Technical Report

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 (Phase 2 – WP4)

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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
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}
$N_{LOG,1IP}$ - 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_{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
$P_{PER,E}$ - 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

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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 contains a report on Phase 2 of 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]. This report addresses WP4 (Phase 2) which includes analysis of all distributed generator (DG) capacities below 5 MW, and covers the predominant existing generating technologies in this range, namely synchronous, inverter, and induction-based generation.

To achieve the objectives of quantifying and assessing risk, detailed dynamic simulations have been carried out to determine the potential islanding non-detection zone (NDZ) associated with different ROCOF and VS settings (eight different options were studied), and under a number of different islanding generation arrangements, including islanding of multiple generators.

As in Phase 1 of this investigation [2] the NDZ has been quantified in terms of the surplus/deficit power supplied by the DG prior to islanding and is expressed as a ratio of this power to the rating of the islanded DG (or the combined rating of multiple units when more than one generator is islanded). The dynamic simulation work uses a transient model of a fragment of the utility network including generation and a numerical model of a DG interface relay commonly used in the UK practice. Thus established NDZ levels have been subsequently utilised by the developed risk assessment methodology to determine the probability of islanding non-detection and to quantify the consequential associated risks. In addition to the NDZ data, the methodology makes use of recorded load profiles, and historical statistics relating to customer interruptions and network incidents.

During the NDZ assessment the operation of ROCOF, VS and G59 protection (Overvoltage - OV, Undervoltage - UV, Overfrequency - OF , Underfrequency – UF) has been considered. The combined NDZ values are established through assessment of the shared region of non-operation of all of these protection functions.

The key outcome of Phase 2 consists in 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}). In particular, risk related to accidental electrocution (IR_E) during undetected islanding operation under the proposed ROCOF setting option 3 (1.5 Hz/s with a time delay of 300 ms) is estimated to be within the ALARP region. In this case additional safety measures (e.g. installation of the NVD protection) should be considered by the network operator to conform with the ALARP principle (i.e. to keep the risk As Low As Reasonably Practicable).

It has been established that the difference in the probability of undetected islanded operation between the existing recommended ROCOF settings and the considered new setting options is minor; the maximum increase is 16.5%. Therefore, the relative impact for the ROCOF-based protection of the proposed change is low. It should also be noted that ROCOF protection becomes less effective with the proposed setting options compared to existing practice, resulting in the increased reliance of LOM protection on the G59 frequency-based protection.

Considering both sensitivity and stability aspects, as well as to preserve consistency of the recommendation across all generation capacities, the report recommends **1.5 Hz/s with a time delay of 300 ms** as the best compromise ROCOF setting recommendation. Detailed analysis of all load profiles indicated that the recommended setting should remain adequate even with significant DG penetration increase in the future.

The change of recommended setting for VS protection from 6° to 12° does not impose any detectable change in the risk levels related to protection sensitivity. The values resulting from the risk estimation are the same for both settings. Therefore, considering the assessment of VS stability reported in WP2 [1] the recommended threshold angle setting should be **12°**, or else, VS protection could be disabled as the risk levels with and without VS are very similar, i.e. the difference is less than 10%. This applies across all generation sizes considered in both Phases 1 and 2.

The study used 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.

Regarding risk levels in the future, there is no straightforward correlation between the installed renewable generation capacity and the overall risk of undetected islanding. To address the issue, the outcome of this study is based on the DG register which includes both already connected as well as contracted but not yet connected generation. The study indicates that in the parts of the distribution network which has a relatively high DG penetration already, there is likely to be a reduction of the non-detection risk with additional DG connections.

The identified high dependence of LOM protection on the operation of G59 frequency protection indicates that after the change both ROCOF and VS-based protections in many cases (up to 45%) will act as a backup rather than as the main LOM protection.

It should be noted that the risk levels calculated in this study are subject to a variety of initial assumptions. Due to a number of pessimistic assumptions used in the 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, and consequently a higher probability of undetected islanding being stated than may actually be the case in practice.

Moreover, the risk levels considered in this report will be further reduced by the presence of neutral voltage displacement (NVD) protection (not considered in the calculations), the application of which is standard practice for all generation connected via a ground mounted substation that can export onto the NIE Networks' distribution system. When a single phase-to-earth fault initiates islanding, the operation of the NVD protection limits the duration of undetected islanded condition to 10 s (standard setting practice for NVD protection), and significantly reduces the risk of out-of-phase reclosure (which takes place 30 s after the fault). As single phase-to-earth faults form the majority of all distribution system faults (especially on overhead lines), NVD protection is an effective way of reducing all risks related to undetected islanding.

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	1.20E-01	1.42E-05	7.03E+04	2.83E-02	2.27E-02	44.10
2	2.0	0.2	1.45E-01	1.66E-05	6.03E+04	3.30E-02	2.64E-02	37.83
3*	**1.5**	**0.3**	**1.45E-01**	**1.66E-05**	**6.03E+04**	**3.30E-02**	**2.64E-02**	**37.83**
4	1.5	0.5	1.45E-01	1.66E-05	6.03E+04	3.30E-02	2.64E-02	37.83
5	1.0	0.8	1.43E-01	1.65E-05	6.07E+04	3.28E-02	2.63E-02	38.07
6	6	-	2.10E-01	2.39E-05	4.18E+04	4.77E-02	3.81E-02	26.22
7*	**12**	**-**	**2.10E-01**	**2.39E-05**	**4.18E+04**	**4.77E-02**	**3.81E-02**	**26.22**
8	-	-	3.54E-01	4.05E-05	2.47E+04	8.07E-02	6.46E-02	15.49

*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 the 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".

The report covers Work Package 4 (WP4) – Investigation and quantification of the risks associated with the relaxation of the ROCOF settings for generation with registered installed capacity below 5 MW.

The following sections describe in detail the available data, the risk assessment methodology, the results, key observations and recommendations related to the intended relaxation of the LOM protection settings.

A flowchart illustrating the dependencies of various work packages and tasks in the project is shown in Figure 1. The elements described in this report specifically are marked in green.

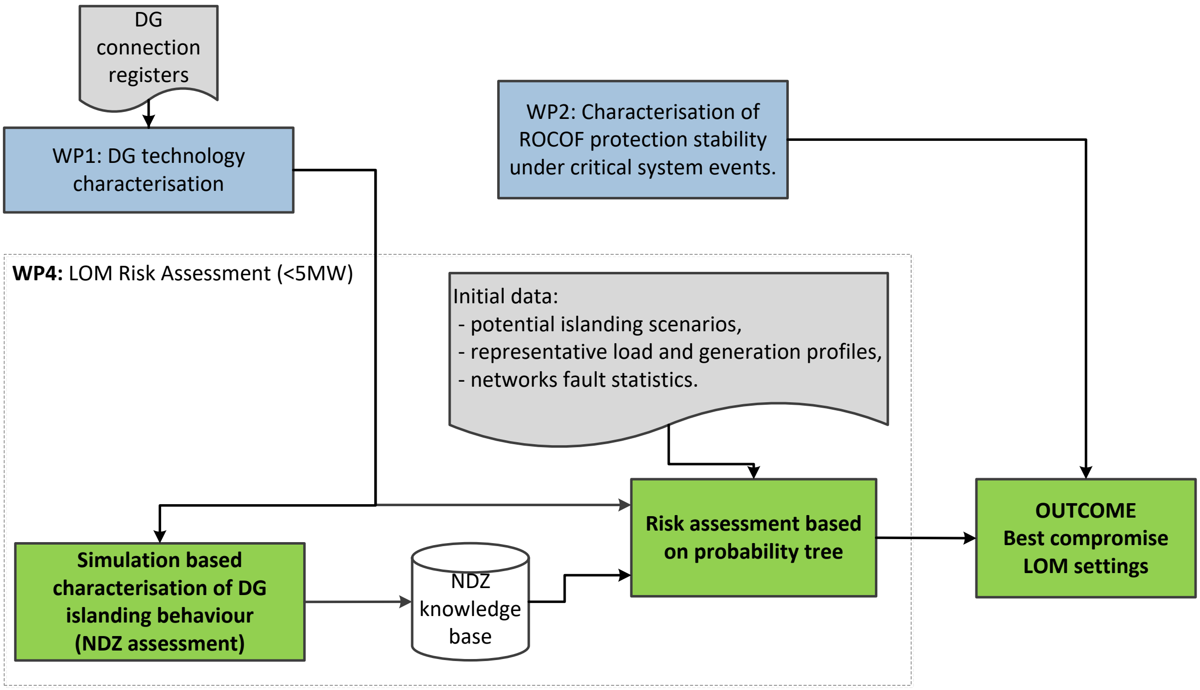


Figure 1: Project work packages and tasks

2 Distributed Generation Modelling

The network model used for the assessment of non-detection zone (NDZ) is based on a reduced section of a typical 11kV distribution network and is schematically presented in Figure 2. The potentially islanded section of the network incorporating the DG and trapped local load is connected through a Point of Common Coupling (PCC) to the main grid. The local load is represented in equal proportions by fixed impedance (50%) and fixed power (50%) models. An LOM condition is initiated by opening the circuit breaker at PCC. The measured voltage (from which frequency is derived) at busbar 'A' forms an input to the relay model under test. The network is modelled using Matlab/Simulink with SimPowerSystems toolbox. Additionally, a model of a commercially-available DG interface relay commonly used in UK practice (MiCOM P341) has been utilised in this test [3]. The full record of network and various generating unit parameters are included in Appendix A.

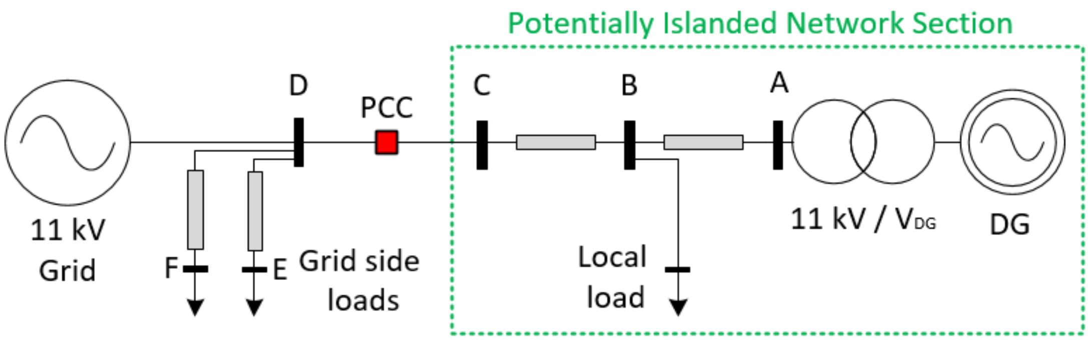


Figure 2: 11 kV Test Distribution Network

2.1 DG Models

Three generating technologies were included in the simulations as evidenced from the analysis of the available NIE Networks DG registers included in WP1 of this work [1].

2.1.1 Synchronous Machine

A synchronous machine is modelled as depicted in Figure 3. Both, active power and voltage control schemes are employed for this machine. A standard IEEE governor/turbine model is also used [4] (available in the SimPowerSystems component library).

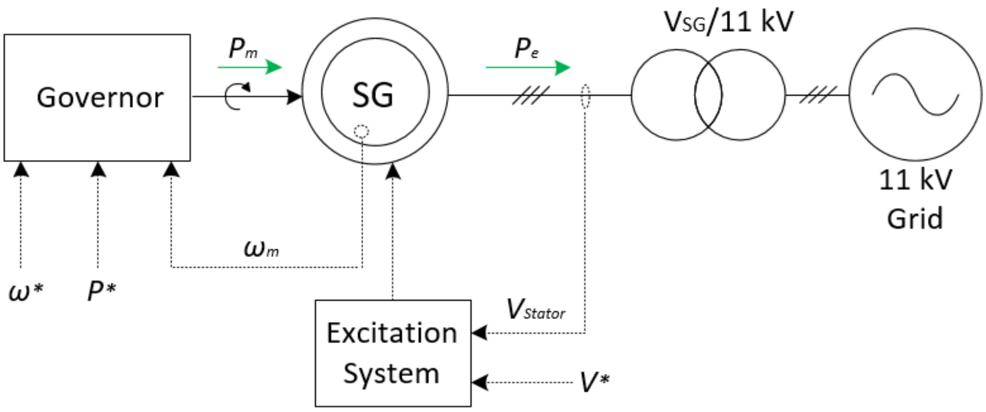


Figure 3: Synchronous Machine model

2.1.2 Inverter Connected generation

Inverter Connected (IC) generation units such as photovoltaic panels (PV) or Fully Rated Converter (FRC) connected wind turbines are represented by an inverter model, connected to a DC voltage source as illustrated in Figure 4. Such approach allows for more computationally-efficient simulation while preserving essential characteristics on the grid side.

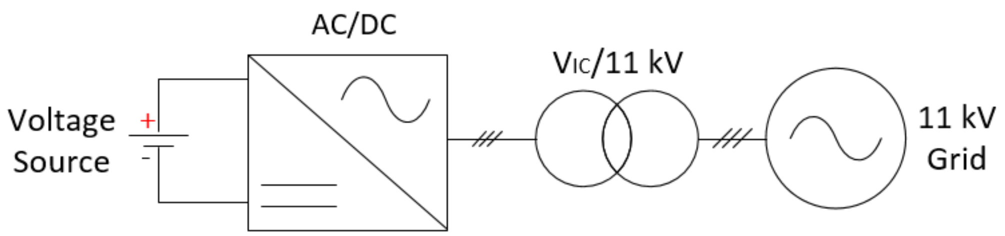


Figure 4: Inverter Connected generation model

Power and voltage control mode (P/V) has been adopted for this type of generation. The classical current vector control strategy for conventional 3-phase converters has been applied as illustrated in Figure 5, utilising measurements and transformations in the *d-q* axes. The exported active power is regulated through the d-axis current while the AC voltage is controlled through the current in the *q*-axis.

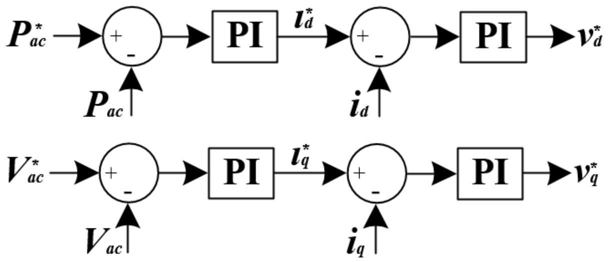


Figure 5:Converter control structure

2.1.3 Induction Machine

An Induction Machine (IM) is modelled as shown in Figure 6. The machine is driven by a wind turbine which feeds mechanical power to the generator. Additionally, a fixed capacitor bank is used for overall compensation purposes related to voltage and reactive power levels at the point of connection.

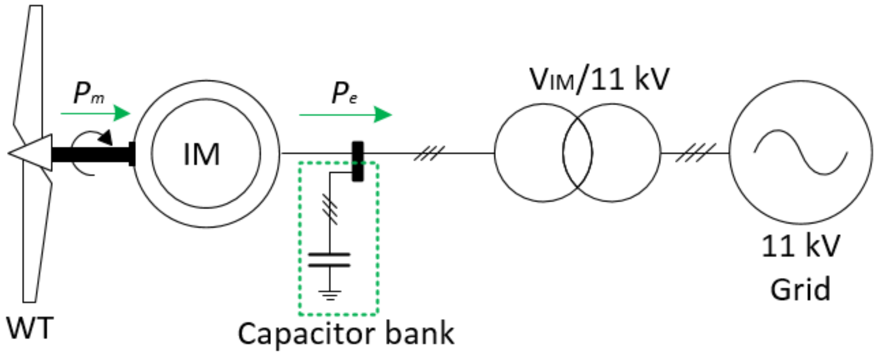


Figure 6: Induction Machine model

3 Simulation-based NDZ evaluation

The objective of this simulation-based evaluation is to determine the non-detection zone (NDZ) of the ROCOF, VS and G59 (OV, UV, OF, UF) protection as a percentage of DG MVA rating. The level of active and reactive power imbalance at the point of common coupling (PCC) is adjusted independently to determine the NDZ.

3.1 Protection Setting Options

A dynamic model of a commercially available DG interface relay commonly used in UK practice has been utilised in this test. The NDZ was assessed 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) 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°
7	Vector Shift	12°
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

3.2 NDZ assessment methodology

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) is changed while holding the other type of power (e.g. reactive) in close balance by adjusting the local demand (and generator reactive power output if necessary). The power imbalance is expressed as a percentage of the DG rating. An automatic search routine developed specifically for this study was employed to iteratively change the power imbalances and monitor the relay trip response. With each incremental change in power imbalance across the PCC, the numerical relay model was injected with the simulated bus 'A' 3-phase voltage. The reported values of NDZ are expressed according to the following equations (1).

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

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 has been assessed for 11 different situations (termed here as generation mixes) which include single generators as well as groups of two and three different technologies as outlined in Table 3. The total DG capacity was held constant for all generation mixes at 3 MVA. These generation mixes have been established using the outcomes of the DG register analysis performed in WP1 of this work [1]. They represent various islanding groups encountered in scenario 3 (individual primary substation islanding) and scenario 4 (11 kV feeder islanding) considering all connected as well as contracted generation (Register 2 in [1]). Both scenarios 3 and 4 are represented by the 11 generation mixes listed in Table 3.

