European Network of
Transmission System Operators
for Electricity

DISPERSED GENERATION IMPACT ON CE REGION SECURITY

DYNAMIC STUDY

FINAL REPORT

22-03-2013

ENTSO-E SPD REPORT

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1 EXECUTIVE SUMMARY

Introduction

The interconnected system of Continental Europe extends from Portugal to Poland and from Denmark to Turkey, and feeds a load between 220 and 440 GW.

This large system is operated in a synchronous way, meaning that, when we neglect phenomena with time constant smaller than a few seconds, the frequency is identical everywhere.

In the last decade, in some countries, the penetration of distributed energy sources has increased significantly. Mostly of the renewable type, these generating units are connected to distribution systems and have been subjected to connection requirements compliant with the historical planning and operating principles of distribution systems, which were designed for passive loads. In areas of distribution grids with increased amount of dispersed generation capacity certain electrical faults cannot be managed by the existing protection schemes in a sufficient manner leading to islanding and undefined system conditions. As people safety is a major concern, the detection of the loss of connection to the main network (loss-of-mains detection) is crucial. Loss-of-mains detection is often performed through the measurement of frequency deviations and triggers generation disconnection to avoid keeping energized isolated networks. However, if applied simultaneously to a large number of units, unique frequency thresholds can jeopardize the security of the whole interconnected system in case of frequency deviations.

Currently, in some countries, there are big capacities of installed distributed generation units whose protection settings for automatic disconnection from the grid are not in line with the standard disconnection limits within the transmission system.

Under the impulse of the Regional Group Continental Europe (RG CE) of ENTSO-E, several countries, led by Germany and Italy, have updated the connection requirements of new distributed generating units in order to ensure the disconnection thresholds are set to deviations beyond 47.5 Hz or 51.5 Hz. At the same time more efficient techniques are investigated for the detection of loss-of-mains. In addition, Germany and Italy have started large programs to upgrade (or *retrofit*) a main part of the existing noncompliant units to these new thresholds. The upgrade programs are expected to be finalized by end of 2014.

Scope of work

The work reported here aimed at assessing the risk for the security of the interconnected system in relationship with the big amount of existing dispersed

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generation with disconnection settings (over and underfrequency) that may jeopardize system security and identifying, if any, needs for further retrofit programs.

Work performed

The analysis was performed through simulations in Matlab/Simulink. A dynamic model of the continental system was developed in order to represent the dynamic frequency behaviour. This model was validated against field measurements and generation behavior was modeled according to currently available, approximate figures of distributed generation in Continental Europe. The principles of the RG CE Policy 1 "load frequency control" were taken as basis and, where uncertainties subsist or for scenarios selection, realistic but pessimistic assumptions were taken.

In addition, the model includes the various disconnection settings applied to different generation technologies according to the national regulations and standards of practices in the respective countries. The main factors influencing the frequency stability in the context of this study are:

- the amount of generation capacities tripping at given thresholds,
- the primary frequency control behavior,
- the total system inertia provided by conventional generation depending on the system load demand and the amount of dispersed generation,
- the load characteristic during transient frequency deviation.

The simulations involve a set of rare but realistic triggering events (loss of large amounts of infeed or consumption) and take into account realistic system conditions, including initial steady-state frequency deviations due to power imbalances, e.g. caused by market effects.

Conclusions

The risk is higher at low load and in case of high generation by distributed generating units (high solar irradiance and high wind), because this results in less rotating electric machines and a smaller inertia.

The most critical thresholds are at 49.5 Hz, at 49.7 Hz and 50.2 Hz. The installed cumulated wind and solar capacity *before and after* the ongoing *retrofit* programs (assuming no new units are installed with these thresholds) is estimated to 18.9 GW and 12.5 GW at 49.5 Hz; to 11.8 GW and 2.3 GW at 49.7 Hz; 19.8 GW and 9.3 GW at 50.2 Hz. For a "normal type contingency" (loss of 2 GW of load or 3 GW of generation) the likelihood to reach one of the critical frequency thresholds is significant or even high, if the initial steady-state frequency deviation is higher than 50 to 100 mHz. For an initial deviation not exceeding 50 mHz, this probability is low except at very low demand periods.

If these thresholds are reached after *retrofit* and in case of maximal generation by the dispersed units, the consequence of the massive disconnections is that the frequency will drop to the first step of the automatic underfrequency load shedding (49 Hz). However, this automatic action is able to save the system from a major system break down.

As long as the ongoing *retrofit* programs are not completed, however, the frequency gradient after massive disconnection of distributed generation is so high that the first step of underfrequency load shedding is not sufficient to prevent the frequency to collapse at maximal generation from dispersed units.

Simulations performed demonstrate that German and Italian retrofit programs significantly reduce the likelihood of load shedding. However, even after the completion of the German and Italian programs, the probability to trigger load shedding remains significant and additional retrofit programs also in other TSO control areas are needed to avoid reaching the load shedding threshold of 49 Hz.

The maximum admissible level of non-retrofitted installed capacity disconnecting at 50.2 Hz shall not exceed 6 000 MW for the whole synchronous area.

Quantification for underfrequency thresholds is less straightforward due to the existence of multiple disconnection settings between 50 Hz and 49 Hz (namely, at 49.8 Hz, 49.7 Hz and 49.5 Hz) and because these thresholds are part of a cascade after disconnection from higher frequency thresholds. However 3 000 MW of non-retrofitted installed capacity with disconnection settings between 50 Hz and 49 Hz is a maximum for the whole synchronous area.

Recommendations

Actions to limit the risk of such an event have already been taken by most members of ENTSO-E and include a more proactive role of TSOs in avoiding risk scenarios, managing frequency and the need to update the connection requirements for distributed generation, involving a close cooperation with DSOs to adapt operating principles and to opt for more selective loss-of-mains detection means. New installations of dispersed generation should comply with requirements given by the network code Requirements for Generators (RfG-code, final version to be delivered to the European Commission for the comitology process). TSOs which have not started these actions are urged to initiate them and local authorities have to support this initiative.

In addition, there is a need to keep track (possibly in a common data base) of the characteristics impacting system security of all units connected at the distribution level.

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Future work

In Germany, a complete study is performed in order to identify accurately the main characteristics of existing distributed generation (frequency thresholds and volumes) as well as the cost of performing retrofit. Accurate figures of the existing units are also necessary for the other countries where distributed generation penetration is not negligible. This work is planned in 2013.

