Technical Report

Assessment of the Effectiveness of Neutral Voltage Displacement (NVD) Protection in Mitigating the Risks Imposed by a Relaxation of Loss-Of-Mains Protection Settings Applied to Generation Connected to the Electricity Network in Northern Ireland (Annexe to Phase 1)

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Table of Contents

Abbreviations and symbols

BSP	- Bulk Supply Point
DRR	- Dynamic Reactive Response
FRC	- Fully-Rated Converter
IC	- Inverter Connected
IM	- Induction Machine
NIE	- Northern Ireland Electricity
NDZ	- Non-Detection Zone
NVD	- Neutral Voltage Displacement
LOM	- Loss-Of-Mains
WFPS	- Wind Farm Power Station
P_L, Q_L	- active and reactive power of the load
P_{DGG}, Q_{DGG}	- active and reactive power supplied by the group of distributed generators
NDZ_{PE}, NDZ_{QE}	- exporting NDZ (generator output is higher than the local load during LOM)
NDZ_{PI}, NDZ_{QI}	- importing NDZ (generator output is lower than the local load during LOM)
T_{NDZmax}	- maximum permissible duration of undetected islanding operation
n_{NDZ}	- number of detected NDZ periods
T_{load_record}	- total length of recorded load profile
$T_{NDZ(k)}$	- length of k-th NDZ period.
P_2	- probability of non-detection zone for generator group P_{DGG}, Q_{DGG}
P_3	- probability of non-detection zone duration being longer than T_{NDZmax}
P_4	- probability of NVD protection not operating
$N_{LOG,1IP}$	- expected number of incidents of losing supply to a single islanding point in 1 year
n_{LOG}	- number of Loss-Of-Grid incidents experienced during the period of T_{LOG} in a population of n_{IP} islanding points
$N_{LOM,1DGG}$	- expected annual number of undetected islanding operations longer than the assumed maximum period T_{NDZmax} for a single DG
T_{NDZavr}	- overall average duration of the NDZ
T_{NVD}	- NVD protection operating time
T_{LOMavr}	- overall average duration of the undetected islanded condition
T_{ARmax}	- expected maximum time of auto-reclose scheme operation
$n_{DGG(m)}$	- number of all connected distributed generator groups in a given generation mix m
$p_{ROCOF(m)}$	- proportion of generators with ROCOF protection in a given generation mix m
$LF_{(m)}$	- load factor for a given generation mix m
$N_{LOM(m)}$	- expected number of undetected islanding incidents in 1 year (in generation mix m)
$T_{LOM(m)}$	- total aggregated time of undetected islanding conditions in 1 year (in generation mix m)
$P_{LOM(m)}$	- probability of the occurrence of an undetected island within a period of 1 year (in generation mix m)
N_{LOM}	- expected national number of undetected islanding incidents in 1 year
$N_{LOM,E}$	- annual rate of occurrence of undetected islanding incidents (with duration longer than $T_{NDZmax} = 0$ s)
$N_{LOM,AR}$	- annual rate of occurrence of undetected islanding incidents (with duration longer than $T_{NDZmax} = 29.5$ s)
T_{LOM}	- total aggregated time of undetected islanding conditions in 1 year
P_{LOM}	- overall probability of the occurrence of an undetected island within a period of 1 year
$P_{NVDtrip}$	- probability of successful operation of NVD protection

$P_{PER,E}$	- probability of a person in close proximity to an undetected energised islanded part of the system being killed
$P_{PER,G}$	- probability of a person in close proximity of the generator while in operation
IR	- annual probability related to individual risk
IR_E	- annual probability related to individual risk (injury or death of a person) from the energised parts of an undetected islanded network
P_{AR}	- probability of out-of-phase auto-reclosing action following the disconnection of a circuit supplying a primary substation
N_{OA}	- annual rate of occurrence of any generator being subjected to out-of-phase auto-reclosure during the islanding condition not detected by LOM protection
IR_{AR}	- annual probability related to individual risk from the generator destruction following an out-of-phase auto-reclosure
T_E	- expected average time between incidents (injury or death of a person) from the energised parts of an undetected islanded network [in years]
T_{OA}	- average time between the occurrences of out-of-phase auto-reclosure during the islanding condition not detected by LOM protection [in years]

Executive Summary

This document reports on the work commissioned by Northern Ireland Electricity and undertaken by the University of Strathclyde to assess and quantify the levels of risks of undetected islands and the consequent risks to individuals' safety associated with proposed changes to Rate-Of-Change-Of-Frequency (ROCOF), Vector Shift (VS), Over Frequency (OF) and Under Voltage (UV) protection settings. The risk of potential equipment damage through unintentional out-of-phase auto-reclosing is also addressed.

The content of this report builds upon the activities of work packages WP1, WP2 [1] and WP3 [2] and provides additional risk assessment considering the application of Neutral Voltage Displacement (NVD) protection as a means of reducing the aforementioned risks. This report addresses Phase 1 which includes analysis of all distributed generator (DG) capacities above 5 MW, and covers the predominant existing generating technologies, namely synchronous, inverter, induction and DFIG-based generation.

The key outcome of this additional work consists of the estimated risk figures, considering both the probability of individual risk, and the expected annual rate of occurrence of out-of-phase auto-reclosure when considering the operation of NVD protection.

With NVD protection included, the levels of risk related to accidental electrocution during undetected islanding operation lie in the broadly acceptable region according to the Health and Safety at Work Act 1974 [3]. This is true for two situations: when the existing ROCOF protection practice is adopted; and under the considered new settings. It must be noted that the inclusion of NVD protection has resulted in the reduction of the individual risk by a factor of 3.8 for ROCOF, and by a factor of 5.1 for VS, which is sufficient to contain the risk values within the broadly acceptable region.

Regarding the expected annual occurrence of out-of-phase auto-reclosures, the risk has also been reduced by the application of NVD protection. In the worst case this would have a value of 0.00290 per annum, which means that one incident would be expected on average every $\frac{1}{0.00290} \cong 344.8$ years. Additional personal risk can result from an element (albeit small) of the probability of a person being in close proximity of the generator while it is in operation and suffering a fatal injury as a result of the generator being destroyed by an out-of-phase auto-reclosure, but the exact estimation of such probabilities depends on the specific generating technology (one would expect generators to have physical containment precautions in place to guard again any major failures), geographical location, and many other factors, and is therefore beyond the scope of this work.

Considering both sensitivity and stability aspects as well as additional results presented in this report, the setting of **1.5 Hz/s with a time delay of 300 ms** is recommended as the best compromise ROCOF setting, and the setting of **12°** for VS protection is recommended. The inclusion of NVD protection does not impact on the choice of recommended best compromise settings. Alternatively, the change of all VS protected generators to ROCOF (with setting option 3) is equivalent from the perspective of risk, but may offer stability advantage under system-wide events (e.g. transmission system faults during stormy weather conditions).

The study assumed modified over-frequency protection setting (**52 Hz with 1s time delay**) and two stage under-voltage protection settings (**stage 1: 0.85 pu with 3s time delay, stage 2: 0.6 pu with 2 s time delay**). These settings meet the system stability criteria and voltage ride through requirements, and do not compromise the sensitivity of the LOM protection.

Summary of risk figures for NIE Networks' distribution system obtained through averaging across all load profiles

LOM Option	LOM Setting [Hz/s] or [°]	Time Delay [s]	Individual risk of electrocution			Risk of out-of-phase reclosure		
			$N_{LOM,E}$	IR_E	T_E [years]	$N_{LOM,AR}$	N_{OA}	T_{OA} [years]
1	0.4	0	3.55E-04	6.96E-09	1.44E+08	1.38E-05	1.11E-05	90,267.77
2	2.0	0.2	1.17E-02	1.00E-06	9.99E+05	1.99E-03	1.59E-03	627.00
3*	**1.5**	**0.3**	**1.16E-02**	**9.97E-07**	**1.00E+06**	**1.99E-03**	**1.59E-03**	**629.37**
4	1.5	0.5	1.57E-02	1.36E-06	7.33E+05	2.72E-03	2.17E-03	459.98
5	1.0	0.8	1.66E-02	1.44E-06	6.94E+05	2.87E-03	2.30E-03	435.34
6	6	-	3.36E-03	3.60E-07	2.78E+06	7.17E-04	5.74E-04	1,742.38
7*	**12**	**-**	**3.36E-03**	**3.60E-07**	**2.78E+06**	**7.17E-04**	**5.74E-04**	**1,742.38**
8	-	-	2.00E-02	1.82E-06	5.50E+05	3.62E-03	2.90E-03	344.87

*Recommended ROCOF and VS settings (in bold).

Where:

- $N_{LOM,E}$ - annual rate of occurrence of undetected islanding incidents (with duration longer than $T_{NDZmax} = 0$ s)
- IR_E - annual probability related to individual risk (injury or death of a person) from the energised parts of an undetected islanded network
- T_E - average duration between incidents (injury or death of a person) from the energised parts of an undetected islanded network [in years]
- $N_{LOM,AR}$ - annual rate of occurrence of undetected islanding incidents (with duration longer than $T_{NDZmax} = 29.5$ s)
- N_{OA} - annual rate of occurrence of any generator being subjected to out-of-phase auto-reclosure during the islanding condition not detected by LOM protection
- T_{OA} - average duration between the occurrences of out-of-phase auto-reclosure during the islanding condition not detected by LOM protection [in years]

Recommended voltage and frequency protection settings

Voltage protection		Voltage [p.u]	Time Delay [s]
Under Voltage	Stage 1	0.85	3.0
	Stage 2	0.60	2.0
Over Voltage	Stage 1	1.10	0.5
Frequency protection		**Frequency [Hz]**	**Time Delay [s]**
Under Frequency	Stage 1	48	0.5
Over Frequency	Stage 1	52	1.0

1 Introduction

This document reports on additional outcomes of the project "Assessment of Increased Risks Imposed by a Relaxation of Loss-Of-Mains Protection Settings Applied to Generation Connected to the Electricity Network in Northern Ireland" and specifically quantifies the impact of NVD protection effectiveness in reducing the risk of undetected islanded operation.

The report is an extension of Work Package 3 (WP3) – Investigation and quantification of the risks associated with the relaxation of the ROCOF settings for generation with registered installed capacity greater than 5MW [2].

The following sections describe in detail the available data, the modified risk assessment methodology, the results, key observations and recommendations related to the application of NVD protection as a risk reduction measure.

A flowchart illustrating the dependencies of various work packages and tasks in the project is shown in Figure 1. The elements marked in blue had been completed previously while the extension work described in this report is marked in green.

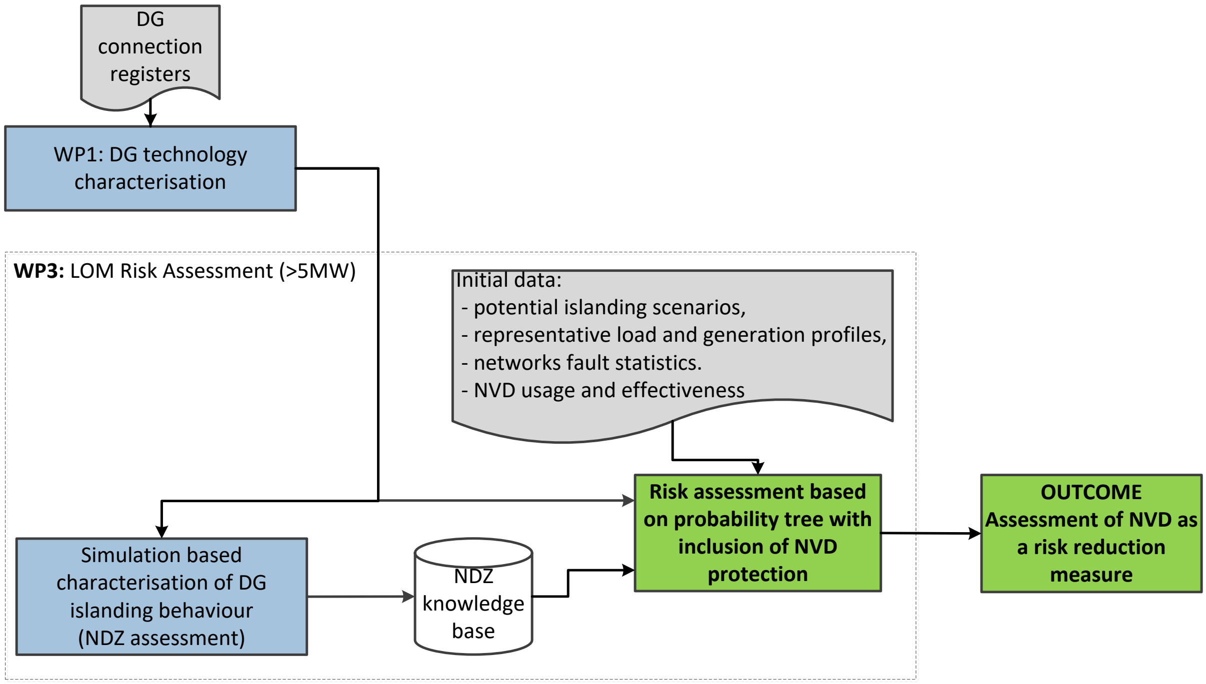


Figure 1: Position of the NVD study within the existing work packages and tasks

2 Neutral voltage displacement protection

2.1 NVD connection and operating principle

NVD protection measures system residual voltage using VTs capable of transforming zero sequence voltage. Either one, five-limb VT, or three individual phase VTs are used for this purpose. The primary side of the VT(s) is star connected and is solidly earthed. The secondary side of the VT(s) is open-delta connected which produces an output proportional to zero sequence voltage. NVD protection is typically time delayed. Within the NIE Networks distribution system, the NVD time delay setting for 33kV connected generation is 3 s, and for 11 kV/6.6 kV connections the delay is 10 s. Therefore, in Phase 1 calculations reported in this document, the NDV operation was assumed to be 3 s.

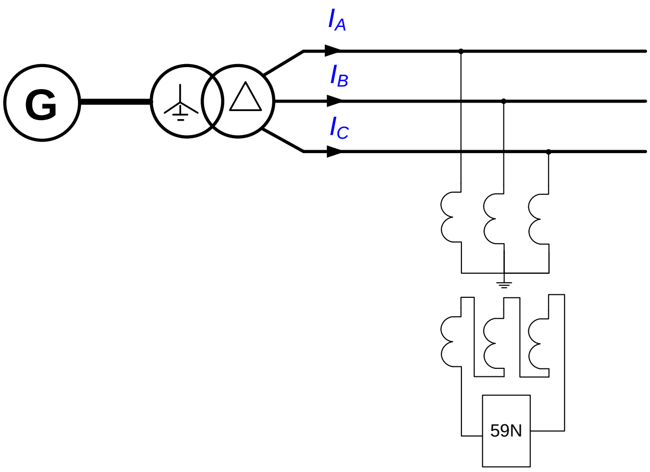


Figure 2. Connection of NVD protection

2.2 Effectiveness of NVD operation

The nature of NVD protection is such that its operation is not dependent on the power balance between generation output and the trapped load, as is the case for ROCOF or VS protection, but it is dependent primarily on the network characteristics and the type of fault. Therefore, the application of an NVD relay does not tend to affect the boundaries of the LOM non-detection zone (NDZ).

The effect of NVD is such that either the duration of the undetected island situation is limited to the NVD operation time T_{NVD} (when there is an earth fault on the system), or the duration of the islanding situation remains unaffected by NVD. Therefore, the reduction of risk that can be achieved is a consequence of the reduction of the duration of an undetected island (i.e. a reduction in the time duration of the occurrence of the safety hazard). However, this is only true for those cases when NVD operates successfully.

For the purposes of this study, it is assumed that NVD protection is effective only in the event of a single phase-to-earth fault being present on an unearthed part of the network, and the fault is sustained longer than the assumed NVD operation time. It is, therefore, understood that all other types of faults do not result in successful operation of NVD. The assumed classification and percentages of different types of faults (based on [4] and agreed through dialogue with NIE Networks) are illustrated in Figure 3. As can be seen from the figure, the faults that are considered detectable by NVD protection are all either permanent earth faults and or transient earth faults with durations greater than 3 s. This results in an overall proportion of 67.2% of all faults being detectable by NVD protection.

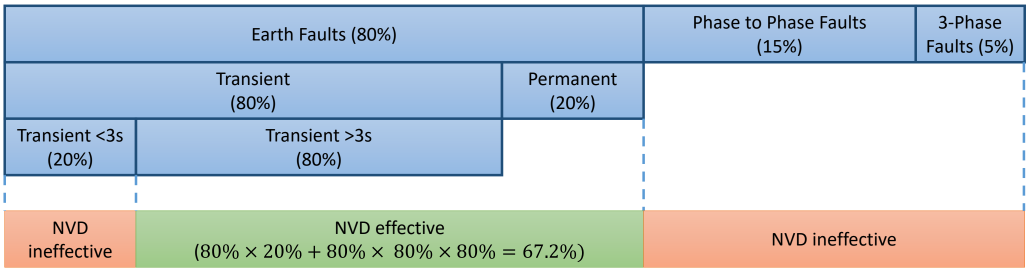


Figure 3. Fault classification and resulting effectiveness of NVD protection

Additionally, it has been recognised that in scenario 1 (loss of BSP) an island can be formed either by the failure of the BSP supply (i.e. fault at transmission level) or by protection failure following a fault on one of the 33 kV feeders. Therefore, in scenario 1, only the islands formed as a result of 33 kV protection failure have been included as potential candidates for successful NVD operation. The exact numbers of such events are included in Table 4 (section 3.3.1).

3 Risk level calculations for various values of NDZ

3.1 Protection setting options and NDZ

A dynamic model (validated in [5]) of a commercially-available DG interface relay commonly used in UK practice (MiCOM P341) had been utilised earlier in [2] to assess the extent of NDZ. The NDZ was established separately for the following protective functions:

- ROCOF with five different setting options as indicated in Table 1.
- Voltage Vector Shift (VS) with two different setting options as indicated in Table 1.
- G59 protection including under and over voltage (OV, UV), and under and over frequency (OF, UF), according to most recent recommendations (with OF adjusted to 52 Hz with 1.0 s time delay, and with the suggested two stage UV settings to meet the RfG requirements [6]) as indicated in Table 2.

The tripping signal for each protection function is monitored separately to determine which functions (ROCOF/VS/ OV/UV/OF/UF) are activated for each test case and are recorded where appropriate.

