Control of Major Accident Hazards Assessment Report

ELECTROGAS MALTA PROJECT & ENEMALTA DELIMARA POWER STATION

COMAH Assessment Report

COORDINATED Safety Report
COORDINATED Safety Management System
COORDINATED Emergency Response Plan

October 2016
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The conclusions and recommendations contained in this Report are based upon information provided by Malta COMAH CA and upon the assumption that all relevant information has been provided by the involved parties from whom it has been requested and that such information is complete and accurate. Information obtained by Gap Analysis S.A. has been independently verified by Gap Analysis S.A., unless otherwise specified.

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1 The Disclaimer contains statements in accordance to Enemalta Safety Report (SR), EGM SR and CSR declarations relevant to limitation of liability, indemnification and jurisdiction issues defined for the use of data derived from those Reports.
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Abbreviations

ALARP: As Low As Reasonably Practicable (ALARA: As Low As Reasonably Achievable)
BLEVE: Boiling Liquid Expanding Vapour Explosion
BOG: Boil-Off Gas
CCGT: Combined Cycle Gas Turbine
CERP: Coordinated Emergency Response Plan
CLP: Classification, Labelling, Packaging (Regulations)
COMAH: Control of Major Accident Hazards (Authority)
CPD: Civil Protection Department (Malta)
CSMS: Coordinated Safety Management System
CSR: Coordinated Safety Report
D3PP (PS): Delimara 3 Power Plant (Power Station)
D4PP (PS): Delimara 4 Power Plant (Power Station)
EGM: ElectroGas Malta Ltd
ENE: ENEMALTA
ERA: Environment & Resources Authority (Malta) former MEPA
ERP: Emergency Response Plan
ESD: Emergency Shutdown
FBR: Full Bore Rupture
FP: Flash Point
FSU: Floating Storage Unit
GRS: Gas Receiving Station
HAZID: Hazard Identification study
HAZOP: Hazard & Operability study
HC: Hydrocarbons
HCV: Hydrocarbons Vapours
HMB: Heat and Material Balances
HSE (UK): Health & Safety Executive (UK)
HSE: Health Safety & Environment
IEP: Internal Emergency Plan
IR: Individual Risk
LA(s): Loading Arm(s)
LFL: Lower Flammability Limit (LEL: Lower Explosive Limit)
LNG: Liquefied Natural Gas
<table>
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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>LNGC</td>
<td>LNG Carrier</td>
</tr>
<tr>
<td>LOC</td>
<td>Loss of Containment</td>
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<tr>
<td>LOPA</td>
<td>Layer of Protection Analysis</td>
</tr>
<tr>
<td>LSIR</td>
<td>Location Specific Individual Risk</td>
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<tr>
<td>LUP</td>
<td>Land Use Planning</td>
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<tr>
<td>MAPP</td>
<td>Major Accident Prevention Policy</td>
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<tr>
<td>MEPA</td>
<td>Malta Environment &amp; Planning Authority</td>
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<tr>
<td>(M)SDS</td>
<td>(Material) Safety Data Sheet</td>
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<tr>
<td>MW</td>
<td>Molecular Weight</td>
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<tr>
<td>NBP</td>
<td>Normal Boiling Point</td>
</tr>
<tr>
<td>NG</td>
<td>Natural Gas</td>
</tr>
<tr>
<td>NVCC</td>
<td>Non Visible Combustion Chamber</td>
</tr>
<tr>
<td>OGP</td>
<td>International Association of Oil &amp; Gas Producers</td>
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<tr>
<td>OHSA</td>
<td>Occupational Health and Safety Authority (Malta)</td>
</tr>
<tr>
<td>PA</td>
<td>Planning Authority</td>
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<td>P&amp;ID (or PID)</td>
<td>Piping &amp; Instrumentation Diagram</td>
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<td>Process Flow Diagram</td>
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<td>ReGasification Unit</td>
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<tr>
<td>RPT</td>
<td>Rapid Phase Transition</td>
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<tr>
<td>SCL</td>
<td>Sectoral Checklist</td>
</tr>
<tr>
<td>SMS</td>
<td>Safety Management System</td>
</tr>
<tr>
<td>TNO</td>
<td>TNO, the Netherlands Organisation for applied scientific research</td>
</tr>
<tr>
<td>UFL</td>
<td>Upper Flammability Limit (UEL: Upper Explosive Limit)</td>
</tr>
<tr>
<td>(U)VCE</td>
<td>(Unconfined) Vapour Cloud Explosion</td>
</tr>
<tr>
<td>WCS</td>
<td>Worst Case Scenario</td>
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</tbody>
</table>
1. Introduction

1.1 Project Background

This Coordinated Safety Report [33] compiles the Safety Reports presented by ENEMALTA plc (henceforth ENEMALTA) [32], ELECTROGAS MALTA Ltd. (henceforth EGM) [1], as well as D3PG Ltd. [6]. The purpose is to identify additional risk, which could arise from the domino effect identified in the mentioned Safety Reports, as well as to assess the individual and societal risk for each part of the site and for the entire site.

ENEMALTA is the operator of part of the existing Power Plant and fuel storage, which falls under the scope of the Seveso III Directive2 due to the presence of Diesel Oil (DO) and Heavy Fuel Oil (HFO). EGM is the operator of the Regasification Unit (RGU), the Floating Storage Unit (FSU), the connecting LNG and Natural Gas (NG) pipelines on the Jetty and onshore which also fall under the scope of the cited Directive due to the presence of LNG and NG, as well as of the Combined Cycle Gas Turbine. D3PG will be the operators of the D3 engines based power plant once they are converted to NG. The presence of hazardous substances in the facilities operated by D3PG will be always below the minimum thresholds established by the Seveso III Directive.

The three operators will share part of the facilities, with ENEMALTA as a main stakeholder and provider of general services to the others. The three operators will run the facilities for which ENEMALTA initially required the permit for construction according to the IPPC regulation. This Coordinated Safety Report has been prepared in order to continue with the permitting application and more specifically in order to provide evidence to the authorities about the overall risk of the entire facilities, combining the outcome from the individual Safety Reports and Risk Assessments and providing a common assessment of the possible Domino Effect between establishments of different operators.

The scope of the Coordinated Safety Report includes all facilities within the establishments, considering several phases of operation, according to the planning for the conversion of the facilities for combustion of NG as the principal source of energy. In other words, the scope includes the unloading, storage, regasification, handling and transfer operations of LNG and NG according to the operations in the establishments as planned, the use of diesel oil only in the power plant and the storage of both HFO and gasoil fuels, as they will take place in the future, as well as the loading, unloading, storage and transfer operation in the power plant, both of DO and HFO, as they take place in the current situation.

Hazards associated to the transitory construction activities carried out at the facilities, have been specifically detected during the HAZOP and HAZID workshops prior to the preparation of the Safety Reports and have also been considered in the Coordinated Safety Report (CSR). The Coordinated Safety Report assesses the hazards normally due to standard operations. Commissioning, start-up, shut-down and switch from one mode of operation to others are

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2 Seveso III Directive has been transposed into Maltese law through the Control of Major Accident Hazards (COMAH) Regulations LN 179/2015.
not specifically mentioned or highlighted in the report, but are fully included in the overall risk assessment. In fact, in this type of power plants, the start-up, shut-down and switch from one mode to another is part of the standard operations and is carried out on a daily basis.

Prior to the commencement of conversion of DPS3, Enemalta will remain responsible for operating all eight diesel engines, steam turbine and auxiliary systems of DPS3. Following the complete transfer of operations of DPS3 to D3PG, Enemalta will no longer be responsible for operating the DPS3 eight diesel engines, steam turbine and auxiliary systems. The transfer of DPS3’s operations is to take place in two phases, each phase coinciding with the conversion phases of the plant to operate on NG. The first phase will see the conversion of the first four diesel engines to operate on both NG and gasoil. Up to completion of this first phase, Enemalta will continue to operate engines 1, 2, 3 and 4. Following completion of the first phase, D3PG will have the capability to operate the converted engines on NG and Gasoil. Simultaneously Enemalta will stop operating engines 1, 2, 3 and 4, and allow said engines to be converted to run on NG. Therefore, upon completion of the first phase, Enemalta will no longer operate any of the eight DPS3 engines.

