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**SUPPORT FOR DEVELOPMENT OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA) PROGRAMME**

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**SUPPORT FOR DEVELOPMENT OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA) PROGRAMME**

# Contents

# 1 INTRODUCTION

The main purpose of this work is to provide support to Fermi Energia OÜ (Fermi) for the development of an Environmental Impact Assessment (EIA) programme and for the implementation of an EIA procedure for an Estonian SMR based on Fortum's experiences on Nuclear Power Plant (NPP) EIA procedures.

The work encompasses lessons learnt and recommendations based on the NPP EIA procedures conducted in Finland, with the focus on nuclear specific topics, as input for the development of an EIA programme for an Estonian SMR. The input is targeted for planning of activities needed and to highlight issues to be considered in implementing the actual EIA procedure.

The work is based on Fortum's experiences on the recent EIA procedure for the operating license renewal of the existing units at the Loviisa NPP (2020-2022)[1] and the Loviisa 3 NPP project's EIA procedure (2007-2008)[2]. However, the EIA procedures carried out by Fortum have been done for the existing Loviisa NPP site. This starting-point is generally different compared to an EIA for a new NPP site, especially with respect to the environmental data and information available and methodologies to assess the environmental impacts. In addition, the environmental impacts are always more extensive on a greenfield site compared to an existing NPP site, which is also clearly reflected in the discussion and statements on the EIA report.

Consequently, as all the potential sites in Estonia are greenfield sites, the material related to the EIA procedures of Fennovoima's NPP project carried out for new nuclear sites in Finland is also utilized, in order to provide a general view related to the discussion and concerns related to new sites. The EIA procedures of Fennovoima's NPP project encompass the original EIA procedure in 2008, before the site was selected and the second EIA procedure in 2014 for the selected Pyhäjoki site, due to change of plant technology and supplier.

In this report, Fortum's experiences and the lessons learnt are described based on the EIA procedures done by Fortum for the existing Loviisa NPP site, but with the focus to provide input particularly considering an EIA for a new nuclear site and a SMR project in Estonia.

[1] https://www.fortum.com/media/2022/01/fortum-loviisa-nuclear-power-plants-eia-procedure-receives-ministrys-informed-conclusion (Accessed on 20.9.2022)
[2] https://www.fortum.com/products-and-services/power-plant-services/nuclear-services/newbuild/loviisa-3 (Accessed on 20.9.2022)

# 2 GENERAL LEVEL LESSONS LEARNT

In this chapter, general level lessons learnt and challenges related to the EIA procedure are highlighted from a NPP EIA procedure point of view. As part of the general level lessons learnt, issues arisen during the national public hearings and international hearings in accordance with the Espoo Convention[3] on transboundary impacts, are reflected. As all information and material related to the hearings of the EIA procedures are publicly available, the main issues arisen are summarized and highlighted on a general level in order to provide a general overview.

## 2.1 Stakeholders

How the EIA procedure is carried out is dependent on the national legislation or practices and despite it is based on the same EU-directives in Europe, it may vary from country to country, affecting also the interaction with stakeholders from the point of view of the project developer. In Finland, the project developer is responsible for implementing and carrying out the EIA procedure, usually by or with the help of a contracted EIA consultant.

In Finland, the Act on Environmental Impact Assessment Procedure (252/2017)[4] sets the legislative basis for the EIA procedures and in accordance with §10 of the Act the coordinating authority (contact authority previously) for EIA procedures related to nuclear facilities, including NPPs, is the Ministry of Economic Affairs and Employment (MEAE). Consequently, the MEAE is the primary stakeholder for the project developer for a NPP EIA procedure in Finland.

The second main stakeholder for the project developer in Finland is the Ministry of the Environment that is according to §28 of the Act on Environmental Impact Assessment Procedure (252/2017)[5] the coordinating authority (contact authority previously) for to the international hearing based on the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)[6].

The third important stakeholder, if not the most important considering the nature of the EIA procedure, for the project developer is the local public that is represented by a wide variety of groups depending on the site and the nearby areas. Different resident groups have different concerns and needs and they might require special focus or arrangements to enable good discussion, such as small focus group meetings. Public informing can also be directed to certain resident groups using different media or ways. The main thing is to share information on the project and provide the possibility for the local residents and other stakeholders to participate in the EIA procedure and to listen to their possible concerns.

[3] https://unece.org/fileadmin/DAM/env/eia/documents/legaltexts/Espoo_Convention_authentic_ENG.pdf (Accessed on 20.9.2022)
[4] https://www.finlex.fi/fi/laki/ajantasa/2017/20170252 in Finnish (Accessed on 20.9.2022)
[5] https://www.finlex.fi/fi/laki/ajantasa/2017/20170252 in Finnish (Accessed on 20.9.2022)
[6] https://unece.org/fileadmin/DAM/env/eia/documents/legaltexts/Espoo_Convention_authentic_ENG.pdf (Accessed on 20.9.2022)

In the case of Loviisa NPP, the local residents have traditionally been grouped according to permanent residents and holidaymakers and according to the living distance to the plant. Gender and age are usually also factors that have a large impact on opinions and concerns. Furthermore, in Loviisa, the local fishermen have formed an own important group, as have those living or having summer cottages less than five kilometres from the Loviisa NPP. Within this distance the presence of the plant is most notable, i.e. noise and impact on landscape. The area also covers roughly the spreading area of the cooling water and forms the precautionary action zone of the NPP.

In addition to these top three stakeholders there are, however, many other stakeholders in an EIA procedure, some more important than others. It can for example be mentioned that in Finland the local Centre for Economic Development (ELY-keskus) is responsible for assessing the environmental issues during the EIA procedure. The Centre makes the judgement on the adequacy of the scope and assessment. In Finland, most of the stakeholders are involved in the EIA procedure, at least, through the coordinating authority as part of the public hearing. However, the project developer can engage in direct dialogue with any stakeholder at its discretion.

In the case of the EIA procedures of Loviisa NPP and the Loviisa 3 NPP project, the discussions have for example included the municipality of Loviisa, a municipality group comprised of the neighbouring municipalities and an audit group explicitly established for the EIA procedures. Considering Finland and a newbuild project, it is worthwhile to emphasise the importance of the local municipality, as it has veto right in the Decision in Principle (DiP) in accordance with §14 of the Nuclear Energy Act (990/1987)[7]. Hence, the Government cannot issue a positive DiP without a positive statement from the municipality intended to be the site of the facility. It can also be noted that, the role of the Radiation and Nuclear Safety Authority of Finland (STUK) is not emphasised during the EIA procedure in Finland, but a positive statement on the safety of the planned NPP from STUK is also a precondition for the Government to issue a positive DiP.

The audit group was set up for the EIA procedures with the purpose of promoting the flow and exchange of information between the project developer, the authorities and the key stakeholders in the area. For the EIA procedures concerning the Loviisa NPP, the audit group included invited representatives of the town of Loviisa, the adjacent municipalities and local stakeholders as well as various experts and authorities, such as the local Centre for Economic Development and STUK. Representatives of the project developer and the EIA consultant also participate in the audit group. During the EIA procedure of the Loviisa NPP, the audit group convened two times.

[7] https://www.finlex.fi/en/laki/kaannokset/1987/en19870990_20200964.pdf (Accessed 20.9.2022)

## Recommendations

Discussions with stakeholders are important, but they can easily consume a lot of resources and time and it is a choice, how much time and effort the project developer puts on different stakeholders. Collecting information on the public opinion regarding the project, both locally and nationally, is valuable to direct and focus the communication correctly.

For the EIA procedure it is highly recommended that regular meetings are scheduled and arranged with the coordinating authorities and that all the meetings and discussions and communications with other stakeholders are planned and scheduled well in advance, in order to ensure necessary preparations and resources. Involvement and strong support of both communication and public relations departments are valuable and cannot be belittled.

The use of social media and its increasing role in public communication and in increasing the public acceptance for the project is also to be noted. Especially amongst persons under the age of 50 years social media can today be a very important and effective communication channel. However, social media has also its draw-backs, such as for example spreading of false information and fear mongering, that needs attention.

One good experience from targeting large public audience that is highlighted from the EIA procedure of the Loviisa 3 NPP project, was participation in both local and national summer events, fairs etc. during late spring and summer 2008. In total, there was six events, with durations ranging from one day up to five days, where public had the possibility to discuss and ask questions regarding the Loviisa 3 NPP project and the EIA procedure. During the EIA procedure of Loviisa NPP, information on the project was also shared to the local residents during few market place events in Loviisa, as presented in Figure 1.


Figure 1. Fortum booth at the Loviisa market place in summer 2008.[8]

As a final remark related to stakeholders, there are always individuals, groups, organisations and networks etc. opposing the use of nuclear energy on a principle level that will participate in the hearings of a NPP EIA procedure. These parties are geographically scattered and include multiple nationalities. Answering to their statements engages the project developer, but usually the content of the statements are similar and appears to be very coordinated.

## 2.2 EIA consultant

In the Finnish NPP EIA procedures, EIA consultants have always been utilized by the project developers as a sub-contractor, partly due to their special expertise on EIAs and the EIA procedure that the project developers do not possess and partly, due to independency from the project developer. However, the EIA consultants are often not experts in nuclear technology and safety, which needs to be taken into consideration in the resourcing and overall planning of the work.

In Finland, the responsibility for carrying out the EIA procedure is totally on the project developer. Consequently, the choice and contracting of the EIA consultant is independently done by the project developer, based on the company's internal contracting procedures. Typically, bids are asked from a limited number of consultants and the contract is awarded after a bid evaluation, considering

[8] Fortum 2008.

the price and scope of the bids as well as the references and experience of the bidders.

As an example, at least 18 experts of various areas from the EIA consultant participated in the EIA procedure of the Loviisa NPP, with most of the resources engaged during the EIA report phase.

**Recommendations**

A good advice is to involve the internal key resources already during the bidding and contract negotiations with the EIA consultants, in order to ensure a good understanding on the agreed scope of work and a clear division of responsibilities. This provides also a possibility for the project manager to influence the setup and plan the work.

Lessons learnt and consultation/discussion with key persons involved in earlier NPP EIA procedures should absolutely not be forgotten. Problems/challenges arisen in previous NPP EIA procedures are very likely to reoccur. Therefore, it is also recommended to pay attention on the true expertise on NPP EIA procedures the EIA consultant has, i.e. the individual experts offered, as NPP EIA procedures are not conducted very often.

## 2.3 Project developer

Despite the use of an EIA consultant, NPP EIA procedures require in Finland a rather significant effort also from the project developer. Firstly, in Finland the project developer is responsible for the project, including project management, both towards the EIA consultant and internally, as well as communication with the coordinating authority and other stakeholders. Secondly, the project developers use their own expertise in the nuclear specific questions to a large extent.

In addition to full time resources, the EIA procedure requires tens of different part-time experts representing a wide variety of know-how. For example, during the EIA procedure of the Loviisa NPP, approximately 30 persons were involved from Fortum in the preparation and review of the EIA report.

**Recommendations**

Sufficient full time resources, both for administrative and expert duties, should be reserved by the project developer for project management and to provide help to the EIA consultant in topics specific to nuclear technology and safety as well as the site, of which the project developer possesses the best knowledge.

It is highly advisable to start the preparations for the EIA procedure at a very early stage. This will allow time to plan the work, become organised with the EIA consultant and possibly organise and conduct site and environmental surveys which are season dependent.

As part of this study, essential site and environmental surveys considering nuclear specific topics (see Chapter 3) are collected in Chapter 4 to a preliminary research programme.

## 2.4 Publishing and press monitoring

In Finland, all the public reports related to the EIA procedure, such as for example the EIA programme and the EIA report, have been published in Finnish, Swedish and English and they need to be available in printed hard copies. Publishing, translations and printing take time and may cost unnecessary much, if not planned and considered in advance.

During the EIA procedure of the Loviisa 3 NPP project, for example hard copies of the EIA programme were printed far too many and the length of the English translations of both the EIA programme and the EIA report exceed much those of the Finnish and Swedish versions. Each additional page has a printing cost, which is for translations even higher. Furthermore, even small changes after translations and especially after pagination and layout have been done, may cause significant extra work.

In order to follow the discussion related to the Loviisa 3 NPP project a press monitoring, covering the most significant newspapers, was started in the beginning of the EIA procedure of the Loviisa 3 NPP project. This was very useful, but even more useful was the decision to order the two local newspapers Loviisan Sanomat and Östra Nyland to the main office in Keilaniemi.

In general, distribution of the news and articles for reading took, however, too long, as did their archiving. News and articles need to be available during the same day. Three or four days later is too late.

### Recommendations

The project developer should have a clear vision of the visual end-result for both the EIA programme and the EIA report as well as other public reports, including the summary report for the international hearing. Full pagination and layout with finished visual look is more time consuming and expensive than simple text documents.