Once accurate figures for unit characteristics and retrofit cost will be available, numbers will be given for an additional retrofit program and rules will be set for the allowed volumes of non-compliant units per country.

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2 INTRODUCTION

Due to significant financial incentives and corresponding attractive prices for renewable and decentralized energy production the percentage of this type of generation has been increased considerably in some European countries reaching more than twenty per cent of the system load of these systems. These generation units are mainly connected to the distribution system on low voltage levels.

In the same time, based on the re-structuring of electricity markets and the related operational boundary conditions, the quality of the common system frequency has also decreased. More and more often and for longer time periods the system frequency of the Continental European system deviates from the setpoint by exceeding 49.9 or 50.1 Hz which corresponds to an activation of more than 50% of the positive or negative primary control reserve.

Currently for most of the distributed generation units the protection settings for automatic disconnection from the grid are not in line with the standard disconnection limits within the transmission system. This results in some countries with a significant capacity of installed non-compliant generation units with respect to interconnected system stability.

The settings for distributed generation are in the range of 50.2 - 50.3 Hz for overfrequency and around 49.7- 49.5 Hz for underfrequency while the ranges to mandatory remain connected within the transmission system is 47.5 - 51.5 Hz.

It should be noted that e.g. according to the latest information the related numbers for Germany are 14 000 MW of installed PV with overfrequency automatic disconnection setting of 50.2 Hz and 18 900 MW of installed wind and other distributed generation with underfrequency disconnection setting of 49.5 Hz. Similar for Italy there are already 11 500 MW of installed PV with disconnection settings of 50.3 Hz and 49.7 Hz for over and underfrequency respectively.

Consequently the risk of serious system disturbances due to an uncoordinated disconnection of a high amount of distributed generation corresponding to a multiple of the available primary control power reserve cannot be excluded anymore. It can be foreseen that the resulting system balance might be managed only by the activation of large scale underfrequency load shedding.

The present report describes the analysis performed for defining the required amount of distributed generation, which will have to be refurbished by changing the disconnection settings in order to mitigate the above described risk.

The report is based on a dynamic model analysis with related model parameters derived from the input of the major affected TSOs impacted by significant infeed of distributed generation as well as on dynamic model calibration based on comparison between measurements and simulation of recent important events.

3 SCENARIO SELECTION

With respect to the security analysis it is necessary to consider load/generation scenarios in the whole possible range from the most critical to the less critical values. To this aim the load demand curves in Continental Europe for the third Wednesday in each month of 2011 are used, see Fig. 1 (The demand of Turkey is not included in these figures, which is estimated in the range between 20 GW and 40 GW).

Fig. 2 shows the load duration curve, which corresponds to the load demand curves in Fig. 1. Based on these figures the total demand of the CE region plus Turkey varies in the following range:

- Maximum demand: 440 GW
- Mean demand: 360 GW
- Low demand: 220 GW

Concerning dispersed generation the scenario with maximum infeed was analyzed. The infeed of dispersed generation (PV and wind) and the capacities tripping at different disconnection thresholds were estimated based on the figures given in Table 1 and the corresponding contemporary factors (0.75 for PV; 0.80 for wind). The table shows the status of dispersed generation in ENTSO-E, based on data collected by ENTSO-E in the year 2012. The most critical frequencies are 50.2 Hz; 49.7 Hz and 49.5 Hz, where big amount of PV and wind generation capacities are disconnected.

The quality of the data in Table 1 is quite different. As some figures are based on assumptions and estimations there is a need of detailed inventory in some areas and for some technologies respectively.

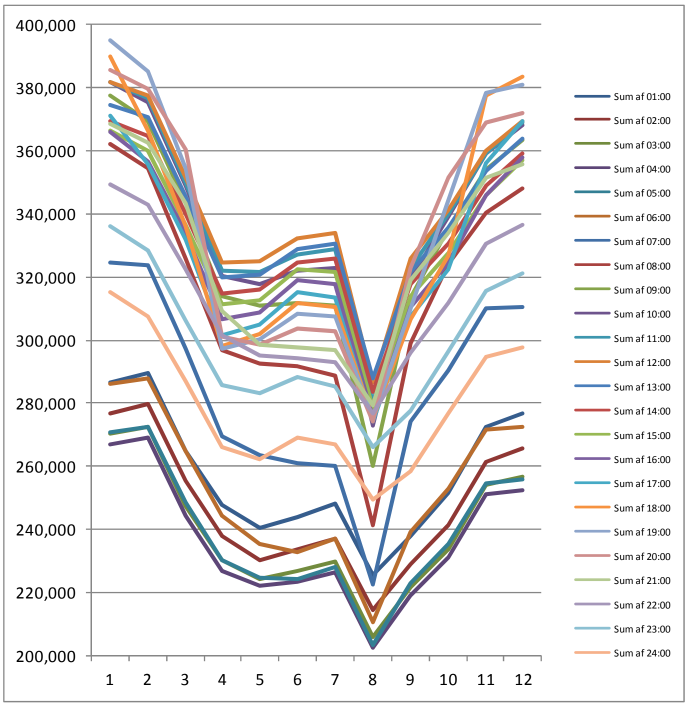

Figure 1: Total demand in MW of the Continental Europe region, third Wednesday of each month in 2011 (without Turkey) /Source: ENTSO-E public webpage/

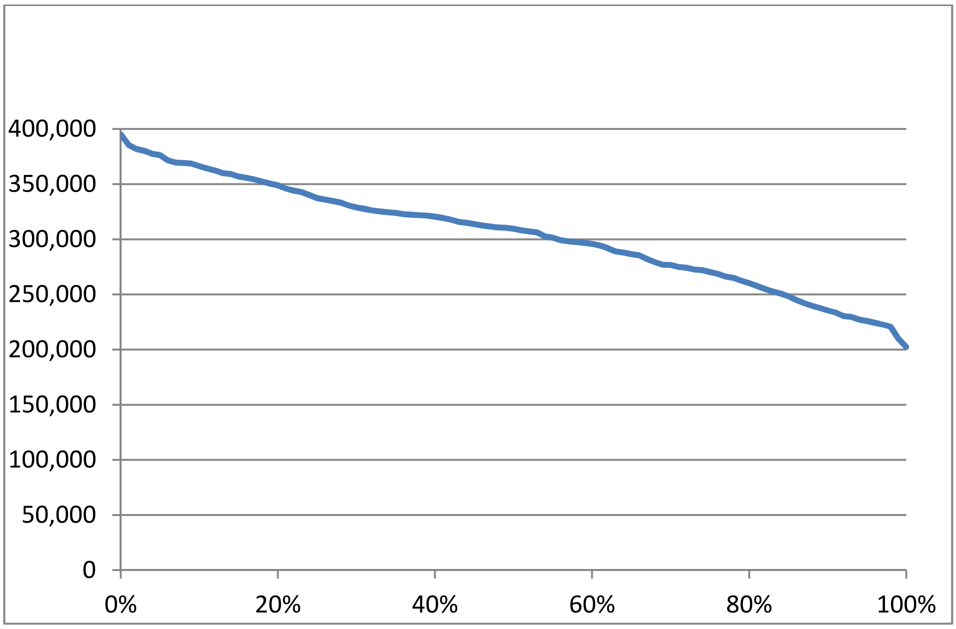

Figure 2: Load duration curve in MW for the third Wednesday of 2011 (without Turkey)