Table 3: DG Generation Mixes

No of technologies	Generation Mix	SM [%]	IC [%]	IM [%]	DG Capacity [MVA]
1	**1**	100	-	-	3
	2	-	100	-	
	3	-	-	100	
2	**4**	80	20	-	
	5	50	50	-	
	6	70	-	30	
	7	30	-	70	
	8	-	60	40	
	9		20	80	
3	**10**	50	15	35	
	11	25	20	55	

3.3 NDZ Results

The combined NDZ results (with ROCOF, VS and G59 protection enabled) are summarised for all the 11 generation mixes in Tables 14 to 24 (Appendix B.1), while the complete set of NDZ results are presented in Appendix B.2, where NDZ values are shown for ROCOF, VS and G59 protection separately.

The results reveal that the majority of generation mixes (i.e. mixes 2, 3, 4, 5, 8, 9, 10, 11) are unable to sustain stable operation for 30 s after being separated from the grid even with load/generation perfectly balanced. This is particularly the case with non-synchronous generation (i.e. IM, and IC).

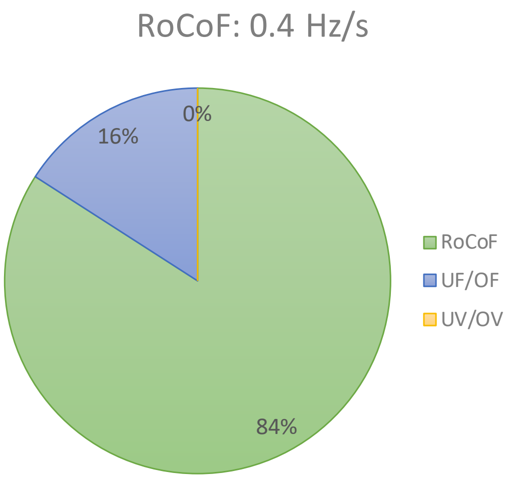
In order to provide further insight into the operation of the LOM protection this section provides an analysis of the percentage dependency of the LOM protection NDZ (established in previous section) on the individual protection modules in two main LOM setups:

- ROCOF relay with Frequency and Voltage protection - Figure 7, and
- VS relay with Frequency and Voltage - Figure 8.

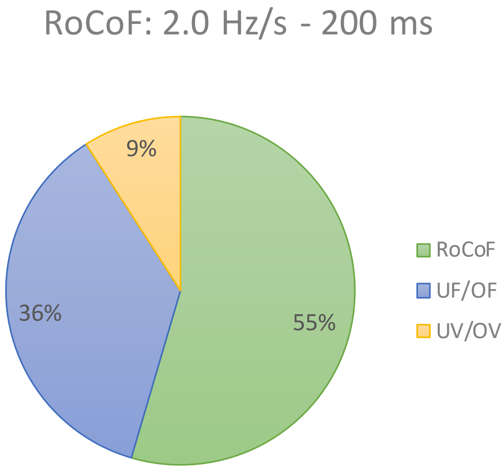
The charts show the percentage of the cases where each protection function has determined the width of the NDZ. These results are based on the inspection of all NDZ result included in Appendix B.1 considering 11 generation mixes and 4 NDZ boundaries (i.e. 44 NDZ cases).

It can be clearly seen in Figure 7 that when using ROCOF protection with the existing setting of 0.4Hz/s the majority of NDZ values (84%) are determined by the RoCoF relay and other DG interface protection modules only provide a backup operation. However, with increased setting and additional time delay a higher proportion (up to 45%) of NDZ values depend on frequency or voltage protection (ROCOF could be acting as backup in those cases).

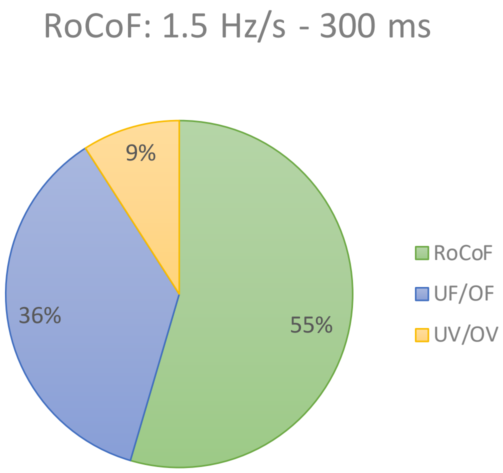
With respect to VS-based LOM protection, the difference between the setting of 6° and 12° is not significant. However, it is worth noting that even with the existing setting of 6°, the NDZ width is determined by frequency or voltage protection in more than 50% of cases (refer to Figure 8).



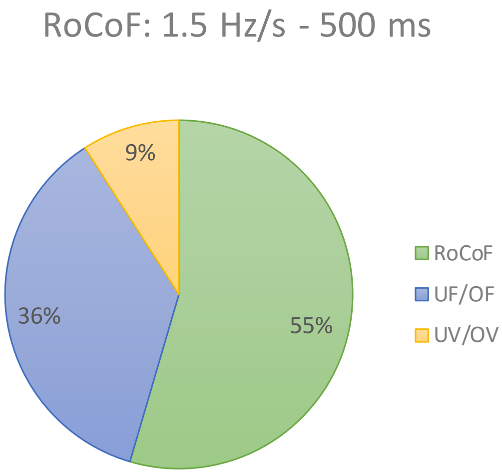
a) setting option 1



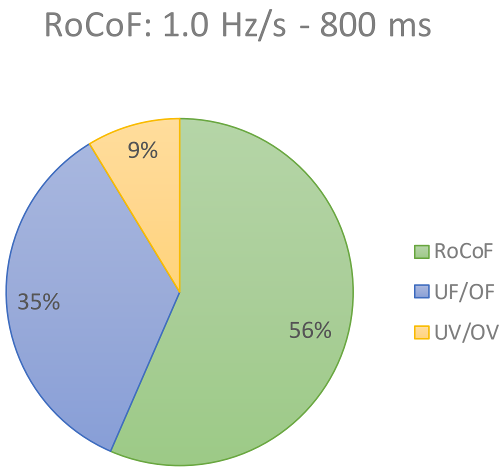
b) setting option 2



c) setting option 3

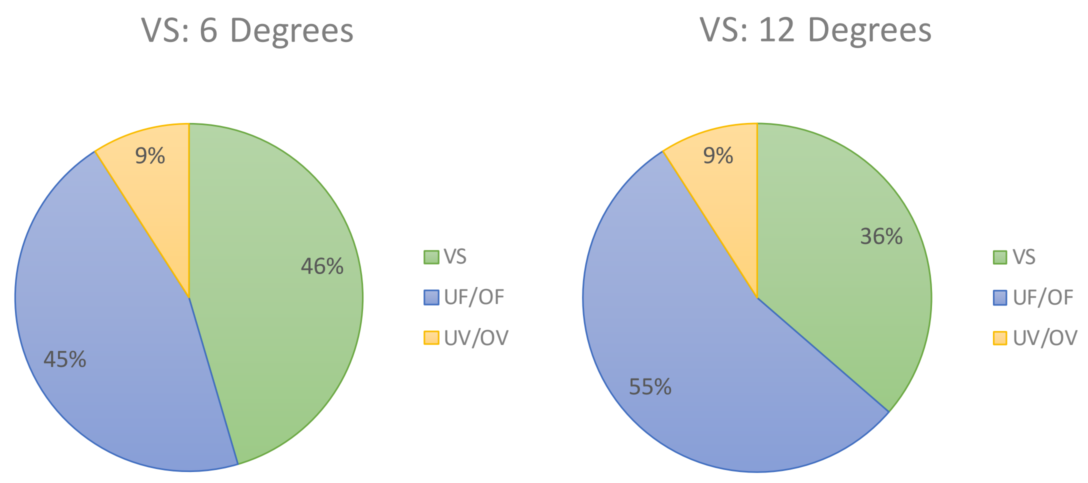


d) setting option 4



e) setting option 5

Figure 7: Combined ROCOF and G59 NDZ performance



a) setting option 6   b) setting option 7

Figure 8: Combined VS and G59 NDZ performance

4 Risk level calculations for various values of NDZ

4.1 Risk calculation methodology

The risk calculation methodology adopted in this section is similar to the method previously applied in the GB system study [6] and further developed in Phase 1 of this work [2]. This approach is based on a statistical analysis of a probability tree depicting perceived probability of specific hazards (including safety of people or damage to equipment).

The methodology makes a number of assumptions regarding the type of utility network, type and size of the distributed generators and generation technology (refer to section 4.2 for details). It utilises the width of the Non Detection Zone (NDZ) established through detailed dynamic simulation described earlier in sections 2 and 3 of this document. Recorded typical utility load profiles, generation profiles, as well as statistics of utility network incidents including loss of supply to primary substations (islanding scenario 3) and loss of supply to individual 11/6.6kV feeders (islanding scenario 4) are also utilised to estimate probabilities of load-generation matching and islanding incidents.

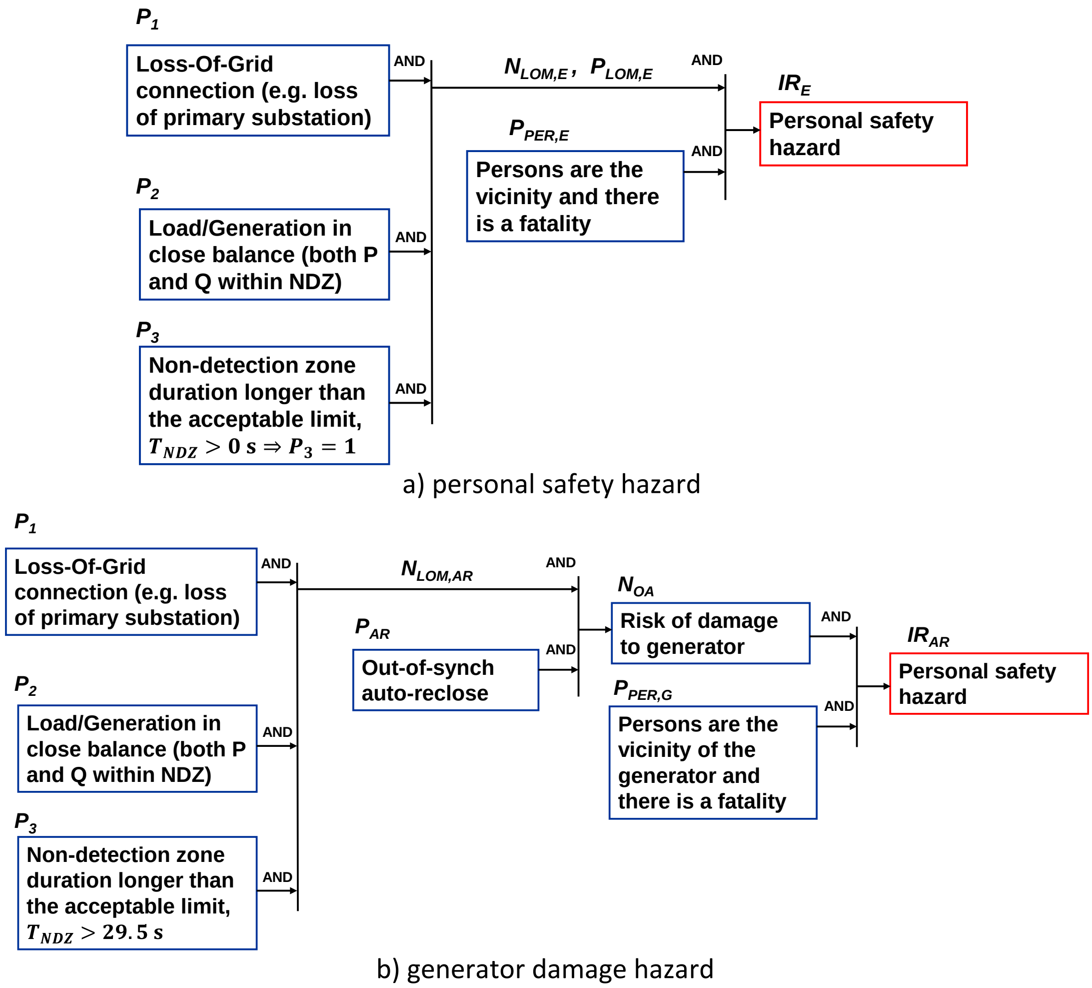


Figure 9. LOM Safety Hazard Probability Tree

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 9, 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 9a), 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 9b).

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

4.1.1 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:

$$N_{LOG,1IP} = \frac{n_{LOG}}{n_{IP} \cdot T_{LOG}} \quad (2)$$

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 4.2.1.

4.1.2 Load and generation profile analysis

For each generation mix and each islanding scenario $m = 1,2,\dots,22$ (11 mixes in each scenario, i.e. $11 \times 2 = 22$ cases) the probabilities $P_{2(m)}$ and $P_{3(m)}$ (refer to Figure 9) are calculated jointly by systematic analysis of the example recorded load and generation profiles captured over a period of 1 week with 1s 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).

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

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 instances (i.e. their durations) are recorded, the NDZ duration cumulative distribution function (CDF) is derived, an example of which is presented in Figure 10. 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.

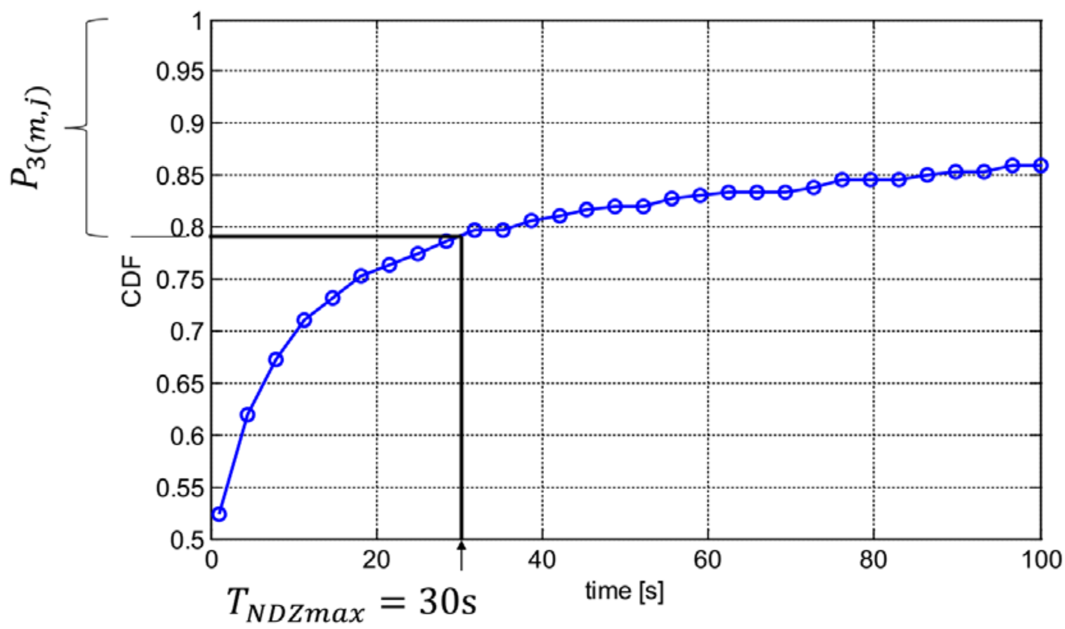


Figure 10. CDF of an example NDZ duration time

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 11.