Table 1: Assumed ROCOF and VS setting options

Setting Option	LOM protection type	Settings
1	ROCOF	0.4 Hz/z (no time delay)
2	ROCOF	2 Hz/s (200ms time delay)
3	ROCOF	1.5 Hz/s (300ms time delay)
4	ROCOF	1.5 Hz/s (500ms time delay)
5	ROCOF	1 Hz/s (800ms time delay)
6	Vector Shift	6^o
7	Vector Shift	12^o
8	UV/OV/UF/OF only	Settings as in Table 2

Table 2: G59 Voltage and Frequency protection settings

Voltage protection		Voltage [p.u]	Time Delay [s]
Under Voltage	Stage 1	0.85	3.0
	Stage 2	0.60	2.0
Over Voltage	Stage 1	1.10	0.5
Frequency protection		**Frequency [Hz]**	**Time Delay [s]**
Under Frequency	Stage 1	48	0.5
Over Frequency	Stage 1	52	1.0

In the Phase 1 report [2], the NDZ was determined for both active and reactive power (including import and export) across the PCC. The pre-island imbalance of one type of power (e.g. active) was modified changed while the other type of power (e.g. reactive) was maintained in close balance (i.e. the transfer was across the PCC held as close to zero as possible) by adjusting the local demand (and generator reactive power output if necessary). The power imbalance is expressed as a percentage of the DG rating. The reported values of NDZ are expressed according to the following equations (1).

$$\begin{aligned} NDZ_{PI} &= \frac{P_{PCCI}}{S_{DG}} \times 100\%, \qquad NDZ_{PE} = \frac{P_{PCCE}}{S_{DG}} \times 100\% \\ NDZ_{QI} &= \frac{Q_{PCCI}}{S_{DG}} \times 100\%, \qquad NDZ_{QI} = \frac{Q_{PCCI}}{S_{DG}} \times 100\% \end{aligned} \tag{1}$$

Where:

NDZ_{PI}, NDZ_{PE} - real power NDZ assessed for import and export respectively

NDZ_{QI}, NDZ_{QE} - reactive power NDZ assessed for import and export respectively

P_{PCCI}, P_{PCCE} - maximum active power across the PCC at which there is no LOM protection operation within the pre-defined acceptable period (defined separately for import and export)

Q_{PCCI}, Q_{PCCE} - maximum reactive power across the PCC at which there is no LOM protection operation within the pre-defined acceptable period (defined separately for import and export)

S_{DG} - DG MVA rating

The NDZ was assessed in the Phase 1 report [2] for 15 different situations (termed as generation mixes), which included single generators as well as groups of two, three and four different technologies as outlined in Table 3. These generation mixes were established using the outcomes of the DG register analysis performed in WP1 of this work [1]. They represent various islanding groups encountered in scenario 1 (BSP islanding) and scenario 2 (33kV feeder islanding) and considered both all of the existing connected generation and the contracted generation (Register 2 in [1]). In particular, as indicated in Table 3, scenario 1 is represented by 12 different generation mixes, and scenario 2 is represented by 5 mixes.

As the NDZ is not affected by the operation of NVD protection, the values of NDZ previously obtained in Phase 1 [2], have also been used in this report. For completeness the NDZ result tables are included here in Appendix A.

Table 3: DG Generation Mixes

No of technologies	Generation Mix	Islanding scenario	SM [%]	IC [%]	DFIG [%]	IM [%]	DG Capacity [MVA]
1	**1**	2	100	-	-	-	10
	2	1, 2	-	100	-	-	10
	3	1, 2	-	-	100	-	30
	4	2	-	-	-	100	10
2	**5**	1	70	30	-	-	30
	6	1	30	70	-	-	70
	7	1	-	50	50	-	100
	8	1	-	-	70	30	100
	9	1	-	-	30	70	100
	10	2			50	50	10
3	**11**	1	20	40	-	40	20
	12	1	50	-	30	20	20
	13	1	30	-	50	20	30
	14	1	-	35	50	15	125
4	**15**	1	15	30	30	25	60

3.2 Risk calculation methodology

The risk calculation methodology adopted in this report is based on the method previously applied in Phase 1 of this work [2]. The modified probability tree is presented in Figure 4 where additional probability element (P_4) has been introduced to take into account the unsuccessful LOM detection by NVD protection.

The methodology makes a number of assumptions regarding the type of utility network, and the type and size of the distributed generators and generation technology (refer to section 3.3 for details). It utilises the width of the Non Detection Zone (NDZ) established through detailed dynamic simulation described earlier in the Phase 1 report [2]. Recorded typical utility load and generation profiles (refer to [2]), as well as statistics relating to utility network incidents, including loss of supply to Bulk Supply Points (islanding scenario 1) and loss of supply to individual 33kV feeders (islanding scenario 2), are also utilised to estimate probabilities of load-generation matching and islanding incidents.

Additionally, detailed DG connection registers (supplied directly by NIE Networks) were utilised to establish the predominant types of generation mixes in the identified typical islanded situations. The outcome of this analysis has been reported in WP1 and included in the report [1].

By utilising the assumed fault tree presented in Figure 4, the calculations described in the following sub-sections of this report are performed to assess:

a) personal safety hazard (the term individual risk IR_E is used in this report to denote the annual probability of death resulting from an undetected LOM condition – as shown in Figure 4a), and
b) damage to generator occurring as a result of sustained undetected islanded operation of DG combined with likely out-of-phase auto-reclosure (the annual rate of occurrence of out-of-phase auto-reclosure N_{OA} is used in this report – as shown in Figure 4b).

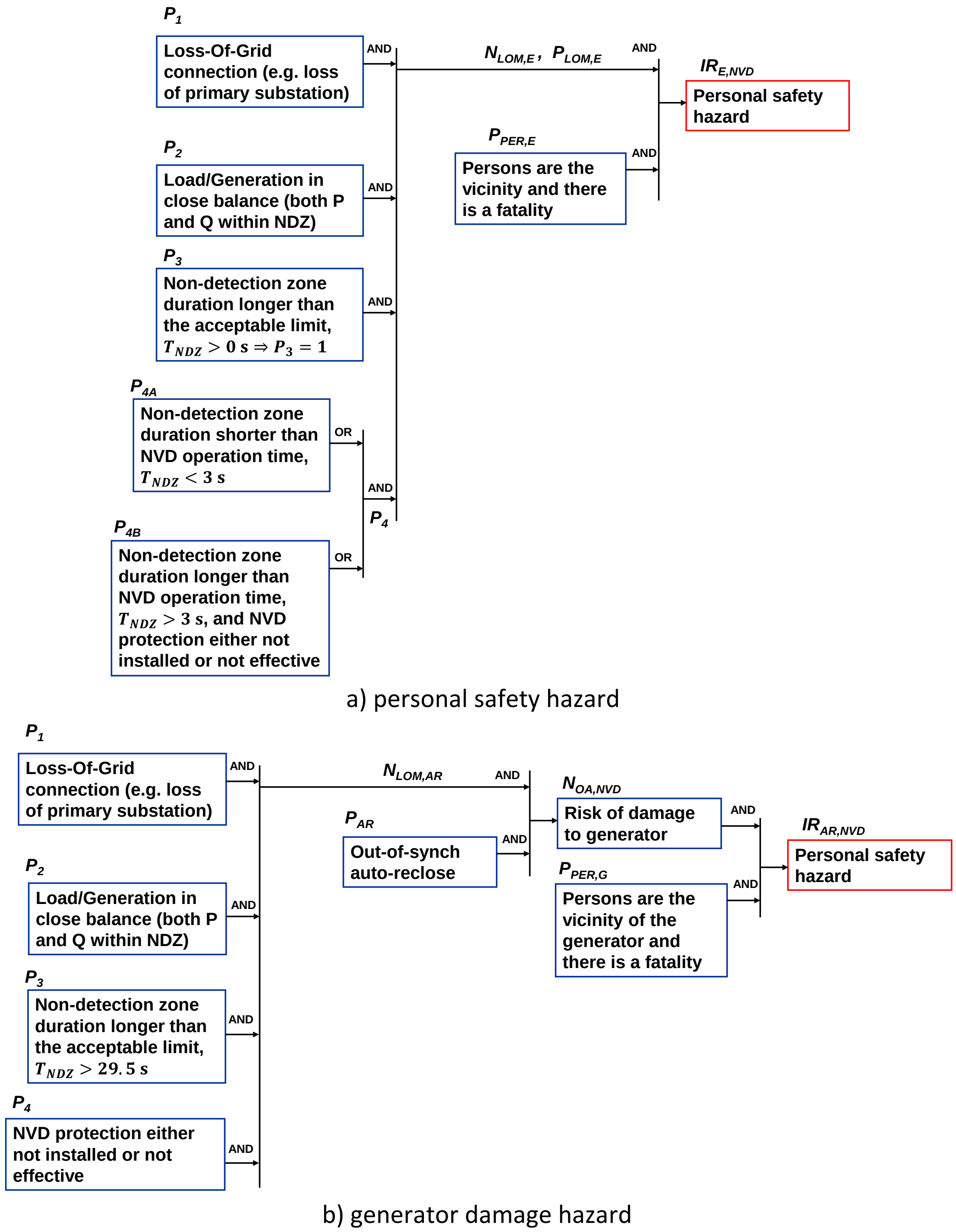


Figure 4. Modified LOM Safety Hazard Probability Tree (with the inclusion of NVD protection)

In order to cover all possible islanding scenarios for the range of possible different generation mixes (refer to Table 3), the application of the risk tree calculation is systematically executed for all combinations of islanding situations and the final probability figures are obtained as a weighted average of the individual results. The following subsections explain this process in more detail.

3.2.1 Expected number of LOM occurrences in a single islanding point

For a single islanding point (whether an entire substation or an individual circuit), the possibility of an undetected islanding situation arises from the loss of grid supply. Accordingly, the expected number of incidents of losing supply to an individual islanding point ($N_{LOG,1IP}$) during the period of one year can be estimated as follows:

$$N_{LOG,1IP} = \frac{n_{LOG}}{n_{IP} \cdot T_{LOG}} \tag{2}$$

where n_{LOG} is the total number of loss of supply incidents experienced during the period of T_{LOG} in a population of n_{IP} islanding points. The assumed values of n_{LOG} and n_{IP} for each islanding scenario have been derived from the network incident statistics, as described in section 3.3.1.

3.2.2 Load and generation profile analysis

For each generation mix and each islanding scenario $m = 1,2, \dots ,17$ (12 mixes in scenario 1 and 5 mixes in scenario 2 = 17 cases) the probabilities $P_{2(m)}$ and $P_{3(m)}$ (refer to Figure 4) are calculated jointly by systematic analyses of the example recorded load and generation profiles captured over a period of 1 week with 1 s resolution. This is performed iteratively in two nested loops. The inner loop (iteration i) progresses through the whole duration of the given record, while the outer loop (iteration j) covers the range of generation mix capacities according to the histogram characteristic of the given mix of technologies. The histograms for all predominant generation mixes were derived from the available DG connection registers and presented in section 2.2 of the report [1]. In each capacity band j there is a certain number of islanding points $n_{IP(m,j)}$. It should be noted that generator maximum output and generator rating are synonymous in the context of this calculation.

Within the inner loop at each time step (iteration i), the instantaneous load values $P_{L(i)}$ and $Q_{L(i)}$ are compared with the scaled version of the generation profile ($P_{DGG(m,j,i)}$ and $Q_{DGG(m,j,i)}$) to check if the difference falls within the NDZ established for the specific generation mix. This condition is described by (3).

$$\begin{gathered} -NDZ_{PE(m)} < P_{L(i)} - P_{DGG(m,j,i)} < NDZP_{PI(m)} \\ \wedge \\ -NDZ_{QE(m)} < Q_{L(i)} - Q_{DGG(m,j,i)} < NDZ_{QI(m)} \end{gathered} \tag{3}$$

Where:

$P_{L(i)}, Q_{L(i)}$	- recorded samples of active and reactive load power
$P_{DGG(m,j,i)}, Q_{DGG(m,j,i)}$	- scaled active and reactive generation profile for the generation mix m and capacity band j
$NDZ_{PE(m)}, NDZ_{QE(m)}$	- NDZ when generator output is higher than the local load (export) for generation mix m
$NDZ_{PI(m)}, NDZ_{QI(m)}$	- NDZ when generator output is lower than the local load (import) for generation mix m

When consecutive samples conform to the conditions specified in equation (3), the time is accumulated until the local load exits the NDZ. After all NDZ durations are recorded, they are compared with the time delay setting for NVD protection ($T_{NVD} = 3$ s in the case of 33 kV connected generation). A proportion of NDZ instances with durations greater that T_{NVD} are shortened to the value of T_{NVD}. These cases represent successful disconnection of the generator by NVD protection and directly corresponds to the assumed probability of NVD protection being effective (the value of $P_{NVDtrip}$ as explained in section 3.3.2). By shortening the NDZ periods in this way, the effect of potential operation of NVD protection on the risk of undetected islanding (indicated in Figure 4 as probability P_4) is taken into account. Subsequently, the NDZ duration cumulative distribution function (CDF) is derived, an example of which is presented in Figure 5. As illustrated in the figure, the probability $P_{3(m,j)}$ that the NDZ is longer than T_{NDZmax} can easily be obtained from the CDF.

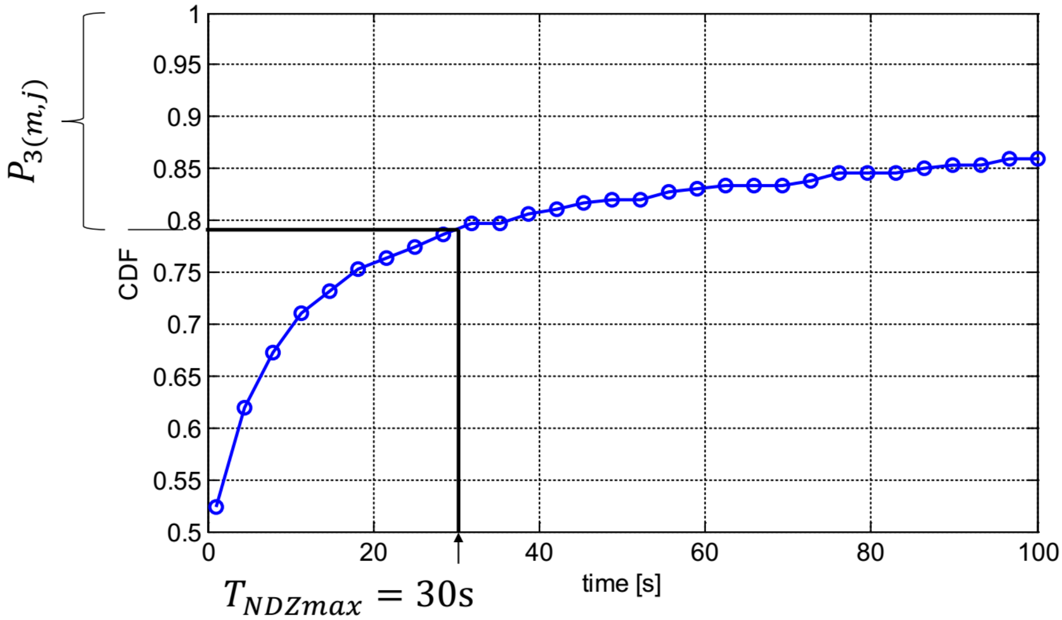


Figure 5. CDF of an example NDZ duration time

At the same time, the probability $P_{2(m,j)}$ of both P and Q being within the NDZ is also calculated as a sum of all recorded NDZ periods with respect to the total length of the recorded load profile (4).

$$P_{2(j)} = \sum_{k=1}^{n_{NDZ(m,j)}} \frac{T_{NDZ(m,j,k)}}{T_{load\_record}} \tag{4}$$

Where:

$n_{NDZ(m,j)}$	- number of detected NDZ periods within the capacity band j
T_{load_record}	- total length of the recorded load profile
$T_{NDZ(m,j,k)}$	- length of k-th NDZ period.

Finally, the joint probability $P_{23(m,j)}$ for each capacity band j can be calculated as (5) which leads to the development of the probability density as shown in Figure 6.

$$P_{23(m,j)} = \frac{n_{DGG(m,j)}}{n_{DGG(m)}} P_{2(m,j)} \cdot P_{3(m,j)} \tag{5}$$

where:

$n_{DGG(m,j)}$	- number of DG islanding groups in the mix m and the capacity band j
$n_{DGG(m)}$	- total number of DG groups in the generation mix m

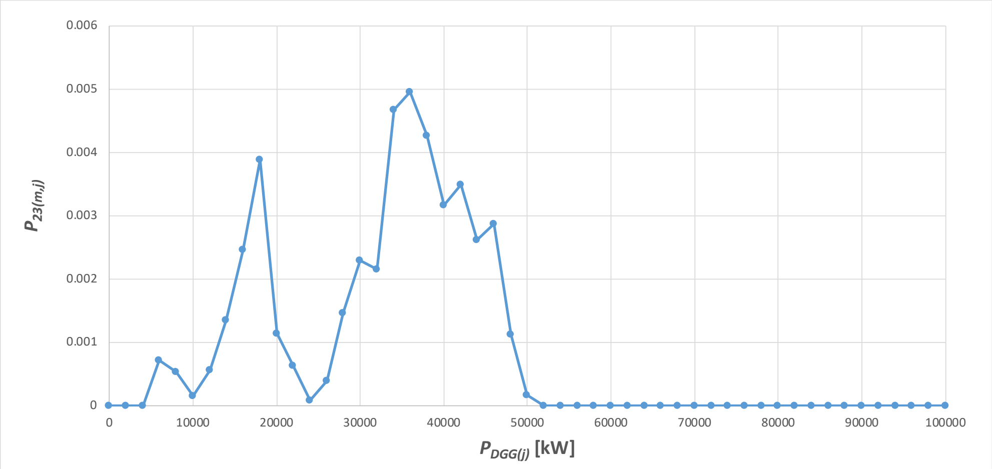


Figure 6. Non-detection zone probability for varying DG group capacities

Consequently, according to the principle of marginal probability [7], the combined probability $P_{23(m)}$, considering all DG groups of certain mix, is calculated using a simple summation as shown in (6).

$$P_{23(m)} = \sum_{j=1}^{n_{CB(m)}} P_{23(m,j)} \tag{6}$$

Where $n_{CB(m)}$ is the number of capacity bands.

The expected annual number of undetected islanding operations longer than the assumed maximum period T_{NDZmax} for an individual DG mix can be calculated as shown in (7).

$$N_{LOM,1DGG(m)} = N_{LOG,1IP} \cdot P_{23(m)} \tag{7}$$

Additionally, the overall average duration of the NDZ for a given mix ($T_{NDZavr(m)}$) is calculated by adding all NDZ durations longer than T_{NDZmax} from all generator groups and dividing the sum by the total number of NDZ occurrences.

The above process described by equations (3)-(7) is repeated for all of the 17 considered islanding cases. The final figures of T_{NDZavr} are calculated as a weighted average (8) from all different generation mixes and islanding scenarios ($m = 1,2,\ldots,12$ for scenarios 1 and $m = 13,14,\ldots,17$ for scenario 2).

$$\begin{gathered} T_{NDZavr,s1} = \frac{\sum_{m=1}^{12} n_{DGG(m)} \cdot T_{NDZavr(m)}}{\sum_{m=1}^{12} n_{DGG(m)}} \\ T_{NDZavr,s2} = \frac{\sum_{m=13}^{17} n_{DGG(m)} \cdot T_{NDZavr(m)}}{\sum_{m=13}^{17} n_{DGG(m)}} \\ T_{NDZavr} = \frac{\sum_{m=1}^{17} n_{DGG(m)} \cdot T_{NDZavr(m)}}{\sum_{m=1}^{17} n_{DGG(m)}} \end{gathered} \tag{8}$$

3.2.3 Calculation of national LOM probability figures and individual risk

For each individual case of generation mix m, the expected annual number of undetected LOM events $N_{LOM(m)}$ and the probability of an undetected islanded system at any given time $P_{LOM(m)}$ are established. Firstly, using the known total number of connected DG groups ($n_{DGG(m)}$) with an assumed proportion of ROCOF based LOM protection ($p_{ROCOF(m)}$) and load factor ($LF_{(m)}$), the expected annual number of undetected islanding incidents can be estimated from:

$$N_{LOM(m)} = N_{LOM,1DG(m)} \cdot n_{DGG(m)} \cdot p_{ROCOF(m)} \cdot LF_{(m)} \tag{9}$$

The expected cumulative time of undetected islanding conditions for all considered DG groups $n_{DGG(m)}$ in mix m can be estimated using:

$$T_{LOM(m)} = N_{LOM(m)} \cdot (T_{LOMavr(m)} - T_{NDZmax}) \tag{10}$$

where $T_{LOMavr(m)}$ is the average time that an undetected island can be sustained in mix m. This time is selected as the minimum value between $T_{NDZavr(m)}$ and assumed maximum operation time of the auto-reclosing scheme (T_{ARmax}). It is assumed that sustained islanded operation following an auto-reclose operation is not possible.

