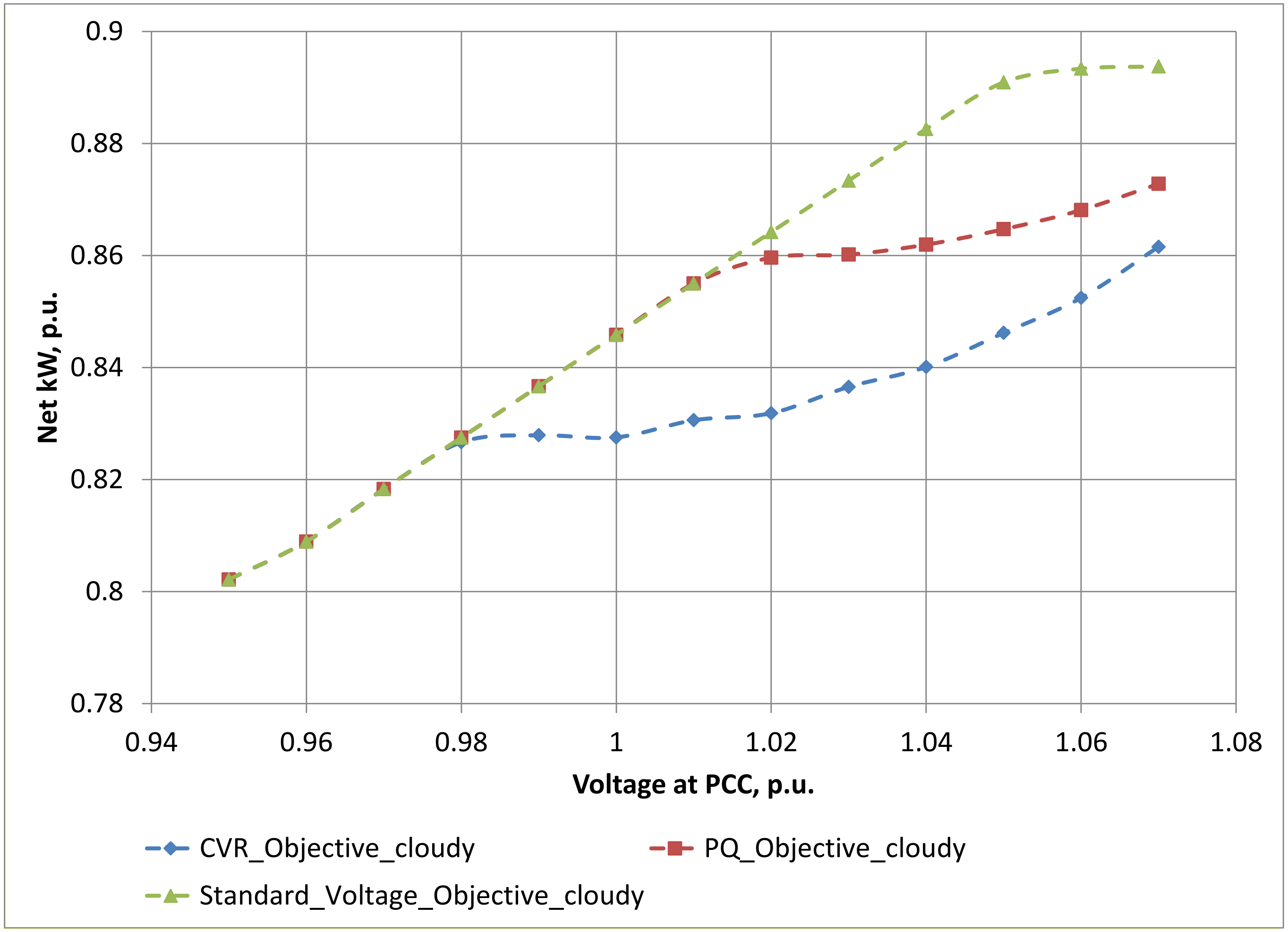

Figure 1-10. Net KW under the maximum var generation requirements. Cloudy Day.

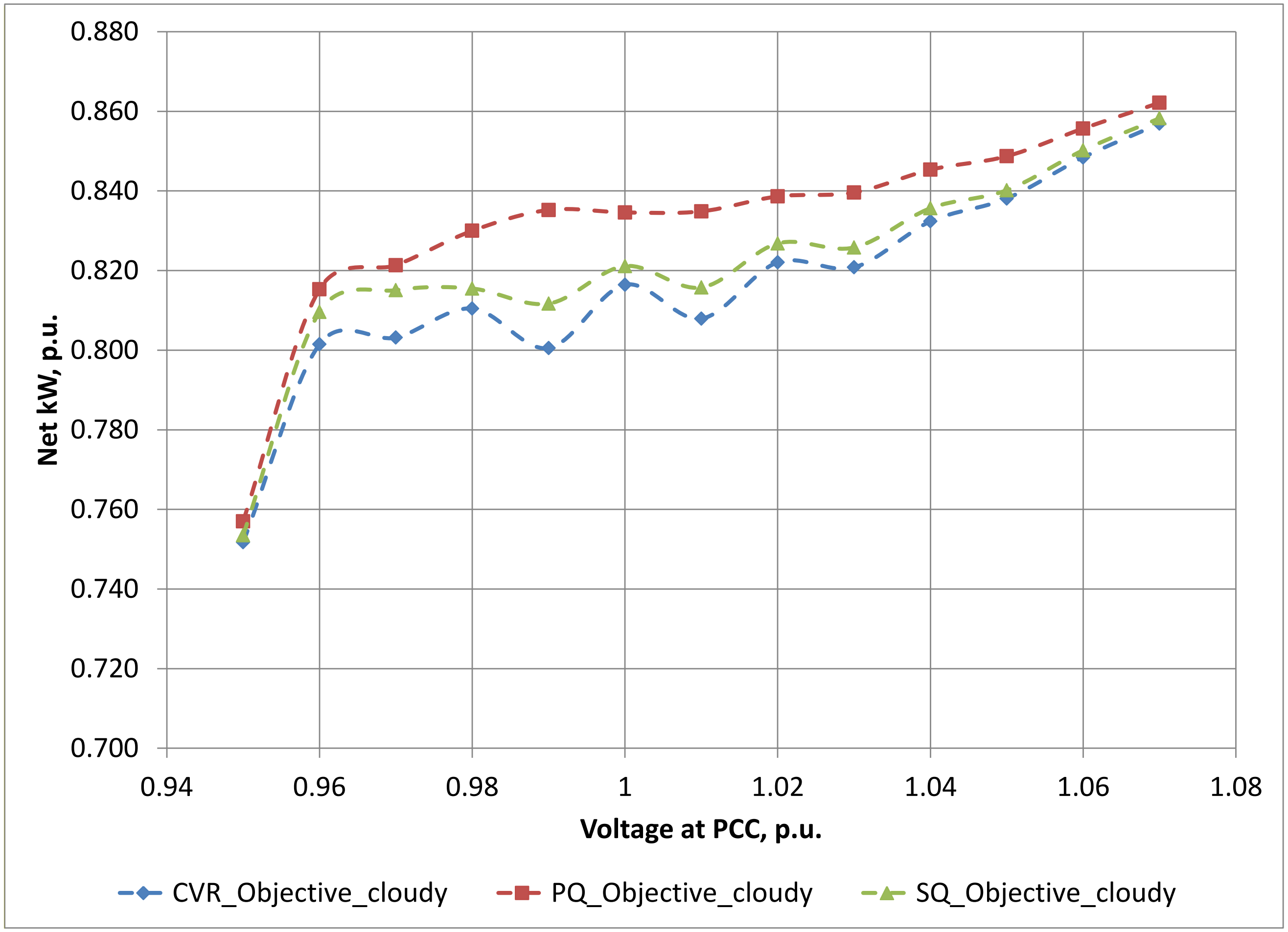

Figure 1-11. Net KW under the minimum var generation requirements. Cloudy Day

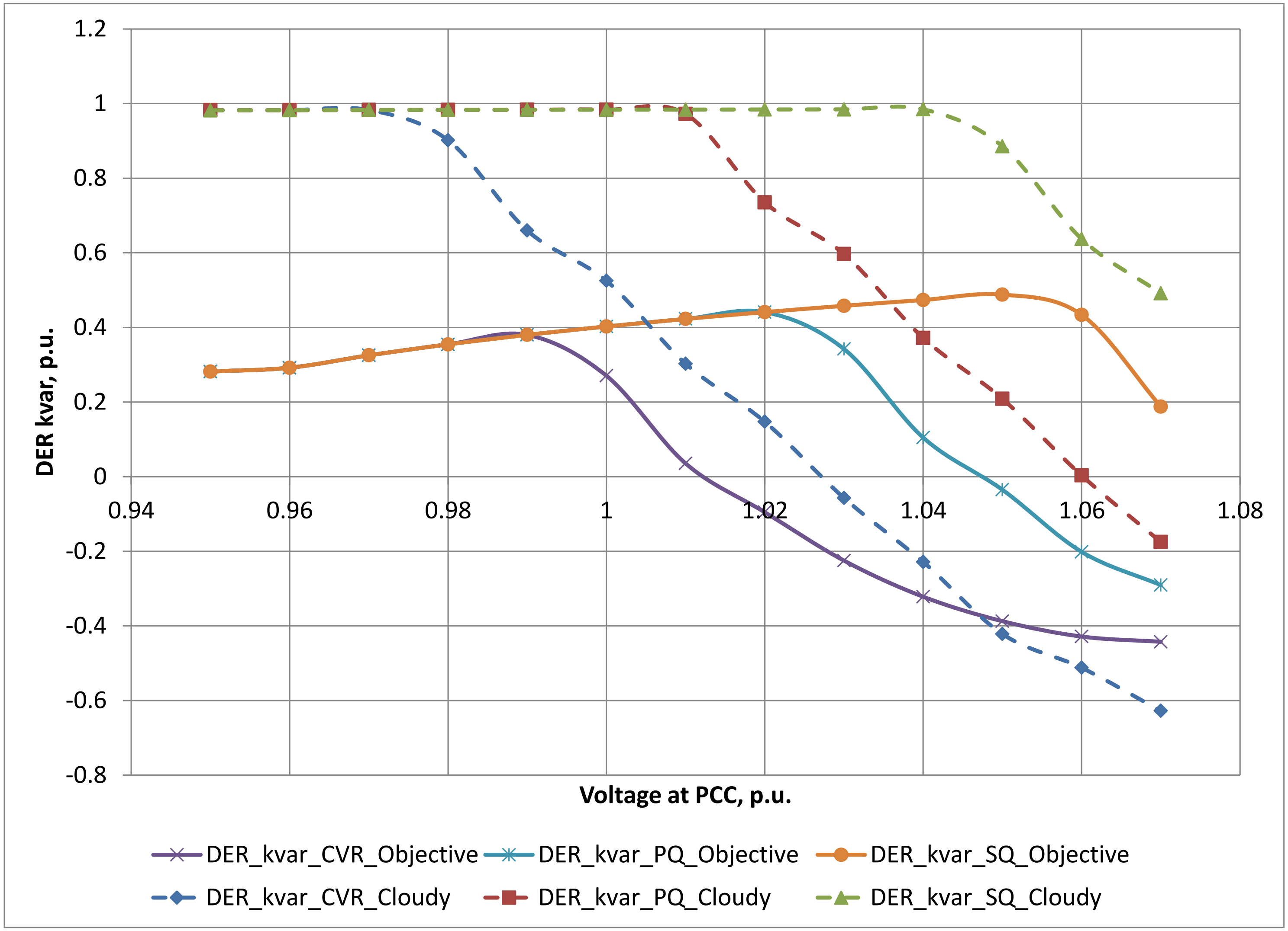

Figure 1-12. Generation of maximum kvars by DERs under different modes of Volt/var control and different weather conditions

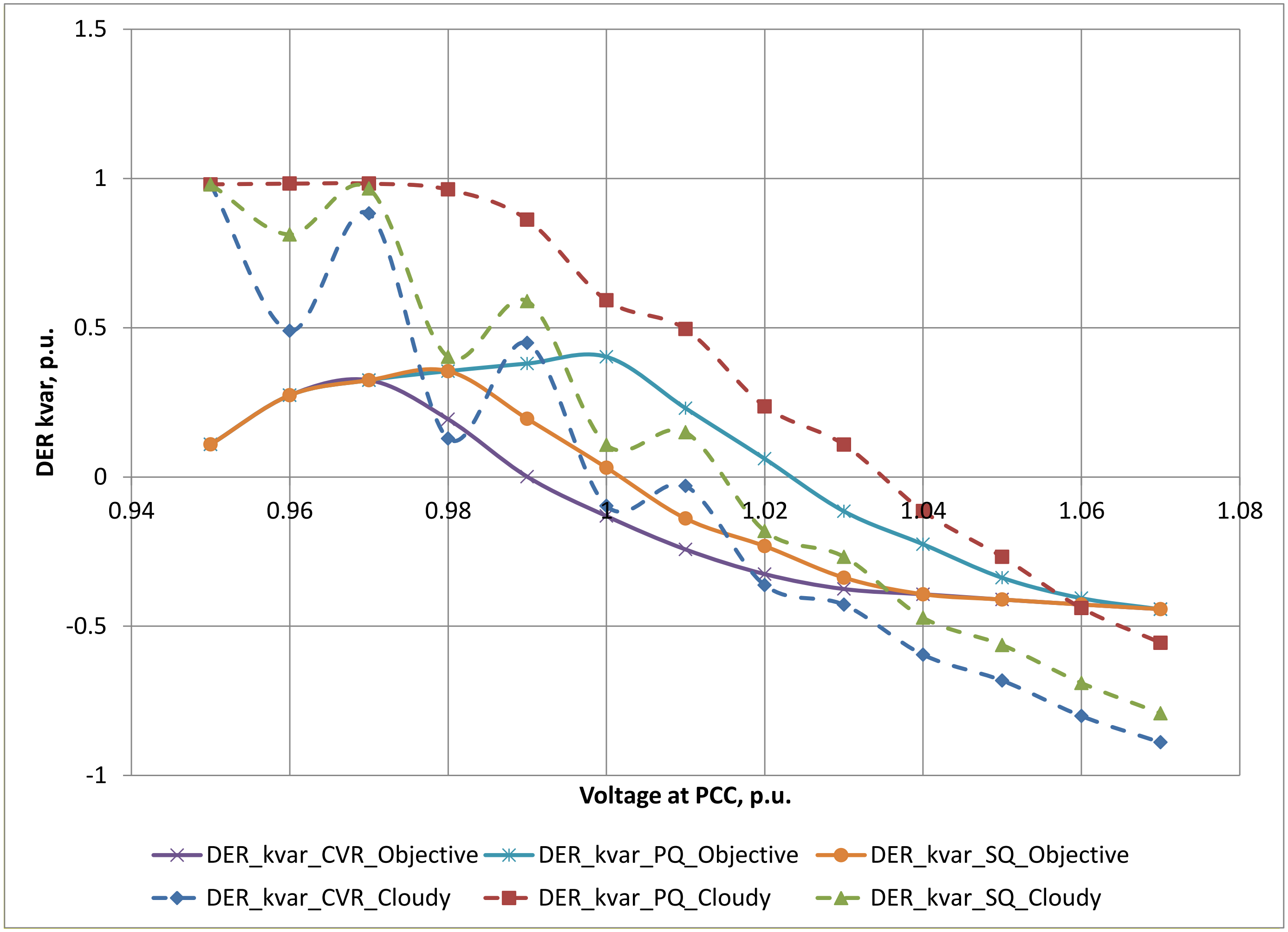

Figure 1-13. Absorption of maximum kvars by DERs under different modes of Volt/var control and different weather conditions

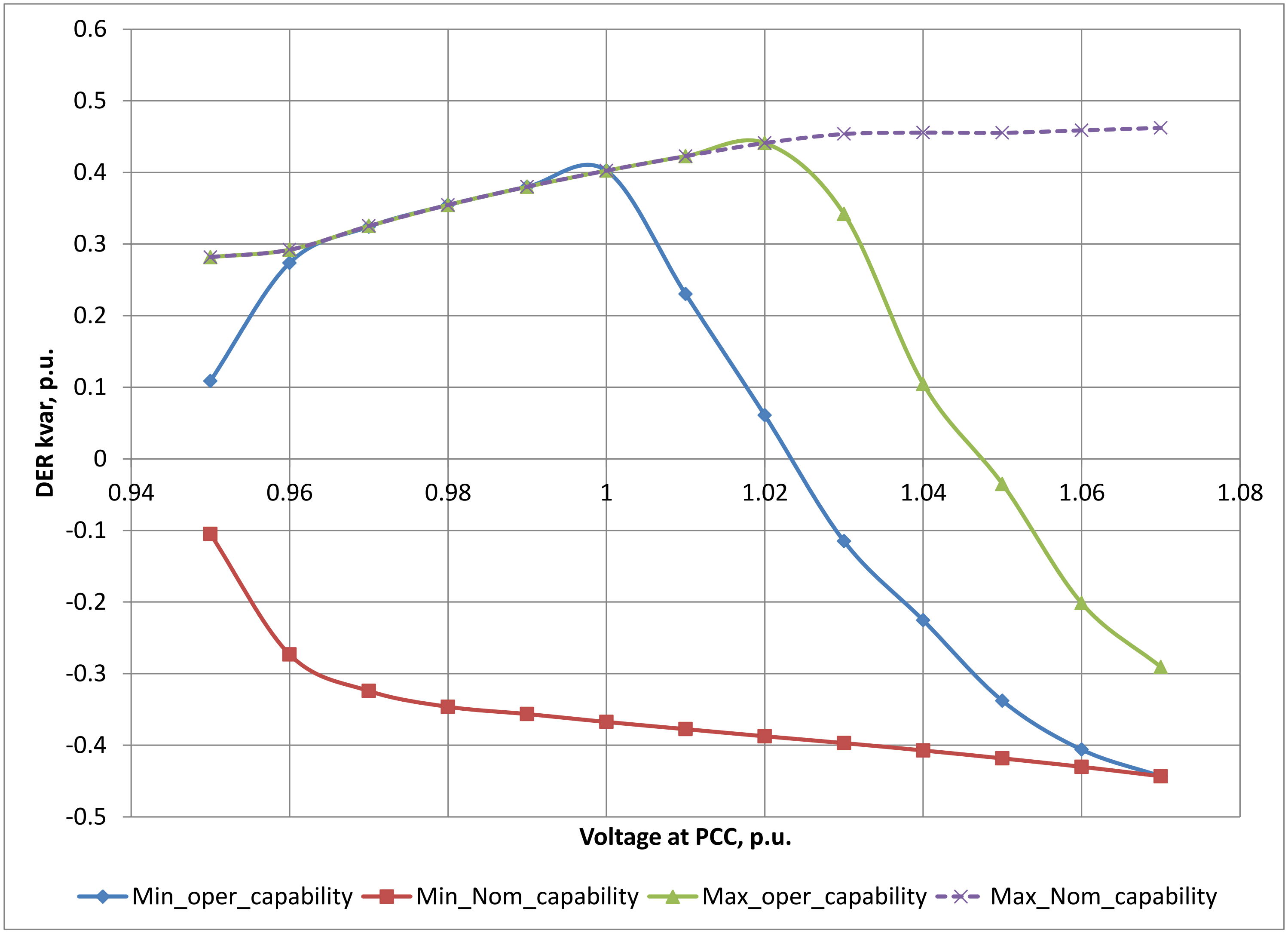

Figure 1-14. Reactive power capability curves under the PQ objective. Sunny day.