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

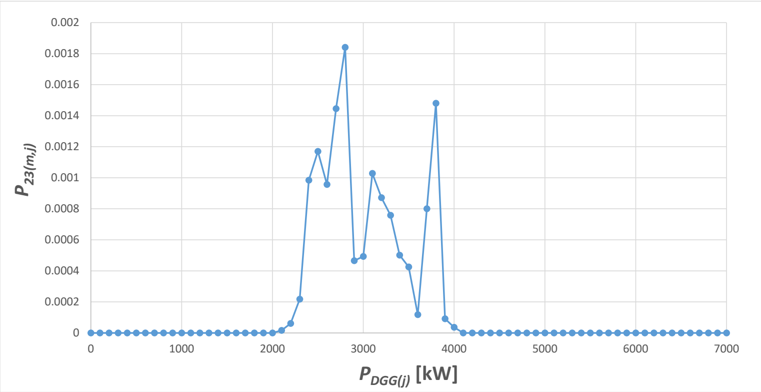


Figure 11. Example non-detection zone probability at varying DG group capacity

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

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

Where:

$n_{CB(m)}$	- number of capacity bands.
$n_{DGG(m,j)}$	- 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

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 (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 considered 22 islanding cases. The final figures of T_{NDZavr} are calculated as a weighted average (8) from all different generation mixes and islanding scenarios ($m = 1,2,\dots,11$ for scenarios 3 and $m = 12,14,..,22$ for scenario 4).

$$T_{NDZavr,s3} = \frac{\sum_{m=1}^{11} n_{DGG(m)} \cdot T_{NDZavr(m)}}{\sum_{m=1}^{11} n_{DGG(m)}}$$

$$T_{NDZavr,s4} = \frac{\sum_{m=12}^{22} n_{DGG(m)} \cdot T_{NDZavr(m)}}{\sum_{m=12}^{22} n_{DGG(m)}} \tag{8}$$

$$T_{NDZavr} = \frac{\sum_{m=1}^{22} n_{DGG(m)} \cdot T_{NDZavr(m)}}{\sum_{m=1}^{22} n_{DGG(m)}}$$

4.1.3 Calculation of national LOM probability figures and individual risk

In each 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 ($m = 1,2,\dots,11$ for scenarios 3 and $m = 12,14,..22$ for scenario 4).

$$P_{LOM,s3} = \sum_{m=1}^{11} P_{LOM(m)}$$

$$P_{LOM,s4} = \sum_{m=12}^{22} P_{LOM(m)}$$

$$P_{LOM} = \sum_{m=1}^{22} P_{LOM(m)} \tag{12}$$

$$N_{LOM} = \sum_{m=1}^{22} N_{LOM(m)}$$

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 ($m = 1,2, \dots ,11$ for scenarios 3 and $m = 12,14, \dots ,22$ for scenario 4).

$$P_{LOM,1DGG,s3} = \frac{\sum_{m=1}^{11} n_{DGG(m)} \cdot P_{LOM,1DGG(m)}}{\sum_{m=1}^{11} n_{DGG(m)}}$$

$$P_{LOM,1DGG,s4} = \frac{\sum_{m=12}^{22} n_{DGG(m)} \cdot P_{LOM,1DGG(m)}}{\sum_{m=12}^{22} n_{DGG(m)}} \quad (14)$$

$$P_{LOM,1DGG} = \frac{\sum_{m=1}^{22} n_{DGG(m)} \cdot P_{LOM,1DGG(m)}}{\sum_{m=1}^{22} n_{DGG(m)}}$$

In order to ascertain whether the risk resulting from the proposed adjustment to the ROCOF settings is acceptable, the analysis and interpretation of the calculated N_{LOM} and P_{LOM} values is performed. 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 in 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:

$$N_{OA} = N_{LOM,AR} \cdot P_{AR} \quad (15)$$

   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:

$$IR_E = N_{LOM,E} \cdot P_{PER,E} \quad (16)$$

$$IR_{AR} = N_{OA} \cdot P_{PER,G} \quad (17)$$

   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 [7] 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 [5], [9].

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. There may be statistics relating to injuries and fatalities from electric shock, but the link between these events and the root cause being an undetected island cannot be made. However, some rationale can be developed based on existing fault-related incidents in electricity networks. In Appendix 5 of the NVD report [10] 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 p.a. 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 needs to 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 $\lambda = -\frac{\ln(1-0.01)}{30} = 3.3501 \times 10^{-4}$.

The probability $P_{PER,G}$ will depend on specific circumstances, generator location and regime of operation, 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 5.5.

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.

4.2 Initial assumptions and available data

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

- Generation range considered has a capacity smaller 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. For solar generation the profiles formerly used in the GB system study [5] have been used.
- Inverter connected (IC) generation was assumed to be predominantly solar.
- 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 Phase 2 study it was assumed that the usage of ROCOF protection (i.e. percentage of generators having ROCOF relay installed) is 33%, 10% and 12% for Synchronous, inverter connected and induction machine based generation respectively. Regarding VS protection the assumed percentages were as follows: 67% (SM), 90% (IC) and 88% (IM). Other percentages related to various generation groupings have been derived as described in section 4.2.3.
- 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].
- Ten different load scenarios recorded on selected 33kV and 11 kV circuits and primary substations were used as described in section 4.2.4.
- 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.
- 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 (i.e. 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).
- The LOM event is simulated as a simple opening of a circuit breaker at the point of common coupling and no initiating fault is simulated prior to islanding (worst case scenario from the LOM detection perspective).

4.2.1 Potential islanding scenarios and estimated frequency of occurrence

Generation above 5 MW can be connected either directly to a BSPs (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 power islanding of one or more of the large generating units.

Scenario 3 considers the loss of grid supply to a primary substation, while scenario 4 involves islanding of an individual 11 kV (or 6.6 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 company's NAFIRS system. These values are summarised in Table 4. Additionally, the following numbers of potential islanding points were assumed:

- scenario 3 – $n_{IP,s3} = 250$ (number of primary substations)
- scenario 4 – $n_{IP,s4} = 1470$ (number of HV feeders)

Table 4. Loss of grid supply statistics for islanding scenario 3 and 4

	Islanding Scenario	Number of incidents					
		2010	2011	2012	2013	2014	Total n_{LOG}
No. of times supply has been lost to a primary substation	3	40	44	34	61	47	**226**
No. of times 11/6.6 kV feeder supplies have been lost	4	584	420	324	509	335	**2172**

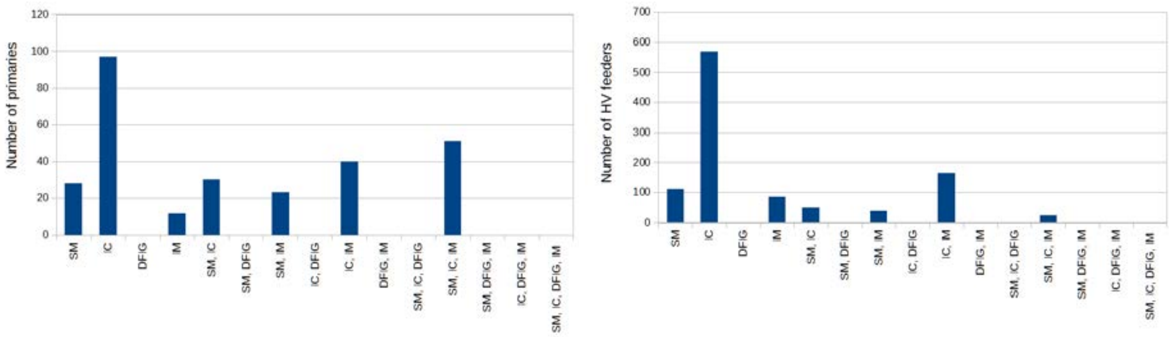
Consequently, using equation (2), the expected number of LOM occurrences in a single islanding point can be calculated for each scenario as follows:

- scenario 3 – $N_{LOG,1IP,s3} = \frac{n_{LOG,s3}}{n_{IP,s3} \cdot T_{LOG,s3}} = \frac{226}{250 \cdot 5} = 0.18080$
- scenario 4 – $N_{LOG,1IP,s4} = \frac{n_{LOG,s4}}{n_{IP,s4} \cdot T_{LOG,s4}} = \frac{2172}{1470 \cdot 5} = 0.29551$

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.

4.2.2 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 report [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 3 and 4 are also presented in Figure 12.



a) scenario 3 b) scenario 4

Figure 12. Islanding groups based on DG Register 2 (connected + contracted DG)

Considering that there are 11 different generating groups in both scenarios 3 and 4, and also, taking into account the variation in the proportions of individual generating technologies in each group, a set of 11 different generation mixes have been established which cover all groupings in both islanding scenarios. This is summarised in Table 5 and used consistently in the NDZ assessment (refer to section 3.2). The same groupings are assumed in the risk assessment calculation included in section 4.3.

Table 5. Assumed generation groupings (mixes)

Grouping	Generation Mix
Single	1 (SM 100%)
	2 (IC 100%)
	3 (IM 100%)
Groups of 2	4 (SM 80%, IC 20%)
	5 (SM 50%, IC 50%)
	6 (SM 70%, IM 30%)
	7 (SM 30%, IM 70%)
	8 (IC 60%, IM 40%)
	9 (IC 20%, IM 80%)
Groups of 3	10 (SM 50%, IC 15%, IM 35%)
	11 (SM 25%, IC 20%, IM 55%)

4.2.3 Usage of ROCOF and VS within 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).

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 – 33% ROCOF, 67% VS
- Inverter Connected – 10% ROCOF, 90% VS
- Induction Generator – 12% ROCOF, 88% VS

For example, in ROCOF risk calculation, the number of power islands formed by inverter connected DG will be reduced by 90% as only 10% of such generators use ROCOF protection, and therefore, the remaining units are not affected by the 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. In terms of probability of an island (including *N* different technologies) being effectively protected by the specific type of LOM protection (either ROCOF or VS), this can be calculated as follows:

$$P_{ROCOF,VS\_OK} = 1 - P_{NO_{ROCOF,VS}} = 1 - \sum_{i=1}^{N} \left(1 - P_{ROCOF,VS(i)}\right) \tag{19}$$

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

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

Table 6. Assumed ROCOF usage in HV connected generation

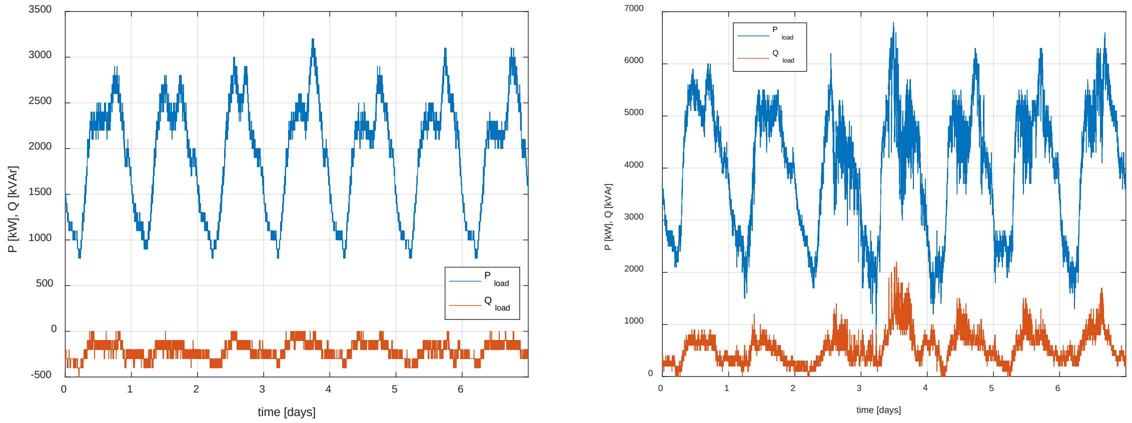
Grouping	Generation Mix	ROCOF Usage	VS Usage	How established?	VS usage applied in risk calculations
Single	1 (SM 100%)	0.330	0.670	Assumed	0.670
	2 (IC 100%)	0.100	0.900		0.900
	3 (IM 100%)	0.120	0.880		0.880
Groups of 2	4 (SM 80%, IC 20%)	0.397	0.967	Derived using equation (19)	0.603
	5 (SM 50%, IC 50%)	0.397	0.967		0.603
	6 (SM 70%, IM 30%)	0.410	0.960		0.590
	7 (SM 30%, IM 70%)	0.410	0.960		0.590
	8 (IC 60%, IM 40%)	0.208	0.988		0.792
	9 (IC 20%, IM 80%)	0.208	0.988		0.792
Groups of 3	10 (SM 50%, IC 15%, IM 35%)	0.469	0.996		0.531
	11 (SM 25%, IC 20%, IM 55%)	0.469	0.996		0.531

4.2.4 Load profile data

In order to cover a wide range of possible loading scenarios and capacities, ten different active and reactive (*P* and *Q*) load profiles have been included in this study. These profiles were recorded by NIE Networks and a number of GB DNOs at various distribution system substations. This section includes a brief description of each record including a graphical illustration of the *P* and *Q* traces.

4.2.4.1 Primary substation load profile (NIE Networks)

This load profile (illustrated in Figure 13) was recorded by NIE Networks capturing the total network load experienced at a primary substation which supplies a mixed urban/rural area (one village and surrounding rural area). The profile was used in scenario 3 of this study. The negative value of reactive power indicates that the aggregate load has a leading power factor which is somewhat unusual.

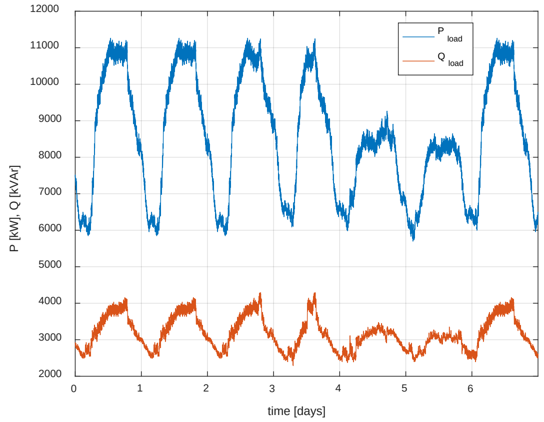


a) LP01 – mixed urban/rural area (July 2016) b) LP02 – rural area (June 2016)

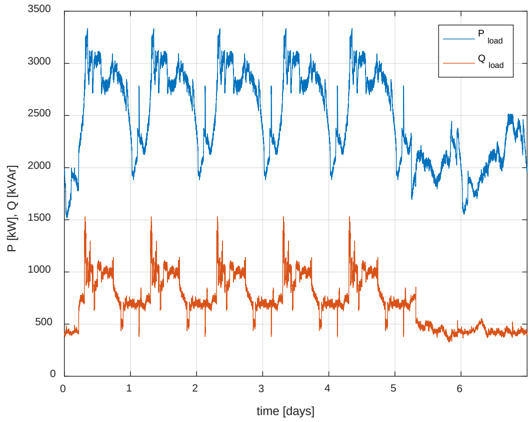
Figure 13. NIE Networks primary substation load profiles

4.2.4.2 Primary substation load profiles (Electricity North West – ENW)

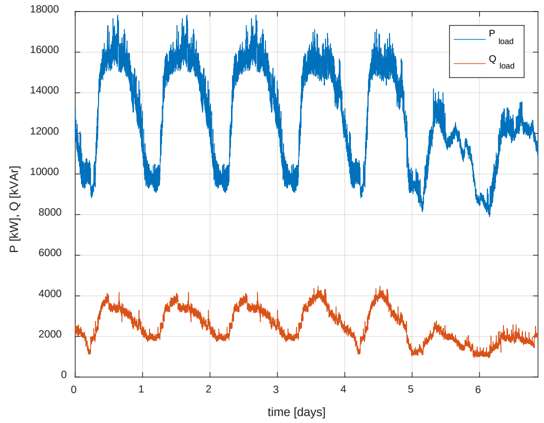
These four records (referred to in this report as LPP03, LP04, LP05 and LP10) have been recorded within the ENW distribution system area at various primary and distribution substations as indicated in Figure 14. The records were previously used in the GB system study [9]. In this study the profiles LP03, LP04 and LP05 (recorded at primary substations) were used in scenario 3, while the profile LP10 (recorded at a distribution substation) was used in scenario 4.



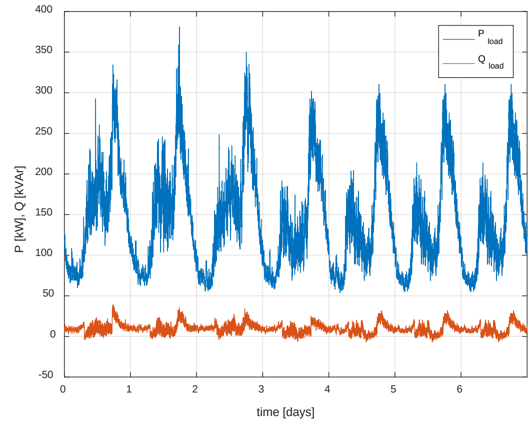
a) LP03 – city centre (April 2013)



b) LP04 – rural area (April 2013)



c) LP05 – suburban area (April 2013)

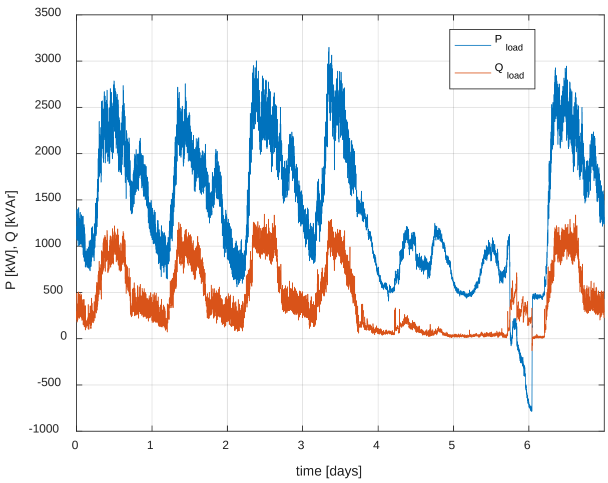


d) LP10 – urban area (February 2015)

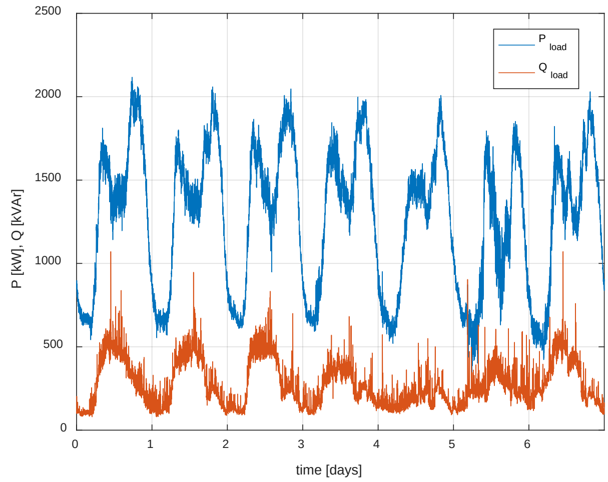
Figure 14. Primary and distribution substation load profiles

4.2.4.3 11 kV feeder load profiles (NIE Networks)

