

**POSSIBILITIES FOR THE IMPLEMENTATION OF NUCLEAR ENERGY IN ESTONIA** 



**WORKING GROUP** 

TABLE	OF CONTENTS	2
ABBRE	VIATIONS	6
SUMMA	ARY AND CONCLUSIONS	8
INTRO	DUCTION	12
1. SHA	PING THE NATIONAL POSITION	15
1.1	PURPOSE AND COMPOSITION OF THE NUCLEAR ENERGY WORKING GROUP	15
1.2	IAEA INIR EXPERT MISSION TO ASSESS THE ACTIVITIES OF THE NEWG	17
1.3	SMALL MODULAR REACTORS (SMRS)	18
	1.3.1 Choosing the right technology for Estonia	20
1.4	CURRENT AND FUTURE DIRECTIONS IN THE ENERGY POLICIES OF ESTONIA'S NEIGHBOURING COUNTRIES AND THE EU'S LARGER COUNTRIES	21
1.5	NEED FOR NUCLEAR ENERGY AND ITS POTENTIAL	21
	1.5.1 Climate change mitigation	22
	1.5.2 Adapting to climate change	
	1.5.3 Hydrogen production and district heating	24
1.6	DECISION OF PRINCIPLE ON THE INTRODUCTION OF NUCLEAR ENERGY	25
2. NUCI	LEAR SAFETY	26
2.1	NUCLEAR LIABILITY	27
2.2	ENSURING NUCLEAR SAFETY IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME	29
3. MAN	AGEMENT	32
3.1	MANAGEMENT SYSTEM FOR THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME	32
	3.1.1 Management system of the nuclear power plant owner/operator	
4. FUNI	DING AND FINANCING	35
4.1	FUNDING FOR THE NUCLEAR ENERGY WORKING GROUP	35
	4.1.1 Expenses of the NUCLEAR ENERGY WORKING GROUP from the EU's Structural Funds	
	4.1.2 Expenses of the NUCLEAR ENERGY WORKING GROUP from the state budget	36
	4.1.3 In-kind contributions to the NUCLEAR ENERGY WORKING GROUP	37
	4.1.4 Funding for the NUCLEAR ENERGY WORKING GROUP in the implementation of a nuclear energy programme	38
4.2	FINANCING THE CONSTRUCTION OF A NUCLEAR POWER PLANT	39
	4.2.1 Share capital and potential investors	
	4.2.2 Borrowed capital	
	4.2.3 Price of electricity produced by a nuclear power plant	41
4.3	RISKS	43
	4.3.1 Bankruptcy risk of the nuclear power plant owner/operator	44
	4.3.2 Investment risks	45
4.4	DISK MITICATION STRATEGIES	4.0





		4.4.1	State participation in the construction of a nuclear power plant	47
	4.5		SES FROM THE STATE BUDGET FOR THE IMPLEMENTATION OF THE NUCLEAR ENERGY	48
		4.5.1	Costs of developing emergency response and technical capabilities	
	4.6		JE TO THE STATE BUDGET FROM THE IMPLEMENTATION OF THE NUCLEAR ENERGY	50
	<b>504</b> 1			
			EWORK	
	5.1		R ENERGY AND SAFETY ACT (TEOS)	54
	5.2		ATION THAT NEEDS TO BE AMENDED TO IMPLEMENT A NUCLEAR ENERGY PROGRAMME, DITIONAL REQUIREMENTS RESULTING FROM CONVENTIONS AND EU DIRECTIVES	56
	5.3		TED TIMETABLE AND COST FOR THE DEVELOPMENT OF A COMPREHENSIVE  ATORY FRAMEWORK	57
6. S	AFEC	SUARDS	S	58
	6.1	IMPLEM	ENTATION OF SAFEGUARDS IN ESTONIA	58
	6.2	IMPLEM	ENTATION OF SAFEGUARDS IN THE NUCLEAR ENERGY PROGRAMME	60
7. R	RADIA	TION P	ROTECTION	63
	7.1	RADIATI	ON PROTECTION IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME	64
8. R	REGU	LATORY	7 FRAMEWORK	67
	8.1	REGULA	TORY FRAMEWORK FOR THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME	
		8.1.1	Nuclear regulator	
	8.2	FUNCTION	ONS AND RESPONSIBILITIES OF THE NUCLEAR SAFETY REGULATORY BODY	69
	8.3	STRUCT	URE AND PERSONNEL OF THE NUCLEAR REGULATOR	70
	8.4		S TO ESTABLISH A REGULATOR FOR THE IMPLEMENTATION OF THE NUCLEAR ENERGY	73
		8.4.1	Legal basis for the creation of a regulator	
		8.4.2	Budget of the regulator	
		8.4.3	An alternative approach to the establishment of the Estonian nuclear regulator	74
			GRID AND THE SUITABILITY OF NUCLEAR ENERGY FOR THE RGY PORTFOLIO	77
	9.1		ICAL POWER SYSTEM IN ESTONIA	
	9.2		MPTION AND PRODUCTION IN THE ESTONIAN ELECTRICAL POWER SYSTEM	
	9.3		TY OF SUPPLY	
	9.4		G GENERATING INSTALLATIONS IN THE ELECTRICAL POWER NETWORK	
	9.5		CTING NEW GENERATING INSTALLATIONS	
	9.6		OF CONNECTING TO THE ELECTRICITY POWER NETWORK	
	9.7		T OF TIME SPENT ON CONNECTION	
	9.8		LITY OF NUCLEAR ENERGY FOR THE ESTONIAN ELECTRICAL POWER SYSTEM	
10.	HUM	AN RES	OURCE DEVELOPMENT	85
	10.1	EXISTIN	G TRAINING PROGRAMMES	85
		10.1.1	Training activities of the NUCLEAR ENERGY WORKING GROUP	87
	10.2	AVAILAB	LE HUMAN RESOURCES IN ECONOMIC SECTORS AND LABOUR FORCE PROJECTIONS	88
		10.2.1	Labour market prospects and needs	88





	10.3	PERSONNEL NEEDS AND COMPETENCE DEVELOPMENT OF THE NUCLEAR REGULATOR	90
	10.4	PERSONNEL OF THE NUCLEAR POWER PLANT OPERATOR	90
	10.5	HUMAN RESOURCES STRATEGY	92
	10.6	DEVELOPING NATIONAL CAPACITY	94
	10.7	FINANCING THE DEVELOPMENT OF NATIONAL CAPACITY	96
11.	STAK	EHOLDER ENGAGEMENT AND COMMUNICATION	98
	11.1	COMMUNICATION STRATEGY OF THE NUCLEAR ENERGY WORKING GROUP	98
	11.2	PUBLIC OPINION STUDIES	99
	11.3	COMMUNICATION AND ENGAGEMENT ACTIVITIES	100
	11.4	COMMUNICATION ACTIVITIES IN THE IMPLEMENTATION OF THE NUCLEAR ENERGY PROGRAMME	102
12.	SITE	AND SUPPORTING FACILITIES	103
	12.1	SPATIAL ANALYSIS OF THE SITE OF AN SMR	104
	12.2	FINAL DISPOSAL SITES FOR RADIOACTIVE WASTE	106
	12.3	NUCLEAR FUEL TRANSPORT	107
	12.4	SOCIO-ECONOMIC IMPACT OF A NUCLEAR POWER PLANT ON THE LOCAL COMMUNITY	108
	12.5	RECOMMENDATIONS FOR FURTHER ACTION FOR SITE SELECTION	108
13.	ENVI	RONMENTAL PROTECTION	111
	13.1	LEGISLATION RELATED TO ENVIRONMENTAL PROTECTION	111
	13.2	INTERNATIONAL OBLIGATIONS	111
	13.3	STUDIES AND ANALYSES CARRIED OUT	113
	13.4	ENVIRONMENTAL IMPACT OF THE LIFE CYCLE OF A NUCLEAR POWER PLANT	114
	13.5	NEXT STEPS IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME	115
14.	EME	RGENCY PLANNING	116
	14.1	ENSURING PREPAREDNESS FOR RADIOLOGICAL EMERGENCIES	116
	14.2	SAFETY OF NUCLEAR POWER PLANTS	118
	14.3	RADIOLOGICAL EMERGENCY RESPONSE, EVENT MANAGEMENT AND MONITORING	119
	14.4	EMERGENCY PLANNING IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME	122
15.	NUC	LEAR SECURITY	124
	15.1	ENSURING NUCLEAR SECURITY IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME .	124
16.	NUC	LEAR FUEL CYCLE	127
	16.1	NUCLEAR FUEL PRODUCTION (FRONT-END)	127
	16.2	ENSURING SECURITY OF NUCLEAR FUEL SUPPLY	127
	16.3	MANAGEMENT OF SPENT NUCLEAR FUEL (BACK-END)	129
17.	RAD	IOACTIVE WASTE MANAGEMENT	131
	17.1	REGULATION OF RADIOACTIVE WASTE	131
	17.2	SPENT NUCLEAR FUEL OR NUCLEAR WASTE	132





	17.3	GENERATION AND MANAGEMENT OF RADIOACTIVE WASTE ARISING FROM THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME	133
		17.3.1 Closed and open fuel cycle	
	17.4	ENSURING THE LONG-TERM SAFETY OF SPENT NUCLEAR FUEL	135
		17.4.1 Fund for radioactive waste disposal and decommissioning of the plant	135
18.	INDU	STRIAL INVOLVEMENT	138
	18.1	THE POTENTIAL OF ESTONIAN INDUSTRIAL FIRMS IN PARTICIPATING IN THE CONSTRUCTION OF	
		A NUCLEAR POWER PLANT	
	18.2	THE ROLE OF THE STATE IN ENGAGING INDUSTRY	139
19.	PRO	CUREMENT	141
	19.1	CONSIDERING SECURITY RISKS WHEN CARRYING OUT PROCUREMENTS	141
	19.2	PUBLIC PROCUREMENT	142
20	<b>THE</b> :	FINALED AME AND ACTION DI AN FOR THE IMPLEMENTATION OF THE	
		FIMEFRAME AND ACTION PLAN FOR THE IMPLEMENTATION OF THE R ENERGY PROGRAMME	143
	20.1	PHASE I: ANALYSIS AND CONSIDERATIONS	145
	20.2	PHASE 2: PREPARATORY WORK	145
	20.3	PHASE 3: ACTIVITIES TO IMPLEMENT THE FIRST NUCLEAR POWER PLANT	147
	20.4	BUDGET FOR PHASES	147
ΑN	NEX 1	.: MEMBERS OF THE NUCLEAR ENERGY WORKING GROUP FOR THE	
PΕ	RIOD	OF 2021–2023	149
A N	NEVO	2: PROPOSALS AND RECOMMENDATIONS OF THE INTERNATIONAL ATOMIC	
		AGENCY (IAEA) INIR MISSION 23.–30.10.2023	153
		: MAPPING OF ENERGY SECTOR DEVELOPMENTS IN ESTONIA'S DURING COUNTRIES AND THE EU'S LARGER ECONOMIES	158
	·	SOUND SOUTHLES AND THE ESS EARSEN ESSISSINGS	100
		EXPENSES FROM THE STATE BUDGET FOR YEARS 0-11 OF THE ENTATION OF NUCLEAR ENERGY	163
	NEX 5	: ANALYSES, STRATEGIES AND STUDIES USED IN THE FINAL REPORT OF	170





<b>3S</b>	nuclear safety, security and safeguards		
BWR	R boiling water reactor		
CBRN	chemical, biological, radiological and nuclear materials		
CfD	Contract for Differences		
CNS	Convention on Nuclear Safety		
CNSC	Canadian Nuclear Safety Commission		
CSC	Convention on Supplementary Compensation for Nuclear Damage		
ECA	Export Credit Agency		
ELINI European Liability Insurance for the Nuclear Industry			
EMANI European Mutual Association for Nuclear Insurance			
ENEF	European Nuclear Energy Forum		
ENMAK Estonian Energy Sector Development Plan			
Euratom European Atomic Energy Community			
FIRST	Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology of the U.S. Department of State		
нтм	Ministry of Education and Research		
IAEA	·		
ICDS	International Centre for Defence and Security		
IEA	International Energy Agency		
IMS	integrated management system		
INIR	Integrated Nuclear Infrastructure Review		
IRRS	Integrated Regulatory Review Service		
JAIF/JICC	JAIF International Cooperation Center		
NICPB	National Institute of Chemical Physics and Biophysics		
KeA	Estonian Environmental Board		





KeHJS	Environmental Impact Assessment and Environmental Management System Act			
KeM	Estonian Ministry of the Environment			
ККО	Climate and Radiation Department of the Environmental Board			
KLIM	Estonian Ministry of Climate			
EIA	environmental impact assessment			
KORAK	National Radiation Safety Development Plan			
SEA	strategic environmental assessment			
LCOE	levelised cost of electricity			
METI	Japan's Ministry of Economy, Trade and Industry			
MOX fuel mixed oxide fuel containing natural or recovered uranium with plutonium imp				
NEA	OECD Nuclear Energy Agency			
NRC	U.S. Nuclear Regulatory Commission			
OECD	Organisation for Economic Co-operation and Development			
PPA	power purchase agreement			
PWR	pressurised water reactor			
REKK	National Energy and Climate Plan			
REP	national designated spatial plan			
SSSC	State Shared Service Centre			
SDR	Special Drawing Rights, an international reserve asset created by the IMF			
SEED	Site and External Events Design Review Service			
SMR	small modular reactor			
SSAC	state system of accounting for and control of nuclear material			
STUK	Radiation and Nuclear Safety Authority in Finland (in Finnish: Säteilyturvakeskus)			
R&D	research and development			
TEOS	Nuclear Energy and Safety Act			
NEWG	Nuclear Energy Working Group			
TTJA	Consumer Protection and Technical Regulatory Authority			
UT	University of Tartu			
WANO	World Association of Nuclear Operators			





### **SUMMARY AND CONCLUSIONS**

The NEWG analysed the possibilities for the construction of a nuclear power plant in Estonia based on the International Atomic Energy Agency (IAEA) guidance publication NG-G-3.1 (Rev.1) *Milestones in the Development of a National Infrastructure for Nuclear Power*<sup>1</sup> (hereinafter *Milestones*), which foresees the consideration of 19 issues. Small modular reactors (SMRs) with a power capacity of less than 400 MVA (400 MW)<sup>2</sup> would be suitable for Estonia.

When selecting the appropriate SMR technology for Estonia, the NEWG considers that the following conditions and considerations should be taken into account:

### Safety

A technology that ensures the highest standard of safety should be chosen. This includes passive safety systems to ensure that the reactor is kept cool even in the event of a power failure.

### Compatibility with the electrical grid

The capacity of one production module to be connected to the Estonian electrical power system may not exceed 400 MVA.

### Maturity of the technology

Preference should be given to technologies that have already been licensed somewhere, with which practical experience exists, to ensure reliability and reduce risks.

### Economic viability

Total cost of investments, operating costs, fuel costs and possible decommissioning costs should be taken into account.