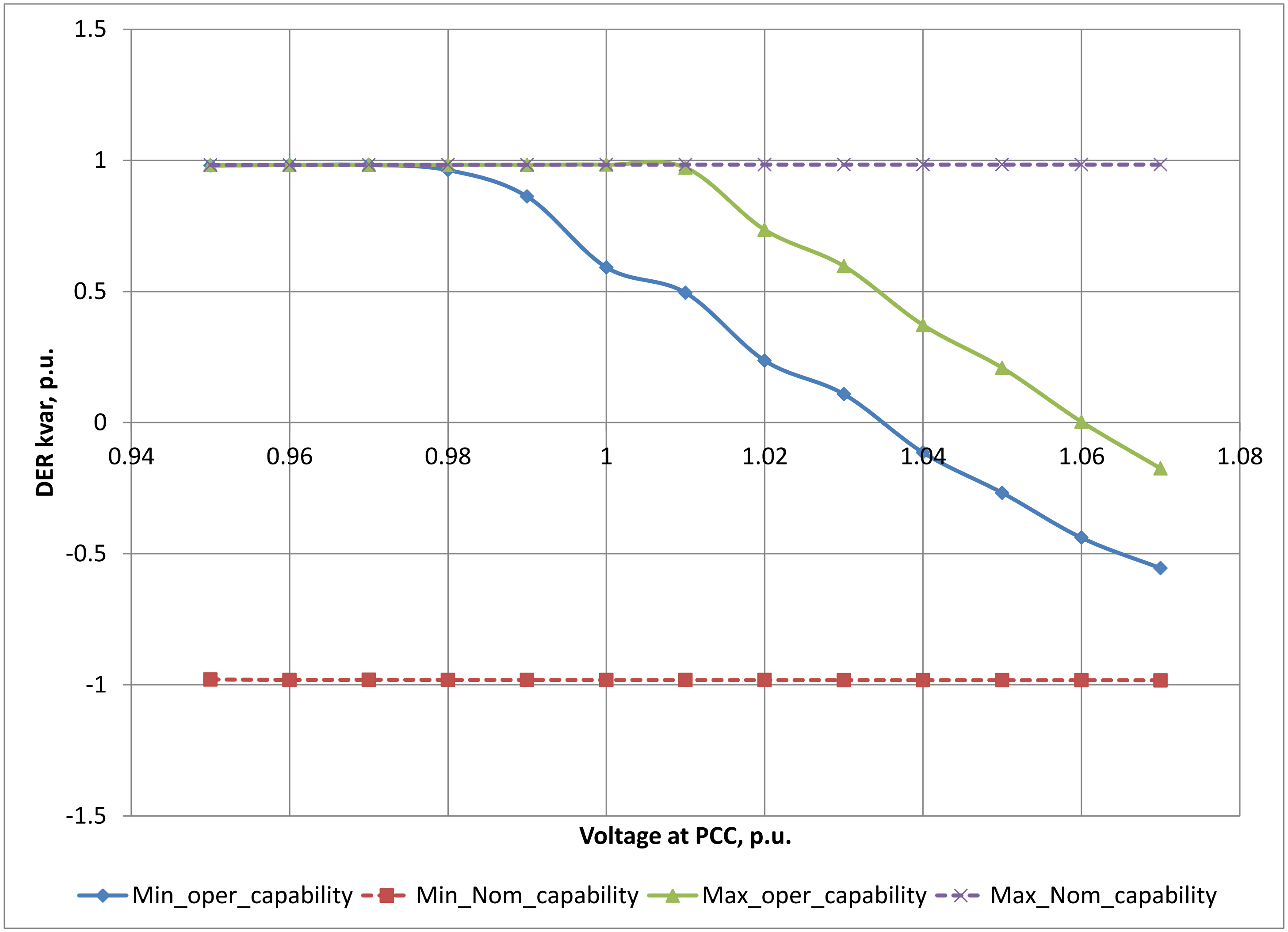

Figure 1-15. Reactive power capability curves under the PQ objective. Cloudy day.

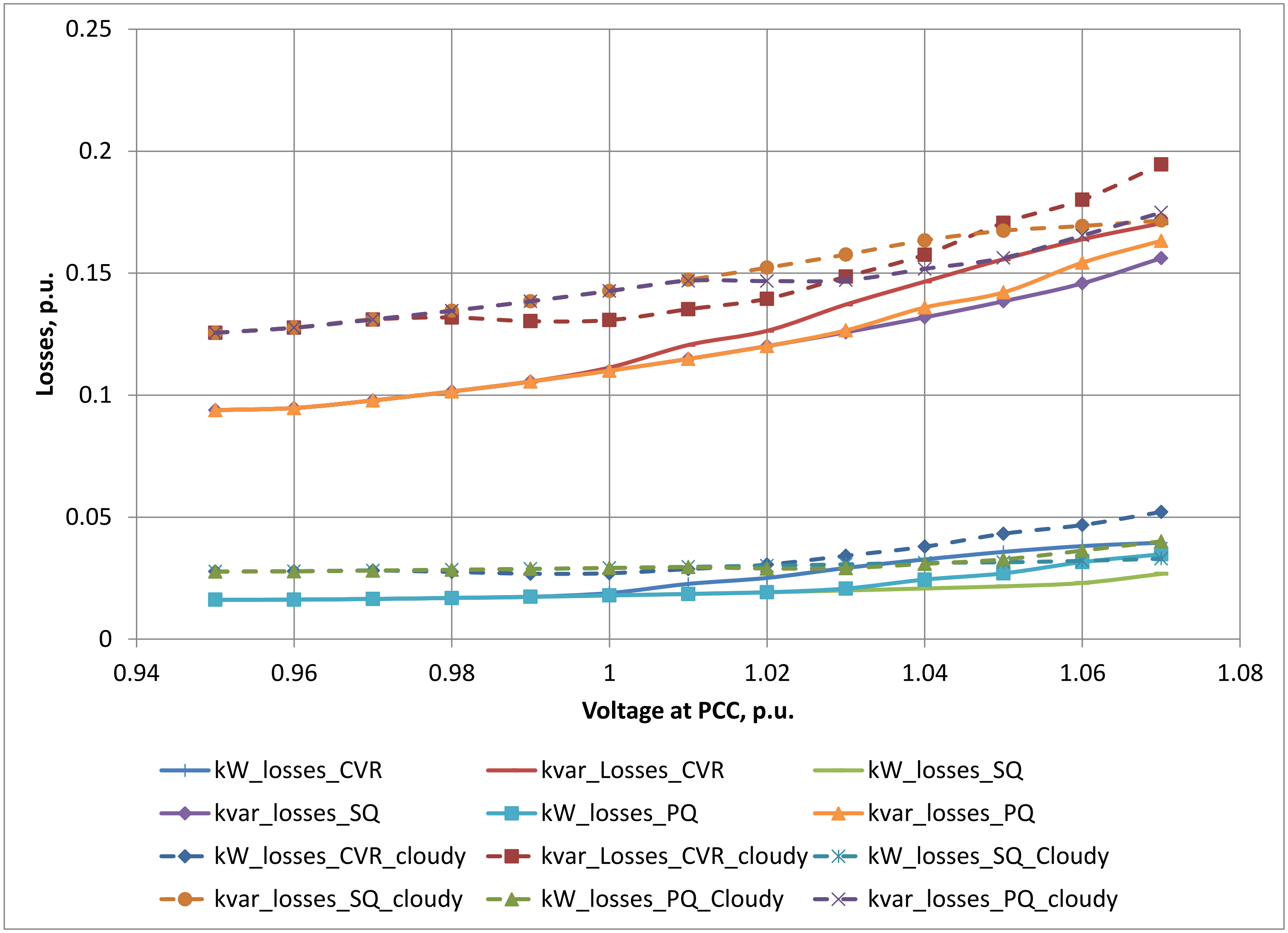

Figure 1-16. Loss dependencies on PCC voltage under different weather conditions

Price related dependencies

An example of the microgrid load management based on real-time pricing is considered below.

The dispatchable load depends on all mentioned above components and on available Demand Response and Energy Storage availability. The preconditions for load management, for this example, are presented in Table 1-1.

Table 1-1. Preconditions for RTP-based load management in the µGrid

Load management action	Amount of load reduction	Price-level tolerance, p.u. of reference price
CVR	~2% of total load	1.5
Electric storage charging	100% of DER 2	0.7
Electric storage discharging	100% of DER 2	2
1st group of DR of load 1	5% of load 1	3
2nd group of DR of load 1	5% of load 1	6
1st group of DR of load 2	5% of load 2	2.5
2nd group of DR of load 2	5% of load 2	4
1st group of DR of load 3	5% of load 3	5
2nd group of DR of load 3	5% of load 3	8

The scenarios considered in the example are presented in Table 1-2. The differences in the Volt/vat control function under different dynamic prices are presented in Figure 1-17. These differences, in turn, cause differences in reactive power generated by the DERs

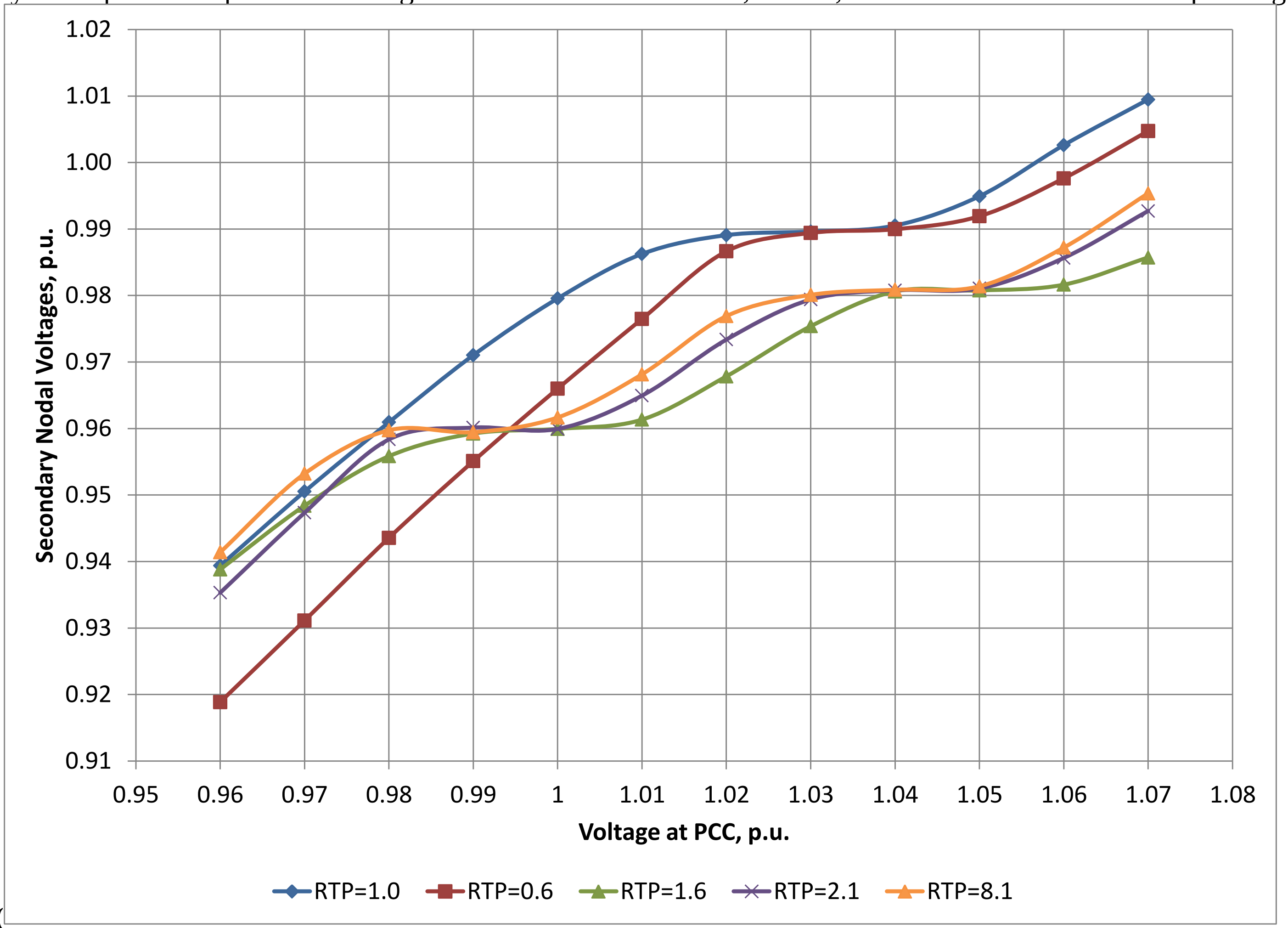

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Figure 1-19), as well as, differences in other operational parameters of the μGrid (see Figure 1-29). As seen in the figures, among all these parameters derived by the μEMS, there are parameters that need to be known to the DMS/ EMS, and there are parameters for the use by the μEMS. The latter ones are mostly for determining the impacts of the different dynamic prices on the power quality and economics of the μGrid (e.g., secondary voltages and losses).

Table 1-2. Scenarios considered in the example.

RTP, p.u.	0.6	1	1.6	2.1	2.6	3.1	4.1	5.1	6.1	8.1
IVVWO	PQ	PQ	CVR	CVR	CVR	CVR	CVR	CVR	CVR	CVR
ES	Charging	0	0	Discharging, if available	Discharging, if available	Discharging, if available	Discharging, if available	Discharging, if available	Discharging, if available	Discharging, if available
DR1	0	0	0	0	0	5% of load 1	5% of load 1	5% of load 1	10% of load 1	10% of load 1
DR2	0	0	0	0	5% of load 2	5% of load 2	10% of load 2	10% of load 2	10% of load 2	10% of load 2
DR3	0	0	0	0	0	0	0	5% of load 3	5% of load 3	10% of load 3

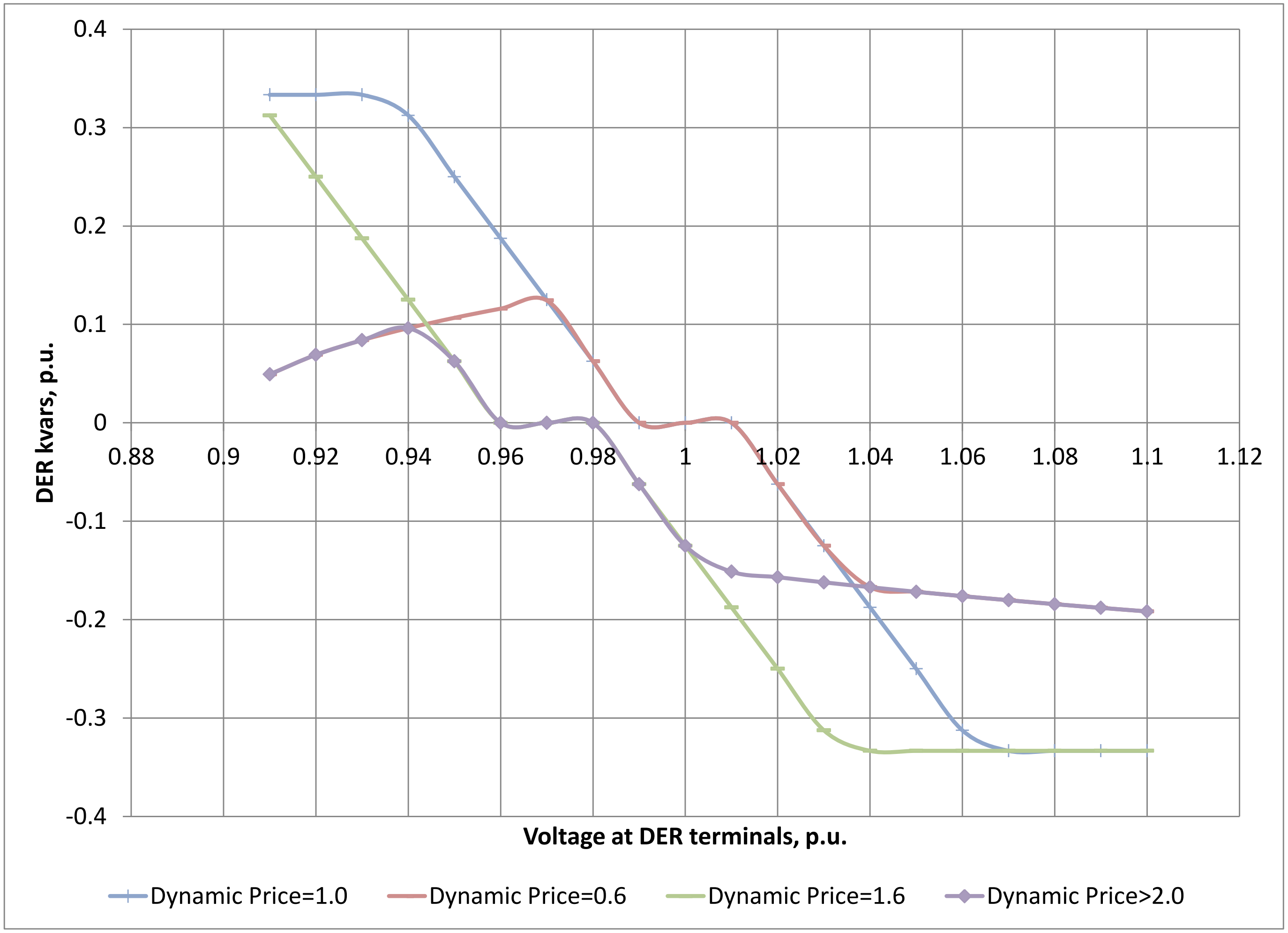

Figure 1-17. Volt/var control functions under different dynamic prices

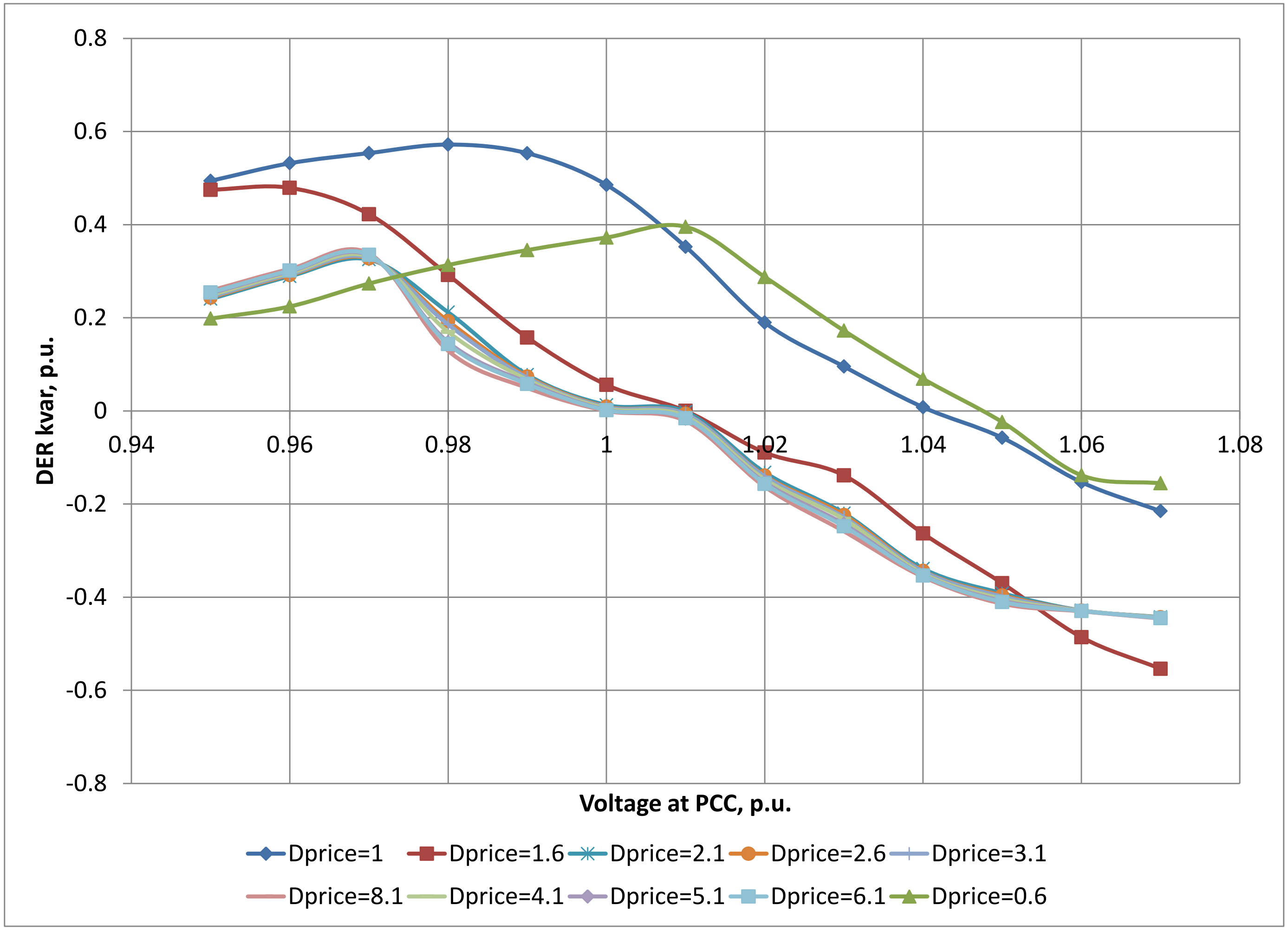

Figure 1-18. Dependencies of DER reactive power on PCC voltage under different dynamic prices