Table 1: Frequency disconnection thresholds and corresponding installed capacity (MW) for dispersed generation in Continental Europe (ENTSO E questionnaire 2012)

	PV						
	installed capacity	50,5	50,3	50,2	49,8	49,7	49,5
Germany	*24800*			14000			
Italy	*14300*		11500			11500	
Spain	*4047*	30					
France	*2500*			2500	75		500
Czech Republic	*1900*			950	860		
Belgium	*2225*	600		1100			
Greece	*1000*	1000					1000
Slovakia	*512*			512			
Portugal	*155*	8		79	79		8
Denmark	*290*			6			
Poland	*5*			5			
Hungary	*4*			4			
Total power at risk	*51738*	1638	11500	19156	1014	11500	1508
After retrofit (D,I)		1638	2300	8656	1014	2300	1508
	WG and other DG						
	installed capacity	50,5	50,3	50,2	49,8	49,7	49,5
Germany	*29100*						18900
Italy	*7200*		350			350	
Spain	*21091*	1032					
France							
Czech Republic							
Belgium	*1402*						
Greece							
Slovakia							
Portugal							
Denmark	*3010*						
Poland							
Hungary							
Total power at risk	*61803*	1032	350	0	0	350	18900
After retrofit (D,I)		1032	0	0	0	0	12500

4 RISK ASSESSMENT IN THE CE REGION

4.1 CLASSIFICATION OF INCIDENTS

With respect to risk assessment it is worth to recall the following standard classification of incidents according to Operational Security Network Code[1] of ENTSO-E:

- Normal incidents,
- Exceptional incidents,
- Out of range incidents.

Incidents are classified as normal, when the triggering event is a single failure. Normal incidents have to be managed by the system in a secure manner, which means that the function of the system has to be maintained without violation of any technical limits. In case of exceptional contingencies interruption of transits or supply is accepted, however the integrity and stability of the system must be ensured. Out of range contingencies might have severe consequences and might be not controllable for the system. In order to avoid a total blackout in such a case a Defence Plan is generally implemented.

In the context of this study such incidents are relevant, which are related with power imbalances and frequency control. Using the above mentioned principles **normal incidents** are:

- loss of load ≤ 2 GW or
- loss of generation ≤ 3 GW,

which might be caused by single events like:

- trip of the HVDC link between France and Great Britain in export conditions or
- busbar failure with generation loss.

The combination of two or more events is considered as **exceptional incident** like:

- loss of load > 2 GW,
- tripping of generation with deficit between 3 GW and 6 GW,

An example for **out of range incidents** are multiple contingencies leading to system splitting with high surplus/deficit of the power balance in different areas.

Normal incidents are investigated in the simulations reported in following chapters.

[1] draft version submitted to ACER by 1 March 2013.

4.2 DETERMINATION OF CRITICAL CONDITIONS TO REACH 50.2 HZ

This chapter is dealing with the security risk in the current situation until the ongoing retrofit programs in Germany and Italy are finished. It is obvious that the frequency shall not cross the first disconnection threshold at 50.2 Hz during time periods of high infeed by solar panels, as a huge amount of PV panels are disconnected at 50.2 Hz. The resulting power deficit cannot be managed by the system; even automatic load shedding might not prevent the system against system collapse due to high frequency transients and extreme variation of the load flow pattern causing risk of overloading of transmission lines. That means in the current situation it has to be ensured that the frequency remains below 50.2 Hz after normal incidents during daytime.

Several simulations in the different scenarios considered by the study were carried out in order to determine the admissible amount of load to be lost, when 50.2 Hz shall not be reached. The results are resumed in Fig. 3, where the box colored in violet represents the loss of 2 GW of load, which has to be considered as the maximum load, which can be lost after a single fault/normative incident in CE.

The simulation results can be summarized as follows. In case of a single fault/normative incident with loss of 2 GW of load:

- starting at 50,0 Hz there is practical no risk to reach 50.2 Hz,
- starting at 50.05 Hz the risk is evident only during very low demand periods (around 220 GW),
- starting at 50.1 Hz the risk is real also at typical load demand (around 360 GW).

The dynamic frequency behaviour can be confirmed by real incidents recorded by WAMs. Fig. 4 shows the frequency after loss of 2000 MW during typical load condition. The transient frequency deviation was 80 mHz and the steady state value around 60 mHz.

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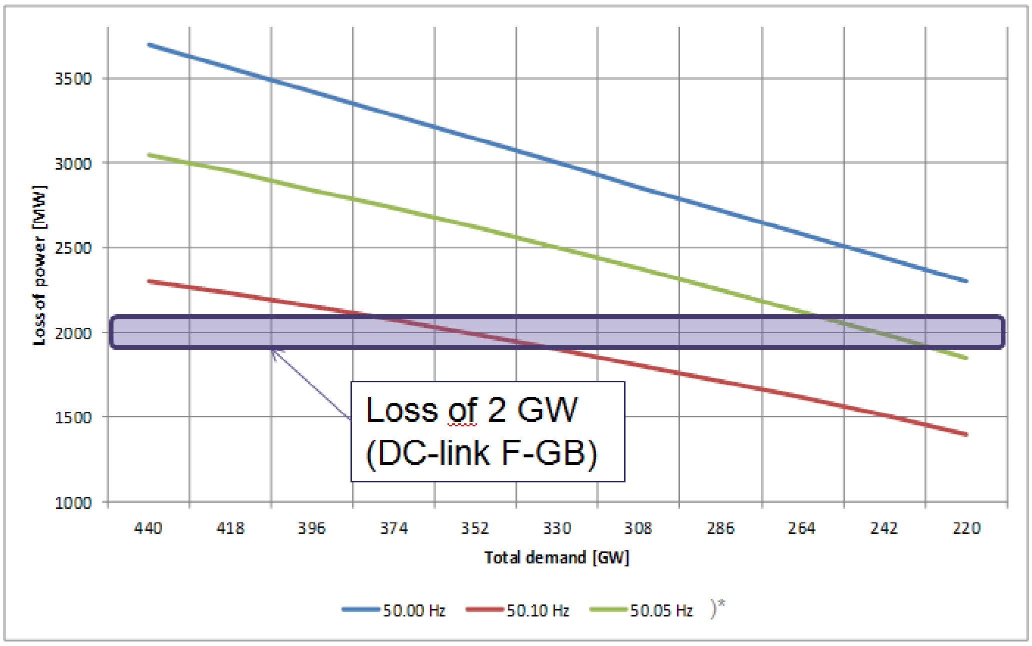