Enough time needs to be reserved for possible translations. Attention should also be put on the length of the different translations from the very beginning to avoid swelling of the translated reports, especially the large EIA report.

In order to serve the media, own communication and public relations as well as the EIA programme/report, graphical presentations and photomontages of the plant are needed in a very early stage. Especially in a newbuild project photomontages are important. However, for the photomontages high quality aerial photos of the site are needed, which are weather and season dependent. Typical pictures needed for the purpose of the EIA procedure are shown in Figure 2 and Figure 3.

Figure 2. Aerial photo of the Loviisa NPP.[9]

Figure 3. Photomontage of the AES2006 plant at Pyhäjoki used in the EIA report of Fennovoima's NPP project NPP project (2014).[10]

[9] https://tem.fi/documents/1410877/89823965/EIA+Report+1.pdf/657bb0d3-06fe-fecd-d06a-3a58213d7a4b/EIA+Report+1.pdf?version=1.2&t=1631083299639 (Accessed on 20.9.2022)
[10] https://tem.fi/documents/1410877/2818159/Fennovoima+EIA+report+2014.pdf/fa421bdd-4f94-405c-be5b-6142eb59f70f/Fennovoima+EIA+report+2014.pdf?t=1464950758000 (Accessed on 20.9.2022)

Setting-up a media bank with pictures for the media and the public can be recommended. This will limit unnecessary requests for pictures that will tie resources.

Search and acquiring of pictures, including fill-up pictures for the publishing of the EIA programme and the EIA report, need to be started immediately once the work starts. This includes also starting of photographing of new pictures for example from the local environment, flora and fauna as well as the site. This is season dependent.

Press monitoring and ordering the local newspaper(s) are highly recommended in order to obtain without delays all local news and discussions etc. related to the project. However, the articles and news need to be distributed and available for reading during the same day.

## 2.5 National participation and interaction

### 2.5.1 General

The main idea with the EIA procedure is that it is carried out interactively, so that the various parties and stakeholders have the opportunity to discuss and express their views on the project and its effects and impacts. One of the key objectives of the EIA procedure is to share information about the project and improve the opportunities for stakeholders to participate in the project planning. The participation brings out views of a wide variety of different stakeholders.

In Finland, the EIA procedure includes minimum of two large public events as part of the formal procedure The large public events have been hosted by the MEAE and the responsible official from the MEAE has acted as the moderator. In addition to the large public events, different stakeholder meetings, smaller focus group meetings and resident surveys, for example, are part of the interactive EIA procedure.

### 2.5.2 Public events and focus group meetings

Figure 3 presents, as an example, the overall time schedule of the EIA procedure of the Loviisa NPP, highlighting also events, meetings and activities related to the participation and interaction.

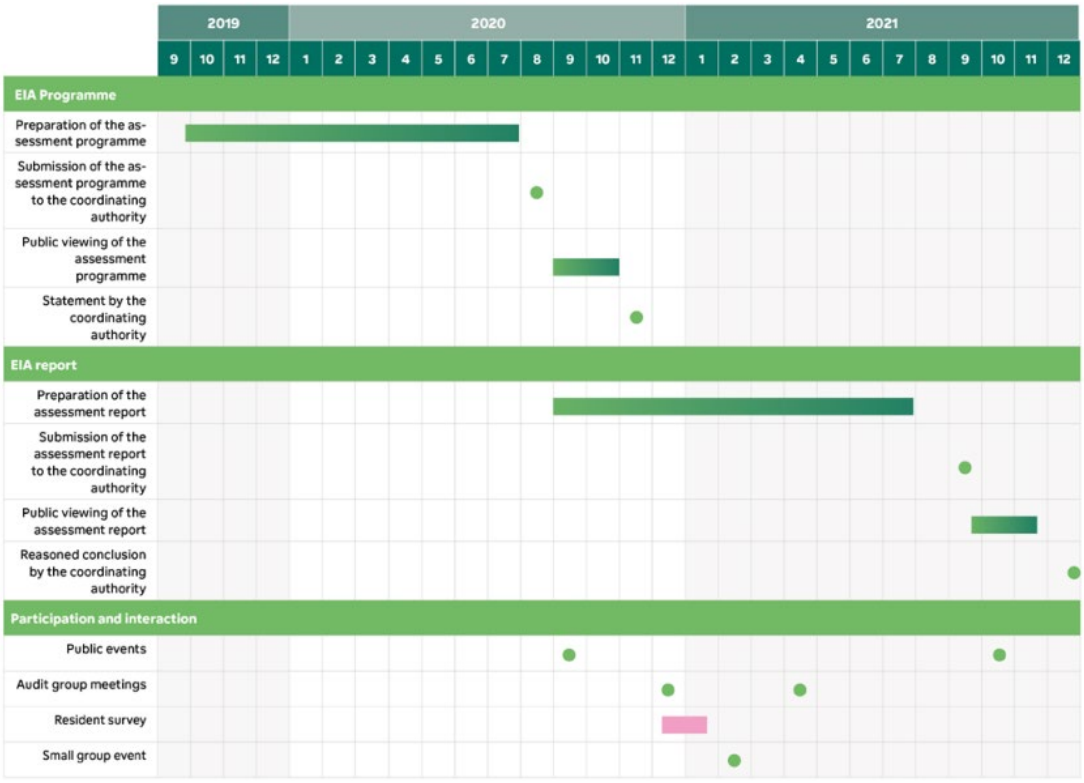


Figure 3. The schedule of the EIA procedure of the Loviisa NPP as presented in the EIA report, including participation and interaction.[11]

In the public events related to the EIA procedure of the Loviisa NPP, the presentation material was for the essential parts also in English. The public events were held in Finnish mainly, but questions could be asked in Finnish, Swedish and English.

The presentations were focusing on the local aspects, such as impacts of the cooling water on the water environment, economic impacts and the results of the resident surveys conducted in the surrounding municipalities. As an example, the questions and the results of the resident survey for the EIA procedure of the Loviisa NPP are presented in Chapter 9.19 of the Loviisa NPP EIA report[12]. In addition to background information of the respondents, the questions of the survey addressed residents' use of waterbodies and shores, opinions about the impacts of power plant's current operation on the nearby area/region, attitudes towards nuclear power, impression of the planned operations and opinion of the best option.

During the EIA procedure of the Loviisa NPP, two public events were arranged, one during the EIA programme phase and one during the EIA report phase. Due to Covid-19, the public events were arranged as hybrid meetings, with the possibility to participate either online or physically at the venue in Loviisa. Due

[11] The reasoned conclusion of the coordinating authority for the EIA report of Loviisa NPP was obtained 1.10.2022.

[12] https://tem.fi/documents/1410877/89823965/EIA+Report+2.pdf/d0d38a17-d4b2-da41-8277-8c73e697fe78/EIA+Report+2.pdf?version=1.0&t=1632227180017 (Accessed on 20.9.2022)

to the circumstances, nearly all participants participated online. During the public events related to the EIA procedure of the Loviisa NPP, the following topics were especially discussed:

- Nuclear waste management and final disposal of nuclear waste.
- Import of radioactive waste generated elsewhere in Finland.
- Impact of cooling water on the local aquatic environment.
- Carbon neutrality of nuclear power.
- Radiation safety.
- Security of supply.
- Many positive issues were also raised, such as employment and direct as well as indirect income to the area and region.

Also during the EIA procedure of the Loviisa 3 NPP project, a public event was held in Loviisa both during the EIA programme phase and the EIA report phase. In addition, a special public event on the condition of the Baltic sea and the sea around the Loviisa NPP was arranged during the EIA report phase. Especially the public events during the EIA report phase gathered a rather large amount of participants. During the public events, the main issues related to the Loviisa 3 NPP project were very similar to those for the EIA report of the Loviisa NPP, apart from importing radioactive waste generated elsewhere in Finland, which was not included in the EIA procedure of the Loviisa 3 NPP project.

In general, the public events have been open to everybody and they were also announced in the local newspapers, but for example in the public event related to the EIA report of the Loviisa NPP, entrance to the venue was granted only after registration to the event at arrival.

In addition to the public events, small group events/focus group meetings were also organised during both the EIA procedures related to the Loviisa NPP with e.g. local fishermen, landowners and entrepreneurs. The composition of the focus groups and the discussions were tailored in accordance with the need for information and the stakeholder group. The small group events/focus group meetings are a good way to limit the discussion on such concerns and environmental impacts affecting a particular stakeholder group.

During the EIA procedure of the Loviisa NPP one small group event was arranged with the local residents, but information on the project was shared also to the local fishermen in their board meeting. In total, five similar smaller focus group meetings were arranged during the EIA procedure of the Loviisa 3 NPP project. In general, if needed, involved persons and company representatives share information on the project upon request or proactively to their own personal stakeholders and connections.

For both Loviisa NPP related EIA procedures surveys of the residents' views on the projects were also carried out, for which a questionnaire and return envelope were sent out to the local residents. The resident survey regarding the EIA procedure of the Loviisa NPP could also be answered online, with an individual code provided in the questionnaire. The small group event during the EIA procedure of the Loviisa NPP, was arranged based on the answers to the resident survey, in which the local residents were offered the possibility for a separate meeting to discuss the project.

During the EIA programme phase related to the first EIA procedure of Fennovoima's NPP project in 2008, public events were arranged in Simo, Pyhäjoki, Ruotsinpyhtää and Kristiinankaupunki. Based on public information, the attendance in the public events was large and for example in Kristiinankaupunki the opposition for the project was so strong that Kristiinankaupunki was dropped out as an alternative site after the EIA programme phase. Thus, public events related to the EIA report were held only in Simo, Pyhäjoki and Loviisa. After the site selection the public events of the second EIA procedure were limited to Pyhäjoki in 2013 and 2014, when also the interest for the project had already clearly weakened compared to 2008. Figure 4 shows a picture from the public event of the EIA programme phase of the second EIA procedure of Fennovoima's NPP project in Pyhäjoki in 2013.


Figure 4. Fennovoima's public event in Pyhäjoki in 2013.[13]

The discussion in the Fennovoima's public events during the EIA programme phase in 2008 has been presented in detail and assessed in a research report[14] by the Department of Social Sciences and Philosophy of Jyväskylä University.

[13] https://yle.fi/uutiset/3-6887785 (Accessed on 20.9.2022)
[14] https://jyx.jyu.fi/bitstream/handle/123456789/44065/Uuden%20ydinkeitaan%20etsint%c3%a4%c3%a4.pdf?sequence=1&isAllowed=y in Finnish. (Accessed on 20.9.2022)

Among other things, the report highlights and reflects well the negative attitude of the local residents in Kristiinankaupunki towards the NPP project.

In general, due to the consideration of greenfield sites and local opposition, the attendance in the public events related to the EIA procedures of Fennovoima's NPP project were much larger compared to the public events of the EIA procedures related to the Loviisa NPP.

### 2.5.3 Recommendations

The EIA report covers numerous topics and the time in the public events is limited. Therefore, the focus in the public event related to the EIA report, i.e. presentations, can only be on topics assessed to have the most significant impact. Despite this, it is highly recommended that there is a wide participation of experts in different fields present in the public events, so that all potential questions can be answered during the events.

It is advisable to have a questionnaire sent out to the local residents as part of the EIA procedure in order to obtain their views on the project and to offer them a possibility for a separate meeting to the discuss the project. This will help to tackle possible problems later. This optional part of the EIA procedure and smaller focus group meetings, in general, were found useful in the EIA procedures related to the Loviisa NPP.

Newbuild projects, such as the Loviisa 3 NPP project, attract generally large public interest. However, the interest for newbuild projects on a greenfield site is still many times higher than for an existing NPP site. This was also demonstrated by the EIA procedure of Fennovoima's NPP project in 2008, where also the discussion in the public events was very hard and loud, due to strong opposition for the project.

In 2008, many environmental and local organisations demonstrated actively against the various newbuild projects planned in Finland (see Figure 5). The demonstrations also mobilized foreigners, which is good to note. The demonstrations resulted in special security arrangements also in the public events related to the EIA procedure of the Loviisa 3 NPP project. The additional security provisions were mainly taken based on the experiences from the public events related to the EIA procedure of Fennovoima's NPP project. Potential disturbances and demonstrations in the public events needs to be prepared for based on a risk analysis.