### **Environmental impact**

The technology chosen should have the lowest possible environmental impact, offering low carbon emissions and the smallest possible amount of waste.

### Dispatchability

The technology should offer a flexible and modular approach, allowing the increase or reduction of reactor capacity as needed.

### Fuel

The security of fuel supply, its country of origin and the environmental footprint of fuel production, as well as the possibilities for spent fuel management and final disposal should be taken into account.

### Geopolitical considerations

Geopolitical aspects should also be considered, through which suppliers from certain countries are excluded and the possibilities for cooperation with the country that supplied the technology, other nuclear states and international organisations are analysed.

### Future prospects and supply chain

When choosing the technology, longer-term prospects, such as the evolution of technology and the potential for cooperation with other countries for the production and supply of SMR components should also be taken into account.

<sup>&</sup>lt;sup>2</sup> MVA takes into account both active and reactive power and is related to the rated capacity of electrical equipment, while MW focuses only on active power and is used to measure energy production or consumption.



8

<sup>1</sup> https://www.iaea.org/topics/infrastructure-development/milestones-approach



The first reactors of the kind considered suitable for Estonia will start operating at the end of this decade. The choice of technology should be based on experience and the security of fuel supply. Although the plant cannot be completed fast enough to contribute to the 2030 climate targets, it can contribute to the 2040 (under consideration) and 2050 targets and will support the security of supply as a dispatchable production capacity. By the second half of the 2030s, oil shale-fired power plants will no longer be sustainable and competitive, while gas-fired power plants will face the guestion of their environmental compliance and a gradual transition to biogas and hydrogen, which are more expensive than conventional natural gas. Gas-fired power plants are necessary to support the system and to supply fast frequency reserves, but a nuclear power plant would be a more cost-effective solution for the largescale base load. A large amount of renewable energy will also be supplied to the electrical power system in Estonia, as the country has set a target to produce as much renewable energy as it consumes (over 10 TWh) by 2030. Nevertheless, in terms of large-scale use of wind power, generation interruptions will inevitably occur during periods of low wind and the current storage technology is not sufficient to compensate for these interruptions. SMRs are technically dispatchable, providing a frequency reserve in addition to the base load of the system. This means that it is possible to vary the output power according to the changing demands of the power grid. When integrated with storage technology, SMRs also significantly increase reserve capacity. In addition, these reactors will provide system inertia capability, which could be crucial for a smaller power system in the future, although three synchronous condensers currently fulfil this role. The use of electricity and process heat from nuclear power plants is also seen as having significant potential for hydrogen production and supplying district heating, in particular in terms of the pursuit of carbon neutrality.

The country needs to make an informed decision on the introduction of nuclear energy, based on a broad political consensus. The Riigikogu can decide whether to support the launch of a nuclear energy programme, which includes the creation of a regulatory and legal framework, the launch of planning processes and the selection of a suitable technology and developer.

Estonia's current legal and regulatory framework in the field of radiation and nuclear safety is sufficient for current activities, but the launch of a nuclear energy programme will require the regulation of more complex activities and the implementation of new measures. An independent nuclear safety regulatory body with around 80 employees during the operational period should be established. In addition to the existing 18 employees of the Climate and Radiation Department of the Environmental Board, which will be merged into the new agency, over 60 new employees should be recruited. This includes a few dozen nuclear specialists, some of whom would come from abroad, at least in the first years of operation.

The expenses from the state budget for launching the nuclear energy programme include the costs of the regulator, the legal framework, policy development and the creation of technical capabilities. The revenues received into the state budget are expected to exceed the expenses in the construction phase of a nuclear power plant. In the years following the decision of principle by the Riigikogu up to the operation of the plant, the total cost from the state budget over a period of 9–11 years would be up to €73 million, plus the cost of developing emergency response and technical capabilities, which is difficult to estimate accurately at this stage due to the lack of comparative data and standards. Based on scenarios of emergencies that could occur in large nuclear power plants with a capacity of over 1,000 MWth, the costs of developing emergency response and technical capabilities could amount to €54 million over a 10-year period.

The construction of a nuclear power plant will require developing a wide range of skills, including acquiring knowledge and experience through international cooperation. Emergency planning and security aspects also need to be considered. The implementation of the nuclear energy programme requires the establishment of a model of competence for nuclear security and emergency planning, and the enhancement of sectoral expertise. In addition to empowering the existing resources, it is also





necessary to develop the capabilities required in the conditions of a hybrid or military threat. The new nuclear regulatory body would be responsible for the implementation of legislative and administrative regulation on both nuclear safety and security.

One potential developer aims to build a 600 MWe nuclear power plant with two units (2x300 MWe) using private financing by the mid-2030s at the latest. While the plant is designed for up to 1,200 MW, ie a maximum of 4 units, considering the small size of the Baltic electricity market, the national renewable energy and security of supply objectives and the likely development of the European market for carbon-free hydrogen products, the possible construction of a 3rd and 4th unit is envisaged for the hydrogen products market instead of electricity generation.

The procurement of equipment and services related to a nuclear power plant is subject to special conditions that cover security aspects and comply with the Public Procurement Act.

The introduction of nuclear energy requires thorough planning, extensive cooperation and informed decisions. The introduction of nuclear energy in a country without previous experience in the field and the necessary infrastructure requires years of preparation, and it would take at least 9–11 years to start generating electricity from a nuclear power plant.

Based on the analyses carried out by the Nuclear Energy Working Group during the period of 2021–2023 and the feedback received during IAEA's Integrated Nuclear Infrastructure Review (INIR), the Nuclear Energy Working Group concludes that the introduction of nuclear energy in Estonia is feasible. This requires timely planning, adequate funding (including private investments), and political and public support. The introduction of nuclear energy would support Estonia's climate targets for 2050 and security of supply.

Important factors that make nuclear energy, alongside renewable energy, a promising option for Estonia include:

### **Energy independence and security of supply**

Renewable energy systems depend on changing solar and wind conditions and need additional resources to ensure a continuous supply of electricity. Nuclear energy provides stable and continuous electricity generation, which helps ensure Estonia's energy independence and security of supply even in extreme weather conditions.

### Achieving climate neutrality

While the use of renewable energy is an important step towards climate neutrality, it may not be enough to reach the target. Nuclear energy is a dispatchable low-carbon way of generating electricity that will enable Estonia to reach its climate neutrality targets. In addition to electricity generation, possibly also in other sectors, eg district heating.

### Balancing energy consumption

The unpredictability of renewable energy sources, such as solar and wind, causes fluctuations in energy production. Nuclear energy would balance the fluctuations related to renewable energy and ensure a stable electricity supply.

### **Energy price**

While building a nuclear power plant may require a higher initial investment, nuclear energy produces electricity at lower long-term costs compared to some renewable energy sources (eg offshore wind farms). This will help ensure a stable and cheaper electricity price for consumers, including large consumers.

### **Promoting research and development**

The construction and operation of a nuclear power plant will allow Estonia to develop





advanced technology and the field of research, which in turn will bring economic benefits and create jobs for locals.

### Long-term perspective

Nuclear energy has proven to be a long-term and sustainable solution in many countries around the world. It has the potential to secure Estonia's energy supply for future generations.

At the same time, there are a number of challenges associated with the introduction of nuclear energy that Estonia should consider:

### 1. Safety issues

The safety of nuclear power plants is one of the top concerns of the public. Although the occurrence of accidents with serious consequences is extremely unlikely, the construction and operation of nuclear power plants must be required to meet the highest safety standards and ensure that all risks are minimised.

### 2. Waste management

Radioactive waste from nuclear power generation, which requires long-term safe storage. Even if the amount of waste generated is small, Estonia should develop a strategy for the management of radioactive waste and consider the establishment of a spent nuclear fuel final disposal site.

### 3. Capital expenditure and time consumption

The construction of a nuclear power plant requires a large initial investment and a long preparation period. Securing funding for projects and keeping to the construction timetable can be difficult.

### 4. Public sentiment and political risks

The construction of a nuclear power plant can lead to public opposition, especially during the site selection process. Political views may change. It is important to involve the public in the decision-making process and to ensure that they are adequately informed.

### 5. Developing alternative technologies

Once a nuclear power plant is operational, the long-term commitments taken need to be considered, which means that there is no quick way to switch out of this energy source. While nuclear energy can provide a stable supply of electricity, investment in renewable energy technologies and energy efficiency should continue.

### 6. Human resource development

Using nuclear energy requires specialists with higher education and appropriately qualified workers. Training these people takes time and they are in short supply in the labour market. Both the nuclear regulatory body and the plant operator would, in the early years of the nuclear energy programme, be heavily dependent on employees imported from other countries.

Overall, it is important to ensure that the introduction of nuclear energy does not undermine the addition of renewable generation and storage capabilities or delay emission reductions.

The introduction of nuclear energy can make an important contribution to achieving Estonia's climate objectives, security of supply and stability of the energy system without limiting the development of renewable energy.





Regardless of the technology used, deploying nuclear energy requires long-term preparation and at least 100 years of continuous activities. The possibility of introducing nuclear energy must also be included in the country's Energy Sector Development Plan.

Pursuant to § 79 of the Radiation Act, a radiation practice licence for the operation of a new nuclear facility can be applied for after the Riigikogu has adopted a decision on the commissioning of a nuclear facility. The Electricity Market Act subsection 3 of § 22 stipulates that a generating installation that uses nuclear energy may be employed for the generation of electricity, provided this is authorised by a resolution of the Riigikogu.

To maintain Estonia's competitiveness, it is essential to move towards carbon-neutral power generation. A nuclear power plant is one way to generate carbon-free electricity. Although a nuclear power plant in Estonia could realistically be completed within the next decade, the introduction of nuclear energy would not directly contribute to the country's 2030 targets. However, it can play an important role in meeting the 2040 (under consideration) and 2050 targets and increasing security of supply.

The current Energy Sector Development Plan (ENMAK) until 2030 does not preclude the construction of any market-based competitive power plants in Estonia. The nuclear power plant scenario has been taken into account in the preparation of ENMAK 2035. Estonia's 2030 National Energy and Climate Plan (NECP 2030) sees SMRs as one of the alternative ways to produce electricity in Estonia. However, nuclear energy production requires extensive preparatory work in the form of creating a national framework. For Estonian conditions, SMRs would be suitable, the kind which will start operating at the end of this decade.

The role of nuclear energy in meeting climate objectives is considered important by the European Union. At the European Nuclear Energy Forum (ENEF) held in Bratislava, Slovakia, in November 2023, representatives of the European Commission noted that there is renewed interest in the use of nuclear energy due to the technology's potential to address the challenges of decarbonisation, security of supply and strategic autonomy. A number of EU Member States are interested in small reactors, including Poland, the Czech Republic, Romania and Finland. In addition to on-grid electricity generation, these technologies enable the decarbonisation of traditionally fossil fuel-based applications. The introduction of small reactors in the next decade will be a significant step towards achieving climate neutrality by 2050. The first small reactors are due to be connected to the European electrical grid by the end of this decade<sup>3</sup>.

In Europe, new nuclear power plants are being built in France, the UK, Slovakia, Poland, Slovenia, Romania, Bulgaria, Hungary and the Czech Republic. In Finland, discussions and activities are ongoing on the use of small reactors in district heating.

The need to increase the share of nuclear energy to meet climate objectives has been highlighted by the International Atomic Energy Agency (IAEA)<sup>4</sup>, the International Energy Agency (IEA)<sup>5</sup> and the EU<sup>6</sup>. In 2022, nuclear power plants produced 2,545 TWh of electricity, representing 10% of the world's total electricity production. In 2023, new nuclear reactors started operating in China, Slovakia, the United States and Belarus<sup>7</sup>.

<sup>&</sup>lt;sup>7</sup> https://world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx



<sup>&</sup>lt;sup>3</sup> https://energy.ec.europa.eu/news/european-nuclear-energy-forum-2023-discusses-benefits-european-small-modular-reactors-smrs-2023-11-07\_en

<sup>&</sup>lt;sup>4</sup> https://www.iaea.org/atoms4netzero

<sup>&</sup>lt;sup>5</sup> https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach

<sup>&</sup>lt;sup>6</sup> https://ec.europa.eu/commission/presscorner/detail/en/speech 23 6156



According to the recommendations of the IAEA, activities in preparation for the introduction of nuclear energy should be split into three phases:

### PHASE 1

Considerations before a decision to launch a nuclear energy programme is taken (pre-project activities). By the end of phase 1, the country should be ready to make a well-considered and knowledgeable decision on nuclear energy. Ultimately, it must answer the question of whether and why nuclear energy would be the best option for the country. During the first phase, a thorough analysis of the effects of the introduction of nuclear energy is carried out.

### PHASE 2

During the second phase, preparatory work for contracting and construction is carried out (project development activities, plans). During this phase, the necessary infrastructure for the introduction of nuclear energy is developed, the necessary organisations and the legal framework are created and the capabilities of existing institutions are developed.

### PHASE 3

Activities to implement the first nuclear power plant (final investment decision, contracting, construction) are carried out. By the end of this phase, the state should be ready to commission and operate the first nuclear power plant. Activities include contracting, obtaining permits and construction.

The length of the phases has not been temporally defined. At the end of each phase, a decision of principle must be taken, upon which the occurrence of the next phase depends. All preparatory activities are planned into the timeframe, and how long each specific activity takes depends on the planning.

The introduction of nuclear energy in a country without previous experience in the field and the necessary infrastructure (such as Estonia) requires thorough preparation, and it will take at least 9–11 years to start generating electricity from a nuclear power plant.

This report has been prepared based on the IAEA's *Milestones*, which foresees the analysis of 19 aspects at each implementation phase of a nuclear energy programme. It forms a whole with the Interim Report of the Nuclear Energy Working Group<sup>8</sup>, which was presented at the cabinet meeting of the Government of the Republic in October 2022, and which describes the general infrastructure for the introduction of nuclear energy and the current situation in Estonia. To get a complete picture, it is important to also consider the analyses commissioned by the NEWG during 2021–2023, available on the NEWG website<sup>9</sup>.

At the invitation of Estonia, an IAEA INIR expert mission took place from 23–30 October 2023 to assess Estonia's readiness for nuclear energy. In addition to the NEWG's activities, the review assessed the preparations of Fermi Energia AS, a company interested in implementing the nuclear energy programme, and the compliance of the analyses commissioned by them with IAEA standards and guidelines. The group of experts concluded that Estonia has carried out a thorough assessment of its nuclear energy infrastructure needs, which allows the country to make an informed decision on whether to launch a nuclear energy programme. The NEWG has decided to make the INIR mission results report public and it will be published on the website of the Ministry of Climate in January 2024.

<sup>&</sup>lt;sup>9</sup> https://kliimaministeerium.ee/en/node/215



<sup>8</sup> https://kliimaministeerium.ee/media/10681/download (in Estonian)



This report, based on the IAEA's *Milestones*, outlines the necessary points of analysis in phase 1 of nuclear energy introduction, ie the phase of considerations on launching a nuclear energy programme, based on which a country should be prepared to make an informed and well-considered decision.