)* stationary frequency before the incident

Figure 3: Loss of load leading to 50,2 Hz depending on total system load

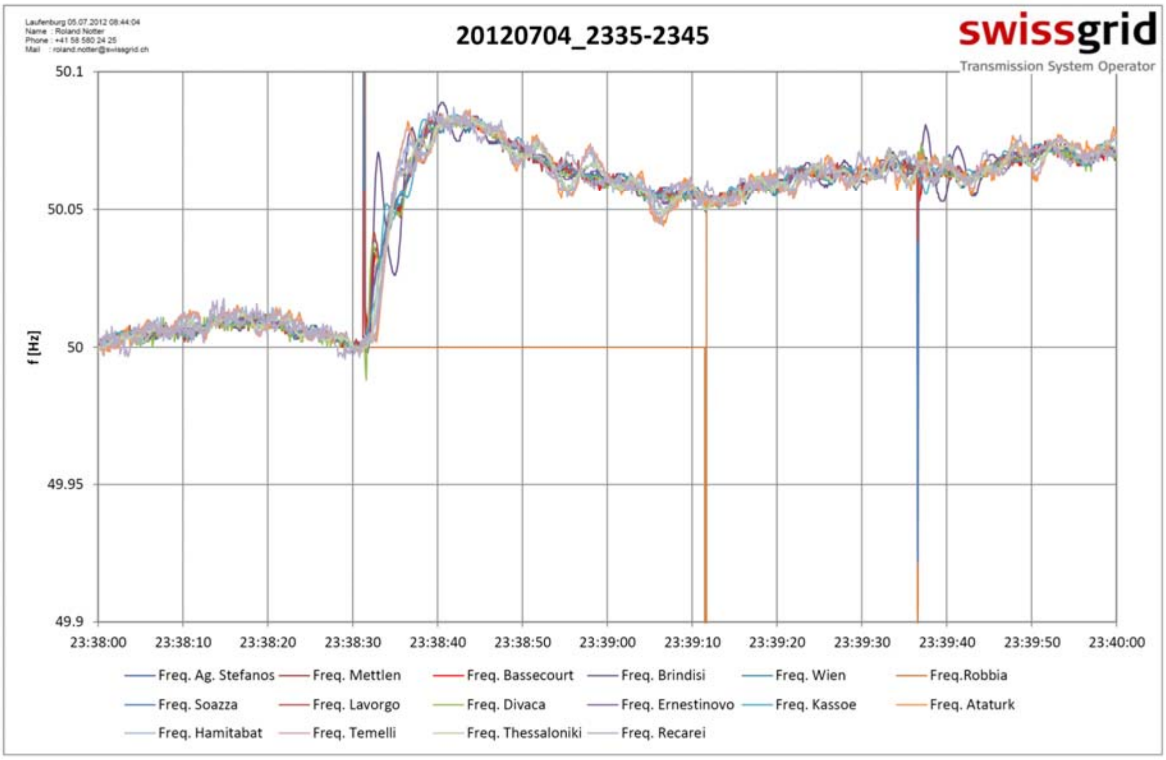

Figure 4: Recording of system frequency after loss of load

Considering the report "Assessment of the System security with respect to disconnection rules of Photovoltaic Panels" it can be quoted that two phenomena cause significant increase of the frequencies up to about 150 mHz:

- *during the daily main load ramping period during morning and evening hours and simultaneous connection/disconnection of large amount of generation units*
- *loss of a DC link with interruption of power export*

The combination of these events might lead to a higher increase of the frequency of more than 200 mHz and consequently to an overfrequency above 50.2 Hz. From the current experience this scenario is less probable during midday, when there is high infeed from solar panels.

In contrast to this previous assessment it must be noted based on recent operational experience that there is a real possibility to reach a steady-state frequency over 50 Hz in normal operation during midday. This risk is evident, like 04/05/2012 midday, Fig. 5, when a frequency around 50.1 Hz was reached as steady-state frequency during normal operation.