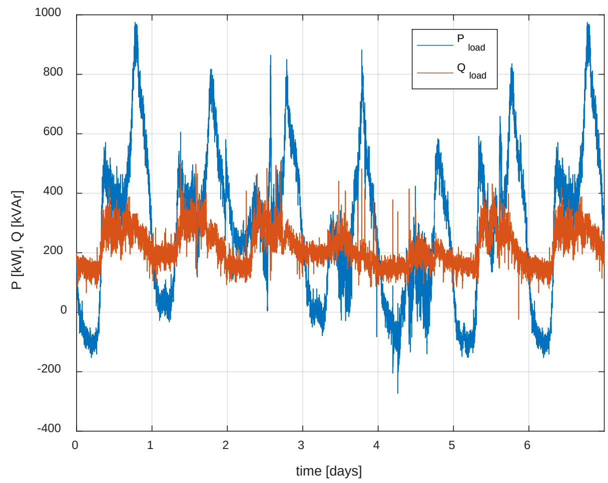
The example three load profiles illustrated in Figure 15 were recorded in the NIE Networks' distribution system on various 11 kV feeders and were used in scenario 4 of this study. Load profiles LP06 and LP07 are characterised by unidirectional power flow and are representative of the feeders with low penetration level of DG. Load profile LP08 features sustained periods of power export, and therefore, characterises feeders with high DG penetration levels. Therefore, load profile LP08 was used twice in the calculation; firstly, combined with various mixes of generation profiles (denoted in results as LP08), and secondly, without any additional generation profile added (denoted as LP09). This is to compare the case of the existing connected generation only (LP08) with the emulation of the potential future case where more DG connections are expected (LP09).



a) Profile LP06 – mixed rural/industrial



b) Profile LP07 – rural area



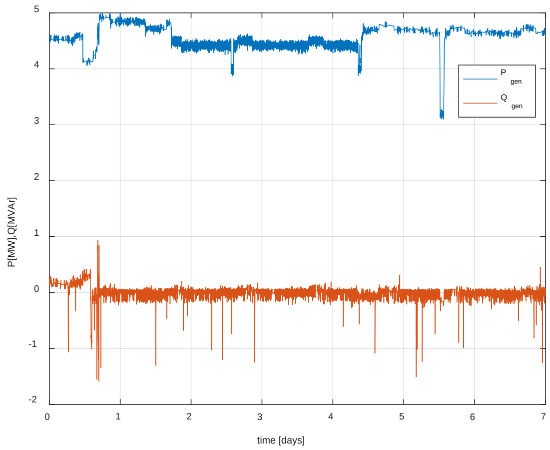
c) LP08/LP09 – domestic area including 250kW wind and 500kW anaerobic digester

Figure 15. NIE Networks 11 kV load profiles

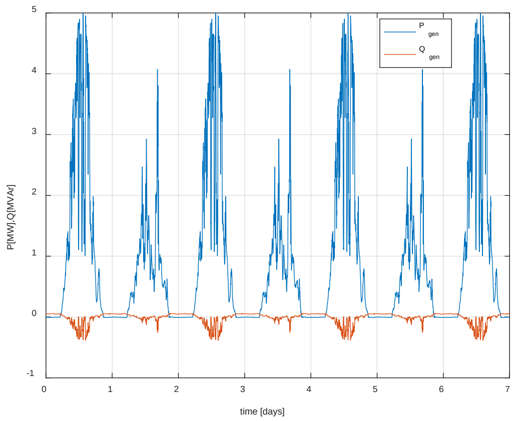
4.2.5 DG generation profiles

In order to match detailed load profiles with realistic generation outputs, example profiles of different technologies were utilised in this work. In this phase two distinct categories of generating profiles were considered, namely: biomass or landfill gas (using synchronous generator), and wind (using DIFIG, IC or IM generators).

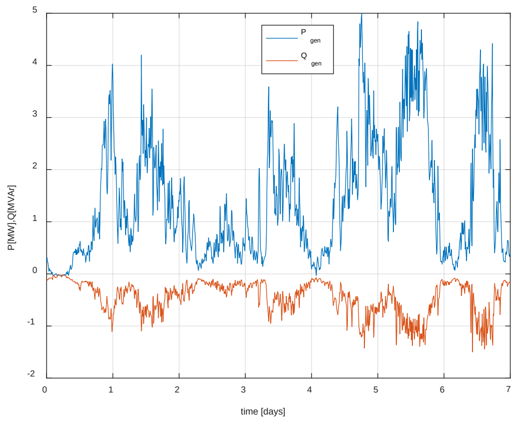
A number of generation profiles were provided by NIE Networks, four of which were selected to represent individual generating technologies as shown in Figure 16.



a) profile representing SM generation (Mix 1)



b) profile representing IC generation (Mix 2)

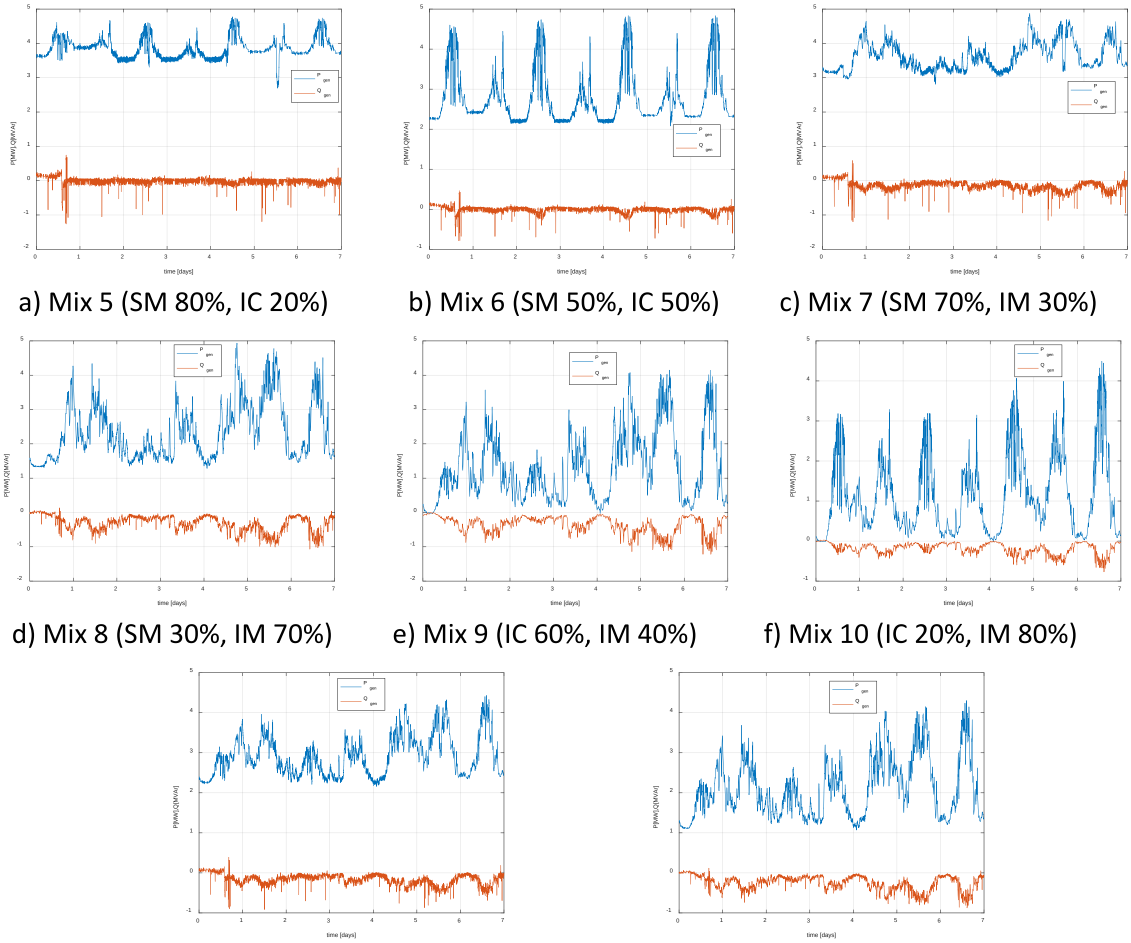


c) profile representing IM (Mix 3)

Figure 16. Weekly profiles representing individual generation technologies

For other generating mixes involving more than one technology, a number of merged generation profiles were created as illustrated in Figure 17. These profiles correspond to the generating mixes defined earlier in section 3.2 (refer to Table 3).

The profile merging was achieved by scaling the peak real power of individual records according to the relative contribution of each generation type in the mix. All profiles were then normalised to have a maximum real power at 5 MW. This value, however, has no bearing on the results, as the profiles are rescaled again when the calculations perform iterations through the capacity bands of the generation distribution histograms (example of which is included in Figure 11).



a) Mix 5 (SM 80%, IC 20%) b) Mix 6 (SM 50%, IC 50%) c) Mix 7 (SM 70%, IM 30%)

d) Mix 8 (SM 30%, IM 70%) e) Mix 9 (IC 60%, IM 40%) f) Mix 10 (IC 20%, IM 80%)

g) Mix 11 (SM 50%, IC 15%, IM 35%) h) Mix 13 (SM 25%, IC 20%, IM 55%)

Figure 17. Mixed generation profiles

4.3 Risk calculation results

The full numerical record of probability calculations performed for the two considered islanding scenarios 3 and 4 (with 11 different generation mixes in each scenario), considering ten load profiles (5 profiles in each scenario), and each of the eight LOM protection setting options, is included in Appendix C. 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 18 to 27. 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^{-7} was used rather than zero. All other non-zero results were always higher than 10^{-7}, so this value can be used as an unambiguous indicator of a zero result.

4.3.1 Calculation of overall figures

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 C). 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 7), and then by averaging the probability figures across all the profiles (Table 8).

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 below 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 be 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 lower rate than the growth rate of the total number of individual DG connections which means that the risk does increase proportionally with the number of connected generators.
- The study does not include assessment of the impact of any changes in practice to move to or additionally use other forms of LOM protection (e.g. reverse reactive power).
- 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 (a degree of pessimism is not necessarily a bad thing in this context).
- The results obtained from the worst case scenario (Table 7) are three to five times higher compared to the result based on averaged figures (Table 8). It is considered more appropriate to select the averaged figures as being more accurate. Similar relation between average and worst case figures was obtained in Phase 1 of this study.
- 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 4.1.3 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, even though likely to be low, 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/VS-only changes (e.g. the summation of the risk figures for LOM options 3 and 7 in the table). Additionally, if the LOM setting recommendation was to be changed at the same time for all distributed generation regardless of installed capacity then corresponding figures from the Phase 1 of this study [2] would have to be added to the results included in this report. Some example calculations are included in section 5.3.

Table 7. Worst load profile based risk figures for P_{LOM}, IR_E and N_{OA}

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	5.47E-01	6.57E-05	1.52E+04	1.31E-01	1.05E-01	9.54
2	2.0	0.2	6.34E-01	7.42E-05	1.35E+04	1.48E-01	1.18E-01	8.46
3*	**1.5**	**0.3**	**6.34E-01**	**7.42E-05**	**1.35E+04**	**1.48E-01**	**1.18E-01**	**8.46**
4	1.5	0.5	6.34E-01	7.42E-05	1.35E+04	1.48E-01	1.18E-01	8.46
5	1.0	0.8	6.28E-01	7.37E-05	1.36E+04	1.47E-01	1.17E-01	8.52
6	6	-	9.17E-01	1.07E-04	9.34E+03	2.13E-01	1.71E-01	5.86
7*	**12**	**-**	**9.17E-01**	**1.07E-04**	**9.34E+03**	**2.13E-01**	**1.71E-01**	**5.86**
8	-	-	1.55E+00	1.81E-04	5.52E+03	3.61E-01	2.89E-01	3.46

Table 8. Risk figures obtained through averaging of 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	1.20E-01	1.42E-05	7.03E+04	2.83E-02	2.27E-02	44.10
2	2.0	0.2	1.45E-01	1.66E-05	6.03E+04	3.30E-02	2.64E-02	37.83
3*	**1.5**	**0.3**	**1.45E-01**	**1.66E-05**	**6.03E+04**	**3.30E-02**	**2.64E-02**	**37.83**
4	1.5	0.5	1.45E-01	1.66E-05	6.03E+04	3.30E-02	2.64E-02	37.83
5	1.0	0.8	1.43E-01	1.65E-05	6.07E+04	3.28E-02	2.63E-02	38.07
6	6	-	2.10E-01	2.39E-05	4.18E+04	4.77E-02	3.81E-02	26.22
7*	**12**	**-**	**2.10E-01**	**2.39E-05**	**4.18E+04**	**4.77E-02**	**3.81E-02**	**26.22**
8	-	-	3.54E-01	4.05E-05	2.47E+04	8.07E-02	6.46E-02	15.49

*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]

5 Conclusions and recommendations

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

- The key outcome of Phase 2 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}).

    a) In particular, risk related to accidental electrocution (IR_E) during the undetected islanding operation under all investigated setting options encroaches onto the ALARP region according to the Health and Safety at Work Act 1974 [7] (i.e. all results are in the order of 10^{-5}). In this case additional safety measures (e.g. installation of NVD protection) should be considered by the network operator to conform with the ALARP principle (i.e. to keep the risk As Low As Reasonably Practicable). However, it should be noted that in this case, the relative impact of the change on the overall risk resulting from the settings change is much lower (maximum 16.5% increase) than it was estimated for large generators in Phase 1 (approximately two orders of magnitude).

    b) Regarding the expected annual occurrence of out-of-phase auto-reclosures (N_{OA}), in the worst case this would have a value of 0.0646 per annum (under setting option 8 where ROCOF and VS are both disabled; refer to Table 8), which means that one incident would be expected on average every $\frac{1}{0.0646} \cong 15.48$ years. 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 the 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, and consequently a higher probability of undetected islanding being stated than may actually be the case in practice.

- Moreover, the risk levels considered in this report can be further reduced by the presence of neutral voltage displacement (NVD) protection (not considered in the calculations) which is a standard practice for all generation connected via a ground mounted substation that can export onto the NIE Networks' distribution system. Such protection will limit the duration of those islanding incidents where single phase-to-earth fault is present in an unearthed islanded part of the network. The time delay setting used by NIE Networks in NVD protection is 10 s. Therefore, it can be assumed that in the case of single phase-to-earth fault the maximum duration of islanding condition (and thus individual risk) is 10 s (as opposed to 30 s which was assumed in the study). The disconnection of the generator by NVD protection also significantly reduces the risk of out-of-phase reclosure (which takes place 30 s after the fault). As single phase-to-earth faults form the majority of all distribution system faults (especially on overhead lines) the NVD protection is a very effective way of reducing all risks related to undetected islanding.

- The study used 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.

5.1 ROCOF protection

Observations specifically related to ROCOF protection can be summarised as follows:

- Even though the absolute risk figures are not very low, it has been established that the relative difference in the probability of undetected islanded operation between the existing recommended ROCOF setting option 1 and the considered new setting options 2, 3, 4 and 5 is minor; the maximum relative increment is approximately 16.5% based on the averaged figures of N_{OA} included in Table 8. Therefore, the relative impact for the ROCOF-based protection of the proposed change is considered low.

- It also should be noted that ROCOF protection becomes much less effective with the proposed setting options (2, 3, 4 and 5) compared to the existing setting option 1 (0.4 Hz/s). As evidenced from the LOM performance analysis in section 3.3 (refer to Figure 7), in up to 45% of the cases the NDZ is determined by frequency or voltage protection with the proposed setting options (2, 3, 4 and 5). By comparison, under the existing setting of 0.4 Hz/s only 16% of the cases rely on frequency or voltage protection. However, the situation is not as serious as it was in Phase 1 where NDZ of up to 62% of the cases was determined by frequency protection.

- It is interesting to note that there is not a great deal of difference (in terms of performance and risk levels) across all considered ROCOF setting options (including the existing practice). For this reason, it would appear that the highest setting could be the preferred option. However, for consistency of settings' recommendation across all generation sizes the best choice for ROCOF protection would be option 3 (i.e. **1.5 Hz/s with a time delay of 300 ms**). Consequently, as an overall outcome of the study, including Phase 1 and 2 as well as the results of an earlier ROCOF stability assessment reported in WP2 [1], option 3 represents the best setting for ROCOF-based LOM protection.

5.2 VS protection

- The change of recommended setting for VS protection from 6° to 12° does not impose any detectable change in the risk levels related to protection sensitivity. The estimated risk values for both options are the same.

- For both considered VS settings (option 6 and 7), the level of risk in terms of undetected islanding operation is higher but comparable to that obtained for the ROCOF protection (options 1 to 5). The main reason for this similarity is high dependence of both types of LOM protection on the operation of G59 frequency protection to identify islanded conditions.

- Considering certain VS stability issues reported in the report for WP2 [1], the best recommended threshold angle setting would be **12°,** or else, VS protection could be replaced by ROCOF protection with setting option 3 (refer to example calculation of "Revision 3" in the following section 5.3).