In addition to the IAEA guidance publication, the report takes into account EU legislation and obligations under international law, and the results of nuclear analyses and the study on public opinion carried out in the period of 2021–2023. Chapters 4 (Financing), 13 (Environmental Protection), 16 (Nuclear Fuel Cycle) and 18 (Industry Involvement) also draw on input from analyses commissioned by Fermi Energia AS and letters sent to the NEWG.

The final report has been prepared with input from the NEWG member institutions and their subsidiary bodies (Annex 1). The proposals and conclusions presented are based on the discussions at the meetings of the NEWG and the recommendations made in the analyses commissioned.

The Nuclear Energy Report was coordinated by the Ministry of Climate (formerly the Ministry of the Environment).



### 1. SHAPING THE NATIONAL POSITION

## 1.1 PURPOSE AND COMPOSITION OF THE NUCLEAR ENERGY WORKING GROUP

With a decision of the cabinet meeting of the Government of the Republic of 5 November 2020, the Ministry of the Environment and the Ministry of Economic Affairs and Communications (from 1 July 2023 the Ministry of Climate), together with other relevant ministries, were instructed to convene the national Nuclear Energy Working Group (the NEWG). The composition of the NEWG was approved at a cabinet meeting on 8 April 2021. According to the cabinet meeting memorandum, the NEWG's tasks include:

- providing an overview of the country's energy needs and ensuring energy security in terms of nuclear energy, the opportunities of nuclear energy and its suitability to the existing electricity grid;
- 2. providing an overview of neighbouring countries' energy management development directions in terms of nuclear energy and cooperation opportunities to achieve climate neutrality;
- analysing the technologies under development and the projects in progress, their safety and waste management, including an assessment and overview of the types of reactors suitable for Estonia and their stage of development;
- 4. analysing the options for the development of a nuclear power plant, including whether it should be carried out by the public or private sector, and the possibilities for cooperation;
- providing an overview of the obligations (administrative, related to international treaties, financial, etc) that would come with building a nuclear power plant, and their possible differentiation depending on the type of developer (state or private developer);
- analysing the options for the management of the waste generated at a nuclear power plant and the solutions for its subsequent decommissioning (including an assessment of the costs of final disposal and an overview of the financing options);
- mapping the current state of sectoral legislation, competences, expertise and available workforce, and identifying development needs with a possible indicative timetable and cost;
- 8. mapping the need for expert assessments, analyses and studies, with a possible indicative timetable and cost;
- if necessary, involving experts (including consultants) in its work, and establishing sectoral
  groups of experts involving representatives of ministries, universities, interest groups, and
  professional associations with competence in this particular field to achieve the objectives set;
- 10. agreeing on a communication strategy;
- 11. submitting its conclusions and proposals regarding the conditions and possibilities for the introduction of nuclear energy to the Government of the Republic. The first interim report and an overview of the working group's work will be presented in September 2022 at the latest;
- 12. preparing a final report in accordance with the International Atomic Energy Agency (IAEA) guidance publication NG-G-3.1 (Rev.1) *Milestones in the Development of a National Infrastructure for Nuclear Power*, submitting the report for review to the IAEA and the Government of the Republic with recommendations on whether or in which case and under which conditions a nuclear power plant could be built in Estonia.





The NEWG was chaired by Meelis Münt, the Secretary General of the Ministry of the Environment, from May 2021 to June 2023, and from July 2023 by Antti Tooming, the Deputy Secretary General of the Ministry of Climate, and the work of the working group was coordinated by Reelika Runnel throughout the period of its activities. In addition to the Ministry of Climate, the NEWG includes the Environmental Board, Ministry of the Interior, Ministry of Regional Affairs and Agriculture (until July 2023 Ministry of Finance), Ministry of Justice, Ministry of Education and Research, Ministry of Defence, Ministry of Foreign Affairs, Ministry of Social Affairs and Government Office. A list of the institutions and associations that are members of the NEWG and its subsidiary parties is given in Figure 1. A list of NEWG members for the period 2021–2023 is set out in Annex 1.

#### **NUCLEAR ENERGY WORKING GROUP** SUB-WORKING GROUPS ON SPATIAL SUB-WORKING GROUPS ON NUCLEAR 1. Estonian Ministry of Climate **PLANNING** SECURITY AND EMERGENCY PREPAREDNESS 2. Ministry of Regional Affairs and Ministry of the Interior Ministry of Finance 3. Ministry of the Interior Ministry of Regional Affairs and Ministry of Defence 4. Ministry of Justice Estonian Ministry of Climate Police and Border Guard Board 5. Ministry of Education and Research Estonian Environmental Board Estonian Internal Security Service 6. Ministry of Defence Ministry of the Interior Estonian Environmental Board 7. Ministry of Foreign Affairs Ministry of Defence Ministry of Foreign Affairs 8. Ministry of Social Affairs Ministry of Economic Affairs and 9 Ministry of Economic Affairs and Communications Consumer Protection and Technical Regulatory Authority Communications Consumer Protection and Technical Regulatory Authority 10 Estonian Environmental Board Ministry of Economic Affairs and Geological Survey 11 Government Office Government Office Estonian Council of Environmental 12 Consumer Protection and Technical Association of Estonian Cities and Municipalities · Tax and Customs Board

Figure 1. Institutions and associations belonging to the Nuclear Energy Working Group and its sub-working groups (Source: NEWG)

The ultimate goal of the NEWG is to form coordinated views with the public on the possibilities of introducing nuclear energy in Estonia and to submit its conclusions and proposals to the Government of the Republic. The interim report on the results of the work done by the NEWG was presented to the Government of the Republic on 13 October 2022. The deadline for a comprehensive report, on the basis of which the state can make a decision of principle on the introduction of nuclear energy, is the end of 2023, as stipulated by a decision of the cabinet of 7 April 2022.

The NEWG based its analyses on the IAEA's *Milestones*, which foresees the analysis of 19 issues when considering the introduction of nuclear energy, as listed in Figure 2.





Figure 2. Topics to be analysed according to the IAEA's guidance publication Milestones in the Development of a National Infrastructure for Nuclear Power (Source: NEWG on the basis of IAEA materials)

# 1.2 IAEA INIR EXPERT MISSION TO ASSESS THE ACTIVITIES OF THE NEWG

The IAEA INIR mission is a service provided by the IAEA in which experts help countries to assess their preparedness for nuclear energy introduction at different phases, in accordance with the *Milestones*. The IAEA INIR phase 1 expert mission, during which it was verified whether we have the necessary understanding of all the obligations associated with the use of nuclear energy and whether we have sufficiently assessed all the issues related to the use of this form of energy, took place in Estonia from 23 to 30 October 2023. In total, 12 proposals and recommendations were made by the IAEA experts, which are mostly directed at the activities of the next phases:

- the commitment to nuclear safety, security and non-proliferation needs to be more explicit in documents (strategies, action plans, NEWG mandate);
- in the next phase, the membership of the NEWG should be expanded;
- the timetable for the implementation of the nuclear energy programme and the analysis of the budgetary resources needed from the national budget need to be reviewed;
- a plan for adding to the state system for accounting for and control of nuclear material (SSAC);
- position the future nuclear regulatory body in the national system in such a way as to ensure its independence and discretion over the content of regulations, and analyse the possibility of starting the process for establishing the regulator as early as possible (even before the entry into force of the nuclear energy act);
- launch a long-term human resources development strategy and a workforce management plan for key organisations;





think more carefully about the process of defining site selection criteria, licensing and involving local industry.

During the mission, experts found 3 good practices:

- 1. the NEWG has used external experts to assist with the analyses made in the process of compiling the final report, which supports informed decision-making;
- a two-step approach has been taken in recruiting the employees of the future regulator, where key competences are outsourced during the start-up phase while also developing national competences, which in turn will support the success of the implementation of the nuclear energy programme in both the short and long term;
- 3. during the preliminary analysis of the possible sites, the feasibility of a geological final disposal site for spent fuel was also assessed.

According to the IAEA, the working group's analysis and preparation for the introduction of nuclear energy has been suitably thorough and sufficient to enable us to make an informed decision on the use of nuclear energy. The INIR mission report will be made public on the IAEA's website<sup>10</sup> and the Ministry of Climate's website<sup>11</sup> in January 2024. A table with the suggestions and recommendations made during the mission, together with the actions planned to address them, can be found in Annex 2.

### 1.3 SMALL MODULAR REACTORS (SMRS)

Small Modular Reactors (SMRs) are significantly smaller in both size and power than traditional nuclear reactors.

The IAEA defines reactors with an electrical capacity equal to or less than 300 MWe as 'small'. For comparison, the newly completed Olkiluoto 3 reactor in Finland has an electrical capacity of 1,720 MWe. A single 300 MWe reactor is able to generate enough electricity for around 300,000 households.

Compared to large nuclear power plants, small modular reactors fit into a relatively small area. In terms of their size, they take up about 1/10 to 1/4 of the area required by a conventional nuclear power plant, ie they require tens of hectares, not hundreds of hectares. To ensure the safety of reactors under any hazardous conditions, a significant number of passive solutions have been developed to ensure the stable and safe operation of reactors without any human intervention.

SMRs have many advantages that are directly linked to their design. Because of the smaller area required, SMRs can be placed in locations that are not suitable for larger nuclear power plants. Manufacturing and assembling components in a factory will allow savings in terms of both costs and construction time, and reactor modules can be added as energy demand increases.

Compared to existing reactors, SMRs are simpler in design. The safety for SMRs often relies on passive systems. This means that in such cases no human intervention or external power is required to shut down systems, because passive systems rely on physical phenomena, such as convection and gravity. These measures will also help to eliminate or significantly lower the potential for releases of radioactivity into the environment.<sup>12</sup>.

<sup>12</sup> https://www.iaea.org/topics/small-modular-reactors



<sup>10</sup> https://www.iaea.org/

<sup>11</sup> https://kliimaministeerium.ee/en/node/215



Outside Russia and China, SMRs have not yet been put into commercial use. The Akademik Lomonosov floating nuclear power plant with two 35 MW reactors began operation in Russia in 2019<sup>13</sup>. In China, the HTR SMR, classified as a fourth-generation reactor, with two 250 MW gas-cooled reactors, has been operating from 2021<sup>14</sup>. In 2026 the Linglong One 126 MW ACP-100 reactor, based on third-generation technology, will also be completed in China<sup>15</sup>. One of the first anticipated Western projects is the GE Hitachi BWRX-300 boiling water reactor project in Canada, due for completion in late 2028<sup>16</sup>. By the beginning of the next decade, other SMRs and microreactors (eg NuScale VOYGR SMR, Holtec SMR-160, Westinghouse eVinci microreactor) will begin commercial operation. In total, more than 80 SMR projects are under development worldwide, of which mostly water-cooled reactors based on the existing third-generation technology will begin commercial operation by the end of this decade. Examples of SMRs under development are shown in Photos 1 and 2.





Photo 1. Westinghouse AP300 SMR (Source: Westinghouse). Photo 2. CAREM SMR construction in Argentina (Source: CNEA)

There is strong interest in the introduction of SMRs worldwide, and a number of national, regional, international and privately funded programmes have been set up to support companies developing them. Developments over the past few years have been rapid and the first setbacks have happened. In November 2023, US SMR technology developer NuScale announced the cancellation of its project in Idaho, USA. The objective of the project was to build six NuScale SMRs by 2029, but the estimated cost of the project increased from the \$5.3 billion planned in 2021 to \$9.3 billion. This in turn would mean that the price of the electricity produced would be \$89 per MW/h instead of the \$58 originally planned, which led to failure to collect necessary support from large-scale consumers at a local level. However, the company will continue with its other projects in Romania, Poland, Canada and Ghana.

On 6 December 2023, the European Parliament approved a report on SMRs confirming their importance for the EU's future energy system.<sup>17</sup>. Nuclear technologies have also been included in the Net Zero Industry Act, which aims to increase the production of clean technologies in the EU<sup>18</sup>. In November 2023, the European Commission announced the launch of the SMR Industrial Alliance, which will focus on the potential for decarbonisation of energy-intensive industries through the use of SMRs, the development of financing mechanisms, securing supply chains and skilled labour, research and innovation<sup>19</sup>.

<sup>&</sup>lt;sup>19</sup> https://energy.ec.europa.eu/news/european-nuclear-energy-forum-2023-discusses-benefits-european-small-modular-reactors-smrs-2023-11-07 en



<sup>13</sup> https://fnpp.info/

<sup>&</sup>lt;sup>14</sup> China's demonstration HTR-PM enters commercial operation: New Nuclear - World Nuclear News (world-nuclear-news.org)

<sup>&</sup>lt;sup>15</sup> https://world-nuclear-news.org/Articles/Linglong-One-reactor-pit-installed-at-Changjiang

<sup>16</sup> GE Hitachi BWRX-300 Small Modular Reactor Achieves Pre-Licensing Milestone in Canada | GE News

<sup>&</sup>lt;sup>17</sup> https://www.europarl.europa.eu/doceo/document/A-9-2023-0408 EN.html

<sup>18</sup> https://single-market-economy.ec.europa.eu/publications/net-zero-industry-act\_en



### 1.3.1 CHOOSING THE RIGHT TECHNOLOGY FOR ESTONIA

When selecting the appropriate SMR technology for Estonia, the NEWG considers that the following conditions and considerations should be taken into account:

### Safety

A technology that ensures the highest standard of safety should be chosen. This includes passive safety systems to ensure that the reactor is kept cool even in the event of a power failure.

### Compatibility with the electrical grid

The capacity of one production module to be connected to the Estonian electrical power system may not exceed 400 MVA.

### Maturity of the technology

Preference should be given to technologies that have already been licensed somewhere, with which practical experience exists, to ensure reliability and reduce risks.

### **Economic viability**

Total cost of investments, operating costs, fuel costs and possible decommissioning costs should be taken into account.

### Environmental impact

The technology chosen should have the lowest possible environmental impact, offering low carbon emissions and low waste.

### Dispatchability

The technology should offer a flexible and modular approach, allowing the increase or reduction of reactor capacity as needed.

#### Fuel

The security of fuel supply, its country of origin and the environmental footprint of fuel production, as well as the possibilities for spent fuel management and final disposal should be taken into account.

### Geopolitical considerations

Geopolitical aspects should also be considered, through which suppliers from certain countries are excluded and the possibilities for cooperation with the country that supplied the technology, other nuclear states and international organisations are analysed.

#### Future prospects and supply chain

When choosing the technology, longer-term prospects, such as the development of technology and the potential for cooperation with other countries for the production and supply of SMR components should also be taken into account.

Each choice must be made based on a thorough analysis and assessment, considering all relevant factors and Estonia's specific needs. The choice of technology will have to be made by the 3rd to 4th year of the nuclear energy programme. Based on the choice of technology, the site selection process can be finalised and the precise conditions for the procedure and issuing of the permits can be laid down. If the developer of the nuclear power plant is the private sector, the role of the state is to validate the developer's choice of technology based on the pre-defined criteria during the process (eg in the site selection process<sup>20</sup>).