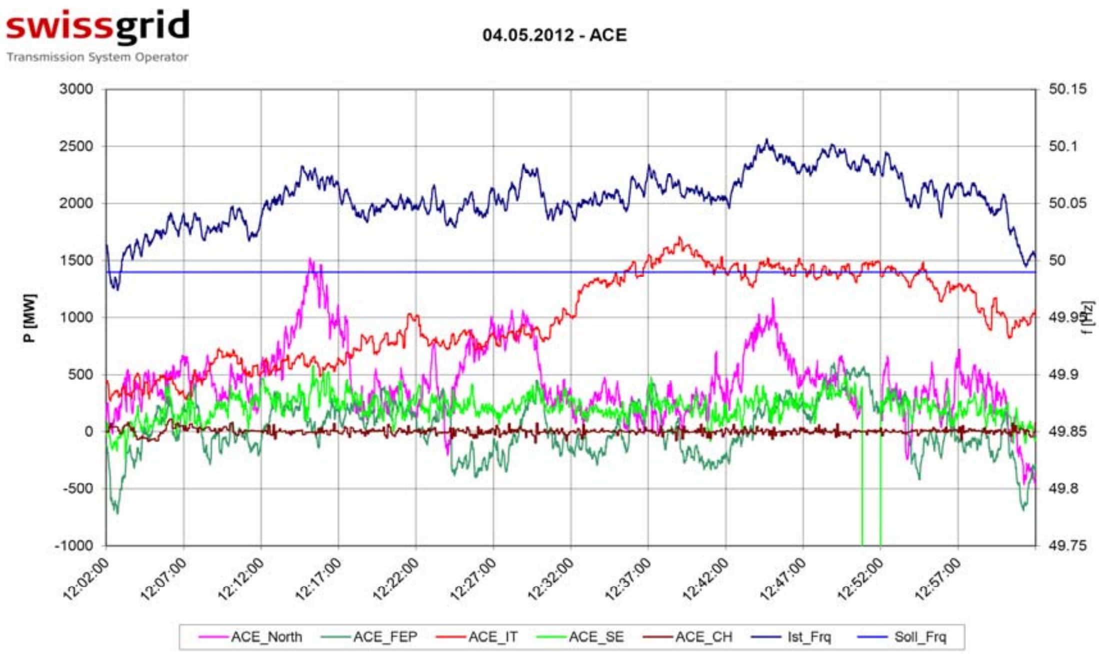

Figure 5: WAMs recording of the frequency on 4/5/2012

Figure 6 shows that the duration and number of occurrences of frequency deviation from nominal value outside the range +/- 75 mHz was increasing during the last years; in particular this phenomena was present during 36.6 hours in 2012 against 28.5 hours in 2011. This corresponds to an increase of 28% within one year.

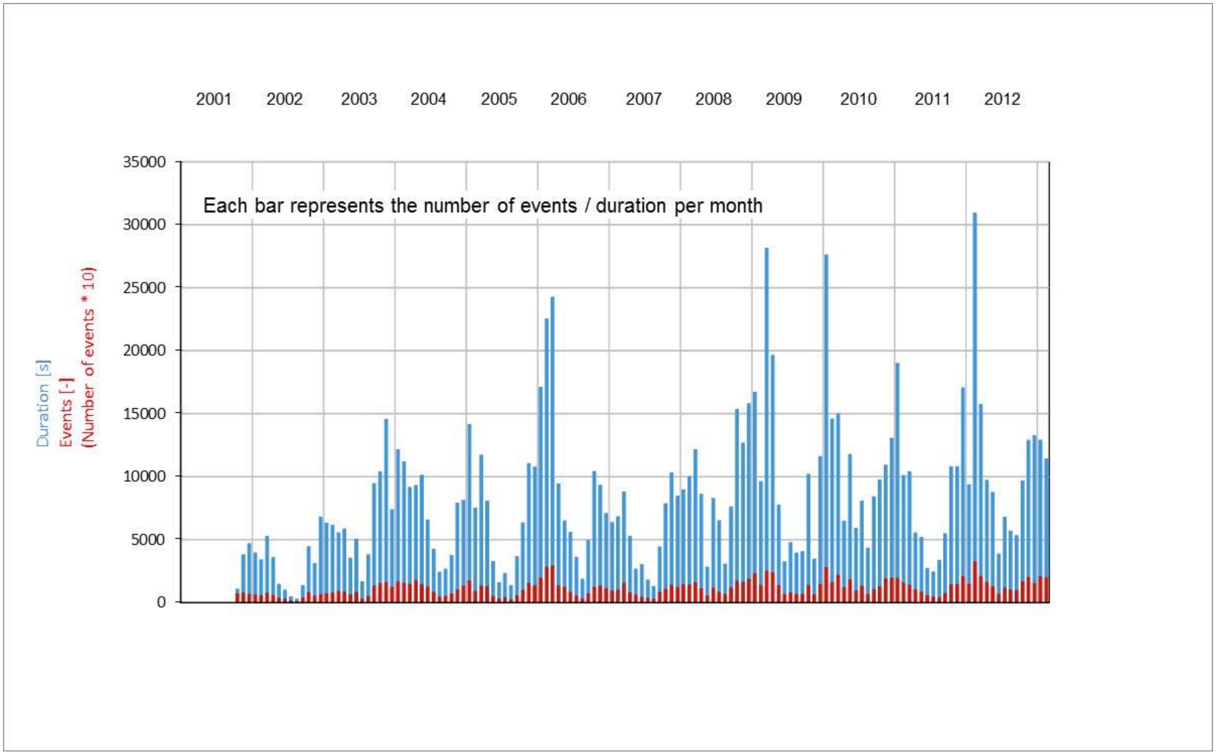

Figure 6: Duration and number of occurrences of frequency deviation (>75 mHz), year 2001 - 2012

These considerations show that

- at typical load demand, a load trip around 2000 MW causes a frequency increase around 100 mHz
- during normal operation, without events, frequency can be in steady-state between 50.05 Hz and 50.1 Hz or even higher

The coincidence of these situations can drive the system to 50.2 Hz and consequently cause a severe risk for the system to collapse. Therefore there is a need for actions in order to keep the steady-state frequency below 50.1 Hz during daytime. Adequate operational measures were implemented by the TSOs in the CE region.

4.3 ANALYSIS OF RETROFIT SCENARIOS

The effect of different contingencies on the system frequency was analyzed under consideration of different scenarios for retrofit programs. The applied contingencies are to be considered as normative incidents and therefore have to be managed in a secure manner, especially load shedding should not be activated; in case of load shedding the assumption is that ENTSOE system activates load shedding plan according to policy 5 prescriptions.

Case 1: Overfequency
Initial contingency: Stationary overfrequency and loss of load causing frequency above 50.2 Hz

Case 1a: Loss of 8600 MW of dispersed generation capacity at 50.2 Hz.

This figure is an estimation of the amount of dispersed generation for all countries tripping at 50.2 Hz after PV retrofit in Germany.

The 50.2 Hz threshold is reached after loss of 2 GW load starting at 50.1 Hz, see Fig. 7. Due to the generation loss the frequency deceases and reaches the threshold 49.7 Hz after a few seconds, where additional generation of 1275 MW trips (corresponding to 2300 MW of installed PV and other dispersed generation, which are currently not included in the ongoing retrofit programs). Subsequently the threshold at 49.5 Hz is crossed triggering the loss of 10400 MW of dispersed generation capacity (estimated amount of dispersed generation, which trips mainly due to non-retrofitted wind generation units in Germany). In this case the impact on the system is only managed with heavy intervention of the automatic load shedding schemes.

The simulation shows the need for further retrofit programs. Especially the amount of generation from PV and wind tripping at 50.2 Hz and 49.5 Hz respectively is too high.

Case 1b: Loss of 6000 MW of dispersed generation capacity at 50.2 Hz

In order to prevent any further cascading effects due to crossing other disconnection thresholds the frequency must not cross 49.7 Hz, because at this threshold generation capacities would trip followed by frequency excursion to the next lower disconnection threshold at 49.5 Hz.