5.3 Considering various G59 revision options

Using the results in Table 8 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

$$IR_{Ea)} = 1.66 \cdot 10^{-5} + 2.39 \cdot 10^{-5} = 4.05 \cdot 10^{-5}$$

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

$$IR_{Eb)} = 4.05 \cdot 10^{-5}$$

c) Revision 3: Applying ROCOF protection with setting option 3 to all DG and removing VS from service. Assuming that on average 50% of islands with small scale generation currently use ROCOF the risk would be:

$$IR_{Ec)} = \frac{1.66 \cdot 10^{-5}}{0.5} = 3.32 \cdot 10^{-5}$$

As can be seen from the above example calculations small reduction of risk can potentially be gained from changing VS protection to ROCOF only. However, each revision option also needs to be weighed against the overall cost of implementation.

5.4 Future risk levels

Even though the study outcome reaches slightly into the future as the DG register used in the work includes both connected as well as contracted (but not yet connected) generation, it is fixed in time, and therefore, may not represent all future generation scenarios. Moreover, there is no straightforward correlation between the installed renewable generation capacity and the overall risk of undetected islanding. Therefore, any predictions of the renewable generation growth in Northern Ireland are not easily translatable into the probability of non-detection of islanded conditions. However, some insight into potential future risks can be gained by comparing the results of load profile LP08 and LP09. This profile has been recorded on an 11 kV feeder with sufficient amount of installed DG to result in frequent power exports to the grid, and therefore, potential for balanced load/generation (refer to Figure 15c). Such a scenario can be seen as representative of the load flow conditions in future power networks. Therefore, this particular profile was used in two ways, firstly combined with various mixes of generation profiles, and secondly, without any additional generation profile. The reason for this approach was to compare the case of the existing connected generation (LP09) with the case of further increasing DG penetration (LP08). When analysing the summary figures for LP08 and LP09 in Table 37 it can be seen that the current risks (represented by LP09) are actually much higher (a few orders of magnitude) than the risks with additional generation added (represented by LP08). This is an indication that in the parts of the network where there is a high DG penetration already, a reduction of the non-detection risk with additional DG connections can be expected.

5.5 Relative contribution to risk of various generation groups and scenarios

Similarly to Phase 1 analysis, 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 9 (based on the detailed results included in Appendix C.2.). As discussed earlier at the end of section 4.1.3, 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, 4, 5, 6, 7, 10 and 11. Those mixes contribute 100% of all expected out-of-phase reclosures (calculated using the percentage values in the right hand side column in Table 9). Therefore, in this case it would not be reasonable to lower the risk figures as all identified stable islanding instances involve some proportion of synchronous generation (e.g. anaerobic digester).

Table 9. Contribution of individual generation mixes to the overall number of LOM incidents (individual figures averaged across all load profiles) – setting option 3

Islanding Scenario	Generation Mix (m)	$N_{LOM,AR(m)}$	$N_{LOM,AR(m)}[\%]$
1	1 (SM 100%)	0.00005	0.1487
	2 (IC 100%)	0.00000	0.0000
	3 (IM 100%)	0.00000	0.0000
	4 (SM 80%, IC 20%)	0.00000	0.0000
	5 (SM 50%, IC 50%)	0.00000	0.0000
	6 (SM 70%, IM 30%)	0.00181	5.4685
	7 (SM 30%, IM 70%)	0.00260	7.8756
	8 (IC 60%, IM 40%)	0.00000	0.0000
	9 (IC 20%, IM 80%)	0.00000	0.0000
	10 (SM 50%, IC 15%, IM 35%)	0.00000	0.0000
	11 (SM 25%, IC 20%, IM 55%)	0.00000	0.0000
2	1 (SM 100%)	0.00031	0.9436
	2 (IC 100%)	0.00000	0.0000
	3 (IM 100%)	0.00000	0.0000
	4 (SM 80%, IC 20%)	0.00000	0.0000
	5 (SM 50%, IC 50%)	0.00000	0.0000
	6 (SM 70%, IM 30%)	0.01792	54.2478
	7 (SM 30%, IM 70%)	0.01035	31.3157
	8 (IC 60%, IM 40%)	0.00000	0.0000
	9 (IC 20%, IM 80%)	0.00000	0.0000
	10 (SM 50%, IC 15%, IM 35%)	0.00000	0.0000
	11 (SM 25%, IC 20%, IM 55%)	0.00000	0.0000
	Total:	0.03304	100.00

6 References

[1] A. Dyśko, D. Tzelepis, and C. Booth, '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 (WP1 and WP2)', University of Strathclyde, NIE/LOM/TR/2016-001, Mar. 2016.

[2] A. Dyśko, D. Tzelepis, and C. Booth, '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 (Phase 1 - WP3)', University of Strathclyde, NIE/LOM/TR/2016-002A, Aug. 2016.

[3] Bugdal, R., Dysko, A., Burt, G.M., and McDonald, J.R., 'Performance analysis of the ROCOF and vector shift methods using a dynamic protection modeling approach', presented at the 15th International Conference on Power System Protection, Bled, Slovenia, 2006, pp. 139–144.

[4] IEEE Power & Energy Society, 'Dynamic Models for Turbine-Governors in Power System Studies', Aug-2013. [Online]. Available: http://resourcecenter.ieee-pes.org/pes/product/technical-publications/PESTR1. [Accessed: 20-Jun-2016].

[5] A. Dyśko, D. Tzelepis, and C. Booth, 'Assessment of Risks Resulting from the Adjustment of ROCOF Based Loss of Mains Protection Settings - Phase II', University of Strathclyde, NGC/LOM/TR/2015-001, Oct. 2015.

[6] 'Marginal distribution', *Wikipedia, the free encyclopedia*, 02-Jun-2016. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Marginal_distribution&oldid=723297349. [Accessed: 21-Jun-2016].

[7] 'Health and Safety at Work etc. Act 1974'. [Online]. Available: http://www.legislation.gov.uk/ukpga/1974/37/contents. [Accessed: 21-Jun-2016].

[8] Distribution Code Review Panel G59 NVD Working Group, 'Embedded generation interface protection: Assessment of risks arising from relaxation in the application of neutral voltage displacement (NVD) interface protection'. Energy Networks Association, 31-Dec-2009.

[9] A. Dyśko, I. Abdulhadi, X. Li, and C. Booth, 'Assessment of Risks Resulting from the Adjustment of ROCOF Based Loss of Mains Protection Settings - Phase I', University of Strathclyde, NGC/LOM/TR/2013-001b, Jun. 2013.

Appendix A: Simulation model parameters

Table 10: Line Parameters used in the 11 kV network

11 kV Distribution Lines		
Line Section	**Resistance (Ω)**	**Inductance (mH)**
A-B	0.169	0.17
B-C	0.169	0.17
D-E	0.67	0.56
D-F	0.613	0.45

Table 11: SM Parameters

General	
Nominal Voltage [V]	440
Nominal Frequency [Hz]	50
Pole Pairs	2
Inertia Constant [s]	1.5
Reactances [p.u.]	
Xd	2.24
Xd’	0.17
Xd’’	0.12
Xq	1.02
Xq’’	0.13
Xl	0.18
Excitation System / Governor	
Tr	0.02
Ka	465
Ta	0.002
Ke	1
Te	0.27
Tb	0
Tc	0
Kf	0.001
Tf	0.1
Efmin	-8
Efmax	8
Kp	0

Table 12: IC Parameters

Inverter	
Current Regulator Kp	1.2
Current Regulator Ki	200
AC Voltage Controller Kp	3
AC Voltage Controller Ki	300

Table 13: IM Parameters

General	
Nominal Voltage [V]	460
Nominal Frequency [Hz]	50
Pole Pairs	2
Inertia Constant [s]	5
Windings	
Stator Resistance [p.u.]	0.01965
Stator Inductance [p.u.]	0.0397
Rotor Resistance [p.u.]	0.01909
Rotor Inductance [p.u.]	0.0397
Mutual Inductance [p.u.]	3

Appendix B: NDZ Assessment results

B.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 14: 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)	1.208*	0.066	0.551	4.754*
2	ROCOF (2.0 Hz/s – 200 ms time delay)	1.208*	1.145*	4.204*	4.754*
3	ROCOF (1.5 Hz/s – 300 ms time delay)	1.208*	1.145*	4.204*	4.754*
4	ROCOF (1.5 Hz/s – 500 ms time delay)	1.208*	1.145*	4.204*	4.754*
5	ROCOF (1.0 Hz/s – 800 ms time delay)	1.208*	0.948	3.799	4.754*
6	VS (6°)	1.208*	1.145*	4.204*	4.754*
7	VS (12°)	1.208*	1.145*	4.204*	4.754*
8	G59 (UV/OV/UF/OF) only	1.208	1.145	4.204	4.754

Table 15: 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 16: ROCOF and VS NDZ results for Generation Mix 3 (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)	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 4 (SM 80%, IC 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 18: ROCOF and VS NDZ results for Generation Mix 5 (SM 50%, IC 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 19: ROCOF and VS NDZ results for Generation Mix 6 (SM 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)	1.71*	2.797	6.507	4.271*
2	ROCOF (2.0 Hz/s – 200 ms time delay)	1.71*	3.777*	11.631*	4.271*
3	ROCOF (1.5 Hz/s – 300 ms time delay)	1.71*	3.777*	11.631*	4.271*
4	ROCOF (1.5 Hz/s – 500 ms time delay)	1.71*	3.777*	11.631*	4.271*
5	ROCOF (1.0 Hz/s – 800 ms time delay)	1.71*	3.777*	11.631*	4.271*
6	VS (6°)	1.71*	3.777*	11.631*	4.271*
7	VS (12°)	1.71*	3.777*	11.631*	4.271*
8	G59 (UV/OV/UF/OF) only	1.71	3.777	11.631	4.271

Table 20: ROCOF and VS NDZ results for Generation Mix 7 (SM 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)	3.777*	6.261	7.63*	4.567*
2	ROCOF (2.0 Hz/s – 200 ms time delay)	3.777*	6.261*	7.63*	4.567*
3	ROCOF (1.5 Hz/s – 300 ms time delay)	3.777*	6.261*	7.63*	4.567*
4	ROCOF (1.5 Hz/s – 500 ms time delay)	3.777*	6.261*	7.63*	4.567*
5	ROCOF (1.0 Hz/s – 800 ms time delay)	3.777*	6.261*	7.63*	4.567*
6	VS (6°)	3.777*	6.261*	7.63*	4.567*
7	VS (12°)	3.777*	6.261*	7.63*	4.567*
8	G59 (UV/OV/UF/OF) only	3.777	6.261	7.63	4.567

Table 21: ROCOF and VS NDZ results for Generation Mix 8 (IC 60%, 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)	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 9 (IC 20%, IM 80%)

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 10 (SM 50%, IC 15%, IM 35%)

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 24: ROCOF and VS NDZ results for Generation Mix 11 (SM 25%, IC 20%, IM 55%)

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

B.2. NDZ results for individual LOM protection elements

Table 25: NDZ results for Generation Mix 1 (SM 100%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	1.992	0.066	0.551	5.163
ROCOF (2.0 Hz/s – 200 ms time delay)	10.804	2.419	7.84	24.638
ROCOF (1.5 Hz/s – 300 ms time delay)	7.868	1.537	5.823	31.372
ROCOF (1.5 Hz/s – 500 ms time delay)	8.358	1.537	5.823	36.457
ROCOF (1.0 Hz/s – 800 ms time delay)	5.91	0.948	3.799	22.962
VS (6°)	42.988	>50	>50	>50
VS (12°)	>50	>50	>50	>50
UV/OV	>50	>50	>50	>50
UF/OF	1.208	1.145	4.204	4.754

Table 26: 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)	0.065	0.716	0.683	0.096
ROCOF (1.5 Hz/s – 300 ms time delay)	0.065	0.716	0.683	0.096
ROCOF (1.5 Hz/s – 500 ms time delay)	0.065	0.716	0.683	0.096
ROCOF (1.0 Hz/s – 800 ms time delay)	0.065	0.716	0.683	0.096
VS (6°)	>50	43.428	>50	12.628
VS (12°)	>50	43.428	>50	12.628
UV/OV	0	0	0	0
UF/OF	0.065	0.716	0.683	0.096

Table 27: NDZ results for Generation Mix 3 (IM 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°)	0.142	0.054	0.092	0.211
VS (12°)	0.24	0.543	0.596	0.312
UV/OV	0	0	0	0
UF/OF	0	0	0	0

Table 28: NDZ results for Generation Mix 4 (SM 80%, IC 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)	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	7.414	27.182	25.227	>50
UF/OF	0	0	0	0

Table 29: NDZ results for Generation Mix 5 (SM 50%, IC 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	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 30: NDZ results for Generation Mix 6 (SM 70%, IM 30%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	3.326	2.797	6.507	5.574
ROCOF (2.0 Hz/s – 200 ms time delay)	17.744	18.503	39.245	24.027
ROCOF (1.5 Hz/s – 300 ms time delay)	13.838	14.572	34.294	25.806
ROCOF (1.5 Hz/s – 500 ms time delay)	14.815	14.572	40.888	32.958
ROCOF (1.0 Hz/s – 800 ms time delay)	10.907	9.662	29.313	34.756
VS (6^o)	>50	47.09	>50	>50
VS (12^o)	>50	>50	>50	>50
UV/OV	25.547	>50	>50	32.958
UF/OF	1.71	3.777	11.631	4.271

Table 31: NDZ results for Generation Mix 7 (SM 30%, IM 70%)

	NDZ_{PI}	NDZ_{PE}	NDZ_{QI}	NDZ_{QE}
ROCOF (0.4 Hz/s – no time delay)	6.467	6.261	7.63	5.986
ROCOF (2.0 Hz/s – 200 ms time delay)	27.435	37.248	35.104	16.945
ROCOF (1.5 Hz/s – 300 ms time delay)	16.72	29.359	26.049	15.987
ROCOF (1.5 Hz/s – 500 ms time delay)	16.72	31.33	29.683	17.905
ROCOF (1.0 Hz/s – 800 ms time delay)	16.72	21.483	24.226	16.945
VS (6°)	>50	37.248	>50	>50
VS (12°)	>50	>50	>50	>50
UV/OV	18.67	25.42	36.902	14.073
UF/OF	3.777	6.261	7.63	4.567

Table 32: NDZ results for Generation Mix 8 (IC 60%, IM 40%)

	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°)	0.839	0.036	0.624	0.032
UV/OV	0	0	0	0
UF/OF	0	0	0	0

Table 33: NDZ results for Generation Mix 9 (IC 20%, IM 80%)

	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	37.341	27.628	14.174
ROCOF (1.5 Hz/s – 300 ms time delay)	>50	45.25	19.828	14.174
ROCOF (1.5 Hz/s – 500 ms time delay)	>50	45.25	23.738	14.174
ROCOF (1.0 Hz/s – 800 ms time delay)	48.687	45.25	23.738	6.553
VS (6°)	>50	>50	>50	24.444
VS (12°)	>50	>50	>50	>50
UV/OV	0	0	0	0
UF/OF	0	0	0	0

Table 34: NDZ results for Generation Mix 10 (SM 50%, IC 15%, IM 35%)

	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 35: NDZ results for Generation Mix 11 (SM 25%, IC 20%, IM 55%)

	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

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Appendix C: Full record of risk assessment results

C.1. Summary Results

Table 36. LOM risk assessment results for islanding scenario 3 (loss of supply to a primary substation)

Load Profile	Setting Option	$T_{NDZavr,s3}$ [min]	$N_{LOM,1DGG,s3}$	$P_{LOM,1DGG,s3}$	$N_{LOM,AR,s3}$	$P_{LOM,E,s3}$	$N_{LOM,E,s3}$
LP01	1	26.48	1.99E-04	1.90E-10	1.47E-02	1.40E-08	5.79E-02
	2	28.59	2.13E-04	2.03E-10	1.58E-02	1.50E-08	6.24E-02
	3	28.59	2.13E-04	2.03E-10	1.58E-02	1.50E-08	6.24E-02
	4	28.59	2.13E-04	2.03E-10	1.58E-02	1.50E-08	6.24E-02
	5	28.52	2.13E-04	2.03E-10	1.58E-02	1.50E-08	6.22E-02
	6	16.20	1.10E-04	1.05E-10	2.28E-02	2.17E-08	9.06E-02
	7	16.20	1.10E-04	1.05E-10	2.28E-02	2.17E-08	9.06E-02
	8	19.46	1.37E-04	1.31E-10	3.86E-02	3.67E-08	1.53E-01
LP02	1	18.53	2.62E-05	2.49E-11	1.94E-03	1.85E-09	1.07E-02
	2	19.33	7.56E-05	7.19E-11	5.59E-03	5.32E-09	2.71E-02
	3	19.33	7.56E-05	7.19E-11	5.59E-03	5.32E-09	2.71E-02
	4	19.33	7.56E-05	7.19E-11	5.59E-03	5.32E-09	2.71E-02
	5	19.23	7.55E-05	7.18E-11	5.58E-03	5.31E-09	2.70E-02
	6	11.15	3.89E-05	3.70E-11	8.05E-03	7.66E-09	3.91E-02
	7	11.15	3.89E-05	3.70E-11	8.05E-03	7.66E-09	3.91E-02
	8	13.30	4.86E-05	4.62E-11	1.36E-02	1.30E-08	6.62E-02
LP03	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
LP04	1	29.15	1.09E-05	1.04E-11	8.05E-04	7.66E-10	2.58E-03
	2	39.53	1.23E-05	1.17E-11	9.13E-04	8.69E-10	3.10E-03
	3	39.53	1.23E-05	1.17E-11	9.13E-04	8.69E-10	3.10E-03
	4	39.53	1.23E-05	1.17E-11	9.13E-04	8.69E-10	3.10E-03
	5	39.53	1.23E-05	1.17E-11	9.13E-04	8.69E-10	3.10E-03
	6	20.30	6.34E-06	6.03E-12	1.31E-03	1.25E-09	4.46E-03
	7	20.30	6.34E-06	6.03E-12	1.31E-03	1.25E-09	4.46E-03
	8	25.36	7.92E-06	7.54E-12	2.23E-03	2.12E-09	7.56E-03
LP05	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 37. LOM risk assessment results for islanding scenario 4 (loss of individual 11kV or 6.6kV feeder)