Figure 5. Demonstration against Fennovoima's NPP project in Kristiinankaupunki in 2008.[15]

## 2.6 International hearing on transboundary impacts

### 2.6.1 Overview of statements

With respect to the international hearing of the EIA report of the Loviisa NPP, the authorities of Austria, Lithuania, Sweden and Estonia provided a statement. In addition, the Ministry of the Environment obtained together 13 statements from European citizens and organisations, in which the use of nuclear energy was generally opposed, for example due to **accident risks**, **outdated technology** and due to concerns related to the **safety of final disposal of spent nuclear fuel**.[16]

It is to be noted that 39 questions, mainly not related in any way to the environmental impacts of the Loviisa NPP lifetime extension, were obtained from Austria. The MEAE prepared answers to the questions, with brief input from the project developer. However, this resulted just in another comment paper with a negative tone, indicating that the counterpart had not understood the essence of what was presented to them.

For the international hearing of the EIA report of the Loviisa 3 NPP project the Ministry of the Environment obtained statements from the authorities of Austria, Lithuania, Germany, Sweden, Norway and Estonia. In addition, five statements from European organisations/networks, mostly opposing the use of nuclear energy were obtained. Name lists, collected by Bundesverband Bürgerinitiativen Umweltschutz from Germany, opposing the Loviisa 3 NPP project were also submitted to the Ministry of the Environment.

One recurring theme in many of the statements was consideration of the environmental impacts for the entire lifecycle of the plant, including also **environ-**

[15] http://sydaby.eget.net/kil/ekstrom.htm (Accessed on 20.9.2022)
[16] All statements from the international hearing related to the EIA report of Loviisa NPP are available at https://tem.fi/loviisan-yva-selostus (Accessed on 20.9.2022)

**mental impacts of uranium mining**, **nuclear waste management**, **transportations of fresh and spent nuclear fuel** and **decommissioning**. Also consideration of alternative energy production was emphasised, in addition to the ordinary topics, i.e. **severe reactor accidents** and **reactor safety**.

Regarding the Loviisa 3 NPP project, a lengthy expert statement was obtained from the Austrian Ministries[17]. The Austrian concerns were addressed by answering thoroughly to the provided questions and a consultation meeting with the Austrian parties was arranged by the Ministry of the Environment in Helsinki. Also Germany and Lithuania specifically asked for written answers to the questions submitted by them related to the Loviisa 3 NPP project.

As part of the international hearing of the EIA report related to the Loviisa 3 NPP project, Fortum, as the project developer, participated also in the public hearing meeting arranged by the Ministry of Environment in Estonia in 2008.

The countries that participated in the international hearing related to the EIA report of Fennovoima's NPP project were in 2008 Austria, Sweden, Norway, Germany, Estonia, Lithuania and Poland and in 2014, Austria, Sweden, Norway, Germany, Latvia, Estonia and Poland.

With regards to the international hearings related to the EIA reports of Fennovoima's NPP project it can be noted that the impact of the two new greenfield sites (Simo and Pyhäjoki) on the coast of the Bothnian Bay was clearly seen in the statements obtained from Sweden in 2008[18] and particularly in 2014[19].

In 2008, the Swedish environmental authority, Naturvårdsverket, received all together comments from 24 authorities (some municipalities sent their statement to their provincial authority) and seven organisations, and two comments or opinions from private individuals. In 2014, the Swedish environmental authority received comments from 20 official organisations, 18 non-governmental organisations and 23 statements or opinions from private individuals or groups. In general, several statements and opinions obtained by the Ministry of the Environment in 2014 expressed doubtful views of Rosatom as the plant supplier and Russia.

Similarly as in the case of the Loviisa 3 NPP project, in 2008 an expert statement with 13 special questions regarding Fennovoima's NPP project was obtained from the Austrian ministries and a consultation meeting with the Austrian parties was arranged by the Ministry of the Environment in Helsinki. Several other statements opposing Fennovoima's NPP project based on various reasons, were also obtained from Austria.

[17] https://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0167.pdf (Accessed on 20.9.2022)
[18] All statements from the international hearing related to the 2008 EIA report of Fennovoima's NPP project are available at https://tem.fi/yva-selostusvaihe-2008 (Accessed on 20.9.2022)
[19] All statements from the international hearing related to the 2014 EIA report of Fennovoima's NPP project are available at https://tem.fi/yva-selostus-ja-yhteysviranomaisen-lausunto (Accessed on 20.9.2022)

As part of the international hearing related to the second EIA report of Fennovoima's NPP project in 2014, a public event was arranged by MEAE and Fennovoima in Luleå, Sweden[20]. Figure 6 show a demonstration outside of the venue of the public event arranged in Luleå regarding the second EIA procedure of Fennovoima's NPP project.

Figure 6. Demonstration against Fennovoima's NPP project in Luleå in 2014.[17]

### 2.6.2 Estonian statements

In order to highlight concerns from Estonian participation in the EIA procedures of the selected NPP projects in Finland, the statements obtained from Estonia as part of the EIA procedure on transboundary impacts, focusing on the EIA reports, are briefly summarized in this section.

The only point raised from the Estonian statements regarding the EIA programmes is that the Estonian environmental authorities argued that alternative energy production should be included in the assessments.

The highlighted topics can be expected to reoccur considering also an Estonia SMR project. However, the involvement, depth of engagement and level of detail will likely be something else for a domestic NPP project in Estonia compared to the NPP projects in Finland. This viewpoint is elaborated in more detail in Chapter 2.7.

#### 2.6.2.1 Loviisa NPP

With regards to the EIA report of the Loviisa NPP, the public display was organised in Estonia from October 4th to November 9th, 2021 by the Ministry of the

[20] https://yle.fi/uutiset/3-7141586 (Accessed on 20.9.2022)

Environment of Estonia that also distributed the documentation to numerous authorities and non-governmental environmental organisations.

According to the Estonian statement[21] the Ministry of the Environment of Estonia did not obtain proposals or comments concerning the EIA report. However, the Environmental Board noted that for conservative purposes a higher value than 100 terabecquerels (TBq) of caesium-137 (Cs-137) that is used for assessing the environmental impacts of a **severe reactor accident** in Finland could be used. This could be 3300 TBq in the case of Loviisa NPP.

The **responsibilities of mitigation measures** (implementation and enforcement) in the event of accidents and transboundary impacts were also highlighted by the Environmental Board.

#### 2.6.2.2 Loviisa 3 NPP project

For the EIA report of the Loviisa 3 NPP project, Estonian participation in the EIA procedure included a public hearing on June 12th, 2008, in Tallinn and a public display arranged by the Ministry of the Environment of Estonia. The public had an opportunity to provide statements on the EIA report from May 23rd to June 16th, 2008.

In its statement, the Ministry of the Environment of Estonia highlighted the **responsibilities and tasks of different parties** (project developer, the state, competent authorities and international organisations) in case of exceptional situations and accidents, including **informing neighbouring countries**. Furthermore, it was noted that the programme for **monitoring of the environmental impacts** could have been described in more detail.[22]

#### 2.6.2.3 Fennovoima's NPP project

Estonia participated in the EIA procedure of Fennovoima's NPP project, both in 2008 and 2014. For Fennovoima's first EIA procedure in 2008, the Ministry of the Environment of Estonia organised a public hearing for the EIA report on December 10th, 2008 in Tallinn and the public had an opportunity to provide statements until December 18th, 2008.

According to the Estonian statement[23] written comments were received from the Ministry of Foreign Affairs of Estonia and the Health Protection Inspectorate and the following concerns were highlighted.

- **Impact of cooling water** on algal bloom of Cyanobacteria considering bathing places in the North Estonia (especially for the Kampuslandet site).
- **Impacts of marine transport.**

[21] https://tem.fi/documents/1410877/89823665/Viro+(EE)+Ministry+of+Environment.pdf/e5973f7c-503a-d4db-2759-1a9efb272c25/Viro+(EE)+Ministry+of+Environment.pdf?version=1.0&t=1638529784814 (Accessed on 20.9.2022)
[22] EIA report of the Loviisa Nuclear Power Plant project, Ministry of the Environment (Keskkonnaministeerium), No 13-3-1/21027-9, 25.6.2008
[23] https://tem.fi/documents/1410877/2442939/Ministry+of+Environment+EE.pdf/d2315671-0133-455a-9cec-2cfd064ba6b4/Ministry+of+Environment+EE.pdf?version=1.1&t=1463487826000 (Accessed on 20.9.2022).

- Regarding **severe reactor accidents** the statement notes that in the assessment it should be considered that Tallinn and Narva in North-Estonia (population over 470 000) use surface water as drinking water.
- Governing legislation and articles as well as plans for **informing the public and neighbouring countries in accidents**.
- Responsibility for the evaluation of **economic losses in accidents** for agricultural companies and based on which legislation, including international agreements, the losses will be covered.
- Fennovoima Oy's possibility to dispose **spent nuclear fuel** of its planned new nuclear power plant in Posiva Oy's planned repository in Olkiluoto.

For Fennovoima's second EIA procedure, the Ministry of the Environment of Estonia arranged a public display from February 27th to April 10th, 2014. The Estonian statement[24] only highlights the use of surface water as drinking water in Tallinn and Narva considering **severe reactor accidents**, which was also mentioned in the Estonian statement for the EIA report in 2008.

### 2.6.3 Recommendations

The countries to be included in the international hearing need to be agreed[25] with the coordinating authority of the international hearing. The project developer needs also to have a clear view and a proposal to the coordinating authority of the international hearing as to what impacts are to be assess and what is the impact zone (distances and other details). This is needed, so that the coordinating authority of the international hearing is able to assess if it is suitable and sufficient.

The international hearing needs to be considered in the resourcing, especially with regards to the translations. The EIA report summary that is prepared for the international hearing needs to be translated to all languages of the countries included in the procedure. In the case of EIA report of Loviisa NPP, for example to Estonian[26].

With regards to the international hearing, the project developer needs to be prepared to also organise or participate in public events or focus group meetings in another country. These requests can come late and they can come even after the hearing process has officially ended in the country in question.

Optionally, it can be proposed that the different countries can send questions instead of a meeting, but then sufficient time to respond to the questions needs to be reserved. It is, however, worth to consider that even detailed answers to the provided questions may not lead to any conclusions, but on the contrary.

[24] https://tem.fi/documents/1410877/2436655/Ministry+of+Environment.pdf/7636d535-384e-40b5-8a64-5d4c30ff1ffc/Ministry+of+Environment.pdf?version=1.1&t=1463546757000 (Accessed on 20.9.2022).
[25] Governed by international treaties, but the coordinating authority of each country makes the final interpretation and decision.
[26] Loviisa tuumaelektrijaam Keskkonnamõju Hindamise aruanne Rahvusvahelise arutelu dokument, Septembril 2021. https://tem.fi/documents/1410877/89823965/Keskkonnamo%CC%83ju+hindamine.pdf/9f77126d-7bbe-2937-a87c-3e01419f77ca/Keskkonnamo%CC%83ju+hindamine.pdf?version=1.0&t=1630928526061 (Accessed on 27.9.2022).

Based on the experiences from the international hearing related to the EIA procedures of the selected NPP projects in Finland, it can be expected that a separate meeting request or questions, or both, will in any case be received from Austria.

With regards to the Estonian statements of the international hearings of the EIA procedures of the selected NPP projects in Finland, the use of surface water as drinking water in Tallinn and Narva is something that is of essential importance considering potential impacts of accidents for the Estonian SMR project.

## 2.7 Summary of main issues and concerns

In the reasoned conclusion (formerly statement) of the coordinating authority (previously contact authority), the MEAE states its view on the significant environmental impacts of the project. The reasoned conclusion of the MEAE is based on the EIA report, statements and opinions issued on it during the EIA procedure as well as the coordinating authority's own evaluation.

The following sections provide a general overview of the main issues and concerns arisen during in the EIA procedures of the selected NPP projects in Finland. More details related to the issues may be found in the reasoned conclusions/statements of the coordinating/contact authority and the statements of the various stakeholders obtained by the coordinating/contact authority.

### 2.7.1 Loviisa NPP

On January 14th, 2022, the MEAE, as the coordinating authority, released its reasoned conclusion on Fortum Power and Heat Oy's EIA report on Loviisa NPP[27]. As a summary, many Finnish parties stated that they were in favour of continuing the operation of the Loviisa NPP based on the greenhouse gas-free emissions of electricity produced from nuclear energy and security of energy supply. Comments were made mainly on the handling of the effects of the cooling water.

In its reasoned conclusion, the MEAE states that the alternatives examined were not found to have such significant adverse environmental impacts that could not be accepted, prevented or mitigated to an acceptable level.

As a whole, the environmental impacts of continuing the use of the Loviisa NPP are greater than those of decommissioning alone, as in the case of continued operation the plant must eventually be decommissioned anyway. The most significant effect of the nuclear power plant during normal operation is the thermal load of the cooling water in the nearby sea area. However, the assessment of environmental impacts of the alternatives must take into account the project's energy-economic significance, which is high nationally.