Finally, the overall probability in mix m of an undetected islanded system at any given time and at specific assumed ROCOF settings is calculated as:

$$P_{LOM(m)} = \frac{T_{LOM(m)}}{T_a} \tag{11}$$

Where:

T_a – period of 1 year

The final figures of P_{LOM} and N_{LOM} are calculated as a direct sum of partial results obtained for individual generation mixes ($m = 1,2,\ldots,12$ for scenarios 1 and $m = 13,14,..21$ for scenario 2).

$$\begin{gathered} P_{LOM,s1} = \sum_{m=1}^{12} P_{LOM(m)} \\ P_{LOM,s2} = \sum_{m=13}^{17} P_{LOM(m)} \\ P_{LOM} = \sum_{m=1}^{17} P_{LOM(m)} \\ N_{LOM} = \sum_{m=1}^{17} N_{LOM(m)} \end{gathered} \tag{12}$$

For a single DG group with ROCOF protection in mix m, the probability can be calculated as:

$$P_{LOM,1DGG(m)} = \frac{P_{LOM(m)}}{n_{DGG(m)} \cdot p_{ROCOF(m)}} \tag{13}$$

In this case, the final figures of $P_{LOM,DGG}$ are calculated as a weighted average (proportional to the number of DG groups) from all different generation mixes and islanding scenarios ($m = 1,2, \dots ,12$ for scenarios 1 and $m = 13,14, \dots ,17$ for scenario 2).

$$\begin{gathered} P_{LOM,1DGG,s1} = \frac{\sum_{m=1}^{12} n_{DGG(m)} \cdot P_{LOM,1DGG(m)}}{\sum_{m=1}^{12} n_{DGG(m)}} \\ P_{LOM,1DGG,s2} = \frac{\sum_{m=13}^{17} n_{DGG(m)} \cdot P_{LOM,1DGG(m)}}{\sum_{m=13}^{17} n_{DGG(m)}} \\ P_{LOM,1DGG} = \frac{\sum_{m=1}^{17} n_{DGG(m)} \cdot P_{LOM,1DGG(m)}}{\sum_{m=1}^{17} n_{DGG(m)}} \end{gathered} \tag{14}$$

In order to ascertain whether the risk resulting from the proposed adjustment to the ROCOF settings is acceptable, analysis and interpretation of the calculated N_{LOM} and P_{LOM} values is required. Note that the values of N_{LOM} are calculated separately for the purposes of assessing the out-of-phase reclosures (denoted as $N_{LOM,AR}$) where $T_{NDZmax} = 30$ s was assumed, and for the purposes of individual risk assessment (denoted as $N_{LOM,E}$) where $T_{NDZmax} = 0$ s was assumed. The final risk calculation is performed using two steps:

1. Firstly, the annual expected number of out-of-phase auto-reclosures (N_{OA}) during the islanding condition (undetected by LOM protection) is calculated as follows:

$$N_{OA} = N_{LOM,AR} \cdot P_{AR} \tag{15}$$

   Where $N_{LOM,AR}$ is the expected annual number of undetected islanding incidents for out-of-phase reclosure assessment, and P_{AR} is the probability of an out-of-phase auto-reclosing action following the disconnection of a circuit supplying a primary substation. Considering that auto-reclosing action would occur in the vast majority of cases of losing supply to a primary substation (unless the system is wholly underground) and also considering the fact that reclosure with small angle differences may be safe, a value of $P_{AR} = 0.8$ was assumed.

2. Secondly, the annual probability values are calculated related to perceived individual risk (*IR*). Two sources of *IR* are considered: (a) the risk of a fatality due to accidental contact with any elements of the energised undetected island (IR_E), and (b) risk of physical injury or death resulting from the generator destruction following an out-of-phase auto-reclosure (IR_{AR}). These two indices are calculated as follows:

$$IR_E = N_{LOM,E} \cdot P_{PER,E} \tag{16}$$

$$IR_{AR} = N_{OA} \cdot P_{PER,G} \tag{17}$$

   where $P_{PER,E}$ is the probability of a person being in close proximity to an undetected islanded part of the system and suffering a fatal injury at the same time, and $P_{PER,G}$ is the probability of a person being in close proximity of the generator while in operation and suffering fatal injury as a result of the generator being destroyed by an out-of-phase auto-reclosure. The resulting *IR* can be then compared with the general criteria for risk tolerability included in the Health and Safety at Work Act 1974 [3] which adopts the risk management principle often referred to as the 'ALARP' or 'As Low as Reasonably Practicable' principle. The ALARP region applies for IR levels between 10^{-6} and 10^{-4}. Risks with probabilities below 10^{-6} can generally be deemed as tolerable. A similar approach has already been used in the risk assessment of NVD protection requirement [8] as well as in the earlier GB system studies [9], [10].

The value of $P_{PER,E}$ needs further consideration. As statistics relating to injuries resulting directly from undetected islanded systems do not appear to exist, it is difficult to obtain an exact estimation of such occurrences. In [8] the following statistics are presented:

- nearly 5% of all HV faults involve a proximity hazard,
- on average, there are 8.6 fatalities p.a. in GB due to close proximity to electricity networks,
- 90% of these fatalities involve the OHL network,
- there are 800 cases per annum where people are in close proximity to HV OHL interruptions.

Therefore, $P_{PER,E}$ can be seen as a joint probability of $P_A = 0.05$ (a person being in the vicinity), and P_B (the person in the vicinity suffering a fatal injury). Based on the above points the probability of a fatality due to an HV OHL interruption would be $P_B = \frac{8.6 \cdot 0.9}{800} \cong 0.01$. However, such probability relates to injuries caused directly by the fault and not by the follow-on period of undetected islanding. It must be emphasised that only additional risk caused by prolonged islanded operation should be included in the calculations for the purposes of assessing the risk of any aspect of the LOM protection. Assuming that the chance of contact with an energised island during the period of up to 30s (maximum realistic period of islanding due to delayed auto-reclose in the NIE Networks system) is the same as the chance of injury during the initial fault occurrence (i.e. 0.01), and also assuming that standard exponential probability distribution ($f(t) = \lambda\, e^{-\lambda t}$) applies during the islanding period following the fault, the following formula can be used to assess probability of injury from an islanded system.

$$P_{PER,E} = P_A \cdot P_B = P_A \cdot (1 - e^{-\lambda \cdot T_{LOMavr}}) \tag{18}$$

Where:

- $P_A = 0.05$
- $P_B = 1 - e^{-\lambda \cdot T_{LOMavr}}$ (according to cumulative distribution function of $f(t) = \lambda\, e^{-\lambda t}$)
- $T_{LOMavr} = \frac{P_{LOM,E} \cdot T_a}{N_{LOM,E}}$ in [s]

The constant λ is established from the assumption that $P_B(t \leq 30s)$ =0.01 which results in $= -\frac{\ln(1-0.01)}{30} = 3.3501 \times 10^{-4}$.

The probability $P_{PER,G}$ will depend on specific circumstances, generator location and operating regime, and therefore, it is beyond the scope of this report to accurately quantify such probabilities. However, it can be generally assumed that while synchronous machines are seriously affected (possibly damaged) by the out-of-phase reclosure, other technologies, such as fixed speed induction machines or fully-rated inverter wind turbines can often ride through such reclosures without much impact on their lifespan. A short analysis which could assist in quantifying the impact of the out-of-phase reclosure on various generation groups/mixes is included in the concluding section 4.2.

The relative difference between the probability of an undetected islanding condition using existing recommended settings and the probability using the proposed settings provides further guidance as to the acceptability of the proposed setting options.

3.3 Initial assumptions and available data

The following assumptions and initial values were made in this study:

- Generation range considered has a capacity greater than 5 MW;
- Generation output is represented by an example measured generation profile characteristic of a particular generation technology. Sample generation profiles for wind and biomass-based distributed generation were provided by NIE Networks (refer to section 4.2.5 in [2]).
- Inverter connected (IC) generation was assumed to be predominantly wind.
- The load factor (LF) was assumed to be 1 for all generation (worst case scenario).
- Based on the DG protection setting records provided by NIE Networks for the purposes of the Phase 1 study, it was assumed that the usage of ROCOF protection is 100%, 0%, 27% and 50% for synchronous, inverter connected, DFIG and induction machine based generation respectively. Regarding VS protection, the assumed percentages were as follows: 0% (SM), 100% (IC), 73% (DFIG) and 50% (IM). Other percentages related to various generation groupings have been derived as described in section 3.3.4.
- Detailed distribution of DG sizes, numbers, predominant groupings, as well as percentage contributions of individual generating technologies within the groups (generation mixes) were obtained from available NIE Networks connection registers and analysed within WP1 [1].
- Nine different load scenarios recorded on selected BSPs as well as other typical 33kV circuits and primary substations used (refer to [2]).
- For the purposes of assessing the probability of out-of-phase reclosure, a period of $T_{NDZmax} = 29.5$ s (i.e. 30 s minus 0.5 s to allow for standard protection grading time) was assumed as the maximum permissible duration of undetected islanding condition (i.e. no auto-reclosing with a time delays of less than T_{NDZmax} is expected to occur). However, in assessing individual risk, all islanding durations were included in the calculation, i.e. $T_{NDZmax} = 0$ s was used.
- The operation of NVD protection is assumed to be $T_{NVD} = 3$ s for all large scale generation considered in Phase 1.
- As the time before the fault is cleared is not technically an islanded situation, it is not considered in this analysis. In other words, the network fault clearance time is assumed to have no impact on the risks associated with the adjustment of the LOM protection settings.
- It is assumed that the generator (or a group of generators) does not continue to supply the system after an out-of-phase auto-reclosing operation.
- A period of $T_{ARmax} = 30$ s was assumed as the maximum expected time of operation of the auto-reclosing scheme (in other words, regardless of load/generation balance, undetected stable island will not continue to operate longer than T_{ARmax} due to the impact of out-of-phase reclosure).

3.3.1 Potential islanding scenarios and estimated frequency of occurrence

Generation above 5MW can be connected either directly to a BSP (trough a dedicated line) or as a teed connection to one of the 33kV feeders. Therefore, there are two possible scenarios which can lead to islanding of one or more of such large generating units.

Scenario 1 considers the loss of grid supply to a BSP, while scenario 2 involves islanding of an individual 33 kV feeder. In order to assess the expected annual number of LOM occurrences at an individual islanding point, NIE Networks provided a summary of the loss of grid supply incidents based on the National Fault and Interruption Reporting System (NAFIRS). These values are summarised in Table 4. Additionally, the following numbers of potential islanding points were assumed:

- scenario 1 – $n_{IP,s1} = 36$ (number of BSPs)
- scenario 2 – $n_{IP,s2} = 158$ (54 radial + 104 ring feeders from all BSPs)

Table 4. Loss of grid supply statistics for islanding scenario 1 and 2

	Islanding Scenario	Number of incidents					
		2010	**2011**	**2012**	**2013**	**2014**	**Total n_{LOG}**
No. of times supply has been lost to a BSP	1	1	4	3	6	2	**16**
No. of times supply has been lost to a BSP as a result of protection mal-operation at 33 kV	0	1	0	0	2	0	**3**
No. of times 33kV feeder supplies have been lost	2	98	85	89	135	94	**501**

Consequently, using equation (2), the expected number of LOM occurrences in a single islanding point can be calculated for each scenario as follows:

- scenario 1 – $N_{LOG,1IP,s1} = \frac{n_{LOG,s1}}{n_{IP,s1} \cdot T_{LOG,s1}} = \frac{16}{36 \cdot 5} = 0.0889$
- scenario 2 – $N_{LOG,1IP,s2} = \frac{n_{LOG,s2}}{n_{IP,s2} \cdot T_{LOG,s2}} = \frac{501}{158 \cdot 5} = 0.6342$

where n_{LOG} is the total number of loss of supply incidents experienced during the period of T_{LOG} (five years in this case) in a population of n_{IP} islanding points.

3.3.2 Probability of NVD protection operation

The probability of successful NVD protection operation ($P_{NVDtrip}$) can be established as:

$$P_{NVDtrip} = P_{EF} \cdot P_{NVDinstalled} \cdot P_{NVDoperating} \tag{19}$$

Where:

P_{EF} - probability of NVD being effective (based on fault type analysis included in section 2.2).

$P_{NVDinstalled}$ - probability of NVD being installed in an island (derived from the DG register for each generation mix and capacity band). It is assumed that the presence of NVD protection on one of the generating technologies forming a mix is sufficient to de-energise the island.

$P_{NVDoperating}$ - probability that the NVD protection will successfully operate during an earth fault. This probability is <1 only if there is a reason to believe (evidenced from network statistics or engineering practice) that some of the earth faults may not be successfully detected by NVD, e.g. high impedance faults or faults on a different part of the network which NVD cannot detect.

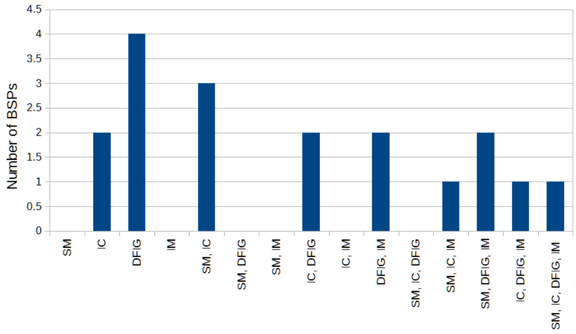
The probability values used in scenario 1 and 2 calculations are shown in Table 5. In scenario 1 it has been assumed that only the BSP isolation incidents related to 33 kV feeder protection failure can be successfully detected by NVD protection.

Table 5. Assumed probabilities related to operation of NVD protection in scenario 1 and 2

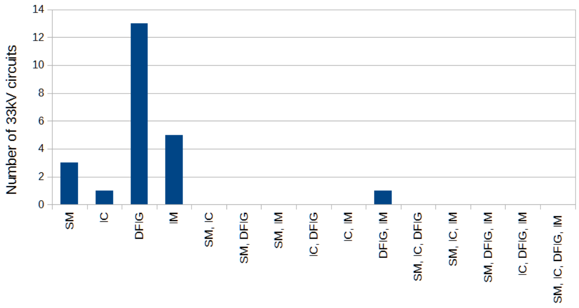
Scenario	P_{EF}	$P_{NVDinstalled}$	$P_{NVDoperating}$	$P_{NVDtrip}$
1	0.672	1	3/16=0.1875 (only 33 kV protection failures are included – refer to Table 4)	0.142875
2	0.672	1	1	0.672

3.3.3 Establishing DG technology mixes

In order to establish the representative mixes of generation technologies with appropriate proportions of each generation in the mix, analysis of the DG register was performed previously and included in WP1 [1]. In order to derive results which correspond to the most "forward looking" DG connection set, the register which combines existing and all contracted generation has been used in this study. A summary of the resulting mixes in scenario 1 and 2 are also presented in Figure 7.



a) scenario 1



b) scenario 2

Figure 7. Islanding groups based on DG Register 2 (connected + contracted DG)

Considering that there are nine different generating groups in scenario 1 and five groups in scenario 2, and also taking into account the variation in the proportions of individual generating technologies in each group, a set of 15 different generation mixes have been established which covers all groupings in both islanding scenarios. This is summarised in Table 6 and used consistently in the NDZ assessment (refer to section 3.2 in [2]). The same groupings are assumed in the risk assessment calculation included in section 3.4.

Table 6. Assumed generation groupings (mixes)

Grouping	Generation Mix	Used in islanding scenario
Single	1 (SM 100%)	2
	2 (IC 100%)	1, 2
	3 (DFIG 100%)	1, 2
	4 (IM 100%)	2
Groups of 2	5 (SM 70%, IC 30%)	1
	6 (SM 30%, IC 70%)	1
	7 (IC 50%, DFIG 50%)	1
	8 (DFIG 70%, IM 30%)	1
	9 (DFIG 30%, IM 70%)	1
	10 (DFIG 50%, IM 50%)	2
Groups of 3	11 (SM 20%, IC 40%, IM 40%)	1
	12 (SM 50%, DFIG 30%, IM 20%)	1
	13 (SM 30%, DFIG 50%, IM 20%)	1
	14 (IC 35%, DFIG 50%, IM 15%)	1
Groups of 4	15 (SM 15%, IC 30%, DFIG 30%, IM 25%)	1

3.3.4 Usage of ROCOF and VS within an overall LOM protection scheme

When performing the assessment of the change of settings, it is crucial that only those generating units which use a particular type of protection (ROCOF or VS in this case) are included in the final risk figures. Some generators use ROCOF while others use VS, and some use both ROCOF and VS.

Based on the DG protection setting records provided by NIE Networks it was assumed that the usage of ROCOF and VS protection in individual generating technologies is as follows:

- Synchronous – 100% ROCOF, 0% VS
- Inverter Connected – 0% ROCOF, 100% VS
- DFIG – 27% ROCOF, 73% VS
- Induction Generator – 50% ROCOF, 50% VS

For example, in ROCOF risk calculation, the islands formed by inverter connected DG only will be excluded from calculations as none of such generators use ROCOF protection, and therefore, they are not affected by any change in ROCOF protection settings. When considering multi-generator islands, the level of ROCOF (or VS) protection usage has been derived under the assumption that an island is de-energised if at least one of the technologies is equipped with a ROCOF (or VS) relay. The probability of an island (including *N* different technologies) being effectively protected by the specific type of LOM protection (either ROCOF or VS) can be calculated as follows:

$$P_{ROCOF,VS\_OK} = 1 - P_{NO_{ROCOF,VS}} = 1 - \prod_{i=1}^{N}\left(1 - P_{ROCOF,VS(i)}\right) \qquad (20)$$

where *N* is a number of different technologies in the group/mix.

Moreover, to ensure the most accurate estimation of risk, it is also assumed ROCOF protection is always more effective than VS (due to narrower NDZ as evidenced from the results in Appendix A) in mixed DG islands where both ROCOF and VS protection are in use. Therefore, it is deemed that any change to VS settings will not affect the overall risk level. Thus, DG islands equipped with VS protection only (as shown in the right hand side column of Table 7) were included in the risk calculation for setting options 6 and 7.

Table 7. Assumed ROCOF usage in HV connected generation

Grouping	Generation Mix	ROCOF Usage	VS Usage	How established?	VS usage applied in risk calculations
Single	1 (SM 100%)	1	0	Assumed	0
	2 (IC 100%)	0	1		1
	3 (DFIG 100%)	0.27	0.73		0.73
	4 (IM 100%)	0.5	0.5		0.5
Groups of 2	5 (SM 70%, IC 30%)	1	1	Derived using equation (20)	0
	6 (SM 30%, IC 70%)	1	1		0
	7 (IC 50%, DFIG 50%)	0.27	1		0.73
	8 (DFIG 70%, IM 30%)	0.63	0.87		0.37
	9 (DFIG 30%, IM 70%)	0.63	0.87		0.37
	10 (DFIG 50%, IM 50%)	0.63	0.87		0.37
Groups of 3	11 (SM 20%, IC 40%, IM 40%)	1	1		0
	12 (SM 50%, DFIG 30%, IM 20%)	1	0.87		0
	13 (SM 30%, DFIG 50%, IM 20%)	1	0.87		0
	14 (IC 35%, DFIG 50%, IM 15%)	0.63	1		0.37
Groups of 4	15 (SM 15%, IC 30%, DFIG 30%, IM 25%)	1	1		0

3.4 Risk calculation results

The full numerical record of probability calculations performed for the two islanding scenarios (with 12 different generation mixes in scenario 1, and 5 mixes in scenarios 2), considering five load profiles in each scenario, and each of the eight LOM protection setting options, is included in Appendix B. The results take into account the fact that G59 (UF/OF/UV/OV) protection is always enabled and trips the generator in situations where ROCOF or VS relay sensitivity is poor. Additionally, for ease of analysis, all results are also presented graphically in Figures 8 to 17. It should be noted that, in a number of cases, the final probability was equal to zero. In order to represent this result on the graph using a logarithmic scale, a small value of 10^{-11} was used rather than zero. All other non-zero results were always higher than 10^{-11}, so this value can be used as an unambiguous indicator of a zero result.