<sup>&</sup>lt;sup>20</sup> The Government of the Republic initiates and establishes the national designated spatial plan for the selection of the nuclear power plant site and the determination of land use and construction conditions.





# 1.4 CURRENT AND FUTURE DIRECTIONS IN THE ENERGY POLICIES OF ESTONIA'S NEIGHBOURING COUNTRIES AND THE EU'S LARGER COUNTRIES

In November 2023, the Ministry of Foreign Affairs, with the help of Estonian embassies in Estonia's neighbouring countries and in major EU countries, mapped the current state of energy policy in those countries and the development trends of the coming decades. An overview was prepared for the following countries: Latvia, Lithuania, Poland, Finland, Sweden, Denmark, Norway, Germany and France. The Ministry of Foreign Affairs prepared a similar overview for the Interim Report of the Nuclear Energy Working Group, but as the energy crisis of the last few years has led countries to constantly update their energy policies, the overview needs to be updated periodically.

The overview focused on countries' current energy portfolios and the choice of energy sources for the purpose of meeting long-term climate targets, electricity consumption projections for the coming years, and the role of and future plans for nuclear energy, including the introduction of SMRs. Based on the mapping, general observations can be highlighted:

- The overall trend in all countries is to already rapidly increase the share of renewable energy to achieve climate neutrality, including ambitious targets for most countries, by 2030. The main growth should come from wind energy, including, depending on the country, offshore wind energy.
- Electricity consumption is projected to increase dramatically by 2050, in some cases by a factor of two (in countries for which data is available). The increase in electricity consumption is driven by the general electrification of the economy, growing industrial consumption and hydrogen production, especially in Norway and Germany.
- Some countries are planning to adopt nuclear energy (Poland has made the most progress among the new countries). In other countries (including Latvia and Lithuania), discussions on the possible introduction of nuclear energy are ongoing with varying degrees of intensity. Sweden has reversed its earlier policy of nuclear energy phase-out and drastically increased its plans for nuclear energy use. Of the EU's larger countries, France is planning to build more nuclear power plants, while Germany closed all its nuclear power plants despite the energy crisis and is investing in renewables, including hydrogen, instead.

A more detailed overview of the mapped countries can be found in Annex 3.

### 1.5 NEED FOR NUCLEAR ENERGY AND ITS POTENTIAL

The lion's share of Estonia's dispatchable electricity generation capacity is made up of power plants using oil shale (and semicoke gas or biomass). The long-term sustainability of Estonia's oil shale-fired power plants (2035+ outlook) is declining, as a large proportion of the plants are old and increasingly uncompetitive in the electricity market due to high carbon emissions. Looking ahead to the year 2035+, it is likely that only the Auvere power plant will be operational<sup>21</sup>. The long-term issue with possible substitute gas-fired power plants is environmental compliance and fuel, as natural gas is gradually substituted with biogas and hydrogen, which is more expensive than fossil natural gas. To a certain extent, gas-fired power plants are certainly supportive of the Estonian electrical power system and are necessary for Estonia, in particular to supply fast frequency reserves. However, when it comes to

<sup>&</sup>lt;sup>21</sup> https://www.elering.ee/sites/default/files/2023-12/Elering VKA 2023 WEB 0.pdf (in Estonian)



21



covering the base load on a large scale, a nuclear power plant is potentially the most cost-effective solution in terms of electricity prices.

A large amount of renewable energy will also be supplied to the electrical power system in Estonia, as the national target for renewable electricity production is to match the country's electricity consumption in 2030 (over 10 TWh), and electricity market prices, together with falling prices for renewable electricity technologies, have created an attractive investment environment for both solar farms and onshore wind farms. It is estimated that around 2,000 MW of wind energy will be connected to the electrical power system by 2030. However, even with such a large amount of wind energy, it is inevitable that there will be periods of low wind, and storage designed primarily for short periods (a few hours to a few days) will not be sufficient to cover these periods. These periods in the electrical power system are covered by Estonia's external connections and the dispatchable power plants located in Estonia. Elering has estimated that the current need for 1,000 MW of dispatchable production capacity is probably increasing over time, and therefore the amount of dispatchable capacity required can be expected to be higher in 2030. Technologically, SMRs are also dispatchable, allowing, for example, power to be increased or reduced at around 1.5 MW per minute<sup>22</sup>. This, in turn, will allow SMRs to provide the system with a few tens of MW of frequency reserve (mFRR product) in addition to the base load. When integrated with storage solutions, the amount of reserve capacity available will increase significantly. In addition, SMRs provide system inertia capacity, which from the perspective of a small power system may also be important in the future, although the inertia needed for Estonia (17,100 MWs) is currently planned to be provided by three synchronous compensators.

### 1.5.1 CLIMATE CHANGE MITIGATION

Estonia's total greenhouse gas (GHG) emissions in 2021 were about 15.6 million tonnes CO2 equivalent with the land-use and forestry (LULUCF) sector and about 12.7 million tonnes CO2 equivalent without the LULUCF sector. The majority (52%) of GHG emissions resulted from the energy industry and energy production. Compared to 1990, total GHG emissions have decreased by about 68.5%, mainly due to a reduction in the production capacity of oil shale-fired power plants and the introduction of renewable energy. However, the preliminary results of the 2022 GHG inventory show that Estonia's emissions increased by 13.9% compared to 2021 due to the production of electricity from oil shale. This is due to the energy crisis in Europe in 2022, which temporarily made electricity produced from oil shale more competitive than that produced from natural gas.

On 12 May 2021, the Riigikogu approved the country's long-term development strategy *Estonia 2035*<sup>23</sup>, in which for the first time Estonia's national climate neutrality goal was agreed upon, ie the goal of balancing greenhouse gas emissions and removal by 2050, which is also included in the General Principles of Climate Policy until  $2050^{24}$ . The *Estonia 2035* action plan also sets an interim target of a 43% reduction in total greenhouse gas emissions in all sectors by 2035 (to a target of 8 million tonnes  $CO_2$  equivalent) compared to 2020 levels. There are no sector-specific national emission reduction targets, but these are expected to be set in the Climate Act that will enter into force in  $2025^{25}$ .

In addition to the national targets, Estonia must also meet the commitments it has made as member of the EU. The European Union's Emissions Trading Scheme (EU ETS)<sup>26</sup>, which sets an overall EU target of a 62% reduction in greenhouse gas emissions by 2030 compared to 2005, is the main instrument for reducing emissions from the EU energy industry (plants with a rated capacity of more than 20 MW). In

<sup>&</sup>lt;sup>26</sup> http://data.europa.eu/eli/dir/2003/87/2023-06-05



<sup>&</sup>lt;sup>22</sup> https://aris.iaea.org/PDF/BWRX-300\_2020.pdf

<sup>&</sup>lt;sup>23</sup> https://valitsus.ee/strateegia-eesti-2035-arengukavad-ja-planeering/strateegia/materjalid (in Estonian)

<sup>&</sup>lt;sup>24</sup> <u>https://kliimaministeerium.ee/en/general-principles-climate-policy</u>

<sup>&</sup>lt;sup>25</sup> https://kliimaministeerium.ee/eesti-kliimaseadus (in Estonian)



addition, in the sectors covered by the Effort Sharing Regulation<sup>27</sup>, which covers road transport, domestic shipping, agriculture (non-CO<sub>2</sub> emissions), waste management, industrial processes (including fluorinated greenhouse gas emissions) and small-scale power generation (plants with a total rated thermal input below 20 MW), Estonia has committed to reducing emissions by 24% by 2030 compared to 2005.

According to the GHG emission projections prepared by the Estonian Environmental Research Centre on behalf of the Ministry of Climate, the implementation of existing and planned measures (mentioned in the sectoral development documents) will result in a 13% reduction in emissions by 2030 in the sectors covered by the Effort Sharing Regulation, instead of the 24% target. By 2050, as a result of existing and planned measures, emissions are projected to reduce by 78% in the energy sector, 82% in the transport sector, 3% in agriculture, 41% in waste management and 45% in industry compared to 2020. In addition, projections show that the land-use, land-use change and forestry sectors will continue to be a source of GHG emissions, meaning that emissions from the sector will exceed total removals. The measures currently in place and planned are therefore not sufficient to meet Estonia's 2030 and 2050 climate objectives. Additional measures are needed. One of the most important actions is to increase climate-neutral electricity generation, as the electrification of and emission reductions in other sectors depend on it.

As part of the preparation of the new Energy Sector Development Plan until 2035<sup>28</sup>, a study has been commissioned and carried out on the options of climate-neutral electricity generation in Estonia. According to the study, climate-neutral electricity generation in Estonia is achievable by 2050 through six or seven different scenarios and combinations of technologies, including:

- renewable energy and storage technology (offshore wind energy),
- renewable energy and gas,
- renewable and nuclear energy,
- carbon capture technology,
- using all technologies.

The implementation of all scenarios, including the nuclear energy scenario, is conditional on the addition of renewable generation and storage capacity on a much larger scale than today. In terms of nuclear energy, the study considered a scenario where a small Generation III+ SMR is built in Estonia by 2040 and the total capacity of the plant is 900 MW. Scenarios were compared on the basis of two alternative sets of criteria. Under the first set of criteria, the best scenarios in terms of implementation costs, benefits, risks and feasibility are 'all technologies' and 'renewable energy and storage technology (offshore wind energy)'. The 'renewable gas' scenario also scores relatively high for these criteria. According to the second set of criteria, which amplified the economic impact parameters, the most attractive scenarios are 'nuclear', 'renewable energy and storage technology (offshore wind energy)' and 'all technologies'. Summing up the results of the two assessments, the best-performing scenarios were 'renewable energy and storage technology (offshore wind energy)' and 'all technologies'.

### 1.5.2 ADAPTING TO CLIMATE CHANGE

Climate policy also includes the objectives and actions for adaptation to the impacts of climate change set out in the Climate Change Adaptation Development Plan until 2030<sup>30</sup>. The impact of extreme

<sup>&</sup>lt;sup>30</sup> https://kliimaministeerium.ee/kliimamuutustega-kohanemise-arengukava (in Estonian)



<sup>&</sup>lt;sup>27</sup>http://data.europa.eu/eli/reg/2018/842/2023-05-16

<sup>&</sup>lt;sup>28</sup> https://energiatalgud.ee/node/8906?category=1687 (in Estonian)

<sup>&</sup>lt;sup>29</sup> https://www.sei.org/wp-content/uploads/2023/02/uleminek-kliimaneutraalsele-elektritootmisele-lopparuanne.pdf (in Estonian)



weather events such as storms, floods, rising sea levels and heat waves due to climate change will increase the vulnerability of infrastructure and buildings, which must also be taken into account in the case of a possible nuclear power plant. In the event that the state decides to authorise the construction of a nuclear power plant, in addition to the climate resilience criteria assessed in the spatial analysis of potential sites for a nuclear power plant and a spent nuclear fuel final disposal site commissioned by the sub-working group on spatial planning, a comprehensive climate impact and climate resilience assessment will need to be carried out in the next site selection phase to assess the susceptibility and resilience of the site and the design of the nuclear power plant to potential long-term climate change impacts. This will include an assessment of the impact of climate change on both the nuclear power plant and related infrastructure, such as interim storage and final disposal sites and the electricity grid.

Overall, Estonia needs to rapidly build new renewable energy generation and storage capacity to meet its 2030 and 2050 climate change mitigation objectives. A nuclear power plant in Estonia will not be operational in time to contribute to the 2030 targets. To meet the 2050 targets, the construction of a nuclear power plant is one possible solution, in addition to renewable power plants, to contribute to climate neutrality. It is important to ensure that relying on nuclear energy does not undermine the addition of renewable generation and storage capabilities or delay emission reductions. In addition, the introduction of nuclear energy must consider climate change adaptation objectives. In particular, this means that the nuclear power plant and associated infrastructure, including the final waste disposal site, must be climate-proof and resilient to the potential aggravating effects of climate change for a very long time.

### 1.5.3 HYDROGEN PRODUCTION AND DISTRICT HEATING

Nuclear power plants are seen as having increasing potential to produce hydrogen and provide district heat, especially in a context where most of the world is striving towards carbon neutrality.

Unlike solar or wind energy, which depend on natural conditions, nuclear power plants offer constant and reliable hydrogen production, making the process more stable and predictable. As this process is carbon-free, it would contribute to reducing the global carbon footprint. The high-temperature heat produced in nuclear power plants (more than 300 °C in existing plants and up to 950 °C in the planned SMRs) increases the efficiency of electrolysis, reducing the cost of hydrogen production and making the process potentially more cost-effective.

Another important use of nuclear power plants is to provide district heat by transferring the heat they produce to district heating systems and thereby supplying heat to nearby areas. This will help to maximise the use of the heat generated in the electricity generation process. This approach would not only reduce heating costs in the region, but also carbon emissions, contributing to the decarbonisation of the district heating sector. Connecting nuclear power plants to district heating networks is more energy efficient than traditional methods as it reduces the need to use additional fuel to produce heat.

In 2023, Finland initiated an amendment with a deadline of 2026 to their Nuclear Act and regulations to allow the introduction of SMRs for, among other things, ensuring district heating. Steady Energy, a company of Finland's VTT Technical Research Centre, is planning to build the world's first district heating plant based on SMR technology by 2030, using its self-developed LDR-50 50 MW reactor designed to operate at 150 °C31.

The use of nuclear power plants for hydrogen production and providing district heat can play an important role in achieving carbon neutrality in sectors other than electricity generation.

<sup>31</sup> https://world-nuclear-news.org/Articles/Finnish-SMR-targets-district-heating-market





## 1.6 DECISION OF PRINCIPLE ON THE INTRODUCTION OF NUCLEAR ENERGY

According to the IAEA *Milestones*, a country needs to make a knowledgeable and informed decision on the introduction of nuclear energy. The national position needs to be clear, reflect broad political support for the intention to develop a nuclear energy programme, and explain this intention at local, national, regional and international levels.

According to the decision approved by the Cabinet of Ministers on 8 April 2021, the NEWG is tasked with preparing a final report in accordance with the IAEA *Milestones*, submitting the report for review to the IAEA and the Government of the Republic with recommendations on whether or under which circumstances and conditions a nuclear power plant could be built in Estonia.

Considering the necessary preparations for the introduction of nuclear energy and the long-term nature, complexity and public interest of its use, it is appropriate that the decision on the introduction of nuclear energy is taken by the representatives of the Estonian people and that the Government of the Republic submit this report to the Riigikogu for discussion and the formation of its position. The NEWG's final report will be submitted to the Riigikogu after discussions by the Government of the Republic in the form of a draft decision formulating a proposal on the introduction of nuclear energy.

