Norsk olje&gas

Handbook

Impact assessment for offshore decommissioning

Decommissioning and final disposal of redundant offshore oil and gas facilities

Revision 1, June 2020

PREFACE

This revision of the handbook has been developed by DNV GL with the participation of a reference group comprising representatives from Equinor, ConocoPhillips and Norske Shell. The handbook replaces the first edition, dated 2001.

The handbook has been approved by Norwegian Oil and Gas's Forum Climate and Environment.

This handbook is owned by the Norwegian Oil and Gas Association. The responsible manager in Norwegian Oil and Gas is the manager, environment, who can be contacted via the switchboard at +47 51 84 65 00.

Norwegian Oil and Gas Association
Vassbotnen 1, NO-4313 Sandnes
P O Box 8065
NO-4068 Stavanger, Norway
Tel: +47 51 84 65 00
Fax: +47 51 84 65 01
Website: www.norskoljeoggass.no
E-mail: firmapost@norog.no

Front page photograph: Removal of the Odin steel jacket in 1997.
Source: Cultural Heritage Frigg (http://www.kulturminne-frigg.no)

CONTENTS

ABBREVIATIONS AND DEFINITIONS

Alarp	As low as reasonably practicable (risk assessment method)
BAT	Best available techniques
BEP	Best environmental practice
BTA	Buoyancy tank assembly
CFC	Chlorofluorocarbon
DG3	Decision gate 3 (final investment decision)
EE	Electrical and electronic (waste)
EIA	Environmental impact assessment
ESHIA	Environmental, social and health impact assessment
FAR	Fatal accident rate
FPSO	Floating production, storage and offloading
GBS	Gravity base structure
GRP	Glassfibre reinforced plastic
HCFC	Hydrochlorofluorocarbon
HSE	Health, safety, and the environment
IA	Impact assessment
IFC	International Finance Corporation
IHM	Inventory of hazardous material
IMO	International Maritime Organisation
IoP	Institute of Petroleum (London)
MLS	Norwegian Ministry of Labour and Social Affairs
MPE	Norwegian Ministry of Petroleum and Energy
NCS	Norwegian continental shelf
NEA	Norwegian Environment Agency
NGO	Non-governmental organisation
NPD	Norwegian Petroleum Directorate
Ospar	Oslo-Paris Convention for the protection of the marine environment of the north-east Atlantic
PDO	Plan for development and operation
PFAS	Per- and polyfluoroalkyl substances
PIA	Programme for impact assessment
PIO	Plan for installation and operation
Plem	Pipeline end manifold
Plet	Pipeline end template
PLL	Potential loss of life
PPA (P&A)	Permanent plug and abandonment (of wells)
PSA	Petroleum Safety Authority Norway
ROV	Remotely operated vehicle
THC	Total hydrocarbons
Unclos	UN convention on the law of the sea
WBS	Work breakdown structure

Key definitions:

- The term "decommissioning" has different definitions when used in different contexts. Its use also varies between countries and over time. In the context of this handbook, decommissioning concentrates on final disposal of a facility and the activities involved in reaching that point, while mandatory activities required to make the facility hydrocarbon-free (cold), clean process and utility systems and so forth are covered at a superior level only, since detailed information is not normally available when the impact assessment (IA) is prepared (the boundaries are discussed in section 4.1).
- The term "impact assessment" generally covers issues relating to natural resources, the environment and society. Various regulations and guidelines internationally may

refer to it as "environmental impact assessment" (EIA) or "environmental, social and health impact assessment" (ESIA/ESHIA) in order to indicate that the assessment covers more than just environmental issues – such as societal aspects, health issues and the like.

1 SUMMARY

This handbook has been developed as guidance for operating oil and gas companies when planning and executing the impact assessment (IA) process for offshore decommissioning projects. It concentrates primarily on Norwegian regulatory requirements and the corresponding IA process. However, guidance on environmental and technical issues with general application is also included. The handbook may therefore by useful for oil and gas companies under other regulatory regimes as a supplement to national legislation and for guidance on IA processes.

The primary objectives of the handbook are to:

- share knowledge on best practice for managing the IA process, including studying alternative disposal options as well as the identification and assessment of key issues
- provide guidance on possible assessment methods and on how results can be presented.

The first edition of the handbook was published in 2001, based on Norwegian decommissioning experience from the mid to late 1990s. Over the past two decades, several decommissioning projects for facilities on the Norwegian continental shelf (NCS) have provided significant experience of such activities in general. That includes specific lessons on issues and impacts from execution and final disposal which are relevant to the IA process.

As in the first edition, the current revision concentrates on two areas:

- the IA process – clarifying alternative disposal options for assessment and providing guidance on stakeholder dialogue processes
- the contents of the IA report – providing guidance on issues and possible methods of assessment, and sharing knowledge of the various issues and aspects.

General guidance on a possible method for presenting IA results (impact matrix) is unchanged from the first edition apart from some minor improvements to demonstrate better the level of certainty in the assessments. The method addresses the combination of the magnitude of the effect with the sensitivity/value of the area to ensure that local environmental characteristics form basis for assessing impacts.

In addition to capturing general lessons learnt from decommissioning in practice, this handbook provides an update on issues being addressed by various stakeholders through consultation processes. Stakeholder involvement is important in the IA process, since it ensures the sharing of viewpoints and the exchange of information in order to arrive at final disposal solutions which have minimal negative impacts and manageable liabilities.

2 INTRODUCTION

2.1 Introduction and background

Decommissioning and final disposal of redundant offshore oil and gas facilities appeared on the agenda in Norway during the early to mid-1990s as production decreased from satellites tied back to the Frigg field.[1] At that time, little was known about relevant issues and the magnitude of impacts related to offshore decommissioning, but an IA was (and is) a requirement when preparing a field/facility decommissioning plan in Norway. The Norwegian Oil and Gas Association therefore conducted a methodological study for IA in 1995 [1], [2] with the aim of clarifying issues, harmonising the assessment approach and ensuring improved knowledge sharing. The findings of this study were applied to the IA processes during the 1990s and early 2000s, including the IA for Ekofisk I [3]. Executing IA processes as well as actual decommissioning and disposal work increased knowledge of the subject. As a consequence, Norwegian Oil and Gas formalised IA practice at the time in a *Handbook for impact assessment in offshore decommissioning* [4]. Published in 2001, this has since formed the basis for most IA processes in decommissioning projects off Norway and several abroad, such as the Brent field decommissioning in the UK [5], and is referenced in the EU's best available technique (BAT) guidance document on upstream hydrocarbon exploration and production [6].

Decommissioning redundant offshore facilities, including final disposal, has become a common industrial activity on the NCS,[2] including the establishment of several licensed onshore yards for dismantling and material management. Significant further knowledge about the relevance of issues as well as the type and significance of impacts from decommissioning and final disposal has been gained over the years. It has accordingly been found appropriate to update the handbook to mirror the present position for best practice in managing the IA process and in sharing relevant experience and knowledge.

2.2 Mandate and objective

The handbook's mandate is to provide a harmonised basis for the IA process in offshore decommissioning with different types, shapes and sizes of facilities to form part of the field/facility decommissioning plan.[3]

The objective of the handbook is to share knowledge on best practice for managing the IA process, including studying alternative disposal options, assessment issues and methods, and presentation of results.

As in the first edition of the handbook, the current revision concentrates on two main areas:

- <u>the IA process</u> – clarifying alternative disposal options for assessment and providing guidance on stakeholder dialogue processes
- <u>the contents of the IA report</u> – providing guidance on issues and possible methods of assessment, and sharing knowledge of the various issues and aspects.

The handbook's primary objective is to provide guidance on IA processes for Norwegian decommissioning projects. However, it has been written in English and provides documentation with a wider applicability to permit its use by operator companies in other countries. That applies primarily to the contents section, since the IA process part

[1] North-East Frigg, East Frigg, Lille Frigg, Frøy and Odin.
[2] According to information from the NPD, a total of 59 facilities (including 30 with a fixed steel jacket) had been decommissioned on the NCS up to 2018 [7].
[3] A decomissioning plan comprises two parts: the disposal section and an IA. The disposal part covers activities in the final and disposal phases.

concentrates on Norwegian regulatory requirements. This section needs to be modified to ensure compliance with national requirements and practice in each country.

3 THE IA PROCESS

IA is a *tool* applied world-wide in large and medium-sized projects with the aim of objectively and transparently identifying, predicting and assessing the type and scale of impacts as well as highlighting relevant stakeholder views in order to provide an appropriate basis for decision-making. The IA process is a formalised procedure described by national regulations, and normally includes statutory stakeholder dialogue.

3.1 Regulatory framework

IA forms part of the decommissioning plan for a redundant petroleum facility/field in Norway pursuant to sections 5-1 and 5-3 of the Petroleum Act. See section 45 of the petroleum regulations. This decommissioning plan must be presented to the Ministry of Petroleum and Energy (MPE) and Ministry of Labour and Social Affairs (MLS), normally two-five years before the expected cessation of production from and use of a facility/field.

International agreements ratified by Norway on the disposal of redundant facilities are incorporated in the legislation.[4] Pursuant to article 60, no 3 of the UN convention on the law of the sea (Unclos), see article 80, the main rule is that facilities on a continental shelf which are not in use must be removed. The key regional regulatory framework for decommissioning redundant offshore facilities is provided by Ospar decision 98/3 [8] (applicable to the north-east Atlantic) and the 1989 IMO guidelines [9] (with worldwide application). The latter are primarily intended to meet the requirements of shipping. Furthermore, Ospar recommendation 2006/5 [14] provides framework guidance for managing drill cuttings in the north-east Atlantic with regard to decommissioning offshore fields/facilities.

Key conditions stated in these international agreements are:

- Ospar decision 98/3: remove to shore all facilities with the exception of the following installed in the sea before 9 February 1999, which may be left in place subject to a derogation process between Ospar countries (abbreviated):
  a. all or part of the footings of a steel facility above 10 000 tonnes in the air
  b. a concrete facility (GBS or floater)
  c. any other facility when exceptional and unforeseen circumstances resulting from structural damage or deterioration, or from some other cause presenting equivalent difficulties, can be demonstrated.

- IMO resolution A.672(16) (abbreviated): redundant facilities to be entirely removed if:
  - standing in less than 75 metres of water and weighing less than 4 000 tonnes in the air, excluding deck and superstructure
  - emplaced on the seabed on or after 1 January 1998, standing in less than 100 metres of water and weighing less than 4 000 tonnes in the air, excluding the deck and superstructure.

  Other facilities should be evaluated by the coastal state (with jurisdiction over the facility or structure) on a case-by-case basis and including different criteria (as listed).

- Ospar recommendation 2006/5: establishes two criteria for evaluating the management strategy for drill-cutting piles:
  - rate of oil loss to water column: 10 tonnes/year
  - persistence over the area of seabed contaminated: 500 km^2-year.

[4] Eg, Ospar decision 98/3 [*8*] and IMO resolution A.672(16) [*9*].

> Where both rate and persistence are below the thresholds and no other discharges have contaminated the cutting pile, no further action is necessary and the pile may be left in place to degrade naturally.
>
> If one or both criteria are exceeded, the BAT and/or the best environmental practice (BEP) for the cutting pile should be determined (relevant disposal options are listed in the document, see also section 4.4 in this handbook), applying the comparable assessment approach as described by Ospar decision 98/3.

Decommissioning pipelines does not fall within the framework of Ospar 98/3. However, it is covered by the UN convention on the law of the sea (Unclos), which identifies the coastal state as the responsible party. Norwegian policy on this subject is specified by Report no 47 (1999-2000) to the Storting on *Disposal of discarded pipelines and cables on the Norwegian continental shelf* [10] (based on a thematic assessment and a knowledge-acquisition programme [11]), and prescribes a case-by-case assessment to identify the best disposal solution in socioeconomic terms which balances costs with environmental protection and fishing interests. The policy is formally implemented through the Petroleum Act as part of the requirements for preparing a decommissioning plan.

Generally speaking, pipelines and cables can be left in place if they do not cause significant inconvenience or pose a safety risk to fishing activities in the specific area, balanced against the costs of implementing the solution. In other words, pipelines and cables can be left in areas with insignificant fishing or when they are safely trenched/buried and covered. Pipelines must be cleaned before disposal so that they pose a minimal risk of pollution.

3.2 Regulatory and stakeholder processes

The formal Norwegian IA process is described in section 45 of the petroleum regulations, which outlines the steps in the process and the overall scope of the assessment (options and issues). At a more detailed level, the IA process for decommissioning in Norway normally follows the same approach used for development projects, as described in the official *Guidelines for plan for development and operation of a petroleum deposit (PDO) and plan for installation and operation of facilities for transport and utilisation of petroleum (PIO)* [12].

Consideration of the decomissioning plan is coordinated by the MPE, and pursued in cooperation with the Ministry of Labour and Social Affairs, the Norwegian Petroleum Directorate (NPD) and the Petroleum Safety Authority Norway (PSA). Gassco is involved if the plans cover gas pipelines. The Ministry of Climate and the Environment, the Ministry of Trade, Industry and Fisherie), the Ministry of Transport, and their subordinate agencies and directorates serve as consultative bodies.

The first step in the process is to develop a draft programme for IA (PIA).[5] Early submission of proposals for an assessment programme and an IA is a precondition for expedient and efficient government consideration of the overall plan.

The magnitude of the assessment work should be aligned with the actual scope of decommissioning and disposal. Licensees should identify at an early stage whether possible existing IAs could wholly or partly fulfil the requirement to conduct an assessment. Should the licensees be thinking of applying to use existing assessments to fulfil the requirement, the possible basis for this should be clarified with the MPE at an early stage. If it can be demonstrated that this work will not have a significant impact on the environment or society, the regulations make provision for exemptions. The latter have been granted for several

[5] In an international context, such as IFC standards for an EIA, the initial steps are referred to as scoping/terms of reference (TOR).

facilities, mainly covering minor installations such as subsea structures and loading buoys.[6] Exemptions are based on applications with supporting documentation. However, most projects will follow the normal IA process with a PIA, an IA report and associated stakeholder consultation. The steps in this process are illustrated in Figure 3-1.