In its reasoned conclusion, the MEAE states that some of the comments made should be taken into account in the further planning of the project. The main

[27] https://tem.fi/documents/1410877/89823965/Reasoned+conclusion_the+EIA+report+_Loviisa+NPP.pdf/1988c1af-aba0-9d13-b1ca-b50c75f46d7b/Reasoned+conclusion_the+EIA+report+_Loviisa+NPP.pdf?version=1.0&t=1654759841447 (Accessed on 20.9.2022)

excerpts from the reasoned conclusion of the MEAE regarding the EIA report of the Loviisa NPP are:

- The climate impacts of continued operation of the Loviisa NPP have been assessed as moderately significant and positive.
- Local people had a more negative attitude towards the operation of the NPP than people living further away, mainly due to impact on the landscape and recreational use, but above all, the processing, interim storage and final disposal of small amounts of radioactive waste generated elsewhere in Finland. This was a new topic added in the EIA report based on Finnish national waste management strategy by the MEAE. However, there is, on the other hand, a big employment effect.
- The safety and volume of transports related to the processing, interim storage and final disposal of small amounts of radioactive waste generated elsewhere in Finland is a matter of concern.
- The Centre for Economic Development (ELY-keskus) emphasizes participation in mitigation measures with respect to the impact of cooling water together with it. The MEAE also suggests possible co-operation with environmental authorities (preparation of a rehabilitation plan and participation in its implementation).
- Adequate knowledge of groundwater conditions is needed and planning of the utilization of blasted stone from quarrying must be carried out.
- Attention must be paid to the prevention of dust and noise nuisance from construction and demolition.
- Contaminated soil must be investigated before construction or demolition work.
- During decommissioning and demolition of buildings, significant amounts of radioactive waste are generated, the final disposal location must be known.
- Associations and non-governmental organisations: “observable regular complainants with same regular statement” (e.g. Naiset atomivoimaa vastaan (“Women against the nuclear power”)).

### 2.7.2 Loviisa 3 NPP project

On August 15th, 2008, the MEAE, released its contact authority’s statement regarding the EIA report for Fortum Power and Heat Oy’s Loviisa 3 NPP project[28]. The main points in the contact authority’s statement were:

[28] Ympäristövaikutusten arviointiselostus Loviisa 3 -ydinvoimalaitosyksikölle; yhteisviranomaisen lausunto. Työ ja elinkeinoministeriö, 15.8.2008, 7536/815/2008.

- More information on the impact of cooling water and combined effects with Fennovoima's planned NPP at Kampuslandet (Ruotsinpyhtää).
- Data describing agricultural production should have been presented.
- Recommendation to include the main cost structure of the project and its alternatives in the EIA report.
- The outermost cooling water discharge alternative presented in the EIA programme has not been assessed in the EIA report, for which the MEAE stated that all alternatives should have been considered equally in the EIA report.
- The impact of the increase in traffic on nature and the environment must be assessed, also taking into account traffic safety.
- The description of the interim storage of spent nuclear fuel was too narrow.
- The employment effects must be assessed for both construction and operations. The amount of foreign labour should be estimated.
- The uncertainties of the project should be taken into account in further planning.
- The survey for residents should aim to be implemented with a much higher response rate.
- The report should have shown the results of the participation and its effectiveness in the EIA procedure.

The MEAE required additional studies and more information with regards to the following:

1. Combined heat and power generation, including environmental impact and nuclear safety.
2. Interactions of cooling water of several reactors (combined effects with Fennovoima's planned NPP at Kampuslandet (Ruotsinpyhtää)), including the criticism related to cooling water modelling.
3. The most important technical information of the plant alternatives with regards to the environmental impacts.
4. Revision of the Natura 2000 assessment.
5. The environmental impacts of nuclear waste management.
6. Factors to be taken into account in the further planning of the project.
7. Agricultural production and fish farming.
8. Cost structure of electricity generation.

### 2.7.3 Fennovoima's NPP project

The first EIA procedure of the Fennovoima Oy's Nuclear Power Project was started in January 2008, when Fennovoima Oy submitted its EIA programme[29] to the MEAE. The actual EIA report phase was started in October 2008, after the MEAE issued its contact authority's statement on the EIA programme[30]. The EIA procedure was concluded on February 20th, 2009, when the MEAE released its contact authority's statement[31] regarding the EIA report[32].

However, due to change of plant technology and supplier, Fennovoima conducted a second EIA procedure in 2013-2014. The contact authority's statements[33, 34] on the second EIA programme[35] and EIA report[36] were issued in February 2014 and June 2014, respectively.

Considering a completely new NPP site in Finland, Fennovoima's EIA procedure raised, especially, in 2008-2009 much more discussion, compared for example to the EIA procedure of the Loviisa 3 NPP project, which was considering a newbuild project on the existing Loviisa NPP site. Regarding Fennovoima's EIA procedure, the magnitude of the discussion was additionally emphasized by the fact that Fennovoima was investigating and considering sites in three[37] alternative locations (Simo, Pyhäjoki and Ruotsinpyhtää), all covered in the same EIA procedure.

Overview of issues risen during the Fennovoima EIA procedure based on the contact authority's statement are summarized in the following.

- All proposed alternative plant sites are located in areas with no previous industrial activity. This has a significant effect on the local environmental impacts.
- The main environmental impacts from the operation phase are related to nuclear safety, nuclear waste management and cooling water.
- Descriptions of the current status of the environment are defective in parts, complicating the assessment of the project's environmental impacts. This in particular concerning the assessment of the magnitude of

[29] https://tem.fi/documents/1410877/2823295/fennovoima+eia2+english.pdf/351d2f24-2df4-4361-8477-f739858788b2/fennovoima+eia2+english.pdf?t=1465198635000 (Accessed on 20.9.2022)
[30] https://tem.fi/documents/1410877/2823295/Contact+authority+statement.pdf/79e024d7-d53a-448e-84a4-4ee883371f16/Contact+authority+statement.pdf?t=1465200227000 (Accessed on 20.9.2022)
[31] https://tem.fi/documents/1410877/2821523/Contact+authority+statement.pdf/36107661-5884-4aa5-a21d-a375c6232cc7/Contact+authority+statement.pdf?t=1465115360000 (Accessed on 20.9.2022)
[32] https://tem.fi/documents/1410877/2821523/EIA+report.pdf/9d862ccb-4478-46e9-95ff-31d7fdbd042e/EIA+report.pdf?t=1465115653000 (Accessed on 20.9.2022)
[33] https://tem.fi/documents/1410877/2819389/Statement+by+the+contact+authority+13.12.2013.pdf/24172485-c40c-47a2-9c22-96941aa7ac8d/Statement+by+the+contact+authority+13.12.2013.pdf?t=1464954985000 (Accessed on 20.9.2022)
[34] https://tem.fi/documents/1410877/2818159/Contact+authority+statement.pdf/d3f50691-f36d-4de1-b535-028f114259b6/Contact+authority+statement.pdf?t=1464950923000 (Accessed 20.9.2022)
[35] https://tem.fi/documents/1410877/2819389/Fennovoima+EIA+program+2013.pdf/6eed19e0-8708-4383-abd5-04c6f3fd68ea/Fennovoima+EIA+program+2013.pdf?t=1464954405000 (Accessed 20.9.2022)
[36] https://tem.fi/documents/1410877/2818159/Fennovoima+EIA+report+2014.pdf/fa421bdd-4f94-405c-be5b-6142eb59f70f/Fennovoima+EIA+report+2014.pdf?t=1464950758000 (Accessed 20.9.2022)
[37] Kristiinankaupunki was dropped out after the EIA programme phase. Two sites, Kampuslandet and Gäddbergsön, in Ruotsinpyhtää.

impacts and their significance. It is problematic that any balanced comparison of site alternatives is jeopardised due to this.

- Combined impacts of cooling water and waste water on the nearby aquatic environment and species considering different cooling water intake and discharge alternatives.
- In case the plant site will be in Ruotsinpyhtää , the joint impacts with the planned Loviisa 3 NPP project shall be assessed.
- Flora, fauna and ecological values have been poorly assessed. Several species of both flora and fauna are missing. Many statements, especially, related to bird migration and overhead power lines.
- Potential chemical leakages outside of the plant and their hazards and potential impacts should be assessed in more detail in a later phase.
- According to Fennovoima the project would not have significant adverse effects on Natura 2000 areas. Many statements draw, however, attention to the need for a separate Natura assessments.
- Assessment of risks and environmental impacts of final disposal and transportation of spent nuclear fuel are needed.
- Intermediate storage of spent nuclear fuel. Different alternatives for intermediate storage of spent nuclear fuel and their environmental impacts should be compared. "Intermediate storage on the plant area", is not enough.
- Own EIA procedure for the final disposal and transportation of spent nuclear fuel. It would be good to anticipate the risks and environmental impacts and address them upfront in the EIA report.
- Cogeneration of electricity and heat should have been investigated in more detail, as this could significantly increase the plant efficiency and reduce the environmental impacts.
- Post-accident actions in case of a severe reactor accident could have been presented in more detail, as the licence holder is obliged to compensate for the damages caused by the accident.
- Assessment of environmental and health impacts of final disposal of low and intermediate radioactive waste and this should be done in an understandable way.
- Due to climate change, the probability of extreme weather phenomena may increase, which requires more detailed assessment.
- Sea level variations currently and during the lifetime of the plant have been considered on the alternative sites based on data from the Finnish Marine Research Centre. The impact of postglacial rebound and climate

change on the water level of the oceans have been considered based on reports of the Intergovernmental Panel on Climate Change (IPCC).

- No experience on air cooling in Finland due to abundant cool water at the sea coast, thus Fennovoima has also focused on direct cooling and cooling water intake.
- Potential alien species, e.g. Mytilopsis leucophaeata, have been considered.
- Additional investigation of the sub-surface aquatic environment to be done during the construction phase.
- Some assessments that have been promised to be done in the EIA programme have not been done and considered in the EIA report.
- Strong concerns related to the health impacts of radioactive emissions by local residents.
- Mitigation measures and monitoring programmes for environmental impacts have been addressed sufficiently in the EIA report.

The MEAE required additional studies and more information/clarifications with regards to the following:

1. Plan and time schedule for specifying the information on water quality and the current status of the aquatic ecosystems.
2. Method and accuracy of adapting the utilised cooling water model to local conditions.
3. Impact of changed initial data (mentioned in point 1) on the current status of the aquatic ecosystems on cooling water modelling and other environmental impact assessments.
4. Distant discharge option for cooling water and its potential impacts.
5. Combined effects of wastewaters and cooling waters.
6. Birdlife analysis methods, specific assessment of bird populations and impact of power lines on bird migration.
7. Spawning of fish and reliable spawning area observations.
8. Position of the Hanhikivi area as a region of particular importance in terms of the diversity of nature.
9. Listing and protection of endangered biotopes, flora and fauna.
10. Overall assessment considering national land use guidelines.
11. Climate change and its impacts together with cooling waters on the local ecology.

12. Key environmental impacts of heat and power cogeneration.
13. Risks and environmental impacts of spent nuclear fuel transportations.
14. Environmental impacts of the construction and operation of a final disposal facility for radioactive waste and safety justification for bedrock disposal.
15. Radiation dosesin severe reactor accident considering inert gases.
16. Partial failure of resident surveys and its impacts.
17. Reasons for the failure to complete the EIA procedure in Kristiinankaupunki, as planned in the EIA programme.

In the second EIA procedure, the MEAE required additional studies and more information/clarifications with regards to the following:

1. Warm cooling water impacts on the success of invasive alien species and their reproduction in the sea area of Pyhäjoki.
2. Impacts on the marine monitoring programme. Impacts on sea bottoms dominated by submerged plants and the occurrence of endangered stonewort meadows.
3. Impacts on the routes of migratory fish species and their access to their spawning rivers.
4. Impacts on annual migratory behaviour of seals and their stay in the area.
5. Impacts on fisheries caused by intake/discharge of cooling.

### 2.7.4 Recommendations

This section provides some general viewpoints as well as brief recommendations, on those non-nuclear specific topics summarized in the previous sections. The nuclear specific topics are addressed in more detail in Chapter 3.

- **Nuclear safety**, including **severe reactor accidents** and **nuclear waste management** are important issues that will be in focus in any NPP EIA procedure. In addition, depending on the technical solution either **cooling water** spreading or visual aspects related to **cooling towers** will be of significant importance.
- It is not possible to develop a NPP EIA report that would not be commented. One can always at least have a different opinion of the results, regardless of the facts. Thus, the work needs to be done independently, proactively and thoroughly and accept small additions based on the reasoned conclusion of the coordinating authority.