The simulation shows that the dynamic frequency deviation is stabilized just above 49.7 Hz. Consequently the loss of 6000 MW is the maximum amount of generation trip at 50.2 Hz in order to meet the requirement, that crossing this critical threshold shall be managed without further cascading effects or activation of load shedding.

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Case 2: Underfrequency
Initial contingency: Loss of 3 GW generation causing underfrequency

Case 2a: Disconnection of:

1725 MW PV generation at 49.7 Hz
1725 MW of wind generation at 49.5 Hz
(corresponding to installed capacity of 2300 MW respectively)

Due to the generation loss, the frequency is decreasing and crosses 49.7 Hz and 49.5 Hz. At each threshold the disconnection of 1725 MW of dispersed generation is triggered. The simulation in Fig. 8 shows that the remaining non-compliant capacities still cause the risk of load shedding activation. This is not acceptable, because the loss of 3 GW generation is considered as a normative contingency.

Case 2b: Disconnection of

1725 MW PV generation at 49.7 Hz
525 MW of wind generation at 49.5 Hz
(corresponding to installed capacity of 2300 MW and 700 MW respectively)

Based on this assumption the loss of 3 GW generation can be managed without triggering the load shedding plan. In total the installed capacity of non-compliant generation capacity tripping in the range between 49 Hz and 50 Hz amounts 3000 MW. The final numbers of the admissible non-compliant capacities at different thresholds shall be adjusted under consideration of technical aspects of possible retrofit programs.

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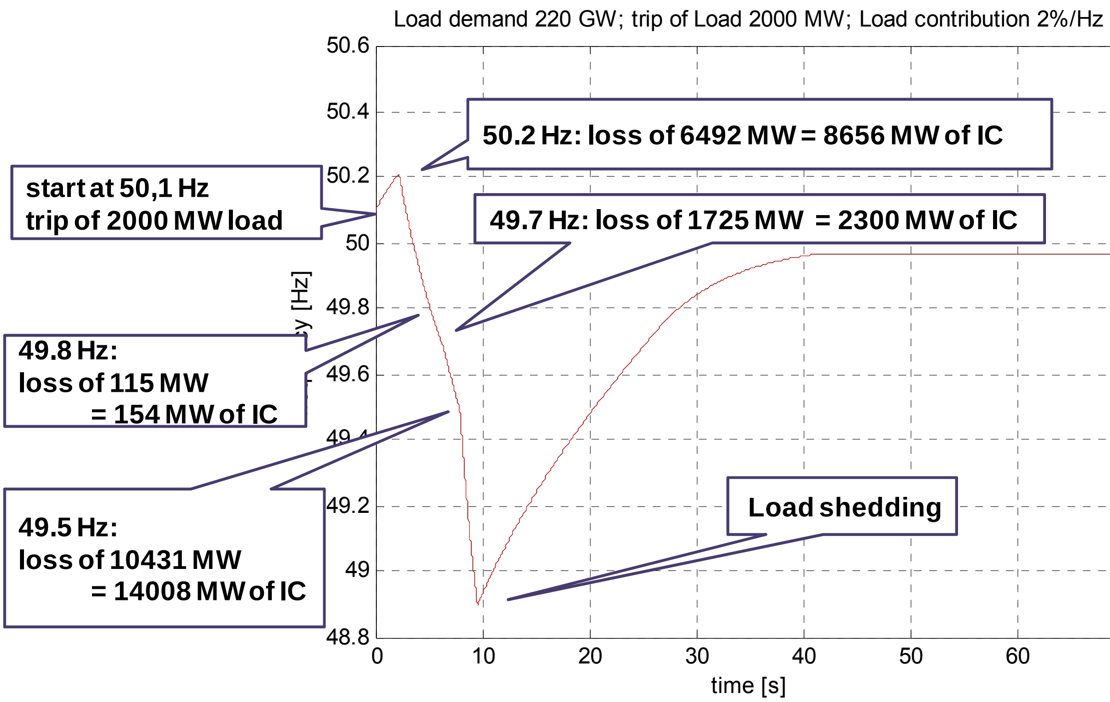
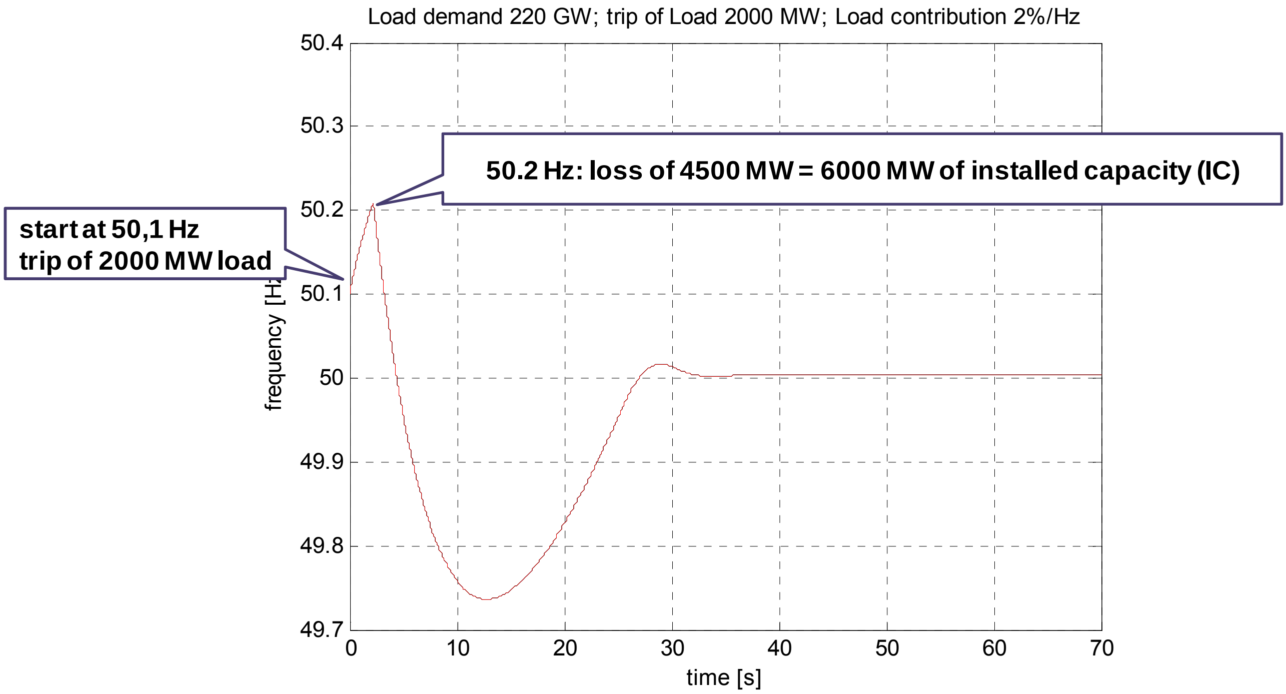
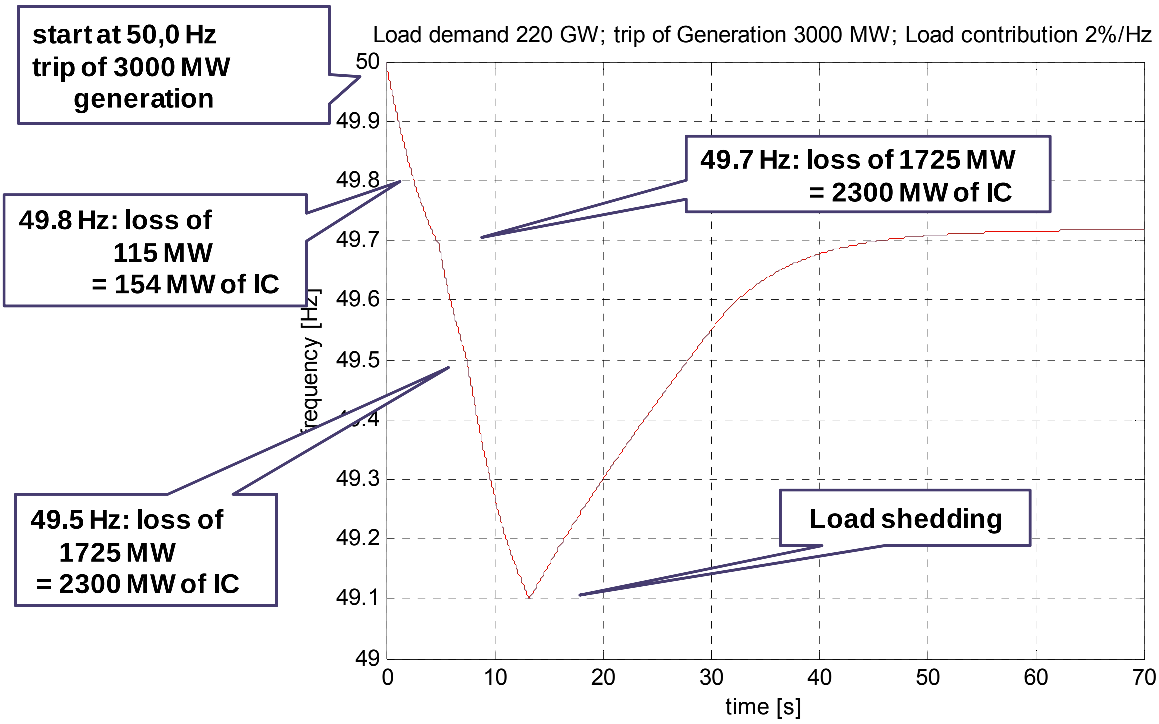