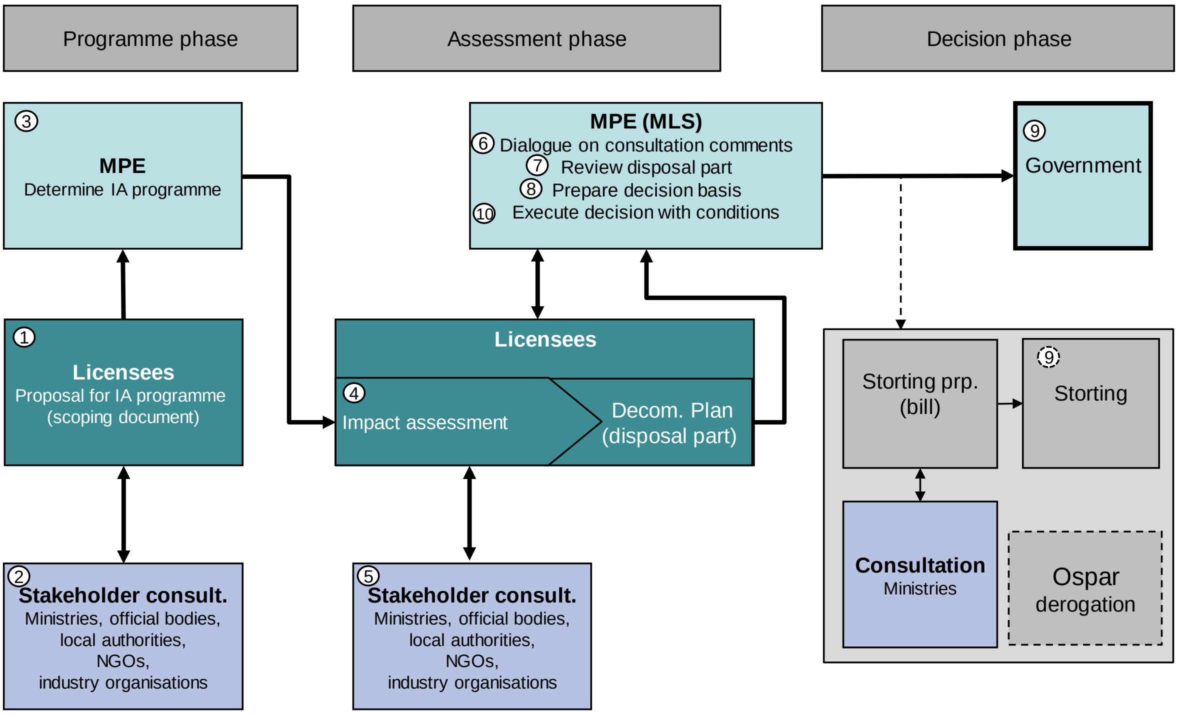


Figure 3-1. Outline of the steps in Norway's formal IA process until the final official decision.

Depending on the nature and complexity of the project, the decommissioning approval process and final decision will normally be made by the Norwegian government and in exceptional cases by the Storting (parliament). Projects subject to an Ospar derogation process or involving specific issues of principal of a societal nature must be presented to and approved by the Storting. This means some projects may go through a two-stage process: non-derogation facilities (such as topsides) approved by the government and derogation facilities (such as concrete GBSs) submitted to the Storting for approval. It is emphasised that the government is responsible for considering the decomissioning plan and conducting the decision process, including consultations related to Ospar and other national governments.

Stakeholder consultation is an important and integral part of an IA, and must be undertaken in accordance with national regulations (described above) for both the PIA and the IA. No fixed consultation period is specified in the regulations, and its duration must be agreed in advance with the MPE. The normal practice is for a consultation period of at least six weeks and usually 12, as specified in the guidelines for development projects [12].

Where projects face particular challenges or issues, early involvement of key stakeholders is important and must be maintained during the project. Such dialogue will identify viewpoints and positions at an early stage, providing opportunities to clarify and supply necessary documentation in the IA. That reduces potential risks related to the schedule or cost.

3.2.1 Programme for an IA

Initiating work with the PIA should be communicated informally to the MPE, including the presentation of an overview of tentative disposal options and key issues for assessment as

[6] Examples include Skirne/Byggve, Atla, Oselvar, Trym, Vale, the Gyda pipelines and the Draugen loading buoy.

well as a tentative schedule which includes milestones where interaction with the MPE is expected. The ministry should also be consulted on the formal consultation process to clarify its duration (six to 12 weeks), with a list of stakeholders to be consulted submitted and agreed.[7]

The timing for initiating work on the PIA will depend on the nature and complexity of the actual project in order to meet the regulatory requirement that a decommissioning plan be submitted two-five years before production ceases (see section 3.1).

In a generic and international context (as described by the IFC or the EU, for example), the PIA step in the Norwegian process covers the screening and scoping (or terms of reference) parts of the IA process. These can be briefly described as follows.

Screening
This should determine what further assessment is required and to what level of detail. Important elements in the screening will be to:

- clarify decommissioning/disposal options
- identify issues which will most probably have significant impacts
- clarify which impacts are uncertain
- identify where environmental management input is likely to be required.

Scoping
This establishes the key issues to be addressed in the IA and will be specific to the actual project and its scope (and options).

Scoping will deliver the terms of reference for the IA (scoping document, PIA).

As part of the scoping, consideration should be given to the availability of relevant baseline data. If these are lacking, field information will need to be acquired. Relevant data should be reviewed and key sources listed in the PIA (and in the IA report).

The structure of the PIA document will generally mirror the structure of the IA document (see section 7), although obviously with some differences and with a less detailed description as well as tentative results based on current knowledge only. Normally, this document will be 25-30 pages long, including illustrations. It must be written in Norwegian.

The following content should be included:

- introduction, with a brief project history, expected date for ceasing production, ownership and so forth
- outline of regulatory requirements and the IA process
- project description, including a description of the facility (and a high-level material inventory), alternative disposal options for assessment, and decision evaluation criteria
- key sources of information for the assessment work
- tentative assessment of environmental issues
- tentative assessment of societal/third-party issues
- PIA: summary highlighting issues and scope of assessment.

[7] In addition to the standard (regional) MPE list of stakeholders to be consulted, the Norwegian Petroleum Museum should be included (as specified by the Directorate for Cultural Heritage in earlier IA processes). Local authorities with onshore dismantling yards may also be included, even if the actual yard to do the work has not been clarified.

A draft PIA may be shared with the MPE (not mandatory) before it is formally issued for public consultation by the operator. It will be distributed by email and made available on the operator company's web site. Comments on the draft PIA should be sent to the operator with a copy to the MPE.

Comments received through the public consultation process should be summarised and evaluated by the operator in dialogue with its fellow licensees. Possible issues considered difficult to accommodate in the IA process should be discussed with the MPE as the key regulator. A letter summarising comments and the accompanying operator evaluation will be sent to the MPE, which formally determines the final PIA.

3.2.2 The IA

The IA will be performed in accordance with the final PIA determined by the MPE.

Where relevant, the resulting report should provide documentation on the alternative disposal options assessed. Once a disposal solution has been recommended by the licensees, this option will probably become the focus of attention in the report.

The magnitude of documentation in the report should reflect the complexity of its scope (the number of facilities involved and options considered). Generally speaking, the main report should be no more than 100 pages (plus appendices as applicable). It must be written in Norwegian.

Further details on the structure and contents of the IA report are provided in section 7. The report should include relevant mitigating measures and a plan for follow-up and monitoring where relevant.

If the project faces particular challenges, holding dialogue meetings with relevant stakeholders (regulators and NGOs) is recommended in order to share information and views and to discuss possible solutions. Meetings early in the process are recommended to clarify issues and to identify possible study requirements while sufficient time is still available to incorporate high-quality documentation in the IA.

The formal consultation process will be similar to that for the PIA, as described above. A summary of comments received and their evaluation by the licensees must be presented to and discussed with the MPE. The need for possible additional assessments will be clarified with the latter.

The summary of comments received and the licensee evaluation will ultimately form part of the decommissioning plan submitted (which will comprise the disposal plan, the IA and the summary of consultation comments).

3.2.3 Cross-border projects

Some petroleum projects are tied into a host facility or pipeline system in other continental shelf sectors, and are thereby subject to regulatory requirements in two or more countries. This may also be relevant for the IA, and the appropriate requirements and processes will need to be clarified with the relevant national authorities.

4 SCOPE OF AN IA

The objective of an IA process is to clarify the possible impacts which decommissioning – including disposal activities and the fate of redundant offshore facilities/installations and associated infrastructure – may have on the environment, natural resources and society.

4.1 Decommissioning phases covered by the IA

Decommissioning comprises several planning and execution steps, from preparing to cease production to final disposal. The structure of these processes may be defined and organised somewhat differently between operator companies. One example of typical decommissioning activities is shown in figure 4-1.

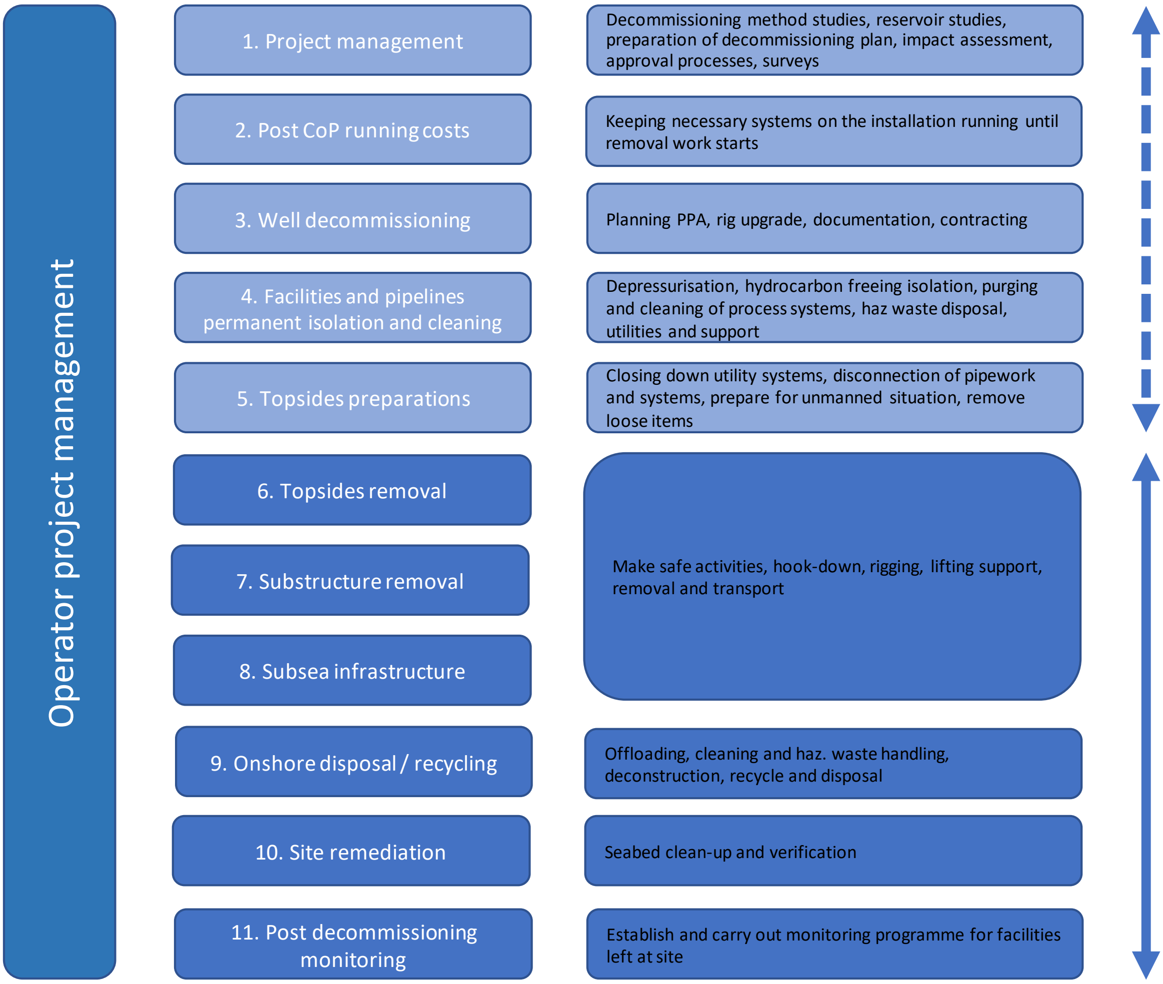


Figure 4-1. Decommissioning phases in the context of the IA's scope (solid arrow: base case, dotted arrow: scope to be addressed but not assessed in detail unless sufficient information is available). Source: Norwegian Oil and Gas decommissioning WBS handbook [13].

Many of these activities will be the same regardless of the final disposal solution. Some are specific regulatory requirements with associated application processes, and are thereby not directly relevant to the IA process. The primary concern of the IA is to clarify and assess the final disposal of a facility, including activities for achieving this solution and possible ongoing liabilities – in other words, steps 6-11 in figure 4-1.

However, it can be argued that some of the decommissioning activities which will not directly influence the decision on a disposal solution are nevertheless relevant to the IA. These may contribute emissions/discharges and possible impacts which may be included in the IA to present a more holistic picture of the overall decommissioning process. Examples are permanent plugging and abandonment (PPA) of wells (step 3) and cleaning of systems (step 4). Such tasks will be performed under specific permits/consents, and their details (like the method of execution) will not be known when the IA is undertaken.[8] Since they may represent significant decommissioning activities,[9] however, it is recommended that strategies for executing them and their course emissions estimate are included in the IA where applicable.

Comments received during consultation processes have requested more information in the IA on issues related to sampling in live pipelines in order to improve documentation on possible harmful components, to provide details on cleaning and so forth. With Norway requiring the submission of a decommissioning plan two-five years before production ceases, such information cannot be provided when the IA is being carried out. However, it will form an important component in later permit-application processes.

One possible exception where more detailed documentation on the cleaning method or strategy should be included in the IA is the issue of cleaning storage cells in substructures which are candidates for a possible Ospar derogation (section 3.1). In such projects, the cleaning strategy may form an integral part of the options under consideration for final disposal, and detailed information may therefore be required as part of the decision basis.

4.2 Field facilities and associated infrastructure

Facilities with associated infrastructure and features which should be included in the IA process are briefly presented below. Some relevant publications for these subjects are referenced.

Field facilities

- Fixed steel jackets [15] with superstructure (topsides)
- Concrete GBSs [16], [17], [18], [19] with superstructure (topsides)
- Floaters (FPSO, tension leg platform, spar, jack-up and so forth)
- Subsea installations (templates, Plem, Plet and so forth).

Pipelines [20]

- Infield flowlines
- Bundles [21]
- Cables and umbilicals
- Export pipelines.

The burial status and/or type of coverage for pipelines/cables has key relevance for decommissioning and final disposal.

Drill cuttings

Where fields have an accumulation (pile) of old oil-contaminated drill cuttings, this should be described and management options assessed as part of the IA. Relevant disposal options are described by Ospar [14] (see section 4.4), and management criteria are briefly outlined in section 3.1.

[8] In Norway, the IA is normally submitted in association with decision gate (DG) 3 (final investment decision) while detail engineering is carried out following the government decision.

[9] The PPA may constitute 50 per cent of the overall decommissioning cost, and involve rig activity with associated discharges to the sea and emissions to the air.

Norwegian Oil and Gas has developed a specific guidance document for characterising such cutting piles [22].