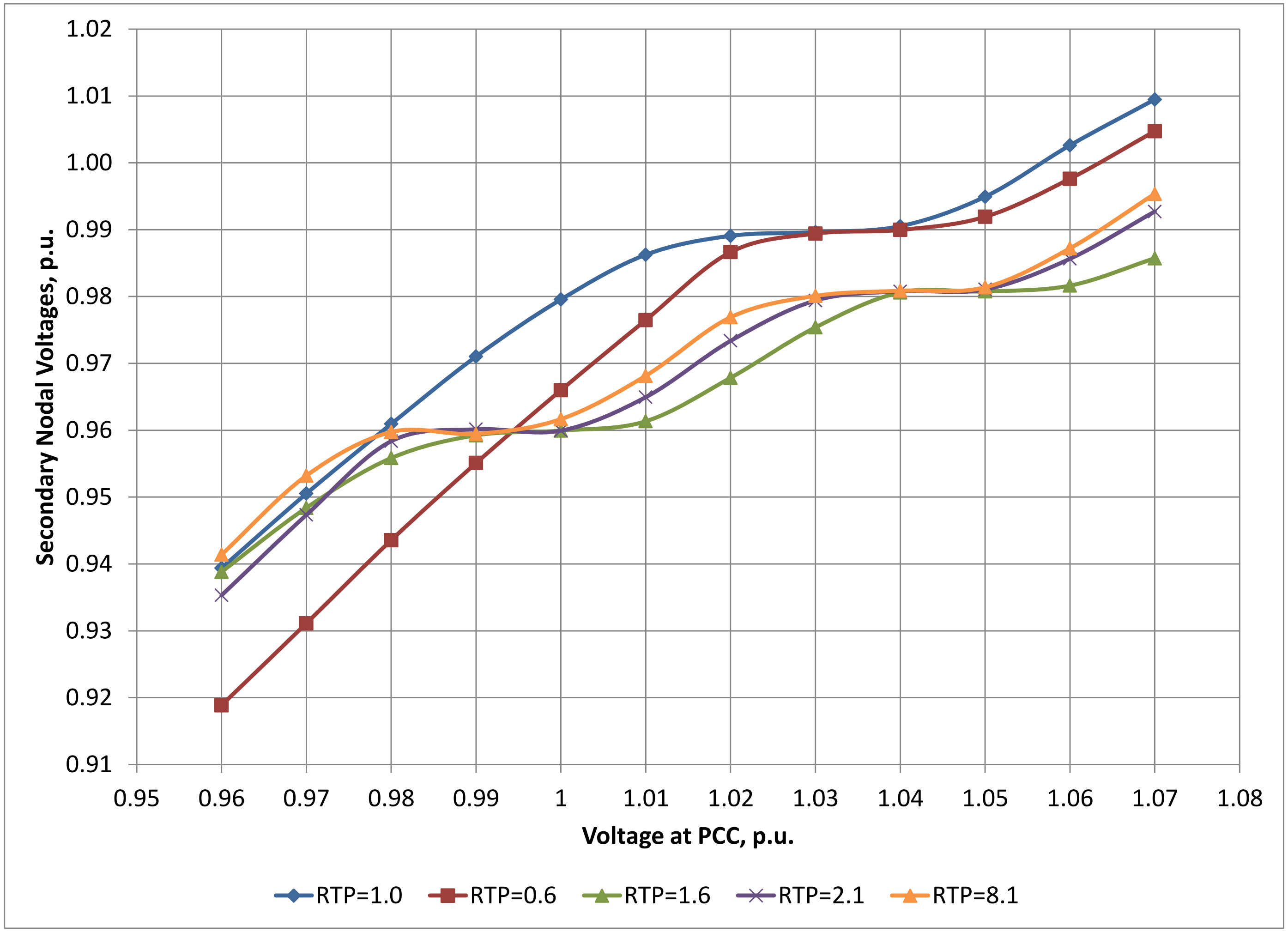

Figure 1-19. Dependencies of secondary voltages on PCC voltage under different dynamic prices

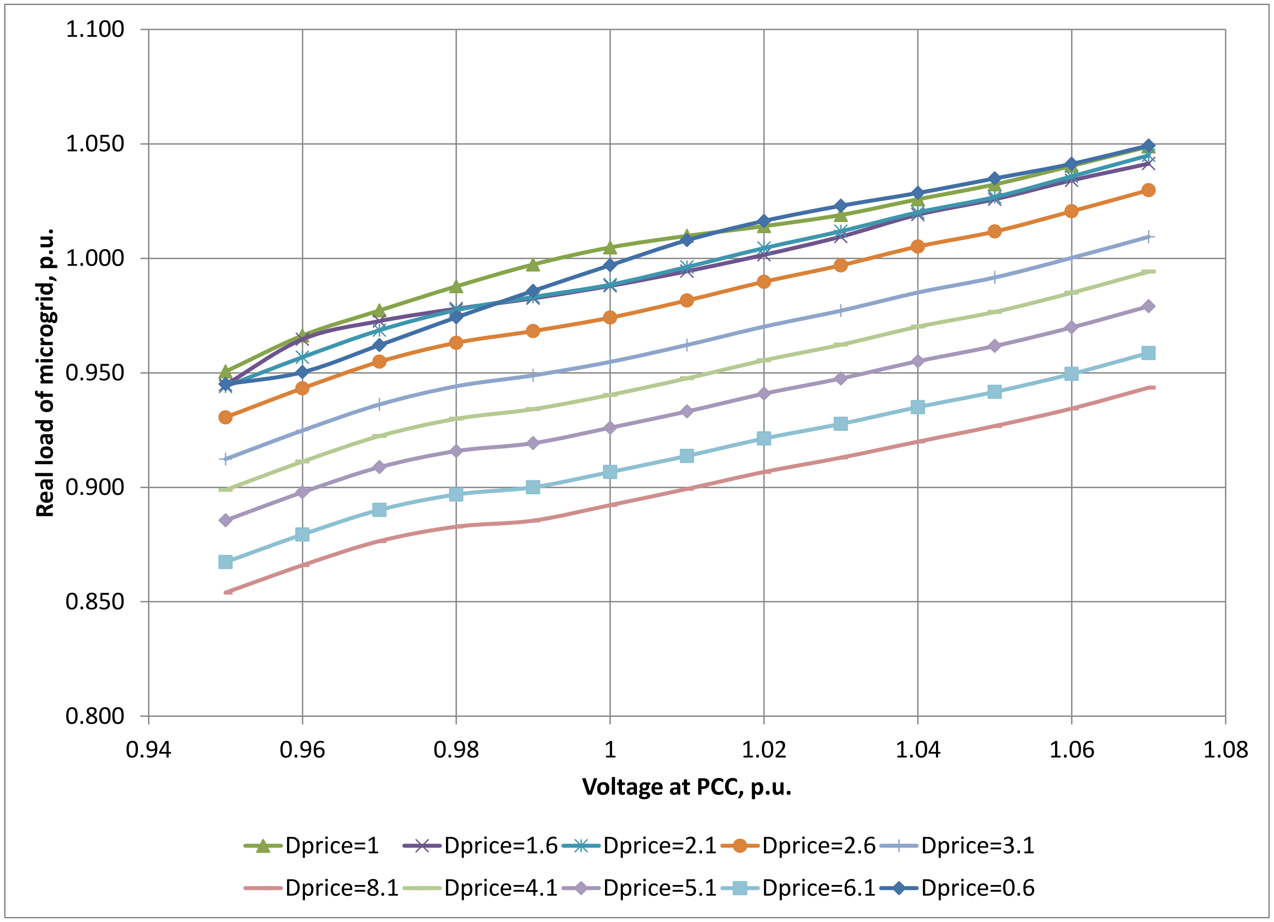

Figure 1-20. Dependencies of real load of the μGrid on PCC voltage under different dynamic prices

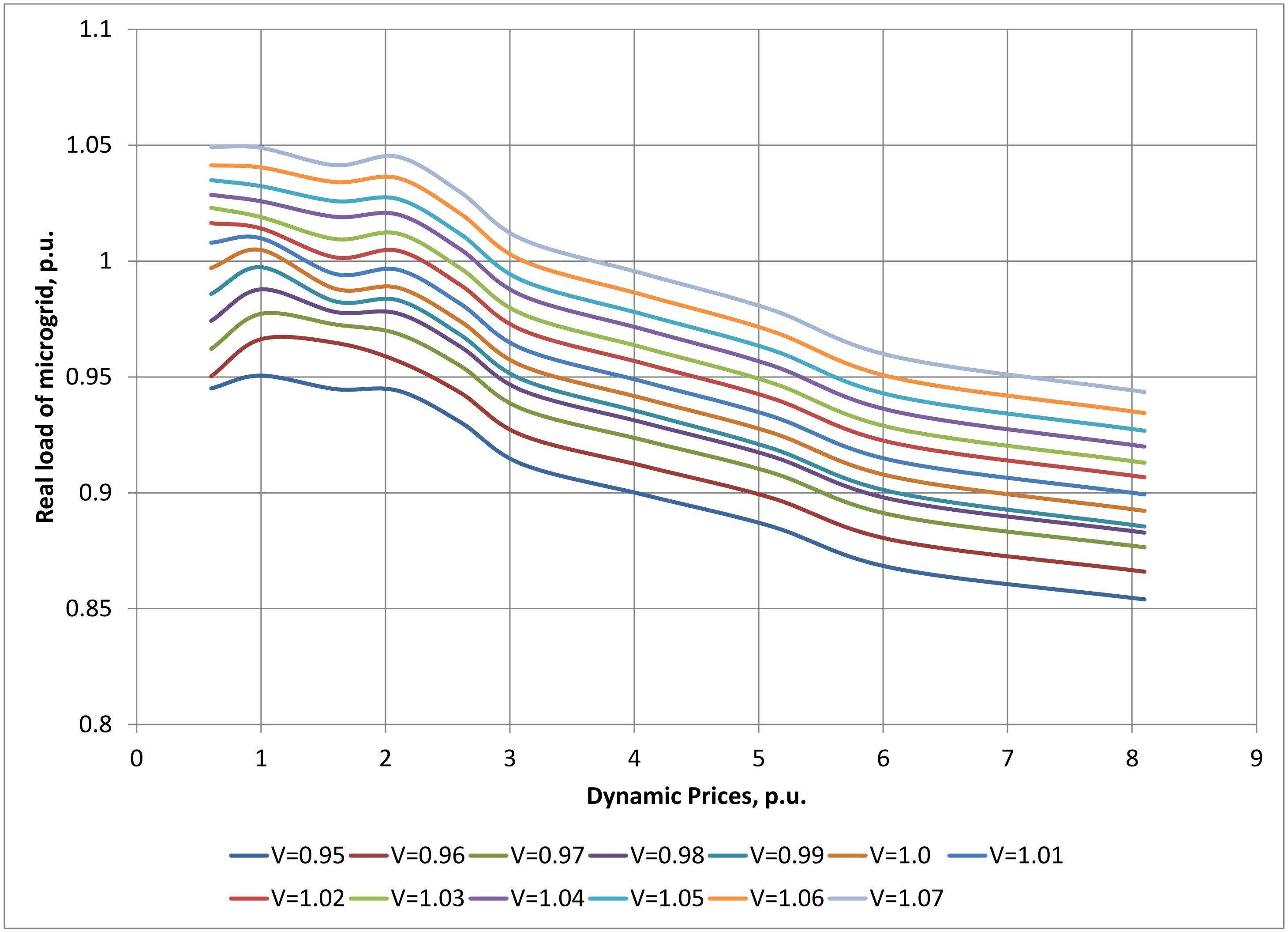

Figure 1-21. Dependencies of real load of the µGrid on dynamic prices under different PCC voltages

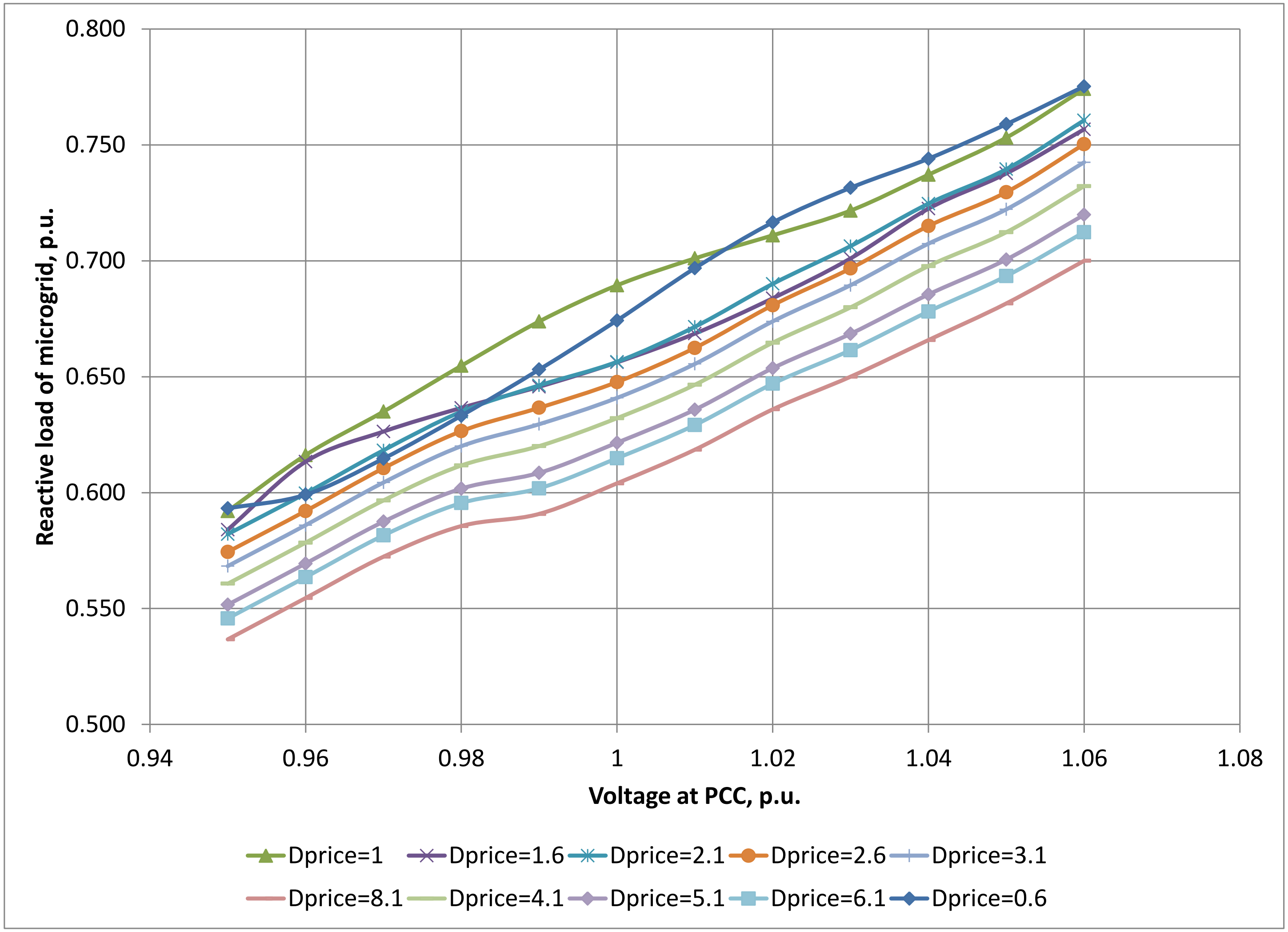

Figure 1-22. Dependencies of reactive load of the μGrid on PCC voltage under different dynamic prices