Case 1a: Simulation of 2 GW load rejection with actual retrofit program (IC= Installed capacity)

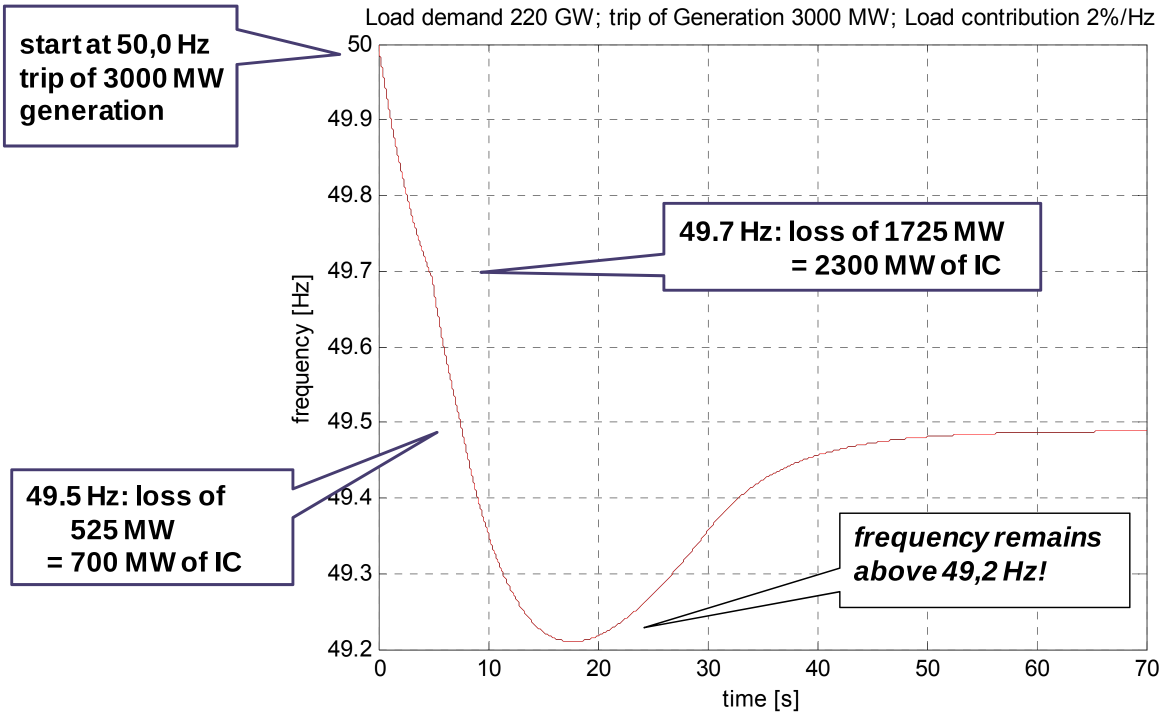


Case 1b: Simulation of 2 GW load rejection with additional retrofit for 50.2 Hz

Figure 7: System frequency behaviour after crossing 50.2 Hz for different retrofit scenarios



Case 2a: Simulation of 3 GW generation loss with retrofit for 49.5 Hz



Case 2b: Simulation of 3 GW generation loss with additional retrofit for 49.5 Hz

Figure 8: System frequency behaviour after loss of 3 GW generation for different retrofit scenarios

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4.4 AUTOMATIC RECONNECTION

With reference to dispersed generation, it is possible to distinguish between different potential causes of trip:

1. Local fault, that involves a few plants in a limited area: this kind of fault must be selectively eliminated by corresponding protection settings;
2. System frequency excursion, that drives the frequency out from the range prescribed for the distributed generation plants (47.5 Hz … 51.5 Hz)
3. Abnormal overfrequency excursion that implies a regulation obtained by controlled trip of cluster of plants.
4. Other local causes (voltage, internal fault, etc.)