Other facilities and items

- Mooring/anchoring systems
- Offloading systems
- GRP covers, mattresses and grout bags
- Permanent subsea seismic array.

4.3 Assessment criteria

A thorough evaluation, applying a wide range of criteria, will underpin the recommendation (selection) for the preferred disposal solution of a redundant facility. The outcome of this evaluation will be documented in the decommissioning plan (in other words, the disposal plan and the IA), including any alternative disposal options which have been considered (see section 4.4.). Taken together, this documentation generally mirrors what is referred to as a "comparative assessment" in Ospar and some countries' regulations.

National regulations and the international framework (such as Ospar) give guidance on the criteria to be use in the evaluation. Licensees may also agree on additional criteria.

Where the north-east Atlantic is concerned, a formal comparative assessment is required pursuant to Ospar decision 98/3[10] for facilities belonging to any category of structure which may be considered a candidate for derogation from the general rule for total removal. Ospar (decision 98/3) provides the following guidance on the evaluation basis for a disposal solution (and its options) facing an Ospar derogation process (article 8):

> The assessment of the disposal options shall take into account, but need not be restricted to:
>
> a. technical and engineering aspects of the option, including re-use and recycling and the impacts associated with cleaning, or removing chemicals from, the installation while it is offshore;
>
> b. the timing of the decommissioning;
>
> c. safety considerations associated with removal and disposal, taking into account methods for assessing health and safety at work;
>
> d. impacts on the marine environment, including exposure of biota to contaminants associated with the installation, other biological impacts arising from physical effects, conflicts with the conservation of species, with the protection of their habitats, or with mariculture, and interference with other legitimate uses of the sea;
>
> e. impacts on other environmental compartments, including emissions to the atmosphere, leaching to groundwater, discharges to surface fresh water and effects on the soil;
>
> f. consumption of natural resources and energy associated with re-use or recycling;
>
> g. other consequences to the physical environment which may be expected to result from the options;
>
> h. impacts on amenities, the activities of communities and on future uses of the environment; and
>
> i. economic aspects.

Section 5-1 of the Petroleum Act states the following with regard to recommending a disposal solution in the decommissioning plan:

---

[10] According to annex 2 to the Ospar decision 98/3 on the framework for assessing proposals for the disposal at sea of disused offshore installations, "The information collated in the assessment shall be sufficiently comprehensive to enable a reasoned judgement on the practicability of each of the disposal options and to allow for an authoritative comparative evaluation".

> In the evaluation on which the decision is based, emphasis shall, inter alia, be attached to technical, safety, environmental and economic aspects as well as the consideration for other users of the sea.

Section 44 of the petroleum regulations further clarifies the subject of other users of the sea: "[…] including information and evaluations on the impact on fisheries and shipping".

With specific reference to the IA, the petroleum regulations state that this must concentrate on commercial and environmental aspects:

> The impact assessment shall contain a description of the effect that each of the relevant disposal alternatives may have on commercial and the environmental aspects, and what can be done to reduce discharges and emissions in connection with disposal, and to remedy any damage or inconvenience.

The IA should therefore, as a minimum, apply overall evaluation criteria which address impacts on:

- the environment, including natural resources
- commercial interests, including fisheries and maritime traffic
- economic aspects (cost).

In addition, the disposal options assessed must be safe and technically feasible. Some companies therefore also include "safety" and "technical feasibility/risk" as evaluation criteria in the IA. These will in any event form part of the overall evaluation as documented in the decommissioning plan (comparative assessment), including results from the IA. They are therefore briefly described in this handbook (section 5.13).

Furthermore, environmental sub-criteria are normally applied in the evaluation process in order to differentiate between various environmental aspects. These could represent all or parts of the environmental issues discussed in section 5.

4.4 Disposal options

According to section 5-1 of the Petroleum Act, the licensees must consider, as part of preparing the decommissioning plan, disposal options which include further use of the facilities in petroleum activities, other applications, complete or partial removal, or abandonment.

All feasible disposal options should be evaluated in the IA. The feasibility of some options is restricted by international agreements (see section 3.1), even though they may be considered technically and economically feasible in isolation. It should be noted that Ospar 98/3 applies only to facilities above the seabed, so that leaving buried items or pipelines in place will not violate the decision's terms. Some options may be eliminated at an early stage as non-feasible for various reasons. This should preferably be documented in the PIA in order to exclude the option(s) formally from the scope of the IA.

Reusing and recycling opportunities are expected to attract more attention in the future, with global and EU initiatives on the circular economy and the green shift also likely to affect the documentation expected to be included in the IA.

Disposal options generally considered feasible for offshore facilities and pipelines (see a more complete overview of facilities in section 4.2) are summarised in Table 4-1.

Table 4-1. Alternative disposal solutions for offshore facilities.

Facility/ component	Other uses in the oil and gas industry	Other use (c)	Complete or partial removal				Leave in place	
			Leave footings (d) in place – remove parts of facility within 55 m of sea surface	Disposal at sea	Reuse of larger components	Dismantling and recycling	Leave in place "as is"	Leave in place with mitigating measures
Topsides	X	X			X	X		
Steel jackets < 10 000 tonnes	X	X			X	X		
Steel jackets > 10 000 tonnes	X	X	X		X	X		
Concrete structures	X	X	X	X	X	X	X	X
Floaters	X	X			X	X		
Subsea installations (a)	X				X	X		
Pipelines and cables (b)	X	X		X	X	X	X	X

a) Including templates, well protection frames and other smaller steel facilities.
b) Including internal field, inter-field and export pipelines, bundles, cables and umbilicals.
c) See definition of "footing" in Ospar 98/3 (appendix 2).
d) May include use as an artificial reef. See Unclos article 60 (as practised for redundant facilities in some areas, but not found appropriate so far for NCS conditions [23], [24], [25]).

In addition, various types of infrastructure associated with the facilities/pipelines may need to be addressed in the IA. Examples are:

- offshore loading systems
- risers
- anchoring systems and mooring lines
- drill-cutting piles
- protection (GRP, rock cover, mattresses, grout bags)

The IA should describe disposal options for the relevant facilities, and outline the process used to identify, screen and take forward decommissioning solutions for the assessment.

Options previously evaluated should be briefly described, with an explanation of the reasons for eliminating them, such as cost, technical feasibility or HSE issues. See section 4.3.

Alternative/recommended options for fixed facilities, pipelines, drill cuttings and other installations and items should be described. These descriptions should be coarse, since detailed information will not be available at this stage, and include planned activities associated with the alternative/recommended disposal options (see section 4.1 on recommended boundaries for the IA scope):

- well abandonment (as applicable)
- preparations for removing facilities and infrastructure:
  - cleaning (or the strategy for this)
  - surveys of the facility, including inventory of hazardous materials
  - seabed survey, including possible drill-cutting piles
  - dredging
  - cutting and pre-cutting preparations (such as marine growth removal)

- removal and transport to shore
    - reference method, including vessel spread
- onshore dismantling and disposal
    - general description of demolition principles and waste management process
    - waste disposal, including reuse/recycling.

The quantity of information should be tailored to the relevant project. Those where final disposal is predetermined because no other options exist require less information than if one or more solutions are available. Projects which include a candidate for Ospar derogation will require more detailed documentation. Descriptions should include information on vessel requirements and the duration of various activities, and will form the basis for assessing energy consumption with associated emissions to the air, discharges to the sea and so forth in the IA. However, the description of methodologies for preparatory work, removal and so forth will be indicative or based on a reference method, since the exact removal method and choice of contractor will be clarified later by competitive tender. The report must therefore note that other methods could be adopted if they are felt to be advantageous in relation to the evaluation criteria in the tendering process.

Pipelines and cables

As described in section 3.1, final disposal of pipelines and cables is subject to a case-by-case evaluation, covering such options as:

- leave in place
- leave in place with mitigation, such as trenching or rock cover
- removal for reuse or material recycling.

Trenching (burial) is generally considered the most cost-efficient solution where pipelines/ cables cannot be left on the seabed, with removal to shore a least favourable option [10]. If local geotechnical conditions limit trenching, other solutions should be considered.

Furthermore, it is worth noting that the owner remains liable for a pipeline "in perpetuity", even after its disposal and termination of the production licence. Long-term liability should therefore be addressed in the IA.

Drill cuttings

According to Ospar recommendation 2006/5, assessment of BAT and/or BEP for drill cuttings should include, but not be limited to, the following options:

- onshore treatment and reuse
- onshore treatment and disposal
- offshore injection
- bioremediation in place
- covering in place
- natural degradation in place.

Knowledge of different options for managing cuttings was enhanced through a joint industry project in the late 1990s and early 2000s [26], and this has been incorporated to a greater or lesser extent in recent IAs on the NCS. Some approaches, such as offshore injection, may no longer be considered relevant. Drill cuttings on the NCS are generally found to comply with the Ospar criteria for being left in place [27], [28] (see section 3.1), and the only other option utilised – subject to a permit from the Norwegian Environment Agency (NEA) – is local repositioning to permit the cutting of jacket foundation piles and the like. Environmental monitoring has determined that this as an acceptable solution [29], [30], with effects which are local and mainly temporary in character.

However, assessing other feasible options – including cost estimates – is important as a basis for decision making. This has been pointed out in recent stakeholder consultations.

4.5 Removal methods

Several methods are available for removing a redundant offshore petroleum facility. The final choice will depend on such considerations as design, condition and weight of the actual structure, and will be clarified by engineering studies and tendering processes – normally not within the timescale of the IA. Where the latter is concerned, one or more feasible methods should be described to determine their technically feasibility and as a basis for cost estimates, quantifying emission and so forth. In most cases, the actual method to be used will be suggested by contractors at a later stage as part of the tendering process.

The following removal methods have so far been tested on the NCS for offshore decommissioning:

- piece small
- one or more heavy lifts, with different sizes and types of crane vessels
- single lift
- buoyancy tank assembly (BTA).

Where pipelines, cables and minor items on the seabed are concerned, other techniques and vessels can be used.

Floating facilities will normally be removed under their own power or with tug assistance, as applicable.

4.6 Onshore dismantling

Onshore dismantling and waste management activities may affect the environment and local communities. See section 5.10. In the IA context, these issues will normally be assessed on a generic basis, since the actual yard has yet to be determined. As the principal enterprise for this work, potential onshore plants will also be required to have all necessary permits and consents in place in order to keep impacts within acceptable and manageable levels. Norwegian yards are further subjected to regular environmental monitoring and the results are publicly available at the norskeutslipp.no website.

Stakeholder consultation comments have called for more information in the IA on the actual effects associated with the onshore activities, and for this aspect to form part of the site selection process. This is not practicable, however, since yard selection normally takes place some time after the IA has been undertaken. But most companies include environmental criteria in their site evaluation process as one of several elements in a total evaluation. This may include assessment of environmental barriers, such as water treatment facilities, the provision of an impermeable surface, administrative procedures, and capacities.

The IA matrix method (section 6) makes it possible to highlight uncertainties related to onshore issues and to indicate possible sensitivity differences between onshore plants and over different issues. This must be documented in the IA, and the operator may include these subjects in its environmental management plan for follow-up during site selection, planning and execution.

5 ISSUES AND ASSESSMENT METHODS

The following sections contain a description of various environmental IA issues and the approach to be taken in assessing their impacts.

Since the removal method and disposal site will normally be clarified by later competitive tendering, evaluations may have to be based on a reference method and/or be generic.

Deferring final disposal may be recommended for some facilities in order to secure synergies by combining execution with other decommissioning projects, for example. Impacts in the interim period should then be assessed and documented in the IA.

5.1 Energy consumption and emissions to the air

Energy consumption and emissions (CO_2, NO_x and SO_x) associated with the shortlisted decommissioning option(s) should be covered in the IA. Pursuant to Ospar guidance [8], energy considerations are subject to a life-cycle approach based on recommendations in guidelines from the Institute of Petroleum (IoP) in London for offshore cessation activities [31]. This method offers a standard approach to energy and emission calculations, and also provides tables of emissions and energy factors which are now widely used for assessing these elements in decommissioning projects. That allows better-founded comparisons to be drawn between options and between decommissioning plans from different operators.

Estimates of energy consumption and emissions in IAs for decommissioning projects may be based on information provided by technical feasibility studies for the specific project as well as on standard calculation factors. Some generic data are provided by the Institute of Petroleum, for example [*31*]. Energy consumption/emissions can also be estimated on the basis of emission factors generated from earlier removal projects (such as Frigg [32], [33] and Ekofisk I [34]). The most reliable input data for the IA must be assessed on a case-by-case basis. The quantity of documentation should be tailored to the relevant project, with greater detail generally required for projects where several disposal options exist.

Based on calculations in previous decommissioning IAs (such as [33], [34]), it is clear that marine operations associated with preparations for and the actual removal are the most energy-intensive. However, they also represent the greatest source of uncertainty. Energy consumption related to dismantling on land is relatively small compared with marine operations. The first edition of this handbook [4] notes that 30-40 per cent uncertainty should be expected in the calculations. Later verification studies have shown that uncertainty over the removal method and the duration of marine operations may far exceed this level [33]. However, better prediction may be difficult with the information available at the time the IA is being prepared, owing to such factors as differences in the removal method and/or vessel spread, or operations being extended by challenging weather conditions.

The recommended approach covers energy consumption by and emissions from preparatory work, removal, marine operations, onshore dismantling, onshore transport, and recycling metals and other materials. In addition, energy associated with replacing "lost" materials (those either left in place or disposed of to landfill, and therefore not recycled) must be considered. Figure 5-1 gives a graphic presentation of total energy consumption in a lifetime perspective (the sum of I + II) when replacement energy is taken into account.

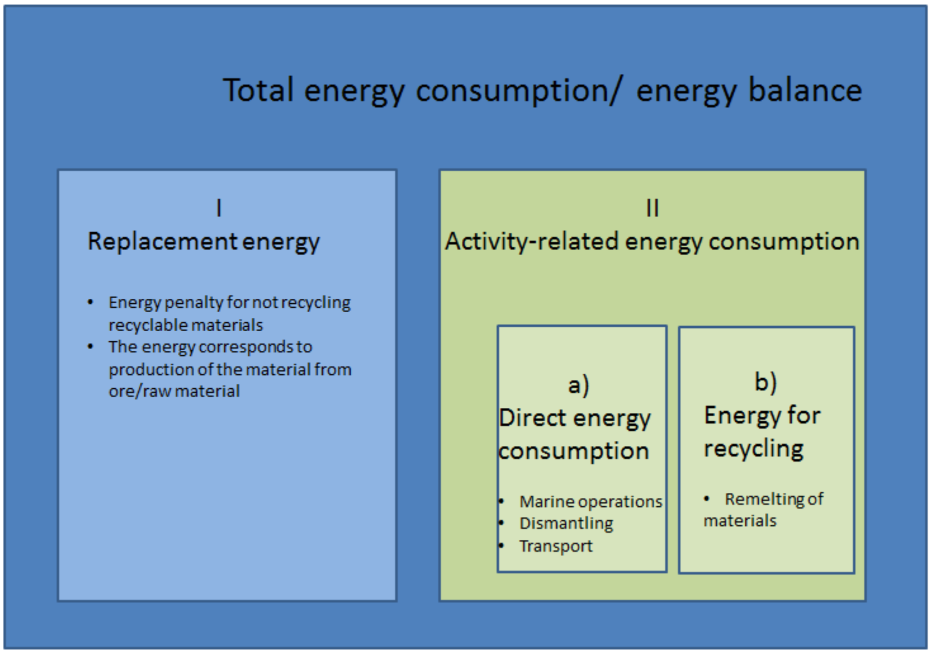


Figure 5-1. Graphic presentation of the energy balance.