- Important to carefully and decisively specify the scope of the EIA procedure during the EIA programme phase. The project developer shall politely state that those parts that are not included (e.g. nuclear fuel production chain) are not part of the project. Furthermore, in case something that was promised to be done in the EIA programme is excluded, the reason for the deviation needs to be clearly expressed and justified externally. If something is just left out this will raise questions. In the EIA programme of the Loviisa NPP, it was for example mentioned that environmental impacts of water construction related to the cooling water intake would be assessed, but this option was abandoned due unfinished plans. The authorities were calling and asking for these.
- The EIA procedure should not be bound to specific plant technologies. Instead the environmental impacts should be assessed based on an envelope approach, so that the EIA procedure should not need to be redone in case there is a change in plant technology and supplier (i.e. case Fennovoima in Finland).
- The environmental impacts are more extensive in greenfield sites compared to existing sites, which is reflected in the public discussion and concerns.
- It is very important to assess the current status of the environment sufficiently enough, in order to enable a proper assessment of the environmental impacts. This is particularly important for greenfield sites. The same level of background information is required for all the potential site alternatives, so that the environmental impacts for the different site alternatives can be appropriately compared. For nuclear sites assessment of radiological status of the environment is a specific need, even though it can be expected that it will not hamper the project.
- Assessment of potential dangers posed to areas outside the plant by chemicals already in the EIA report would be good, especially for a greenfield site.
- With regards to employment effects the amount of foreign labour and the degree of domestication should not be forgotten.
- In case there are Natura 2000 areas near the alternative sites, these require special attention.
- Preliminary results from cooling water modelling are needed when the discussions with the authorities are started.
- Extreme weather phenomena and sea level extreme values, considering impact of climate change, need to be thoroughly assessed. For extreme weather phenomena existing data and information from nearby weather measuring stations can be utilized.
- It is important to consider mitigation measures and monitoring programmes for environmental impacts in the EIA report.

- Resident surveys shall be done carefully and it is worth to invest in them.
- Endangered species are not necessarily a show-stopper, in case the species can be protected or moved.
- Potential partners/customers, technical and economical pre-conditions as well as environmental impacts for cogeneration need to be preliminary considered.
- Thorough assessment of birdlife, specific assessment of bird populations and impact of power lines on bird migration, is needed from the beginning. However, the 400 kV and 110 kV power lines will require an own EIA procedure.[38]
- Whatever the environmental impacts are, combined impacts need to be considered.
- Investigations related to sub-surface aquatic environment are emphasized. Sub-surface noise is something that has been emerging lately and it is most likely something that would need to be considered nowadays in Finland in under water construction.
- It is worth to note and well in advance prepare to assess aggregated impacts in case there are any other industrial activity in the vicinity of the alternative sites.
- Important to clearly state on what the results and assessments are based on. Old data and background information may not be relevant or reliable.

[38] In Finland, Fingrid Oy is responsible for the EIA procedures for the power lines.

# 3 MORE DETAILED INPUT

The more detailed input is provided in this chapter focusing on the following nuclear specific topics:

- Radioactive emissions (to the air and the sea).
- Impacts of cooling water discharge.
- Low and intermediate level active waste (LILW).
- Spent nuclear fuel.
- Impacts of nuclear accidents.
- Nuclear fuel production.

The data and information used in the EIA procedures related to the Loviisa NPP and their origin will be explained for each topic and the impact assessment approach used will be compared with the approach used in Fennovoima's EIA, thus, setting the basis for needed recommendations and research activities with respect to these topics for a greenfield NPP site.

## 3.1 Radioactive emissions

In Finland, the limit for the annual dose of a member of the public resulting from the radioactive emission to the air and sea during the normal operation of NPPs is 0,1 mSv a year according to the Nuclear Energy Decree (161/1988)[39].

This annual dose limit sets the basis for the emission limits of radioactive nuclides to the air and sea during normal operation. However, compared to these limits, Loviisa NPP has set much lower target values for the emissions of radioactive substances to the air and sea in the ALARA (As Low As Reasonably Achievable) operational programme based on plant's operating experiences.

At the Loviisa NPP, the emissions of radioactive substances into the air and sea are constantly monitored with accurate measurements in order to ensure that the radioactive emissions do not exceed the limits set by the Loviisa NPP and enforced by STUK and that the annual radiation doses are below the limits of the Nuclear Energy Decree (161/1988).

The radiation control of Loviisa NPP's environment is based on continuous dose rate measurements, air and fallout samples, seawater samples and samples taken from the food chain. The radioactive emissions are monitored by measurements, both within the power plant area and its environment and the emissions' dispersion into the environment is monitored in accordance with the environmental radiation control programme approved by STUK. Loviisa NPP's radioactive emissions are reported to STUK every three months. STUK's independent monitoring complements the power plant's own monitoring.

[39] https://www.finlex.fi/fi/laki/kaannokset/1988/en19880161_20200000.pdf (Accessed on 20.9.2022)

### 3.1.1 Loviisa experiences

The radiation doses caused by the radioactive emissions to the air and sea during the operation of the Loviisa NPP are calculated and reported yearly to STUK. The caused radiation doses are calculated based on the actual measured emissions, their spreading and dispersion in the atmosphere as well as their transportation and accumulation in the food chain.

The radiation dose calculations for radioactive emissions to the air are based on Tuulet programme, which is developed by Fortum and approved by STUK for use in the calculation of the radiation doses of the residents of nearby areas. The calculations are performed up to 100 km distance from the plant.

Meteorological data is essential for the radiation dose calculations considering radioactive emissions to the air. At the Loviisa NPP there is a weather mast with meteorological measurements (air temperature, wind direction, wind speed, precipitation etc.) as presented in Figure 7, so reliable and relevant meteorological data is available. Consequently, neither the meteorological data nor the radiation dose calculations have been a problem in the Loviisa NPP related EIA procedure regarding radioactive emissions to the air.

Figure 7. Weather mast and new weather station at the Loviisa NPP.[40]

[40] Fortum 2014.

As liquid radioactive effluents are discharged to the sea with the cooling water, spreading of the radioactive emissions to the sea is connected with the cooling water modelling, but for this purpose very rough results have been enough for the EIA reports related to the Loviisa NPP. There are also sea water temperature measurement in the sea area around the Loviisa NPP, one at the cooling water intake side and three at the cooling water discharge side. Additional, sea water measurements, including among other things current and temperature profile measurements, have been performed since the start of the Loviisa 3 project.

With regards to radioactive emissions to the air and sea, an assessment of the radiation doses for species is needed. For the EIA procedure of the Loviisa 3 NPP project, this was carried out by VTT based on the ERICA Assessment Tool[41]. In addition, both Fortum and STUK have as part of the environmental monitoring programme investigated radioactivity in species in the environment surrounding the Loviisa NPP, particularly in selected indicator organisms.

However, as with radioactivity in general, the biggest challenge regarding the radioactive emissions to the air and sea during normal operation are related to communication. Despite that the radiation doses caused by these radioactive emissions are insignificant compared to for example the background radiation and the total annual radiation dose of a person living near the Loviisa NPP and only a fraction of the set radiation dose limit, they generate fears and concerns in the public. The health effects of small radiation doses are stochastic and there are no reliable data or evidence on what the health effects of small radiation doses are. This has been and is being discussed in the international radiation protection community, but there is no consensus on how the effects small radiation doses are to be considered.

Regarding EIA procedures related to NPPs and radioactive emissions, this is of course not helped by the fact that there are studies claiming an increased incidence of childhood leukaemia in the vicinity of NPPs. Similar studies will be raised during the EIA procedure by both opponents and also by concerned local residents, with poor knowledge and understanding on this difficult to communicate topic.

In the case of the EIA procedure of the Loviisa 3 NPP project, STUK stated separately their opinion on the issue, noting that an increased incidence of childhood leukaemia in the vicinity of NPPs could not be observed in Finland. The statement by STUK was a really good reference and made it possible to keep the discussion related to the issue rather short.

### 3.1.2 Greenfield considerations

In the EIA procedure of Fennovoima's NPP project, the radioactive emissions to the air and sea have been presented based on the operating experiences of the operating NPPs in Finland. References have been made to public reports of STUK, including information from the yearly reports from the license holders

[41] https://erica-tool.com/ (Accessed on 20.9.2022)

on measured radioactive emission to the air and sea as well as the radiation doses caused by them to the nearby residents.

As demonstrated by the operating experiences from the Finnish NPP, the emissions of radioactive substances to the air and to the sea are significantly below the set limits and the caused radiation doses are insignificant. Thus, the radioactive emissions to the air and sea are no way a show-stopper for any modern NPP, if the viewpoint is on health effects and fear-mongering does not manage to direct the discussion away from the facts.

The monitoring of the radioactive releases to the air and to the sea will eventually be defined in the environmental monitoring programme. The details will come later and thus, for a greenfield site it is sufficient to address the radioactive releases to the air and sea on a general level, based on national/international experiences, during the EIA procedure. The spreading of the radioactive emissions to the sea are connected with the cooling water modelling.

However, the concerns related to the health impacts of radioactive emissions to the air and to the sea by the local residents are surely stronger for a greenfield site compared to an existing NPP site. The local people at a greenfield site does neither have the “own experience” nor the same amount of understanding on the issue.

### 3.1.3 Recommendations

The radioactive releases to the air and sea are important for the overall acceptance of the project. However, it is not truly a problem. It is, nevertheless, important that the project developer takes the radioactive releases to the air and sea seriously and is prepared to discuss health effects of small radiation doses.

Detection of radioactive emissions is easy and even small emissions of radioactive substances both to the air and sea can be detected reliably. There are always some small emissions of radioactive substances from a NPP during normal operation and radioactive substances originating from the NPP will be found in the surroundings of the plant. However, the levels are insignificant and they do not have any impact on the health of people and for species. It is imperative that the project developer does not fail in communication related to this issue.

In order to set the framework for discussing and assessing radioactive releases to the air and sea, the national legislation and regulations need to define possible emission limits and/or radiation dose limits for normal operation as well as for incidents and accidents.

A strong advice is to hold a firm position that the radiation dose limits are set primarily based on health effects. Changing any limits later will be very difficult, if not impossible, due to link to EU notifications etc. In case only radiation dose limits (and not emission/release limits) are set in the legislation, as in Finland, the project developer needs to be capable to calculate and define the corresponding site relevant nuclide specific emission limits.

In the EIA procedures related to the Loviisa NPP, the radioactive emission to the air and sea and the related dose calculations have been presented and performed, respectively, too heavily, mainly because it has been possible due to existing data and capabilities. For a greenfield site, calculations based on detailed site specific meteorological data is really not needed at the EIA procedure stage. The assessments can be carried out based on meteorological data available nearby the intended site. Small uncertainties regarding meteorological data is completely acceptable in the beginning of the project.

In case more detailed and site specific meteorological data is wanted for the EIA procedure, this can be obtained by sounding technologies, such as sodar/lidar, instead of a fixed weather mast. The length and goal of the measurement campaign needs to commensurate with the height of the emission to the air.

However, it must be noted that more detailed local site and environmental data is needed for the design of the plant compared to what is needed for the EIA procedure. Thus, if the plant design is to be started early, detailed site and environmental data must be available, which could then also be possible to utilized in the EIA report.

With regards to radioactive emissions to the air and sea, an assessment of the radiation doses for species needs to be performed. For example the ERICA Assessment Tool[42] can be utilized to assess the radiological risk to terrestrial, freshwater and marine biota. With the small amounts of radioactive emission to the air and sea during normal operation, it is not a problem for a NPP, but in case this is not done, it can cause some trouble.

Finally, social media is nowadays in a key position regarding spreading of false information and fear-mongering, therefore it should be considered what kind of role the project developer takes in that regard.

## 3.2 Impacts of cooling water discharge

### 3.2.1 Loviisa experiences

Since the Loviisa 3 NPP project, Fortum has developed four different cooling water models and Fortum's subcontractor DHI has performed some additional cooling water investigations. DHI[43] is a global consulting company specialised in water environment offering unique software also for cooling water modelling. DHI developed for Fortum the first cooling water model based on the Mike 3 FM software[44]. After this Fortum acquired the Mike 3 FM software and it has been used to develop several versions of the cooling water model.

All the different cooling water models and simulations for the EIA procedures related to the Loviisa NPP have been done in-house and independently by Fortum. For the EIA report of Loviisa NPP, the hydraulic calculations were carried

[42] https://erica-tool.com/ (Accessed on 20.9.2022)
[43] https://www.dhigroup.com/ (Accessed on 20.9.2022)
[44] https://www.mikepoweredbydhi.com/products/mike-3-wave-fm (Accessed on 20.9.2022)

out with the Mike 3 FM non-hydrostatic flow model with an adjustable computational mesh, in which the calculations are based on complete three-dimensional equations. The used cooling water model, modelling methods and the results for the EIA report of Loviisa NPP are presented in a separate report (Appendix 4 of the EIA Report)[45].