Maltese COMAH Competent Authority\(^3\) launched a project for the assessment of the Coordinated Safety Report, namely the Coordinated Safety Report (CSR), Coordinated Safety Management System (CSMS) and Coordinated Emergency Response Plan (CERP), according to the provisions of Seveso III Directive. GAP ANALYSIS S.A. has undertaken the task of performing the Assessment of the Coordinated Reports (Coordinated SR, CSMS and CERP) and of developing the COMAH Assessment Report on behalf of COMAH CA.

A consistent and systematic approach has been adopted aligned with practices used by the European Competent Authorities (CAs) and Third Parties controlling major accident hazard risks in the EU Member States (Maltese Proposed COMAH Framework and LUP Policy, Health & Safety Executive UK, RIVM, etc.), aiming at providing advice to further improve the safety of the project and enhance human and environmental protection. Compliance with regulatory requirements (SEVESO III - COMAH) has been verified in terms of completeness and adequacy of safety related documentation according to EC Guidelines on the preparation of SEVESO SRs and on Inspections of COMAH sites, and according to Hazard Identification Checklists and SMS Evaluation Checklists adopted by UNECE.

The present COMAH Assessment Report summarises findings, conclusions and recommendations derived during the assessment of the final versions of the Coordinated Safety Report, the Coordinated Safety Management System and the Coordinated Emergency Response Plan as submitted to COMAH CA and supplemented by relevant supporting studies, reports and information.

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\(^3\) The Competent Authority is the Occupational Health and Safety Authority (OHSA) together with the Environment and Resources Authority, the Planning Authority (PA) (former Malta Environment and Planning Authority (MEPA)) and the Civil Protection Department of the Ministry for Home Affairs and National Security (CPD).
1.2 Study Scope

The purpose of the present Assessment Report titled “COMAH Assessment Report of EGM and ENEMALTA DPS” or “COMAH Assessment Report of CSR-CSMS-CERP” is to provide technical support to Maltese COMAH CA in order to verify compliance with regulatory requirements (SEVESO III Directive) as mainly related to Art.10 (Safety Report) of the Directive and particularly on:

- par. 1 (a) "... demonstrating that a MAPP and SMS for implementing it have been put into effect in accordance with the information set out in Annex III of the Directive"
- par. 1 (b) "... demonstrating that major-accident hazards and possible major-accident scenarios have been identified and that the necessary measures have been taken to prevent such accidents and to limit their consequences for human health and the environment"
- par. 1 (c) "... demonstrating that adequate safety and reliability have been taken into account in the design, construction, operation and maintenance of the installation, storage facility, equipment and infrastructures connected with its operation which are linked to major-accident hazards inside the establishment"
- par. 1 (d) "... demonstrating that internal emergency plans have been drawn up and supplying information to enable external emergency plan to be drawn up"
- par. 1 (e) "... providing sufficient information to the competent authority to enable decisions to be made regarding the siting of new activities or developments around existing establishments".

The findings, conclusions and recommendations of the present COMAH Assessment Report of EGM and ENEMALTA DPS (COMAH Assessment Report of CSR-CSMS-CERP) provide:

- technical documentation for the definition of specific terms (before commissioning and after commissioning) for Licensing purposes, and
- technical guidance to COMAH Inspections which should be performed according to Art. 19 and 20 of the SEVESO III Directive, prior or following the start of operations.

All recommendations are developed based on the results of the assessment of the CSR, CSMS and CERP, for the completeness, correctness, adequacy and credibility of their contents according to SEVESO III requirements.

The Coordinated Safety Report (CSR, CSMS and CERP) has been prepared on the basis of the information provided by ENEMALTA and EGM in their Safety Report (report no. 02-901-200560-15958, Rev. 0.3 and report no. ENEM-AEC-E0-00-RP-SE-000xx REV 03 respectively) and additional information from D3PG. Results, criteria, output tables and descriptive chapters have been extracted by these reports with the permissions from ENEMALTA and EGM.

Coordinated SR deliverables that fall under the scope of COMAH Assessment Report of CSR-CSMS-CERP and have been reviewed, are presented in Table 1.
Table 1: List of Reviewed Coordinated SR Deliverables

<table>
<thead>
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<tr>
<td>Coordinated Safety Report (CSR)</td>
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</tr>
<tr>
<td>Coordinated Emergency Response Plan (CERP)</td>
<td>All</td>
</tr>
<tr>
<td>Coordinated Safety Management System (CSMS)</td>
<td>All</td>
</tr>
</tbody>
</table>

The above Deliverables make reference to supplementary data, reports and studies, plots and drawings, etc., which are not explicitly mentioned in Table 1. For assessment purposes, all safety related documentation included in that supplementary material has been considered during the review process. In all cases, where supplementary material has been reviewed, relevant references are included in the assessment performed and in the present COMAH Assessment Report of CSR-CSMS-CERP.

The Documents reviewed refer to the facilities of Electrogas Malta Project and of Delimara Power Station (D1, D2A, D2B, D3). The documents related to the conversion of Delimara D3 PP are not included in the present Assessment Report, since Delimara D3 PP is not classified as an upper tier COMAH site.

1.3 Report Layout

The Sections of the “COMAH Assessment Report of EGM and ENE DPS CSR” are set out as follows:

- Section 1 provides description of Project background and the Scope of the COMAH Assessment Report of the EGM and ENE DPS Coordinated Safety Report
- Section 2 provides a brief Project Description
- Section 3 presents the methods and tools applied for the assessment of the Coordinated Safety Report, Safety Management System and Emergency Response Plan. Section 3 describes also the Damage Thresholds and Risk Acceptance Criteria applied for the evaluation of the major accident scenarios included in the CSR and refers to the approach applied for the evaluation of risk analysis parameters and assumptions relevant to population data, meteorological data, initiating events, selection of LOCs, incident types and Worst Case Scenarios (WCSs).
- Section 4 presents the results of Risk Assessment and Risk Evaluation based on the WCSs consequences assessment and QRA Analysis (LSIR and F-N Curve), as performed by the evaluators in order to verify the Coordinated Safety Report risk assessment results and presents the cumulative risk profile for Delimara region.
- Section 5 presents the review recommendations based on the results of the assessment of the CSR, CSMS and CERP. The proposed recommendations are divided in two categories according to their significance:
  - “General Recommendations” to be considered after commissioning, and
  - “Specific Requirements (or recommendations)” to be regarded as conditions, limitations or binding terms for licensing purposes before commissioning starts.
The COMAH Assessment Report of CSR-CSMS-CERP includes Annexes A and B, which constitute an integral part of the present Assessment Report:

- Annex A, includes the Assessment Checklists applied for addressing completeness, correctness and credibility evaluation of the CSR, CSMS and CERP contents. UNECE Sectoral Check Lists (SCLs) have been used as the basic guidance tool for the evaluation procedure and the development of SR, SMS and ERP Checklists.
2 Brief Project Description

2.1 Location of the New Establishments

The new establishments include facilities that are located outside the boundaries, but also within the perimeter of the existing Delimara Power Station (DPS). The location is approximately 1 km south east of Marsaxlokk Village, at L-Inginier, on the Delimara Peninsula. This power station is built on partly reclaimed land and commenced operations in 1991. The site is bounded to the east by a road which runs between Tas-Silġ Fort and Fort Delimara, at an elevation of approximately 40 m above sea level. The western boundary of the site is delineated by Marsaxlokk Bay.

The location of the project is shown in Figure 1

![Figure 1: Location of ENEMALTA Delimara Power Station](image)

2.2 Facilities Description

2.2.1 Enemalta Delimara Power Station Facilities

The main components in the Delimara Power Station are:

- **PHASE 1 (D1)**: Two HFO steam units with boiler, steam turbine and generator, for baseload operations, 2 x 60 MW
- **PHASE 2a (D2A)**: Two DO open cycle gas turbines and generator units at 37.5 MW, designed for peak load
- **PHASE 2b (D2B)**: Two DO combined cycle gas turbines with heat recovery steam generators and a steam turbine for midrange duties, with a total capacity of 110 MW
- **PHASE 3 (D3)**: Eight medium-speed diesel engines of the Wartsila Model 18V46, as well as a steam turbine generator of the Dresser-Rand model Frame 30 (Multi Stage Impulse Condensing), designed to combust heavy fuel oil as the main fuel and diesel fuel oil as a backup option.
The thermal power station of the plant is resumed in Table 2.