Energy/emission categories considered are described in more detail below.

Marine operations

- Energy consumption and emissions associated with marine operations are estimated on the basis of information for vessel spreads given by technical studies (type of vessel and duration of operation), and/or experience from earlier removal projects.

Onshore dismantling

- Energy and emission considerations related to onshore dismantling activities are based on data about the quantity of materials to be dismantled at the facility, IoP factors for energy consumption and emissions [31], and/or experience from earlier dismantling projects.

Material recycling

- Energy and emission considerations related to recycling materials are based on data about the quantities and types of materials to be recycled, and on IoP factors for energy consumption and emissions [31].

Replacement energy

- Replacement energy is a “penalty” for failing to recycle otherwise recyclable materials (such as offshore disposal of pipelines), and corresponds to the energy required to produce them from scratch. Calculating such energy is based on the quantities and types of materials to be abandoned offshore, and generic energy/emission data for mining, transport and smelting.

Figure 5-2 gives an example of the energy balance with two alternatives for a pipeline – leave in place or remove. Total energy consumption (GJ) is shown on the y axis. This shows that new steel production consumes more energy than recycling the same amount of metal. Total energy consumption associated with leaving the pipeline in place (taking replacement energy into account) is accordingly considerably higher than for removal.

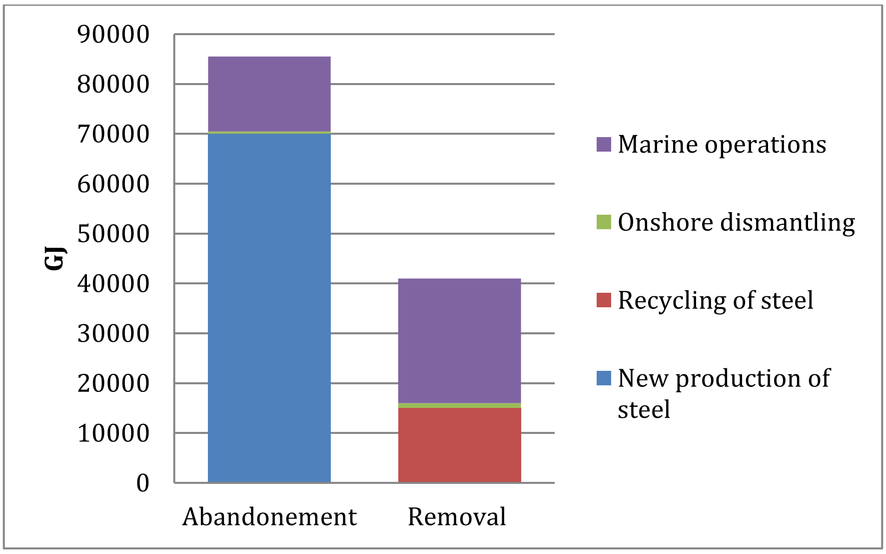


Figure 5-2. Example of the energy balance for two alternatives with a pipeline: leave in place or remove.

A guide for evaluating impacts from energy consumption is provided below (Table 5-1). This is unchanged from the first edition of the handbook [4].

Table 5-1. Guide for evaluating impacts [4].

	Impact category				
	None/ insignificant	**Small negative**	**Moderate negative**	**Large negative**	**Very large negative**
Energy (million GJ)	<0.1	0.1-1	1-3	3-6	>6

5.2 Planned discharges to the sea or ground

The level of description in the IA for planned discharges will be coarse, since activities have not been planned in detail when the assessment is made. All activities will be presented in more detail in specific applications to the government at a later stage. Relevant issues to be discussed in IAs for assessing planned discharges to the sea or ground in a project relate to:

- cleaning (processing plants, tanks, pipelines) before removal/disposal
- discharging structural water (from steel jackets)
- discharging cutting sand during underwater cutting operations
- discharging paint/plastics
- discharges during pipeline cutting (such as preserving chemicals)
- disposing of marine growth (see also section 5.4 on waste management)
- handling water flows during dismantling on land
- secondary contamination (seabed disturbance).

Small quantities of chemicals are also used during the various activities on the facility and the vessels. These may encompass a number of different product types (detergents, lubricating oils, lye and so forth). Norwegian experience [32], [34] indicates that a chemical consumption of 0.5-1.5 litres/tonnes of material removed can be assumed. The bulk of this relates to activities on land (detergents and the like).

Environmental impacts are assessed by studying specific discharges for the disposal option(s), such as type, quantity, time/duration, toxicity and resistance. Pursuant to the IA method (described in section 6), assessments should be based on the value or sensitivity of the area or environmental receptor and utilise information presented in the environmental baseline (see section 7.2.5). How large an effect the discharge will have should then be evaluated. More detailed assessments can be performed for activities in a known area. If the exact area (such as the disposal site) is not known or has not been decided, more general assessments are recommended.

Based on experience from previous decommissioning projects, discharges to the sea, water and ground are normally minimal. However, the IA should recommend necessary environmental monitoring on the field (during dredging, for example) or for dismantling activities at the disposal site as and when applicable.

5.3 Physical impacts

This topic is included in order to cover possible consequences caused mainly by physical disturbances of the seabed or a habitat. These may include:

- dredging before underwater operations
- removing buried pipelines or structures, including relocation of rock cover
- covering pipelines for leave-in-place options
- mooring vessels involved in operations
- removing or relocating drill cuttings (see section 5.4 on waste management)
- underwater cutting/use of explosives.

Periods of increased underwater noise may occur during decommissioning, and should therefore be discussed in the IA. This is relevant with such activities as underwater cutting and vessel operation (propellers). Particular attention was paid to the environmental effects of noise in the 1990s, when explosives were the primary method for underwater cutting. These had a real potential for causing local environmental damage from the energy pulse involved [35]. The development of novel steel cutting techniques has significantly reduced the potential impact of underwater noise/energy. Generally speaking, ship propellers are considered to have little significance in a noise context. Earlier studies and modelling for decommissioning operations indicate that acoustic noise will probably have a minor effect on fish and marine mammals (see, for example, the Brent field decommissioning [5]). Noise from decommissioning work is therefore not expected to cause anything more than disturbances for the receptors over a short period unless explosives are involved.

Evaluating the value or sensitivity of a seabed area or a habitat is essential for the ability to assess likely physical impacts. Such evaluation is based on data from the environmental baseline study and collected from literature and field measurements, and may also include discussions with relevant local authorities and other stakeholders. The presence of any endangered species or vulnerable habitats in an area will elevate its ecological value and make protecting it more important.

Criteria which can be used to scale the effect of physical impacts are as follows.

- *Permanence*. Describes whether the physical impacts are temporary or permanent.
- *Cumulative*. Measures whether the effect will be a single direct impact, whether synergies will occur with other impacts, or whether an impact is cumulative over time.
- *Recovery time*. This is widely applied as a general and overall parameter appropriate for classifying the significance of impacts.

C ~~c~~ombining the value or sensitivity of the area and the scale of expected physical impacts allows the overall significance of the latter to be predicted. See the impact matrix in section 6.

5.4 Waste management and resource utilisation

The IA should describe relevant expected waste fractions, including the amounts involved and treatment options for these.

The principles in the waste hierarchy [36] form the basis for waste management in decommissioning projects for redundant offshore petroleum facilities. See the simplified diagram in Figure 5-3. Considerable efforts are therefore devoted to optimising solutions for the different waste streams in order to achieve the best environmental solution.

It should be noted that targets for reuse and recycle are often set in a contractual context, and that this produces a rather different categorisation and concept definition than that indicated in the figure. The reuse concept, for example, is somewhat expanded compared with the description below. In any event, the aim is to achieve the best environmental solution.

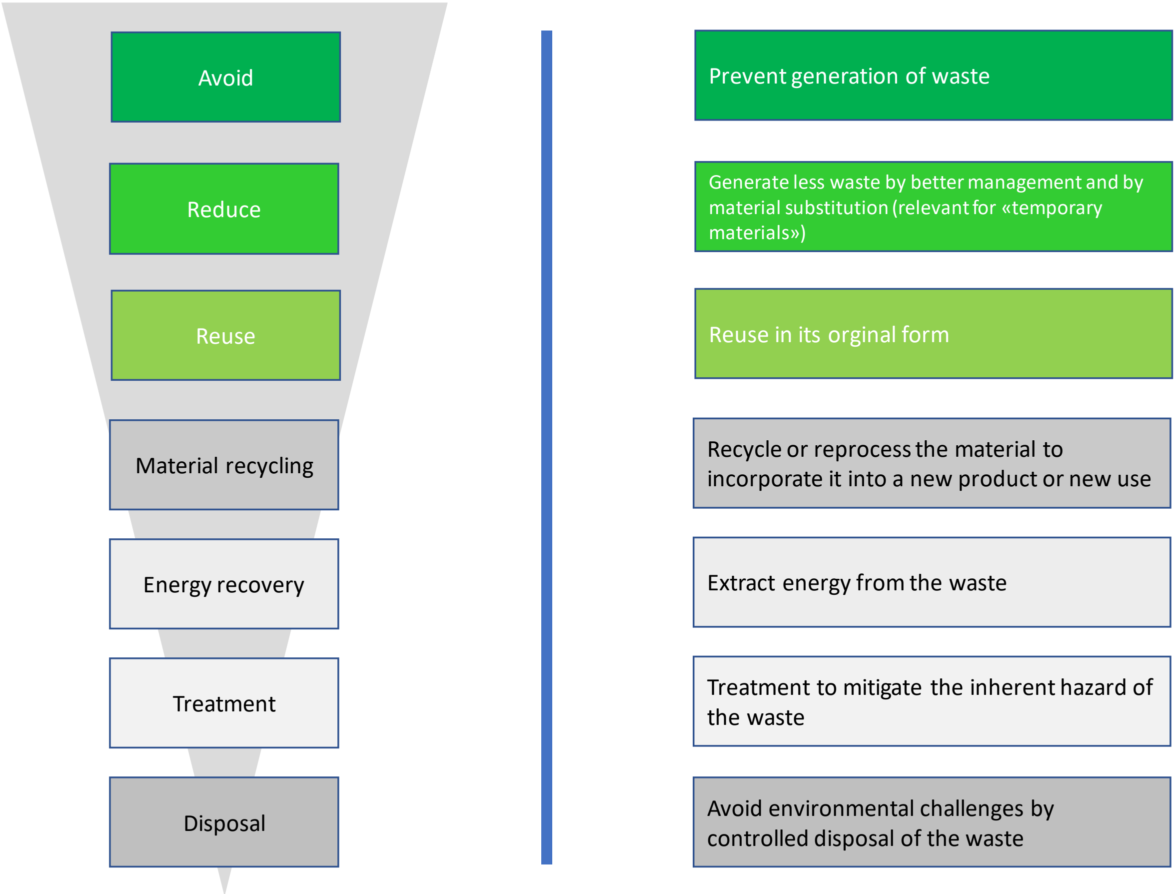


Figure 5-3 Waste triangle in relation to the decommissioning and disposal of petroleum facilities (avoid → reduce → reuse → recycle → energy recovery → treatment → landfill).

Inventory for the relevant facility should be mapped, preferably before submission of the IA, in order to obtain an overview of the types and amounts of materials in the individual facility. This is important for various reasons. Results from the mapping should provide input for removal/disposal and the IA (calculating energy matters, for example, and assessing recovery and waste treatment). Where leave-in-place options are concerned, it may also be important for assessing possible environmental impacts – including the potential for littering. Statistically, the following list of materials will represent the bulk of the materials and is therefore important for assessments related to recycling and waste disposal:

- steel
- stainless steel
- copper

- aluminium
- concrete
- plastic
- insulation materials
- building materials/fire protection
- electronic equipment
- marine fouling.

Inventory mapping should be accurate to within ± 20 per cent. Accuracy should be significantly better for steel, which represents the largest volume of material involved. Cleaning process systems, tanks and so forth is not normally subject to the IA, since this activity relates to the final stages in the operating phase (covered by different regulatory requirements).

The amounts and kinds of materials depend heavily on the type of facility to be removed. Experience from earlier Norwegian decommissioning projects show that metals accounted for 84 per cent of the topsides, while non-metals (such as cement, glass, plastics, insulating materials and wood) and hazardous waste (such as asbestos, coating, oil waste, batteries, waste containing mercury and waste with a high content of heavy metals) amounted to about five and six per cent respectively (see Figure 5-4).

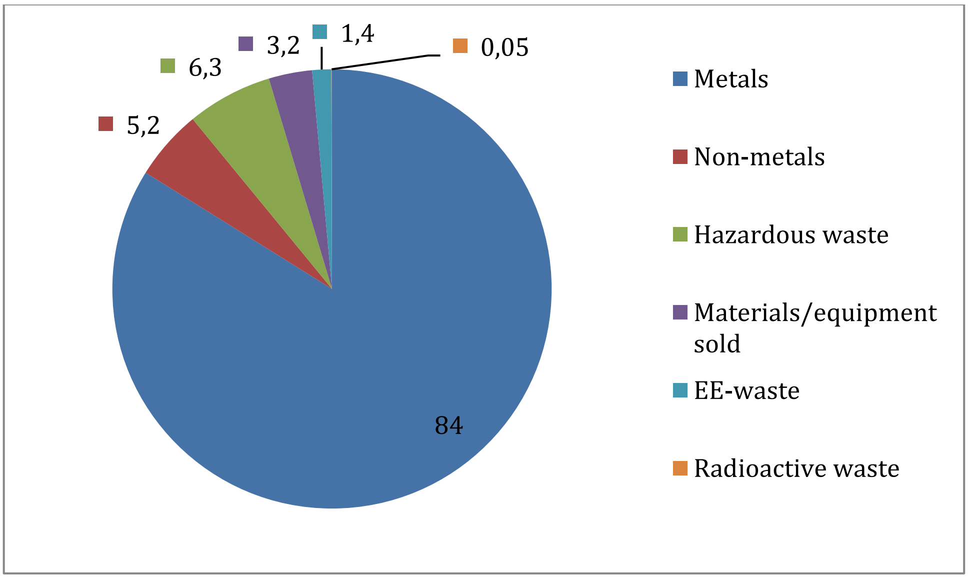


Figure 5-4. Example of materials/waste from topsides removal on the NCS, broken down (%) by waste categories.