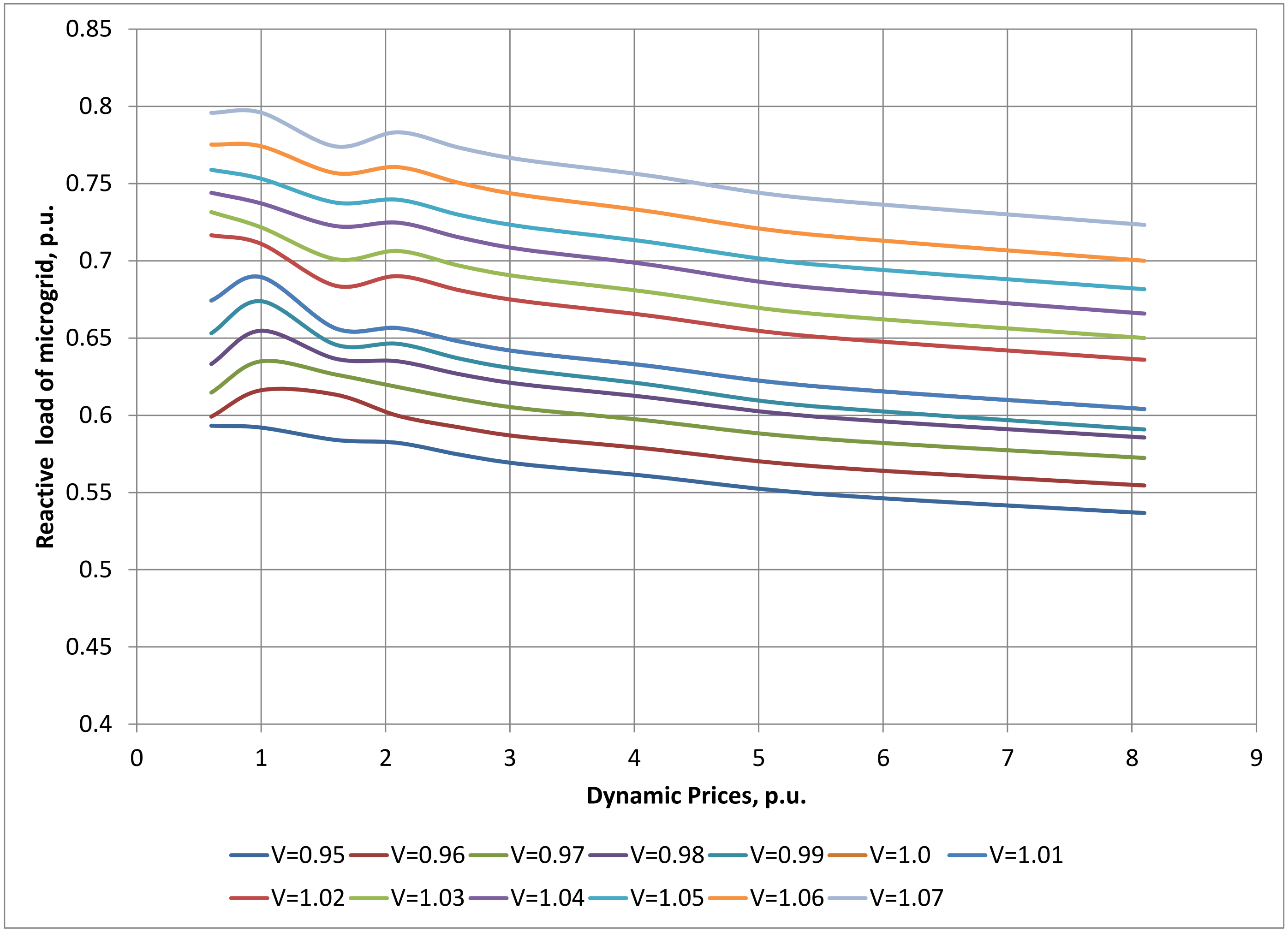

Figure 1-23. Dependencies of reactive load of the μGrid on dynamic prices under different PCC voltages

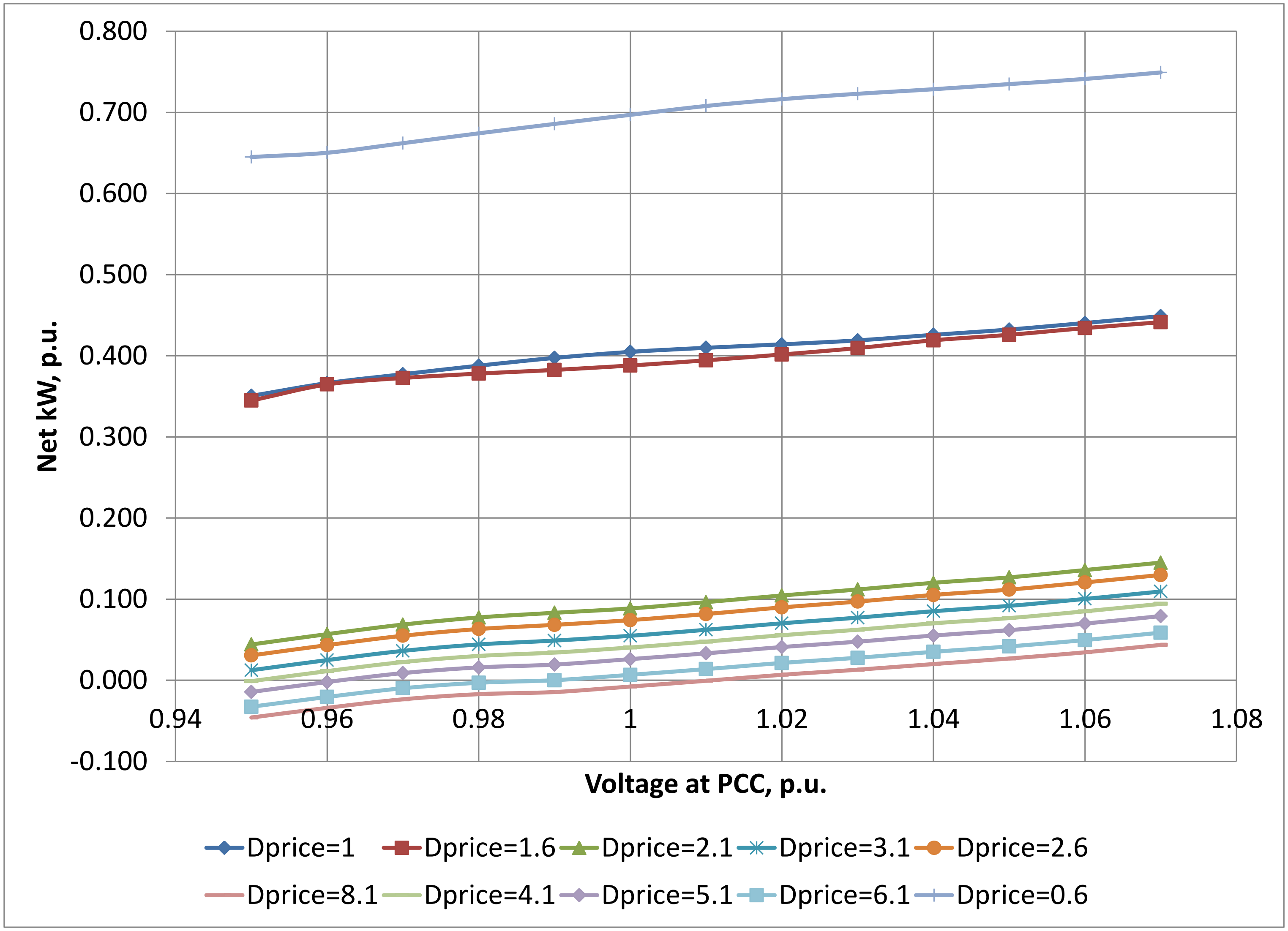

Figure 1-24. Dependencies of net real load of the μGrid on PCC voltage under different dynamic prices

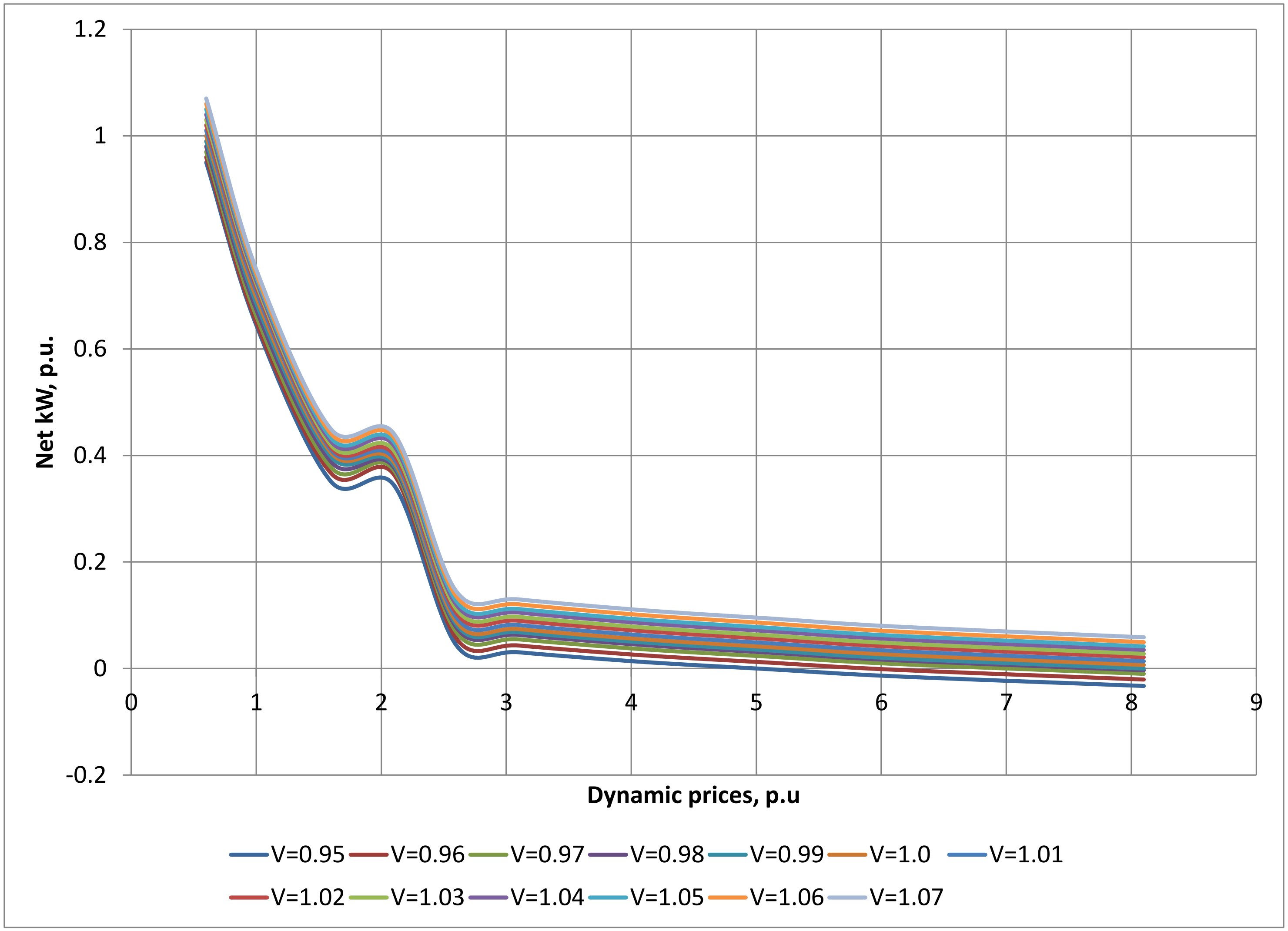

Figure 1-25. Dependencies of net real load of the μGrid on dynamic prices under different PCC voltages

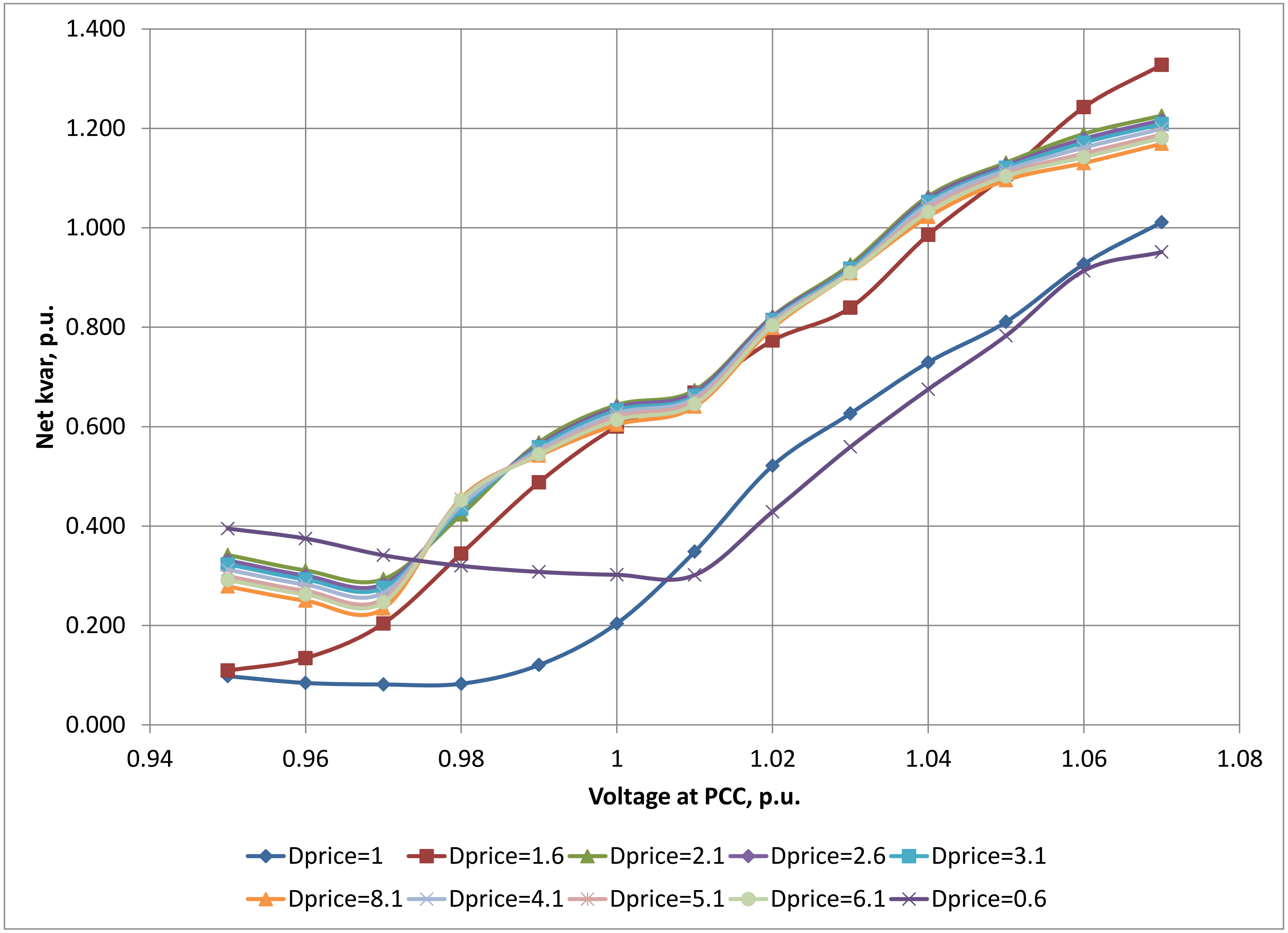

Figure 1-26. Dependencies of net reactive load of the μGrid on PCC voltage under different dynamic prices

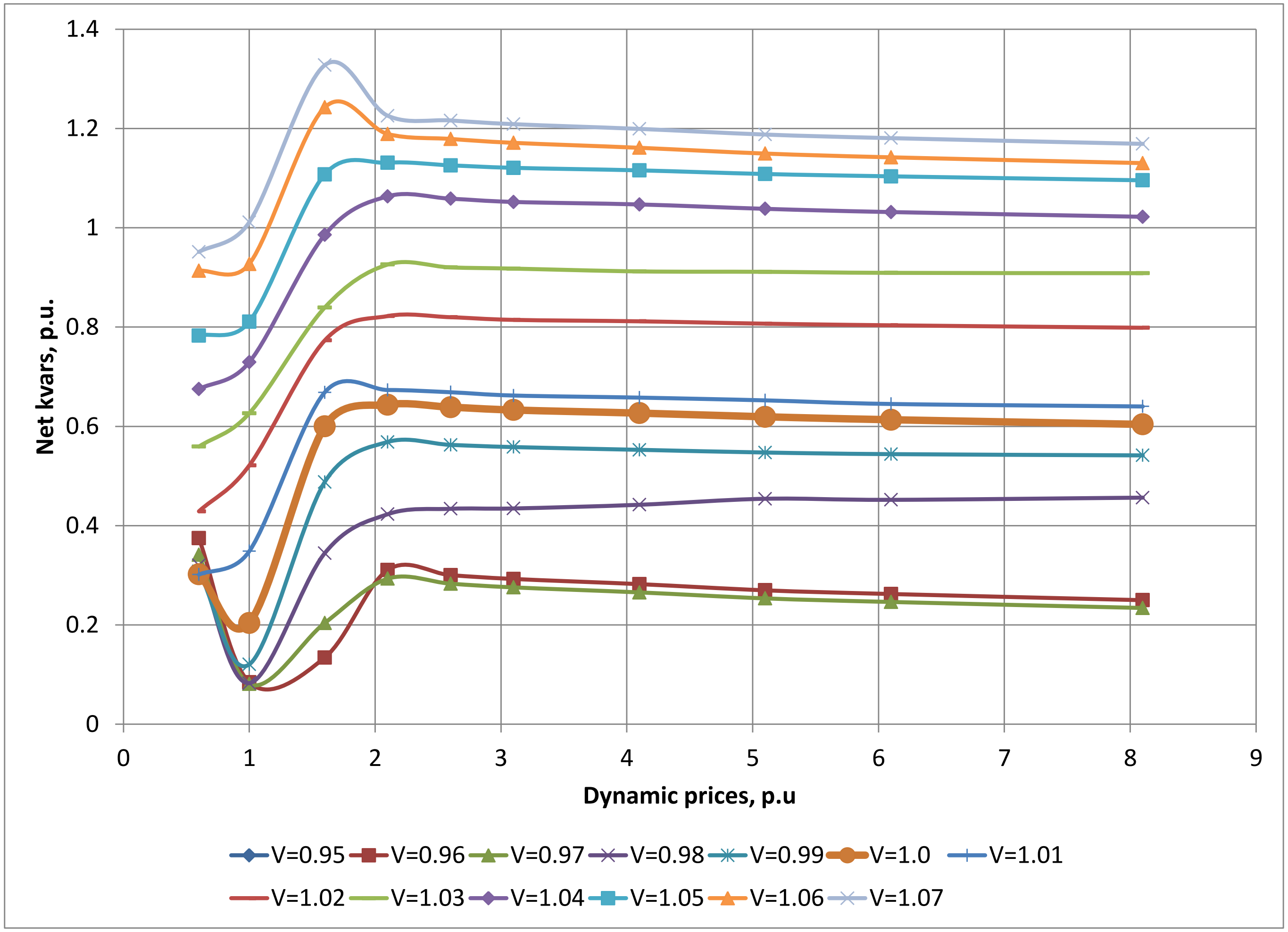

Figure 1-27. Dependencies of net reactive load of the µGrid on dynamic prices under different PCC voltages