Considering all load cases, generation mixes and islanding scenarios, the overall probability figures N_{LOM} and P_{LOM} have been obtained (based on results in Appendix B). Both probability of individual risk (IR_E) and expected annual rate of occurrence of out-of-phase auto-reclosure (N_{OA}) were calculated using the formulae (16) and (17). The figures were obtained in two different ways: first by using the worst load profile result (as presented in Table 8), and then by averaging the probability figures across all the profiles (Table 9). Additionally, for convenience of easier comparison the original results achieved without considering NVD protection have been included in Tables 11 and 12.

The figures represent the probabilities of the perceived hazards (*IR* and *OA*) under eight different ROCOF protection setting options when applied to the existing and contracted generators in the NIE Networks distribution system with ratings above 5 MW. It is important to bear in mind the following points when using these results to inform decision-making processes:

- The presented probability figures are based on connections registers at a specific point in time, which will become out-of-date at some point in the future due to the growing number of DG installations (and changes in DG types).
- The probabilities will increase (or decrease) in proportion to the total number of separate islanding points as well as being dependent on the usage of dedicated ROCOF- and VS-based protection. However, due to generation grouping, the number of islanding points grows at a rate less than the growth rate of the total number of individual DG connections.
- The study does not include assessment of the impact of any changes in practice to change the type of LOM protection or additionally use other forms of LOM protection (e.g. reverse reactive power) in conjunction with existing methods.
- Wherever exact data has not been available, pessimistic assumptions have been made so that the final probability values will ideally never be lower than reality; but this also means that the final figures are potentially and probably higher than reality (however, a degree of pessimism is not necessarily a bad thing in this context).
- The results obtained from the worst case scenario (Table 8 and Table 11) are three to four times higher compared to the result based on averaged figures (Table 9 and Table 12). It is considered more appropriate to select the averaged figures as being more accurate.
- The results are expressed as probabilities of specific events or occurrences happening over a period of one year. By inverting these values, the average expected times between such occurrences are also calculated (i.e. T_E and T_{OA}).
- The individual risk IR_E includes the fatalities resulting from the direct contact with energised parts of the undetected islanded system and does not include the risk IR_{AR} defined in section 3.2.3 as the risk of physical injury or death resulting from the generator destruction following an out-of-phase auto-reclosure. The probability of such occurrences depends on specific circumstances, including generator location, technology and regime of operation, and is beyond the scope of this report. Therefore, the value IR_E is potentially an underestimate of the total individual risk.
- The risk of LOM settings adjustment must be considered for three different cases. Firstly, if ROCOF settings *only* are changed, then the risk figures (e.g. LOM option 3 in the table) apply under the assumption that no changes are made to VS. Secondly, if VS settings *only* are changed, then the risk figures (e.g. LOM option 7 in the table) apply under the assumption that no changes are made to ROCOF. Thirdly, if both ROCOF and VS settings are changed, then the resultant risk figures would be the sum of the ROCOF-only and VS-only changes (e.g. the summation of the risk figures for LOM options 3 and 7 in the table). Some example calculations are included in section 4.1.
- An option of changing all large scale generation (LSG) currently using VS relay to ROCOF protection has also been explored by repeating the calculations (setting options 1 to 5) with the assumed ROCOF usage of 1. The results are presented in Table 10.

Table 8. Worst load profile based risk figures for P_{LOM}, IR_E and N_{OA} (with NVD)

LOM Option	LOM Setting [Hz/s] or [°]	Time Delay [s]	Individual risk of electrocution			Risk of out-of-phase reclosure		
			$N_{LOM,E}$	IR_E	T_E [years]	$N_{LOM,AR}$	N_{OA}	T_{OA} [years]
1	0.4	0	1.41E-03	2.14E-08	4.68E+07	4.25E-05	3.40E-05	29,378.82
2	2.0	0.2	2.24E-02	2.67E-06	3.74E+05	5.32E-03	4.26E-03	234.85
3*	**1.5**	**0.3**	**2.23E-02**	**2.66E-06**	**3.76E+05**	**5.30E-03**	**4.24E-03**	**235.75**
4	1.5	0.5	2.96E-02	3.37E-06	2.97E+05	6.71E-03	5.36E-03	186.42
5	1.0	0.8	3.02E-02	3.44E-06	2.91E+05	6.85E-03	5.48E-03	182.41
6	6	-	8.32E-03	1.11E-06	9.00E+05	2.21E-03	1.77E-03	564.50
7*	**12**	**-**	**8.32E-03**	**1.11E-06**	**9.00E+05**	**2.21E-03**	**1.77E-03**	**564.50**
8	-	-	3.86E-02	4.56E-06	2.19E+05	9.08E-03	7.27E-03	137.60

Table 9. Risk figures obtained through averaging of all load profiles (with NVD)

LOM Option	LOM Setting [Hz/s] or [°]	Time Delay [s]	Individual risk of electrocution			Risk of out-of-phase reclosure		
			$N_{LOM,E}$	IR_E	T_E [years]	$N_{LOM,AR}$	N_{OA}	T_{OA} [years]
1	0.4	0	3.55E-04	6.96E-09	1.44E+08	1.38E-05	1.11E-05	90,267.77
2	2.0	0.2	1.17E-02	1.00E-06	9.99E+05	1.99E-03	1.59E-03	627.00
3*	**1.5**	**0.3**	**1.16E-02**	**9.97E-07**	**1.00E+06**	**1.99E-03**	**1.59E-03**	**629.37**
4	1.5	0.5	1.57E-02	1.36E-06	7.33E+05	2.72E-03	2.17E-03	459.98
5	1.0	0.8	1.66E-02	1.44E-06	6.94E+05	2.87E-03	2.30E-03	435.34
6	6	-	3.36E-03	3.60E-07	2.78E+06	7.17E-04	5.74E-04	1,742.38
7*	**12**	**-**	**3.36E-03**	**3.60E-07**	**2.78E+06**	**7.17E-04**	**5.74E-04**	**1,742.38**
8	-	-	2.00E-02	1.82E-06	5.50E+05	3.62E-03	2.90E-03	344.87

Table 10. Risk figures obtained through averaging of all load profiles assuming all LSG generation uses ROCOF as LOM protection (with NVD)

LOM Option	LOM Setting [Hz/s] or [°]	Time Delay [s]	Individual risk of electrocution			Risk of out-of-phase reclosure		
			$N_{LOM,E}$	IR_E	T_E [years]	$N_{LOM,AR}$	N_{OA}	T_{OA} [years]
1	0.4	0	3.55E-04	6.96E-09	1.44E+08	1.38E-05	1.11E-05	90,267.82
2	2.0	0.2	1.51E-02	1.36E-06	7.35E+05	2.71E-03	2.17E-03	461.08
3*	**1.5**	**0.3**	**1.49E-02**	**1.36E-06**	**7.37E+05**	**2.70E-03**	**2.16E-03**	**462.36**
4	1.5	0.5	1.91E-02	1.72E-06	5.80E+05	3.43E-03	2.75E-03	363.91
5	1.0	0.8	1.99E-02	1.80E-06	5.55E+05	3.59E-03	2.87E-03	348.31

Table 11. Worst load profile based risk figures for P_{LOM}, IR_E and N_{OA} (without NVD)

LOM Option	LOM Setting [Hz/s] or [°]	Time Delay [s]	Individual risk of electrocution			Risk of out-of-phase reclosure		
			$N_{LOM,E}$	IR_E	T_E [years]	$N_{LOM,AR}$	N_{OA}	T_{OA} [years]
1	0.4	0	2.00E-03	3.35E-08	2.99E+07	6.66E-05	5.33E-05	18,765.54
2	2.0	0.2	3.76E-02	1.15E-05	8.69E+04	2.30E-02	1.84E-02	54.40
3*	**1.5**	**0.3**	**3.75E-02**	**1.15E-05**	**8.69E+04**	**2.30E-02**	**1.84E-02**	**54.44**
4	1.5	0.5	4.52E-02	1.23E-05	8.10E+04	2.46E-02	1.97E-02	50.74
5	1.0	0.8	4.58E-02	1.24E-05	8.04E+04	2.48E-02	1.99E-02	50.37
6	6	-	1.68E-02	6.14E-06	1.63E+05	1.23E-02	9.81E-03	101.99
7*	**12**	**-**	**1.68E-02**	**6.14E-06**	**1.63E+05**	**1.23E-02**	**9.81E-03**	**101.99**
8	-	-	6.26E-02	1.86E-05	5.38E+04	3.71E-02	2.97E-02	33.70

Table 12. Risk figures obtained through averaging of all load profiles (without NVD)

LOM Option	LOM Setting [Hz/s] or [°]	Time Delay [s]	Individual risk of electrocution			Risk of out-of-phase reclosure		
			$N_{LOM,E}$	IR_E	T_E [years]	$N_{LOM,AR}$	N_{OA}	T_{OA} [years]
1	0.4	0	4.81E-04	9.97E-09	1.00E+08	1.99E-05	1.59E-05	62,961.13
2	2.0	0.2	1.95E-02	3.86E-06	2.59E+05	7.70E-03	6.16E-03	162.34
3*	**1.5**	**0.3**	**1.93E-02**	**3.86E-06**	**2.59E+05**	**7.69E-03**	**6.15E-03**	**162.50**
4	1.5	0.5	2.37E-02	4.29E-06	2.33E+05	8.56E-03	6.85E-03	146.03
5	1.0	0.8	2.46E-02	4.38E-06	2.28E+05	8.74E-03	6.99E-03	143.06
6	6	-	6.60E-03	1.85E-06	5.41E+05	3.69E-03	2.95E-03	338.85
7*	**12**	**-**	**6.60E-03**	**1.85E-06**	**5.41E+05**	**3.69E-03**	**2.95E-03**	**338.85**
8	-	-	3.12E-02	6.25E-06	1.60E+05	1.25E-02	9.97E-03	100.28

*Recommended ROCOF and VS settings (in bold).

Where:

$N_{LOM,E}$ - annual rate of occurrence of undetected islanding incidents (with duration longer than $T_{NDZmax} = 0$ s)

IR_E - annual probability related to individual risk (injury or death of a person) from the energised parts of an undetected islanded network

T_E - average duration between incidents (injury or death of a person) from the energised parts of an undetected islanded network [in years]

$N_{LOM,AR}$ - annual rate of occurrence of undetected islanding incidents (with duration longer than $T_{NDZmax} = 29.5$ s)

N_{OA} - annual rate of occurrence of any generator being subjected to out-of-phase auto-reclosure during the islanding condition not detected by LOM protection

T_{OA} - average duration between the occurrences of out-of-phase auto-reclosure during the islanding condition not detected by LOM protection [in years]

4 Conclusions and recommendations

From analyses of the results presented in this report, the following general observations and recommendations can be made:

- The key outcome of the Phase 1 annexe consists of the estimated risk figures, considering both the probability of individual risk (IR_E), and the expected annual rate of occurrence of out-of-phase auto-reclosure (N_{OA}) when considering the operation of NVD protection.

  a) In particular, with NVD protection included, the risk related to accidental electrocution (IR_E) during the undetected islanding operation both under the existing ROCOF protection practice (in the order of 10^{-9} for setting option 1) and under the considered new settings (in the order of 10^{-7} for setting option 3 and 7) lie in the broadly acceptable region according to the Health and Safety at Work Act 1974 [3]. It should be noted that the inclusion of NVD protection has resulted in the reduction of the IR_E risk by a factor of 3.8 for ROCOF (setting option 3), and by a factor of 5.1 for VS (setting option 7), which was sufficient to move the risk values into the broadly acceptable region.

  b) Regarding the expected annual occurrence of out-of-phase auto-reclosures (N_{OA}), the risk has also been reduced by the application of NVD protection. In the worst case this would have a value of 0.00290 per annum (under setting option 8 where ROCOF and VS are both disabled; refer to Table 9), which means that one incident would be expected on average every $\frac{1}{0.00290} \cong 344.8$ years (100.3 years without NVD has been obtained previously). Additional personal risk (IR_{AR}) can result from an element (albeit small) of the probability ($P_{PER,G}$) of a person being in close proximity of the generator while it is in operation and suffering a fatal injury as a result of the generator being destroyed by an out-of-phase auto-reclosure, but the exact estimation of such probabilities depends on the specific generating technology, geographical location, and many other factors, and therefore, is beyond the scope of this work.

- The risk levels calculated in this study are subject to a variety of initial assumptions, including the amount of connected generation, characterisation of the dynamic behaviour of generation, and characterisation of load/generation profiles. Due to a number of pessimistic assumptions used in this study, the absolute risk and rate-of-occurrence values presented in the report are likely to be overestimated. In particular, the assumption of the presence of voltage controllers on all connected generators, as well as the absence of network faults during islanding incidents, will have contributed to wider NDZ values being calculated than may actually be the case in reality, and consequently a higher probability of undetected islanding being stated than may actually be the case in practice.

- As in Phase 1 report [2] the study assumed modified over-frequency protection setting (**52 Hz with 1s time delay**) and two stage under-voltage protection settings (**stage 1: 0.85 pu with 3s time delay, stage 2: 0.6 pu with 2 s time delay**). These settings meet the system stability criteria and voltage ride through requirements, and do not compromise the sensitivity of the LOM protection.

- The inclusion of NVD protection does not impact on the choice of recommended best compromise settings. For ROCOF option 3 is recommended (i.e. **1.5 Hz/s with a time delay of 300 ms**) and for VS the threshold angle of **12°** is advised. Alternatively, the change of all VS protected generators to ROCOF (with setting option 3) is equivalent from a risk perspective but may offer stability advantage under system wide events (e.g. transmission system faults during stormy weather conditions).

4.1 Consideration of the impact of various G59 revision options

Using the results in Table 9 and Table 12 various G59 revision options can be considered and directly compared in terms of overall aggregated risk. For example, regarding the individual risk of electrocution the following calculations can be made:

a) Revision 1: Changing ROCOF protection to setting option 3 and VS to setting option 7

- without NVD
  $IR_{Ea)} = 3.86 \cdot 10^{-6} + 1.85 \cdot 10^{-6} = 5.71 \cdot 10^{-6}$

- with NVD
  $IR_{Ea)NVD} = 9.97 \cdot 10^{-7} + 3.60 \cdot 10^{-7} = 1.357 \cdot 10^{-6}$

b) Revision 2: Removing both ROCOF and VS protections and relying on G59 voltage and frequency protection only (setting option 8)

- without NVD
  $IR_{Eb)} = 6.25 \cdot 10^{-6}$

- with NVD
  $IR_{Eb)NVD} = 1.82 \cdot 10^{-6}$

c) Revision 3: Applying ROCOF protection with setting option 3 to all DG and removing VS from service. This can be established directly from the results included in Table 10. Assuming that NVD protection is present the risk was calculated as:

- $IR_{Ec)NVD} = 1.36 \cdot 10^{-6}$

As can be seen from this example, with NVD included the overall risk of changing VS protection to ROCOF only (setting option 3) is the same as the simultaneous adjustment of settings for ROCOF (setting option 3) and VS (setting option 7). Even though the values are very similar, each revision option needs to be weighed against the overall cost of implementation and the LOM protection stability requirements under system wide events.

4.2 Relative contribution to risk of various generation groups and scenarios

To provide additional guidance on the impact of out-of-phase reclosure, the individual percentage contributions to the overall number of out-of-phase incidents ($N_{LOM,AR}$) have been established for the proposed setting option 3, and presented in Table 13 (based on the detailed results included in Appendix B.2.). As discussed earlier at the end of section 3.2.3, various generating technologies are affected by out-of-phase reclosure in different ways. For example, the groups which are particularly vulnerable to such events are those including synchronous generators, i.e. generation mixes 1, 5, 6, 11, 12, 13 and 15. Those mixes contribute approximately 37.61% of all expected out-of-phase reclosures (calculated using the percentage values in the right hand side column in Table 13). Therefore, assuming hypothetically that other technologies are not affected the risk value would be reduced to $N_{LOM,AR} = 0.00199 \cdot 0.3761 = 0.000747$.

Other assumptions related to potential damage to various DG technologies can be assessed in a similar manner using the percentage values in Table 13.

To facilitate an easier comparison of results, the contribution of individual generation mixes without considering NVD protection is included in Table 14 [2].

Table 13. Contribution of individual generation mixes to the overall number of LOM incidents (individual figures averaged across all load profiles) – setting option 3 (with NVD)

Islanding Scenario	Generation Mix (m)	$N_{LOM,AR(m)}$	$N_{LOM,AR(m)}[\%]$
1	2 (IC 100%)	0.00000	0.0000
	3 (DFIG 100%)	0.00000	0.0000
	5 (SM 70%, IC 30%)	0.00023	11.6884
	6 (SM 30%, IC 70%)	0.00000	0.0000
	7 (IC 50%, DFIG 50%)	0.00000	0.0000
	8 (DFIG 70%, IM 30%)	0.00000	0.0000
	9 (DFIG 30%, IM 70%)	0.00038	19.3235
	11 (SM 20%, IC 40%, IM 40%)	0.00006	3.1003
	12 (SM 50%, DFIG 30%, IM 20%)	0.00006	3.0901
	13 (SM 30%, DFIG 50%, IM 20%)	0.00000	0.0000
	14 (IC 35%, DFIG 50%, IM 15%)	0.00000	0.0000
	15 (SM 15%, IC 30%, DFIG 30%, IM 25%)	0.00031	15.3730
2	1 (SM 100%)	0.00009	4.3566
	2 (IC 100%)	0.00000	0.0000
	3 (DFIG 100%)	0.00000	0.0000
	4 (IM 100%)	0.00000	0.0000
	10 (DFIG 50%, IM 50%)	0.00086	43.0682
	Total:	0.00199	100.00

Table 14. Contribution of individual generation mixes to the overall number of LOM incidents (individual figures averaged across all load profiles) – setting option 3 (without NVD)

Islanding Scenario	Generation Mix (m)	$N_{LOM,AR(m)}$	$N_{LOM,AR(m)}[\%]$	
1	2 (IC 100%)	0.00000	0.0000	
	3 (DFIG 100%)	0.00000	0.0000	
	5 (SM 70%, IC 30%)	0.00028	3.6073	
	6 (SM 30%, IC 70%)	0.00000	0.0000	
	7 (IC 50%, DFIG 50%)	0.00000	0.0000	
	8 (DFIG 70%, IM 30%)	0.00000	0.0000	
	9 (DFIG 30%, IM 70%)	0.00047	6.1504	
	11 (SM 20%, IC 40%, IM 40%)	0.00007	0.9313	
	12 (SM 50%, DFIG 30%, IM 20%)	0.00007	0.9560	
	13 (SM 30%, DFIG 50%, IM 20%)	0.00000	0.0000	
	14 (IC 35%, DFIG 50%, IM 15%)	0.00000	0.0000	
	15 (SM 15%, IC 30%, DFIG 30%, IM 25%)	0.00036	4.6664	
2	1 (SM 100%)	0.00054	7.0055	
	2 (IC 100%)	0.00000	0.0000	
	3 (DFIG 100%)	0.00000	0.0000	
	4 (IM 100%)	0.00000	0.0000	
	10 (DFIG 50%, IM 50%)	0.00590	76.6831	76.6831
	Total:	0.00769	100.00	

5 References

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Appendix A: NDZ Assessment results

A.1. Combined NDZ results (with ROCOF, VS and G59 protection enabled)

Note: Values denoted by * and # indicate that voltage or frequency protection operated first, resulting in a narrower NDZ than the ROCOF or VS protection (considering 30s as a maximum operation time).