Table 2: Delimara Power Station Main Components

<table>
<thead>
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<th>Source</th>
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<th>Fuels</th>
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<td>Phase 1</td>
<td>Steam Boilers (phase 1A and phase 1B )</td>
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<td>Heavy Fuel oil (HFO)</td>
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<td>Phase 2A</td>
<td>CCGT1</td>
<td>121</td>
<td>Gasoil (DO)</td>
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<tr>
<td></td>
<td>CCGT2</td>
<td>121</td>
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<tr>
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<td>CCGT3A</td>
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<td>Gasoil (DO)</td>
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<td></td>
<td>CCGT3B</td>
<td>121</td>
<td></td>
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<td>Phase 3</td>
<td>Diesel engines 41 &amp; 42</td>
<td>77</td>
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</tr>
<tr>
<td></td>
<td>Diesel engines 47 &amp; 48</td>
<td>77</td>
<td></td>
</tr>
</tbody>
</table>

2.2.2 ElectroGas Malta Project

The main components of EGM project are the:

- Floating Storage Unit (FSU) and LNG terminal;
- Regasification Plant;
- Combined Cycle Gas Turbine (CCGT) Power Plant.

The Malta FSU project involves the conversion of the “Wakaba Maru”, an existing Moss® type Liquefied Natural Gas carrier (LNGC) into an LNG Floating Storage Unit (FSU) designed for continuous operation without dry-docking for a service life of 18 years. This facility will be moored alongside a jetty in Marsaxlokk Bay in Malta, where it will discharge to an onshore Regasification Plant which will supply a new CCGT Power (D4) and Converted Delimara D3 Plant.

Analytically, the new LNG Terminal and CCGT Power Plant include the following facilities, partitioned into 5 areas:

- LNG Facility (Area E)
- Regasification Compound (Area B)
- CCGT Power Plant (Area A)
- Delimara 3 Gas Reduction Station (Area C)
- MV Switchgear (Area D)

The above areas are outlined in Figure 2.
The facilities located outside the perimeter of the existing establishment of ENEMALTA Delimara Power Station (ENEMALTA DPS) are the following:

- the new LNG Facility (in Area E) including the FSU and the Jetty pier & platform, and
- the new Regasification Compound (in Area B).

The facilities located within the perimeter of the existing establishment of the ENEMALTA DPS are:

- the new CCGT D4 Power Plant (in Area A),
- the converted Delimara D3 PP with the D3 Gas Reduction Station (in Area C), and
- the new main NG pipeline that supplies Natural Gas to the Power Plants from the Compressor station of the Regasification Plant.
The locations of the individual facilities (designated areas of individual operators) and the perimeter of the existing ENEMALTA DPS establishment are presented in Figure 3.

Figure 3: Locations of Individual Facilities and ENE DPS perimeter (designated areas of individual operators). Source: Drawing #3, Annex 3 of the Coordinated Safety Report [33].
3 Methodology

3.1 Methodological Framework

3.1.1 Legislation, Guidelines and Technical Framework

The COMAH Assessment Report of CSR-CSMS-CERP, has been based on the following instruments:

- UNECE convention on the transboundary effects of industrial accidents and EU Directive 96/82/EC (SEVESO II) by a consistent Checklist system
- Guidance on inspections as required by article 18 of the Council Directive 96/82/EC (Seveso II)
- Guidelines on a Major Accident Prevention Policy and Safety Management System, as required by Council Directive 96/82/EC (Seveso II)
- Guidance on the preparation of a safety report to meet the requirements of Directive 96/82/EC as amended by Directive 2003/105/EC (Seveso II)
- JRC, Implementing Art.12 of the Seveso II Directive: Overview of Roadmaps for Land-Use Planning In Selected Member States, 2008
- CCPS Guidelines for Developing Quantitative Safety Risk Criteria, 2009 (Center for Chemical Process Safety)
- An international comparison of four quantitative risk assessment approaches, RIVM Report 620552001, 2011
- Guide Dépôts de Liquides Inflammables, Groupe de Travail Dépôt de Liquides Inflammables (GTDLI), 2008
- Probabilistic accident assessment in the context of the French regulation, HAL Id: ineris-00973347 http://hal-ineris.ccsd.cnrs.fr/ineris-00973347
- International Association of Oil & Gas Producers OGP Process Release Frequencies – Risk Assessment Data Directory, March 2010
- UK HSE-Health and Safety Executive, Hydrocarbon Release Database (HCDR)-Phast database
- LIFE+ EU Project PROTEAS Seveso SMS Inspection Checklist
- EN 1473: Installation of Equipment for Liquefied Natural Gas – Design of Onshore Installations
- EN 1474: Installation and equipment for LNG – Design and testing of LNG loading/unloading arms


### 3.1.2 Project Execution

The approach adopted for the Assessment of the Coordinated Reports (CSR-CSMS-CERP) and the development of COMAH Assessment Report of CSR-CSMS-CERP, includes the following steps:

- Determination of requested technical and design data regarding safety documentation for the development of CSR, CSMS and CERP.
- Determination of a Checklist System based on UNECE Sectoral Checklists for the systematic and consistent assessment of the completeness, correctness and credibility of safety related data included in the Coordinated Safety Report deliverables (see Section 3.2).
- Review, assessment and definition of supplementary data of the submitted CSR, CSMS and CERP.
- Consultation with COMAH Authority, ElectroGas Malta and ENEMALTA representatives for clarifying the proposed risk analysis framework, review of recommendations on the Coordinated Safety Report, reaching common understanding on key COMAH requirements, agreement on process design parameters of safety critical equipment and verification that relevant good industrial practices and Standards are accepted, adopted and applied in all project phases.
- Review of the assumptions adopted for risk analysis purposes with special reference to the definition of Worst Case Scenarios (WCSs) of major accident hazards and of software simulation parameters for consequence assessment regarding thermal radiation and overpressure effects, as presented in the individual EGM Safety Report [2] and ENE Safety Report [32].
- Validation of consequence assessment results and Individual and Societal Risk (IR Contour and FN Curve). Evaluation of Location Specific Individual Risk (LSIR) and FN Curve for the WCSs using the EFFECTS 9.0.26/TNO software. The model parameters have been based on the design and operation data as provided by EGM and ENE Safety Report developers.
- Delivery of complete sets of Assessment Checklists, Sections 1-6 for the CSR, CSMS and CERP.
- Development of the COMAH Assessment Report of CSR-CSMS-CERP with recommendations based on the results of the Assessment Checklists and the supplementary information provided by the operators via the recommendation action tracking lists developed during the assessment process.
3.2 Evaluation Checklists

UNECE Sectoral Checklists (UNECE-SCLs) have been applied to support the assessment and present the assessment findings for the Coordinated Safety Report (CSR), the Coordinated Safety Management System (CSMS) and the Coordinated Emergency Response Plan (CERP). Information has been also drawn from the individual EGM Safety Report [2] and ENEMALTA Safety Report [32].

The findings and recommendations can also facilitate effective COMAH inspections after commissioning of operations.

UNECE SCLs are divided in 6 sections, as follows:

1. SCL description of the environment and site
2. SCL main activities and products for single installations
3. SCL dangerous substances
4. SCL identification of hazards, risk assessment and preventive measures
5. SCL limitation of consequences and mitigation
6. SCL Major Accident Prevention Policy (MAPP) & Safety Management System (SMS)

The system of checklist is used in a single electronic document, which allows an easy switch between the checklists, guidance text, literature, and progress tracking. All questions are organized in three categories, so-called “3-Cs”:

- Under “Complete” questions will verify the presence of the required, essential information that a safety report should contain; and
- Under “Correct” and “Credible” will go questions that would be used to verify the ones in complete (to cross-check them).

The different SCLs give an overview on all safety performances, expressed by the simple yes/limited/no evaluation system. Detailed description of findings and comments are summarized for each element of every SCL.