The current legislation provides in two sectoral acts for a decision of principle by the Riigikogu as a prerequisite for the introduction of nuclear energy. Pursuant to § 79 of the Radiation Act, a radiation practice licence for the operation of a new nuclear facility can be applied for after the *Riigikogu* has adopted a decision on the commissioning of a nuclear facility<sup>32</sup>. The Electricity Market Act subsection 3 of § 22 stipulates that a generating installation that uses nuclear energy may be employed for the generation of electricity, provided this is authorised by a resolution of the Riigikogu<sup>33</sup>.

According to the IAEA *Milestones*, the establishment of both an informed and well-considered political decision in principle and a legal framework is a prerequisite for the preparatory work related to a specific nuclear facility (implementing legislation, designs, project development, establishment of a monitoring capability, development of other technical prerequisites).

Based on the NEWG's final report, the Riigikogu can decide whether to support the launch of a nuclear energy programme in the Republic of Estonia and the creation of the related regulatory and legal framework. In the event of a positive decision on the introduction of nuclear energy, this will create the prerequisites for the drafting of an act regulating nuclear energy and processing this act in the Riigikogu, the selection of a suitable site for a nuclear power plant to initiate the planning process and the identification of a suitably safe technology and a reliable developer by the state. The regulator must be involved in the planning process, and planning cannot be imposed until the legislation governing the site selection of a nuclear power plant has entered into force. In light of the above, while it is possible to start planning before the establishment of a nuclear regulatory body and the adoption of sectoral legislation, the detailed preparation of a national designated spatial plan requires the existence of both a regulator and a legal framework to assess safety issues.

A positive decision of principle in favour of the introduction of nuclear energy will also require the amendment of existing legislation and the establishment of the necessary national legal framework,

<sup>33</sup> https://www.riigiteataja.ee/en/eli/515122023010/consolide



<sup>32</sup> https://www.riigiteataja.ee/en/eli/501072023002/consolide



which must also provide for the final decision on the construction of a nuclear power plant to be taken by the Riigikogu<sup>34</sup>.

The NEWG based its analyses on the IAEA's *Milestones*, which foresees the analysis of 19 issues when considering the introduction of nuclear energy. For Estonian conditions, SMRs would be suitable, the kind which will start operating at the end of this decade. To mitigate risks, it is important to choose a technology that the world has experience with and that has guaranteed security of fuel supply.

Estonia needs to rapidly build new renewable energy generation and storage capacity to meet its 2030 and 2050 climate change mitigation objectives. A nuclear power plant would not be operational in Estonia in a timeframe that would allow it to contribute to the 2030 targets, but building a nuclear power plant along with renewable power plants is a possible solution to meet the 2050 targets and ensure security of supply. Nuclear power plants are also seen as having increasing potential to produce hydrogen and provide district heat, especially in a context where most of the world is striving towards carbon neutrality.

It is important to ensure that relying on nuclear energy does not undermine the addition of renewable generation and storage capabilities or delay emission reductions.

According to the IAEA *Milestones*, a country needs to make a knowledgeable and informed decision on the introduction of nuclear energy. The national position needs to be clear, reflect broad political support for the intention to develop a nuclear energy programme, and explain this intention at local, national, regional and international levels. The establishment of both an informed and well-considered political decision in principle and a legal framework is a prerequisite for the preparatory work related to a specific nuclear facility (implementing legislation, designs, project development, establishment of a monitoring capability, development of other technical prerequisites).

Based on the NEWG's final report, the Riigikogu can decide whether to support the launch of a nuclear energy programme in the Republic of Estonia and the creation of the related regulatory and legal framework. In the event of a positive decision on the introduction of nuclear energy, this will create the prerequisites for the drafting of an act regulating nuclear energy and processing this act in the Riigikogu, the selection of a suitable site for a nuclear power plant to initiate the planning process and the identification of a suitably safe technology and a reliable developer by the state.

The existing legal and regulatory framework in Estonia in the field of nuclear and radiation safety is sufficient for current radiation practices. The requirements applicable to radiation practices are regulated by the Radiation Act and its subsidiary legislation. The National Radiation Safety Development Plan 2018–2027 (KORAK) has been adopted, which aims to organise radiation protection

<sup>&</sup>lt;sup>34</sup> Pursuant to subsection 1 of § 1 of the Referendum Act, the Riigikogu may submit to a referendum not only constitutional questions but also other affairs of the state. Therefore, a referendum on the introduction of nuclear power can also be held. During this century there has been only one referendum in Estonia – on joining the EU in 2003. In EU, referendums related to nuclear energy have been held in Austria (1978), Sweden (1980), Italy (1987, 2011), Lithuania (2008, 2012) and Bulgaria (2013). The decision on nuclear energy, as one of the development options in the energy sector, is usually taken at a governmental or parliamentary level. For example, Germany's 2011 decision to cease using nuclear energy was taken in the parliament.



2



to ensure optimal radiation safety, as well as operation and development of radiation protection in Estonia. The strategic sub-objectives of the development plan are the following:

- 1. the functioning of the radiation safety infrastructure is improved;
- 2. radiation safety awareness and competence building are ensured;
- 3. the risks associated with radioactive waste and its management are reduced;
- 4. preparedness for the prevention and resolution of radiation events is ensured;
- 5. the risks from natural sources of radiation are reduced;
- 6. the justified use of medical exposure and radiation safety are ensured.

In Estonia, radiation sources are used by industrial and service companies, healthcare and veterinary service providers, scientific and research institutions and government agencies. Approximately 630 radiation practice licences have been issued in Estonia, of which the majority (75%) have been granted to healthcare providers, followed by industrial companies.

Estonia hosted an IAEA Integrated Regulatory Review Service (IRRS) mission in 2016 and a follow-up mission in March 2019. The IRRS missions found that the legal framework related to radiation safety meets the IAEA's radiation and nuclear safety standards regarding current radiation practices.

Estonia has joined/ratified/transposed international and European Union legal instruments related to nuclear safety, which is covered in Chapter 5. The safety of nuclear power plants from the point of view of the likelihood of potential emergencies is covered in Chapter 14.

### 2.1 NUCLEAR LIABILITY

Nuclear accidents can cause major nuclear damage, triggering claims for compensation. Such claims may include damage outside the territorial jurisdiction of the country where the nuclear incident occurred. This situation can raise difficult evidentiary issues, as the health effects of exposure to ionising radiation may only become apparent after a long time. The international procedure for civil liability for nuclear damage is established by various international instruments. Almost all of the foundations of the world's nuclear liability regimes today are based on two international conventions – the 1960 OECD Paris Convention and the 1963 IAEA Vienna Convention – but the expansion has been such that there are now five main pieces of legislation in this area:

- The 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention) and the 1963 Brussels Convention supplementary to the Paris Convention (Brussels Supplementary Convention), concluded under the auspices of the Organisation for Economic Co-operation and Development (OECD) and open to OECD Member countries.
- The Protocol of 12 February 2004 to the 1960 Paris Convention (the 2004 Paris Convention) and the Protocol of 12 February 2004 to the 1963 Brussels Supplementary Convention (the 2004 Brussels Supplementary Convention), concluded under the auspices of the OECD and open to OECD Member countries. Both Protocols entered into force in January 2022.
- The 1963 Vienna Convention on Civil Liability for Nuclear Damage, concluded under the auspices of the IAEA, is open to all Member States of the United Nations, its specialised agencies or members of the IAEA.





- Protocol amending the Vienna Convention, concluded under the auspices of the IAEA and open to all States (1997 Vienna Convention). The 1997 Vienna Convention was adopted on 12 September 1997 and entered into force on 4 October 2003.
- The Convention on Supplementary Compensation for Nuclear Damage (CSC, 1997) is open to all states that are party to the Paris or Vienna Conventions, as well as to states that are not parties to either the Paris or Vienna Conventions but whose national legislation is consistent with the principles contained in these Conventions. The 1997 Convention entered into force on 15 April 2015.
- Joint Protocol of 21 September 1988 relating to the application of the Vienna Convention and the Paris Convention, which merges the Paris Convention and the Vienna Convention.

The main principles common to all nuclear liability conventions (ie the Vienna and Paris Conventions and Convention on Supplementary Compensation for Nuclear Damage), which have also been reflected in most national nuclear liability laws worldwide, are as follows:

- the exclusive liability of the operator of the nuclear facility where the nuclear incident occurred (the principle applies that the victim should not have to go to too much trouble to establish liability). Liability is thus 'transferred' to the operator, but this is accompanied by a requirement for the operator to have insurance or other financial security.
- strict (absolute) liability of the operator (again, in favour of the victim);
- a definition of the type of nuclear damage covered;
- the establishment of a maximum liability amount to be borne by the operator;
- the obligation for the operator to have and maintain financial security to cover its nuclear liability and ensure availability of funds;
- the obligation of the victims to file claims within a certain period (prescription period);
- the international nuclear liability conventions also incorporate principles specifically designed to address the complexities posed by the potential transboundary damage and cross-border compensation claims, including: the determination of the competent jurisdiction and enforcement of judgments, the determination of the applicable law and equal treatment (no discrimination based upon nationality, domicile or residence).

The nuclear liability conventions set a minimum threshold of financial liability borne by the operator of a nuclear power plant. For example, the 2004 Paris Convention Protocol requires Member States to guarantee an amount of at least €700 million in the event of a nuclear accident. The 1997 Protocol to the Vienna Convention sets a minimum threshold of about 300 million international reserve assets created by the IMF (SDR), which is about €400 million. Member States may set higher thresholds or even unlimited liability. It is up to each country to set its own maximum liability amounts, depending on their laws and policies. As a result, the maximum amounts vary from country to country. While there is a general understanding that the polluter pays, a balance must be struck to allow the nuclear industry to develop. Therefore, the operator does not incur unlimited liability for a fixed maximum amount of liability. Nevertheless, a number of countries, such as Germany, Switzerland and Japan, have introduced unlimited liability under their nuclear liability legislation, as a condition allowed by the Paris Convention. The Swedish Nuclear Liability Act requires operators to be insured for at least 1,000 million SDR (approx. €1.2 billion), above which the state would cover up to SEK 6 billion (approx. €540 million) per incident. In Europe, two associations are involved in the insurance of nuclear plant operators: The European Mutual Association for Nuclear Insurance (EMANI), established in 1978, and the European





Liability Insurance for the Nuclear Industry (ELINI), established in 2002. The majority of nuclear plant operators in the EU are members of ELINI. EMANI has about 55 members and covers around 100 nuclear plants.

Nuclear liability is usually limited in time, but the exact period within which claims can be brought varies depending on the relevant international conventions and national legislation. For example, under the Paris and Vienna Conventions, the usual time period for bringing a claim after a nuclear accident is 10 years. This means that claims related to a nuclear accident must be brought within 10 years of the accident. Damages may be subject to a different time limit depending on the type of damage (eg personal injury, damage to property or environmental damage)<sup>35</sup>.

## 2.2 ENSURING NUCLEAR SAFETY IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

At present, Estonia's competence in the field of nuclear safety mainly relates to its ability to assess the safety of nuclear power plants in neighbouring countries and the consequences of possible incidents and accidents in these plants. The Environmental Board signed a Memorandum of Cooperation with the Radiation and Nuclear Safety Authority in Finland (STUK) in May 2019, with the Latvian State Environmental Service (VVD) in March 2020 and with the Canadian Nuclear Safety Commission (CNSC) in May 2023 on cooperation and exchange of information on radiation and nuclear safety and regulatory issues, covering preparation and response to nuclear or radiological events and emergencies, taking into account international emergency response agreements. In autumn 2023, the preparation of a Memorandum of Cooperation was also started with the Environmental Board and the U.S. Nuclear Regulatory Commission (NRC).

Launching a nuclear energy programme would significantly increase the complexity of the practices to be regulated and would require new measures to mitigate potential radiation risks. The structure and budget of the regulator overseeing all aspects of nuclear and radiation practices must take into account all areas of responsibility (including management, funding, human resource development). In launching a nuclear energy programme and carrying out safety assessments, existing national competences should be used, but it should be kept in mind that Estonia does not have all the necessary competences and some need to be sourced externally. For example, in cooperation with the IAEA and other organisations and countries with experience in the field.

In January 2022, Estonia signed a cooperation agreement with the United States Department of State to participate in the FIRST programme<sup>36</sup> to introduce and develop nuclear safety principles. FIRST (*Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology*) is a knowledge enhancement programme designed to strengthen strategic connections, support energy innovation and promote technical cooperation.

Estonia also participates in European Commission initiatives such as EU SMR seminars. In the future, Estonia plans to participate in the activities of the European SMR Regulators' Forum, WENRA (Western European Nuclear Regulators' Association) and WANO (World Association of Nuclear Operators).

Estonia is in active contact with the IAEA's Nuclear Infrastructure Development Section and Department of Technical Cooperation. Building competences in the field of nuclear energy is included in the framework agreement on technical cooperation between Estonia and the IAEA for the period of 2022—

<sup>36</sup> https://www.smr-first-program.net/



29

<sup>35</sup> https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/liability-for-nuclear-damage.aspx



2027, signed in September 2022. Areas where the IAEA's technical cooperation programme could be used include:

- 1. developing a regulatory and legal framework for the use of nuclear energy throughout the life cycle of a nuclear power plant;
- 2. preparing and carrying out international audits and expert missions;
- 3. developing organisational competences;
- 4. establishing comprehensive education and training programmes to ensure nuclear safety and to train staff.

The IAEA's Technical Cooperation Programme supports fellowships and scientific visits, offers participation in meetings and training courses, and provides expert services based on international guidelines and recommendations published by the IAEA. In 2022, the national project EST9007 Enhancing the Effectiveness of the Legislative, Regulatory and Organizational Infrastructure and Technical Capabilities of Radiation Protection and Nuclear Safety was launched under the IAEA Technical Cooperation Programme. The project will run from 2022 to 2025 and will enhance overall radiation protection and nuclear safety competences.

If a nuclear energy programme is launched, the country will put in place a nuclear safety policy and strategy, which will include nuclear energy. In addition to the existing policy development plan for radiation protection, KORAK, it would be advisable for the ministry responsible for the sector to draw up a nuclear energy development plan aimed at ensuring the sustainable and responsible development of the sector. The national nuclear energy development plan must be consistent with the country's overall energy strategy and policy and take into account all relevant aspects, from safety to environmental impacts. To integrate the management and storage of waste from a nuclear power plant into the national strategy, the existing National Action Plan for Radioactive Waste Management<sup>37</sup> should be complemented. Both the regulator and the owner/operator need to develop detailed knowledge and competences of international nuclear safety standards and nuclear power plant safety requirements and how to assess compliance.

To achieve the above objectives, it is necessary to establish a regulator responsible for nuclear safety as soon as possible and ensure that key posts are filled with senior specialists with the necessary expertise, and to start the necessary activities and programmes (management system, processes, training, development, legislation, etc) to build a nuclear safety culture. In the case of a prospective owner/operator, the same activities should also be started within that organisation. The requirements for qualifications/competences of nuclear safety-related posts within the organisation need to be laid down in legislation.

The owner/operator needs to define the expectations/requirements of a potential reactor technology vendor/supplier, in terms of the necessary technical support and training.