Table 15: ROCOF and VS NDZ results for Generation Mix 1 (SM 100%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0.308	0.385	1.286	0.977
2	ROCOF (2.0 Hz/s – 200 ms time delay)	2.485#	1.177#	3.33#	8.243#
3	ROCOF (1.5 Hz/s – 300 ms time delay)	2.485#	1.177#	3.33#	8.243#
4	ROCOF (1.5 Hz/s – 500 ms time delay)	2.485#	1.177#	3.33#	8.243#
5	ROCOF (1.0 Hz/s – 800 ms time delay)	2.485#	1.177#	3.33#	8.243#
6	VS (6°)	2.485#	1.177#	3.33#	8.243#
7	VS (12°)	2.485#	1.177#	3.33#	8.243#
8	G59 (UV/OV/UF/OF) only	2.485	1.177	3.33	8.243

Table 16: ROCOF and VS NDZ results for Generation Mix 2 (IC 100%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	0	0	0	0
3	ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
4	ROCOF (1.5 Hz/s – 500 ms time delay)	0	0	0	0
5	ROCOF (1.0 Hz/s – 800 ms time delay)	0	0	0	0
6	VS (6°)	0	0	0	0
7	VS (12°)	0	0	0	0
8	G59 (UV/OV/UF/OF) only	0	0	0	0

Table 17: ROCOF and VS NDZ results for Generation Mix 3 (DFIG 100%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	0#	0#	0#	0#
3	ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
4	ROCOF (1.5 Hz/s – 500 ms time delay)	0	0	0	0
5	ROCOF (1.0 Hz/s – 800 ms time delay)	0	0	0	0
6	VS (6°)	0#	0#	0#	0#
7	VS (12°)	0#	0#	0#	0#
8	G59 (UV/OV/UF/OF) only	0	0	0	0

Table 18: ROCOF and VS NDZ results for Generation Mix 4 (IM 100%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	2.97	2.716	0.906	0.807
2	ROCOF (2.0 Hz/s – 200 ms time delay)	5.934#	5.932#	1.811#	1.816#
3	ROCOF (1.5 Hz/s – 300 ms time delay)	5.934#	5.932#	1.811#	1.816#
4	ROCOF (1.5 Hz/s – 500 ms time delay)	5.934#	5.932#	1.811#	1.816#
5	ROCOF (1.0 Hz/s – 800 ms time delay)	5.934#	5.932#	1.811#	1.816#
6	VS (6°)	5.934#	5.932#	1.811#	1.816#
7	VS (12°)	5.934#	4.448#	1.811#	1.816#
8	G59 (UV/OV/UF/OF) only	5.934	4.448	1.811	1.816

Table 19: ROCOF and VS NDZ results for Generation Mix 5 (SM 70%, IC 30%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	10.778	7.862#	5.361	18.812
3	ROCOF (1.5 Hz/s – 300 ms time delay)	10.778	7.37	5.361	17.209
4	ROCOF (1.5 Hz/s – 500 ms time delay)	10.778	7.862	5.361	17.209
5	ROCOF (1.0 Hz/s – 800 ms time delay)	10.778	7.37	5.361	17.209
6	VS (6°)	10.778	7.862	5.361	2.475
7	VS (12°)	10.778#	7.862#	5.361	6.947
8	G59 (UV/OV/UF/OF) only	10.778	7.862	5.361	20.417

Table 20: ROCOF and VS NDZ results for Generation Mix 6 (SM 30%, IC 70%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	0.59	0.577	4.898	0.057
3	ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
4	ROCOF (1.5 Hz/s – 500 ms time delay)	21.184#	6.333	4.898	3.049
5	ROCOF (1.0 Hz/s – 800 ms time delay)	21.184#	7.801#	4.898	6.959
6	VS (6°)	0.882	0.091	0.096	0.057
7	VS (12°)	1.173	7.801#	4.898#	0.057
8	G59 (UV/OV/UF/OF) only	21.184	7.801	4.898	15.027

Table 21: ROCOF and VS NDZ results for Generation Mix 7 (IC 50%, DFIG 50%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	0	0	0	0
3	ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
4	ROCOF (1.5 Hz/s – 500 ms time delay)	0	0	0	0
5	ROCOF (1.0 Hz/s – 800 ms time delay)	0#	0#	0#	0#
6	VS (6°)	0	0	0	0
7	VS (12°)	0	0	0	0
8	G59 (UV/OV/UF/OF) only	0	0	0	0

Table 22: ROCOF and VS NDZ results for Generation Mix 8 (DFIG 70%, IM 30%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	0#	0#	0#	0#
3	ROCOF (1.5 Hz/s – 300 ms time delay)	0#	0#	0#	0#
4	ROCOF (1.5 Hz/s – 500 ms time delay)	0#	0#	0#	0#
5	ROCOF (1.0 Hz/s – 800 ms time delay)	0	0	0	0
6	VS (6°)	0#	0#	0#	0#
7	VS (12°)	0#	0#	0#	0#
8	G59 (UV/OV/UF/OF) only	0	0	0	0

Table 23: ROCOF and VS NDZ results for Generation Mix 9 (DFIG 30%, IM 70%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	3.108#	6.241#	6.105#*	7.306#
3	ROCOF (1.5 Hz/s – 300 ms time delay)	3.108#	6.241#	6.105#*	7.306#
4	ROCOF (1.5 Hz/s – 500 ms time delay)	3.108#	6.241#	6.105#*	7.306#
5	ROCOF (1.0 Hz/s – 800 ms time delay)	3.108#	6.241#	6.105#*	7.306#
6	VS (6°)	3.108#	6.241#	6.105#*	7.306#
7	VS (12°)	3.108#	6.241#	6.105#*	7.306#
8	G59 (UV/OV/UF/OF) only	3.108	6.241	6.105	7.306

Table 24: ROCOF and VS NDZ results for Generation Mix 10 (DFIG 50%, IM 50%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	1.788#	4.198#	10.963*	9.043#
3	ROCOF (1.5 Hz/s – 300 ms time delay)	1.788#	4.198#	10.963*	9.043#
4	ROCOF (1.5 Hz/s – 500 ms time delay)	1.788#	4.198#	10.963*	9.043#
5	ROCOF (1.0 Hz/s – 800 ms time delay)	1.788#	4.198#	10.963*	9.043#
6	VS (6°)	1.788#	4.198#	10.963*	9.043#
7	VS (12°)	1.788#	4.198#	10.963*	9.043#
8	G59 (UV/OV/UF/OF) only	1.788	4.198	11.955	9.043

Table 25: ROCOF and VS NDZ results for Generation Mix 11 (SM 20%, IC 40%, IM 40%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	6.947	4.136	3.836	3.741
2	ROCOF (2.0 Hz/s – 200 ms time delay)	12.841#	17.73#	4.071	95
3	ROCOF (1.5 Hz/s – 300 ms time delay)	12.841#	17.73#	4.071	75
4	ROCOF (1.5 Hz/s – 500 ms time delay)	12.841#	17.73#	4.071	85
5	ROCOF (1.0 Hz/s – 800 ms time delay)	12.841#	17.73	4.071	80
6	VS (6°)	12.841#	17.73#	4.071	8.043
7	VS (12°)	12.841#	17.73#	4.071	16.249
8	G59 (UV/OV/UF/OF) only	12.841	17.73	4.071	100

Table 26: ROCOF and VS NDZ results for Generation Mix 12 (SM 50%, DFIG 30%, IM 20%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	2.48#	0.567#	13.034#	7.432#
3	ROCOF (1.5 Hz/s – 300 ms time delay)	2.48#	0.567#	13.034#	7.432#
4	ROCOF (1.5 Hz/s – 500 ms time delay)	2.48#	0.567#	13.034#	7.432#
5	ROCOF (1.0 Hz/s – 800 ms time delay)	2.48#	0.567#	13.034#	7.432#
6	VS (6°)	2.48#	0.567#	13.034#	7.432#
7	VS (12°)	2.48#	0.567#	13.034#	7.432#
8	G59 (UV/OV/UF/OF) only	2.48	0.567	13.034	7.432

Table 27: ROCOF and VS NDZ results for Generation Mix 13 (SM 30%, DFIG 50%, IM 20%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	0#	0#	0#	0#
3	ROCOF (1.5 Hz/s – 300 ms time delay)	0#	0#	0#	0#
4	ROCOF (1.5 Hz/s – 500 ms time delay)	0#	0#	0#	0#
5	ROCOF (1.0 Hz/s – 800 ms time delay)	0#	0#	0#	0#
6	VS (6°)	0#	0#	0#	0#
7	VS (12°)	0#	0#	0#	0#
8	G59 (UV/OV/UF/OF) only	0	0	0	0

Table 28: ROCOF and VS NDZ results for Generation Mix 14 (IC 35%, DFIG 50%, IM 15%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	0	0	0	0
3	ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
4	ROCOF (1.5 Hz/s – 500 ms time delay)	0	0	0	0
5	ROCOF (1.0 Hz/s – 800 ms time delay)	0	0	0	0
6	VS (6°)	0	0	0	0
7	VS (12°)	0	0	0	0
8	G59 (UV/OV/UF/OF) only	0	0	0	0

Table 29: ROCOF and VS NDZ results for Generation Mix 15 (SM 15%, IC 30%, DFIG 30%, IM 25%)

Setting Option	Protection type and settings	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
1	ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
2	ROCOF (2.0 Hz/s – 200 ms time delay)	10.551#	11.619#	5.71	11.872
3	ROCOF (1.5 Hz/s – 300 ms time delay)	10.551#	11.619#	5.71	10.936
4	ROCOF (1.5 Hz/s – 500 ms time delay)	10.551#	11.619#	5.71	15.657
5	ROCOF (1.0 Hz/s – 800 ms time delay)	10.551#	11.619#	5.71	8.612
6	VS (6°)	0	0	0	0
7	VS (12°)	10.551	2.646	5.71	0.351
8	G59 (UV/OV/UF/OF) only	10.551	11.619	5.71	16.613

A.2. NDZ results for individual LOM protection elements

Table 30: NDZ results for Generation Mix 1 (SM 100%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0.308	0.385	1.286	0.977
ROCOF (2.0 Hz/s – 200 ms time delay)	11.88	5.93	13.934	24.576
ROCOF (1.5 Hz/s – 300 ms time delay)	8.42	3.454	9.614	28.141
ROCOF (1.5 Hz/s – 500 ms time delay)	8.915	3.454	9.614	31.711
ROCOF (1.0 Hz/s – 800 ms time delay)	5.453	1.771	5.288	17.488
VS (6°)	>50	49.642	>50	>50
VS (12°)	>50	>50	>50	>50
UV/OV	35.56	>50	>50	>50
UF/OF	2.485	1.177	3.33	8.243

Table 31: NDZ results for Generation Mix 2 (IC 100%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	0	0	0	0
ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
ROCOF (1.5 Hz/s – 500 ms time delay)	0	0	0	0
ROCOF (1.0 Hz/s – 800 ms time delay)	0	0	0	0
VS (6°)	0	0	0	0
VS (12°)	0	0	0	0
UV/OV	0	0	0	0
UF/OF	0	0	0	0

Table 32: NDZ results for Generation Mix 3 (DFIG 100%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	>50	2.633	26.848	4.728
ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
ROCOF (1.5 Hz/s – 500 ms time delay)	0	0	0	0
ROCOF (1.0 Hz/s – 800 ms time delay)	0	0	0	0
VS (6°)	>50	12.661	26.848	14.095
VS (12°)	>50	12.661	26.848	14.095
UV/OV	30.978	8.252	21.243	14.095
UF/OF	0	0	0	0

Table 33: NDZ results for Generation Mix 4 (IM 100%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	2.97	2.716	0.906	0.807
ROCOF (2.0 Hz/s – 200 ms time delay)	14.819	12.864	5.026	3.784
ROCOF (1.5 Hz/s – 300 ms time delay)	11.859	9.892	3.772	3.027
ROCOF (1.5 Hz/s – 500 ms time delay)	11.859	9.892	3.772	3.027
ROCOF (1.0 Hz/s – 800 ms time delay)	7.416	6.922	2.515	2.522
VS (6°)	>50	>50	31.827	47.212
VS (12°)	>50	>50	31.827	>50
UV/OV	10.872	4.448	3.018	2.017
UF/OF	5.934	5.932	1.811	1.816

Table 34: NDZ results for Generation Mix 5 (SM 70%, IC 30%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	10.778	8.354	5.361	18.812
ROCOF (1.5 Hz/s – 300 ms time delay)	10.778	7.37	5.361	17.209
ROCOF (1.5 Hz/s – 500 ms time delay)	10.778	7.862	5.361	17.209
ROCOF (1.0 Hz/s – 800 ms time delay)	10.778	7.37	5.361	17.209
VS (6°)	10.778	7.862	5.361	2.475
VS (12°)	11.756	14.762	5.361	6.947
UV/OV	13.71	>50	>50	>50
UF/OF	10.778	7.862	5.361	20.417

Table 35: NDZ results for Generation Mix 6 (SM 30%, IC 70%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	0.59	0.577	4.898	0.057
ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
ROCOF (1.5 Hz/s – 500 ms time delay)	23.086	6.333	4.898	3.049
ROCOF (1.0 Hz/s – 800 ms time delay)	23.086	8.291	4.898	6.959
VS (6°)	0.882	0.091	0.096	0.057
VS (12°)	1.173	18.619	5.269	0.057
UV/OV	23.086	23.565	5.269	31.326
UF/OF	21.184	7.801	4.898	15.027

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Table 36: NDZ results for Generation Mix 7 (IC 50%, DFIG 50%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	0	0	0	0
ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
ROCOF (1.5 Hz/s – 500 ms time delay)	0	0	0	0
ROCOF (1.0 Hz/s – 800 ms time delay)	0.094	0.096	0.097	0.097
VS (6°)	0	0	0	0
VS (12°)	0	0	0	0
UV/OV	0	0	0	0
UF/OF	0	0	0	0

Table 37: NDZ results for Generation Mix 8 (DFIG 70%, IM 30%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	>50	6.046	38.018	5.155
ROCOF (1.5 Hz/s – 300 ms time delay)	>50	0.739	30.428	1.016
ROCOF (1.5 Hz/s – 500 ms time delay)	>50	1.48	31.991	1.22
ROCOF (1.0 Hz/s – 800 ms time delay)	0	0	0	0
VS (6°)	>50	8.863	16.168	34.011
VS (12°)	>50	9.334	16.168	34.011
UV/OV	31.929	20.767	15.272	34.011
UF/OF	0	0	0	0

Table 38: NDZ results for Generation Mix 9 (DFIG 30%, IM 70%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	>50	>50	11.085	13.729
ROCOF (1.5 Hz/s – 300 ms time delay)	>50	>50	11.085	12.648
ROCOF (1.5 Hz/s – 500 ms time delay)	>50	>50	19.809	12.648
ROCOF (1.0 Hz/s – 800 ms time delay)	>50	>50	14.027	11.571
VS (6°)	35.697	>50	8.109	16.998
VS (12°)	35.697	>50	8.109	16.998
UV/OV	32.007	17.372	6.105	11.571
UF/OF	3.108	6.241	6.105	7.306

Table 39: NDZ results for Generation Mix 10 (DFIG 50%, IM 50%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	>50	>50	41.346	18.151
ROCOF (1.5 Hz/s – 300 ms time delay)	>50	12.864	27.718	17.135
ROCOF (1.5 Hz/s – 500 ms time delay)	>50	12.864	29.674	22.22
ROCOF (1.0 Hz/s – 800 ms time delay)	>50	7.911	23.796	18.151
VS (6°)	>50	47.646	19.862	22.22
VS (12°)	>50	>50	23.796	22.22
UV/OV	33.547	23.776	10.963	22.22
UF/OF	1.788	4.198	11.955	9.043

Table 40: NDZ results for Generation Mix 11 (SM 20%, IC 40%, IM 40%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	6.947	4.136	3.836	3.741
ROCOF (2.0 Hz/s – 200 ms time delay)	13.823	21.695	4.071	95
ROCOF (1.5 Hz/s – 300 ms time delay)	13.823	18.721	4.071	75
ROCOF (1.5 Hz/s – 500 ms time delay)	13.823	21.695	4.071	85
ROCOF (1.0 Hz/s – 800 ms time delay)	13.823	17.73	4.071	80
VS (6°)	13.823	23.68	4.071	8.043
VS (12°)	13.823	47.573	4.071	16.249
UV/OV	13.823	47.573	4.071	>100
UF/OF	12.841	17.73	4.071	100

Table 41: NDZ results for Generation Mix 12 (SM 50%, DFIG 30%, IM 20%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	14.739	13.767	25.752	17.691
ROCOF (1.5 Hz/s – 300 ms time delay)	15.718	7.358	22.387	17.691
ROCOF (1.5 Hz/s – 500 ms time delay)	15.718	7.358	22.387	28.573
ROCOF (1.0 Hz/s – 800 ms time delay)	9.841	2.927	16.451	24.926
VS (6°)	16.696	29.59	>50	19.492
VS (12°)	17.675	29.59	>50	35.93
UV/OV	4.69	43.488	>50	17.691
UF/OF	2.48	0.567	13.034	7.432

Table 42: NDZ results for Generation Mix 13 (SM 30%, DFIG 50%, IM 20%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	6.366	4.858	24.148	27.417
ROCOF (1.5 Hz/s – 300 ms time delay)	6.853	1.925	20.789	27.417
ROCOF (1.5 Hz/s – 500 ms time delay)	16.564	2.414	20.789	29.31
ROCOF (1.0 Hz/s – 800 ms time delay)	8.798	0.264	16.55	25.533
VS (6^o)	6.366	17.614	22.472	27.417
VS (12^o)	6.366	17.614	22.472	27.417
UV/OV	6.366	37.367	>50	27.417
UF/OF	0	0	0	0

Table 43: NDZ results for Generation Mix 14 (IC 35%, DFIG 50%, IM 15%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	0	0	0	0
ROCOF (1.5 Hz/s – 300 ms time delay)	0	0	0	0
ROCOF (1.5 Hz/s – 500 ms time delay)	0	0	0	0
ROCOF (1.0 Hz/s – 800 ms time delay)	0	0	0	0
VS (6^o)	0	0	0	0
VS (12^o)	0	0	0	0
UV/OV	0	0	0	0
UF/OF	0	0	0	0

Table 44: NDZ results for Generation Mix 15 (SM 15%, IC 30%, DFIG 30%, IM 25%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	0	0	0	0
ROCOF (2.0 Hz/s – 200 ms time delay)	11.504	12.594	5.71	11.872
ROCOF (1.5 Hz/s – 300 ms time delay)	11.504	12.594	5.71	10.936
ROCOF (1.5 Hz/s – 500 ms time delay)	11.504	12.594	5.71	15.657
ROCOF (1.0 Hz/s – 800 ms time delay)	11.504	12.594	5.71	8.612
VS (6^o)	0	0	0	0
VS (12^o)	10.551	2.646	5.71	0.351
UV/OV	10.551	12.594	5.71	>50
UF/OF	10.551	11.619	5.71	16.613

Appendix B: Full record of risk assessment results

B.1. Summary Results

Table 45. LOM risk assessment results for islanding scenario 1 (loss of supply to BSP)