For the assessment of the Coordinated Safety Report (CSR) and the Coordinated Safety Management System (CSMS), the actual UNECE Checklists have been applied. Regarding the assessment of the Coordinated Internal Emergency Response Plan (CERP), the UNECE Checklist (Section-5) has been further elaborated including in each specific thematic area supplementary relevant provisions, as applied for COMAH sites based on “Guidance on inspections as required by article 18 of the Council Directive 96/82/EC (Seveso II)” and on EU Program LIFE+ PROTEAS Seveso SMS Inspection Checklist.

The detailed description of the evaluation findings: references to provisions and procedures, identified gaps and comments, according to completeness, correctness and credibility assessment of the information provided in the Coordinated Safety Documents (CSR-CSMS-CERP) were presented in COMAH CA according to UNECE SCLs format.

The overall conclusions based on the evaluation findings and the review recommendations per each SCLs Section 1-6 (as described above) are presented in Section 5 of the present report.
3.3 Risk Acceptance Criteria

3.3.1 HSE UK LUP Policy - PADHI System

Land Use Planning Policy (New Version 2015) (Revised MEPA, Land Use Planning Policy 2004) as proposed by Maltese COMAH Authority is in line with the widely accepted LUP practice proposed by HSE in UK (PADHI system [19]). According to the PADHI System, a proposed development in the vicinity of major hazard establishments is classified into one of four “Sensitivity Levels”. The main factors that determine these levels are the number of persons at the development, their sensitivity (vulnerable populations, such as children) and the intensity of the development. With these two factors known, a simple decision matrix is used to give a clear “Advise Against” (AA) or "Don’t Advise Against" (DAA) response, as presented in Table 3.

Table 3: Decision Matrix for LUP (HSE UK)

<table>
<thead>
<tr>
<th>Location Risk of fatality (per year)</th>
<th>Development in Inner Zone</th>
<th>Development in Middle Zone</th>
<th>Development in Outer Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x 10^{-5}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development in Inner Zone</td>
<td>DAA</td>
<td>DAA</td>
<td>DAA</td>
</tr>
<tr>
<td>Development in Middle Zone</td>
<td>AA</td>
<td>AA</td>
<td>DAA</td>
</tr>
<tr>
<td>Development in Outer Zone</td>
<td>AA</td>
<td>AA</td>
<td>AA</td>
</tr>
</tbody>
</table>

The three contours in Figure 4 represent levels of individual risk of 10 chances per million (cpm) or 10^{-5}, 1 cpm or 10^{-6} and 0.3cpm or 3x10^{-7} per year respectively of receiving a dangerous dose or defined level of harm. The contours form three zones, with the outer contour defining the Consultation Distance (CD) around major hazard sites.
3.3.2 Evaluation of Risk Control – The French Approach

According to the French legal framework with reference to COMAH sites, the *Evaluation of the risk control approach* as specified in *Appendix II of the Circular of 29 September 2005* allows the Prefect to assess the major accident risk control policy undertaken by the operator of a SEVESO site.

A Risk Matrix (risk assessment grid) is officially established in France, according to “probability” and “seriousness” combinations, outlining three accidental risk areas. Risk Acceptance Criteria thus involve the probability of accident scenarios and the severity of their consequences (parameter defined by the combination of consequence threshold value and affected persons).

The Risk Matrix (see Table 4) is divided into 25 cells, corresponding to “probability” / “seriousness of the consequences” combinations (identical to those of the model in appendix V of the amended order of 10 May 2000: transposing the SEVESO II Directive into French Law) that the operator of the SEVESO site should use it as a model to position each potential accident (scenario) within the risk assessment. It is therefore used by superimposing it onto the table appearing in the risk assessment.

The “seriousness of the consequences” for the individuals corresponding with the interests targeted by article L. 511-1 of the environmental code *(in France)* and the “probability of accident (scenarios)” are assessed according to the scales defined by the order of 29 September 2005 *(4)* on the evaluation and consideration of the occurrence probability, kinetics, effect intensity and seriousness of the consequences of potential accidents in the risk assessments of permit holding classified installations (“A” to “E” for the probability) and “Moderate” to “Disastrous” for the seriousness of the consequences for individuals.

Detailed information on the application of the Risk Acceptability Matrix and Risk Acceptance Criteria based on the French approach is presented in the Annex B of the present report. The general procedure for the implementation of the Risk Matrix is presented in Figure 1 of Annex B, while a brief description of key parameters of French methodological framework is presented below.

Specifically:

The scale used in France for the probability “A” to “E” is presented in Table 5, Section 3.3.3 *(see also Annex B Table 4)*.

The scale used in France for the “seriousness of the consequences” is presented in Table 6, Section 3.3.3.

An assessment grid is therefore established (in France) according to “probability” and “seriousness” combinations, outlining three accidental risk areas (see Table 4):

---

4 The law of 30 July 2003 *(in France)* relative to the prevention of technological and natural risks and damage reparation imposed the introduction of an estimation of probability, seriousness and kinetics in the risk assessments issued by the operators of permit holding installations. The Ministerial Order of 29 September 2005 completes this legislative requirement by determining regulatory thresholds to evaluate the intensity of the physical effects of hazardous phenomena, the seriousness of accidents and the probability of these phenomena and accidents.
• a high-risk area, represented by the word “NO”;
• an intermediate risk area, represented by the acronym “MMR” (risk control measures), for which a continuous improvement approach is particularly relevant in order to attain, within economically acceptable conditions, a risk level as low as possible, taking into account current knowledge and practices as well as the vulnerability of the installation’s environment;
• a lesser risk area, which does not involve a “NO” or “MMR”. The gradation of “NO” or “MMR” cells into “rows” corresponds with an increasing risk, from row 1 to row 4 for “NO” cells and from row 1 to row 2 for “MMR” cells. This gradation corresponds with the priority given to risk reduction, focusing first and foremost on reducing the most significant risks (top rows).

Table 4: Risk Acceptability Matrix - French Assessment Grid

<table>
<thead>
<tr>
<th>Seriousness of the consequences for individuals exposed to the risk (note 1)</th>
<th>E</th>
<th>D</th>
<th>C</th>
<th>B</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disastrous</td>
<td>Partial NO (new sites: note 2) / MMR row 2 (existing sites: note 3)</td>
<td>NO row 1</td>
<td>NO row 2</td>
<td>NO row 3</td>
<td>NO row 4</td>
</tr>
<tr>
<td>Catastrophic</td>
<td>MMR row 1</td>
<td>MMR row 2 (note 3)</td>
<td>NO row 1</td>
<td>NO row 2</td>
<td>NO row 3</td>
</tr>
<tr>
<td>Significant</td>
<td>MMR row 1</td>
<td>MMR row 2 (note 3)</td>
<td>MMR row 1</td>
<td>NO row 2</td>
<td>NO row 1</td>
</tr>
<tr>
<td>Serious</td>
<td>MMR row 1</td>
<td>MMR row 2</td>
<td>NO row 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MMR row 1</td>
</tr>
</tbody>
</table>

Note 1: Probability and seriousness of the consequences are evaluated in accordance with the Ministerial Order relative to the evaluation and consideration of the occurrence probability, kinetics, effect intensity and seriousness of the consequences of potential accidents in the risk assessments of permit holding classified installations.

Note 2: The operator must implement additional technical measures to retain probability level E in case one of the risk control measures fails.

Note 3: In the case of an “AS” permit application: also check criterion C of section 3 of appendix I (of the order of 29 September 2005). (AS installations: this category corresponds with permit holding installations with public easement to control urban planning, including the so-called “upper tier” sites of the SEVESO II Directive)
3.3.3 Common Risk Matrix adopted for the preparation and evaluation of Delimara Safety Reports

For purposes of performing Risk Evaluation in the Safety Reports and the assessment of resulting risks in comparison with the measures and safeguards taken, a common Risk Matrix was developed and proposed by the evaluators. The common Risk Matrix was adopted by all Safety Report developers involved in ENE DPS SR and Electrogas Malta Project as approved by the COMAH Authority.

The common Risk Matrix was set as the basis for the evaluation of risks resulting from the analysis of major accident hazards, the selection of worst case scenarios (WCSs), the evaluation of WCSs consequences, the estimation of WCSs frequency, the assessment of risk per WCS and the definition of risk reduction measures per WCS.