The existing legal and regulatory framework in Estonia in the field of nuclear and radiation safety is sufficient for current radiation practices. Launching a nuclear energy programme would significantly increase the complexity of the practices to be regulated and would require new measures to mitigate potential radiation risks. New sectoral policy and strategy documents should be developed to ensure the sustainable development of nuclear energy. Maximum use should be made of existing national

<sup>&</sup>lt;sup>37</sup> https://kliimaministeerium.ee/elurikkus-keskkonnakaitse/kiirgus/radioaktiivsed-jaatmed (in Estonian)



30



competences and the missing competences should be sourced externally, in cooperation with the IAEA and countries with nuclear experience.



To launch a nuclear energy programme, public management capabilities and development needs need to be considered.

The members of the NEWG include high-level representatives from almost all ministries in Estonia, the Government Office, the Environmental Board and the Consumer Protection and Technical Regulatory Authority. They have the capacity and the power to steer the development of people and knowledge management in their institutions and domains. The NEWG has an understanding of the need for management and safety requirements in line with IAEA safety standards. The experience gained in setting up management systems in other new nuclear countries will also be taken into account. To support the establishment of management systems, the IAEA has also issued a guidance publication NG-T-1.3 Development and Implementation of a Process Based Management System<sup>38</sup>.

The visible support of senior management and the involvement of employees are essential for the development and implementation of a successful management system. A management system is needed to support the regulator in achieving its objectives and credibility. It provides managers with a tool to develop and introduce the desired safety culture throughout the organisation. A management system will also support transparency and openness and ensure that issues related to nuclear safety, security and safeguards are not dealt with in isolation.

### 3.1 MANAGEMENT SYSTEM FOR THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

In the event of a positive decision, to establish a management system for the introduction of a nuclear energy programme, swift action is needed in amending the Government of the Republic act to establish a nuclear regulatory body and adopting the Nuclear Energy and Safety Act (TEOS). This establishes a framework for the organisation of the work of the regulator and appoints its senior officials. An adequate budget must be allocated that takes into account human resource development and the recruitment of external experts. In addition to the recruitment of employees, the development and implementation of an integrated management system (IMS) covering nuclear and radiation safety, nuclear security and safeguards (3S) will be a priority for the new management. This will involve working with a consultant to draw up an IMS project plan focusing on the initial work stream and developing it further in the next phases. To prepare the IMS project plan, Estonia has entered into a preliminary agreement under Project Phoenix, which is a sub-programme of the US Department of State's FIRST programme<sup>39</sup> and which will provide Estonia with free consulting services and analyses related to the nuclear energy introduction process. The management system should:

- 1. consist of processes and internal guidelines to support employees in carrying out their task;
- 2. ensure that the tasks entrusted to the regulator are properly carried out;
- 3. maintain and improve efficiency;
- 4. encourage and support the implementation of a safety culture;
- 5. allow internal processes to be monitored and improved;
- 6. include processes for self-assessments, management reviews, internal audits and independent reviews.

<sup>39</sup> https://www.smr-first-program.net/project-phoenix/



<sup>38</sup> https://www.iaea.org/publications/10709/development-and-implementation-of-a-process-based-management-system



Greater emphasis needs to be placed in the IMS on supporting activities related to the development of competences, taking into account the development of both the regulator and the nuclear developer. The programme should take into account the following possibilities, which should also be considered in the budget planning:

- 1. hiring external experts with experience related to the nuclear sector;
- 2. using consultants from countries with strong long-term nuclear experience;
- 3. sending our experts to various international conferences, seminars, training programmes and courses (eg work exchange programmes).

In the implementation of a nuclear energy programme, all three key organisations - the NEWG, the nuclear regulatory body and the owner/operator - will need to develop management systems at the appropriate level.

Following a positive decision on the introduction of nuclear energy, the NEWG will need to be substantially extended and several sub-working groups will be set up with parallel activities. Therefore, the NEWG management system needs to be improved to provide mechanisms to manage the development of the infrastructure of a nuclear energy programme.

### 3.1.1 MANAGEMENT SYSTEM OF THE NUCLEAR POWER PLANT OWNER/OPERATOR

The IMS of the owner/operator must cover safety, security and safeguards and be in line with the principles of IAEA's guidance publication GSR 2 Leadership and Management for Safety<sup>40</sup>. The IMS must support a strong safety and security culture, including a commitment to internal and external audits and the maintenance of knowledge relevant to nuclear safety and security. The owner/operator needs to develop the necessary conditions for procurement procedures and the evaluation criteria. This includes a description of the negotiation strategy with a vendor of a reactor. The owner/operator must be able to demonstrate that they have the necessary competences to organise the procurement and to manage the contract to be awarded, as well as a plan to develop the competences necessary to operate the nuclear power plant to be built. Contract management includes both the verification and monitoring of the progress of the project and the fulfilment and evaluation of quality requirements. The owner/operator's plan for the development of the competences necessary for the safe and secure operation of the nuclear power plant should include:

- a recruitment and training plan;
- procedures for maintaining the knowledge necessary for safe and secure operation;
- procedures on non-proliferation measures related to the import and export of nuclear material.

The NEWG has an understanding of the need for management and safety requirements in line with IAEA safety standards. In the event of a positive decision, to establish a management system for the introduction of a nuclear energy programme, swift action is needed in adopting the Nuclear Energy and Safety Act. An adequate budget must be allocated to the NEWG and its sub-working groups that takes into account human resource development and the recruitment of external experts. The development and implementation of an Integrated Management System (IMS), which will be launched

<sup>40</sup> https://www.iaea.org/publications/11070/leadership-and-management-for-safety





under Project Phoenix, sub-programme of the FIRST programme, in partnership with Sargent & Lundy, must also be a priority.



### 4.1 FUNDING FOR THE NUCLEAR ENERGY WORKING GROUP

During the period of April 2021 to December 2023, €377,438 of public resources from the budget of the Ministry of the Environment (KeM) / Ministry of Climate (KLIM) have been spent on the activities of the Nuclear Energy Working Group. In addition, €209,590 of the EU's Structural Funds have been used for the studies. Budgetary resources have been used to commission thematic analyses and for communication and training activities. To coordinate the activities of the Nuclear Energy Working Group, one temporary post was created in the KeM/KLIM in March 2022 with a salary fund of €37,464 in 2022 and €47,205 in 2023. Representatives of ministries and agencies who are members of the Nuclear Energy Working Group were not remunerated for their participation in the working group.

In-kind contributions have been received from the IAEA, the OECD Nuclear Energy Agency (NEA), the US Department of State, Japan's Ministry of Economy, Trade and Industry (METI), the Radiation and Nuclear Safety Authority in Finland (STUK) and the French Ministry of Foreign Affairs in the form of training, consultancy, seminars and study visits.

No budgetary resources from companies developing nuclear technology or potential developers have been used to fund the activities of the working group.

The percentage distribution of the expenses of the NEWG by sector for the period of 2021–2023 is shown in Figure 3.

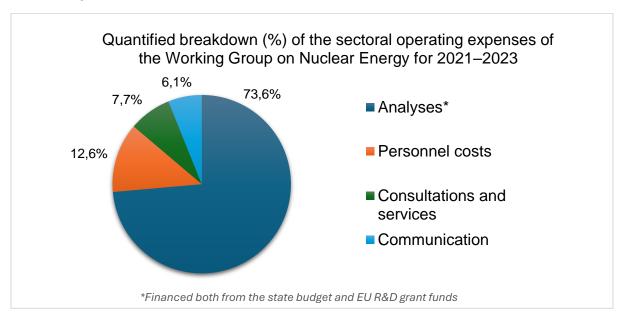


Figure 3. The percentage distribution of the expenses of the NEWG by sector in 2021–2023 (Source: NEWG)

### 4.1.1 EXPENSES OF THE NUCLEAR ENERGY WORKING GROUP FROM THE EU'S STRUCTURAL FUNDS

EU funds totalling €209,590 were used for the activities of the Nuclear Energy Working Group that qualified as research and development activities. R&D grants come from a variety of EU funds: the largest share comes from the European Regional Development Fund (ERDF) in the research and development field. An overview of the analyses funded from the R&D budget is given in Table 1.





Study	Payment time	Sum	Service provider
reliminary analysis of potential ocations for a nuclear power plant	December 2022	€49,950	Skepast&Puhkim OÜ and OÜ Inseneribüroo
and a disposal site for spent nuclear fuel	May 2023	€49,950	STEIGER
Analysis of security and readiness for emergencies	January 2023	€50,000	International Centre for Defence and Security
Analysis of spent nuclear fuel and	April 2023	€14,995	Breitenstein-Solutions
radioactive waste management	July 2023	€14,995	
Analysis of safeguards	August 2023	€29,700	Proxion Plan OY

Table 1. The analyses funded from the R&D budget (Source: NEWG)

### 4.1.2 EXPENSES OF THE NUCLEAR ENERGY WORKING GROUP FROM THE STATE BUDGET

The budgetary resources needed for the working group's activities were planned annually in the KeM/KLIM budget. By decision of the Cabinet meeting of 7 April 2022, an additional €250,000 was allocated from the state budget to the working group to accelerate the final report process by 6 months, moving the deadline from the originally planned June 2024 to December 2023. In total, the amounts used from the budget of the KeM/KLIM for the activities of the Nuclear Energy Working Group were €0 in 2021, €47,322 in 2022 and €330,116 in 2023. The total amount spent on salaries related to the activities of the NEWG for the period 2022–2023 is €84,669. An overview of the use of budgetary resources is given in Table 2.

Analysis, service	Payment time	Sum	Service provider
Expert analysis by the Finnish nuclear regulatory body STUK of the NEWG interim report	November 2022	€20,000	STUK International OY
Public opinion survey Awareness of the field of nuclear energy and readiness for its adoption in Estonia	March 2022	€4,250	AS Emor
Communication Strategy of the Nuclear Energy Working Group	October 2022	€17,850	META Advisory Group OÜ
Preparation of a human resources development strategy for the NEWG and mapping of a regulatory framework	March 2023	€147,000	Advokaadibüroo SORAINEN AS
Mapping the legal framework	March 2023	€48,000	TRINITI Advokaadibüroo AS
required to start the nuclear	August 2023	€24,000	





programme, updating the draft nuclear legislation and preparation of an explanatory letter	November 2023	€24,000	
Public opinion survey Awareness of the field of nuclear energy and	May 2023	€3,500	Norstat Eesti AS
readiness for its adoption in Estonia	November 2023	€2,950	
Radiation protection analysis	July 2023	€22,000	STUK International OY
Public information day 'Nuclear energy – good or bad?'	November 2022	€5,222	Conference equipment rental, event management and catering companies
Integrated Nuclear Infrastructure Review expert mission	August 2023	€42,000	IAEA
Organisational costs related to the pre-mission assessment of the preparedness of nuclear energy infrastructure	June 2023	€2,077	Catering, accommodation, conference and transport services companies
	October 2023	€7,589	
Nuclear energy information day for the public	November 2023	€7,000	Conference equipment rental, event management and catering companies

Table 2. Activities financed from the state budget (Source: NEWG)

#### 4.1.3 IN-KIND CONTRIBUTIONS TO THE NUCLEAR ENERGY WORKING GROUP

The IAEA has been the main contributor to the activities of the Nuclear Energy Working Group, providing support to Estonia under the bilateral framework agreement on technical cooperation for the period of 2022–2027. This mainly includes a variety of seminars, training, consultancy and expert services related to the introduction and use of nuclear energy. In the period of 2021–2023, seminars and training sessions on the introduction of nuclear deployment, in particular on SMR technology, have been the most commonly used methods to increase the nuclear competences of professionals working in the NEWG member institutions and their subsidiary agencies. During this period, staff from KeM/KLIM, KeA, the Estonian Environmental Research Centre, the Ministry of Regional Affairs and Agriculture, the Ministry of Education and Research (HTM), the University of Tartu (UT), the National Institute of Chemical Physics and Biophysics (NICPB), the Consumer Protection and Technical Regulatory Authority (TTJA), Elering and AS A.L.A.R.A. have participated in IAEA seminars, training and technical meetings. The IAEA technical cooperation programme also partly covered the costs of the INIR expert mission to Estonia in October 2023 to assess the preparedness of nuclear infrastructure.

In March 2023, the OECD NEA hosted a seminar at its headquarters in Paris for a delegation of the NEWG to present the services and training offered to countries.

Support from the United States for the activities of the Working Group has been predominantly offered through their FIRST programme, coordinated by the Department of State, which aims to increase small reactor-related competencies in partner countries. Estonia joined the FIRST programme in November





2021 and training activities started in January 2022. In September 2023, a nuclear energy study visit to the USA was organised for an Estonian delegation. In total, more than 60 specialists have participated in the FIRST training, including stakeholder representatives from the Estonian Green Movement and the Association of Estonian Cities and Municipalities, as well as the working group's contractual partners. In the spring of 2023, the US announced Project Phoenix under the FIRST programme, which will focus on replacing coal plants with SMRs. During the period from October 2023 to October 2024, Estonia will have the opportunity to receive various consulting and advisory services and applied research from the US within the framework of this project.

Cooperation with Japan started at the end of 2021 through the IAEA nuclear energy management training and the FIRST programme, in which the METI International Cooperation Center (JAIF/JICC) also participated. In May 2022 and April 2023, JAIF/JICC organised seminars in Tallinn on the introduction of nuclear energy. In October 2022 and November 2023, JAIF/JICC hosted study visits to Japan for a delegation of the Nuclear Energy Working Group.

The Finnish nuclear regulatory body STUK has, in addition to the paid services provided by its subagency STUK International OY, supported the working group in March 2023 by organising a seminar and a study visit to Finland, and has provided online and physical consultation meetings on regulatory issues and the establishment of the regulator.

The French Ministry of Foreign Affairs, with the support of its embassies in Tallinn, Helsinki and London, organised a seminar on nuclear energy for the members of the NEWG in Tallinn in November 2021, presenting France's experience with nuclear energy and the services offered by their nuclear industry. In November 2022, a study visit was organised for the representatives of the NEWG to nuclear installations and regulatory authorities in France.

The NEWG has not made use of any training or study visits provided by the nuclear industry, nor has it taken part in study visits organised by a potential developer. Members of the NEWG have participated and made presentations as national representatives at conferences and seminars organised by the potential developer.

## 4.1.4 FUNDING FOR THE NUCLEAR ENERGY WORKING GROUP IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

During a period of societal debate on the introduction of nuclear energy, communication activities need to be stepped up to raise public awareness. It may also be necessary to carry out further analyses to address issues raised during the debate. It is also necessary to be prepared for the follow-up activities to a possible positive decision, in particular the initiation of the legislative and regulatory process and the coordination of the activities. Assuming a favourable decision on the introduction of nuclear energy, the estimated budgetary needs for the NEWG and its sub-working groups amount to €368,000 (in year 0 of the nuclear energy programme launch), which should be allocated by the Government of the Republic to the budget of the KLIM on the basis of a supplementary budget request. It is estimated that up to 30% of these costs can be covered by R&D funds, the US Department of State Project Phoenix and the IAEA's Technical Cooperation Programme.