Load Profile	Setting Option	$T_{NDZavr,s1}$ [min]	$N_{LOM,1DGG,s1}$	$P_{LOM,1DGG,s1}$	$N_{LOM,AR,s1}$	$P_{LOM,E,s1}$	$N_{LOM,E,s1}$
LP01	1	9.37	3.94E-08	3.75E-14	4.14E-07	3.94E-13	5.30E-05
	2	109.37	3.42E-05	3.26E-11	3.60E-04	3.42E-10	3.69E-03
	3	97.93	3.44E-05	3.27E-11	3.61E-04	3.44E-10	3.61E-03
	4	162.88	5.67E-05	5.39E-11	5.95E-04	5.66E-10	5.38E-03
	5	164.48	6.17E-05	5.87E-11	6.48E-04	6.17E-10	5.51E-03
	6	25.22	7.77E-06	7.39E-12	5.83E-05	5.54E-11	6.53E-04
	7	25.22	7.77E-06	7.39E-12	5.83E-05	5.54E-11	6.53E-04
	8	106.88	3.92E-05	3.73E-11	7.05E-04	6.71E-10	6.17E-03
LP02	1	19.88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	144.96	5.98E-05	5.69E-11	6.28E-04	5.98E-10	5.61E-03
	3	133.39	5.78E-05	5.50E-11	6.07E-04	5.78E-10	5.37E-03
	4	164.29	8.50E-05	8.09E-11	8.93E-04	8.49E-10	8.06E-03
	5	164.00	1.01E-04	9.59E-11	1.06E-03	1.01E-09	8.89E-03
	6	20.01	2.12E-05	2.02E-11	1.59E-04	1.51E-10	1.03E-03
	7	20.01	2.12E-05	2.02E-11	1.59E-04	1.51E-10	1.03E-03
	8	105.40	6.76E-05	6.43E-11	1.22E-03	1.16E-09	9.92E-03
LP03	1	59.46	1.87E-06	1.78E-12	1.96E-05	1.86E-11	2.44E-04
	2	324.03	8.05E-05	7.66E-11	8.45E-04	8.04E-10	4.56E-03
	3	312.35	8.19E-05	7.79E-11	8.59E-04	8.18E-10	4.47E-03
	4	379.86	2.02E-04	1.92E-10	2.12E-03	2.02E-09	1.09E-02
	5	397.12	2.43E-04	2.32E-10	2.56E-03	2.43E-09	1.33E-02
	6	31.85	1.19E-05	1.14E-11	8.96E-05	8.52E-11	5.44E-04
	7	31.85	1.19E-05	1.14E-11	8.96E-05	8.52E-11	5.44E-04
	8	250.04	1.56E-04	1.48E-10	2.80E-03	2.66E-09	1.42E-02
LP04	1	24.33	3.41E-06	3.24E-12	3.58E-05	3.40E-11	3.10E-04
	2	156.51	7.29E-05	6.94E-11	7.66E-04	7.28E-10	4.15E-03
	3	149.03	7.18E-05	6.83E-11	7.54E-04	7.17E-10	4.00E-03
	4	209.92	1.17E-04	1.11E-10	1.23E-03	1.17E-09	6.49E-03
	5	212.18	1.14E-04	1.08E-10	1.19E-03	1.14E-09	6.82E-03
	6	16.52	1.75E-05	1.67E-11	1.31E-04	1.25E-10	6.52E-04
	7	16.52	1.75E-05	1.67E-11	1.31E-04	1.25E-10	6.52E-04
	8	131.01	7.42E-05	7.06E-11	1.33E-03	1.27E-09	7.48E-03
LP05	1	48.34	4.33E-22	4.12E-28	4.55E-21	4.33E-27	2.05E-05
	2	321.57	2.53E-04	2.41E-10	2.66E-03	2.53E-09	1.31E-02
	3	313.73	2.51E-04	2.39E-10	2.64E-03	2.51E-09	1.30E-02
	4	510.64	3.85E-04	3.66E-10	4.04E-03	3.85E-09	2.03E-02
	5	518.74	3.99E-04	3.80E-10	4.19E-03	3.99E-09	2.09E-02
	6	15.04	8.97E-05	8.53E-11	6.73E-04	6.40E-10	2.90E-03
	7	15.04	8.97E-05	8.53E-11	6.73E-04	6.40E-10	2.90E-03
	8	309.21	2.71E-04	2.58E-10	4.88E-03	4.64E-09	2.38E-02

Table 46. LOM risk assessment results for islanding scenario 2 (loss of individual 33kV feeder)

Load Profile	Setting Option	$T_{NDZavr,s2}$ [min]	$N_{LOM,1DGG,s2}$	$P_{LOM,1DGG,s2}$	$N_{LOM,AR,s2}$	$P_{LOM,E,s2}$	$N_{LOM,E,s2}$
LP06	1	13.18	6.96E-07	6.62E-13	6.68E-06	6.36E-12	1.10E-03
	2	80.21	4.16E-05	3.96E-11	4.00E-04	3.80E-10	7.86E-03
	3	80.21	4.16E-05	3.96E-11	4.00E-04	3.80E-10	7.86E-03
	4	80.21	4.16E-05	3.96E-11	4.00E-04	3.80E-10	7.86E-03
	5	80.21	4.16E-05	3.96E-11	4.00E-04	3.80E-10	7.86E-03
	6	16.65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	16.65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	43.18	1.74E-05	1.65E-11	4.00E-04	3.80E-10	7.86E-03
LP07	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LP08	1	10.31	7.05E-07	6.70E-13	6.77E-06	6.44E-12	5.41E-05
	2	43.75	7.68E-05	7.31E-11	7.38E-04	7.02E-10	7.60E-03
	3	43.75	7.68E-05	7.31E-11	7.38E-04	7.02E-10	7.60E-03
	4	43.75	7.68E-05	7.31E-11	7.38E-04	7.02E-10	7.60E-03
	5	43.75	7.68E-05	7.31E-11	7.38E-04	7.02E-10	7.60E-03
	6	8.85	3.04E-05	2.90E-11	4.08E-04	3.88E-10	4.12E-03
	7	8.85	3.04E-05	2.90E-11	4.08E-04	3.88E-10	4.12E-03
	8	23.42	4.98E-05	4.74E-11	1.15E-03	1.09E-09	1.17E-02
LP09	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	57.12	9.47E-05	9.01E-11	9.09E-04	8.65E-10	2.58E-03
	3	57.12	9.47E-05	9.01E-11	9.09E-04	8.65E-10	2.58E-03
	4	57.12	9.47E-05	9.01E-11	9.09E-04	8.65E-10	2.58E-03
	5	57.12	9.47E-05	9.01E-11	9.09E-04	8.65E-10	2.58E-03
	6	23.69	3.93E-05	3.74E-11	5.26E-04	5.01E-10	1.49E-03
	7	23.69	3.93E-05	3.74E-11	5.26E-04	5.01E-10	1.49E-03
	8	37.64	6.24E-05	5.94E-11	1.44E-03	1.37E-09	4.07E-03
LP10	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	754.29	2.77E-04	2.64E-10	2.66E-03	2.53E-09	9.36E-03
	3	754.29	2.77E-04	2.64E-10	2.66E-03	2.53E-09	9.36E-03
	4	754.29	2.77E-04	2.64E-10	2.66E-03	2.53E-09	9.36E-03
	5	754.29	2.77E-04	2.64E-10	2.66E-03	2.53E-09	9.36E-03
	6	379.54	1.15E-04	1.09E-10	1.54E-03	1.47E-09	5.42E-03
	7	379.54	1.15E-04	1.09E-10	1.54E-03	1.47E-09	5.42E-03
	8	535.96	1.83E-04	1.74E-10	4.20E-03	4.00E-09	1.48E-02

Table 47. Summary LOM risk assessment results – based on maximum load profile figures

LOM Scenario	Setting Option	T_{NDZavr} [min]	$N_{LOM,1DGG}$	$P_{LOM,1DGG}$	$N_{LOM,AR}$	$P_{LOM,E}$	$N_{LOM,E}$
S1	1	59.5	3.41E-06	3.24E-12	3.58E-05	3.40E-11	3.10E-04
	2	324.0	2.53E-04	2.41E-10	2.66E-03	2.53E-09	1.31E-02
	3	313.7	2.51E-04	2.39E-10	2.64E-03	2.51E-09	1.30E-02
	4	510.6	3.85E-04	3.66E-10	4.04E-03	3.85E-09	2.03E-02
	5	518.7	3.99E-04	3.80E-10	4.19E-03	3.99E-09	2.09E-02
	6	31.9	8.97E-05	8.53E-11	6.73E-04	6.40E-10	2.90E-03
	7	31.9	8.97E-05	8.53E-11	6.73E-04	6.40E-10	2.90E-03
	8	309.2	2.71E-04	2.58E-10	4.88E-03	4.64E-09	2.38E-02
S2	1	13.18	7.05E-07	6.70E-13	6.77E-06	6.44E-12	1.10E-03
	2	754.29	2.77E-04	2.64E-10	2.66E-03	2.53E-09	9.36E-03
	3	754.29	2.77E-04	2.64E-10	2.66E-03	2.53E-09	9.36E-03
	4	754.29	2.77E-04	2.64E-10	2.66E-03	2.53E-09	9.36E-03
	5	754.29	2.77E-04	2.64E-10	2.66E-03	2.53E-09	9.36E-03
	6	379.54	1.15E-04	1.09E-10	1.54E-03	1.47E-09	5.42E-03
	7	379.54	1.15E-04	1.09E-10	1.54E-03	1.47E-09	5.42E-03
	8	535.96	1.83E-04	1.74E-10	4.20E-03	4.00E-09	1.48E-02
Combined S1 & S2	1	37.36	2.12E-06	2.01E-12	4.25E-05	4.05E-11	1.41E-03
	2	529.52	2.65E-04	2.52E-10	5.32E-03	5.06E-09	2.24E-02
	3	524.14	2.64E-04	2.51E-10	5.30E-03	5.04E-09	2.23E-02
	4	627.01	3.34E-04	3.17E-10	6.71E-03	6.38E-09	2.96E-02
	5	631.24	3.41E-04	3.24E-10	6.85E-03	6.52E-09	3.02E-02
	6	254.77	1.06E-04	1.01E-10	2.21E-03	2.11E-09	8.32E-03
	7	254.77	1.06E-04	1.01E-10	2.21E-03	2.11E-09	8.32E-03
	8	436.41	2.22E-04	2.11E-10	9.08E-03	8.64E-09	3.86E-02

Table 48. Summary LOM risk assessment results – based on average load profile figures

LOM Scenario	Setting Option	T_{NDZavr} [min]	$N_{LOM,1DGG}$	$P_{LOM,1DGG}$	$N_{LOM,AR}$	$P_{LOM,E}$	$N_{LOM,E}$
S1	1	32.28	1.06E-06	1.01E-12	1.12E-05	1.06E-11	1.25E-04
	2	211.29	1.00E-04	9.53E-11	1.05E-03	1.00E-09	6.21E-03
	3	201.29	9.94E-05	9.46E-11	1.04E-03	9.93E-10	6.08E-03
	4	285.52	1.69E-04	1.61E-10	1.78E-03	1.69E-09	1.02E-02
	5	291.30	1.84E-04	1.75E-10	1.93E-03	1.84E-09	1.11E-02
	6	21.73	2.96E-05	2.82E-11	2.22E-04	2.11E-10	1.15E-03
	7	21.73	2.96E-05	2.82E-11	2.22E-04	2.11E-10	1.15E-03
	8	180.51	1.22E-04	1.16E-10	2.19E-03	2.08E-09	1.23E-02
S2	1	4.70	2.80E-07	2.66E-13	2.69E-06	2.56E-12	2.30E-04
	2	187.07	9.81E-05	9.33E-11	9.42E-04	8.96E-10	5.48E-03
	3	187.07	9.81E-05	9.33E-11	9.42E-04	8.96E-10	5.48E-03
	4	187.07	9.81E-05	9.33E-11	9.42E-04	8.96E-10	5.48E-03
	5	187.07	9.81E-05	9.33E-11	9.42E-04	8.96E-10	5.48E-03
	6	85.75	3.70E-05	3.52E-11	4.95E-04	4.71E-10	2.21E-03
	7	85.75	3.70E-05	3.52E-11	4.95E-04	4.71E-10	2.21E-03
	8	128.04	6.25E-05	5.94E-11	1.44E-03	1.37E-09	7.69E-03
Combined S1 & S2	1	19.11	6.89E-07	6.55E-13	1.38E-05	1.32E-11	3.55E-04
	2	199.72	9.92E-05	9.44E-11	1.99E-03	1.90E-09	1.17E-02
	3	194.50	9.88E-05	9.40E-11	1.99E-03	1.89E-09	1.16E-02
	4	238.50	1.35E-04	1.29E-10	2.72E-03	2.59E-09	1.57E-02
	5	241.52	1.43E-04	1.36E-10	2.87E-03	2.73E-09	1.66E-02
	6	62.77	3.43E-05	3.27E-11	7.17E-04	6.82E-10	3.36E-03
	7	62.77	3.43E-05	3.27E-11	7.17E-04	6.82E-10	3.36E-03
	8	151.07	8.84E-05	8.41E-11	3.62E-03	3.45E-09	2.00E-02

B.2. Detailed results for different generation mixes and load profiles

Table 49. LOM risk assessment results (islanding scenario 1, load profile LP01)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	151.31	6.60E-05	6.27E-11	9.89E-05	9.41E-11	6.98E-04
	3	146.27	6.71E-05	6.38E-11	1.01E-04	9.57E-11	6.90E-04
	4	151.31	6.60E-05	6.27E-11	9.89E-05	9.41E-11	6.98E-04
	5	146.27	6.71E-05	6.38E-11	1.01E-04	9.57E-11	6.90E-04
	6	150.86	6.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	150.50	6.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	151.31	6.60E-05	6.27E-11	9.89E-05	9.41E-11	6.98E-04
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	75.02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.63E-05
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	449.57	1.57E-04	1.49E-10	2.36E-04	2.24E-10	1.76E-03
	5	465.80	1.91E-04	1.82E-10	2.87E-04	2.73E-10	1.90E-03
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	300.22	1.10E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	465.80	1.91E-04	1.82E-10	2.87E-04	2.73E-10	1.90E-03
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
7	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	515.92	1.59E-04	1.51E-10	1.01E-04	9.57E-11	1.13E-03
	3	515.92	1.59E-04	1.51E-10	1.01E-04	9.57E-11	1.13E-03
	4	515.92	1.59E-04	1.51E-10	1.01E-04	9.57E-11	1.13E-03
	5	515.92	1.59E-04	1.51E-10	1.01E-04	9.57E-11	1.13E-03
	6	515.92	1.59E-04	1.51E-10	5.83E-05	5.54E-11	6.53E-04
	7	515.92	1.59E-04	1.51E-10	5.83E-05	5.54E-11	6.53E-04
	8	515.92	1.59E-04	1.51E-10	1.59E-04	1.51E-10	1.78E-03
8	1	98.40	4.14E-07	3.94E-13	4.14E-07	3.94E-13	5.30E-05
	2	205.10	4.34E-06	4.12E-12	4.34E-06	4.12E-12	2.11E-04
	3	205.10	4.34E-06	4.12E-12	4.34E-06	4.12E-12	2.11E-04
	4	205.10	4.34E-06	4.12E-12	4.34E-06	4.12E-12	2.11E-04
	5	205.10	4.34E-06	4.12E-12	4.34E-06	4.12E-12	2.11E-04
	6	205.10	4.34E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	205.10	4.34E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	205.10	4.34E-06	4.12E-12	4.34E-06	4.12E-12	2.11E-04
9	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	91.88	1.56E-05	1.49E-11	1.56E-05	1.49E-11	2.31E-04
	3	91.88	1.56E-05	1.49E-11	1.56E-05	1.49E-11	2.31E-04
	4	91.88	1.56E-05	1.49E-11	1.56E-05	1.49E-11	2.31E-04
	5	91.88	1.56E-05	1.49E-11	1.56E-05	1.49E-11	2.31E-04
	6	91.88	1.56E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	91.88	1.56E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	91.88	1.56E-05	1.49E-11	1.56E-05	1.49E-11	2.31E-04
10	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	185.18	1.40E-04	1.33E-10	1.40E-04	1.33E-10	1.35E-03
	3	185.18	1.40E-04	1.33E-10	1.40E-04	1.33E-10	1.35E-03
	4	185.18	1.40E-04	1.33E-10	1.40E-04	1.33E-10	1.35E-03
	5	185.18	1.40E-04	1.33E-10	1.40E-04	1.33E-10	1.35E-03
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	146.56	3.22E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	185.18	1.40E-04	1.33E-10	1.40E-04	1.33E-10	1.35E-03

Table 50. LOM risk assessment results (islanding scenario 1, load profile LP02)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	147.08	1.75E-05	1.67E-11	2.63E-05	2.50E-11	2.40E-04
	3	130.29	1.80E-05	1.72E-11	2.70E-05	2.57E-11	2.38E-04
	4	147.08	1.75E-05	1.67E-11	2.63E-05	2.50E-11	2.40E-04
	5	130.29	1.80E-05	1.72E-11	2.70E-05	2.57E-11	2.38E-04
	6	147.08	1.75E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	147.08	1.75E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	147.08	1.75E-05	1.67E-11	2.63E-05	2.50E-11	2.40E-04
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	64.22	1.45E-05	1.37E-11	2.17E-05	2.06E-11	2.36E-04
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	199.56	1.91E-04	1.82E-10	2.86E-04	2.72E-10	2.69E-03
	5	214.29	3.01E-04	2.86E-10	4.52E-04	4.30E-10	3.52E-03
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	195.66	2.71E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	214.29	3.01E-04	2.86E-10	4.52E-04	4.30E-10	3.52E-03
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
7	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	409.31	4.34E-04	4.13E-10	2.75E-04	2.61E-10	1.77E-03
	3	409.31	4.34E-04	4.13E-10	2.75E-04	2.61E-10	1.77E-03
	4	409.31	4.34E-04	4.13E-10	2.75E-04	2.61E-10	1.77E-03
	5	409.31	4.34E-04	4.13E-10	2.75E-04	2.61E-10	1.77E-03
	6	409.31	4.34E-04	4.13E-10	1.59E-04	1.51E-10	1.03E-03
	7	409.31	4.34E-04	4.13E-10	1.59E-04	1.51E-10	1.03E-03
	8	409.31	4.34E-04	4.13E-10	4.34E-04	4.13E-10	2.80E-03
8	1	208.75	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	529.08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	529.08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	529.08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	529.08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	529.08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	529.08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	529.08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	113.07	1.88E-04	1.79E-10	1.88E-04	1.79E-10	2.16E-03
	3	113.07	1.88E-04	1.79E-10	1.88E-04	1.79E-10	2.16E-03
	4	113.07	1.88E-04	1.79E-10	1.88E-04	1.79E-10	2.16E-03
	5	113.07	1.88E-04	1.79E-10	1.88E-04	1.79E-10	2.16E-03
	6	113.07	1.88E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	113.07	1.88E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	113.07	1.88E-04	1.79E-10	1.88E-04	1.79E-10	2.16E-03
10	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	303.73	1.17E-04	1.12E-10	1.17E-04	1.12E-10	1.20E-03
	3	303.73	1.17E-04	1.12E-10	1.17E-04	1.12E-10	1.20E-03
	4	303.73	1.17E-04	1.12E-10	1.17E-04	1.12E-10	1.20E-03
	5	303.73	1.17E-04	1.12E-10	1.17E-04	1.12E-10	1.20E-03
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	180.28	7.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	303.73	1.17E-04	1.12E-10	1.17E-04	1.12E-10	1.20E-03