The results of Risk Evaluation have been considered into the assessment performed through UNECE Section-4 Checklists.

The adopted common Risk Matrix is in compliance with:
- The French legal framework for the Evaluation of the risk control approach in Seveso establishments, as an appropriate practice for Delimara Safety Reports.
- The Threshold / End point values for the definition of Hazard Zones in consequence assessment as accepted by COMAH Malta Authorities for COMAH establishments, and
- Good Industrial Practices applied in EU countries.

The Societal Risk criteria on which the common Risk Matrix is based, are in line with the Societal Risk criteria adopted by HSE (UK) and in other countries. Societal Risk criteria adopted in the Netherlands are the most conservative compared with other national practices. While evaluation of Societal Risk in the individual Safety Reports is performed under the common Risk Matrix criteria, the overall Societal Risk for all the establishments is performed in the present assessment under the most conservative Dutch criteria (see section 4.2).

The common Risk Matrix, presented in Table 5, has been developed as identical to the French Assessment Grid (Risk Acceptability Matrix officially established in France, analytically presented in Annex B).

The Risk Matrix outlines three accidental risk areas (red, yellow and green) identical to the three risk areas of the French Assessment Grid:
- Red for “high-risk area” represented by “NO”,
- Yellow for “intermediate risk area”, represented by “MMR” (risk control measures), and
- Green for “lesser risk area”, which does not involve a “NO” or “MMR”.
Table 5: Common Risk Matrix adopted for the preparation and evaluation of Delimara Safety Reports

<table>
<thead>
<tr>
<th>Probability</th>
<th>Per year</th>
<th>1 Moderate</th>
<th>2 Serious/Medium</th>
<th>3 Major/Significant</th>
<th>4 Catastrophic</th>
<th>5 Disastrous/Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Likely</td>
<td>Greater than or equal to $10^{-2}$</td>
<td>Yellow</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>B Unlikely</td>
<td>Greater than or equal to $10^{-3}$ and less than $10^{-2}$</td>
<td>Green</td>
<td>Yellow</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>C Very Unlikely</td>
<td>Greater than or equal to $10^{-4}$ and less than $10^{-3}$</td>
<td>Green</td>
<td>Green</td>
<td>Yellow</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>D Extremely Unlikely</td>
<td>Greater than or equal to $10^{-5}$ and less than $10^{-4}$</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Yellow</td>
<td>Red</td>
</tr>
<tr>
<td>E Remote</td>
<td>Less than $10^{-5}$</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>

Table 6: “Seriousness of Consequences” Scale

<table>
<thead>
<tr>
<th>Severity of Consequences</th>
<th>Significant Lethal Effect</th>
<th>First Lethal Effect</th>
<th>Irreversible Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme</td>
<td>PE&gt;10</td>
<td>PE&gt;100</td>
<td>PE&gt;1000</td>
</tr>
<tr>
<td>Catastrophic</td>
<td>1&lt;PE≤10</td>
<td>10&lt;PE≤100</td>
<td>100&lt;PE≤1000</td>
</tr>
<tr>
<td>Significant</td>
<td>PE≤1</td>
<td>1&lt;PE≤10</td>
<td>10&lt;PE≤100</td>
</tr>
<tr>
<td>Medium</td>
<td>0</td>
<td>PE≤1</td>
<td>1&lt;PE≤10</td>
</tr>
<tr>
<td>Moderate</td>
<td>No lethal effects outside the facility</td>
<td>PE≤1</td>
<td>PE≤1</td>
</tr>
</tbody>
</table>

Note: PE=Persons Exposed

The scale of “Seriousness of Consequences” presented in Table 6 is applied for Persons Exposed OUTSIDE the boundaries of the SEVESO establishment.

3.3.4 Damage Thresholds - Endpoint Values

The intensity of the effects (consequence) of dangerous phenomena (accident scenarios) is defined in comparison with reference values expressed in form of thresholds (threshold values /end point values) of toxic effects, effects of overpressure, thermal effects and effects linked to the impact of projectiles, for human and structures.

For Delimara Safety Reports the Effects are defined according to the following Threshold/End Point Values (Table 7).
Table 7: Threshold/End Point values for Delimara Safety Reports (End Point Values in bold are proposed in the new Land Use Planning Policy (New Version 2015) (Revised MEPA, Land Use Planning Policy 2004)).

<table>
<thead>
<tr>
<th>Effects</th>
<th>Significant Lethal Effects</th>
<th>First Lethal Effects</th>
<th>Irreversible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Zones: Threshold / End point values</td>
<td>Domino Zone (99% fatality)</td>
<td>Inner Zone (Very Serious Hazard)</td>
<td>Middle Zone (Serious Hazard)</td>
</tr>
<tr>
<td>Thermal Radiation</td>
<td>37.5 kW/m²</td>
<td>15 kW/m²</td>
<td>5 kW/m²</td>
</tr>
<tr>
<td>Thermal Dose</td>
<td>1800 (to 2000) TDU (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overpressure</td>
<td>700 mbar</td>
<td>300 (to 350) mbar</td>
<td>140 mbar</td>
</tr>
<tr>
<td>Toxic</td>
<td>-</td>
<td>LC50: Lethal concentration for 50% lethality</td>
<td>LC1: Lethal concentration for 1% lethality</td>
</tr>
</tbody>
</table>

The selected criteria for thermal radiation and for overpressure effects as specified in Table 7 are considered a conservative approach.

Further Hazard Zones with Significant Lethal effects may also be defined according to the following Threshold/End Point Values (Table 8).

Table 8: Further Hazard Zones with Significant Lethal effects for Delimara Safety Reports

<table>
<thead>
<tr>
<th>Effects</th>
<th>Significant Lethal Effects</th>
<th>Significant Lethal Effects</th>
<th>Significant Lethal Effects</th>
<th>Lethal Effects</th>
<th>First Lethal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Zones: Threshold / End point values</td>
<td>Inner Zone (Very Serious Hazard)</td>
<td>40% fatality</td>
<td>5% fatality</td>
<td>3% fatality</td>
<td>Middle Zone (Serious Hazard)</td>
</tr>
<tr>
<td></td>
<td>50% fatality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Radiation</td>
<td>15 kW/m²</td>
<td>9.3 kW/m²</td>
<td>7.3 kW/m²</td>
<td>5 kW/m²</td>
<td></td>
</tr>
<tr>
<td>Thermal Dose</td>
<td>1800 (to 2000) TDU</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overpressure</td>
<td>300 (to 350) mbar</td>
<td>170-200 mbar</td>
<td>140 mbar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic</td>
<td>LC50: Lethal concentration for 50% lethality</td>
<td>LC5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5 TDU: Thermal Dose Units in ((kW/m²)⁴/₃)sec
Domino Effect Criteria

With special reference to Domino Effect Analysis, during the evaluation process additional criteria have been proposed by the evaluators and agreed upon with the project stakeholders for a detailed evaluation of possible domino effect, not only on the basis of the radiation or overpressure at which critical equipment is exposed, but also on the basis of the exposure duration. Specifically:

**VCE** may provoke catastrophic rupture of affected pressurized, elongated and small equipment with a probability higher than 80%, and of atmospheric equipment with a probability higher than 95% at overpressure exceeding 700 mbar [application of Probit functions (Mingguang & Juncheng 2008, Cozzani et al. 2006) ref. Kardell & Loof 2014].

**Pool Fires and Jet Fires** with duration of more than 10 minutes may generate structural damage and loss of inventory of exposed pressurized equipment (of volume > 1 m³) with a probability higher than 50%, and of atmospheric equipment with a probability higher than 85% at heat radiation exceeding 37.5 kW/m² [application of Probit functions (Landucci et al. 2009, Antonioni et al. 2009, Cozzani et al. 2006) ref. Kardell & Loof 2014].

Additionally, it is considered that no domino effect to pressurized equipment can be realistically sustained from Pool Fires or Jet Fires with a duration of less than 10 minutes, for all phenomena engulfing pressurized equipment (of volume > 1 m³) in flame, specifically for HFO/DO flames since heat emission level of HFO/DO flame is not expected to exceed a level of 50 kW/m².

The same circumstance can also apply to the atmospheric equipment (up to a volume of 28000 m³) when engulfed in flame with the condition that the fraction of heat radiated to the atmospheric equipment is lower than the 30-50% of the heat emitted by the flame.