Load Profile	Setting Option	$T_{NDZavr,s4}$ [min]	$N_{LOM,1DGG,s4}$	$P_{LOM,1DGG,s4}$	$N_{LOM,AR,s4}$	$P_{LOM,E,s4}$	$N_{LOM,E,s4}$
LP06	1	13.51	3.60E-05	3.42E-11	2.66E-03	2.53E-09	1.69E-02
	2	22.12	5.34E-05	5.08E-11	3.95E-03	3.76E-09	2.55E-02
	3	22.12	5.34E-05	5.08E-11	3.95E-03	3.76E-09	2.55E-02
	4	22.12	5.34E-05	5.08E-11	3.95E-03	3.76E-09	2.55E-02
	5	21.68	5.32E-05	5.06E-11	3.94E-03	3.74E-09	2.52E-02
	6	12.52	2.76E-05	2.63E-11	5.71E-03	5.44E-09	3.72E-02
	7	12.52	2.76E-05	2.63E-11	5.71E-03	5.44E-09	3.72E-02
	8	15.05	3.44E-05	3.27E-11	9.67E-03	9.20E-09	6.28E-02
LP07	1	16.28	6.57E-05	6.25E-11	4.86E-03	4.62E-09	1.98E-02
	2	19.04	8.79E-05	8.37E-11	6.51E-03	6.19E-09	2.77E-02
	3	19.04	8.79E-05	8.37E-11	6.51E-03	6.19E-09	2.77E-02
	4	19.04	8.79E-05	8.37E-11	6.51E-03	6.19E-09	2.77E-02
	5	19.04	8.79E-05	8.37E-11	6.51E-03	6.19E-09	2.77E-02
	6	9.78	4.52E-05	4.30E-11	9.35E-03	8.89E-09	3.98E-02
	7	9.78	4.52E-05	4.30E-11	9.35E-03	8.89E-09	3.98E-02
	8	12.21	5.64E-05	5.37E-11	1.59E-02	1.51E-08	6.74E-02
LP08	1	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-07
	2	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-07
	3	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-07
	4	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-07
	5	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-07
	6	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-07
	7	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-07
	8	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-07
LP09	1	79.19	1.57E-03	1.49E-09	1.16E-01	1.11E-07	4.89E-01
	2	115.08	1.78E-03	1.70E-09	1.32E-01	1.26E-07	5.71E-01
	3	115.08	1.78E-03	1.70E-09	1.32E-01	1.26E-07	5.71E-01
	4	115.08	1.78E-03	1.70E-09	1.32E-01	1.26E-07	5.71E-01
	5	112.19	1.77E-03	1.68E-09	1.31E-01	1.25E-07	5.65E-01
	6	65.84	9.20E-04	8.75E-10	1.90E-01	1.81E-07	8.26E-01
	7	65.84	9.20E-04	8.75E-10	1.90E-01	1.81E-07	8.26E-01
	8	78.80	1.15E-03	1.09E-09	3.22E-01	3.07E-07	1.40E+00
LP10	1	11.07	6.46E-06	6.14E-12	4.78E-04	4.55E-10	3.34E-03
	2	19.26	6.49E-06	6.17E-12	4.80E-04	4.56E-10	5.91E-03
	3	19.26	6.49E-06	6.17E-12	4.80E-04	4.56E-10	5.91E-03
	4	19.26	6.49E-06	6.17E-12	4.80E-04	4.56E-10	5.91E-03
	5	19.11	6.49E-06	6.17E-12	4.80E-04	4.56E-10	5.28E-03
	6	11.51	3.34E-06	3.17E-12	6.91E-04	6.57E-10	1.02E-02
	7	11.51	3.34E-06	3.17E-12	6.91E-04	6.57E-10	1.02E-02
	8	13.55	4.17E-06	3.96E-12	1.17E-03	1.11E-09	1.61E-02

Table 38. Summary LOM risk assessment results – based on maximum load profile figures

LOM Scenario	Setting Option	T_{NDZavr} [min]	$N_{LOM,1DGG}$	$P_{LOM,1DGG}$	$N_{LOM,AR}$	$P_{LOM,E}$	$N_{LOM,E}$
S3	1	29.1	1.99E-04	1.90E-10	1.47E-02	1.40E-08	5.79E-02
	2	39.5	2.13E-04	2.03E-10	1.58E-02	1.50E-08	6.24E-02
	3	39.5	2.13E-04	2.03E-10	1.58E-02	1.50E-08	6.24E-02
	4	39.5	2.13E-04	2.03E-10	1.58E-02	1.50E-08	6.24E-02
	5	39.5	2.13E-04	2.03E-10	1.58E-02	1.50E-08	6.22E-02
	6	20.3	1.10E-04	1.05E-10	2.28E-02	2.17E-08	9.06E-02
	7	20.3	1.10E-04	1.05E-10	2.28E-02	2.17E-08	9.06E-02
	8	25.4	1.37E-04	1.31E-10	3.86E-02	3.67E-08	1.53E-01
S4	1	79.19	1.57E-03	1.49E-09	1.16E-01	1.11E-07	4.89E-01
	2	115.08	1.78E-03	1.70E-09	1.32E-01	1.26E-07	5.71E-01
	3	115.08	1.78E-03	1.70E-09	1.32E-01	1.26E-07	5.71E-01
	4	115.08	1.78E-03	1.70E-09	1.32E-01	1.26E-07	5.71E-01
	5	112.19	1.77E-03	1.68E-09	1.31E-01	1.25E-07	5.65E-01
	6	65.84	9.20E-04	8.75E-10	1.90E-01	1.81E-07	8.26E-01
	7	65.84	9.20E-04	8.75E-10	1.90E-01	1.81E-07	8.26E-01
	8	78.80	1.15E-03	1.09E-09	3.22E-01	3.07E-07	1.40E+00
Combined S3 & S4	1	54.17	8.85E-04	8.42E-10	1.31E-01	1.25E-07	5.47E-01
	2	77.31	9.99E-04	9.50E-10	1.48E-01	1.41E-07	6.34E-01
	3	77.31	9.99E-04	9.50E-10	1.48E-01	1.41E-07	6.34E-01
	4	77.31	9.99E-04	9.50E-10	1.48E-01	1.41E-07	6.34E-01
	5	75.86	9.92E-04	9.43E-10	1.47E-01	1.40E-07	6.28E-01
	6	43.07	5.15E-04	4.90E-10	2.13E-01	2.03E-07	9.17E-01
	7	43.07	5.15E-04	4.90E-10	2.13E-01	2.03E-07	9.17E-01
	8	52.08	6.42E-04	6.11E-10	3.61E-01	3.43E-07	1.55E+00

Table 39. Summary LOM risk assessment results – based on average load profile figures

LOM Scenario	Setting Option	T_{NDZavr} [min]	$N_{LOM,1DGG}$	$P_{LOM,1DGG}$	$N_{LOM,AR}$	$P_{LOM,E}$	$N_{LOM,E}$
S3	1	14.83	4.73E-05	4.50E-11	3.50E-03	3.33E-09	1.42E-02
	2	17.49	6.03E-05	5.73E-11	4.46E-03	4.24E-09	1.85E-02
	3	17.49	6.03E-05	5.73E-11	4.46E-03	4.24E-09	1.85E-02
	4	17.49	6.03E-05	5.73E-11	4.46E-03	4.24E-09	1.85E-02
	5	17.46	6.02E-05	5.72E-11	4.45E-03	4.23E-09	1.85E-02
	6	9.53	3.11E-05	2.96E-11	6.43E-03	6.12E-09	2.68E-02
	7	9.53	3.11E-05	2.96E-11	6.43E-03	6.12E-09	2.68E-02
	8	11.62	3.88E-05	3.69E-11	1.09E-02	1.04E-08	4.54E-02
S4	1	24.01	3.36E-04	3.19E-10	2.48E-02	2.36E-08	1.06E-01
	2	35.10	3.86E-04	3.68E-10	2.86E-02	2.72E-08	1.26E-01
	3	35.10	3.86E-04	3.68E-10	2.86E-02	2.72E-08	1.26E-01
	4	35.10	3.86E-04	3.68E-10	2.86E-02	2.72E-08	1.26E-01
	5	34.40	3.84E-04	3.65E-10	2.84E-02	2.70E-08	1.25E-01
	6	19.93	1.99E-04	1.90E-10	4.12E-02	3.92E-08	1.83E-01
	7	19.93	1.99E-04	1.90E-10	4.12E-02	3.92E-08	1.83E-01
	8	23.92	2.49E-04	2.36E-10	6.98E-02	6.64E-08	3.09E-01
Combined S3 & S4	1	19.42	1.92E-04	1.82E-10	2.83E-02	2.70E-08	1.20E-01
	2	26.30	2.23E-04	2.12E-10	3.30E-02	3.14E-08	1.45E-01
	3	26.30	2.23E-04	2.12E-10	3.30E-02	3.14E-08	1.45E-01
	4	26.30	2.23E-04	2.12E-10	3.30E-02	3.14E-08	1.45E-01
	5	25.93	2.22E-04	2.11E-10	3.28E-02	3.12E-08	1.43E-01
	6	14.73	1.15E-04	1.10E-10	4.77E-02	4.54E-08	2.10E-01
	7	14.73	1.15E-04	1.10E-10	4.77E-02	4.54E-08	2.10E-01
	8	17.77	1.44E-04	1.37E-10	8.07E-02	7.68E-08	3.54E-01

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

Table 40. LOM risk assessment results (islanding scenario 3, 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	54.91	6.17E-06	5.87E-12	5.70E-05	5.42E-11	5.08E-04
	2	57.29	2.36E-05	2.24E-11	2.18E-04	2.07E-10	1.48E-03
	3	57.29	2.36E-05	2.24E-11	2.18E-04	2.07E-10	1.48E-03
	4	57.29	2.36E-05	2.24E-11	2.18E-04	2.07E-10	1.48E-03
	5	56.67	2.06E-05	1.96E-11	1.90E-04	1.81E-10	1.22E-03
	6	57.29	2.36E-05	2.24E-11	4.42E-04	4.21E-10	3.01E-03
	7	57.29	2.36E-05	2.24E-11	4.42E-04	4.21E-10	3.01E-03
	8	57.29	2.36E-05	2.24E-11	6.60E-04	6.28E-10	4.49E-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	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	86.27	5.39E-04	5.13E-10	3.54E-03	3.37E-09	1.55E-02
	2	106.76	6.73E-04	6.40E-10	4.42E-03	4.21E-09	1.92E-02
	3	106.76	6.73E-04	6.40E-10	4.42E-03	4.21E-09	1.92E-02
	4	106.76	6.73E-04	6.40E-10	4.42E-03	4.21E-09	1.92E-02
	5	106.76	6.73E-04	6.40E-10	4.42E-03	4.21E-09	1.92E-02
	6	106.76	6.73E-04	6.40E-10	6.35E-03	6.04E-09	2.75E-02
	7	106.76	6.73E-04	6.40E-10	6.35E-03	6.04E-09	2.75E-02
	8	106.76	6.73E-04	6.40E-10	1.08E-02	1.02E-08	4.67E-02

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	308.12	3.88E-03	3.69E-09	1.11E-02	1.06E-08	4.18E-02
	2	308.12	3.88E-03	3.69E-09	1.11E-02	1.06E-08	4.18E-02
	3	308.12	3.88E-03	3.69E-09	1.11E-02	1.06E-08	4.18E-02
	4	308.12	3.88E-03	3.69E-09	1.11E-02	1.06E-08	4.18E-02
	5	308.12	3.88E-03	3.69E-09	1.11E-02	1.06E-08	4.18E-02
	6	308.12	3.88E-03	3.69E-09	1.60E-02	1.52E-08	6.01E-02
	7	308.12	3.88E-03	3.69E-09	1.60E-02	1.52E-08	6.01E-02
	8	308.12	3.88E-03	3.69E-09	2.72E-02	2.58E-08	1.02E-01
8	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
9	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
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

Table 41. LOM risk assessment results (islanding scenario 3, 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	52.00	1.35E-22	1.29E-28	1.25E-21	1.19E-27	9.57E-06
	2	46.20	3.01E-06	2.87E-12	2.78E-05	2.65E-11	3.65E-04
	3	46.20	3.01E-06	2.87E-12	2.78E-05	2.65E-11	3.65E-04
	4	46.20	3.01E-06	2.87E-12	2.78E-05	2.65E-11	3.65E-04
	5	45.45	2.09E-06	1.98E-12	1.93E-05	1.83E-11	2.57E-04
	6	46.20	3.01E-06	2.87E-12	5.65E-05	5.38E-11	7.42E-04
	7	46.20	3.01E-06	2.87E-12	5.65E-05	5.38E-11	7.42E-04
	8	46.20	3.01E-06	2.87E-12	8.44E-05	8.02E-11	1.11E-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	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	78.18	1.34E-04	1.27E-10	8.80E-04	8.37E-10	5.89E-03
	2	95.28	6.86E-04	6.53E-10	4.51E-03	4.29E-09	2.19E-02
	3	95.28	6.86E-04	6.53E-10	4.51E-03	4.29E-09	2.19E-02
	4	95.28	6.86E-04	6.53E-10	4.51E-03	4.29E-09	2.19E-02
	5	95.28	6.86E-04	6.53E-10	4.51E-03	4.29E-09	2.19E-02
	6	95.28	6.86E-04	6.53E-10	6.47E-03	6.16E-09	3.14E-02
	7	95.28	6.86E-04	6.53E-10	6.47E-03	6.16E-09	3.14E-02
	8	95.28	6.86E-04	6.53E-10	1.10E-02	1.04E-08	5.33E-02

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	131.40	3.69E-04	3.51E-10	1.06E-03	1.01E-09	4.84E-03
	2	131.40	3.69E-04	3.51E-10	1.06E-03	1.01E-09	4.84E-03
	3	131.40	3.69E-04	3.51E-10	1.06E-03	1.01E-09	4.84E-03
	4	131.40	3.69E-04	3.51E-10	1.06E-03	1.01E-09	4.84E-03
	5	131.40	3.69E-04	3.51E-10	1.06E-03	1.01E-09	4.84E-03
	6	131.40	3.69E-04	3.51E-10	1.52E-03	1.45E-09	6.95E-03
	7	131.40	3.69E-04	3.51E-10	1.52E-03	1.45E-09	6.95E-03
	8	131.40	3.69E-04	3.51E-10	2.58E-03	2.46E-09	1.18E-02
8	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
9	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
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

Table 42. LOM risk assessment results (islanding scenario 3, 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	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
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	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
8	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
9	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
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

Table 43. LOM risk assessment results (islanding scenario 3, 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	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
6	1	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	116.96	1.65E-05	1.57E-11	1.08E-04	1.03E-10	5.22E-04
	3	116.96	1.65E-05	1.57E-11	1.08E-04	1.03E-10	5.22E-04
	4	116.96	1.65E-05	1.57E-11	1.08E-04	1.03E-10	5.22E-04
	5	116.96	1.65E-05	1.57E-11	1.08E-04	1.03E-10	5.22E-04
	6	116.96	1.65E-05	1.57E-11	1.56E-04	1.48E-10	7.50E-04
	7	116.96	1.65E-05	1.57E-11	1.56E-04	1.48E-10	7.50E-04
	8	116.96	1.65E-05	1.57E-11	2.64E-04	2.51E-10	1.27E-03

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	750.70	2.80E-04	2.67E-10	8.05E-04	7.66E-10	2.58E-03
	2	750.70	2.80E-04	2.67E-10	8.05E-04	7.66E-10	2.58E-03
	3	750.70	2.80E-04	2.67E-10	8.05E-04	7.66E-10	2.58E-03
	4	750.70	2.80E-04	2.67E-10	8.05E-04	7.66E-10	2.58E-03
	5	750.70	2.80E-04	2.67E-10	8.05E-04	7.66E-10	2.58E-03
	6	750.70	2.80E-04	2.67E-10	1.16E-03	1.10E-09	3.71E-03
	7	750.70	2.80E-04	2.67E-10	1.16E-03	1.10E-09	3.71E-03
	8	750.70	2.80E-04	2.67E-10	1.96E-03	1.87E-09	6.29E-03
8	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
9	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
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

Table 44. LOM risk assessment results (islanding scenario 3, 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	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
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	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
8	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
9	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
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