During the period of the implementation of the nuclear energy programme, once the nuclear regulatory body has been established, the NEWG's tasks will be transferred to the regulator and the ministry managing it, whose budget will include the costs of programme coordination, legislation and policy development, including the necessary staff costs. However, following the establishment of the regulator and the designation of the responsible ministry, it is necessary to maintain the NEWG as a collection of senior officials and stakeholder representatives during the implementation period of the nuclear energy





programme up to the operation of the plant, to ensure inter-agency cooperation, coherence and information exchange. An overview of the costs of the nuclear energy programme implementation period for the activities of the regulator and the ministry up to the operation of the nuclear power plant is presented in Annex 4.

# 4.2 FINANCING THE CONSTRUCTION OF A NUCLEAR POWER PLANT

One potential developer, Fermi Energia AS, aims to build a 600 MWe nuclear power plant by 2035 using private financing. Fermi Energia is planning a larger plant with a capacity of 1,200 MWe, consisting of up to four reactors with a capacity of 300 MWe. Taking into account the size of the Baltic electricity market, the national renewable energy and security of supply objectives, and the likely development of the European market for decarbonised hydrogen products, Fermi Energia AS is currently planning to build reactors 3 and 4 for the large-scale European market of decarbonised hydrogen products (ammonia or synthetic jet fuel) instead of the electricity market.

Various financing models have been used to finance nuclear power plants, such as price guarantees from the state, available cash flow of large companies, association of companies (the so-called Mankala principles in Finland, where several different private/ state-owned companies and local governments share the obligations and benefits of building and operating power plants, ie by guaranteeing the costs of construction and operation and by sharing the electricity produced at cost price based on the proportion of guarantees provided by each participant).

On 17 October 2023, the European Union's council of energy ministers reached an agreement on electricity market reform measures under which renewable and nuclear energy should equally receive two-way contracts for differences (CfDs) to ensure investment security from 2026 onwards for the construction of new zero-carbon plants.<sup>41</sup>

Fermi Energia AS expects that 60% of the investment in the nuclear power plant and network construction (approx. €3 billion) would be borrowed capital and 40% equity capital. They estimate that financing during construction is covered by equity capital, export credits from component supplier countries (eg Canada, USA, Japan) and loans from strategic investors. Bank loans will be mobilised in proportion to the construction phases. During the construction phase, bank loans are covered by collaterals from the owners, and in the later phase, the cash flow is guaranteed by 10-20-year electricity contracts with retail and industrial customers, the plant's assets and other collaterals required by banks. The expected share of industrial customers is 60-80% of total electricity sales and the geographical area of the contracts is the Nord Pool Baltic pricing area. Depending on the banks' expectations and requirements, a fixed (possibly partially indexed) electricity sales portfolio is expected to cover loan payments and interest and account for up to 60–80% of total production. The aim is to offer an average price in the range of €70-80/MWh with fixed price contracts of at least 15 years. Currently, Fermi Energia AS is known to have concluded preliminary contracts for the sale of electricity at a fixed price with 96 companies in Estonia with a total consumption of 500 GWh. While Fermi Energia AS states that their primary interest is funding security and mitigation of the risk of the new production capacity, not maximising revenue in the electricity market, the developer attempts to cover the maximum capacity (up to 4.8 TWh, ie 56% of Estonia's consumption in 2021) with preliminary sales contracts on the Estonian and Baltic electricity markets, including with public sector consumers interested in price certainty. To ensure certainty of financing it is proposed to cover the capacity not covered by long-term

<sup>&</sup>lt;sup>41</sup> https://www.consilium.europa.eu/en/press/press-releases/2023/10/17/reform-of-electricity-market-design-council-reaches-agreement/





electricity contracts with a CfD. In Europe, there are examples of offshore wind farms (Moray East 950 MW and Moray West 860 MW) where 50/50 certainty of financing is guaranteed through preliminary contracts and a CfD.

For equity investment, investment is planned from strategic investors, domestic capital of industries and financial investors. In the longer term, after the first reactor is operational, a minority stake in Fermi Energia AS will be considered for listing on the Tallinn Stock Exchange. The ownership structure and financial structure of the company can change over time, in particular because the lifetime (at least 60 years) and depreciation of a power plant are several times longer than the normal loan periods, and the free cash flows of a power plant are different at different stages of its operation. Fermi Energia AS sees its current shareholder Vattenfall AB as a strategic investor, but negotiations are ongoing with several other energy companies in Northern Europe that have decided to invest in energy generation with small reactors. The plan of Fermi Energia AS is to increase the share capital and the number of shareholders step by step between 2023 and 2029. They are also open to state participation when the state has made an informed decision to introduce nuclear energy<sup>42</sup>.

#### 4.2.1 SHARE CAPITAL AND POTENTIAL INVESTORS

Fermi Energia AS has estimated the total capital required for a production capacity of 600 MWe at around €3 billion. Equity should optimally account for 40–60% of total capital. The following are seen as potential investors:

#### 1. Public investors

The importance of a nuclear power plant's strategic regional security of supply makes state ownership crucial, and Baltic state-owned energy companies such as Eesti Energia, Latvenergo in Latvia and Ignitis Group in Lithuania are seen as potential investors.

#### 2. Strategic investors

They can bring more than just equity by contributing with training, technical support and services. Examples of such investors include Vattenfall AB in Sweden, Equinor in Norway, Orlen Group in Poland, UPM Energy in Finland and OPG in Canada.

#### 3. Funds

International funds investing in energy and/or electrification such as OMERS Infrastructure (Canada), Norges Bank Investment Management (Norway), EQT funds (Sweden), AP funds (Sweden).

#### 4. Other investors

Individual investors / investment firms in Estonia, the United States, Canada and the Nordic countries.

#### 4.2.2 BORROWED CAPITAL

Fermi Energia AS plans to include the borrowed capital for the project through:

#### 1. Shareholder loans

Shareholder loans come from strategic investors and are part of an agreement concluded at the same time as the FID (*Final Investment Decision*).

#### 2. Banks

Interest rate = risk-free rate + credit margin. The current standard construction credit is 2-

<sup>&</sup>lt;sup>42</sup> Fermi Energia AS's reply to the NEWG's questions of 13.11.2023 sent by e-mail on 21.11.2023.





10%, depending on the assessed risk. Public participation in the project in the form of direct loans or guarantees lowers the estimated level of risk of the project (in particular political risk) for other parties. Borrowing of this magnitude takes place both on the international market and on the local regional market, including the Nordic countries. The most recent major lender to the Estonian energy sector was Deutsche Bank with around €600 million. In the regional market, the largest creditors are Luminor Estonia (owned by US venture capital firm Blackstone), LHV Estonia, Citadele Latvia, SEB Sweden, Swedbank Sweden, EBRD, NIB − Nordic Investment Bank, EIB − European Investment Bank. The French banks BNP Paribas and Credit Agricole are strong in financing nuclear energy. Canadian commercial banks CBIC, Royal Bank of Canada, Bank of Montreal finance large-scale nuclear investments in Canada.

#### 3. Trade finance

This not only includes financing but also risk mitigation, guarantees and insurance. Trade finance usually involves sellers (or exporters in the case of international trade), buyers (or importers), credit institutions, and insurers, but also export credit agencies (ECAs) and other service providers. In the case of Fermi Energia AS, the likely partners would be EDC – Export Development Canada; EXIM Bank – Export-Import Bank of the United States (US); JBIC – Japan Bank for International Cooperation. The payment for goods is transferred to a loan with interest and mortgage payments over a certain period (according to the OECD rules, the loan is generally up to 18 years and up to 90% of the project costs).

#### 4. Bonds

Companies issue bonds to raise alternative capital to bank loans. Bonds offer greater discretion and more flexible terms, with the possibility of longer maturities. Potential buyers of Fermi Energia AS bonds: international, Nordic and local pension funds, EBRD, NIB – Nordic Investment Bank and various institutional investors.

Calculated levelised costs for different scenarios show that proactively addressing risk mitigation is important, and that a project that takes this into account from the outset will clearly be more successful than one that does not. The size of the initial investment (capital cost) determines the cost of financing (the investment should be recovered within a certain period of time). Cost control and active value engineering can have a significant impact on overall costs. Additional costs will come from cutting-edge project support with expertise and IT tools (simulations, BIM software with planning and costs). It is important to cooperate early with potential lenders to obtain the best possible interest rate, as even a change of a few basis points will have a significant impact on the final price of electricity due to the capital intensity of the project. It is of utmost importance that the reference project is implemented on time and within budget in Canada<sup>43</sup>.

#### 4.2.3 PRICE OF ELECTRICITY PRODUCED BY A NUCLEAR POWER PLANT

The price of electricity produced by a nuclear power plant depends on the cost of construction and capital, ownership costs, operating costs including fuel, fees for final waste disposal and the plant's decommissioning fund, the EU's taxonomy for sustainable finance<sup>44</sup> and the amount of energy produced by the plant (load factor). As the SMRs that are considered to be suitable for Estonia are not yet operational, electricity price projections will also largely depend on the final price of the first reactors of this type and the total cost of replicating these projects. Since the first reactors of this type are more expensive than the subsequent reactors of the same type, the estimated electricity price should be based on the cost of the 2nd or 3rd reactor. By this time, the regulator has also developed a

<sup>44</sup> https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities\_en\_



<sup>&</sup>lt;sup>43</sup> Fermi Energy Financing Strategy. Preliminary Studies 2022. Vattenfall



practice of issuing permits for this type of reactor, and the project has applied the lessons learned from the construction of the first reactor. Given the possible timeframe for the implementation of Estonia's nuclear energy programme, from the decision of principle to the start of electricity generation (9–11 years), Estonia is unlikely to be the first country in Europe to deploy SMR(s). For the timeframe from the end of the current decade to the early 2030s, several SMR projects are in the permitting and construction pipeline, eg in Poland, Romania, France, Czech Republic. In terms of technology choice, it would be wise to choose the type of reactor that other European countries are planning to build, which would give project financiers and investors, as well as the regulator, greater certainty, a more secure supply chain for plant components and fuel, and lower overall costs.

The cost of the plant and the electricity it generates will also be influenced by the interest rates on loans, CO2 prices and the volume of closed fossil fuel-fired power generation capacities at the time of the final investment decision in the 4th to 6th year of the nuclear energy programme, as well as electricity demand in the Baltic/Nordic region, which may create a favourable long-term investment environment. The objective of securing generation is to maximise the volume of sales contracts concluded and, in the interest of the developers, also CfDs to ensure that short-term market volatility does not significantly constrain generation. The modelling and business goals of Fermi Energia AS is presented in Table 3:

	1. reactor	2. reactor	Average
Ownership cost	€300 million	€120 million	
Construction cost	€1,550 million	€1,350 million	€1,400 million
Weighted average cost of capital (WACC)	7.5% 40/60 (equity/debt)	6.5% up to 45 / up to 65	7%
Load factor	92%	92%	92%
Operating costs (including scrapping, fuel fund, etc)	20 €/MWh	20 €/MWh	20 €/MWh

Table 3. Cost modelling for building a nuclear power plant and business goal of Fermi Energia AS (Source: Fermi Energia)

An OECD study in 2020 on the projected costs of generating electricity showed that the sensitivity of the levelised cost of electricity (LCOE) for nuclear energy to different discount<sup>45</sup> rates was significantly higher than for other energy sources such as coal- or gas-fired power plants, due to their capital intensity. According to the study, at a discount rate of 3%, nuclear energy was significantly cheaper than the alternatives, at 7% it was comparable to coal and cheaper than gas, and at 10% it was comparable to both. At low discount rates, nuclear energy was cheaper than wind and solar energy. Compared to a 0% discount rate, the LCOE of nuclear energy at a 10% discount rate was three times higher, while for coal it was 1.4 times higher and for gas-fired power plants it changed very little. The LCOE of solar energy was 2.25 times higher and onshore wind energy almost two times higher at a 10% discount rate, although their capacity factors were very different compared to the 85% baseload variant of nuclear energy<sup>46</sup>. The OECD's projected LCOE €/MWh for nuclear power plants starting operation from 2025 in eight countries is shown in Table 4.

#### LCOE €/MWh

<sup>46</sup> https://www.oecd-nea.org/upload/docs/application/pdf/2020-12/egc-2020 2020-12-09 18-26-46 781.pdf



<sup>&</sup>lt;sup>45</sup> the interest rate applied to loans from the central bank to commercial banks and other financial intermediaries.



Country	3% discount rate	7% discount rate	10% discount rate
France	41.1	64.5	87.9
Japan	55.5	78.7	101.7
South Korea	35.7	48.4	61.0
Slovakia	52.3	92.4	132.5
USA	39.8	64.7	89.5
China	45.3	59.9	74.5
Russia	24.9	38.1	51.4
India	43.7	59.9	76.1

Table 4. The OECD's projected LCOE €/MWh for nuclear power plants starting operation from 2025 in different countries (Source: OECD)

#### 4.3 RISKS

Like all capital-intensive industrial projects, the implementation of a nuclear energy programme involves a number of risks related to technological, environmental, economic, political and social impacts. Becoming aware of the risks and finding possible mitigation measures are actions that need to be taken before the project starts. The general risks and challenges for the implementation of the nuclear energy programme are:

#### Market risk

Fluctuations in electricity prices and changing demand may affect the stability of the revenues planned for the project. As a mitigating measure, preliminary sales contracts and CfDs would be used to the maximum extent possible.

#### **Financing risks**

A high equity to debt ratio can cause problems if project costs exceed budget or if financing arrangements prove more difficult than expected. Thorough budgeting and cost control and diversification of funding are essential.

#### Technological risks

The implementation of new SMR technologies can bring unexpected technical challenges. A proven technological solution should therefore be chosen.

#### Social and political risk

The construction of nuclear power plants may lead to public opposition (eg in the site selection process) and political views on nuclear energy may change. It is important to carry out public opinion surveys, to involve as much of the public as possible in the decision-making process, to raise the awareness of decision-makers at a political level, and to ensure the timely sharing of information and transparency of decisions.

#### Construction risks

Construction delays and budget overruns are common risks in major projects, and good project management is key to mitigating them.

#### Safety risk

The safety of nuclear power plants is one of the top concerns of the public. Although the occurrence of accidents with serious consequences is extremely unlikely, the construction and





operation of nuclear power plants must be required to meet the highest safety standards and ensure that all risks are minimised.

#### **Waste management risk**

Radioactive waste from nuclear power generation, which requires long-term safe storage. Even if the amount of waste generated is small, Estonia should develop a strategy for the management of radioactive waste and consider the establishment of a spent nuclear fuel final disposal site.

#### Developing alternative technologies

Once a nuclear power plant is operational, the long-term commitments taken need to be considered, which means that there is no quick way to switch out of this energy source. While nuclear energy can provide a stable supply of electricity, investment in renewable energy technologies and energy efficiency should continue.