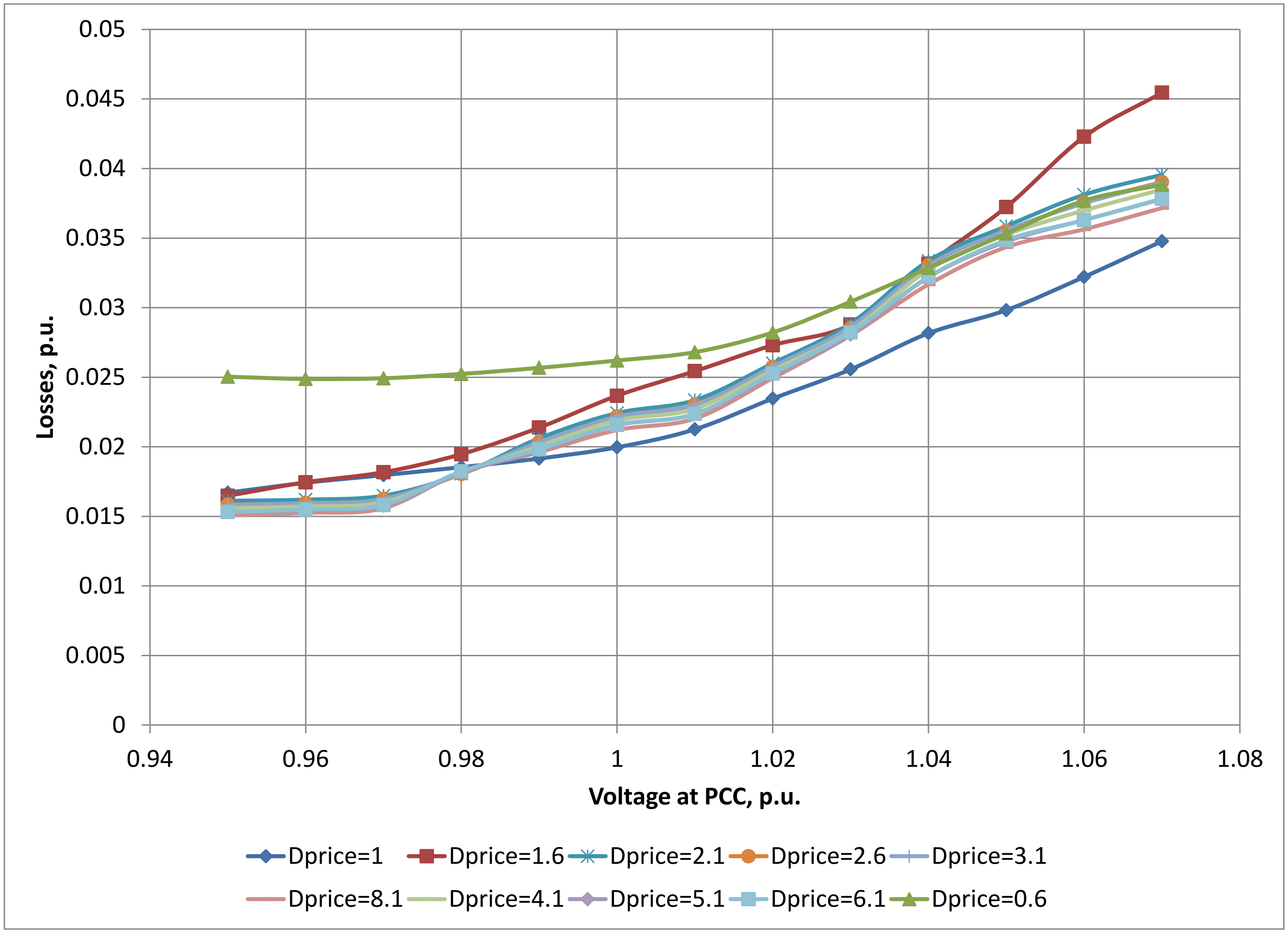

Figure 1-28. Dependencies of real load losses in the μGrid under different dynamic prices

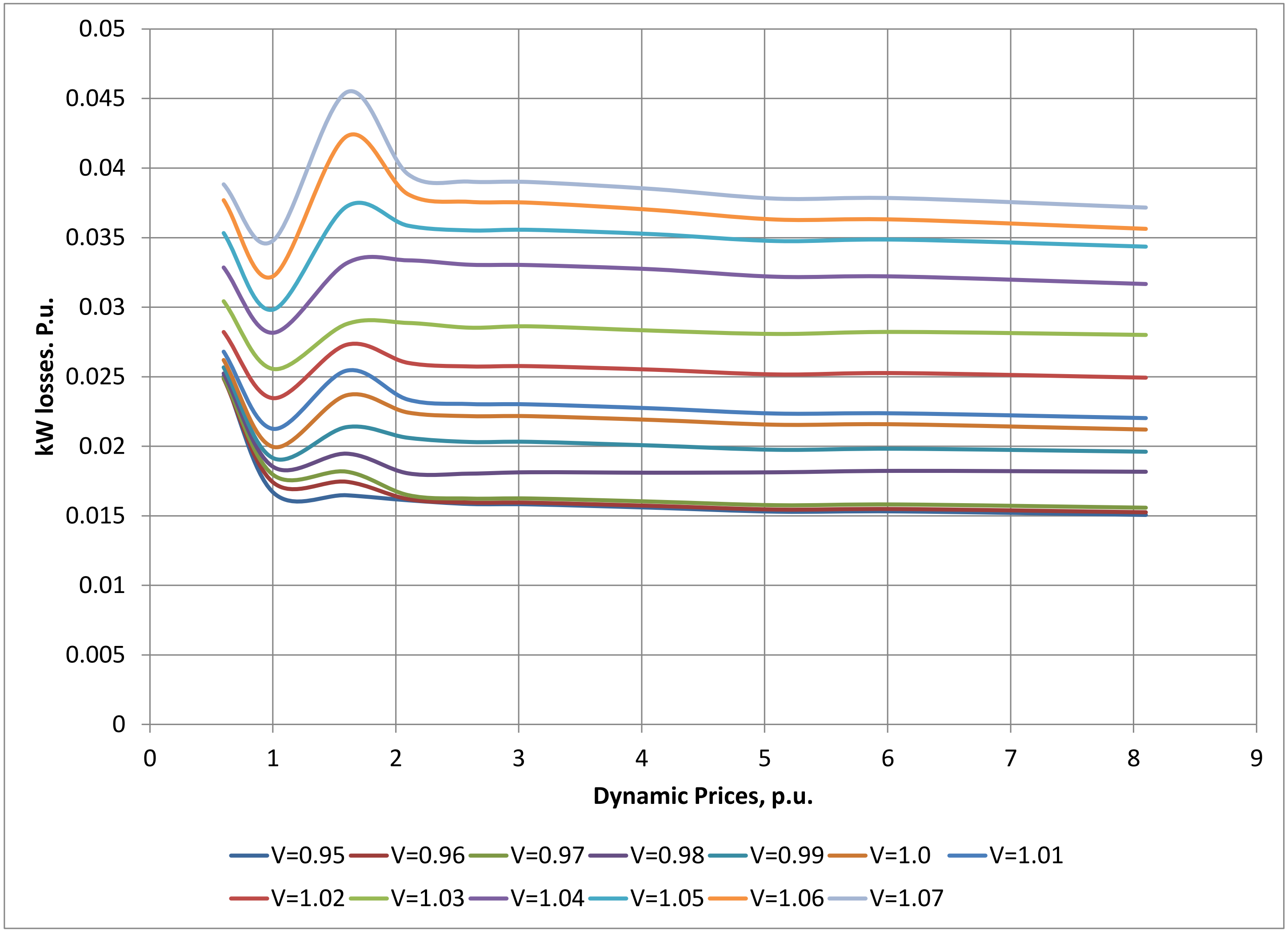

Figure 1-29. Dependencies of real load losses in the μGrid on dynamic prices under different PCC voltages

Volt/var support related dependencies

Another possible external factor is the EPS' request for a particular Power Factor at the PCC. In our example, the initial conditions are as follows:

- Volt/var control objective is Power Quality with voltage settings 0.99-1.01 and initial var settings = 0.
- The dynamic price is 1 p.u.
- The weather condition – sunny day.

The EPS required keeping the Power Factor at the PCC of the µGrid equal or above 0.9 under the entire normal range of voltages at the PCC.

To meet the EPS' request under different PCC voltages, the µEMS needs to take the following steps:

- Keep the initial settings of Volt/var Control functions within PCC voltage of 0.95 through 0.99
- Change the reactive power settings of the Volt/var control function to maximum kvars within PCC voltage of 1.00 through 1.02
- Change the voltage settings of the Volt/var control function to 0.99 – 1.04 and keep the maximum kvars within PCC voltage of 1.03 through 1.05
- Change the voltage settings of the Volt/var control function to 1.02 – 1.04 and keep the maximum kvars for PCC voltage above 1.05

The differences in the operational parameters of the µGrid for two conditions "PF not required" and "PF required" are presented in the figures below.