Where steel jackets were concerned, materials comprised 79 per cent metals, about 14 per cent non-metals (such as grout/cement, marine silt and wood), four per cent hazardous waste (like sweepings after demolition work, asbestos, coating, batteries and materials containing mercury (anodes)) and three per cent marine fouling (see Figure 5-4).

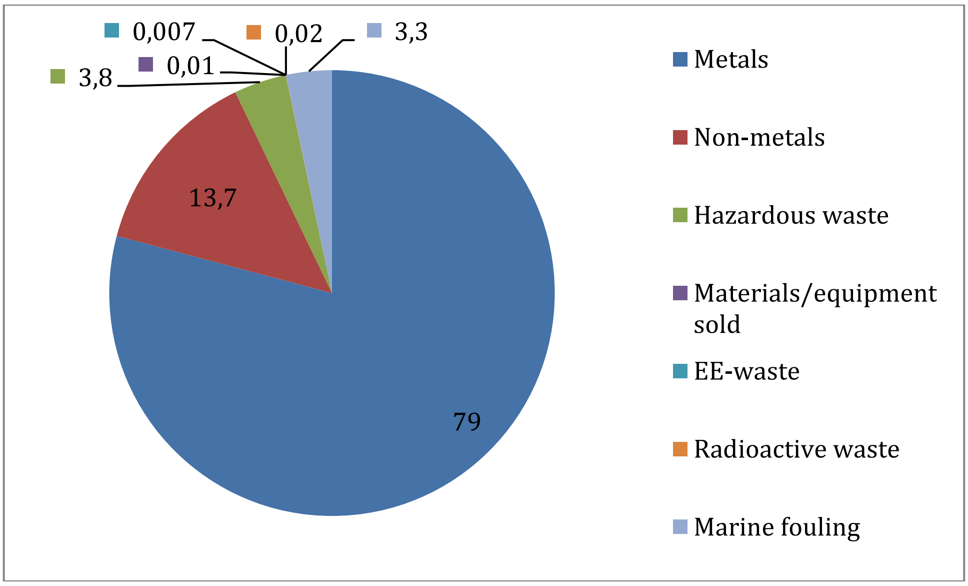


Figure 5-5. Example of materials/waste from jacket removal on the NCS, broken down (%) by waste categories.

A concrete GBS will naturally have a different breakdown by waste categories than topsides and steel jackets owing to its large content of concrete and reinforcement bars.

Marine growth
Submerged structures allow flora and fauna to become established and form marine growth/fouling, which may accumulate over time and represent significant quantities. In a decommissioning context, this needs to be managed for such purposes as preparing for underwater cutting, incorporation in the weight estimate for lifting, and treatment as waste. When exposed to the air, marine growth will dry and decay to generate odour, which may become fairly intense in certain circumstances and thereby represent a nuisance when brought ashore. This has been identified as a key issue for many years [39], with removal offshore and disposal at sea offering an alternative which can reduce the odour nuisance. Oil & Gas UK studied alternative management options for marine growth and concluded that offshore removal is feasible but time-consuming, and thereby costly. It also scored lower for technical feasibility, energy usage and safety compared with onshore removal [40]. In a recent study for Equinor on decommissioning the Heimdal field, DNV GL looked into management options for marine growth and assessed associated impacts [41]. While removal to shore for onshore disposal is considered the preferable option for these facilities, no significant environmental impacts are foreseen with either of the options studied. This issue should be considered on a comparative basis in IAs covering facilities which feature marine growth.

Hazardous waste
Establishing an inventory of hazardous materials (IHM) is an important element in decommissioning planning, and also needs to be updated and managed throughout the execution phase. Common industry practice is a stepwise approach which gradually increases the level of knowledge. See Figure 5-6, where the step which can provide input to the IA is shown.

Materials used in a facility depend partly on its age, since some substances have been banned in more recent years. Modules built 30-40 years ago may contain larger quantities or different types of hazardous substances and materials than those constructed more recently, while more exotic organic components may be found in more recent facilities. Examples of hazardous waste fractions from decommissioning include:

- asbestos and ceramic fibres

- zinc anodes (which may contain Hg)
- batteries (heavy metals and acid)
- flame retardants, such as brominated flame retardants
- waste electrical and electronic (EE) equipment
- phthalates (plasticisers in flooring and cables)
- hydraulic oil, grease, lubricants and oily wastes
- CFC and HCFC gases released from cooling agents
- chemicals
- chloroparaffins
- mercury (in level switches, process equipment and so forth)
- radioactive waste (scale sludge and sediments)
- PCBs (polychlorinated biphenyls)
- PFAS (per- and polyfluoroalkyl substances)
- PVC (polyvinyl chloride)
- organotin compounds from anti-fouling systems
- heavy metals
- polyurethane paints, which may generate isocyanates if heated.

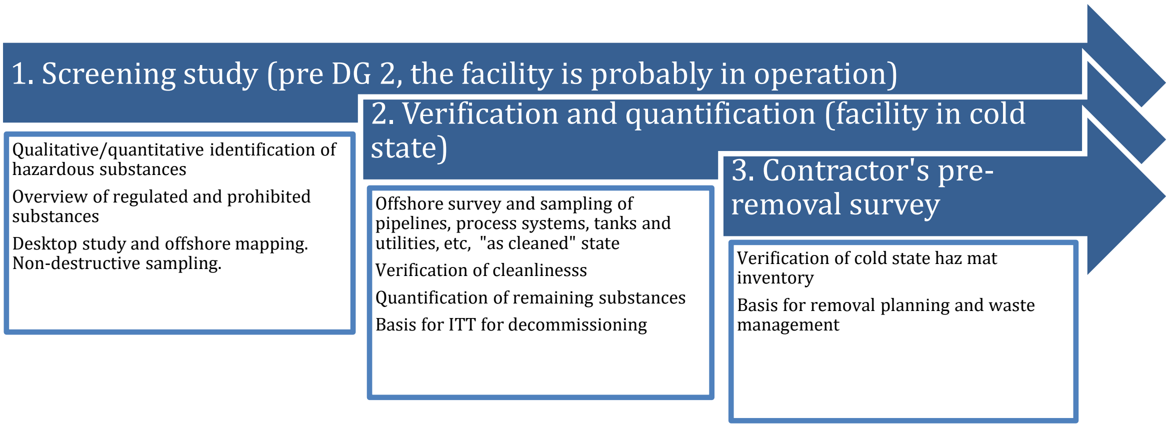


Figure 5-6. Various stages in a hazardous material inventory study. Step 1 normally provides input to the IA. Source: DNV GL.

Incorrect management and final disposal of hazardous wastes have negative impacts. It is therefore important to map these materials and substances in detail to ensure that their types and amount are as precise as possible, and that they are being managed throughout project execution. The overview should be presented in the IA, including a strategy for management and final disposal.

The waste-treatment contractor and location may not be known at a early stage of the decommissioning process. As a result, waste management and resource utilisation issues are often described in general terms in the IA.

Drill cuttings
An introduction to the issues involved and management options is provided in section 4.2, with the regulatory framework presented in section 3.1.

Characterising the cutting pile is important in order to provide a basis for evaluating management options to be presented in the IA. The specific guidelines from Norwegian Oil and Gas [22] provide a foundation for such characterisation.

Oil, derived mainly from former base oil, is the key contaminant associated with drill-cutting piles. However, various types and concentrations of heavy metals and other contaminants may also be present. No lifting of significant amounts of old drill cuttings from the seabed and out of the water has been done so far. Onshore thermal treatment of such waste has been studied, and is likely to be feasible. However, the actual removal and logistical processes are considered to be complex and costly and to have negative environmental impacts [26] [42]. Local relocation has been practised on the NCS – examples include Ekofisk and Valhall for foundation pile cutting and rig placement respectively. Environmental monitoring has demonstrated that the effects are mainly local in character, and mostly temporary [29] [30].

Important issues to be addressed in the IA for the relevant management options include:

- technical feasibility
- energy and emissions – from vessels and possible treatment
- secondary pollution of water masses and sediment (short- and long-term)
- smothering effects on seabed habitats/benthic fauna
- operational and logistical issues
- waste management, including debris
- cost.

5.5 Cultural heritage

In the decommissioning context, cultural heritage covers two different aspects: possible pre-existing items (shipwrecks and the like) and the heritage value of the petroleum facility.

The likelihood of discovering new items of cultural-heritage value, such as old shipwrecks or Stone Age remains, is generally greater for a development project, since decommissioning normally deals with areas which are already disturbed. However, the possibility of making a discovery should be taken into account in the project management system, including procedures for notification of the cultural heritage authorities pursuant to section 14 of the Cultural Heritage Act), and be specified in the IA. The Bergen Maritime Museum is the relevant regulator for such issues on behalf of the Directorate for Cultural Heritage.

Pioneering offshore structures on the NCS form part of Norway's cultural heritage. A list of priorities for such facilities has been established, with requirements for preserving relevant documentation. A dialogue with the Norwegian Petroleum Museum in Stavanger will be required in this context, and should be described in the IA.

5.6 Littering

Littering primarily relates to pollution of the sea. As part of the overall decommissioning plan, the seabed around the facility must be inspected for items like scaffolding, pipeline cuttings or smaller items lost during activities or storms. If debris is identified, it should be removed from the seabed, transported to land and handled in accordance with applicable regulations.[11] Plastic materials pose a particular challenge for littering and are attracting increasing attention, including in the decommissioning and IA context.

Partial removal and leave-in-place will involve a potential for long-term material breakage and degradation. Assuming some degree of pollution from degradation of materials and from

[11] Project experience includes cases of equipment or protection (mattresses, grout bags) being damaged and/or considered to pose a high risk during removal. Companies will normally perform Alarp evaluations and engage in dialogue with the competent authority to arrive at an acceptable overall solution.

external forces (waves, ocean currents and so forth) for these options is realistic, but this will be very local and have limited potential for spreading over larger areas.

Littering also has an ethical component. Although this may not appear to have any direct environmental impacts, people can take a negative view of it. That in turn may affect the reputation of the companies concerned.

5.7 Unplanned discharges to the sea

When decommissioning (removal/disposal) work begins, wells will already be plugged and tanks, process equipment and pipelines cleaned. The possible impact associated with unplanned discharges to the sea is therefore very limited. However, some failures will have the potential to affect the environment through operations (such as lifting) which result in the spillage of oil or chemicals (from vessels or broken pipelines) or disposal failures (dropped objects).

Relevant issues to be discussed in the IA and later planning relate to:

- transfer of fuel or other liquids to the facility or between vessels
- unplanned discharges from hydraulic systems, including ROVs
- trapped oil during removal operations
- unplanned discharges of diesel oil
- dropped object falling on live infrastructure
- incidents with supporting vessels.

The probability of more serious incidents related to the vessels involved is very low and will be covered by the field's risk analysis. Unplanned discharges as a result of ship collisions are therefore not normally evaluated in IAs.

Assessing the impact of unplanned discharges to the sea involves studying possible discharges associated with decommissioning activities (type, quantity, time/duration, toxicity, resistance and so forth) to determine how large an effect the discharge could have. This is then combined with the value or sensitivity of the area or environmental receptor.

Applying a risk matrix (frequency – consequences) is recommended for addressing and presenting the risks.

5.8 Impacts on fishing

Assessing impacts of decommissioning on fishing must take account of such aspects as increased marine operations and traffic affecting fishing vessels. The possible effects of the recommended disposal solution for the topsides/substructure, pipelines/other seabed structures and drill cuttings should be evaluated, and the assessment should describe:

- operational disadvantages related to the dismantling phase, including transport of structures to shore
- impacts as a result of area occupation (in the long or short term)
- obstacles to or restrictions on fishing in the long term.

According to the impact matrix method (section 6), the importance of a fishery should first be evaluated as the basis for the assessments. This normally draws on satellite tracking data and fishing statistics on catches landed for the relevant years and area.

When assessing operational disadvantages, the size of the effect will depend on the recommended removal method (piece small/medium, reversed installation, single lift), since piece small removal and removal by reversed installation will involve marine operations over a longer period. The assessments should accordingly be based on the vessel spread required for a reference removal method. Other relevant issues are whether fishing may be disrupted by marine operations outside the offshore safety zone and by transport along the route to shore. Since the exact location of the disposal site is normally clarified at a later date, assessing impacts on fishing during transport to shore may need to be based on assumptions, a reference site (such as the west Norwegian coast), or a generic location (see section 4.6).

When assessing impacts on fishing from occupying areas and possible long-term obstacles, the size of the effect will depend on the alternative/recommended disposal solution(s) for the offshore structures, such as whether the facility will be removed wholly or partly or left in place. Where leaving in place is an option, mitigating measures (such as maintaining safety zones or installing navigation lights) should be considered.

5.9 Impacts on shipping

The presence of offshore facilities and their decommissioning presents a risk to shipping. Impacts on maritime traffic and shipping lanes from decommissioning operations should therefore be assessed under this heading. The proximity of shipping routes to the facility and the frequency of vessel traffic should be considered, as well as the projected use of vessels.

The evaluation of impacts on shipping should consider the effects of alternative/ recommended disposal solutions for the facility (jacket/topside) and describe:

- operational disadvantages related to the dismantling phase, including transport of structures to shore
- impacts resulting from occupation of an area (in the long or short term).

According to the impact matrix method (see section 6), the importance of regular shipping traffic – in other words, vessel intensity in the affected area – should first be evaluated to provide a basis for the assessments. The baseline descriptions in the IA should therefore cover regular shipping traffic in the affected offshore area, including along the proposed transport route to shore. Descriptions of regular vessel activity within a given distance of the relevant field can be based on shipping databases or retrieved from a risk analysis for the relevant field/facility.

Impacts on shipping traffic in the dismantling phase are associated with the risk of vessel collisions during removal work and transport of structure(s) to the disposal site(s). The size of the effect depends on the removal method (piece small/medium, reversed installation, single lift), since the various removal methods have different durations and utilise different vessels. The distance to the disposal site(s) and the density of vessels along the transport route are among factors determining the effect. Since the exact location of the disposal site(s) is normally clarified at a later date, assessments of collision risk during transport to shore should be based on assumptions or a reference site (such as the west Norwegian coast).

Impacts associated with occupation of an area should be evaluated on the basis of alternative/recommended disposal solution(s), the extent of marine activities in the area of concern, and existing measures and systems for detecting the facility and avoiding contact. Where applicable, the assessment should include long-term impacts on shipping as a result of leaving structures in place.