At the Loviisa NPP, there are continuous temperature measurements in the surrounding sea, one on the cooling water intake side and three on the discharge side providing valuable data with regards to cooling water modelling. In the Loviisa 3 NPP project, there were several cooling water intake and discharge combinations considered, including options with both distant intake and distant discharge. In order to provide data for the cooling water modelling as well as for the assessment of the environmental impacts, there were several additional measurements carried out at the potential intake/discharge locations and nearby sea area for the Loviisa 3 NPP project.

Sea water temperatures, stratification and currents were measured and monitored at different depths with long-term measurement buoys, as presented in Figure 8. In addition, nutrients and salinity were measured manually from time to time. Since the beginning of the Loviisa 3 NPP project many cooling water modelling and potential underwater construction related investigations have been carried out, including also sounding of the seabed in the areas of the cooling water intake and discharge locations and the main flow paths.

Figure 8. Additional sea water measurement buoy in the sea area outside of the Loviisa NPP.[46]

With regards to cooling water modelling, it is to be noted that even with good data and background information, the development of the cooling water model

[45] https://tem.fi/documents/1410877/89823965/EIA+Report+3.pdf/47bb439d-550a-8018-a1d9-ef8913013bb6/EIA+Report+3.pdf?version=1.0&t=1632227202524, Appendix 4 (Accessed on 27.6.2022).
[46] Fortum 2013.

as well as the simulations take time. The computers and software have significantly developed, but the computational time for a sophisticated and detailed cooling water model is still hundreds of hours for a single case. During the EIA procedure of the Loviisa 3 NPP project, the results of the cooling water modelling came unnecessary late considering a smooth overall progress of the EIA procedure.

In order to validate the cooling water model, aerial photography and satellite images during winter have been used to evaluate the ice conditions, as presented in Figure 9 and Figure 10, respectively. In general, the validation of the cooling water model for winter is difficult, due to the ice cover. Computationally, summer time is ok, but winter time is problematic, due to the ice cover. It can be said, that there are at the moment not good enough models to take into account freezing of the sea and melting of the ice.

Figure 9. Aerial photo of the Loviisa NPP in winter 2009.[47]

[47] Fortum 2009.

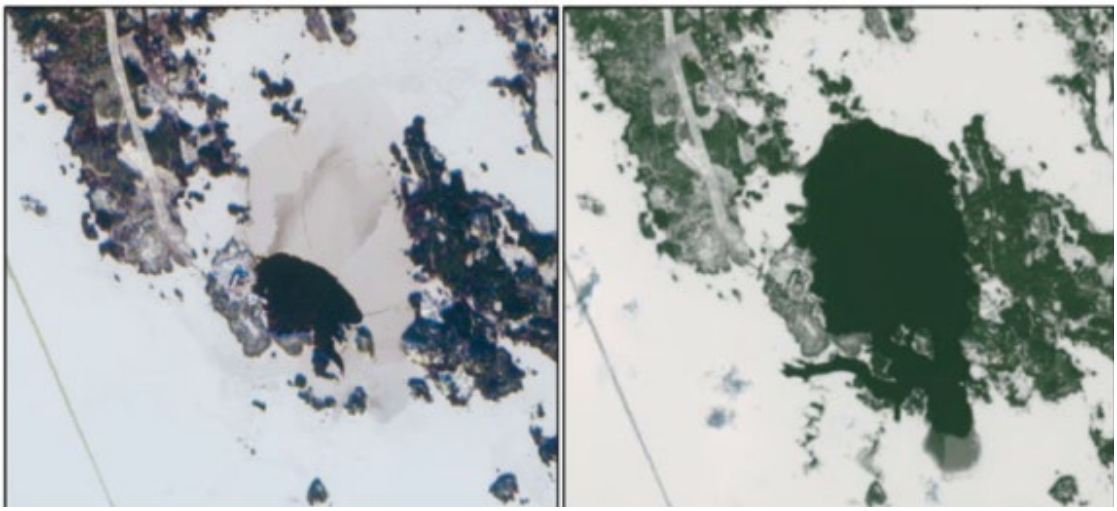

Figure 10. Variation in the size of the area of meltwater in the Loviisa NPP's sea area in the winter of 2018 (left picture February 27th and right picture April 3rd).[48]

When assessing the environmental impacts of the cooling water the EU Water Framework Directive (WFD) must be considered, which might even be a show-stopper, considering heat load and a particular sea area type. Due to the WFD and the proposed classification of the Hästholmsfjärden to where the cooling water of Loviisa NPP is discharged, discharging of any additional heat load to Hästholmsfjärden is extremely problematic.

In the EIA procedure for Loviisa NPP, the cooling water modelling was performed for the exceptionally warm summer of 2011. The selection of the modelling year aimed to consider the impact of climate change which will increase the mean annual temperature and as a result of which conditions warmer than average may occur at sea. For the winter time year 2018 was used.

### 3.2.2 Greenfield considerations

The environmental impacts related to the cooling water of a NPP are those that are highlighted in the discussions. Especially, for a greenfield site, the impacts on the aquatic environment, birdlife and fish etc. are of great interest and concern to environmental authorities as well as local residents.

The biggest challenge regarding cooling water modelling for a greenfield site is the availability of good and relevant meteorological and hydrological data as well as bathymetry needed to define the boundary conditions for the model and for the validation of the model. As always with modelling, the validation of the cooling water model is also something that is more difficult for a greenfield site compared to an existing site with NPP in operation, where the spreading of the

[48] Original images: ESA Copernicus Sentinel Data, processed by: SYKE. TARKKA service. https://wwwi4.ymparisto.fi/i4/eng/tarkka/index.html?type=RGB&date=2021-06-27&datespan=1&name=DEFAULT&lang=en&zoom=5.31&lat=64.23000&lon=26.00000 (Accessed on 20.9.2022)

warm cooling water of the existing NPP can be measured and its impact during winter on the ice conditions can be observed.

In the EIA procedures of Fennovoima's NPP project, the cooling water modelling was done using the 3D flow model of Suomen YVA Oy[49, 50]. In the second EIA report of Fennovoima's NPP project, the cooling water model used data received from continuously operating measurements in the Hanhikivi sea area (current, temperature and salinity), data from the Nahkiainen weather station of the Finnish Meteorological Institute (wind, temperature and humidity), the discharge data of the major rivers that empty into the Bothnian Bay and Baltic Sea water depth data.

The cooling water model included the entire Bothnian Bay with the most detailed data given with a 80 m resolution for a 14,5 x 15,7 km area in front of the Hanhikivi headland. The accuracy of the model was tested by comparing the results with actual measurement data and observations. In the first EIA report of Fennovoima's NPP project, the cooling water model was validated against data from the Finnish Environmental Institute's Hertta database.

Due to availability of measurement data, in the second EIA report of Fennovoima's NPP project the cooling water modelling was based on the situation in the summers of 2009–2013 and the winters of 2010–2011 and 2012–2013. In the first EIA report, the calculations were based only on data from summer 2003 and the ice conditions were modelled based on January and February in 2002 and 2003.

### 3.2.3 Recommendations

In order to be able to assess the environmental impacts of cooling water discharge, data and background information on the current status of the environment as well as cooling water modelling is needed. Cooling water modelling is very important.

For the cooling water modelling and the validation of the model, the availability of relevant data is the key. Data is needed on sea water temperatures, stratification, currents, local wind conditions and on bathymetry. In order to obtain the necessary data, local measurement and investigations expanding over a longer time period is needed. Data from measurements and investigations extending over one calendar year is a minimum. Once started the measurements should continue incessantly in order to collect more data (reliability, yearly variations).

It is, however, highly recommended that preliminary cooling water modelling is started already based on rough data, in order to obtain early on understanding on possible challenges, such as for example re-circulation of warm water to the cooling water intake and impact on Natura 2000 or other preservation areas.

[49] https://tem.fi/documents/1410877/2821523/EIA+report.pdf/9d862ccb-4478-46e9-95ff-31d7fdbd042e/EIA+report.pdf?t=1465115653000, Chapter 7.4.2 (Accessed on 27.6.2022). Link not working 20.9, but should be available at https://tem.fi/en/eia-report-2008. MEAE has been contacted.
[50] https://tem.fi/documents/1410877/2818159/Fennovoima+EIA+report+2014.pdf/fa421bdd-4f94-405c-be5b-6142eb59f70f/Fennovoima+EIA+report+2014.pdf?t=1464950758000, Chapter 7.4.2 (Accessed on 20.9.2022)

One important note is that access to detailed bathymetry of larger sea areas is in Finland limited due to security reasons. The depth information in normal nautical charts has not been sufficient anymore regarding the cooling water modelling of the Loviisa NPP and therefore, Fortum has conducted soundings of the sea bed subject to license in the sea areas around the Loviisa NPP.

Cooling water modelling requires special knowledge and expertise and it is extremely important that there is a good understanding of the modelling methods and the model, including computational grids, equations and solvers. Unless the project developer is experienced in Computational Fluid Dynamics (CFD) modelling, the cooling water modelling should be sub-contracted. However, the project developer should have a good understanding on the modelling process or at least, on the reporting needs.

The impacts of cooling water discharge on the aquatic environment etc. need to be thoroughly assessed. The thermal impact of the cooling water increases among other things eutrophication. Different levels of the ecosystem need to be taken into account in the assessment, such as for example algae, plankton and fish. In general, the earlier results from cooling water modelling are available the better it is for a smooth progress of the whole EIA procedure.

Both recreational and professional fishing may have an important role locally and therefore, the impacts on fishing needs to be assessed thoroughly. This includes impacts on spawning of fish and spawning areas as well as on the routes of migratory fish species. It is also important to consider the impact of the thermal load on the ice conditions and its impact on fishing during winter.

The cooling water modelling needs to be done well and the model, modelling and the results need to be documented, so that the data used and the modelling methods etc. are clear. It is not sufficient to only present the results. In the Loviisa NPP related EIA procedures the cooling water modelling has been described in a separate topical reports.

In general, the planning of the cooling water arrangements are of essential importance regarding the environmental impacts related to cooling water discharge. Possibilities to limit the environmental impacts should be thoroughly investigated and discussed in the EIA report, e.g. use of cooling towers as well as distant discharge and distant deep intake options for the cooling water.

For the EIA procedure it is important to notice that both combined impacts of cooling water discharge and discharge of nutrients to the aquatic environment as well as aggregated impacts with other actors need to be considered. One challenge related to aggregated impacts may be obtaining initial data from other actors.

Fortum has developed several cooling water models for the Loviisa NPP that have successfully been utilized in the EIA procedures related to the Loviisa NPP in order to assess the spreading of the cooling water and as basis for the assessment of the environmental impacts. In the future, Fortum can support Fermi

in cooling water modelling either as a matter expert or even develop the cooling water model and perform the cooling water modelling as a consultant.

## 3.3 Low and intermediate level radioactive waste

### 3.3.1 Loviisa experiences

Considering the EIA procedures related to the Loviisa NPP and management of low and intermediate level radioactive waste (LILW), the existing practices and facilities at the Loviisa NPP as well as earlier promises made were to some extent an encumbrance. Thus, near surface storage and final disposal of LILW were for example not included in the EIA procedure of Loviisa NPP. However, the construction of a deep geological repository is an expensive solution.

Handling, storing and final disposal of radioactive waste generated elsewhere in Finland was introduced as an alternative in the EIA procedure of the Loviisa NPP based on national interest. Despite this, it was a completely new issue and even though the amounts and activity were negligible compared to the wastes generated in the Loviisa NPP the issue was raised in many statements and the concerns were highlighted in the resident surveys. The concerns were not limited to the final disposal, but also to related transportations.

In the EIA procedure of Loviisa 3 NPP project, the management of LILW was based on the current practices at the Loviisa NPP with an extension of the existing geological repository for LILW. In general, due to the existing LILW repository at the Loviisa NPP site, the topic was not considered very relevant in the case of the EIA procedure of Loviisa 3 NPP project.

### 3.3.2 Greenfield considerations

For a new site, handling, storing and final disposal of LILW might even be a bigger concern for the local residents considering the NPP site than accidents and the NPP itself. The role and significance of LILW were in the EIA procedures of Fennovoima's NPP project much larger compared to the EIA procedure of the Loviisa 3 NPP project. Therefore, the project developer needs to have both expertise and plans to present regarding the management of LILW and its environmental impacts.

In the EIA procedure all different alternatives for the final disposal of LILW should be kept open, if not clearly limited by the national legislation. There are plenty of examples of different practices from operating NPPs around the world that can be used to describe different solutions and their environmental impacts. However, some site specific information is also needed.