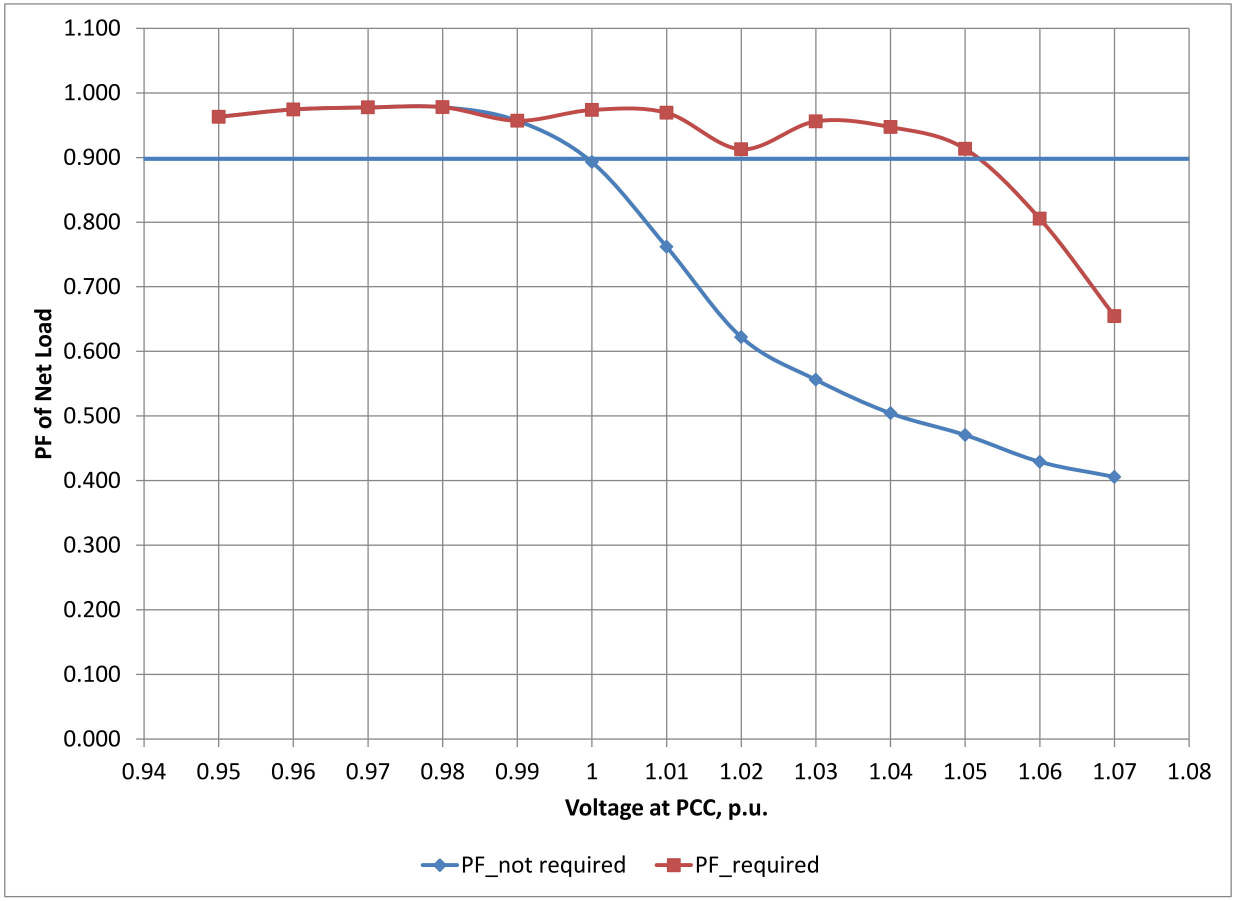

Figure 1-30. Power factors before and after EPS request

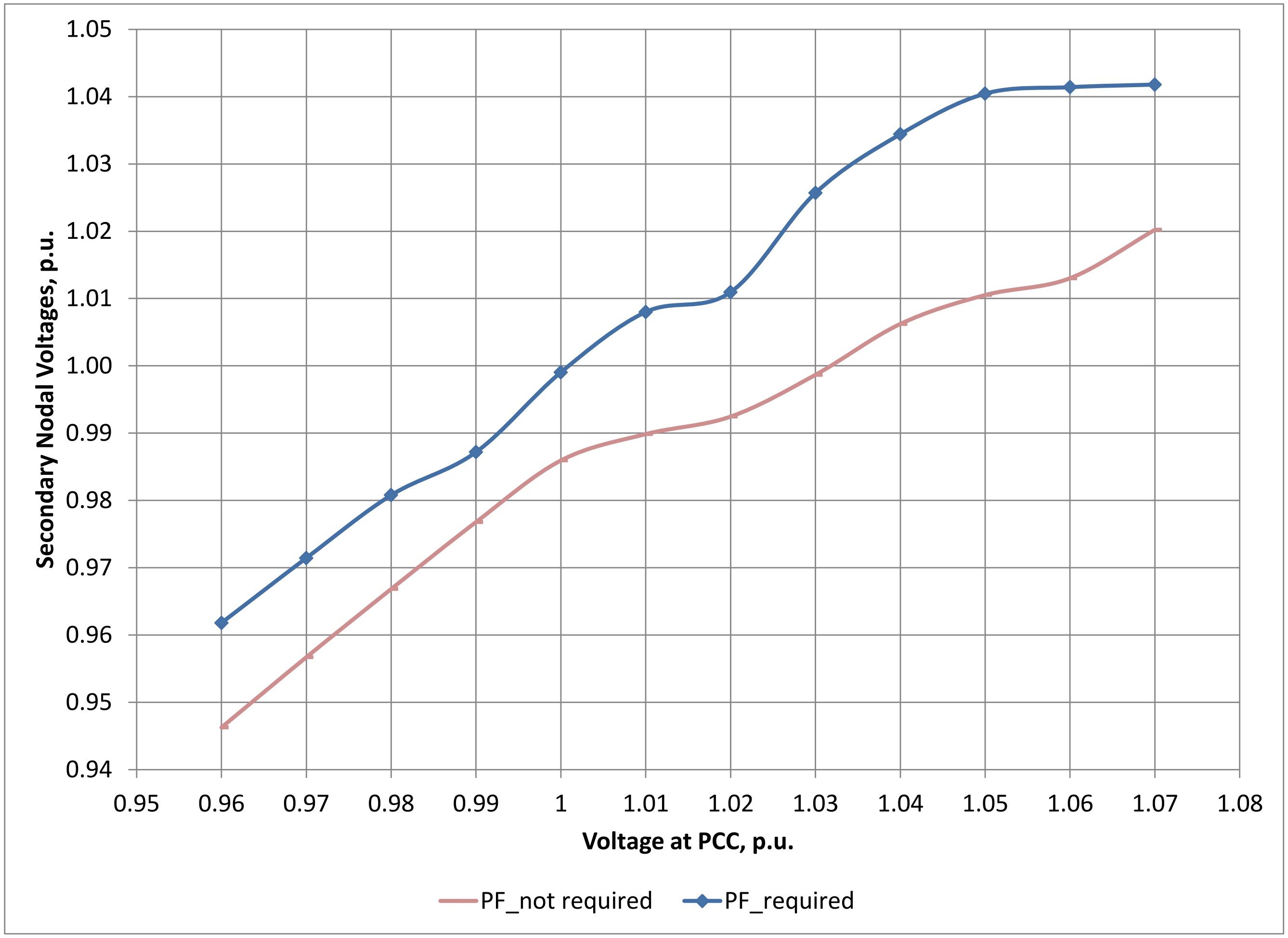

Figure 1-31. Secondary voltage before and after EPS request

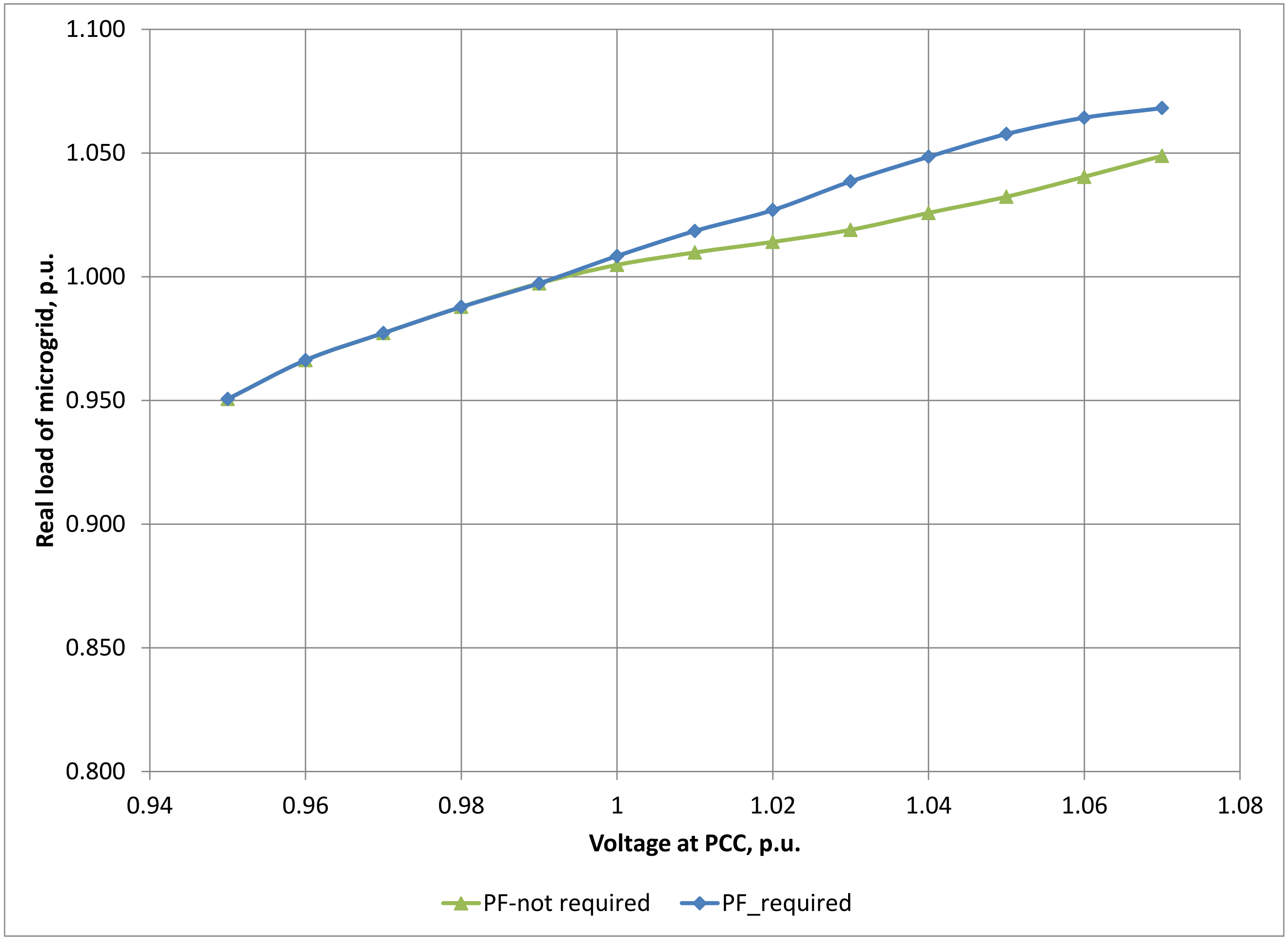

Figure 1-32. Real load of µGrid before and after EPS request

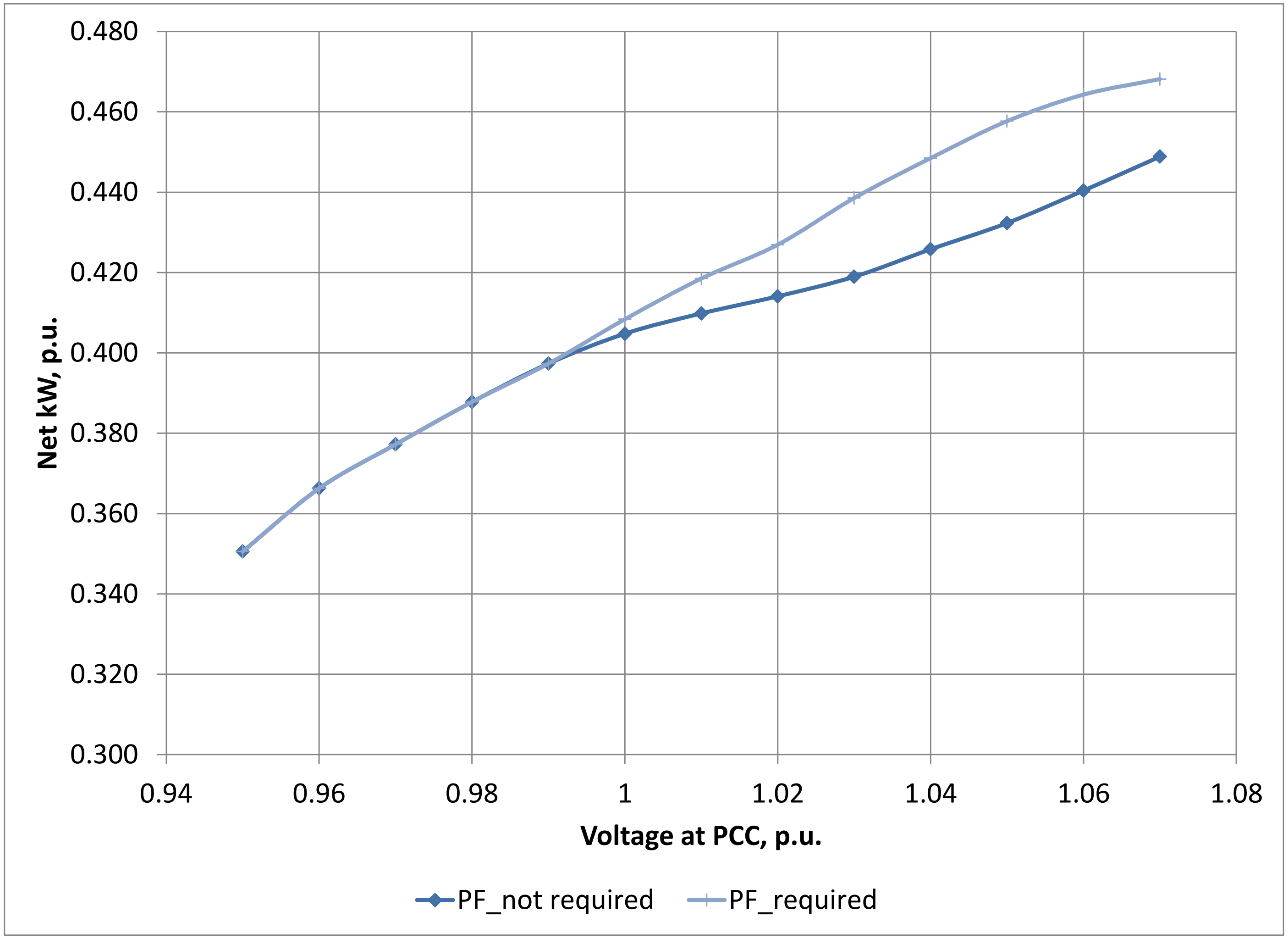

Figure 1-33. Net kW before and after EPS request

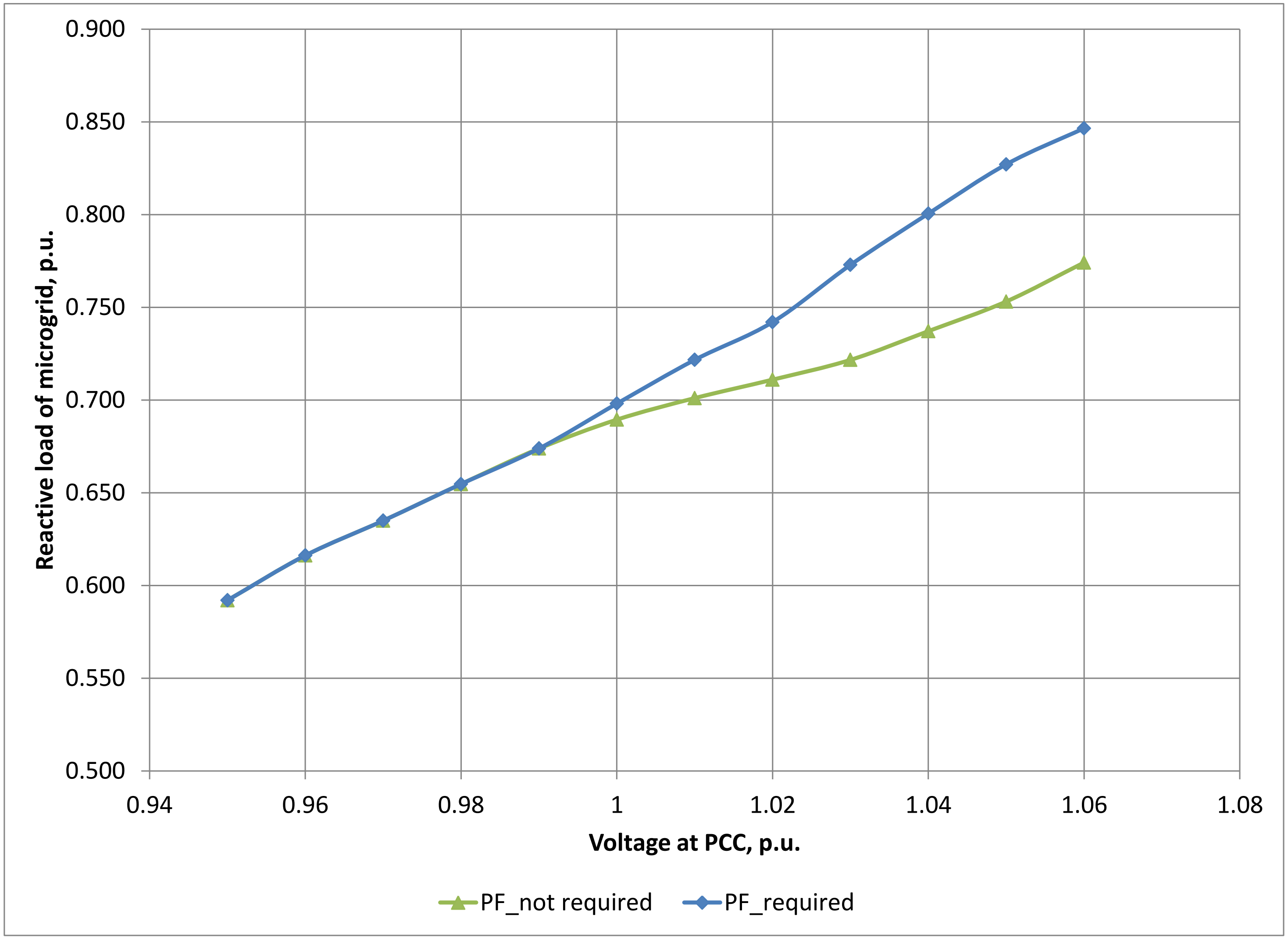

Figure 1-34. Reactive load of µGrid before and after EPS request

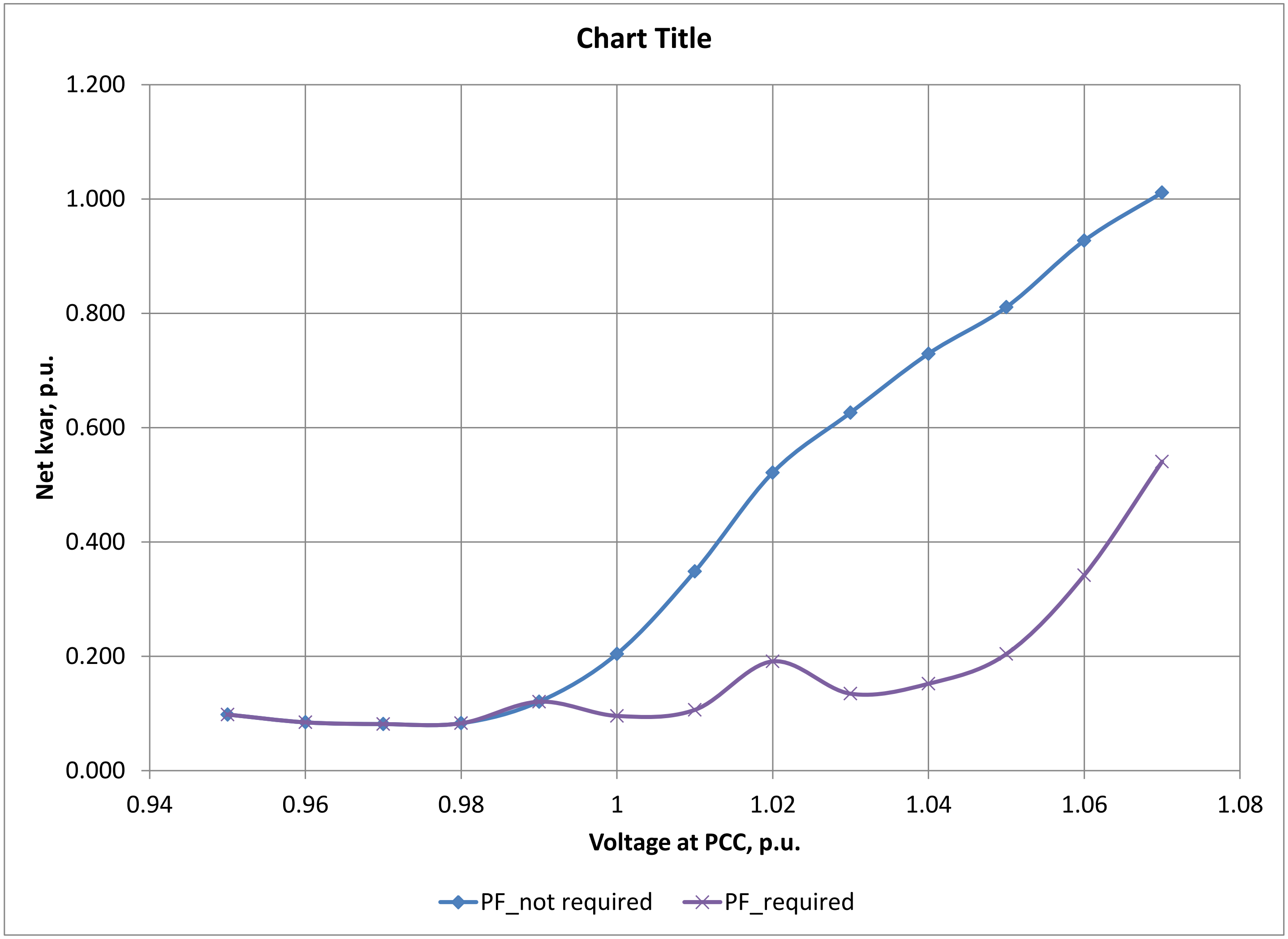

Figure 1-35. Net kvar before and after EPS request

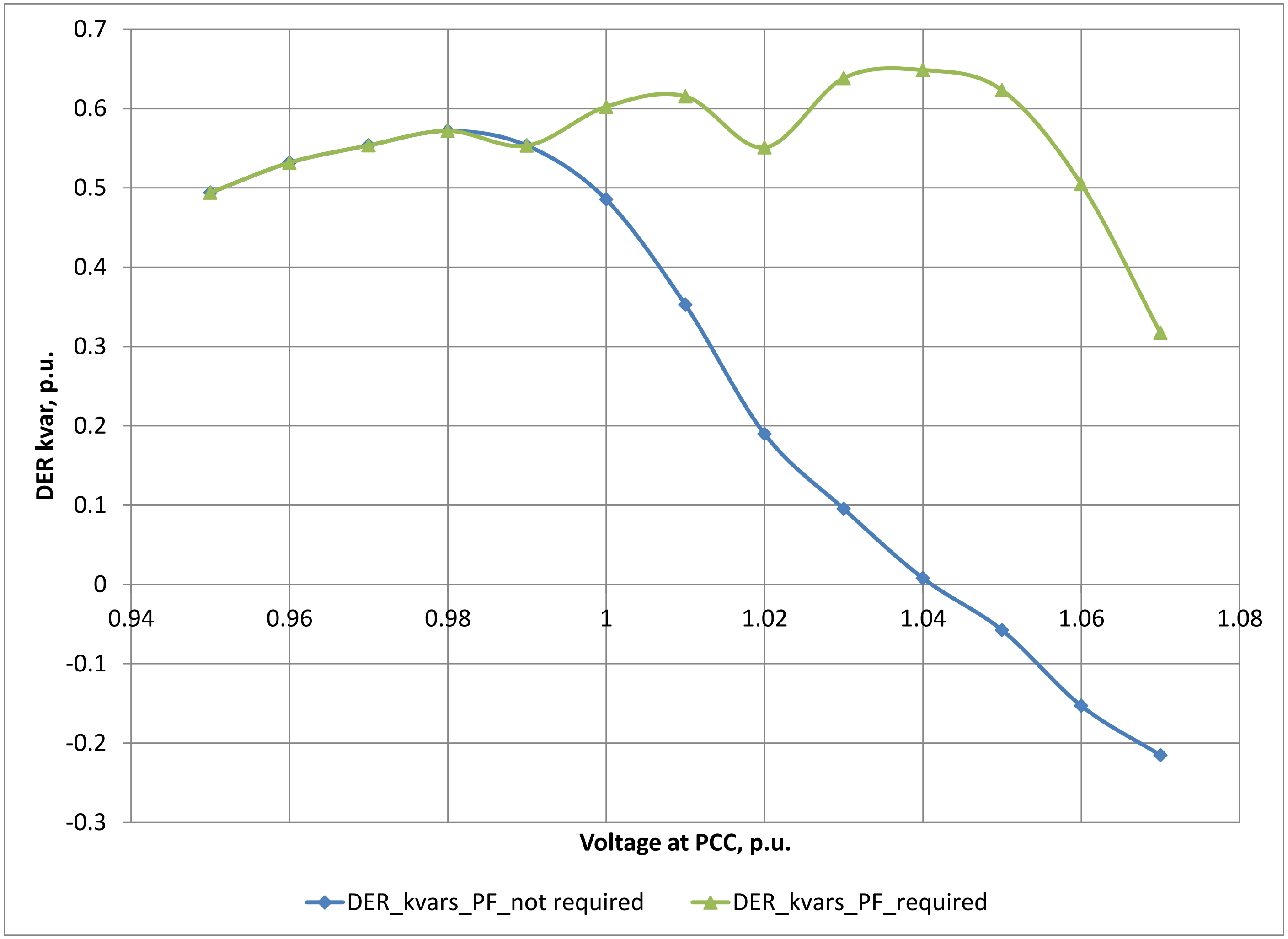

Figure 1-36. DER kvar before and after EPS request

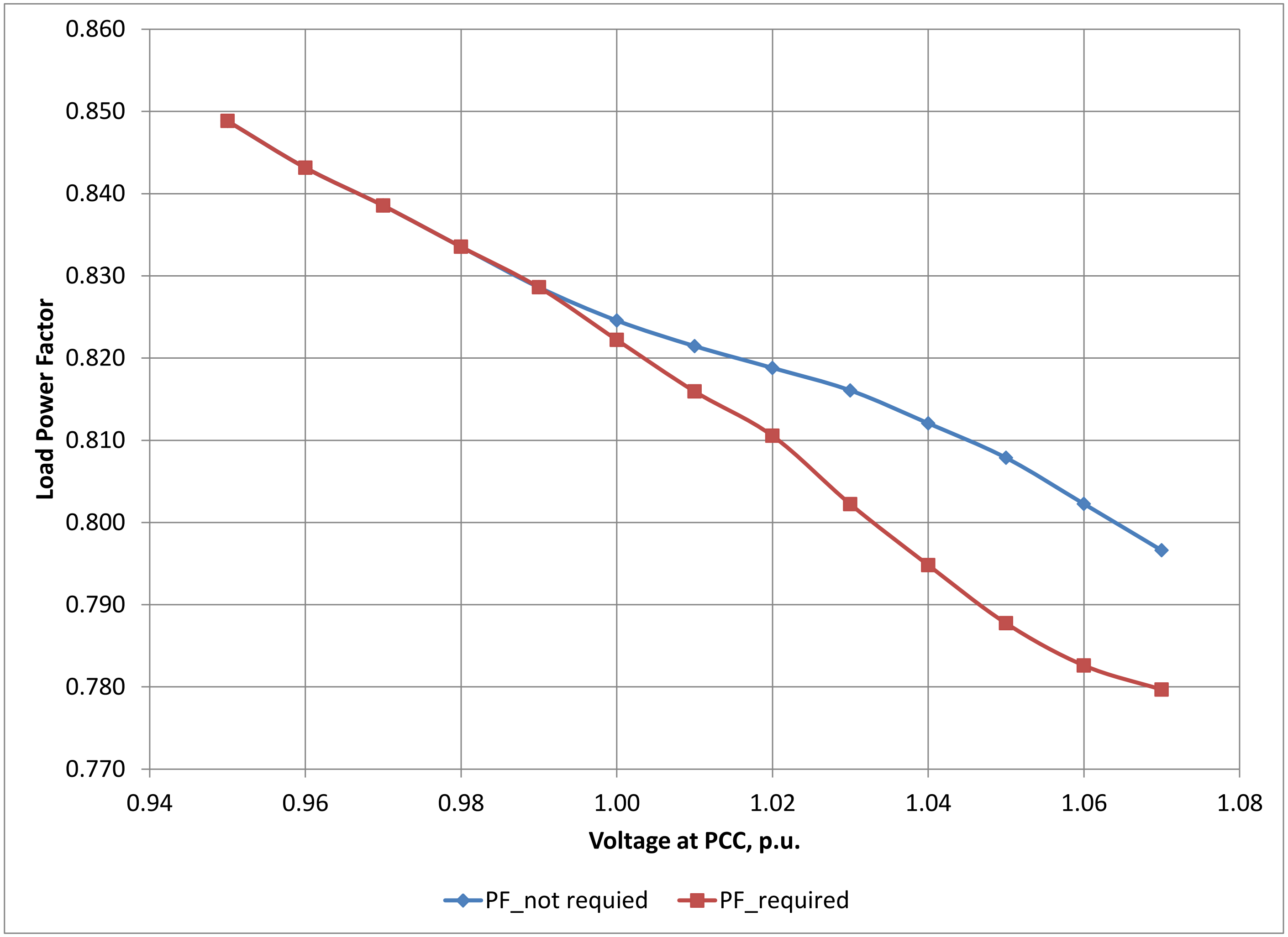

Figure 1-37. Load Power Factor before and after EPS request

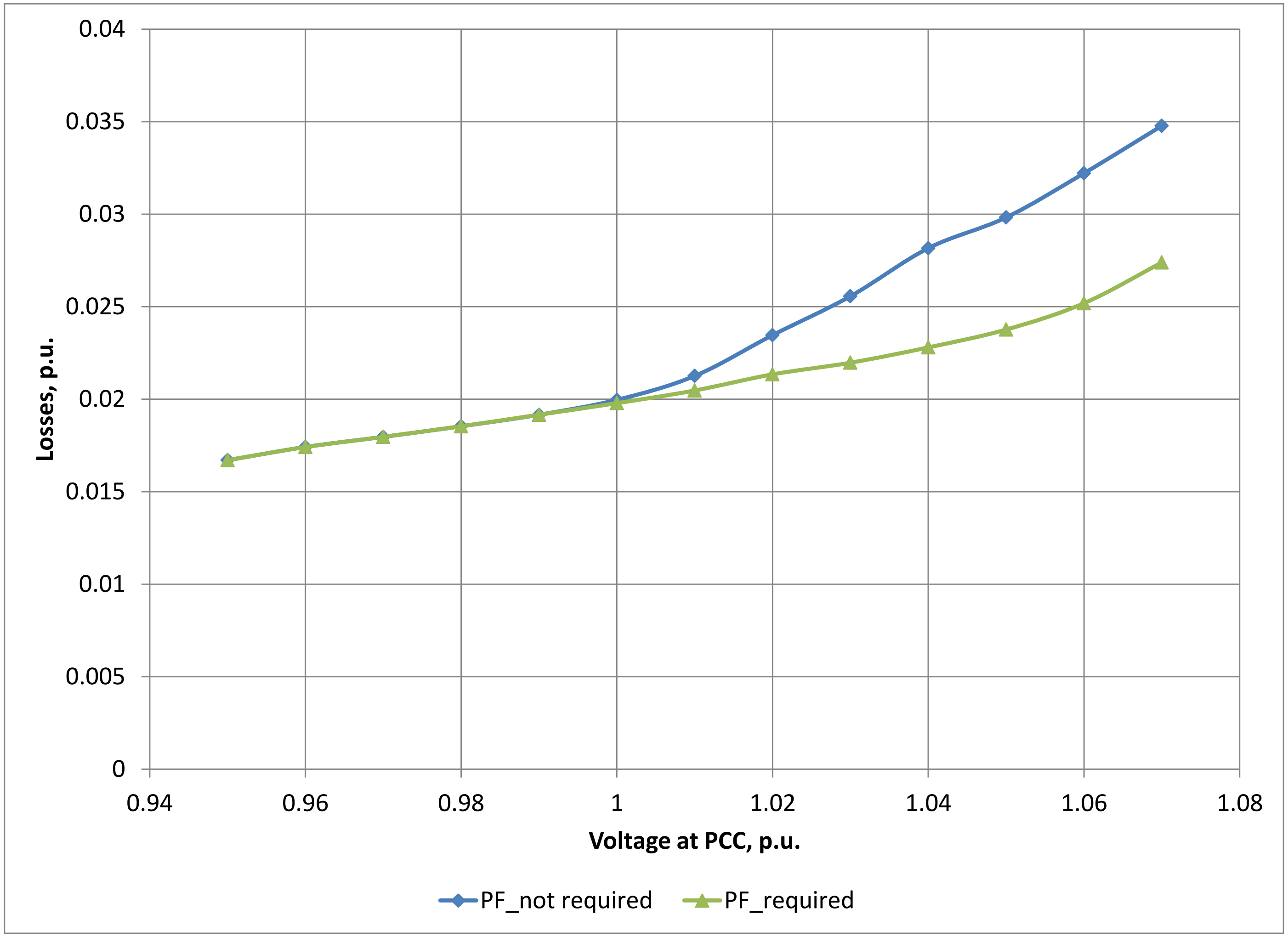

Figure 1-38. Losses before and after EPS request