**For LNG / NG Pool Fires and Jet Fires** of short duration (30 seconds to 10 minutes) the heat radiation level of the flame is expected to be high e.g. 140 kW/m², so Domino zones of LNG and NG Pool Fires and Jet Fires, should be handled as following:

- For Pool Fires, the pool fire envelope (with pool centre at the location of release), and
- For Jet fires, the zone around the release location with distance equal to the jet fire frustum length.

The damage criteria applied for Domino effects to buildings and building elements for thermal and blast overpressure, are presented in the relevant Safety Reports.
3.4 Evaluation of Source Term and Risk Assessment Modelling Parameters

The evaluation of the Source Term and Risk Assessment Modelling Parameters has been performed in the individual COMAH Assessment Reports of EGM Project [16] and ENEMALTA DPS [15] with reference to the following:

- Meteorological data,
- Initiating events of the WCSs in the SR,
- Loss Of Containment (LOCs) per type of release and equipment and Bow-Ties,
- Incident Types, Worst Case Scenarios and Consequence Zones,
- Event Frequencies and Ignition Probabilities,
- Risk Assessment Results.

The analytical results and review recommendations are presented in Sections 4 & 5 of the individual COMAH Assessment Reports (namely the EGM COMAH Assessment Report, Doc. No. P800-CA-001 and the ENE DPS COMAH Assessment Report, Doc. No. P801-CA-001).

3.4.1 Population Data

For purposes of evaluation of Societal Risk in the COMAH Assessment Report of the Coordinated Safety Report (CSR), the data presented in the individual Safety Reports of EGM and ENE DPS have been used in order to identify areas with public presence in the vicinity of the establishments of EGM Project and ENE DPS. Table 9 presents the Population data taken into consideration for the simulation of the WCSs. Figure 5 presents areas with population in the vicinity of the establishment (under several land uses).

Table 9: Population Data

<table>
<thead>
<tr>
<th>Area code (ref. EGM SR) – Area Description</th>
<th>Total population per area Day</th>
<th>Average per cell (cell size: 50m x 50m) Day</th>
<th>Total population per area Night</th>
<th>Average per cell (cell size: 50m x 50m) Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
<td>4,067.00</td>
<td>-</td>
<td>3,721.00</td>
<td>-</td>
</tr>
<tr>
<td>101. Marsaxlokk village</td>
<td>3,366.00</td>
<td>18.9</td>
<td>3,366.00</td>
<td>18.9</td>
</tr>
<tr>
<td>123. Primary school</td>
<td>300</td>
<td>102.3</td>
<td>60</td>
<td>20.5</td>
</tr>
<tr>
<td>102. Historic fort</td>
<td>20</td>
<td>3.3</td>
<td>20</td>
<td>3.3</td>
</tr>
<tr>
<td>103. Low density residential</td>
<td>20</td>
<td>2.4</td>
<td>20</td>
<td>2.4</td>
</tr>
<tr>
<td>104. Low density residential</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>105. Low density residential</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>106. Low density residential</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>107. Low density residential</td>
<td>3</td>
<td>0.8</td>
<td>3</td>
<td>0.8</td>
</tr>
<tr>
<td>108. Horse farm</td>
<td>3</td>
<td>0.4</td>
<td>3</td>
<td>0.4</td>
</tr>
<tr>
<td>109. Historic fort</td>
<td>40</td>
<td>4.7</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>110. Low density residential</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Figure 5: Areas with population in the vicinity of the establishment (under several land uses)
4 Risk Assessment and Risk Evaluation

The individual COMAH Assessment Reports (for EGM [16] and ENE DPS [15]) include the assessment results of the Risk Evaluation (ranking) of each WCS (as within acceptable, tolerable or unacceptable level), following the application of a common Risk Matrix as a means of Societal Risk criteria for people external to the SEVESO establishments.

In the Safety Reports of Enemalta [32] and ElectroGas [1] regarding existing and new establishments, three hundred and fifty five (355) WCSs have been examined for fifty (50) safety critical equipment in total. The WCSs include all primary scenarios and the secondary scenarios identified as internal Domino scenarios for the individual installations or establishments. The risk associated with each WCS has been calculated in the individual Safety Reports of EGM and ENEMALTA on the basis of the deduced WCS frequency and the calculated number of fatalities expected within the extent of the predicted Consequence Zones. The overall Risk Evaluation in the present report is presented in the form of Individual Risk contours (Location Specific Individual Risk - LSIR) and of Societal Risk curve (FN curve). The assumptions on which LSIR contours and FN curve are based have been analytically presented to the COMAH Authority. COMAH Authority has agreed to include in the COMAH Assessment Report the Risk Evaluation results produced during the assessment of CSR as updated and submitted to COMAH Authority.

The Coordinated Safety Report (CSR) presents the external Domino scenarios between establishments of different operators. An assessment of the outputs is presented in Section 4.3. The analytical results and review recommendations are presented in Sections 4 & 5 of the individual COMAH Assessment Reports.

The present COMAH Assessment Report presents the results of the Risk Evaluation in the form of the overall LSIR and Societal Risk of all new and existing establishments, as based on the assumptions agreed upon during the assessment of CSR. The results of the Risk Evaluation in the form of the overall LSIR (LSIR contours) are presented in Section 4.1, while those in the form of the overall Societal Risk (FN curve) in Section 4.2.

4.1 Individual Risk (Location Specific Individual Risk –LSIR) and Analysis Points

The overall Individual Risk (LSIR) contours for all new and existing establishments, concerning all WCSs examined in the individual Safety Reports, have been performed in the framework of the present assessment.

The evaluators, during the assessment of CSR, have calculated on behalf of COMAH Authority, the overall LSIR by using the RiskCurves/TNO 9.0.26 software, based on the verified results and data of the individual Safety Reports. The assumptions made in the individual Safety Reports have been adopted6.

6 For reasons of realistic demonstration of the Risk Evaluation results, in the form of LSIR contours and FN curves, the following supplementary assumptions were made, mostly reflecting a conservative approach. It has been assumed that: a) each Safety Relief Valve on the FSU LNG tanks will open fully once per year, b) the average width of the Natural Gas flammable cloud is a constant fraction of its maximum length, in all cases, and c) the maximum effects of pool fires, flash fires and explosions are depicted at zero offset from the release location per case.
The overall results are presented below (see Figures 6 to 11: LSIR maps).

Figure 6: LSIR Map 1 (Overall site map): Location Specific Individual Risk in Delimara Area (Individual Risk curves)
LSIR maps (2-a, 2-b, 2-c, 2-d & 2-e): (Individual Risk curves) Zoom in to the site maps of:
- FSU (map 2-a)
- Jetty (map 2-b)
- RGU (map 2-c)
- NG pipeline (map 2-d)
- ENE PP (map 2-e)

Figure 7: LSIR Map (2-a): (Individual Risk curves) Zoom in to the site map of FSU area

Figure 8: LSIR Map (2-b): (Individual Risk curves) Zoom in to the site map of Jetty area
Figure 9: LSIR Map (2-c): (Individual Risk curves) Zoom in to the site map of RGU area

Figure 10: LSIR Map (2-d): (Individual Risk curves) Zoom in to the site map of Natural Gas pipeline area
The level of LSIR has been examined in fifteen areas (Analysis Points) inside and outside the establishments. The locations of the analysis points are described in Figure 12 and presented accordingly.

**List of Analysis Points:**

1. Agricultural Land
2. Beach
3. CCGT
4. Closest Residence
5. D3 PP
6. ENE Main Building
7. ENE Unloading Berth
8. Existing Dolphin
9. Fire Station
10. Historic Fort
11. Horse farm
12. LNG Carrier
13. NVCC
14. Platform
15. RGU Electrical Building
The total Individual Risk observed per area is presented in ascending order in Table 10.