Table 45. LOM risk assessment results (islanding scenario 4, 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	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	9.67E-07
	2	43.73	6.52E-06	6.20E-12	6.03E-05	5.73E-11	9.50E-04
	3	43.73	6.52E-06	6.20E-12	6.03E-05	5.73E-11	9.50E-04
	4	43.73	6.52E-06	6.20E-12	6.03E-05	5.73E-11	9.50E-04
	5	40.18	4.84E-06	4.61E-12	4.48E-05	4.26E-11	6.30E-04
	6	43.73	6.52E-06	6.20E-12	1.22E-04	1.16E-10	1.93E-03
	7	43.73	6.52E-06	6.20E-12	1.22E-04	1.16E-10	1.93E-03
	8	43.73	6.52E-06	6.20E-12	1.83E-04	1.74E-10	2.88E-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	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	77.33	2.63E-05	2.50E-11	1.81E-04	1.72E-10	1.17E-03
	2	111.16	2.05E-04	1.95E-10	1.41E-03	1.34E-09	8.83E-03
	3	111.16	2.05E-04	1.95E-10	1.41E-03	1.34E-09	8.83E-03
	4	111.16	2.05E-04	1.95E-10	1.41E-03	1.34E-09	8.83E-03
	5	111.16	2.05E-04	1.95E-10	1.41E-03	1.34E-09	8.83E-03
	6	111.16	2.05E-04	1.95E-10	2.03E-03	1.93E-09	1.27E-02
	7	111.16	2.05E-04	1.95E-10	2.03E-03	1.93E-09	1.27E-02
	8	111.16	2.05E-04	1.95E-10	3.44E-03	3.27E-09	2.15E-02

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	183.05	9.73E-04	9.26E-10	2.48E-03	2.36E-09	1.58E-02
	2	183.05	9.73E-04	9.26E-10	2.48E-03	2.36E-09	1.58E-02
	3	183.05	9.73E-04	9.26E-10	2.48E-03	2.36E-09	1.58E-02
	4	183.05	9.73E-04	9.26E-10	2.48E-03	2.36E-09	1.58E-02
	5	183.05	9.73E-04	9.26E-10	2.48E-03	2.36E-09	1.58E-02
	6	183.05	9.73E-04	9.26E-10	3.57E-03	3.39E-09	2.26E-02
	7	183.05	9.73E-04	9.26E-10	3.57E-03	3.39E-09	2.26E-02
	8	183.05	9.73E-04	9.26E-10	6.05E-03	5.75E-09	3.84E-02
8	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
9	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
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

Table 46. LOM risk assessment results (islanding scenario 4, 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	1.34E-22	-1.25E-28	1.24E-21	0.00E+00	1.44E-05
	3	0.00	1.34E-22	-1.25E-28	1.24E-21	0.00E+00	1.44E-05
	4	0.00	1.34E-22	-1.25E-28	1.24E-21	0.00E+00	1.44E-05
	5	0.00	1.20E-22	-1.12E-28	1.11E-21	0.00E+00	1.26E-05
	6	0.00	1.34E-22	-1.25E-28	2.51E-21	0.00E+00	2.91E-05
	7	0.00	1.34E-22	-1.25E-28	2.51E-21	0.00E+00	2.91E-05
	8	0.00	1.34E-22	-1.25E-28	3.74E-21	0.00E+00	4.35E-05
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
6	1	82.00	8.73E-07	8.31E-13	6.02E-06	5.72E-12	5.82E-05
	2	111.61	2.40E-04	2.28E-10	1.65E-03	1.57E-09	7.95E-03
	3	111.61	2.40E-04	2.28E-10	1.65E-03	1.57E-09	7.95E-03
	4	111.61	2.40E-04	2.28E-10	1.65E-03	1.57E-09	7.95E-03
	5	111.61	2.40E-04	2.28E-10	1.65E-03	1.57E-09	7.95E-03
	6	111.61	2.40E-04	2.28E-10	2.38E-03	2.26E-09	1.14E-02
	7	111.61	2.40E-04	2.28E-10	2.38E-03	2.26E-09	1.14E-02
	8	111.61	2.40E-04	2.28E-10	4.03E-03	3.83E-09	1.94E-02

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	250.78	1.90E-03	1.81E-09	4.85E-03	4.62E-09	1.97E-02
	2	250.78	1.90E-03	1.81E-09	4.85E-03	4.62E-09	1.97E-02
	3	250.78	1.90E-03	1.81E-09	4.85E-03	4.62E-09	1.97E-02
	4	250.78	1.90E-03	1.81E-09	4.85E-03	4.62E-09	1.97E-02
	5	250.78	1.90E-03	1.81E-09	4.85E-03	4.62E-09	1.97E-02
	6	250.78	1.90E-03	1.81E-09	6.97E-03	6.63E-09	2.83E-02
	7	250.78	1.90E-03	1.81E-09	6.97E-03	6.63E-09	2.83E-02
	8	250.78	1.90E-03	1.81E-09	1.18E-02	1.12E-08	4.80E-02
8	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
9	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
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

Table 47. LOM risk assessment results (islanding scenario 4, 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	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
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	1.08E-07
	2	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	1.08E-07
	3	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	1.08E-07
	4	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	1.08E-07
	5	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	1.08E-07
	6	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	1.56E-07
	7	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	1.56E-07
	8	0.00	0.00E+00	-0.00E+00	0.00E+00	0.00E+00	2.64E-07
8	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
9	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
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

Table 48. LOM risk assessment results (islanding scenario 4, 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	254.55	1.62E-04	1.54E-10	1.50E-03	1.42E-09	9.67E-03
	3	254.55	1.62E-04	1.54E-10	1.50E-03	1.42E-09	9.67E-03
	4	254.55	1.62E-04	1.54E-10	1.50E-03	1.42E-09	9.67E-03
	5	231.35	5.68E-05	5.40E-11	5.24E-04	4.99E-10	3.90E-03
	6	254.55	1.62E-04	1.54E-10	3.04E-03	2.89E-09	1.96E-02
	7	254.55	1.62E-04	1.54E-10	3.04E-03	2.89E-09	1.96E-02
	8	254.55	1.62E-04	1.54E-10	4.54E-03	4.31E-09	2.93E-02
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
6	1	554.45	1.05E-02	9.99E-09	7.23E-02	6.88E-08	3.11E-01
	2	598.53	1.26E-02	1.20E-08	8.66E-02	8.23E-08	3.83E-01
	3	598.53	1.26E-02	1.20E-08	8.66E-02	8.23E-08	3.83E-01
	4	598.53	1.26E-02	1.20E-08	8.66E-02	8.23E-08	3.83E-01
	5	598.53	1.26E-02	1.20E-08	8.66E-02	8.23E-08	3.83E-01
	6	598.53	1.26E-02	1.20E-08	1.24E-01	1.18E-07	5.50E-01
	7	598.53	1.26E-02	1.20E-08	1.24E-01	1.18E-07	5.50E-01
	8	598.53	1.26E-02	1.20E-08	2.11E-01	2.01E-07	9.32E-01

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	799.58	1.72E-02	1.64E-08	4.39E-02	4.18E-08	1.79E-01
	2	799.58	1.72E-02	1.64E-08	4.39E-02	4.18E-08	1.79E-01
	3	799.58	1.72E-02	1.64E-08	4.39E-02	4.18E-08	1.79E-01
	4	799.58	1.72E-02	1.64E-08	4.39E-02	4.18E-08	1.79E-01
	5	799.58	1.72E-02	1.64E-08	4.39E-02	4.18E-08	1.79E-01
	6	799.58	1.72E-02	1.64E-08	6.31E-02	6.00E-08	2.57E-01
	7	799.58	1.72E-02	1.64E-08	6.31E-02	6.00E-08	2.57E-01
	8	799.58	1.72E-02	1.64E-08	1.07E-01	1.02E-07	4.36E-01
8	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
9	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
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

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Table 49. LOM risk assessment results (islanding scenario 4, 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	3.12E-04
	2	61.22	2.24E-07	2.13E-13	2.07E-06	1.97E-12	2.89E-03
	3	61.22	2.24E-07	2.13E-13	2.07E-06	1.97E-12	2.89E-03
	4	61.22	2.24E-07	2.13E-13	2.07E-06	1.97E-12	2.89E-03
	5	60.00	2.18E-07	2.08E-13	2.02E-06	1.92E-12	2.25E-03
	6	61.22	2.24E-07	2.13E-13	4.20E-06	3.99E-12	5.86E-03
	7	61.22	2.24E-07	2.13E-13	4.20E-06	3.99E-12	5.86E-03
	8	61.22	2.24E-07	2.13E-13	6.26E-06	5.96E-12	8.75E-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	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	52.55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	2	58.38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	3	58.38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	4	58.38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	5	58.38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	6	58.38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	7	58.38	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	8	58.38	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	179.16	1.87E-04	1.78E-10	4.78E-04	4.55E-10	3.03E-03
	2	179.16	1.87E-04	1.78E-10	4.78E-04	4.55E-10	3.03E-03
	3	179.16	1.87E-04	1.78E-10	4.78E-04	4.55E-10	3.03E-03
	4	179.16	1.87E-04	1.78E-10	4.78E-04	4.55E-10	3.03E-03
	5	179.16	1.87E-04	1.78E-10	4.78E-04	4.55E-10	3.03E-03
	6	179.16	1.87E-04	1.78E-10	6.86E-04	6.53E-10	4.35E-03
	7	179.16	1.87E-04	1.78E-10	6.86E-04	6.53E-10	4.35E-03
	8	179.16	1.87E-04	1.78E-10	1.16E-03	1.11E-09	7.38E-03
8	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
9	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
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

C.3. Result figures

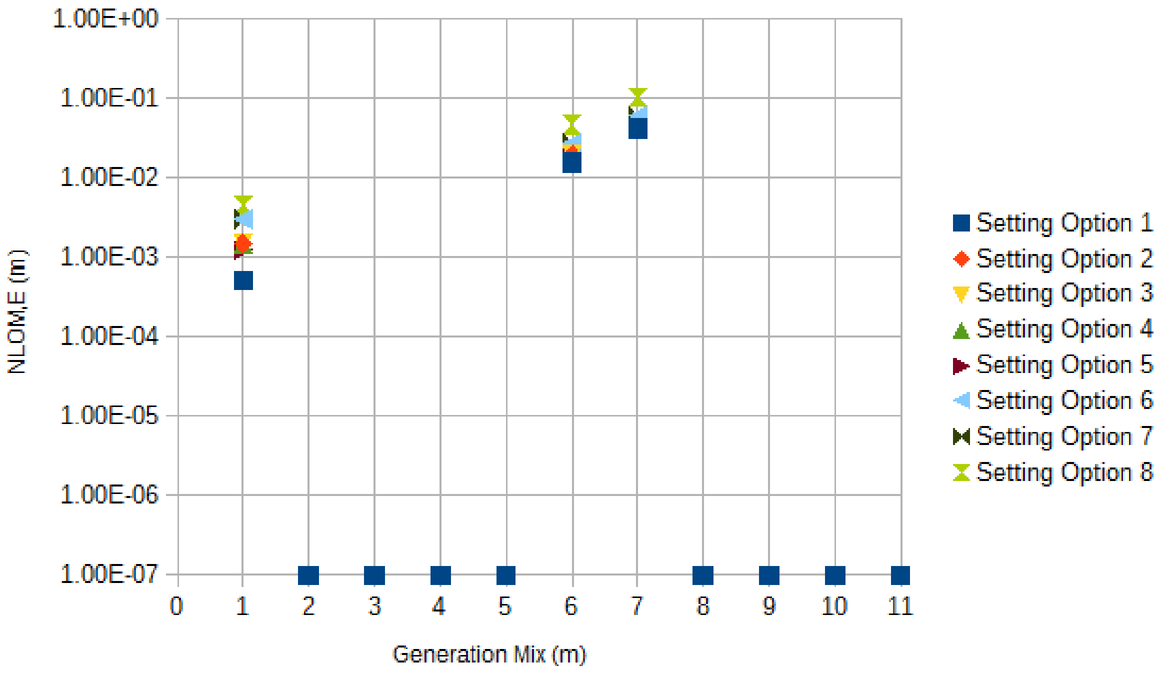

Figure 18. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 3, Load Profile LP01

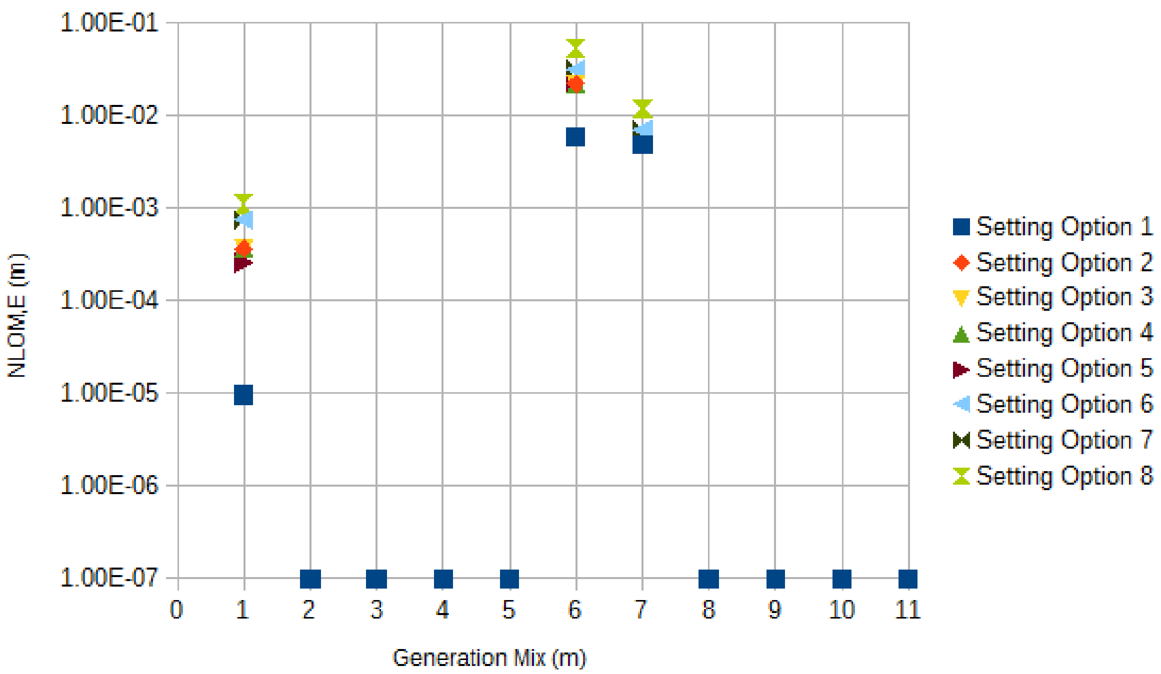

Figure 19. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 3, Load Profile LP02

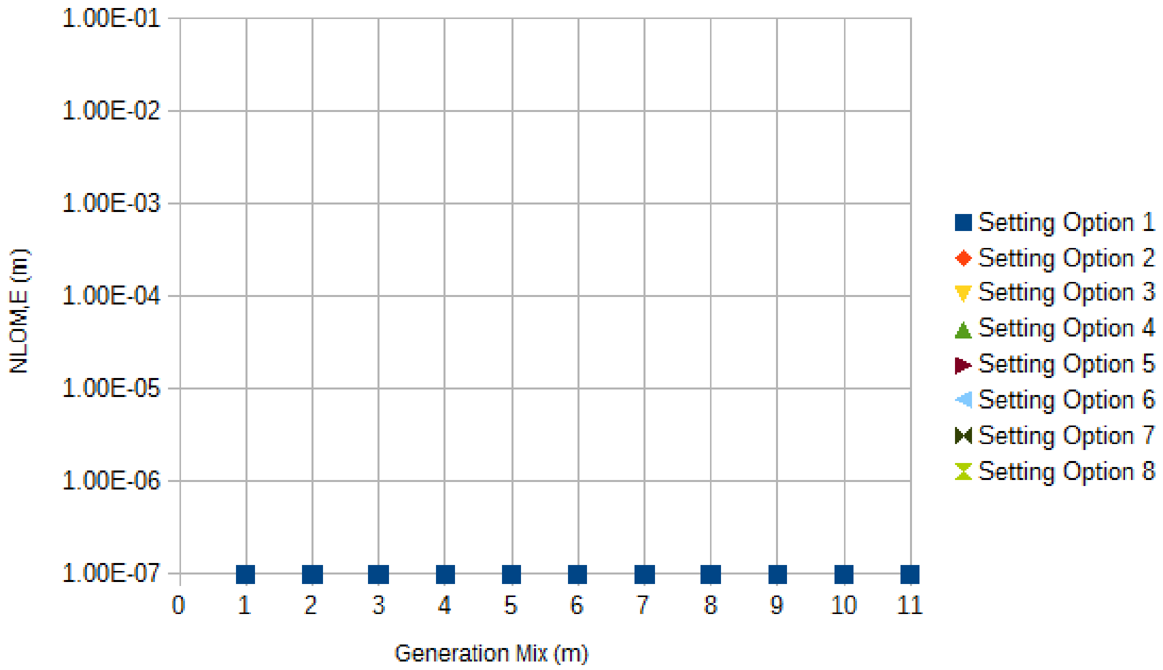

Figure 20. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 3, Load Profile LP03