5.10 Impacts on local communities

Impacts on local communities are only relevant for alternatives involving onshore or near-shore activities. Appropriate issues to be discussed in IAs relate to:

- noise associated with vessel activities, lifting/cutting and material/waste handling
- dust escapes
- odour associated with the decay of marine fouling
- visual disturbance, including lights
- traffic
- temporary accommodation/work camps.

The assessment should be done by studying the effect of the specific issues combined with the value or sensitivity of the area, taking the time/duration of the activities into account.

Impacts will vary between different sites. The location of the disposal facility will normally be clarified through tendering processes at a later date. Evaluating impacts on local communities must therefore normally be done on a fairly general basis, see section 4.6.

5.11 Socioeconomic impacts

One aspect when assessing social impacts is to identify potential employment benefits from removal and disposal of offshore facilities for various industries, such as engineering, transport, hotels, restaurants and manufacturing.

Quantification of such effects depends on the complexity of the decommissioning project and knowledge about the typical national share of relevant service industries. Given project complexity, simpler assessments based on cost estimates and experience with spin-offs for the various industries may be sufficient for the IA. Project experience shows that onshore-related disposal expenses are a minor part of overall decommissioning costs (about two per cent), while marine operations and P&A of wells account for the bulk of spending (in the order of about 25-30 and 45-55 per cent respectively) [37], [38], [7]. These activities are by and large performed by international companies, with the national share uncertain and generally low. The onshore part attracts the greatest attention in the IA context. Since this part is quite modest, however, less attention has been paid to quantification of socioeconomic effects in the most recent IAs.

More complex assessments need to be based on a national economic model, and may be applicable to large decommissioning projects. A simple projection can be made on the basis of knowledge about petroleum-related industry as well as in-house information on the supply chain. The model is based on estimated deliveries, broken down by industry sector and year. That makes is possible to calculate the total value of the output generated. See the example in Figure 5-7.

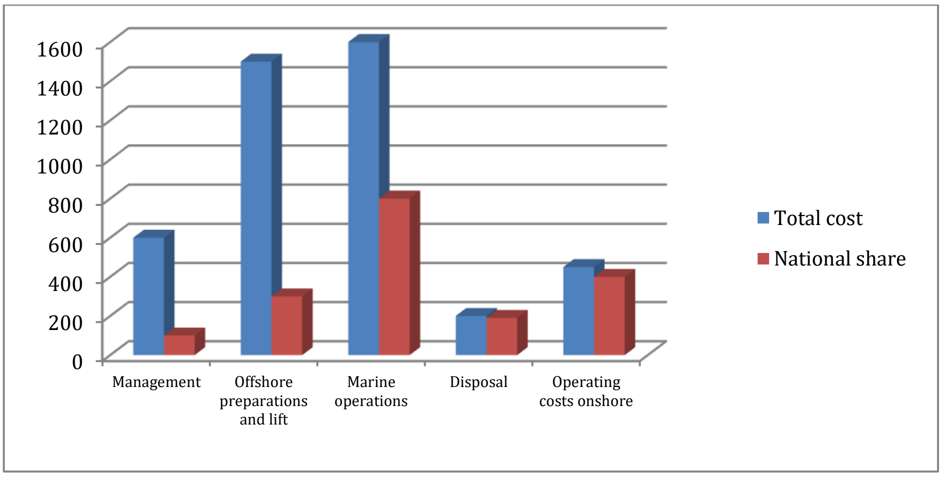


Figure 5-7. Categorised total value of output generated (example only – no actual costs, therefore no unit on the y axis).

The output value is then converted into employment by person-year. See the example in Figure 5-8). The sum of direct employment effects in the supplier companies and indirectly at sub-suppliers, broken down by industry, can also be presented. See the example in Figure 5-8).

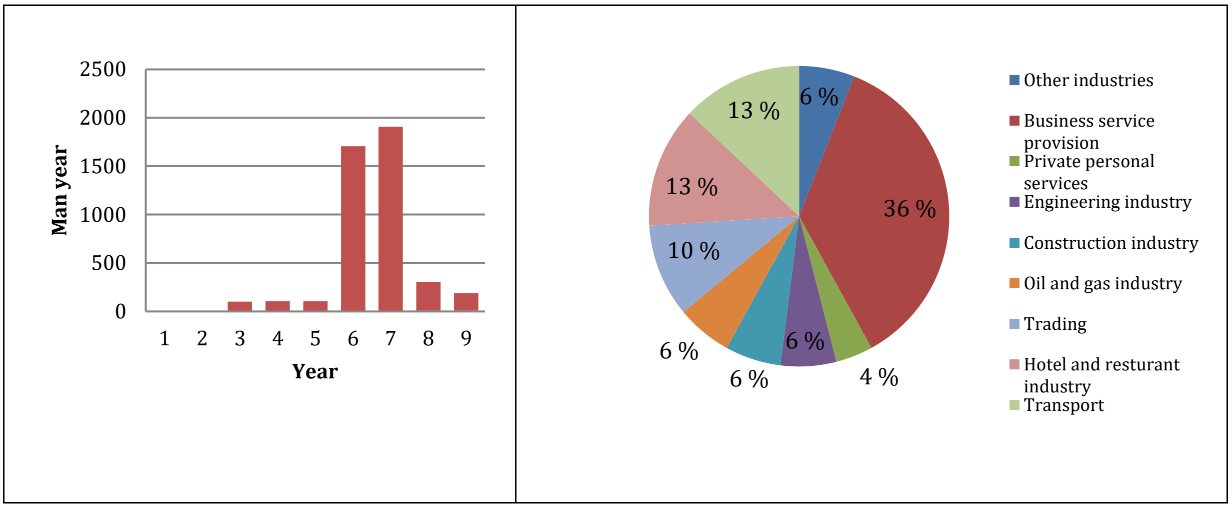


Figure 5-8. (Left) Example of total employment effect per year after project start-up. (Right) Total employment effect broken down by industry.

5.12 Costs

Costs are an important component in evaluating a recommended decommissioning option (see assessment criteria, section 4.3). Estimated costs with a comparable level of certainty should preferably be presented for all disposal options as part of the justification for the recommended solution. It is generally acknowledged that cost estimates at concept selection (DG 2) have an uncertainty level of ±10-20/30 per cent (class 3 estimate). Comparable cost estimates for all options are of primary importance for the IA. An updated cost estimate for the recommended solution will be presented when the decommissioning plan is submitted.

Furthermore, it is important that documentation of possible mitigating measures addressed in the IA include implementation costs as part of providing the basis for a decision by establishing that such management action is feasible.

In the IA context, cost estimates may also provide input to the socioeconomic assessments – in estimating employment effects, for example. See section 5.11.

5.13 Other issues

As noted in section 4.3, important issues which form part of the disposal evaluation process are not necessarily included the IA but are presented in the decommissioning plan as part of the comparative assessment. However, important effects from these issues on the overall disposal recommendation should be included in the IA in order to justify the recommended solution. Some companies also prefer to address these subjects more thoroughly in the IA in order to balance the issues of evaluation and increased transparency.

5.13.1 Technical risk

Some disposal options may require developing new technology, applying approved technological solutions in a new context, or performing an operation which has never been done before. This may add to project risk in the form of risk of failure (and associated consequences), cost uncertainty or schedule delay. One example is the option of removing a concrete GBS, which has so far never been done.

The technological challenges are generally complex, and the IA should strive to keep descriptions simple and not too technical. Using illustrations can prove beneficial when presenting such technically challenging activities.

5.13.2 Personnel safety

Safety of personnel forms an important part of planning and execution for decommissioning projects, and is addressed in risk analyses and job-specific planning to ensure safe execution of the work at every stage. Safety is also a key criterion in evaluating disposal options, since activities associated with one option may pose a significantly higher risk of injuries or fatalities than with others.

The safety risk of an activity can be quantified by applying empirical data (the fatal accident rate or FAR) and an estimate of exposure time (person-hours). The safety risk is often presented as potential loss of life (PLL), which expresses the probability of a fatality occurring when doing the work. Such quantification allows disposal options to be compared and ranked, and provides an overall and generic picture of safety risk.

More specific safety issues will be addressed in risk assessments and presented as part of the decommissioning plan and subsequent consent applications submitted to the PSA.

5.13.3 Artificial reefs

No experience has been acquired on the NCS with creating artificial reefs from redundant offshore structures. However, programmes for such conversions exist in other parts of the world. The potential benefits of this option were studied as part of the IA for Ekofisk I [23] and Frigg [24], among others, but it was not recommended. The effects of turning structures into reefs arise from changing the natural habitat. This can, for example, create a substrate for organisms not naturally found in the area which will eventually become part of the local ecology. Another potential effect is to enhance local biological production.

6 METHOD FOR PRESENTING NON-QUANTIFIABLE IMPACTS

Companies may have internal management procedures which specify methods or practices for IAs. The method presented in this handbook is an example only, and not mandatory for IA processes in Norway.

6.1 Methodological principles

The IA method described below is the same in principle as the one in the first edition of this handbook [4]. It is based on the approach described in the Norwegian Public Roads Administration handbook for IA [43], as amended [44], and has been adjusted for use in an offshore context. It primarily targets non-quantifiable and non-economic impacts.

The proposed methodology does not aim to assess all impacts in detail. Its main objective is to distinguish the important environmental impacts from those which are less significant, so that attention can be devoted to those issues considered to have the greatest potential impact. That facilitates decision-making and highlights the differences between decommissioning options.

The significance of impacts from a particular decommissioning activity depends on two considerations:

1. the ecological value/sensitivity of the receiving environment (assigned after considering the environmental setting)
2. the scale of the impact produced by the decommissioning activity.

These two are combined to provide an assessment of the activity's overall environmental impact .

6.2 Description of IA stages

The IA falls into the following three stages.

1. General description of the receiving environment
The value or sensitivity of an area or environmental receptor is evaluated on the basis of the information in the environmental baseline chapter. This may be categorised in two ways.

Conservation/ecological value: Protecting a resource with a high conservation value is considered more important than safeguarding one which ranks lower. Furthermore, a high conservation value often reflects a high level of scientific importance owing to abundance on a local/regional scale and/or rarity on a regional/global scale.

Economic value: Economic value is reflected, for example, by annual fishing incomes or the value of materials (such as recyclable steel) brought to shore.

Examples of the value aspect are given in Table 6-1.

Table 6-1. Examples of the value aspect.

Value	Status of and interest in conservation	Economic value
Low value	Not protected nor proposed/ considered for protection	Less than x per cent of the total national/regional fishing catch
Medium value	Protected or proposed/considered for protection and of interest locally/regionally	Between x and y per cent of the total national/regional fishing catch
High value	Protected or proposed/considered for protection and of interest nationally/internationally	More than y per cent of the total national/regional fishing catch

A receptor may have a low conservation value but a high economic value. In that case, the value selected should relate to the one which is potentially impacted by the activity.

The value criteria in the table for the various subjects should as far as possible be coordinated or harmonised so that a large value in one area is comparable with a large value in another. This is obviously challenging and to some extent subjective. However, reference should be made as far as possible to literature/official publications or databases.

2. Scale of the effect

The scale of the decommissioning activity's effect on the environment should be based as far as possible on scientific documentation. It is then evaluated and ranked from very negative to very positive.

Several criteria can be used to assess the scale of the effect (depending on the effect under consideration).

Classification of substances. Formalised criteria for classifying substances as harmful to the environment should be used. Detailed specific criteria for the aquatic environment should be elaborated on the basis of:

- acute toxicity
- biodegradability
- bioaccumulation.

Permanence and reversibility. This defines whether an exposure is temporary or permanent, and should be regarded only as a measure of the temporal status of the effect:

- no change/not applicable
- temporary
- permanent.

Cumulative. This is a measure of whether the effect will have a single direct impact, a cumulative effect over time, or synergies with other impacts:

- no change/not applicable
- non-cumulative single impact
- synergies.

Recovery time. Emissions/discharges and other sources may have many types of ecological effects, at many different levels – such as tissue, organ, individual, population or community. A general scientific view is that effects must be measurable at the population or community level in order to qualify as significant. Furthermore, recovery time is widely applied as a general and overall parameter appropriate for classifying the significance of ecological effects.

3. Determining overall impact for each environmental and socioeconomic category
Combining steps 1 and 2 from the description above allows the overall significance of the impact to be predicted (see the impact matrix in Figure 6-1). The scale of the effect is represented on the left-hand vertical axis, and can range from "high negative" through "low" to "high positive". The sensitivity of the receiving environment on the top horizontal axis can range from "low" to "high".

Combining the two steps produces a defined area, as shown in Figure 6-1, which indicates the magnitude of the impact as defined on the right-hand vertical axis. The magnitude of the impact can range from "very large negative" to "very large positive". Noted that a "moderate negative" or "large negative" impact does not necessarily mean that the impact is considered unacceptable, but that further attention should be given to these issues. A description of the different impact levels should be supplied to provide additional context for and understanding of the assessment. Examples of documentation for the assessments which arrive at the impact are presented in Table 6-2. Such summary tables per subject can be included in the appendices to the IA (as with the Brent Field IA [5], for example).

Table 6-2: Example of documentation table for evaluations which form the basis for presentation in the IA matrix.

<table>
<tr><td colspan="2"><Facility and decommissioning activity>

Impact evaluation for: <socioeconomic and environmental category></td></tr>
<tr><td colspan="2">1. General description of the receiving environment (position and characteristics)</td></tr>
<tr><td colspan="2">Describe the basis for evaluating the value or sensitivity of an area. What are the facts, literature sources or statements which this is based on? Furthermore, indicate factors considered more important than others in arriving at this conclusion.

Evaluation of the value:

Low Medium High

|----X----|----------|</td></tr>
<tr><td>2. Description of the scale of the effect</td><td>3. Total (environmental) impact</td></tr>
<tr><td>Describe the scientific information and data which the assessment is based on. Also describe how it is interpreted in this context. What has been given the highest priority, and why?