Table 51. LOM risk assessment results (islanding scenario 1, load profile LP3)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	462.68	9.06E-05	8.62E-11	1.36E-04	1.29E-10	9.41E-04
	3	448.26	1.02E-04	9.72E-11	1.53E-04	1.46E-10	9.20E-04
	4	456.71	9.06E-05	8.62E-11	1.36E-04	1.29E-10	9.41E-04
	5	448.26	1.02E-04	9.72E-11	1.53E-04	1.46E-10	9.20E-04
	6	287.23	7.76E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	377.39	7.88E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	470.61	9.06E-05	8.62E-11	1.36E-04	1.29E-10	9.41E-04
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	67.72	2.31E-06	2.20E-12	3.47E-06	3.30E-12	7.75E-05
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	464.92	8.52E-04	8.11E-10	1.28E-03	1.22E-09	6.39E-03
	5	593.81	1.13E-03	1.08E-09	1.70E-03	1.61E-09	8.81E-03
	6	0.00	1.18E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	216.49	1.79E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	633.67	1.25E-03	1.19E-09	1.87E-03	1.78E-09	9.20E-03
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
7	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	651.57	2.44E-04	2.32E-10	1.55E-04	1.47E-10	9.39E-04
	3	651.57	2.44E-04	2.32E-10	1.55E-04	1.47E-10	9.39E-04
	4	651.57	2.44E-04	2.32E-10	1.55E-04	1.47E-10	9.39E-04
	5	651.57	2.44E-04	2.32E-10	1.55E-04	1.47E-10	9.39E-04
	6	651.57	2.44E-04	2.32E-10	8.96E-05	8.52E-11	5.44E-04
	7	651.57	2.44E-04	2.32E-10	8.96E-05	8.52E-11	5.44E-04
	8	651.57	2.44E-04	2.32E-10	2.44E-04	2.32E-10	1.48E-03
8	1	624.38	1.96E-05	1.86E-11	1.96E-05	1.86E-11	2.44E-04
	2	1480.43	1.88E-04	1.79E-10	1.88E-04	1.79E-10	1.22E-03
	3	1480.43	1.88E-04	1.79E-10	1.88E-04	1.79E-10	1.22E-03
	4	1480.43	1.88E-04	1.79E-10	1.88E-04	1.79E-10	1.22E-03
	5	1480.43	1.88E-04	1.79E-10	1.88E-04	1.79E-10	1.22E-03
	6	1482.46	1.87E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	1480.43	1.88E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	1480.43	1.88E-04	1.79E-10	1.88E-04	1.79E-10	1.22E-03
9	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	140.56	7.31E-05	6.95E-11	7.31E-05	6.95E-11	3.74E-04
	3	140.56	7.31E-05	6.95E-11	7.31E-05	6.95E-11	3.74E-04
	4	140.56	7.31E-05	6.95E-11	7.31E-05	6.95E-11	3.74E-04
	5	140.56	7.31E-05	6.95E-11	7.31E-05	6.95E-11	3.74E-04
	6	140.56	7.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	140.56	7.31E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	140.56	7.31E-05	6.95E-11	7.31E-05	6.95E-11	3.74E-04
10	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	573.02	2.90E-04	2.76E-10	2.90E-04	2.76E-10	1.02E-03
	3	573.67	2.90E-04	2.76E-10	2.90E-04	2.76E-10	1.02E-03
	4	572.46	2.90E-04	2.76E-10	2.90E-04	2.76E-10	1.02E-03
	5	572.96	2.90E-04	2.76E-10	2.90E-04	2.76E-10	1.02E-03
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	491.49	1.13E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	571.70	2.90E-04	2.76E-10	2.90E-04	2.76E-10	1.02E-03

Table 52. LOM risk assessment results (islanding scenario 1, load profile LP4)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	273.34	1.38E-04	1.31E-10	2.07E-04	1.97E-10	7.62E-04
	3	269.00	1.32E-04	1.25E-10	1.97E-04	1.88E-10	7.50E-04
	4	273.34	1.38E-04	1.31E-10	2.07E-04	1.97E-10	7.62E-04
	5	269.00	1.32E-04	1.25E-10	1.97E-04	1.88E-10	7.50E-04
	6	236.19	1.38E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	262.59	1.38E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	273.34	1.38E-04	1.31E-10	2.07E-04	1.97E-10	7.62E-04
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	48.01	1.42E-06	1.35E-12	2.14E-06	2.03E-12	1.35E-04
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	421.89	3.09E-04	2.94E-10	4.64E-04	4.41E-10	2.48E-03
	5	442.02	2.93E-04	2.79E-10	4.40E-04	4.19E-10	2.82E-03
	6	32.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	185.91	1.75E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	442.02	2.93E-04	2.79E-10	4.40E-04	4.19E-10	2.82E-03
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
7	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	337.82	3.58E-04	3.41E-10	2.27E-04	2.16E-10	1.13E-03
	3	337.82	3.58E-04	3.41E-10	2.27E-04	2.16E-10	1.13E-03
	4	337.82	3.58E-04	3.41E-10	2.27E-04	2.16E-10	1.13E-03
	5	337.82	3.58E-04	3.41E-10	2.27E-04	2.16E-10	1.13E-03
	6	337.82	3.58E-04	3.41E-10	1.31E-04	1.25E-10	6.52E-04
	7	337.82	3.58E-04	3.41E-10	1.31E-04	1.25E-10	6.52E-04
	8	337.82	3.58E-04	3.41E-10	3.58E-04	3.41E-10	1.78E-03
8	1	255.47	3.58E-05	3.40E-11	3.58E-05	3.40E-11	3.10E-04
	2	620.14	1.08E-04	1.03E-10	1.08E-04	1.03E-10	9.30E-04
	3	620.14	1.08E-04	1.03E-10	1.08E-04	1.03E-10	9.30E-04
	4	620.14	1.08E-04	1.03E-10	1.08E-04	1.03E-10	9.30E-04
	5	620.14	1.08E-04	1.03E-10	1.08E-04	1.03E-10	9.30E-04
	6	620.14	1.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	620.14	1.08E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	620.14	1.08E-04	1.03E-10	1.08E-04	1.03E-10	9.30E-04
9	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	90.34	2.74E-05	2.61E-11	2.74E-05	2.61E-11	2.42E-04
	3	90.34	2.74E-05	2.61E-11	2.74E-05	2.61E-11	2.42E-04
	4	90.34	2.74E-05	2.61E-11	2.74E-05	2.61E-11	2.42E-04
	5	90.34	2.74E-05	2.61E-11	2.74E-05	2.61E-11	2.42E-04
	6	90.34	2.74E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	90.34	2.74E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	90.34	2.74E-05	2.61E-11	2.74E-05	2.61E-11	2.42E-04
10	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	236.91	1.94E-04	1.85E-10	1.94E-04	1.85E-10	9.50E-04
	3	236.91	1.94E-04	1.85E-10	1.94E-04	1.85E-10	9.50E-04
	4	236.91	1.94E-04	1.85E-10	1.94E-04	1.85E-10	9.50E-04
	5	236.91	1.94E-04	1.85E-10	1.94E-04	1.85E-10	9.50E-04
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	198.29	1.32E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	236.91	1.94E-04	1.85E-10	1.94E-04	1.85E-10	9.50E-04

Table 53. LOM risk assessment results (islanding scenario 1, load profile LP5)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	804.48	4.67E-04	4.44E-10	7.00E-04	6.66E-10	3.59E-03
	3	800.32	4.55E-04	4.33E-10	6.82E-04	6.49E-10	3.55E-03
	4	804.48	4.67E-04	4.44E-10	7.00E-04	6.66E-10	3.59E-03
	5	800.32	4.55E-04	4.33E-10	6.82E-04	6.49E-10	3.55E-03
	6	804.41	4.67E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	804.48	4.67E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	804.48	4.67E-04	4.44E-10	7.00E-04	6.66E-10	3.59E-03
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	50.77	1.88E-06	1.79E-12	2.82E-06	2.68E-12	7.58E-05
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	1374.26	9.24E-04	8.79E-10	1.39E-03	1.32E-09	7.27E-03
	5	1435.10	1.03E-03	9.83E-10	1.55E-03	1.48E-09	7.91E-03
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	243.24	6.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	1435.10	1.03E-03	9.83E-10	1.55E-03	1.48E-09	7.91E-03
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
7	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	307.59	1.83E-03	1.75E-09	1.16E-03	1.11E-09	5.01E-03
	3	307.59	1.83E-03	1.75E-09	1.16E-03	1.11E-09	5.01E-03
	4	307.59	1.83E-03	1.75E-09	1.16E-03	1.11E-09	5.01E-03
	5	307.59	1.83E-03	1.75E-09	1.16E-03	1.11E-09	5.01E-03
	6	307.59	1.83E-03	1.75E-09	6.73E-04	6.40E-10	2.90E-03
	7	307.59	1.83E-03	1.75E-09	6.73E-04	6.40E-10	2.90E-03
	8	307.59	1.83E-03	1.75E-09	1.83E-03	1.75E-09	7.90E-03
8	1	507.61	4.55E-21	4.33E-27	4.55E-21	4.33E-27	2.05E-05
	2	988.89	7.77E-06	7.39E-12	7.77E-06	7.39E-12	9.90E-05
	3	988.89	7.77E-06	7.39E-12	7.77E-06	7.39E-12	9.90E-05
	4	988.89	7.77E-06	7.39E-12	7.77E-06	7.39E-12	9.90E-05
	5	988.89	7.77E-06	7.39E-12	7.77E-06	7.39E-12	9.90E-05
	6	988.89	7.77E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	988.89	7.77E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	988.89	7.77E-06	7.39E-12	7.77E-06	7.39E-12	9.90E-05
9	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	108.41	2.62E-06	2.49E-12	2.62E-06	2.49E-12	1.10E-04
	3	108.41	2.62E-06	2.49E-12	2.62E-06	2.49E-12	1.10E-04
	4	108.41	2.62E-06	2.49E-12	2.62E-06	2.49E-12	1.10E-04
	5	108.41	2.62E-06	2.49E-12	2.62E-06	2.49E-12	1.10E-04
	6	108.41	2.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	108.41	2.62E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	108.41	2.62E-06	2.49E-12	2.62E-06	2.49E-12	1.10E-04
10	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	801.53	7.85E-04	7.46E-10	7.85E-04	7.46E-10	4.18E-03
	3	801.53	7.85E-04	7.46E-10	7.85E-04	7.46E-10	4.18E-03
	4	801.53	7.85E-04	7.46E-10	7.85E-04	7.46E-10	4.18E-03
	5	801.53	7.85E-04	7.46E-10	7.85E-04	7.46E-10	4.18E-03
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	677.46	6.42E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	801.53	7.85E-04	7.46E-10	7.85E-04	7.46E-10	4.18E-03

Table 54. LOM risk assessment results (islanding scenario 2, load profile LP06)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	42.17	2.23E-06	2.12E-12	6.68E-06	6.36E-12	1.10E-03
	2	128.18	1.33E-04	1.27E-10	4.00E-04	3.80E-10	7.86E-03
	3	128.18	1.33E-04	1.27E-10	4.00E-04	3.80E-10	7.86E-03
	4	128.18	1.33E-04	1.27E-10	4.00E-04	3.80E-10	7.86E-03
	5	128.18	1.33E-04	1.27E-10	4.00E-04	3.80E-10	7.86E-03
	6	128.18	1.33E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	128.18	1.33E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	128.18	1.33E-04	1.27E-10	4.00E-04	3.80E-10	7.86E-03
2	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	608.60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	608.60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	608.60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	608.60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	608.60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	608.60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	608.60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 55. LOM risk assessment results (islanding scenario 2, load profile LP07)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 56. LOM risk assessment results (islanding scenario 2, load profile LP8)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	33.00	2.26E-06	2.15E-12	6.77E-06	6.44E-12	5.41E-05
	2	71.73	1.10E-05	1.05E-11	3.30E-05	3.14E-11	4.85E-04
	3	71.73	1.10E-05	1.05E-11	3.30E-05	3.14E-11	4.85E-04
	4	71.73	1.10E-05	1.05E-11	3.30E-05	3.14E-11	4.85E-04
	5	71.73	1.10E-05	1.05E-11	3.30E-05	3.14E-11	4.85E-04
	6	71.73	1.10E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	71.73	1.10E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	71.73	1.10E-05	1.05E-11	3.30E-05	3.14E-11	4.85E-04
2	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	323.43	1.11E-03	1.06E-09	7.05E-04	6.70E-10	7.12E-03
	3	323.43	1.11E-03	1.06E-09	7.05E-04	6.70E-10	7.12E-03
	4	323.43	1.11E-03	1.06E-09	7.05E-04	6.70E-10	7.12E-03
	5	323.43	1.11E-03	1.06E-09	7.05E-04	6.70E-10	7.12E-03
	6	323.43	1.11E-03	1.06E-09	4.08E-04	3.88E-10	4.12E-03
	7	323.43	1.11E-03	1.06E-09	4.08E-04	3.88E-10	4.12E-03
	8	323.43	1.11E-03	1.06E-09	1.11E-03	1.06E-09	1.12E-02

Table 57. LOM risk assessment results (islanding scenario 2, load profile LP9)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	865.82	1.44E-03	1.37E-09	9.09E-04	8.65E-10	2.58E-03
	3	865.82	1.44E-03	1.37E-09	9.09E-04	8.65E-10	2.58E-03
	4	865.82	1.44E-03	1.37E-09	9.09E-04	8.65E-10	2.58E-03
	5	865.82	1.44E-03	1.37E-09	9.09E-04	8.65E-10	2.58E-03
	6	865.82	1.44E-03	1.37E-09	5.26E-04	5.01E-10	1.49E-03
	7	865.82	1.44E-03	1.37E-09	5.26E-04	5.01E-10	1.49E-03
	8	865.82	1.44E-03	1.37E-09	1.44E-03	1.37E-09	4.07E-03

Table 58. LOM risk assessment results (islanding scenario 2, load profile LP10)

Generation Mix (m)	Setting Option	$T_{NDZavr(m)}$ [min]	$N_{LOM,1DGG(m)}$	$P_{LOM,1DGG(m)}$	$N_{LOM,AR(m)}$	$P_{LOM,E(m)}$	$N_{LOM,E(m)}$
1	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	678.96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	678.96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	678.96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	678.96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	678.96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	678.96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	678.96	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	1969.20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	1969.20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	1969.20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	1969.20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	1969.20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	1969.20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	1969.20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	444.10	4.20E-03	4.00E-09	2.66E-03	2.53E-09	9.36E-03
	3	444.10	4.20E-03	4.00E-09	2.66E-03	2.53E-09	9.36E-03
	4	444.10	4.20E-03	4.00E-09	2.66E-03	2.53E-09	9.36E-03
	5	444.10	4.20E-03	4.00E-09	2.66E-03	2.53E-09	9.36E-03
	6	444.10	4.20E-03	4.00E-09	1.54E-03	1.47E-09	5.42E-03
	7	444.10	4.20E-03	4.00E-09	1.54E-03	1.47E-09	5.42E-03
	8	444.10	4.20E-03	4.00E-09	4.20E-03	4.00E-09	1.48E-02

B.3. Result figures

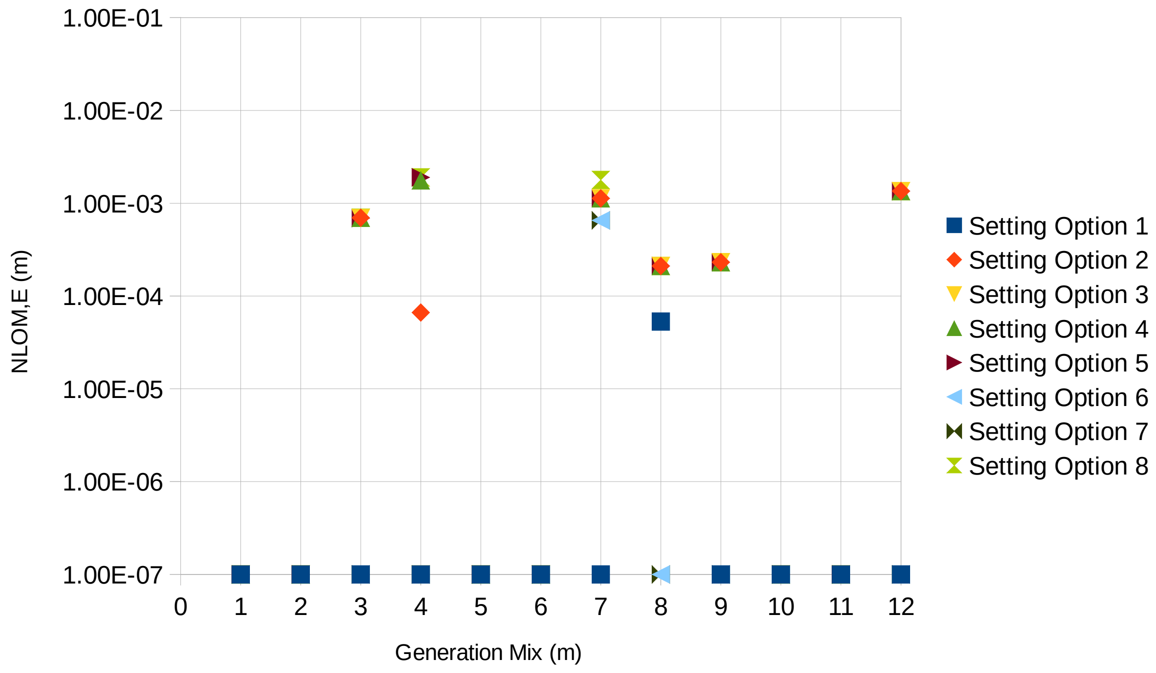

Figure 8. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 1, Load Profile LP01

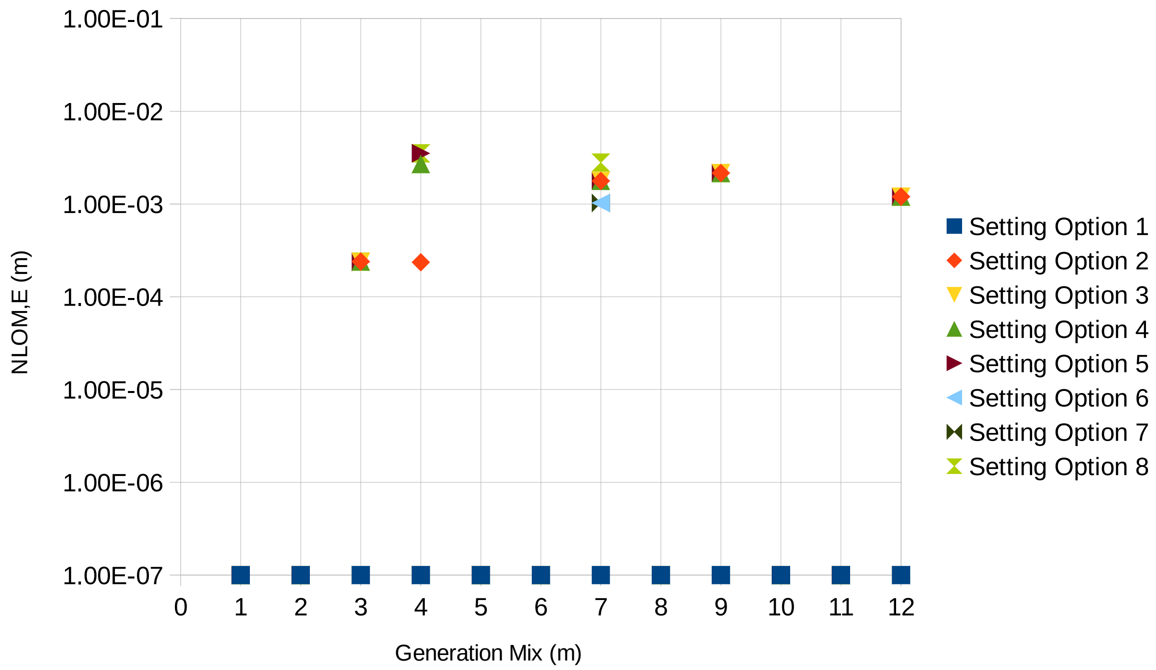

Figure 9. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 1, Load Profile LP02