Due to the enormous quantity of dispersed generation plants, it is not possible for the TSO underfrequency coordinator action, to manage the gradual reconnection acting on single site. On the other side, the system needs as soon as possible the contribution from dispersed generation, in order to restore balance between loads and generation.

Due to these reasons, it is necessary to assume a transitory phase that will bring the system toward the smart grid control where it can be handled with the following rules: an automatic reconnection rule can be accepted, but limited to type A, B and C plants, with reference to ENTSO-E Connection Grid Code. For D type plants, typically under direct TSO control, the automatic reconnection must be forbidden.

The main requirements for the system security are:

- The plant must recognize that frequency it stable;
- The ramp of the plants that are automatically reconnected must be sustainable by the system

The check of frequency stability can done defining a range where frequency it is contained for at least a certain time interval; the proposed logic it is displayed in Fig 9.

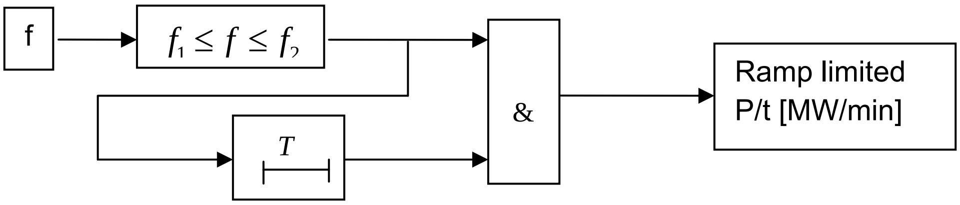

Figure 9: Block scheme for automatic reconnection

The recommended settings are:

- Frequency stable in the range between 49.9 (f_1) Hz and 50.1 (f_2) Hz
- Delay time T: from 60 to 300 s, established by single TSO
- Maximum gradient of ramp limited delivered power: ≤ 20% of maximum power / min

The suggested criteria imply a revision of ENTSO-E P5-C-S3.7 “RECONNECTION OF GENERATORS AFTER ABNORMAL FREQUENCY EXCURSION”, designed explicitly in order to avoid the uncontrolled automatic reconnection of large power plants (now in the ENTSO-E grid code, named “D” type).

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5 CONCLUSIONS AND RECOMMENDATIONS

This report provides an assessment of the system security with respect to disconnection rules of dispersed generation.

Conclusions

- The coincidence of steady-state frequency deviations and the loss of approx. 2000 MW load (e.g. HVDC link France-Great Britain) can drive the system to 50.2 Hz. The disconnection of a large amount of noncompliant generation capacity causes large power imbalances and consequently very high frequency transients, which can only be managed by large amount of underfrequency load shedding. There is a severe risk for the system to collapse.

- The already started PV retrofit programs in Germany and in Italy are essential for the overall system security. After completion of the program the security risk will be reduced. However, the total quantity of generation loss according to the remaining not retrofitted dispersed generation capacity is still too high and needs further retrofit programs concerning 50.2 Hz, 49.8 Hz and 49.5 Hz.

Recommendations

1. **Automatic reconnection**
   After a severe frequency transient, the system can be partially split in some electrical islands or in a totally Blackout state; the frequency coordinator must manage the system re-meshing taking into account the single TSO PV generation at risk of trip during the maneuvers. Due to the dramatic diffusion of PV panels on LV and MV networks, automatic reconnection is permitted, but specific logics are required in order to avoid reconnection during restoration phase and to guarantee a maximum total gradient of the PV power generation after resynchronization.

2. **Responsibility of the DSOs during restoration**
   During a single TSO restoration it is under responsibility of the DSOs to manage the PV plants in order to guarantee the requested total load/generation equilibrium requested by the National Restoration plans under coordination of the affected TSO.

3. **Implementation of Requirements for Generators (RfG-code)**
   According to Article 8, GENERAL REQUIREMENTS FOR TYPE A UNITS /5/ all generation units (capacity ≥ 800 W) shall fulfill the following requirements referring to frequency stability: in case of deviation of the Network frequency from its nominal value, due to a deviation within the frequency ranges and time periods

specified in /5/, table 2, any automatic disconnection of a generating unit from the network shall be prohibited and power infeed shall be maintained.

Figures for the CE region are:

- 47.5 Hz – 48.5 Hz To be decided by each TSO pursuant to Article 4(3), but not less than 30 minutes
- 48.5 Hz – 49.0 Hz To be decided by each TSO pursuant to Article 4(3), but not less than the period for 47.5 Hz – 48.5 Hz
- 49.0 Hz – 51.0 Hz Unlimited
- 51.0 Hz – 51.5 Hz 30 minutes.

That means no automatic disconnection in the frequency range from 47.5 Hz to 51.5 Hz shall take place. This regulation should be implemented as soon as possible in all CE areas.

4. Maximum admissible amount of noncompliant generation capacity

Realistic scenarios like loss of generation due to disconnection at 50.2 Hz or loss of 3 GW generation shall be managed without further cascading effects and without load shedding.

To this aim the maximum admissible amount of non-retrofitted installed capacity with disconnection settings at 50.2 Hz is 6 000 MW for the whole synchronous area. The maximum admissible installed capacity of generation units with disconnection settings in the range between 50 Hz and 49 Hz is 3 000 MW for the whole synchronous area.

When the retrofit programs in Germany and Italy are finished, the total installed capacity that would be disconnected between 50 Hz and 49 Hz is still too high and therefore further retrofit programs are required.

5. European wide inventory about dispersed generation

It is important to initiate an inventory of the current disconnection settings and technical parameters of dispersed generation in the CE region. These parameters depend e.g. on the various technologies of dispersed generation and the different development of connection rules/standards during the last years in the respective countries. A huge amount of information has to be collected from different sources; the information must be detailed and synchronized in terms of picture of different countries at same time.

These data are needed for the assessment and implementation of further retrofit strategies.

ENTSO-E • Boulevard Saint-Michel, 15 • 1040 Brussels • Belgium • Tel +32 2 737 15 80 • Fax +32 2 741 69 49 • info@entsoe.eu • www.entsoe.eu

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