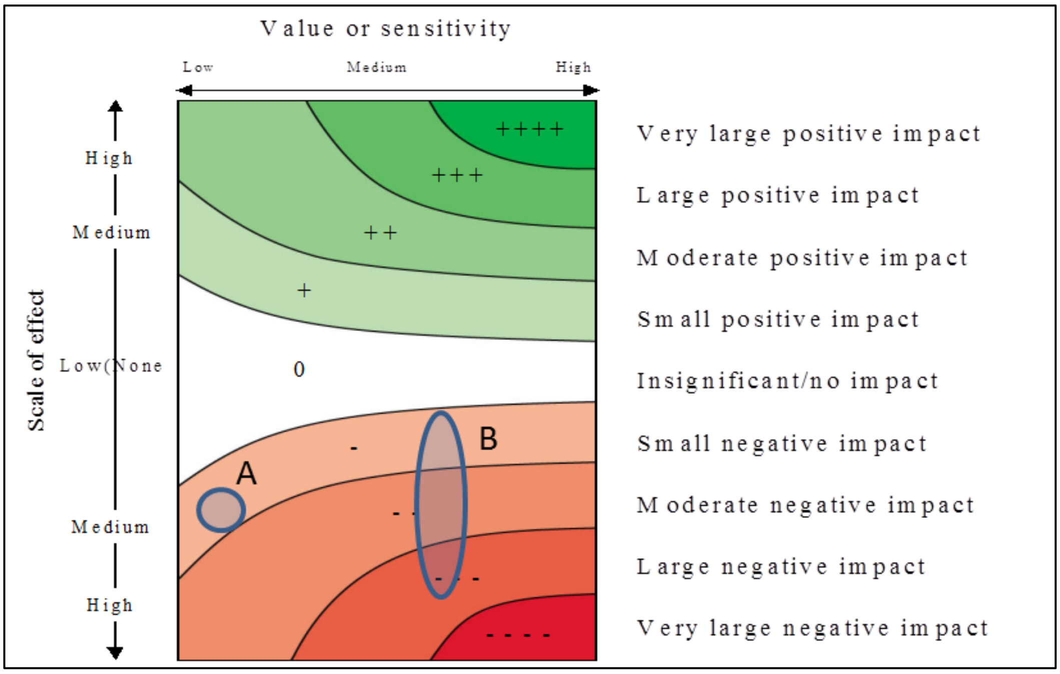
Document the reasons for the conclusions.

Evaluation of the scale of the effect:

High neg Medium neg Low/none Medium pos High pos

|--------------|---X----------|--------------|--------------|</td><td>Combine steps 1 and 2 in the impact matrix. The total impact can then be identified and stated here.

The impact can range from "very large negative" to "very large positive".</td></tr>
</table>



A = low uncertainty. B = high uncertainty about the scale of the effect, low uncertainty about the sensitivity of the receiving environment.

Figure 6-1: Example of an IA matrix.

It is worth noting that the same scale of the effect may have a different impact, depending on the value or sensitivity of the recipient/environment.

The size of the circle indicates the uncertainty in the assessment of the impact. In the example above, A has a small negative impact and a relatively low level of uncertainty, as indicated by its small size. The value or sensitivity (x axis) is well defined, and the assessment of the effect (y axis) is robust. By contrast, B represents a relative higher level of uncertainty since, although the value or sensitivity (x axis) is well defined, uncertainty about the effect (y axis) is high. This is conveyed by an elongated ellipse, with the scale of the effect ranging from “low” to “high”. The resulting overall impact ranges from “small negative” to “large negative”. Detailed planning of activities, substantial knowledge, and robust methodologies and procedures can help to reduce the level of uncertainty when assessing impacts.

7 THE IA REPORT

This section presents an example of a table of contents for an IA report, and includes a walk-through of its different sections with guidance on issues, methods, level of documentation and so forth.

7.1 Report structure

The report structure is normally fairly standardised. However, it should be tailored to the actual decommissioning scope and possible internal company standards. Where complex projects are concerned, individual facilities or groupings of facility components (such as topsides, jackets or pipelines) may comprise either their own main chapters or sub-sections of the generic main chapters in the report (environmental impacts, societal impacts and so forth). See the example in Table 7-1. Attention should be concentrated on presenting results for the relevant disposal options by facility (or main component) to ensure easy communication of results.

Table 7-1. Two examples for structuring the contents of the IA report (starting from chapter 5, 6 and so on).

a) Table of contents: facility focus	b) Table of contents: technical focus
5. Topsides 1. Options assessed 2. Environmental impacts 3. Socioeconomic impacts	5. Environmental impacts 1. Topsides 2. Steel jacket structures 3. Pipelines
6. Steel jacket structures 1. Options assessed 2. Environmental impacts 3. Socio economic impacts	6. Socioeconomic impacts 1. Topsides 2. Steel jacket structures 3. Pipelines

The proposed IA report structure may be presented in the PIA, but as “tentative” to provide flexibility for possible later changes.

An example of a standard table of contents (technical focus) for an IA report is given in Table 7-2.

Table 7-2. Standard table of contents for the IA report.

Preface
Non-technical summary
1. Introduction
   - Objective of the IA
   - Field history
   - Regulations and requirements, company standards, IA process
   - Ownership structure
2. Plans for decommissioning and disposing of the facility
   - Description of facility and infrastructure
   - Options evaluated
   - Recommended disposal solution
   - Schedule
   - Final disposal
3. Summary of stakeholder consultation
4. IA methodology
5. Baseline description
   - Natural resources and environmental conditions
   - Commercial activities and societal conditions
6. Environmental impacts and mitigating measures
   - Operational impacts (removal, dismantling and disposal)

- Impacts after final disposal (long-term)

7. Socioeconomic impacts and mitigating measures
   - Operational impacts (removal, dismantling and disposal)
   - Impacts after final disposal (long-term)
8. Summary of impacts, cumulative impacts and proposed mitigating measures
9. Environmental planning and monitoring

List of abbreviations
References

7.2 Individual chapters of the IA report

Some guidance on the contents of and focus areas in the individual chapters is provided below by main chapter.

7.2.1 Introduction

Chapter 1 should give a brief introduction to the field (facility) – history, production development and relevant factors which make it necessary to start planning for decommissioning.

The operator and its licence partners should be presented, with their respective licence shares.

A description of the IA process should be provided, including plans for public consultation and the timeline for the assessment work.

The objective of the IA should be described and an introduction provided to key elements of the field/company decommissioning strategy, including HSE management.

A review of legislation is required to ensure legal compliance, including international treaties and conventions, national legislation, government policies, regional plans and so forth. A list of permits and consents required to execute the decommissioning work should be presented.

7.2.2 Plans for decommissioning and disposal

Chapter 2 should describe the facilities and infrastructure covered by the IA, the relevant disposal options being assessed, the evaluation criteria, and the timeline for further planning and execution of the decommissioning work.

Each facility, including pipelines, drill-cutting accumulations and other structures and items to be covered by the IA, should be described briefly, preferably with the inclusion of some illustrations to provide a visualisation of shape, size, location and so forth.

Fixed facilities/other structures and items
The description should include function, age and condition. An overview of the materials accounting for the largest quantities/weights (such as steel and concrete) should be given in this chapter. It should also include a description of the materials involved with probabilities for their recycling/reuse and disposal as well as the fractions to be treated as hazardous waste (to be covered in more detail in the waste management section).

Pipelines
The description of pipelines to be covered by the IA should include information about:

- location/route

- length
- weight
- material composition
- protection strategy (trenched/buried/exposed on the seabed)
- cleaning strategy.

Drill cuttings

Drill cuttings may derive from drilling with oil-based or synthetic mud, and have accumulated in a pile of a certain height (specified in metres). On fields where drilling has been conducted with water-based drilling fluids only, and where an accumulation of drill cuttings beneath the facility would not be expected, the recommendation is to exclude drill cuttings as a separate topic in the IA. However, the reason for this exclusion should be discussed, preferably in the PIA.

A more comprehensive assessment should be carried out for fields where drilling has been conducted with oil-based or synthetic mud, or if large cutting piles are present on the seabed. Drill-cutting characterisation should be performed as a basis for evaluating disposal options for such deposits in the IA. This characterisation should include the size and extent of drill-cutting accumulations as well as determining contamination in the pile. These assessments should be based on surveys of the specific pile, including leakage tests and analyses for total THC/heavy metal content (see section 3.3).

Further evaluation of drill cuttings in the IA should be based on results from their characterisation. Requirements for future monitoring of cutting piles left in place should also be evaluated in the IA.

7.2.3 Summary of stakeholder consultation

Statutory stakeholder consultation forms an important part of the IA process. Comments on the PIA must be evaluated by the operator/licensees before final determination by the MPE (see section 3.2.1). The summary of comments with the corresponding evaluation must be presented in the IA report, normally in Chapter 3 or as an attachment. It may also be appropriate in this summary to include a reference to the sections of the IA where the relevant comments are being addressed.

The comment summary may be presented in different ways, depending on company guidance/practice or the magnitude of comments received. They are normally presented either by stakeholder or by subject. Examples of these approaches are provided in Table 7.3 and Table 7-4. Providing a general summary of comments in the IA supplemented by a detailed comprehensive summary in the appendices is also possible.

Table 7-3. Example 1. Summary of comments by subject. In this case, the overview covers only subjects commented on per stakeholder as an introduction to the subject presentation (one table or sub-section per subject). Source: Equinor.

Date	Stakeholder	Comments on subject **A** General **B** Topsides **C** Concrete substructure **D** Pipelines **E** Drill cuttings **F** Environmental impacts **G** Cultural heritage **H** Impacts on society/industries **I** Management actions									
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	No comment
	National and regional authorities										
	a		x			x					
	b										x
	Local authorities										
	c	x		x		x	x				
	d		x		x	x			x		
	Industry organisations and unions										
	e	x	x	x					x	x	
	f	x		x			x		x		
	Environmental NGOs										
	g			x		x	x			x	
	h	x		x	x	x	x			x	
	Other parties										
	i	x						x	x		
	j	x		x					x		

Table 7-4. Example 2: Summary of comments by stakeholder.

Stakeholder	Comment	Licensee evaluation	Coverage in the IA (ref to section)
Stakeholder a, comment 1	Exact citation of the comment, or a shortened version without changing the actual content of the comment.	Evaluation of whether the comment has been or will be taken into account in the IA, with argumentation.	
Stakeholder a, comment 2		Comment is "noted for information" if it does not imply any direct impact on or change to the IA.	
Stakeholder b, comment 1			
Etc			

The original comments (letters, emails) may be included in the appendices to the IA, and will form part of the overall decommissioning plan which is submitted.

7.2.4 Method for IA

Chapter 4 should provide a description of the assessment method(s) being applied in the IA, both in general and/or for individual issues. The approach normally applied is presented in section 6 above, and issue-specific methods are presented in section 5 as applicable.

7.2.5 Baseline description

Impacts should be assessed on the basis of a baseline description which documents physical conditions, environmental and natural resources, fishing activity, ship traffic and social conditions in the relevant area.

It is important to present the current knowledge base, including key data sources, and possible uncertainties about what is known. In the PIA stage, possible plans for data and knowledge acquisition during the IA step should be presented.

Important subjects for the baseline description include:

- climatic conditions
- environmental conditions (seabed)
- seabirds
- marine mammals
- fish occurrences and spawning areas
- particularly valuable and vulnerable areas
- cultural heritage assets
- fishing activities
- ship traffic
- other industries (as applicable)
- society (local, regional, national), demography, economics, employment conditions and so forth.

The baseline chapter should contain a brief text on each subject, and be supported as applicable by thematic maps and/or other illustrations.

7.2.6 Environmental impacts and mitigating measures

The individual environmental issues are presented in sections 5.1 to 5.7, with a corresponding review of relevant effects, methods of assessment and so forth.

Section 6.2 also provides guidance on the application of the impact matrix, and on which factors may be relevant when considering both the value/sensitivity axis and the effect axis. The relevance of these should be considered for each environmental issue in the specific case.

Relevant aspects for consideration with regard to effects are:

- nature of effect: positive or negative
- type: direct, indirect or cumulative
- magnitude or intensity: high, medium, low
- duration: immediate, weeks, months, years
- geographical context: local, regional, global
- reversibility: yes, no.

7.2.7 Socioeconomic impacts and mitigating measures

The chapter assessing societal impacts in the IA should concentrate on the shortlisted decommissioning options considered feasible at the time of the IA process.

Since the removal method and disposal site will normally be clarified at a later date through tendering processes, evaluations should be based on a reference method.

The individual socioeconomic issues are presented in sections 5.8 to 5.11, with a corresponding review of relevant effects, methods of assessment and so forth.

Establishing the value scale for the impact matrix is essential. That includes, for example, determining the importance of the relevant area for fishing. Satellite tracking (AIS data) in combination with catch statistics normally forms basis for the evaluation. Since catch (statistical) reporting is registered for rather extensive geographical areas (cells), actual vessel movements provided by AIS give a better indication of the relative importance of fishing in one statistical cell. Long time series may be utilised in order to take account of medium- to long-term changes in fishing activities locally, since final disposal may have to be considered in a long-term perspective (for leave-in-place solutions). Seasonal (monthly or quarterly) data will identify differences for use in planning removal/disposal activities.

Statistical data on maritime traffic are available in databases and on maps, and thereby provide a good basis for determining the relative importance of an area.

Employment effects and local community issues should be considered at the local/regional level, taking into consideration the actual position in determining the significance of the decommissioning work and associated impacts. Since the actual onshore location is normally not decided, uncertainty levels should be indicated also on the significance scale.

7.2.8 Summary of direct and cumulative impacts and proposed mitigating measures

In conclusion, the various decommissioning options evaluated and their impacts should be listed in a summary table. Even though the different impacts are not rated in relation to each other, a colour code for impacts will give the reader a quick and comprehensive overview of those which are important and how many significant impacts each decommissioning option represents.

An IA evaluates the consequence of the decommissioning process for the environment, natural resources and society. As discussed in section 4.3, however, other and significant criteria may be present in the evaluation process which are not assessed in the IA but which will influence the choice of decommissioning solution. These could include technical feasibility and safety-related issues, which may be decisive in certain projects. Where applicable, such aspects should be discussed and presented in the summary section (as well as in the main report) in order to show how the recommended solution was reached.

An example of a summary table presenting significant impacts colour-coded for four different disposal options is shown below (Table 7-5).

Table 7-5. Summary of the impacts for different decommissioning options.

Issue	**Type of facility/category**			
	Alternative A	Alternative B	Alternative C	Alternative D
Energy	Large negative	Moderate negative	Large negative	Small negative
Emissions to the air	Large negative	Moderate negative	Large negative	Large negative
Discharge to the sea	Moderate negative	Small negative	Small negative	Small negative
Physical	Moderate negative	Small negative	Moderate negative	Small negative
Waste and resources	Moderate positive	Insignificant	Small positive	Small positive
Littering	Insignificant	Insignificant	Small negative	Small negative
Fishing	Moderate positive	Moderate positive	Moderate negative	Moderate negative
Ship traffic	Insignificant	Insignificant	Small negative	Small negative
Local communities	Moderate positive	Small positive	Insignificant	Small negative
Socioeconomic	Small positive	Moderate positive	Small positive	Moderate positive

The summary of the environmental impacts should also include an overview of the impacts for the recommended option, where the scale of the effect and the sensitivity value are shown (see the impact matrix). Figure 7-1 gives an example of how estimated impacts in various categories from one solution for removal and disposal of an offshore facility may be presented.