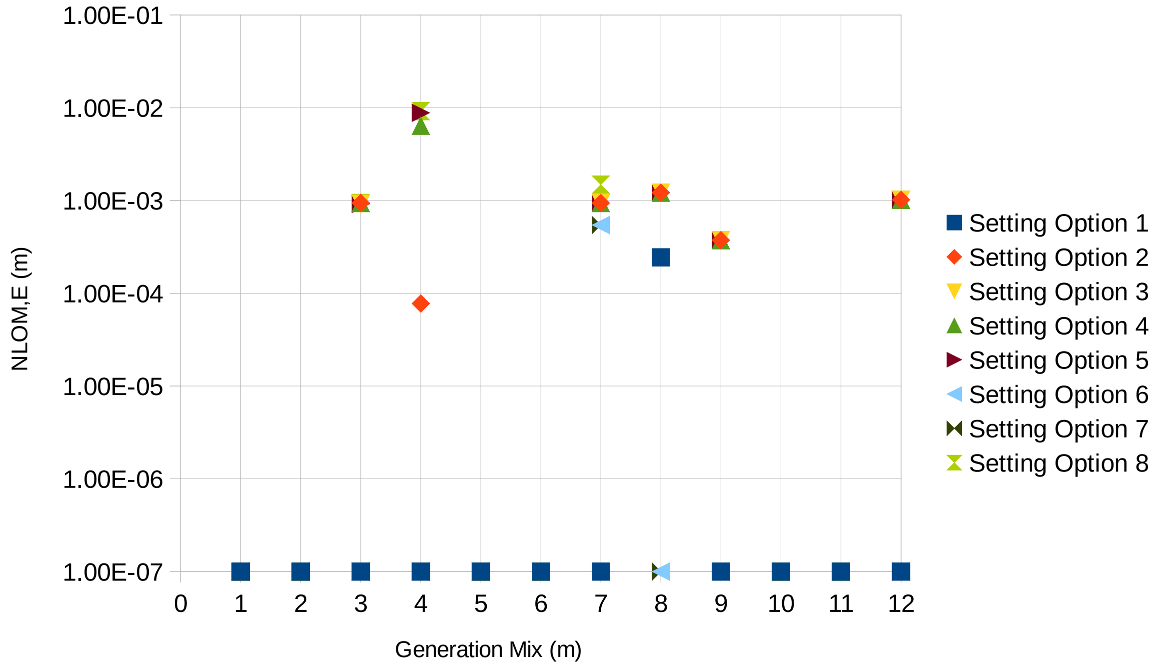

Figure 10. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 1, Load Profile LP03

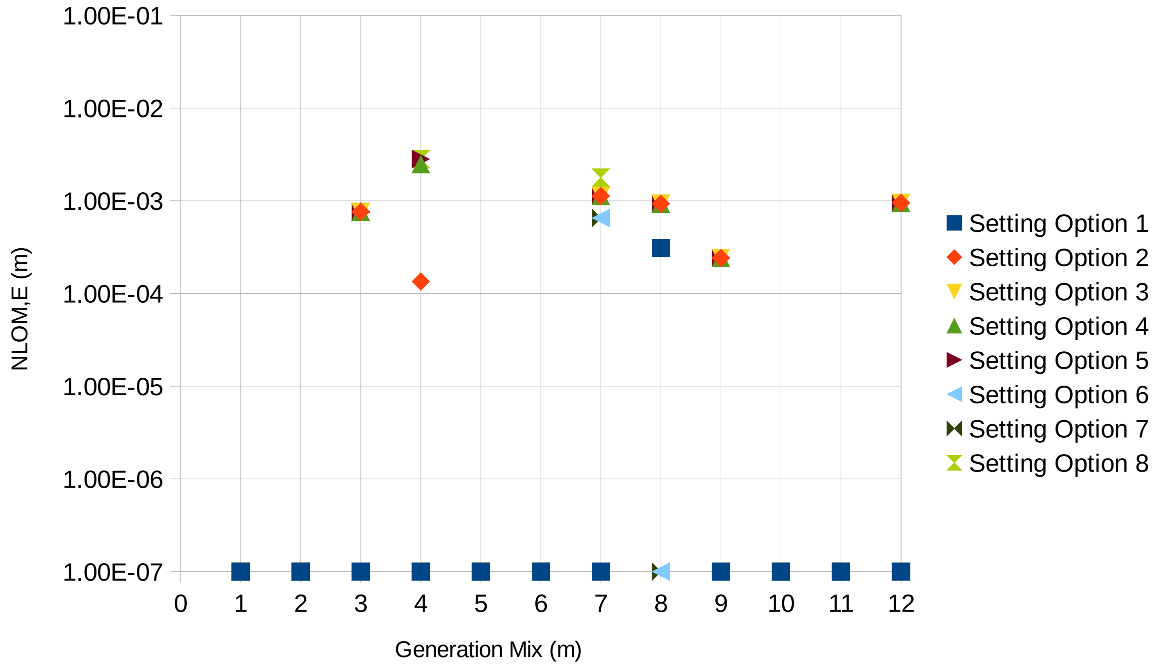

Figure 11. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 1, Load Profile LP04

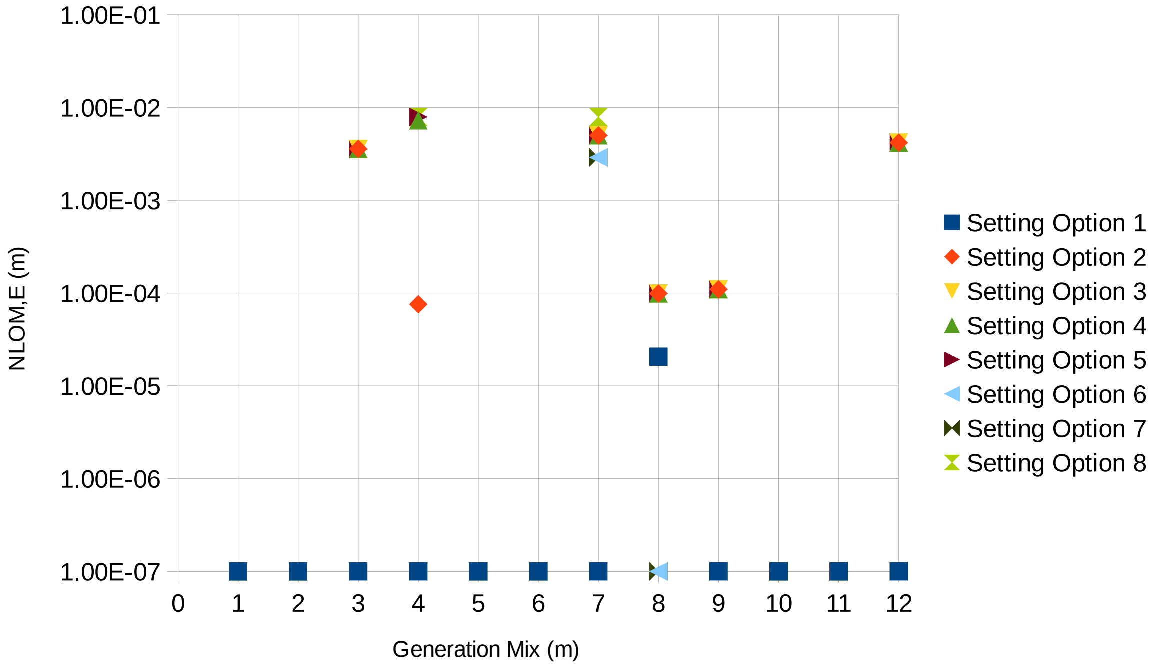

Figure 12. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 1, Load Profile LP05

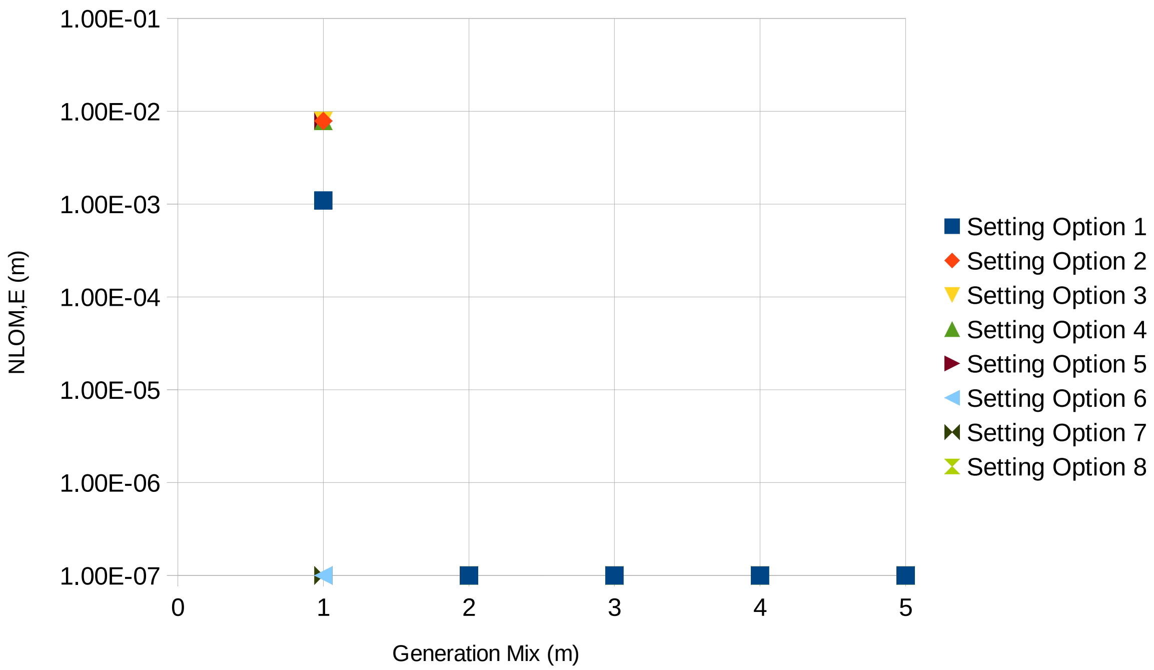

Figure 13. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 2, Load Profile LP06

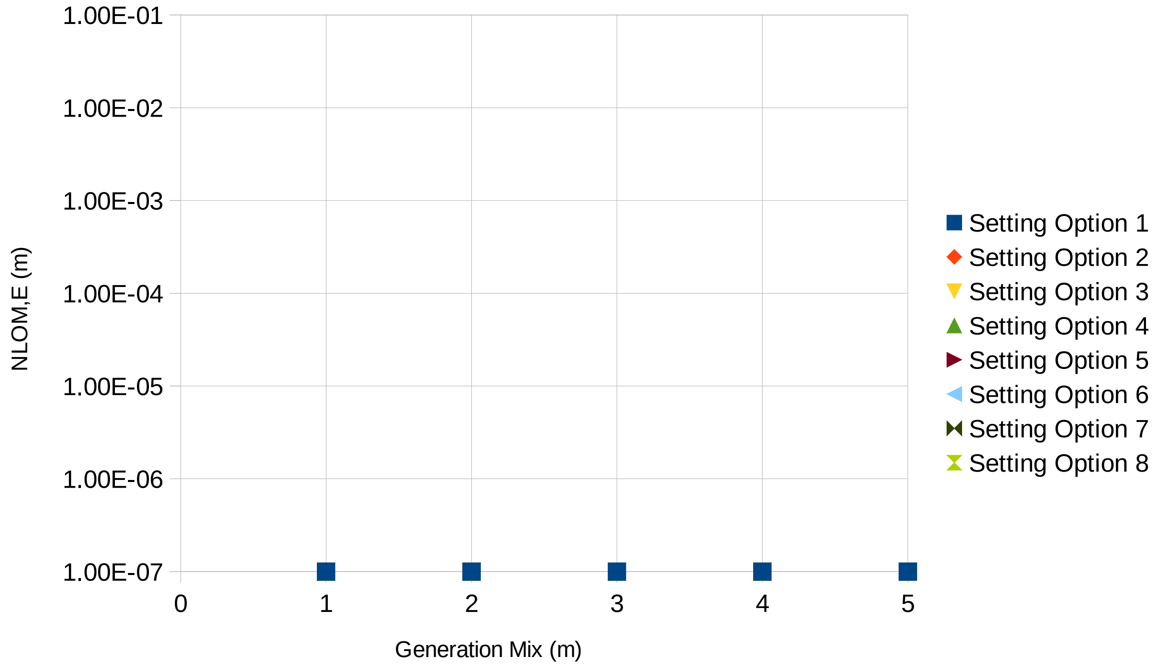

Figure 14. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 2, Load Profile LP07

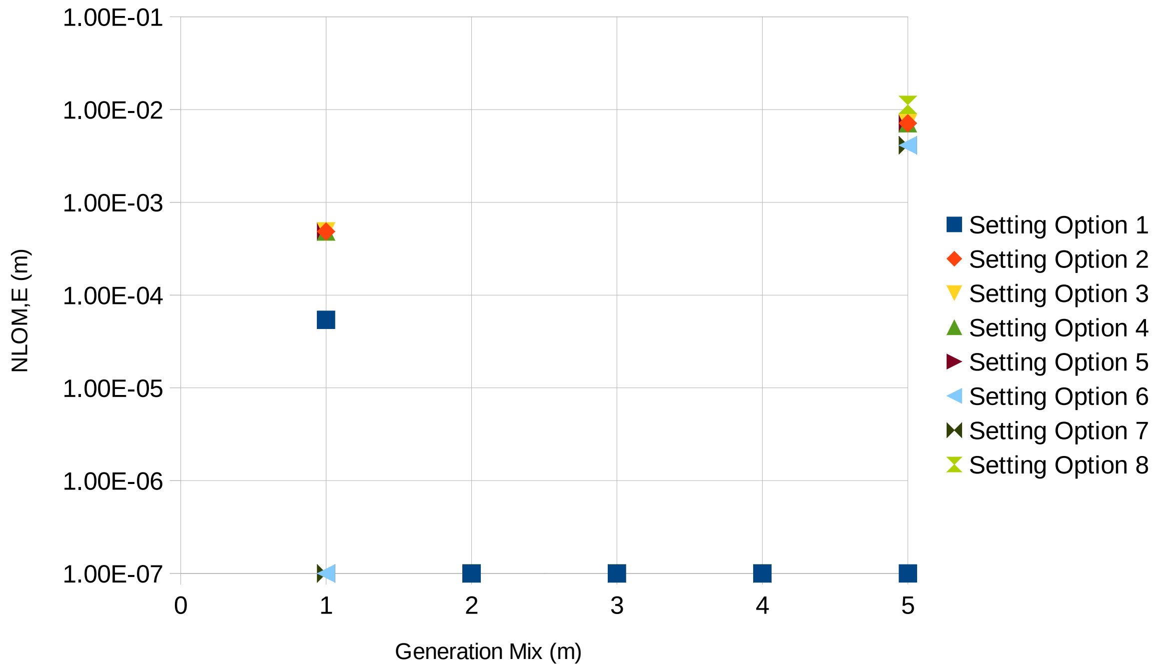

Figure 15. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 2, Load Profile LP08

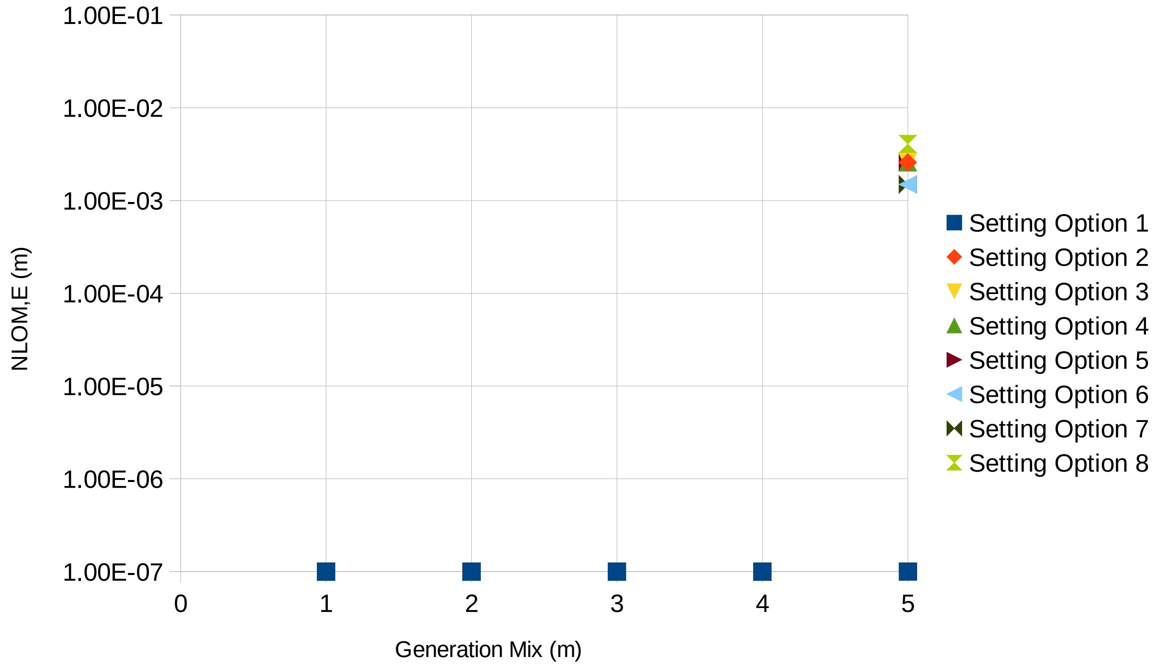

Figure 16. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 2, Load Profile LP09

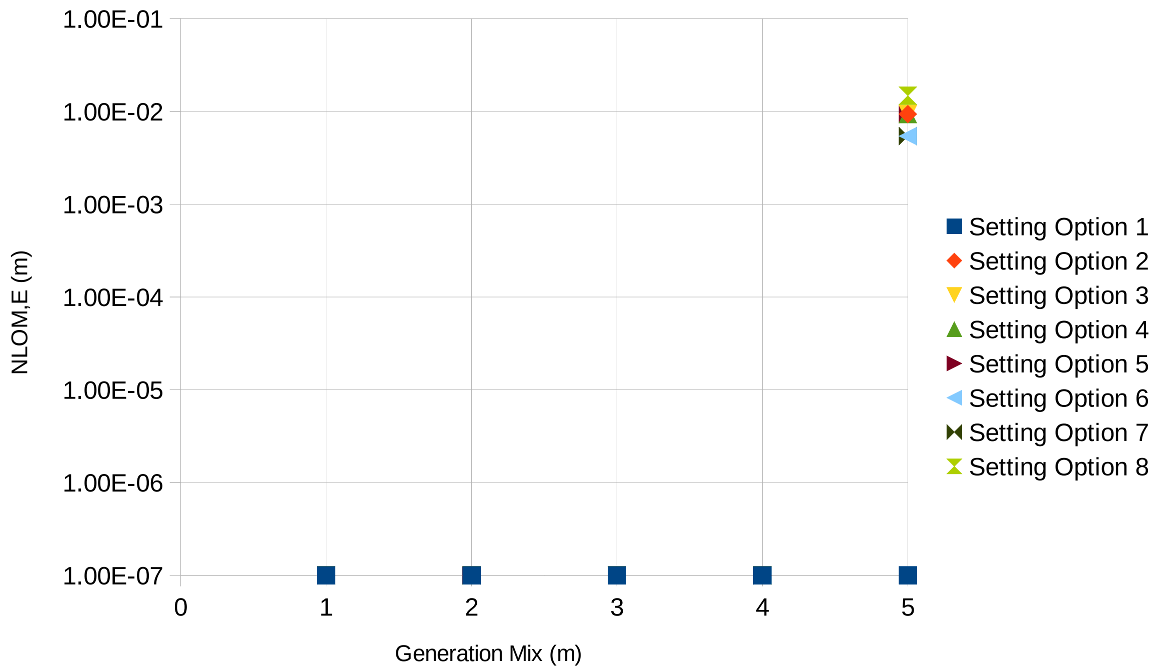

Figure 17. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 2, Load Profile LP10