As seen in the figures, among all these parameters derived by the μEMS, there are parameters that need to be known to the DMS/EMS, and there are parameters for the use by the μEMS. The latter ones are mostly for determining the impacts of the EPS request on the power quality and economics of the μGrid (e.g., secondary voltages, real load, load power factor, and losses, which affect the customers' bills).

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2 Diagrams of Use Case

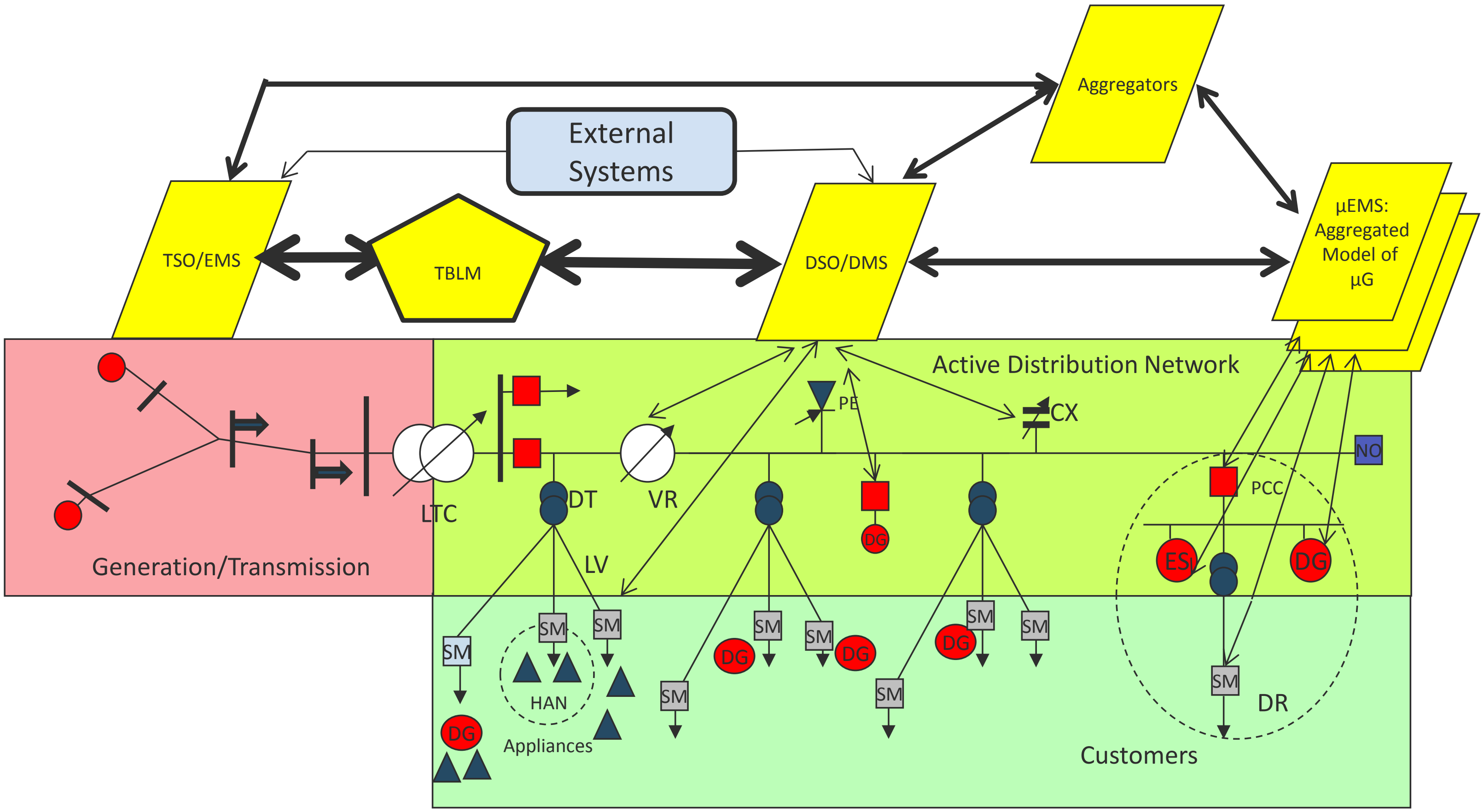

Figure 2-1. Conceptual information exchange between µEMS, other distribution active components, DMS, and EMS

Figure 2-2 through **Figure 2-4** 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.

Microgrid Interactive Use Case #IA-7

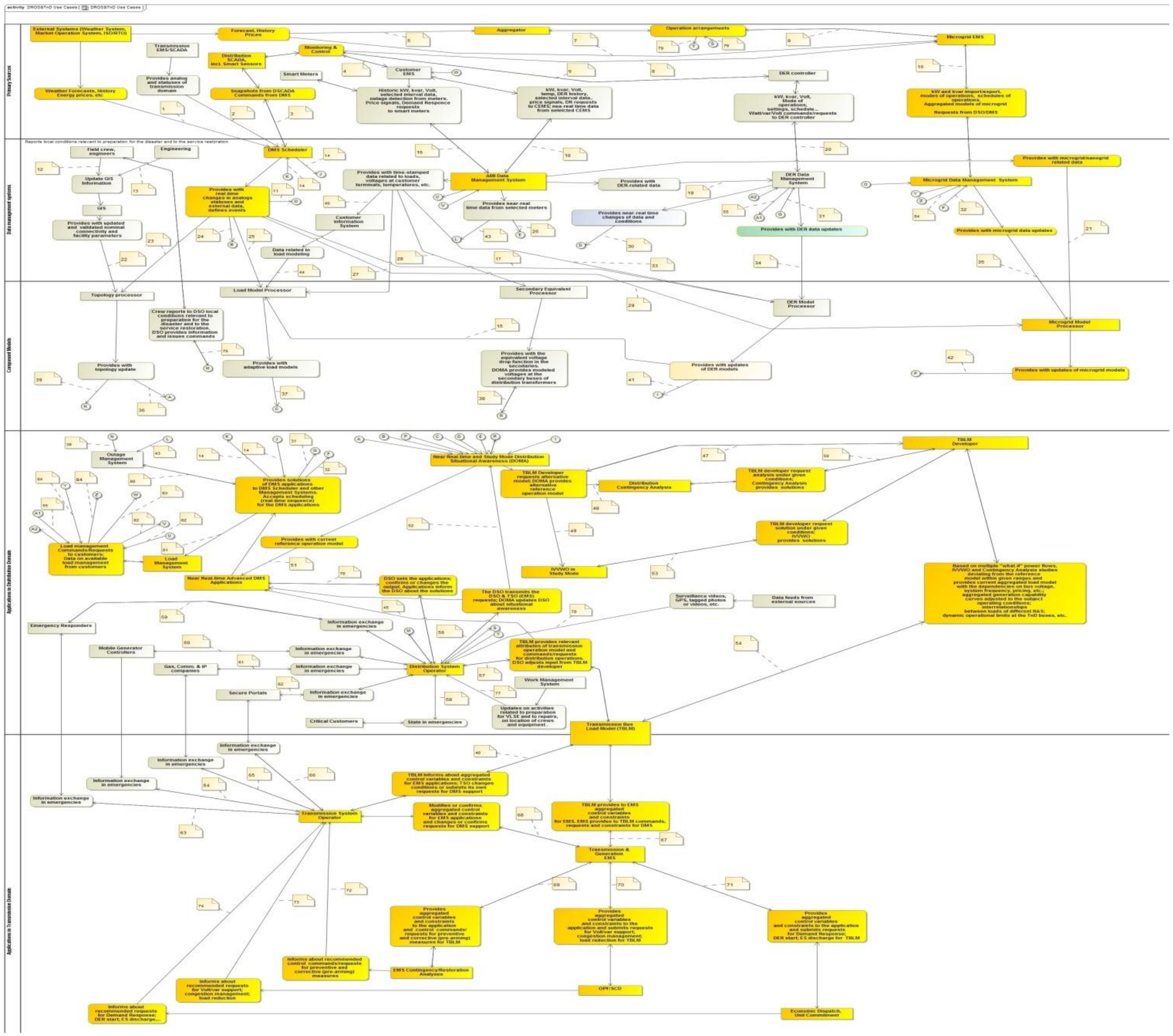

Figure 2-2. Activity diagram for use cases on interactions between customer, distribution and transmission domains

Microgrid Interactive Use Case #IA-7

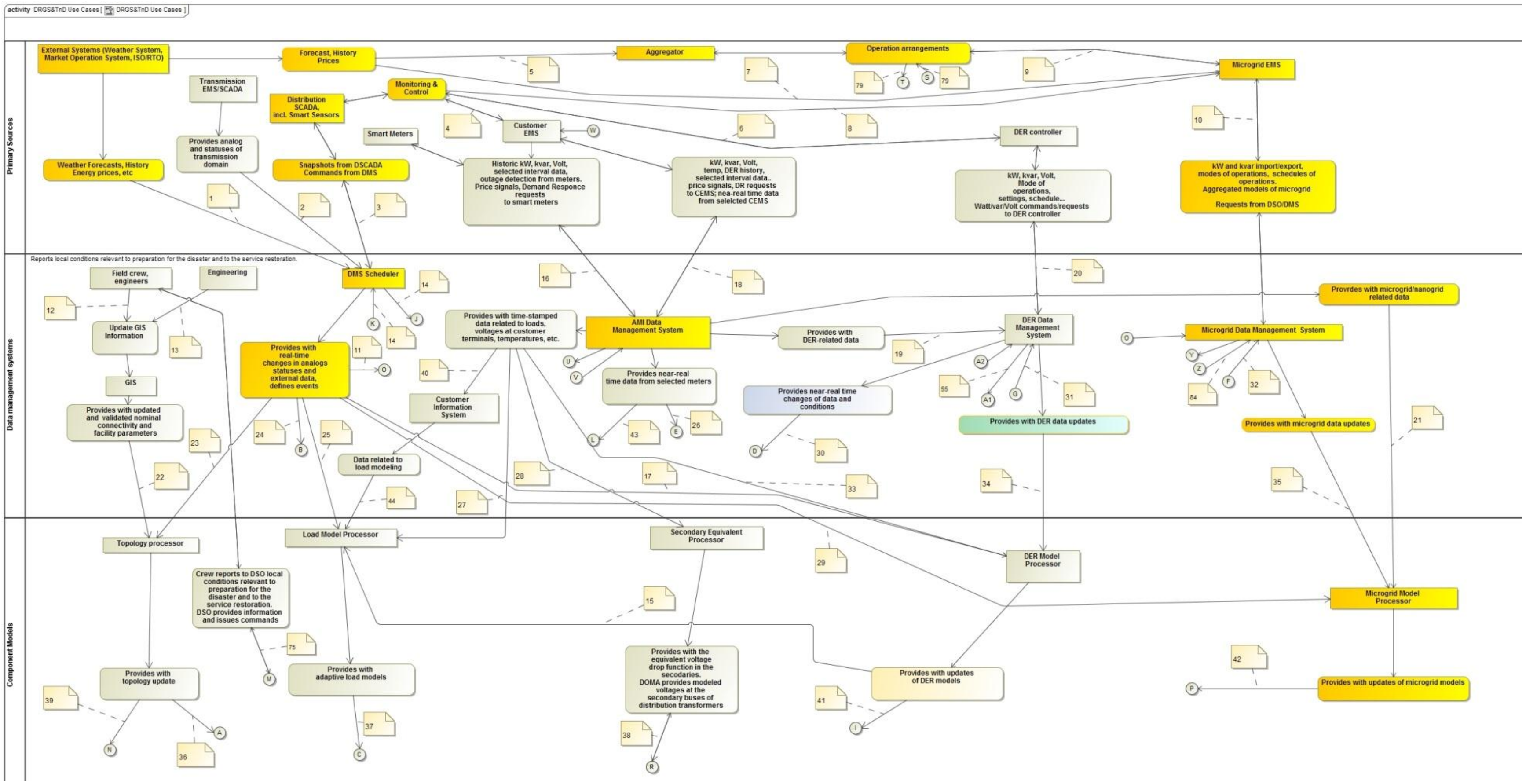

Figure 2-3. Portion of activity diagram for primary information sources and back office systems