Table 10: Individual Risk per Analysis Point (in ascending order)

<table>
<thead>
<tr>
<th>Analysis Points</th>
<th>Location of Area in relation to the establishment boundaries</th>
<th>Total IR [1/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENE Main Building (6)</td>
<td>Inside (close to boundaries)</td>
<td>&lt;1.00E-20</td>
</tr>
<tr>
<td>Agricultural land (1)</td>
<td>Outside</td>
<td>1.43E-07</td>
</tr>
<tr>
<td>Closest Residence (4)</td>
<td>Outside (close to boundaries)</td>
<td>1.80E-07</td>
</tr>
<tr>
<td>D3 PP (5)</td>
<td>Inside</td>
<td>3.34E-07</td>
</tr>
<tr>
<td>Beach (2)</td>
<td>Outside</td>
<td>4.35E-07</td>
</tr>
<tr>
<td>Horse Farm (11)</td>
<td>Outside</td>
<td>5.43E-07</td>
</tr>
<tr>
<td>Existing Dolphin (8)</td>
<td>Outside</td>
<td>1.38E-06</td>
</tr>
<tr>
<td>Historic Fort (10)</td>
<td>Outside</td>
<td>1.88E-06</td>
</tr>
<tr>
<td>ENE Unloading berth (7)</td>
<td>Within safety zone (close to boundaries)</td>
<td>7.09E-05</td>
</tr>
<tr>
<td>CCGT (3)</td>
<td>Inside</td>
<td>3.26E-04</td>
</tr>
<tr>
<td>Fire Station (9)</td>
<td>Inside (on Jetty)</td>
<td>3.29E-04</td>
</tr>
<tr>
<td>RGU Electrical Building (15)</td>
<td>Inside</td>
<td>9.36E-04</td>
</tr>
<tr>
<td>NVCC (13)</td>
<td>Inside</td>
<td>2.67E-03</td>
</tr>
<tr>
<td>LNG Carrier (12)</td>
<td>Within safety zone (close to boundaries)</td>
<td>4.98E-03</td>
</tr>
<tr>
<td>Jetty Platform (14)</td>
<td>Inside</td>
<td>1.81E-02</td>
</tr>
</tbody>
</table>

The results on Individual Risk (IR) as presented above per area are well compared with the Individual Risk criteria adopted by MEPA (see section 3.3.1). In particular, according to the results on Individual Risk it is concluded that:

- The level of overall Individual Risk (LSIR) is “acceptable” or “broadly acceptable” in all areas examined (Analysis Points) outside or in the close vicinity to the boundaries of the establishment where public is expected to be present, e.g. in the areas of the neighboring agricultural land (Analysis Point 1) west to the establishment, the closest Residence (Analysis Point 4) east of the HFO tanks, the Beach (Analysis Point 2) and the Horse Farm (Analysis Point 11) to the south of the establishment.

- The areas in which Individual Risk (LSIR) is found higher, are limited within the boundaries of the establishment where public is not present, e.g. the areas of: ENE Unloading berth (Analysis Point 7), the CCGT (Analysis Point 3), the Fire Station on Jetty (Analysis Point 9), the RGU Electrical Building (Analysis Point 15), the NVCC (Analysis Point 13), the FSU area including the area of LNGC (Analysis Point 12) and the Jetty Platform (Analysis Point 14).

- The locations of the ENE Main Building (Analysis Point 6) and D3 Power Plant (Analysis Point 5) within the establishment are areas of negligible individual risk for employees.
4.2 Societal Risk (FN curve)

The overall Societal Risk (FN curve) for all new and existing establishments, concerning all WCSs examined in the ENE and EGM individual Safety Reports, is presented in the present COMAH Assessment Report of CSR-CERP-CSMS.

The evaluators, during the assessment of CSR, have independently calculated on behalf of COMAH Authority, the Societal Risk (F-N curve) for the public (people outside the boundaries of the establishments) by using the RiskCurves/TNO 9.0.26 software. The calculations are based on the verified results and data as presented in the ENE and EGM individual Safety Reports. The population data are extracted from the data presented in the EGM SR. The population data used together with the realistic assumptions made for the occupancy of people (DAY and NIGHT) per area (occupancy factor) are presented in section 3.4.1 of the present report (see Table 9 and Figure 5).

The overall results on the conditional cumulative frequency (F per year) of a number of expected fatalities (N) as compared to the guide values used in the Netherlands (F=10^{-3} /N^2), are presented in the form of F-N curve in Figure 13.

![Figure 13: Societal Risk (F-N Curve) for Delimara](image)

The results on Societal Risk as presented above, are well compared with the most conservative Societal Risk criteria as adopted in the Netherlands (guide value F=10^{-3} /N^2). It should be highlighted that the Dutch Societal Risk criteria used in the present report are more conservative than the common Risk Matrix criteria applied for Risk Evaluation purposes (see section 3.3.1).
In particular, according to the results on Societal Risk, it is concluded that:

The Societal Risk posed by all new and existing establishments is within the “acceptable” risk levels.

It should be noted that, almost 90% of the contribution to the overall Societal Risk comes from the operations of the suction lines of LNG pumps and the FSU liquid header. The remaining 10% contribution comes from the operations of the LNG loading hoses and the FSU tanks. The suction lines of LNG pumps and the FSU liquid header exhibit scenarios, which are among the ALAPR scenarios with the highest risks as identified in the individual Safety Reports after applying the Risk Matrix. An ALAPR study has been performed for all WCSs scenarios that fall within the ALARP risk region. Additional safeguards have been implemented, resulting to further risk reduction for those scenarios.

4.3 Domino Effects Analysis

In the Safety Reports of Enemalta [32] and ElectroGas [1] regarding existing and new establishments, three hundred and fifty five (355) WCSs have been examined for fifty (50) safety critical equipment in total. The WCSs include all primary scenarios and the secondary scenarios identified as internal Domino scenarios for the individual establishments. All internal and external Domino scenarios have been examined as WCSs in the individual Safety Reports. No additional WCSs need to be examined. The analytical results are presented in Section 5.4.

The Coordinated Safety Report presents the external Domino scenarios between establishments of different operators. The list of secondary scenarios between establishments of different operators (external Domino) has been reviewed by the evaluators, considering the Consequence Zones maps of the final versions of individual Safety Reports and the Domino criteria adopted (see section 3.3.4; Damage Thresholds and Domino Effect criteria). The list of external Domino of the Coordinated Safety Report has been reviewed and updated according to the final revised versions of the Safety Reports. The evaluation verified that all cases of external Domino have been considered.

The list of external Domino scenarios examined in the CSR has been found to be complete and correct according to the Damage Thresholds and Domino Effect criteria adopted by the project.

4.4 Risk Evaluation of EGM and ENE Safety Reports

The evaluation of LSIR (Individual risk) in characteristic locations as derived from all three hundred and fifty five (355) WCSs in 50 safety critical equipment, provide evidence for the rating of risk contribution of specific safety critical equipment. In addition, the level of LSIR in two characteristic locations, the Jetty Platform and the RGU area can support a number of firm conclusions about the origin of higher risks and the priority of ALARP measures to be implemented. Such conclusions are listed below:

- The WCSs that exhibit Consequence Zones greater than 100m amount to 21% of all 355 WCSs. The vast majority of those scenarios (87%) are related to LNG. Of those, the highest frequencies (higher than 1x10-
4/yr) are exhibited by the LNG recirculation line, the LNG pumps, the LNG lines on the jetty and onshore and the liquid header and new liquid line on FSU.

- The largest Consequence Zones are exhibited by the WCSs of LNG releases from the FSU cargo tanks, the LNG liquid Header and the LNG loading.

In the FSU and the Jetty platform area:

- The safety critical equipment with highest contribution to LSIR, besides the SRVs of the FSU tanks, are the LNG new liquid line, the spray header and the LNG recirculation line on the Jetty. High contributions to LSIR are also attributed to the LNG liquid Header of FSU, the LNG pipeline on the Jetty and the FSU cargo tanks (particularly to FSU tank rupture due to process hazards).
- The phenomenon with the highest contribution to LSIR, is Jet Fire from the SRVs of the FSU tanks and the LNG recirculation line. Pool fire has also high contribution to LSIR and appears as the most common phenomenon, when developed from LNG releases in the FSU tanks and LNG pipelines on FSU and the Jetty.
- The Loading Hoses and the Unloading Arm exhibit similar contributions to the LSIR, although of low level.