The environmental impacts during the construction of the final disposal facility of LILW must at least be presented and assessed. Aspect regarding ensuring the long-term safety of the final disposal of LILW will likely, and can, remain open at the stage of the EIA procedure.

The main question regarding final disposal of LILW is, however, how much can be left open in the EIA procedure for the NPP, so that an own EIA procedure would not later be needed for the final disposal facility of LILW.

### 3.3.3 Recommendations

The management of LILW is an important issue for the public acceptance of any NPP project. The challenge is that the public needs to be convinced of an issue that they do not know anything about. Therefore, it is recommended that in communication and in the EIA report simple examples based on information and guidelines of the IAEA are utilized.

Regarding LILW, it needs to be considered in Estonia how the Soviet time legacy and allegations and suspicions related to poor management of radioactive waste in Sillamäe and Paldiski are handled. It is very difficult to imagine that this would not be raised in the discussions in case of a NPP EIA procedure in Estonia. The main message should be that the generated waste is dealt with immediately and not left waiting, i.e. clear plans for handling, storing and final disposal of LILW. In addition, the experiences from Sillamäe and Paldiski should be used to the maximum extent and if still needed, consider possible synergies in handling, storing and final disposal of LILW. The idea of a national waste management strategy would most likely be very good for the political acceptance of the project.

In general, minimization of LILW is essential and it is meaningful to put effort on handling and packaging of LILW. However, the most economical alternatives and solutions for handling, storing and final disposal of LILW need to be identified and included in the EIA procedure. This could also include considerations of cooperation and synergies with other actors handling and generating LILW.

## 3.4 Spent nuclear fuel

### 3.4.1 Loviisa experiences

In the EIA reports related to the Loviisa NPP the descriptions concerning management of spent nuclear fuel, including intermediate storage and final disposal of spent nuclear fuel, were based on the current practices at the Loviisa NPP and the plans for final disposal of spent nuclear fuel by Posiva.

The spent nuclear fuel of the Loviisa NPP is to be disposed in Posiva's final disposal facility in Eurajoki, where there would also have been space for the spent nuclear fuel of the Loviisa 3 NPP. The descriptions regarding the final disposal of spent nuclear fuel in the Loviisa NPP related EIA procedures are based on material from Posiva.

In the public events of the EIA procedures related to the Loviisa NPP, there was an expert available with sufficient knowledge of final disposal of spent nuclear fuel that could immediately provide answers related to questions on final disposal of spent fuel. For example, the always returning question regarding the corrosion of the copper capsule in the so-called KBS-3V method was again raised.

### 3.4.2 Greenfield considerations

For a greenfield site, especially in a nuclear newcomer country, the status of possible national plans, if any and/or national arrangements related to the final disposal of spent nuclear fuel are the most essential. The national legislation is decisive considering for example export of spent nuclear fuel and reprocessing.

For example, the final disposal of the spent nuclear fuel of the NPP units owned by Fortum and Teollisuuden Voima (TVO) in Finland is in the responsibility of Posiva, owned by Fortum and TVO. However, Posiva was presented as one alternative for the final disposal of spent nuclear fuel in the EIA reports of Fennovoima's NPP project. The second alternative was to construct an own final disposal facility. For the descriptions Fennovoima has utilized to a large extent material from Posiva.

In June 2016 Fennovoima submitted an EIA programme on Fennovoima's own spent nuclear fuel disposal facility to the MEAE[51].

### 3.4.3 Recommendations

Handling, storing and final disposal of spent nuclear fuel is defined by the national approach set in the nuclear legislation. In 1994 the import and export of spent nuclear fuel was prohibited in Finland when the Nuclear Energy Act (990/1987)[52] was amended. The amendment entered into force in 1996 and until year 1996, the spent nuclear fuel from the Loviisa NPP was returned to Russia.

Especially for a greenfield site, both water and air cooled alternatives for the intermediate storage of spent nuclear fuel should be considered, without any prejudices. At existing NPP sites the current solution for the intermediate storage of spent nuclear fuel can be much guiding, due to experience, licensing and economics.

It is recommended that the environmental impacts of the intermediated storage of spent nuclear fuel, including different types of storage alternatives, are assessed in the EIA report for the NPP, so that the intermediate storage facility for spent nuclear fuel does not need an own EIA procedure. Timewise, the intermediate storage facility is for traditional large NPPs needed roughly 10 years after the start of operation, but if handled separately later, a EIA procedure is required.

Transportation alternatives for spent nuclear fuel from the intermediate storage facility to the final disposal facility should be described to the extent possible and their environmental impacts assessed at least on a general level. The location of the final disposal facility does not need to be determined at this stage.

Regarding final disposal of spent nuclear fuel, it is very likely that at the stage of the EIA procedure many things are still open. However, it is of utmost importance that there is at least a clear and solid plan on how to proceed with the

[51] https://tem.fi/en/eia-programme-2016 (Accessed on 20.9.2022)
[52] https://www.finlex.fi/en/laki/kaannokset/1987/en19870990_20200964.pdf (Accessed 20.9.2022)

questions related to the final disposal of spent nuclear fuel. In practice, background work needs to have been done, but everything does not need to be included in the EIA report for the NPP project.

Whatever, the plan or intended solution for the final disposal of spent nuclear fuel is, the final disposal facility will, nevertheless, require an own EIA procedure. In addition, there is tens of years of time after the start of operation of the NPP to decide on the final disposal of spent nuclear fuel.

However, the problematic of the final disposal of spent nuclear fuel requires a proactive actions, in order to define the national strategy or in order to ensure the acceptance of the proposed plans.

Questions related to the final disposal of spent nuclear fuel are surely to arise in the public events. Therefore, it is suggested to have in the public events an expert on final disposal of spent fuel.

## 3.5 Impacts of nuclear accidents

In Finland, the assessment of the environmental impacts of a severe reactor accident is based on the postulation that 100 terabecquerels (TBq) of the caesium-137 (Cs-137) nuclide is released into the environment as referred to in section 22 b of the Nuclear Energy Decree (161/1988)[53]. This hypothetical severe reactor accident includes other radionuclides in proportion to how much of them would be expected to be released in proportion to Cs-137 and be equal to a level 6 accident on the International Nuclear Event Scale (INES).

While the impacts of nuclear accidents are part of the EIA procedure, in Finland the actual accidents are analysed and the analyses are assessed and approved by STUK as part of the Construction License that is applied for in accordance with the Nuclear Energy Act.

In the EIA procedures of the selected Finnish NPP projects, impacts of nuclear accidents have been assessed and addressed to a different extent during the years. Based on the recent EIA procedure of Loviisa NPP, the requirement level seems to be tightening in Finland and the environmental impacts of less severe accidents must nowadays also be considered. So far more severe reactor accidents than 100 TBq Cs-137 have not needed to be assessed in the EIA procedures, despite the re-occurring questions and statement related to this. This discussion has, however, also had its impacts.

### 3.5.1 Loviisa experiences

#### General

Considering environmental impacts related to nuclear accidents, more was required for the EIA report of the Loviisa NPP compared to the EIA report of the Loviisa 3 NPP project. In the EIA report of Loviisa 3 NPP project, the environmental impacts were assessed only for a severe reactor accident (100 TBq,

[53] https://www.finlex.fi/fi/laki/kaannokset/1988/en19880161_20200000.pdf (Accessed on 20.9.2022)

INES 6), whereas in the EIA report of Loviisa NPP a more likely Design Basis Condition (DBC) 3 accident (INES 4) was also addressed.

The INES 4 accident was included in the EIA report based on the statement of the contact authority for the EIA programme of the Loviisa NPP. The starting-point for this might well be the fact that an INES 4 accident was assessed in the EIA reports of Fennovoima's NPP project already in 2008.

During the EIA procedures related to Loviisa NPP, the discussion concerning the environmental impacts of severe reactor accidents has been limited to the release of 100 TBq of Cs-137 in accordance with the Nuclear Energy Decree. Answers have not been provided to questions about more or most severe accidents, but simply referring to the accident defined in the Finnish legislation. The Finnish approach has mainly been criticised in the international hearing.

In general, the discussions related to the environmental impacts of severe reactor accidents are stigmatized by the Chernobyl accident and Fukushima, which represent different technology than NPPs with e.g. Gen III reactors and SMRs or even Loviisa, in which continuous safety improvements have been carried out through-out the years. Nevertheless, in the EIA report of Loviisa NPP, the magnitude and impacts of the assessed INES 6 accident were qualitatively compared to those of the Chernobyl and Fukushima accidents.

It is also worth to note, that Fennovoima included an assessment of a INES 7 accident, which was five times higher compared to the INES 6 accident, in the second EIA procedure of Fennovoima's NPP project in 2014. This was also discussed with the contact authority during the EIA procedure of Loviisa NPP.

**Modelling**

The modelling of the radiation doses and the radioactive fallout in a severe reactor accident in the Loviisa NPP related EIA procedures have been performed in-house by Fortum with the Tuulet programme, which is developed by Fortum. Tuulet programme has been approved by STUK for use in the Loviisa NPP licensing/safety calculations of the radiation doses of the residents of nearby areas (up to 100 km).

In the EIA procedure of Loviisa NPP, the modelling was based on the Tuulet 2.0.0 programme version, which was modified for the purpose to allow for an assessment of the emission and the obtained radiation doses up to a distance of 1000 km from plant in a severe reactor accident. The 1000 km distance was proposed as the impact area by Fortum to the Ministry of the Environment based on established practice, especially considering the transboundary environmental impacts. For the less severe INES 4 accident the emission and radiation doses were assessed up to 100 km distance from the plant.

However, extending the calculations from 100 km to 1000 km is somewhat problematic. At longer distances, a Gaussian model is not feasible. Instead a trajectory model should be utilised, but this would increase the calculation capacity exponentially. Therefore, three years' weather data was utilized in the EIA report of Loviisa NPP, in order to allow statistical radiation dose and fall-out

modelling. The analysis results were reported using 5 % exceedance probability meaning that no more than 5 % of the radiation doses may be higher than those reported.

In the EIA procedure of the Loviisa NPP, the source terms used for the radiation dose calculations in accident situations were obtained directly from the safety analyses of the existing units. For the EIA procedure of the Loviisa 3 NPP project, the source term for a severe reactor accident was scaled to 100 TBq Cs-137 based on the source term of the existing units at the Loviisa NPP, taking the longer fuel burn-up of the considered plant alternatives into consideration.

In the assessment of the radiation doses both the external and internal radiation doses need to be calculated, in order to obtain the total radiation dose. For the calculation of the internal radiation dose, food chains and eating habits etc. are needed. These are local and they need to be specified separately, for different geographical areas as well as age groups. The definition of the so called representative person (living and eating habits) is challenging and finding the right calculation parameters is difficult. The Finnish regulations and guidelines do not include requirements on calculation parameters.

The radiation dose calculations are partly best estimate and partly conservative. For example, in the assessment no account for actions that aim to protect the population, such as seeking shelter indoors and changes in food intake are taken.

In the EIA procedures related to the Loviisa NPP, radiation doses and fallout have been presented as results. This has been sufficient. The results have been presented for various distances from the NPP for integration times ranging from one day to one year, as well as lifetime, for three different age groups.

Meteorological data is essential for the radiation dose calculations, in order to assess the dispersion of the radioactive release and fallout. At the Loviisa NPP there is a weather monitoring system including a fixed weather mast and an extensive local meteorological database. For the radiation dose calculations of the EIA procedure related to the Loviisa NPP, meteorological data of three representative years over a 10 year period has been used. However, due to excellent data available from the past years (new weather measurements), most likely data for a longer consecutive period would be directly used today. An important note is that even though there is local meteorological data available for the Loviisa NPP site for nearly 50 years, old data does not matter, as the climate and weather has changed.

### 3.5.2 Greenfield considerations

The radiation dose calculations for the EIA procedures of Fennovoima's NPP project were performed by a German consultant. The calculation model (Gaussian model) was based on the regulations of the German authorities regarding dispersion and fallout parameters and radiation dose calculations and thus, provided additional results compared to Tuulet program used in the EIA procedures related to the Loviisa NPP. For example, in the EIA reports of Fennovoima's

NPP project, thyroid gland radiation doses and activity concentration in various food products were presented.

For a new nuclear company, without existing NPPs in operation, the definition of the source term might be challenging. In the EIA procedures of Fennovoima's NPP project, the source term has been defined based on the regulations of Strahlenschutzkommission Störfallberechnungsgrundlagen (SBG) and Nuclear Regulatory Commissioning (NRC), scaled based on the 100 TBq Cs-137 set in the Nuclear Energy Decree. Due to the different methods used in the first and second EIA report, there is a significant difference in the release of other nuclides than Cs-137.