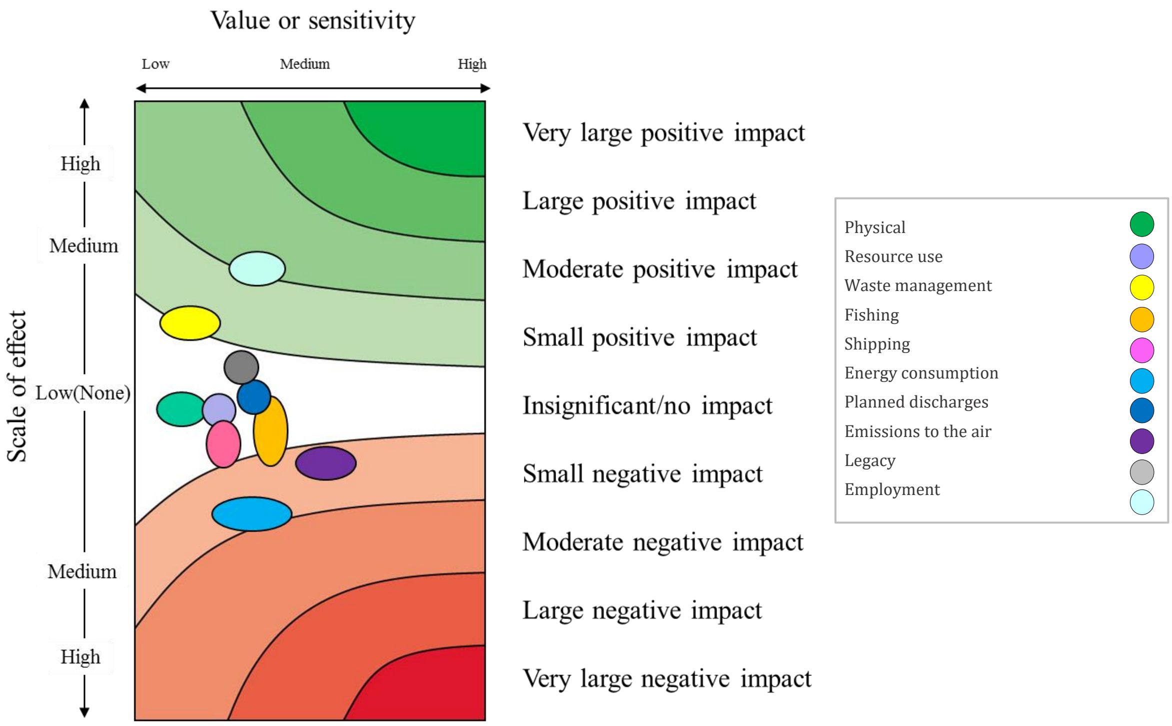


Figure 7-1. Example of estimated impacts from the removal and disposal of one facility.

In addition, it will be appropriate to tabulate the key environmental impacts and include the evidence for arriving at the selected impact categories in Figure 7-1. Any estimated numbers should be listed as well. Where complex projects with more than one facility are concerned, it will also be relevant to discuss cumulative impacts, including possible escalation of or reduction in impact levels owing to the combination of decommissioning activities. The more obvious effects involve quantifiable issues, such as costs and the energy balance where combined operations offer synergies.

How the recommended solution is presented may differ in line with the company's preferences, the complexity of the field or other considerations. However, the IA will provide an objective review, where all the alternatives are evaluated equally and in accordance with the same methodology. The recommended solution may then be presented in a separate chapter where its consequences are discussed in relation to the options, and where attention is concentrated on mitigating measures (see below).

In addition to the example above, Table 7-6 and Table 7-7 provide some alternative ways of presenting impacts for the recommended solution and relevant disposal options.

Table 7-6. Summary of predicted impacts for the recommended disposal solution and alternatives, presented by impact subject and in relation to the recommended solution (base case).

Impacts		Disposal alternatives (legend: Similar; Little better; Significantly better; Little worse; Significantly worse)			
Main aspect	Subsidiary aspect	Recommended solution, base case (brief text what is involved)	Option 1 (brief text)	Option 2 (brief text)	Option 3 (brief text)
Technical	Feasibility	Low risk			
Environmental	Energy balance	<figure>			
	Emissions to the air (eg, CO_2)	<figure>			
	Discharges to the sea	Negligible			
	Physical, seabed	Small negative			
	Biota	Limited			
	Littering	Negligible			
	Waste/resource utilisation	Small positive			
	Cultural heritage	Negligible			
Socioeconomic	Local environment	Negligible			
	Employment	Small positive			
	Safety	Low risk			
	Fishing - operational	Negligible			
	Fishing – long term	Small positive			
	Ship traffic	Small positive			
Cost	Costs	<cost figure>			

Table 7-7. Example. Summary of predicted impacts for the recommended disposal solution and alternatives, indicating both impact subjects and relevance of affectors.

Type and magnitude of effect		Emissions to the air	Energy balance	Discharges to the sea	Seabed impact	Biota	Littering	Local communities	Waste/ resource utilisation	Socio-economic	Fishing
Nature of effect	Positive								x	x	x
	Negative	x		x	x	x	x	x	x		x
Value/ sensitivity	High	x	x				x				x
	Medium					x		x	x		x
	Low			x	x					x	x
Type of effect	Direct	x		x	x	x		x			x
	Indirect			x				x			
	Cumulative	x	x				x	x	x	x	x
Magnitude of effect, intensity	High										
	Medium								x		
	Low	x	x		x	x	x	x		x	x
	Negligible			x			x				
Duration	Immediate			x							
	Months	x		x				x		x	x
	Years				x	x	x				
Geographic context	Global	x							x		
	Regional	x									
	Local	x		x	x	x	x	x		x	x
Reversibility	Reversible			x	x	x					
	Irreversible	x	x				x			x	x
Total impact – recommended solution		Negligible	Small negative	Negligible	Negligible	Negligible	Negligible	Negligible	Medium positive	Negligible	Negligible
Option 1		Small negative	Small negative	Negligible	Medium negative	Small negative	Negligible	Small negative	Medium positive	Small positive	Small positive
Option 2		Medium negative	Small negative	Negligible	Negligible	Small negative	Negligible	Small negative	Small positive	Negligible	Negligible

Mitigations

Proposing measures to reduce the negative and strengthen the positive impacts of the recommended disposal solution is a vital part of the IA. Impacts of some severity should be further discussed in the context of possible mitigating measures and management actions to reduce the magnitude of impacts or otherwise ensure proper management in the short and long terms.

Mitigating measures can also be discussed for other options, but these may be regarded as being of most importance for the recommended solution, since the company will document what it actually plans to do if its solution is accepted.

This chapter should discuss how negative impacts identified in the IA can be controlled (reduced or eliminated) through further planning and execution of decommissioning and final disposal. The plan for mitigating measures may either be presented in a separate chapter or entered in each subject or facility chapter.

Typical issues to be discussed include:

- clean-up of seabed debris to eliminate the risk of damaging fishing gear and to reduce the littering potential
- installing navigation lights on facilities left in place
- ensuring sound material and waste management in accordance with the waste hierarchy and the BAT principle
- ensuring that the disposal site has the necessary permits and licences to do such work
- concentrating attention on measures to prevent dust generation when planning and implementing the disposal work.

7.2.9 Environmental management plan and monitoring

Mandatory legislative requirements for environmental monitoring of seabed sediments and benthic fauna mean that this must be conducted twice after production ceases or as otherwise agreed with the NEA as the regulator [45]. A brief description of the mandatory environmental monitoring programme for the seabed, including drill cuttings where relevant, should be included in the IA.

Depending on the recommended disposal solution, further environmental monitoring may be relevant for different issues. Examples of such measures and verification activities to be discussed and proposed include:

- monitoring the seabed, including drill cuttings left in place, after completion of the removal operations
- checks of abandoned pipelines
- checks of facilities left in place
- checks of artificial reefs or other items for reuse
- final disposal verification (in other words, verifying debris removal and the state of left-in-place facilities).

8 REFERENCES

1. Norwegian Oil Industry Association (OLF), 1996. *Method study – Environmental and socio-economic impacts from platform disposal*. (Metodestudie – Miljø-og Samfunnsmessige Konsekvenser ved Plattformdisponeringer). Report no 9719. January 1996.

2. Nesse, Lind and Sandgren, 1995. "Methodology for Assessing Environmental Impacts of Offshore Installation Abandonment and Disposal". SPE 35917

3. Phillips Petroleum Company Norway, 1999. *Ekofisk I Cessation - Impact Assessment*

4. Norwegian Oil Industry Association (OLF), 2001. *Handbook for Environmental Impact Assessment for Offshore Decommissioning.*

5. DNV GL, 2017. *Brent Field Decommissioning. Environmental Statement*. Report to Shell UK. BDE-F-GEN-HE-0702-00006.

6. Wood, 2019. *Best available techniques guidance document on upstream hydrocarbon exploration and production*. Report to the European Commission. ISBN: 978-92-76-01443-0

7. Dr techn Olav Olsen 2018. *Avslutning og disponering av utrangerte innretninger*. 12635-01-OO-R-001 (Decommissioning and disposal of redundant installations). Report to the NPD.

8. Ospar, 1998. *Ospar decision 98/3 on the disposal of disused offshore installations*.

9. International Maritime Organisation (IMO), 1998. *Guidelines and standards for the removal of offshore installations and structures on the continental shelf and in the exclusive economic zone* (IMO resolution A. 672 (16)).

10. Ministry of Petroleum and Energy, 1999. *Disposal of discarded pipelines and cables on the Norwegian continental shelf*.

11. Ministry of Petroleum and Energy, 1999. *Disposal of discarded pipelines and cables. Summary report of the thematic assessment*s (Disponering av utrangerte rørledninger og kabler. Sammenfatningsrapport fra utredningsprogrammet). Report no 47 (1999-2000) to the Storting.

12. Ministry of Petroleum and Energy and Ministry of Labour and Social Affairs, 2018. *Guidelines for plan for development and operation of a petroleum deposit (PDO) and plan for installation and operation of facilities for transport and utilisation of petroleum* (PIO).

13. Norwegian Oil and Gas Association, 2020. *Decommissioning work breakdown structure handbook*.

14. Ospar. *Recommendation 2006/5 on a management regime for offshore cutting piles*.

15. Oil & Gas UK, 2011. *The decommissioning of steel piled jackets in the North Sea region*.

16. Dr tech Olav Olsen, 2010. *The disposal of concrete installations* (Disponering av betonginnretninger). Report 11318-OO-R-0001.

17. International Association of Oil and Gas Producers (OGP), 2012. *Decommissioning of concrete gravity based structures (CGBS) in the Ospar maritime area/other global regions*. Report 484.

18. Multiconsult, 2011. *Assessing environmental impacts from disposal of concrete installations. Leave in place and onshore disposal* (Utredning av miljøkonsekvenser ved disponering av betonginstallasjoner. Etterlating offshore og disponering ved land). Report to the Norwegian Environment Agency, 613547-RIM-RAP- / 001.

19. Norwegian Petroleum Directorate, Norwegian Environment Agency and Petroleum Safety Authority Norway, 2012. *Disposal of concrete facilities* (Disponering av betonginnretninger). ISBN 978-82-7257-067-4.

20.Oil & Gas UK, 2013. *Disposal of pipelines in the North Sea area*.

21. International Association of Oil and Gas Producers (OGP), 2014. *Options for decommissioning subsea bundles*. Report 469.

22. Norwegian Oil and Gas Association. *Guidance document for characterisation of offshore drill-cutting piles*. Version 4, 21 October 2016.

23. Cripps, S J, Kjeilen, G and Aabel, J P, 1995. *Ekofisk artificial reef.* Rogaland Research report, RF 95/205.

24. Dames and Moore/Rogaland Research, 1999. *Frigg Reef – Feasibility Study for an Artificial Reef on the Frigg Field*.

25. Soldal et al, 1999. "Abandoned oil installations as artificial reefs" (Utrangerte oljeinnretninger som kunstig rev). *Fisken og Havet* no 1, 1999, Norwegian Institute of Marine Research.

26. UK Offshore Operators Association, 26 January 2005. *Drill Cuttings Initiative Phase III*: Final report 20132900 from joint industry project 1999-2004.

27. Ospar, 2009. *Implementation Report on Recommendation 2006/05 on a Management Regime for Offshore Cutting Piles*. Publication 2009/451.

28. DNV, October 2008. *Drill cuttings on the NCS. Data compilation*. (OLF borekaks. Datasammenstilling), report 2008-4132 to the Norwegian Oil Industry Association.

29. DNV, 2013. *Environmental impacts from drill cuttings relocation at Albuskjell/Ekofisk*. Report 2012-4176. rev 1 to ConocoPhillips.

30. DNV GL, 2014. *Valhall DP PA environmental monitoring of drill cuttings relocation.* Report no 2014-4067 to BP Norge.

31. Institute of Petroleum (London), *Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in Removal & Disposal of Offshore Structures,* 2000, ISBN 0 85293 255 3.

32. Moltu and Aavik, 2010. "Developing key performance indicators (KPIs) for energy consumption and air emissions versus material recovery and removal options applied for the Frigg & MCP-01 project in the North Sea". SPE 126825.

33. Nesse and Moltu, 2012. "Frigg cessation project. Environmental footprint and EIA comparison". SPE 157361 (rev 1).

34. DNV, 2013. *Amendment to decommissioning and disposal of Ekofisk I impact assessment – Ekofisk 2/4 C and Tor 2/4 E*. Report 2013-4225 to ConocoPhillips.

35. Asplan and DNV, 1995. I*mpacts to the environment and society from decommissioning of the Odin platform*. Report to Esso Norge.

36. International Association for Oil and Gas Producers (OGP), 2009. *Guidelines for waste management with special focus on areas with limited infrastructur*e. Report no 413, rev 1.1.

37. UK Oil & Gas Authority (OGA) , July 2019. *UK decommissioning. 2019 cost estimate report.*

38. Oil and Gas UK, *Decommissioning Insight 2018*, ISBN 978-1-9164677-4-3, 2018.

39. Norwegian Environment Agency, 2010. *Report on offshore decommissioning*. TA 2643. (Avvikling av utrangerte offshoreinstallasjoner).

40. Oil & Gas UK, 2013. T*he management of marine growth during decommissioning*.

41. DNV GL, 2020. *Heimdal decommissioning. BAT for marine growth removal and underwater steel cutting*. Report 2020-0283 to Equinor Energy.

42. DNV, 2012. *Valhall Drill Cuttings Management Study*. DNV report no 2011-1513 to BP Norge.

43. Norwegian Public Roads Administration, 1995. *Handbook 140 on impact assessment*.

44. Norwegian Public Roads Administration, 2018. *Handbook V712 on impact assessment*. ISBN: 978-82-7207-718-0.

45. Norwegian Environment Agency, 2020. M-300/M-408. *Guidelines for environmental monitoring of petroleum activities on the Norwegian continental shelf*.