In the RGU area (Electrical Building location):

- The highest contribution to LSIR is attributed almost entirely (93%) to the WCSs of LNG pumps and their suction and discharge pipelines. The WCSs of the LNG pumps show high frequencies (as high as 6x10-4/yr) for Consequence Zones extended more than 100m.
- The two small scale LNG pumps and the four LNG pumps exhibit similar contribution to the LSIR of the RGU area.
- The suction lines of LNG pumps exhibit more than two times higher contribution than the LNG pump discharge lines.
- The LNG pump lines (suction and discharge) exhibit WCSs with most of fire types involved, such as Flash fires, Jet fires, Pool fires and Vapour Cloud Explosions of NG in confined or semi-confined spaces.

The evaluation of Societal Risk as derived from all 355 WCSs, provides evidence for the acceptability of risk to the public. The Societal Risk results are comparable with the results of Risk Matrix application for people external to the site.

From the Risk Evaluation results the following overall conclusions can be drawn:

1. The Societal Risk posed by all new and existing establishments of Delimara project is within the acceptable risk levels;
2. The level of overall Individual Risk (LSIR) is acceptable or broadly acceptable in all areas examined outside or in the close vicinity to the boundaries of the establishment where public is expected to be present;
3. The areas in which Individual Risk (LSIR) is found high are limited within the boundaries of the COMAH establishments.
The above conclusions concerning the characteristic contribution to the Societal Risk and the LSIR, compare well with those WCSs which exhibit the highest risk among the ALAPR scenarios, as identified in the individual Safety Reports after applying the Risk Matrix. This particularly concerns the following safety critical equipment:

- suction and discharge lines of LNG pumps,
- the recirculation line on the Jetty, and
- the LNG liquid header and tanks in FSU.

The COMAH Assessment Report of the Coordinated SR concludes that, according to the verified results of the individual Safety Reports, the risk level at all new and existing facilities (ENEMALTA, EGM and D4 PP) is compatible with the surrounding activities provided that all the safeguards considered or recommended in the individual COMAH Assessment Reports of Safety Reports, of the SMSs and ERPs [15] [16] are properly implemented and maintained.
5 Review Recommendations

A. Coordinated Safety Report

The evaluation results concerning the first four sections of Assessment Checklist (SCL-1 to SCL-4), are based on UNECE – SCLs format.

The overall conclusions regarding the data provided on

- 1. SCL description of the environment and site
- 2. SCL main activities and products for single installations
- 3. SCL dangerous substances
- 4. SCL identification of hazards, risk assessment and preventive measures

are as follows.

5.1 Description of the environment and site (SCL-1)

o Description of the environment (SCL-1.1)

Coordinated SR contents are referred to the contents of individual Safety Reports of ENEMALTA and ELECTROGAS.

<table>
<thead>
<tr>
<th>General Recommendations to be considered after commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS Safety Reports.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific Requirements (or recommendations) to be regarded as conditions, limitations or binding terms for issuing an operational permit before commissioning starts</th>
</tr>
</thead>
<tbody>
<tr>
<td>No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS Safety Reports.</td>
</tr>
</tbody>
</table>

o Description of the site (SCL-1.2)

Coordinated SR contents are referred to the contents of individual Safety Reports of ENEMALTA and ELECTROGAS.

<table>
<thead>
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<tbody>
<tr>
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</tbody>
</table>
### 5.2 Main activities and products for single installations (SCL-2)

Coordinated SR contents are referred to the contents of individual Safety Reports of ENEMALTA and ELECTROGAS.

**General Recommendations to be considered after commissioning**

No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS Safety Reports.

### 5.3 Dangerous substances (SCL-3)

Coordinated SR contents are referred to the contents of individual Safety Reports of ENEMALTA and ELECTROGAS.

**General Recommendations to be considered after commissioning**

No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS Safety Reports.

**Specific Requirements (or recommendations) to be regarded as conditions, limitations or binding terms for issuing an operational permit before commissioning starts**

No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS Safety Reports.
5.4 Identification of hazards, risk assessment and preventive measures (SCL-4)

Coordinated SR contents are referred to the contents of individual Safety Reports of ENEMALTA and ELECTROGAS (Hazard identification, implementation of common Risk Matrix, results of Risk Assessment, etc.).

In addition, the Coordinated Safety Report presents:
- Domino effects between establishments of different operators;
- Location Specific Individual Risk (LSIR) contours for people outside the establishments; and
- Societal Risk results for people outside the establishments, in the form of FN curve as compared to Societal Risk criteria adopted by TNO guide values (Dutch Criteria).

The overall recommendations regarding the data provided in the CSR on (SCL-4) identification of hazards, risk assessment and preventive measures, are as follows:

CSR contents are complete and adequate.

<table>
<thead>
<tr>
<th>CSR-</th>
<th>General Recommendations to be considered after commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR 4.1</td>
<td>Domino effects between establishments of different operators must be updated as necessary if future revisions of Safety Reports produce additional information on Domino effects based on operational experience.</td>
</tr>
<tr>
<td>GR 4.2</td>
<td>Consequence zones of Pool Fire outside the DO tank bunds (in the area of escape routes of RGU) to be examined in the case of FBR of DO tanks outflow pipes as secondary Domino scenario to the NG release/fire from NG main pipe (Consequence zones of DO Pool Fire inside the DO tank bund have been examined for the same reason in the case of catastrophic rupture of DO tanks).</td>
</tr>
<tr>
<td>GR 4.3</td>
<td>In case future regulatory framework in Malta refers to quantified terms and criteria for Risk Evaluation, the Coordinated Safety Report should be updated accordingly.</td>
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<tr>
<th>CSR-</th>
<th>Specific Requirements (or recommendations) to be regarded as conditions, limitations or binding terms for issuing an operational permit before commissioning starts</th>
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<tbody>
<tr>
<td></td>
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</table>
B. Coordinated Emergency Response Plan (CERP)

5.5 Limitation of consequences and mitigation measures (SCL-5)

5 – Coordinated Emergency

Coordinated Emergency Response Plan (CERP) contents are referred to the contents of individual Emergency Plans (ERP and IEP) of ENEMALTA and ELECTROGAS respectively.

The provisions of CERP concerning Emergency Plans issues refer to section (SCL-5) of UNECE–SCLs Checklists.

In this section the contents of the Coordinated Emergency Response Plan (CERP) are assessed. The overall conclusions regarding the data provided on (SCL-5) limitation of consequences and mitigation measures, are as follows:

Coordinated Emergency Plan (CERP) contents are overall complete, correct and credible provided that recommendations made to the individual ERPs reviews are considered.

<table>
<thead>
<tr>
<th>CERP-</th>
<th>General Recommendations to be considered after commissioning</th>
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<td>No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS ERPs.</td>
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<td>No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS ERPs.</td>
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</table>

C. Coordinated Safety Management System (CSMS)

5.6 Major Accident Prevention Policy (MAPP) & Safety Management System (SMS) (SCL-6)

6 - Coordinated SMS

Coordinated Safety Management System (CSMS) contents are referred to the contents of individual Safety Management Systems of ENEMALTA and ELECTROGAS.

The provisions of CSMS concerning SMS issues refer to (SCL-6) of UNECE–SCLs Checklists.

In this section the contents of the Coordinated Safety Management System (CSMS) are assessed. The overall conclusions regarding the data provided on (SCL-6) Major Accident Prevention Policy (MAPP) & Safety Management System (SMS), are as follows:

Coordinated Safety Management System (CSMS) contents are overall complete, correct and credible provided that recommendations made to the individual SMSs reviews are considered.

<table>
<thead>
<tr>
<th>CSMS</th>
<th>General Recommendations to be considered after commissioning</th>
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<tr>
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<td>No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS SMSs.</td>
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<td>No additional recommendations to the individual reviews of ENEMALTA and ELECTROGAS SMSs.</td>
</tr>
</tbody>
</table>

References

[13] DIPPR - Design Institute for Physical Properties, American Institute of Chemical Engineers (AIChe).


[34] www.proteas-reach.gr, EU Program LIFE+ PROTEAS, Seveso SMS Inspection Checklist.
ANNEX A - Assessment Checklists UNECE Sectoral Check Lists (SCLs)

See attached Folder
ANNEX B - French Methodological Framework and Risk Acceptance Criteria

See attached File