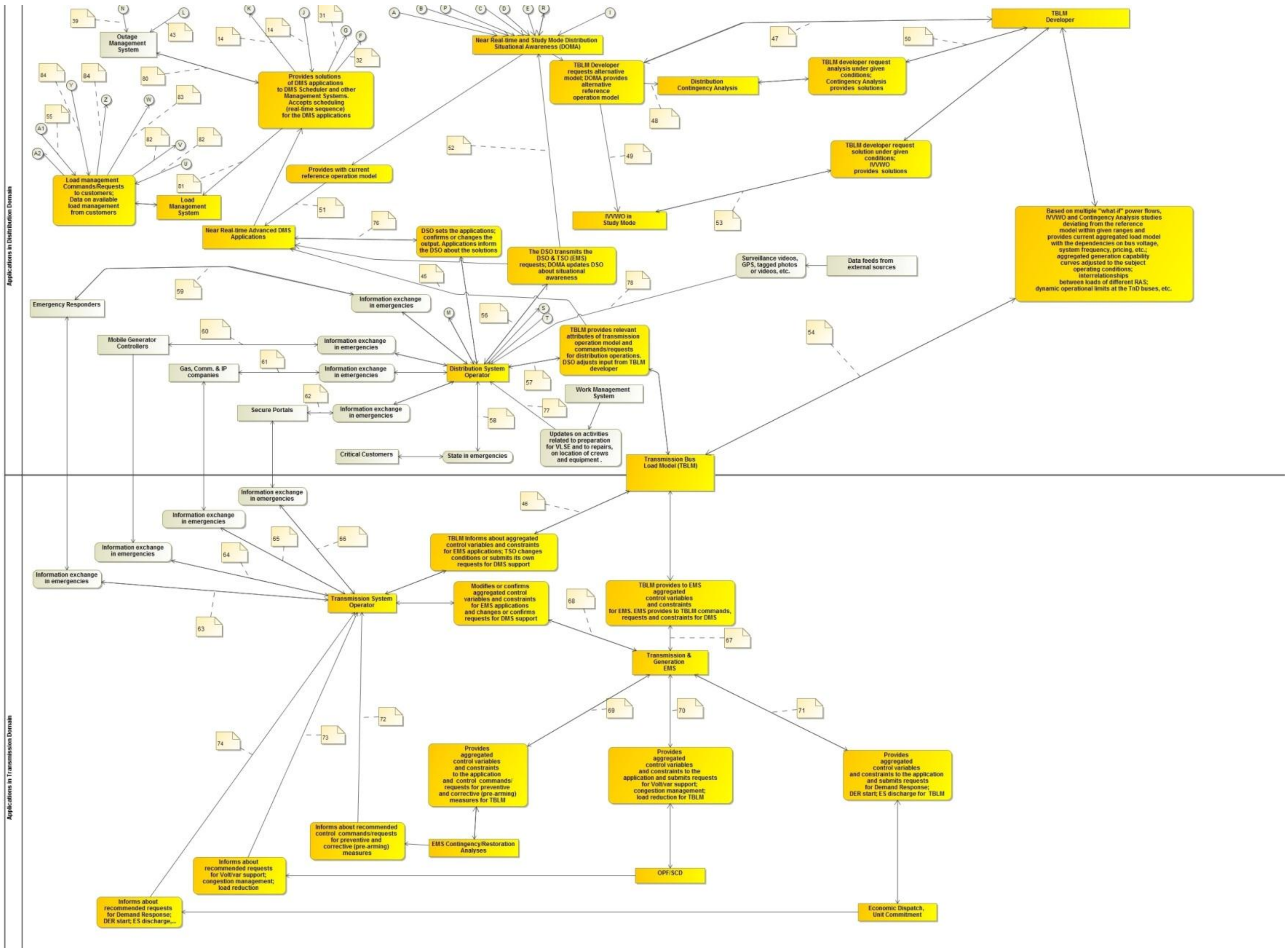

Figure 2-4. Portion of activity diagram for DMS and EMS applications and TBLM

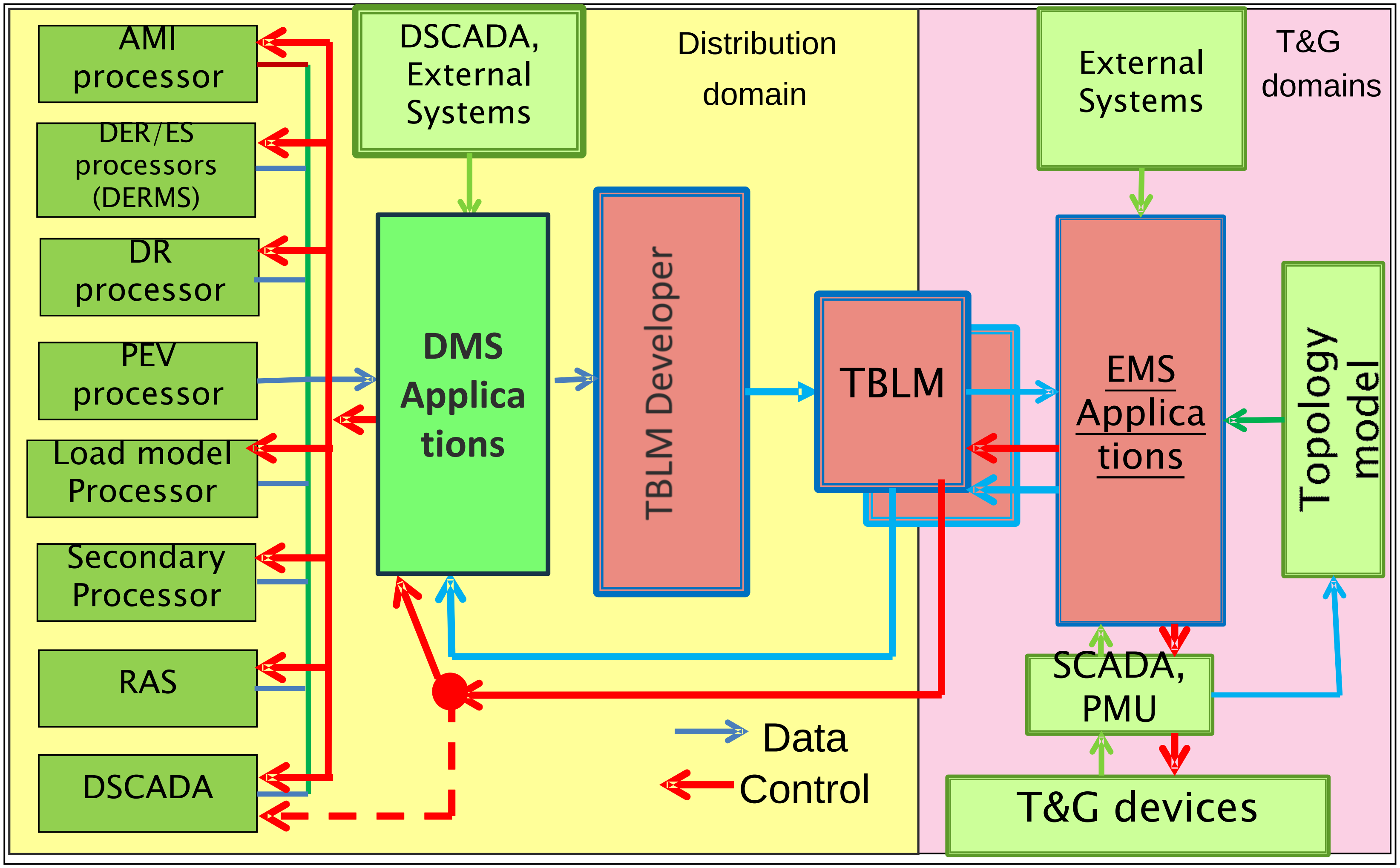

Figure 2-5. Conceptual information exchange between the DMS and EMS through TBLM

3 Technical Details

3.1 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.

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			scenarios.	
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**.
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	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**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			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.	**voltages** • **Critical instantaneous voltages** • **Instantaneous frequency** • **Weather data** • **Attributes of load shedding schemes** • **Attributes of Demand Response** • **Attributes of dispatchable load** • **Aggregated load-to-voltage dependences in the normal and emergency ranges (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,	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

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			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 .	of services, such as: • **Last Gasp/AC Out** • **Demand Response functions** • **Information for customers and third parties** • Communications with HAN
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 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 community, protection 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**
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	Communicates with Data Management System of DMS or other systems dedicated to manage

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			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.	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, protection 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**.
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.	The DER controller communicates 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 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**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				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 and with DMS applications. 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, 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	The participation of a microgrid in a VPP should be governed under

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			one control area.	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. (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

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				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)	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 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 injections and separate	The information obtained from these may contain the following:. • **Temperature** • **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**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			them from the net load of the customer.	**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 for energy products, **including products of the bulk generation, distributed generation, electric storage, electric transportation, and demand response, and composite participants, such as large microgrids. 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	AM/FM/GIS system contains the **geographical information of the distribution power system circuit connectivity, as well as the parameters describing the power**

#	Actor	Actor Type	Actor Description	Further information specific to this use case. New functionalities
			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.	**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 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	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**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			transformers	**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 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 EMS of large and composite consumers and prosumers, including μEMS. 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	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

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			DA applications and initiates execution of their instructions. . .	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.) 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). .	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 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.

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				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 available to authorized systems.	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 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,**	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.

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			etc., according to the designs of the object models and DMS 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: • **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**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				• **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 DMS applications**.	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 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**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				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 and DMS applications**.	Such application may be needed in the µEMS, and other EMS of composite prosumers.
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

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
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.
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**	The operational models of the µG and other composite prosumers should be aggregated in the TBLM

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			• **Overlaps of different load management functions, which use the same load under different conditions.** • **Degree of uncertainty of the distribution model** • **Other**	
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 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 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. 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

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
				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 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 should include the modeling and control of the operations of DER, µGrids, 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.**
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	The application should include the modeling and control of the operations of DER, µGrids, and DR. The application issues **advice to the DSO and/or commands to switching devices in the EPS circuits, to Demand Response**

#	*Actor*	*Actor Type*	*Actor Description*	*Further information specific to this use case. New functionalities*
			• Minimize losses • Minimize exposure to faults • Equalize voltages. • Swap loads to reduce LMPs and assist in congestion management	**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**. 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 µGrids, as well as the generation-load balances of microgrids and other composite prosumers. The existing contractual agreements between the EPS and prosumers of**

#	Actor	Actor Type	Actor Description	Further information specific to this use case. New functionalities
				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 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 application should include the modeling and control of the operations of DER, µGrids, DR, and relevant DMS applications under 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**.

#	Actor	Actor Type	Actor Description	Further information specific to this use case. New functionalities
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 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.	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

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 Figure 2-2 through Figure 2-4**.**

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 status information from the observable portions of the distribution power system Protection and Remedial Action Schemes data	Medium to Large	Minimum exchange times	According to 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	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
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	
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	Small to average	Once a day	Revenue accuracy for kW and kvar; 0.5%-0.2% accuracy for Voltages

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			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.			
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, ride-trough settings, and electric storage parameters.	Small to average	Last gasp - immediately from selected first-reporters; Instantaneous voltages within minutes after fault; Instantaneous frequency – report by exception in autonomous mode of operations. Changes - immediately	0.5%-0.2% for Volt; 0.1% for Hz
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	Small	During the presence at the subject in the field	Verified information

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			(template)			
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 Data requests	Small to average	Immediately after change	
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	kW and kvar	Large	Once a day	Revenue

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
		System (including Last Gasp service)	kWh Load profiles Interval average voltages Weather data Demand response triggers received with timestamps; Commands issued for Demand Response (thermostat, appliances, DER, Storage).			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 increase, or both) Data requests	Small to average	Immediately after change	
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	Small to average	Once a day	Revenue accuracy for kW and kvar; 0.5%-0.2% accuracy for Voltages

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			Action Schemes data			
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 System	Generation kW and kvar 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	Small to average	Once a day	Revenue accuracy for kW and kvar; 0.5%-0.2% accuracy for Voltages

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			Synchronization settings O&M cost functions			
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 operation and setpoints Desired ride-through settings Data requests Synchronization commands	Small	Immediately after change	
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	Small	Immediately after	Verified data

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			changes in topology		change	
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 Management System	Load Model Processor	Load impacting factors with time stamps, e.g., local weather data, Demand Response requests with start and stop times, other related events with timestamps	Large	Once a day	Verified 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	Small	As needed due to significant changes	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			prices			
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 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	Provides with adaptive load models	Average	Once a day	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
		(DOMA)				
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	
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	Small	Periodically and by event	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			conditions or submits its own requests for DMS support			
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	
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	Transmits the DSO & TSO (EMS) requests;	Small	By event	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
		(DOMA)				
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, etc.	Small	By event	
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

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
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 Operator	Transmission Bus Load Model `	Authorizes and/or changes the components in the TBLM	Small	By event	
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	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
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 Controllers	Transmission System Operator	Information exchange in emergencies	Small	By event	
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	Verified information

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
					times a day	
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 Contingency Analyses	Transmission & Generation EMS	Submits control commands/ requests for preventive and corrective (pre-arming) measures	Small	When preventive and corrective measures in distribution are needed	Verified information
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	Small	After every update of TBLM	Verified information

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			EMS applications			
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 needed	Verified information
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	Small	By event	

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			issues commands			
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 System	Advanced DMS applications	Data on outage and restoration management	Small to medium	By events	
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			

# in AD	Source	Recipient	Contents of information	Volume	Timing	Accuracy
			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) Weather related external signals
2) Price related external signals
3) Volt/var support of EPS related external signals
4) VLSE related external signals

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 [i]	Primary Actor [ii]	Name of Process/Activity [iii]	Description of Process/Activity [iv]	Information Producer [v]	Information Receiver [vi]	Name of Info Exchanged [vii]	Additional Notes [viii]
1	A significant change	Weather	Short-term weather forecast	The weather system issues a	Weather	DMS, µEMS	Short-term	

	of the ambient conditions is predicted	system		forecast of the local ambient conditions	system		weather forecast	
1.1	The attributes of the µGrid short-term look-ahead operation model are significantly changed	µEMS	Update of µGrid short-term look-ahead operation model	µEMS provides DMS with the updated short-term look-ahead operation model of the µGrid	µEMS	DMS	Update of µGrid short-term look-ahead operation model	
1.2	The short-term look-ahead operational model of the subject distribution system is significantly changed	DMS	Update of distribution short-term look-ahead operation model	DMS provides the TBLM with the updated short-term look-ahead operation model of the distribution system	DMS, TBLM developer	TBLM	Update of distribution short-term look-ahead operation model	
1.3	DMS runs its applications based on the updated distribution model	DMS	Updates of the solutions of the DMS applications	DMS informs µEMS about adjusted solutions of the DMS applications relevant to the µGrid	DMS	µEMS	Updates of the solutions of the DMS applications	For instance, an intermittent cloudiness is expected in the subject area. The DMS may request that the µGrid prepares its reactive power sources for compensation of the voltage variability. This may result in initial reduction of reactive power generation by the µGrid sources, in loss increase, voltage reduction, etc.

1.4	µGrid changed the setup of its control	µEMS	Updates of the µGrid short-term look-ahead model due to the DMS requests	µEMS informs DMS about the µGrid short-term look-ahead model changes due to the DMS requests	µEMS	DMS	Updates of the µGrid short-term look-ahead model due to the DMS requests	
2	The dynamic prices for energy and or ancillary services are significantly changed	External systems (Market system, ISO, etc.)	Information about significant change in the dynamic prices	The external systems issue new dynamic prices for the look-ahead time interval	External systems	DMS, µEMS	Information about significant change in the dynamic prices	.
2.1	The attributes of the µGrid short-term look-ahead operation model are significantly changed due to the new dynamic prices	µEMS	Update of µGrid short-term look-ahead operation model	µEMS provides DMS with the updated short-term look-ahead operation model of the µGrid	µEMS	DMS	Update of µGrid short-term look-ahead operation model	For instance, the dynamic price is increased above the price-level tolerance of the discharge of the ES. The µEMS decided to employ CVR and start discharging its ES. This results in changes of the µGrid parameters at the PCC and in changes of the attributes of the µGrid operation model.
2.2	The short-term look-ahead operational model of the subject distribution system is significantly changed due to the change in dynamic prices and change in µGrid models	DMS	Update of distribution short-term look-ahead operation model	DMS provides the TBLM with the updated short-term look-ahead operation model of the distribution system	DMS, TBLM developer	TBLM	Update of distribution short-term look-ahead operation model	

2.3	DMS runs its applications based on the updated distribution model	DMS	Updates of the solutions of the DMS applications	DMS informs µEMS about adjusted solutions of the DMS applications relevant to the µGrid	DMS	µEMS	Updates of the solutions of the DMS applications	
2.4	µGrid changed the setup of its control based on new solutions of the DMS applications	µEMS	Updates of the µGrid short-term look-ahead model due to the DMS requests	µEMS informs DMS about the µGrid short-term look-ahead model changes due to the DMS requests	µEMS	DMS	Updates of the µGrid short-term look-ahead model due to the DMS requests	
3	A warning about a coming VLSE is issued	External systems, EPS	Issue of a warning about a coming VLSE	The external systems, EPS issue a warning about the nature and timing of an expected VLSE	External systems, EPS	µEMS	Issue of a warning about a coming VLSE	
3.1	The µGrid implements preventive measures in expectation of the VLSE	µEMS	Update of the µGrid operation model	µEMS updates the_ µGrid operation model for the time interval of the expected VLSE based on the preventive measures implemented by microgrid in response to warning about a VLSE and planned/expected measures to be implemented by microgrid during the VLSE	µEMS	DMS	Update of the µGrid operation model	For instance, the µGrid decided to fully charge its ES regardless of the current energy price, which will change some attributes of the µGrid operation model

3.2	The short-term look-ahead operational model of the subject distribution system is significantly changed due to the preparation for the VLSE	DMS	Update of distribution short-term look-ahead operation model	DMS provides the TBLM with the updated short-term look-ahead operation model of the distribution system	DMS, TBLM developer	TBLM	Update of distribution short-term look-ahead operation model	
3.3	DMS runs its applications based on the updated distribution model	DMS	Updates of the solutions of the DMS applications	DMS informs µEMS about adjusted solutions of the DMS applications relevant to the µGrid	DMS	µEMS	Updates of the solutions of the DMS applications	
3.4	µGrid changed the setup of its control based on new solutions of the DMS applications	µEMS	Updates of the µGrid short-term look-ahead model due to the DMS requests	µEMS informs DMS about the µGrid short-term look-ahead model changes due to the DMS requests	µEMS	DMS	Updates of the µGrid short-term look-ahead model due to the DMS requests	
4	The VLSE started, µEMS implemented the planned measures	µEMS	Updates of the µGrid current model due to the VLSE	µEMS updates the_ µGrid operation model based on the situation during the VLSE based on the implemented measures and other changes due to the VLSE	µEMS	DMS	Updates of the µGrid current model due to the VLSE	

4.1	The short-term look-ahead operational model of the subject distribution system is significantly changed due to the VLSE	DMS	Update of distribution short-term look-ahead operation model	DMS provides the TBLM with the updated short-term look-ahead operation model of the distribution system	DMS, TBLM developer	TBLM	Update of distribution short-term look-ahead operation model	
4.2	DMS runs its applications based on the updated distribution model	DMS	Updates of the solutions of the DMS applications	DMS informs µEMS about adjusted solutions of the DMS applications relevant to the µGrid	DMS, DSO	µEMS	Updates of the solutions of the DMS applications	
4.3	µGrid changed the setup of its control and mode of operations based on new solutions of the DMS applications and the actual situation during the VLSE	µEMS	Updates of the µGrid short-term look-ahead model and status due to the DMS requests and VLSE situation	µEMS informs DMS about the µGrid short-term look-ahead model changes due to the DMS requests and/or due to the VLSE situation	µEMS	DMS, DSO	Updates of the µGrid short-term look-ahead model and status due to the DMS requests and VLSE situation	For instance, the µGrid may go into island mode.
5	The VLSE ended, and the restoration process started.	µEMS	Updates of the µGrid status after the VLSE	µEMS informs DMS about the status after the VLSE and about the desired restoration sequence	µEMS	DMS, DSO	Updates of the µGrid status after the VLSE	For instance, the µGrid is in island mode with a portion of disconnected load and would like to reconnect with the EPS and receive the supply for the disconnected load.

5.1	The transmission/generation system has limited resources for full restoration of services	EMS	Information about restrictions for restoration from the transmission/generation side	The transmission/generation EMS and/or the TSO informs the DMS/DSO about available restoration resources and desirable restoration sequence from the distribution side	TBLM, TSO	DMS, DSO	Information about restrictions for restoration from the transmission/ generation side	
5.2	DMS/DSO develop the restoration strategy	DMS	Instructions for restoration sequences	DMS/DSO informs the µGrid about the restoration orders and issues requests for the µGrid contribution to the overall restoration, if needed	DMS, DSO	µEMS, microgrid operator	Instructions for restoration sequences	For instance, DMS may delay the reconnection of a deficit microgrid, or permit reconnection with limited power intake, or request that the µGrid assists in a black start of a portion of the distribution system, etc.
5.3	µGrid adjusts it operations based on the DMS	µEMS	Updates of the µGrid restorative model, current status and actions due to the DMS requests	µEMS informs DMS about the µGrid restorative model and actions according to the EPS restoration strategy	µEMS	DMS, DSO	Updates of the µGrid restorative model, current status and actions due to the DMS requests	For instance, the µEMS informs about the amount of power the µGrid can supply for a black start of a portion of the distribution system
5.4	DMS/DSO started the restoration process	DMS, µEMS	Information exchange in accordance with the steps of restoration	DMS and µEMS exchange information during the restoration process	DMS, DSO and µEMS, microgrid operator	DMS, DSO and µEMS, microgrid operator	Information exchange in accordance with the steps of restoration	

6	The restoration process is complete	µEMS	Post-factum information about the sequence of event related to the µGrid	µEMS provides DMS with the logs of µEMS activities and other records for the post-factum analyses of the VLSE.	µEMS, microgrid operator	DMS, DSO	Post-factum information about the sequence of event related to the µGrid	

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	10/22/2014	Nokhum	Added illustrations on the dependencies of the microgrid	

		Markushevich	model components on the weather conditions	
7	11/11/14	Nokhum Markushevich	Derived and described the examples for dynamic pricing and volt/var support	
8	11/12/14	Nokhum Markushevich	Added the description of the VLSE scenario	
9	12/11/14	Nokhum Markushevich	Edited the Narrative	
10	1/20/15	Nokhum Markushevich	Revised the list of actors, based on comments	
11	03/23/15	Nokhum Markushevich	Updated to version 2	
12	03/30/15	Nokhum Markushevich	Added the step-by-step actions table	
13	07/07/15	Jim Reilly and Nokhum Markushevich	Formatting for posting	

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[i] Triggering Event corresponds to a Classifier Role that serves as an Activator.

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

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

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

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

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

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