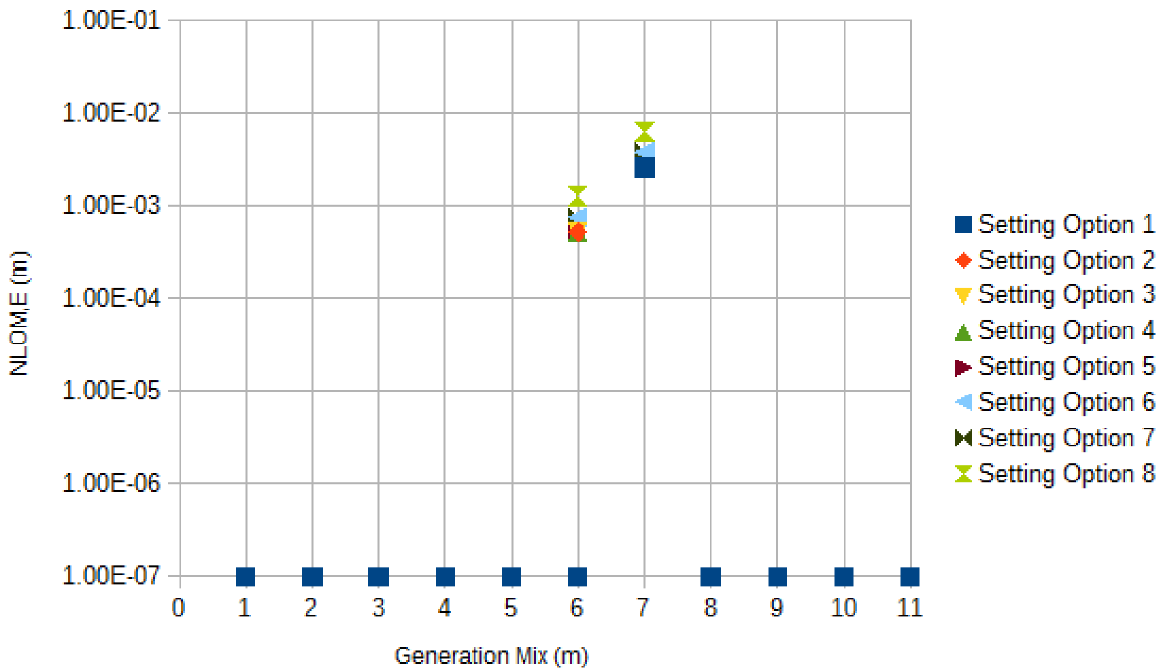

Figure 21. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 3, Load Profile LP04

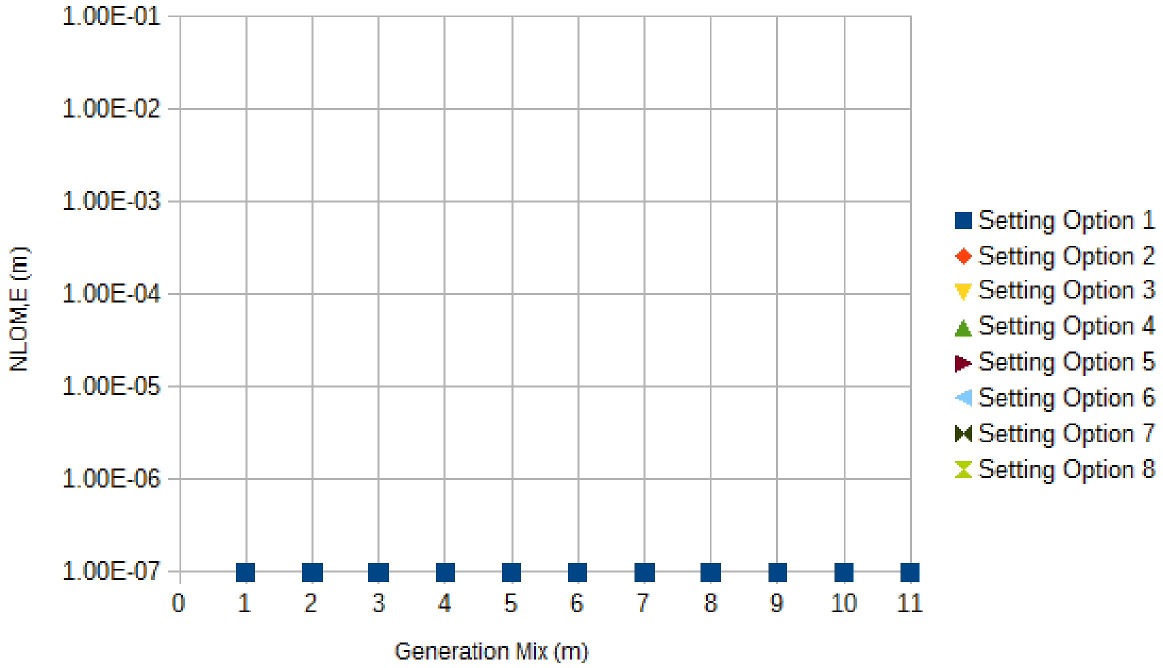

Figure 22. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 3, Load Profile LP05

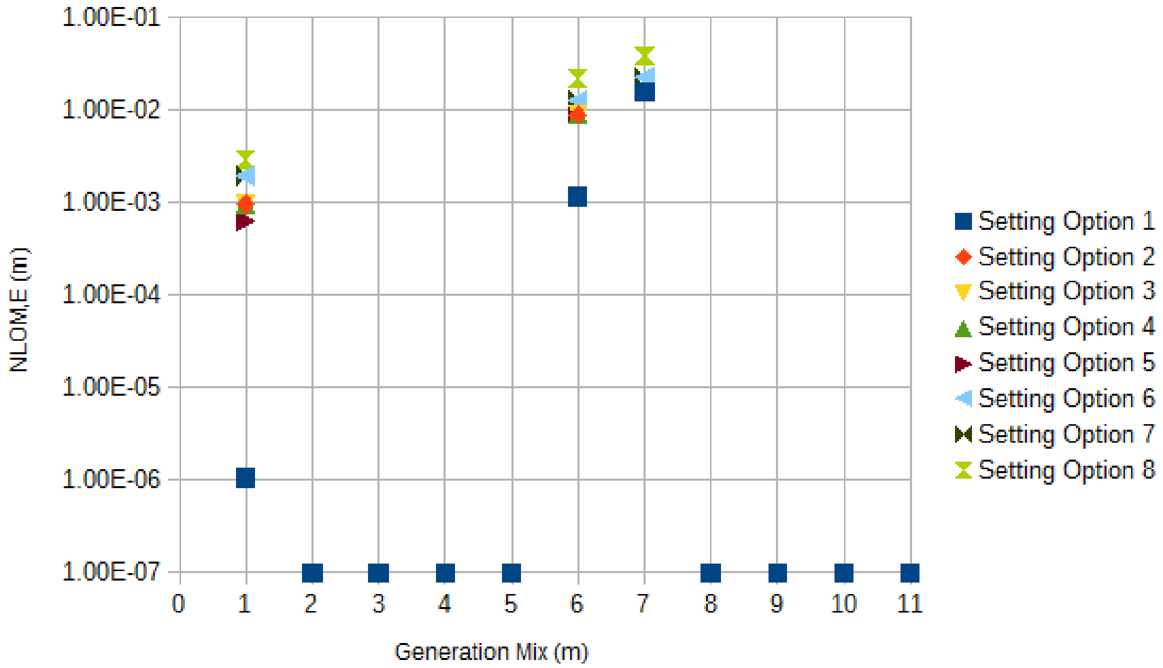

Figure 23. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 4, Load Profile LP06

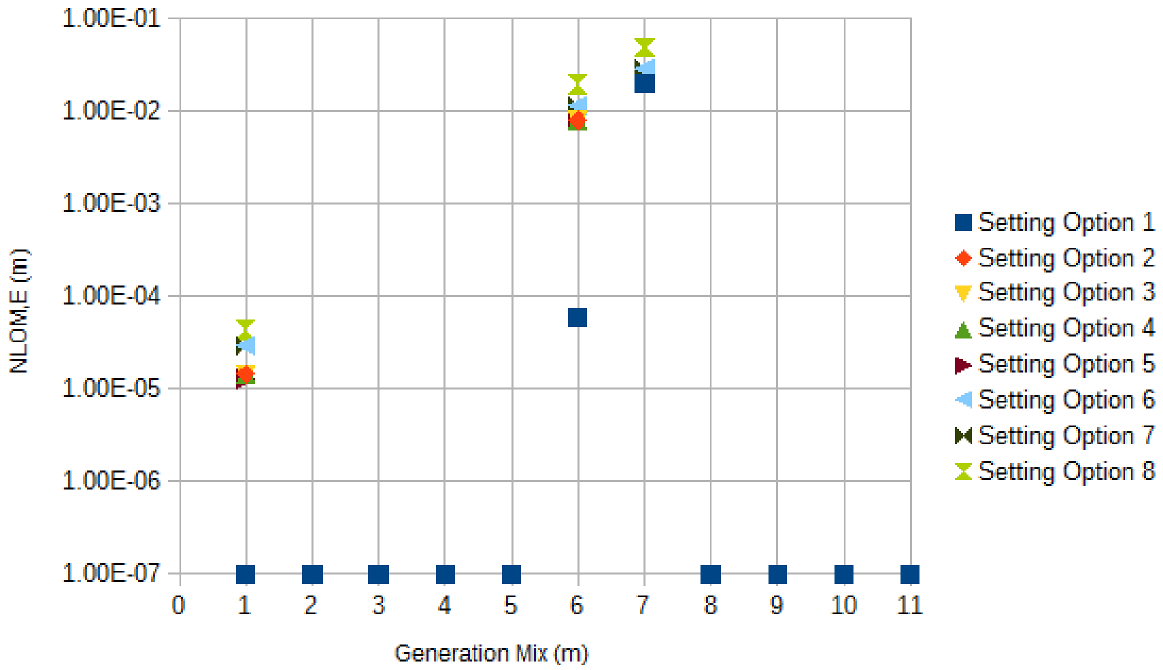

Figure 24. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 4, Load Profile LP07

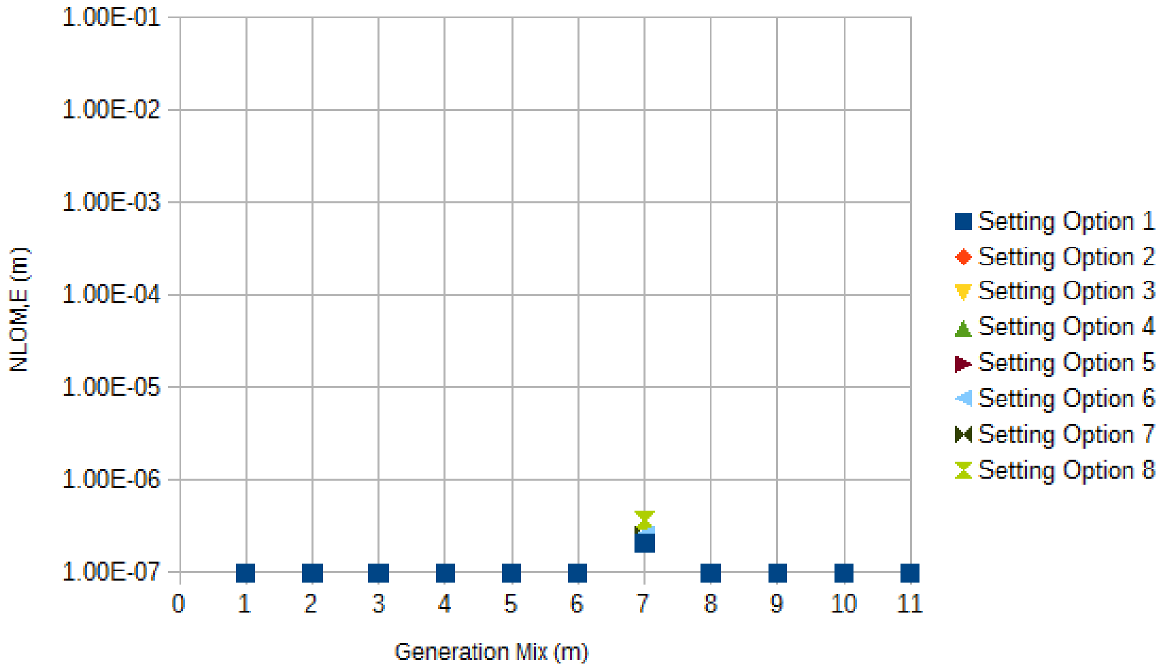

Figure 25. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 4, Load Profile LP08

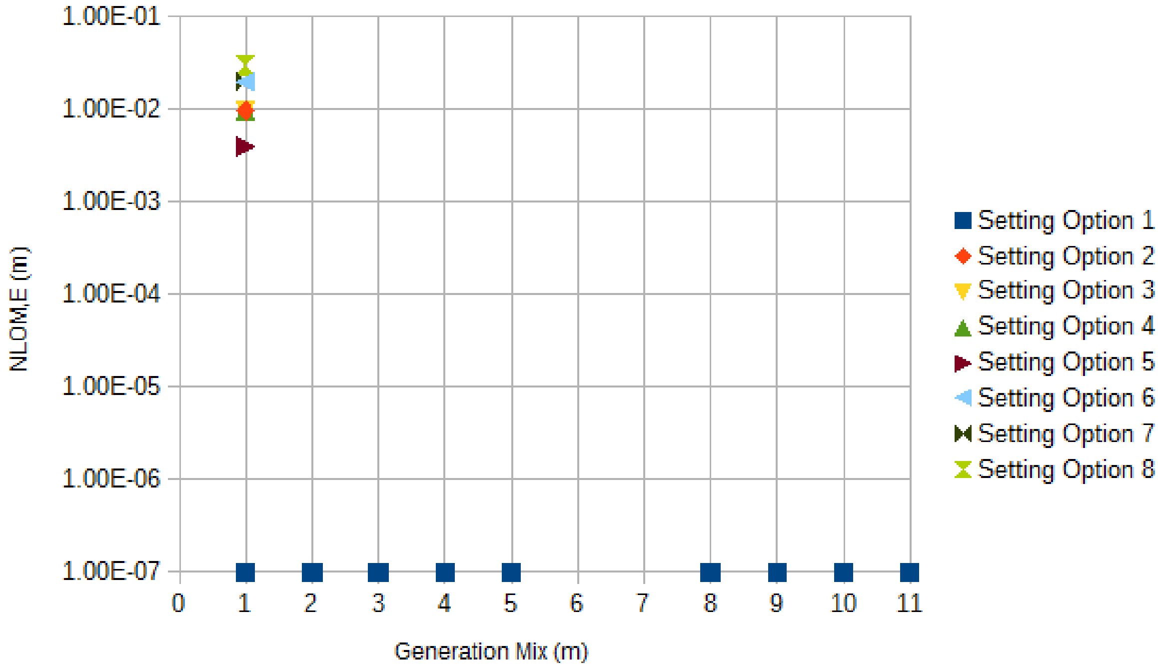

Figure 26. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 4, Load Profile LP09

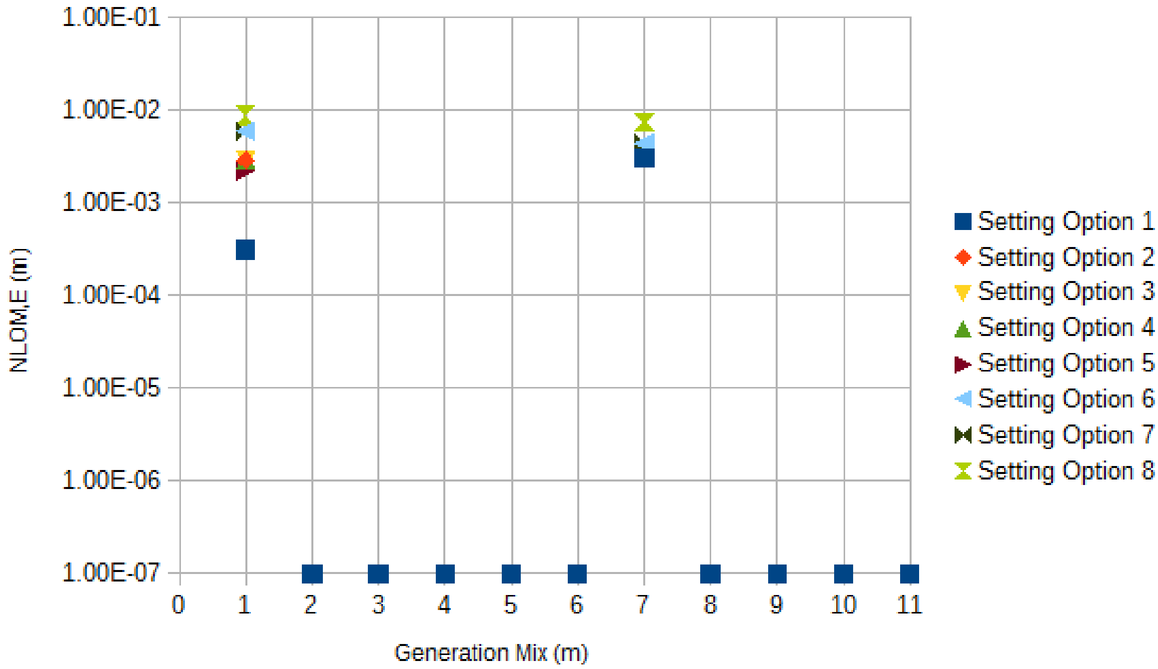

Figure 27. Probability $N_{LOM,E}$ of undetected islanding operation – Scenario 4, Load Profile LP10