For a newbuild project, clearly specified severe accident and radiation dose limits in the national regulations would be good. Despite complaints, the approach taken in Finland has turned out very pragmatic and useful.

For a greenfield site, the availability of meteorological data needed for the radiation dose calculations might be a challenge. However, the data can be accumulated using nearby existing national weather monitoring stations and if needed by combining data from several monitoring stations as the first order approximation.

### 3.5.3 Recommendations

The main issue regarding the environmental impacts of nuclear accidents and their assessment is, what the national approach is. This needs to be defined in the national legislation and regulations, as it determines what is needed and how the issue shall be addressed/presented. This includes the definition of the emergency preparation zones (EPZ), evacuations, radiation doses and the release.

In Finland, the 100 TBq Cs-137 has been a very useful number for large NPPs, as it is defined in the legislation, but this approach is not feasible for SMRs. Considering radiation dose calculations, the importance of the source term cannot be stressed enough. Definition of the source term for SMRs and the acceptable releases and radiation doses needs to be carefully thought. The Estonian Environmental Board, for example, noted that in the case of Loviisa NPP 3300 TBq should be used for assessing the environmental impacts of a severe reactor accident (see Section 2.6.2.1).

Fortum has long experience in radiation dose calculations and it can easily be stated that simplifications must be done for the EIA report. The most simple recommendation is to limit the considered cases and keep away from so called "worst case scenario" discussions. Note that impacts of larger releases can be scaled easily based on the results of for example the 100 TBq Cs-137 release, as nuclide ratios do not significantly change in larger releases. The calculated radiation doses and fall-outs can simply be multiplied with a chosen number. Furthermore, it is not recommended to calculate or even present results for organ specific radiation doses, if they are not required.

It is recommended to document the radiation dose calculations, including description of model, modelling methods and results with conclusions, in a separate report. As a detail, it can be mentioned that in an extreme case a single analysis report on severe accident dose calculations can be more than 450 pages long, if all data plots for different analysis cases are shown. This is more than the entire EIA report for the Loviisa NPP.

In case the project developer does not possess long experience on radiation dose calculations, accident modelling and radiation dose calculations must be sub-contracted to an expert organization on the topic. In the future, Fortum can support Fermi in radiation dose calculations either as a matter expert or even develop the dispersion and radiation dose calculation model and perform the radiation dose calculations as a consultant. Fortum is constantly performing analysis and radiation dose calculations for operating unit at the Loviisa NPP.

## 3.6 Nuclear fuel production

### 3.6.1 Loviisa experiences

In the EIA report related to the Loviisa NPP project, the environmental impacts of the nuclear fuel supply chain, i.e. mining, milling, conversion, enrichment, fuel fabrication and transportations, that arise outside of the Finnish borders were not included in the scope of the EIA report.

In the EIA report related to the Loviisa 3 NPP project, the environmental impacts of the nuclear fuel production chain have been presented on a generic level. The environmental impacts have been presented, but not assessed in more detail. The descriptions in the EIA report are based on the experience and fuel contracts of the existing units of the Loviisa NPP, with reference to international guidelines and reports as well as STUK reports.

In the public events of the EIA procedures related the Loviisa NPP, there was a person present that had visited facilities of the front end of the nuclear fuel production chain, including mines, for the existing units of the Loviisa NPP. Consequently, the person was able, based on own experiences, to answer questions related to the front end of the nuclear fuel production chain.

### 3.6.2 Greenfield considerations

In the EIA reports related to Fennovoima’s NPP projects the description of the nuclear fuel production chain and the environmental impacts are based on public sources, including reports by STUK, World Association of Nuclear Operators (WANO) and the International Atomic Energy Agency (IAEA). General description, concerning uranium production volumes and availability of uranium etc., but no assessment of the environmental impacts. Environmental impacts are covered by brief description of quality and environmental goals set for nuclear fuel procurement.

It is worth to note that, in case the plant supplier would have been chosen, most likely also the fuel supplier for the plant would be known. Thus, providing the

possibility to describe the nuclear fuel production chain in more detail, if necessary.

Closely connected with nuclear fuel production chain and nuclear fuel, safeguards and proliferation of nuclear weapons must be mentioned as they may be topics of concern and be raised in the discussions. Especially, in nuclear newcomer countries these topics may not be well known.

### 3.6.3 Recommendations

Whatever the timing of the EIA procedure is compared to the signing of the plant supply contract or choice of plant supplier, it would be very good to have experience by one's own hand of the different steps of the nuclear fuel production chain, for example having seen a uranium mine with own eyes. The environmental impacts of the nuclear fuel production chain have been a recurring topic in the statements for the EIA procedures in Finland, mainly that they have not been assessed in detail.

A more detailed assessment of the environmental impacts of the nuclear fuel production chain in the EIA report is, however, not recommended, but own-handed experience provides a completely different starting point and credibility when answering questions related to the topic.

In general, World Nuclear Association's (WNA), World Association of Nuclear Operators' (WANO) and the International Atomic Energy Agency's (IAEA) instructions and guidelines for best practices with regard to both safety and the environment to be observed in the different stages of the nuclear fuel production chain is a good starting point. In particular, the principles of the WNA guidelines are intended for countries where legislation is not mature enough for taking environmental aspects of the nuclear fuel production chain into account to a sufficient degree.

With regards to the nuclear fuel production chain, it would be sensible to mention/consider in the EIA report also the possibility for own uranium production. This could be compared to uranium extraction operations of Terrafame in Finland.

In a nuclear newcomer country, some additional focus on describing safeguards and proliferation against nuclear weapons, based on for example IAEA guidelines should be considered.

# 4 PRELIMINARY RESEARCH PROGRAMME

The preliminary research programme presented in this Chapter encompasses a listing of necessary activities with indicative durations and time schedule for ensuring that all the required data/information is timely available and that the level of detail of the information is sufficient for the preparation of the EIA report.

The focus is on assessing the environmental impacts related to the nuclear specific topics addressed in Chapter 3, but some recommended activities related to the preparation for the public events have also been included. The duration of some of the activities is dependent on the level of detail that is targeted or required for the EIA report, whereas for some of the activities the duration and/or timing is due to seasonal dependency. The following activities related to the nuclear specific topics addressed in this report are presented in the preliminary research programme in Figure 11.

### Radioactive emissions to the air/sea

- Preliminary assessment of the current radiological state of the environment (radiological baseline) based on publicly available information
  - Possible radiological legacy of the alternative plant sites needs to be ruled out. In case there are indications of radioactive substances in the ground and sea bed of previous activities, more detailed field investigations are needed.
- Simple radiation dose estimates
  - Simplified dose estimates based on release data from reference plant or existing nuclear power plants. Preliminary cooling water modelling may be used for spreading description.

More detailed radiation dose estimates would require:

- ✓ Meteorological data and/or measurements (one year)
  - Temperature
  - Wind speeds and directions
  - Precipitation
- ✓ Dispersion and spreading modelling/cooling water modelling
- ✓ Detailed radiation dose modelling

### Impacts of cooling water discharge

The time required for the development of the cooling water model and cooling water modelling is highly dependent on the target level. Less can be enough for EIA purposes, but insufficient for the project development, i.e. design and optimisation of the cooling water arrangements.

- Acquiring publicly available satellite images of alternative plant sites
  - Good to have for assessing potential combined effects
- Acquiring publicly available local hydraulic and meteorological data
  - Sea water temperatures and stratification
  - Salinity
  - Water level
  - Currents
  - Wind conditions
- Local hydraulic (and meteorological) measurements
- Bathymetry
  - Intake and discharge locations and main flow paths. Sea bead soundings are season dependent.
- Cooling water model development
- Preliminary cooling water modelling
  - Based on publicly available data.
- Detailed cooling water modelling
  - Cooling water modelling based on one year measurement data (summer and winter conditions modelled separately).

**Impacts of nuclear accidents**

- Acquiring publicly available meteorological data
- Source term definition
  - Source term will need discussions between the project developer, plant supplier and regulator, unless it is defined in the legislation.
- Dispersion model development
- Radiation dose modelling

**Radioactive waste (low and intermediate active waste)**

- Visit to LILW repositories, e.g. Loviisa and Olkiluoto

Detailed assessment of the environmental impacts of final disposal of LILW and especially, for geological repository would require extensive additional investigations regarding:

- ✓ Ground water
- ✓ Soil/bed rock conditions

**Spent nuclear fuel**

- Visit to Posiva (encapsulation plant and final repository)

**Nuclear fuel production**

- Visit to facilities related to the fuel production, including uranium mine

It would be good that all of the aforementioned visits would to be done before the writing of the EIA report starts. However, the visits should be done at the latest before the public events related to the EIA report, as preparation for the public events.

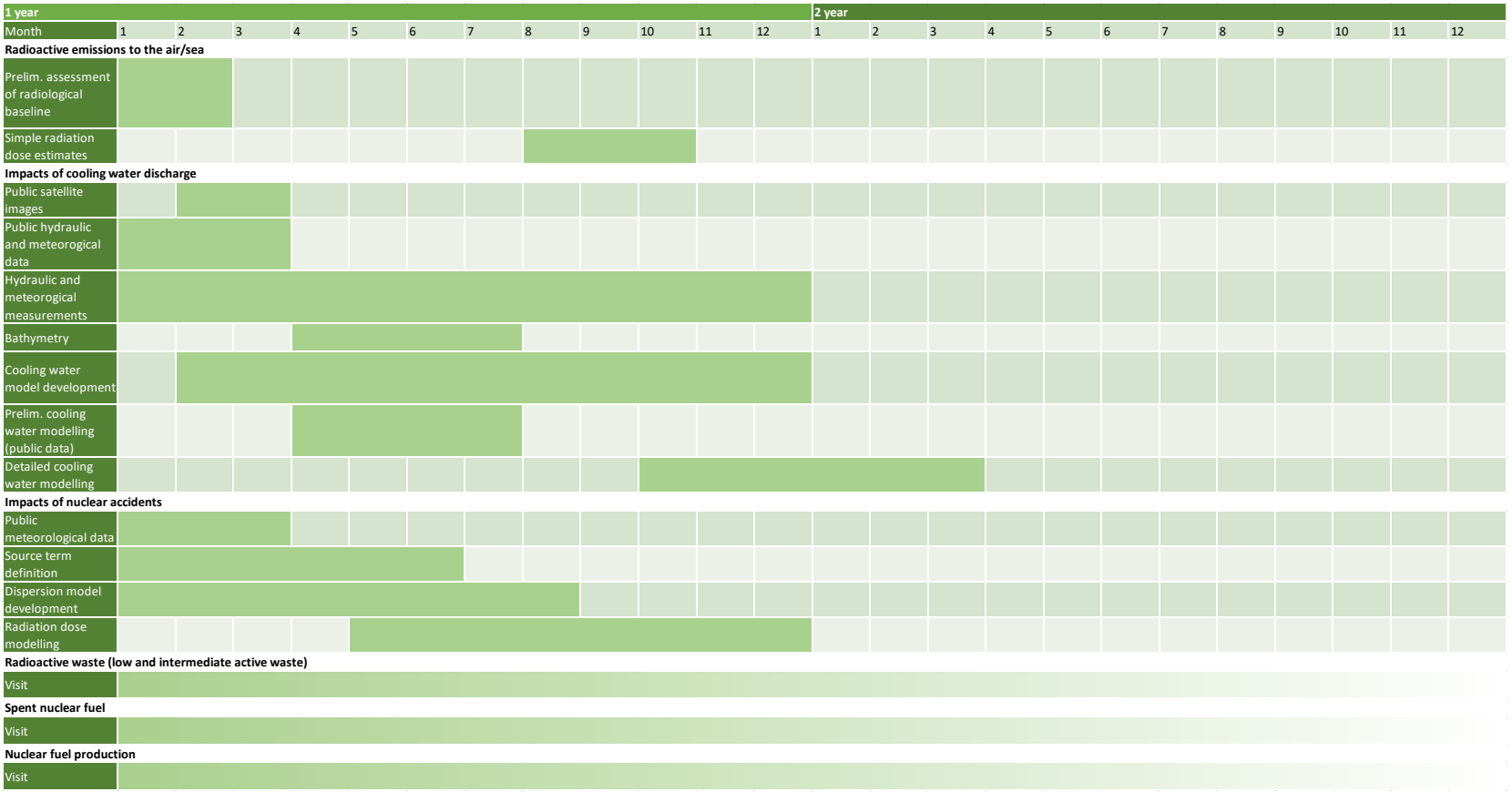


Figure 11. Preliminary research programme.[54]

[54] The presented durations and timings of the activities are indicative and assuming start of activities from the beginning of the calendar year. The duration of some of the activities is dependent on the level of detail that is targeted or required for the EIA report, whereas for some of the activities the duration and/or timing is due to seasonal dependency.