#### Human resource development

Using nuclear energy requires specialists with higher education and appropriately qualified workers. Training these people takes time and they are in short supply in the labour market. Both the nuclear regulatory body and the plant operator would, in the early years of the nuclear energy programme, be dependent on employees imported from other countries.

## 4.3.1 BANKRUPTCY RISK OF THE NUCLEAR POWER PLANT OWNER/OPERATOR

One of the risks to be considered even before a nuclear power plant is built is what would happen to the plant in the event of the owner/operator going bankrupt. The bankruptcy of a nuclear power plant operator requires coordinated action by the state, regulators, financial institutions and other stakeholders. Ensuring safety, resolving legal and financial issues and determining the future of the plant are key aspects of the process.

When a private operator of a nuclear power plant declares bankruptcy, it raises a number of complex issues and requires swift action. The first priority in such a situation will be to ensure safety. State intervention may be necessary to ensure the safe operation and maintenance of the plant during the bankruptcy proceedings. The bankruptcy process must deal with legal and financial issues, including the assessment of creditors' claims and debt restructuring. Depending on the extent to which loans have been repaid over the operating time of the plant, the financial consequences of a declaration of bankruptcy in the 10th to 15th year of the plant's operation could be significant. During this period, the issue of covering the costs of decommissioning the plant and waste storage may also be problematic, as the payments made by the operator to the relevant national fund are not yet sufficient to finance these activities. To resolve the situation, the trustee in bankruptcy or the state can look for a new operator to continue operating the plant. The plant can be an important regional employer and contribute to the economic development of the region, so its closure would have wider economic and social consequences.

A proactive approach is essential to avoid the bankruptcy of a nuclear power plant operator, involving a wide range of measures from policy and regulatory support to financial and technical assistance. The state must be ready to intervene and support the project in its different phases, while ensuring that all activities are in line with international standards and best practices.

There are several ways for the state to avoid the bankruptcy of the plant operator, especially if the nuclear power plant project is considered to be of strategic importance. These measures include both preventive strategies and crisis management solutions. To prevent bankruptcy, the state can offer





various support measures, such as price guarantees, tax incentives or subsidised loans, to ensure the economic viability of the project. One option is also to facilitate negotiations with international financial institutions and investment banks to ensure access to the necessary financing and, where possible, to provide state guarantees for loans. The state can participate in risk-sharing, for example through joint ventures or public-private partnerships. It is also possible to develop crisis management plans to help identify and resolve potential problems before they become critical.

However, it is unlikely that the plant will be shut down for economic reasons, as the high capital intensity requires a thorough risk analysis at the investment stages. Electricity production is secured by long-term sales contracts or risk mitigation measures such as Contracts for Difference (CfDs), and loans are backed by a number of collaterals, including owner or state guarantees. Extensive modelling must be carried out before final investment to ensure that the risks of construction and operation are balanced against the revenues generated and the project revenues. If the power plant's revenues do not cover its borrowing costs, the first step is restructuring and modifying debt contracts to reduce capital costs. In the event of temporary problems, existing owners can increase equity to cover costs. If existing shareholders do not increase equity, new investors can be attracted. Many of the plant's major fixed costs, such as fuel, maintenance and salaries, are fixed for the long term, so short-term price fluctuations do not have a significant impact on the cost price of electricity. As a last step, bankruptcy proceedings are being considered, in which the power plant will continue to produce electricity but shareholders may lose their stakes. In the event of exceptional capital needs, the state may consider acquiring a stake or increasing its stake in the nuclear power plant.

Historically, nuclear plants have mainly been closed due to changes in national policies (Germany, Italy). However, several projects have been cancelled for economic reasons before construction has started (eg Wylfa Newydd in the UK). In the US, there have also been cases where nuclear power plants have been shut down before the end of their originally planned lifetime due to the economic difficulties of the operator. For example, the Zion Nuclear Power Station in Illinois, USA, which started operating in 1973, was closed in 1998 after a plant employee, by not following procedures when inserting and removing control rods from the reactor, caused damage that, if remedied, would not have paid for itself by the end of the plant's planned lifetime (2013) and would not have allowed the plant to generate electricity at competitive prices<sup>47</sup>.

#### 4.3.2 INVESTMENT RISKS

Total investment risk is the sum of non-systemic and systemic risk. A non-systemic risk is a risk that is specific to a particular company or industry, while a systemic risk is a risk that relates to the broader market and is not based on an individual investment or company. Systemic risk is related to price volatility, market price, interest rates and global changes. They need to be thoroughly managed over the lifetime of a company. All new ventures are of course subject to a high level of overall risk in their early stages, mainly due to non-systemic risks:

- Technical risk
  - Is the technology right and working with high reliability?
- Legal and regulatory risks
  - Are all the permits in place, can the state change its decisions and regulations during the project?
- **©** Construction risk
  - Are the construction volume, input costs and timing within the planned limits?

<sup>47</sup> https://en.wikipedia.org/wiki/Zion Nuclear Power Station





#### Financial risk

The capital structure, the best possible ratio between bank debt, bonds and equity. Financing the construction budget overrun.

#### Business risk

Can the sales and revenue targets be met?

#### Operational risk

Can timely operational capacity be ensured?

#### Counterparty risk

Do buyers, suppliers, etc meet their obligations and how are risks distributed using different contracts?

Some of the mentioned risks may also be present during the operational phase of a nuclear power plant, but to a different extent.

A large part of the total life-cycle costs of a nuclear power plant are the construction costs that are incurred before the first MWh is produced. Construction risk is high at the start of the project and zero after the plant is operational. Initially, the risk is borne by the investors/owners, but can be shared through cooperation agreements, risk management and with the help of the Trade Finance Facility in cooperation with contractors and suppliers.

On liberalised markets, where competition is allowed, prices are regulated by the market and the cost of generating electricity can change rapidly depending on many factors such as fuel prices, demand and policy decisions, and the operator needs someone to share the risk with. In supply arrangements, consumers temporarily give up the potential benefit of lower prices but receive lower average long-term costs. Supply arrangements transfer risk to the consumer and thereby reduce the risk premium.

Both financial and ESG<sup>48</sup> aspects of potential counterparties need to be analysed to mitigate the risks of sanctions, insolvency, reputational damage and breach of contract. New nuclear power plants have been included in the European Union's taxonomy for sustainable investments with certain technical requirements.<sup>49</sup>

#### 4.4 RISK MITIGATION STRATEGIES

For each risk, it is important to assess both the likelihood and the potential impact when implementing the project to develop effective mitigation strategies. General risk mitigation measures for nuclear projects include:

#### Diversification and risk mitigation

Diversification of electricity sales contracts across different customers and geographic areas can help mitigate market risks.

#### Risk analysis and reserves

Budgets should take into account potential cost overruns and build in financial reserves for contingencies.

#### Technology

Thorough testing and quality control of technology will help to reduce technical risks.

<sup>&</sup>lt;sup>49</sup> https://finance.ec.europa.eu/publications/eu-taxonomy-complementary-climate-delegated-act-accelerate-decarbonisation\_en



<sup>&</sup>lt;sup>48</sup> ESG is a set of environmental, social and governance measures and standards, a concept of governance.



#### Cooperation with regulators

Close cooperation with national authorities and international organisations influences the regulatory environment, avoiding unforeseen delays and reducing the time needed for authorisation procedures.

#### Enhancing project management

Effective project management, including monitoring of time schedules and budgets, helps to avoid the increase of construction risks.

#### Network development

Early cooperation with network operators will help to ensure a smooth connection.

#### Long-term contracts

Long-term fixed-price contracts help to ensure cash flow stability.

#### State support and participation

State support and possible participation in the project can increase the credibility of the project and reduce financial risks.

## 4.4.1 STATE PARTICIPATION IN THE CONSTRUCTION OF A NUCLEAR POWER PLANT

From the point of view of the state, it is important to choose between taking a stake in the construction of a nuclear power plant to mitigate the project implementation risk, and with it the willingness to mitigate other potential risks, or limiting the state's risk to the investments made to create the necessary infrastructure for the introduction of nuclear energy. Both options have their advantages and disadvantages.

Direct state participation allows for a say in the management of the project and a share of its revenues, which can help offset the initial investment. State participation would also give investors and lenders the necessary certainty and make it easier to raise capital for the successful implementation of the project. At the same time, the state also incurs financial liabilities that can have a significant impact on the national budget if the project goes over budget or delays occur, which in turn can have political consequences.

Limiting the investments to the creation of a national infrastructure would mean lower direct financial risks, as the investments would only involve the creation of a regulatory and legal framework. It would also allow the state to remain neutral and avoid direct links with possible negative project outcomes, as well as additional administrative burdens arising from project management. The drawbacks of this option are limited control and influence over the project, lost potential returns from project participation, and reliance on the private sector for successful investment and project management.

Both scenarios call for a balanced approach, where the country has to consider its financial capacity, political objectives, energy security needs and social responsibility. In the case of both options, compliance with international environmental and safety standards and best practices is a priority.

Due to the high capital costs, the most common practice in building nuclear power plants is for the state to build them or use public-private partnerships. Private ownership of nuclear power plants is common in several countries where energy markets are liberalised, such as the US, as well as in Canada (although some are owned by provincial governments). In the UK and Sweden, the ownership structure of nuclear power plants is different and includes both full private ownership and ownership stake by a national energy company. In Finland, nuclear power plants are privately owned, but they are operated based on the Manakala model, in which private companies as well as municipalities and other





organisations participate. Although most of France's nuclear power plants are owned by the national energy company EDF (*Électricité de France*), there are also private investors<sup>50</sup>.

In the case of SMRs, which require significantly less investment than large nuclear power plants, it is expected that they can be built entirely by the private sector. The development of SMRs is largely driven by private sector investment, including small business investment. The involvement of new investors in the development of nuclear energy is a sign of a shift from traditionally government-led programmes to the private sector<sup>51</sup>.

The NEWG's recommendation is to leave the state with the option of taking a stake in the nuclear power plant project. For example, one of the conditions for the developer of this project could be that the state must have the possibility to participate if it so wishes.

# 4.5 EXPENSES FROM THE STATE BUDGET FOR THE IMPLEMENTATION OF THE NUCLEAR ENERGY PROGRAMME

In regard to the legal framework, international obligations and the development of infrastructure to ensure nuclear safety, it makes no difference whether a nuclear power plant is developed by the state or a private developer. In any case, as Estonia has no experience in operating nuclear facilities, the introduction of nuclear energy requires the creation of national infrastructure.

The expenses from the state budget for launching the nuclear energy programme include the costs of the regulator, the legal framework, policy development and the creation of technical and emergency response capabilities, and the development of competences. In the years following the decision to introduce nuclear energy until the start of electricity generation in a nuclear power plant (9–11 years), the total cost from the state budget for the regulatory framework and education programmes would amount to €73 million with today's prices. The lion's share of these costs (62%) is the personnel expenses of the regulator, followed by education and research programmes (17%) (Figure 4).

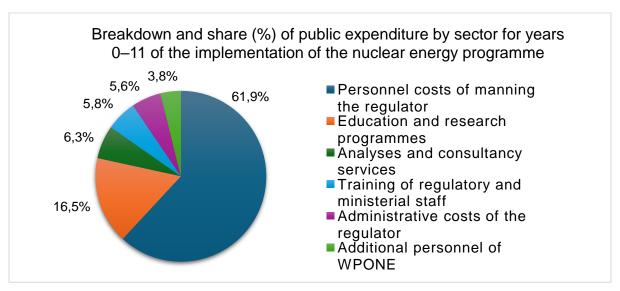


Figure 4. Percentage of public expenditure on the implementation of the nuclear energy programme by sector (Source: NEWG)

<sup>&</sup>lt;sup>51</sup> https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx



 $<sup>{\</sup>color{red}^{50}} \ \underline{\text{https://world-nuclear.org/information-library/economic-aspects/financing-nuclear-energy.aspx}$ 



The highest costs from the state budget will be incurred starting from the 4th year of the nuclear energy programme, when the personnel of the regulator will be increased for the licensing process, and costs from the state budget will amount to €8.5 million. In years 9 to 11, there will be an increase in the costs of developing technical capabilities to ensure emergency planning, the exact total of which will be determined following the technology and site selection process, once the risks associated with the chosen technology and its location, the likelihood and scale of emergencies have been assessed in more detail. During the operational phase of the nuclear power plant, the fixed costs from the state budget for maintaining the regulatory framework and educational programmes will be around €6.5 million. An overview of the state budget expenses by year of implementation of the nuclear energy programme is presented in Figure 5.

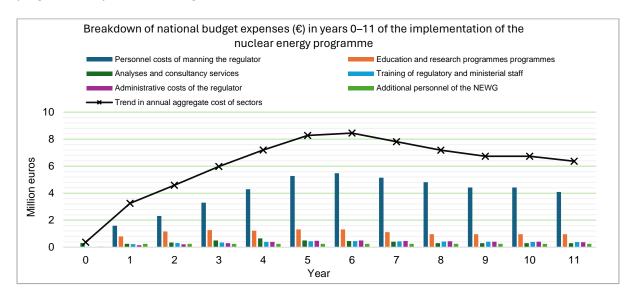


Figure 5. Expenses from the state budget for the implementation of the nuclear energy programme in years 0–11 (Source: NEWG)

For a more detailed overview of state budget expenses, see Annex 4.

Expenses from the state budget can be reduced through various external funding programmes, in particular in cooperation with the IAEA, the US and Canada, as well as EU structural funds. To finance the regulator, it is recommended that, based on the practice in other countries, an annual licence fee be charged to the owner/operator of the plant, a state fee corresponding to the cost of processing the licence application, and hourly consultancy fees that can be used to partially cover the fixed costs of the regulator.

## 4.5.1 COSTS OF DEVELOPING EMERGENCY RESPONSE AND TECHNICAL CAPABILITIES

The estimation of fixed costs for the development of emergency response and technical capabilities is highly imprecise at this stage due to the lack of bases for planning (safety analyses, design, technology, plant location, impact assessments and risk analyses) for SMRs.

On the basis of preliminary estimates, the total cost of emergency response and technical capabilities could amount to €54 million over a 10-year period. The calculations are currently based on a conservative assumption of potential emergency scenarios for large nuclear power plants with a rated





thermal input of more than 1,000 MWth, which are not necessary for SMRs at this scale, given the amount of nuclear material contained in their reactors and the additional design-based safety measures.

At this stage, it is unreasonable to estimate the costs of developing emergency response capabilities, as it will depend on the results of models, calculations, impact assessments and risk analyses that will be prepared in the future. In the next phases, it will be necessary to estimate the costs more accurately, depending on the emergence of necessary details on the SMRs and more precise planning bases. Costs are tending to fall, and today's high costs are mainly the result of the failure to fill past capability gaps in the chemical, biological, radiological and Nuclear (CBRN) area as a whole, which will need to be addressed retrospectively if a nuclear power plant is built.

The cost of mitigating military risks has not been taken into account – further details in this area will emerge in the next stages in both the risk and impact assessment phases. The budgetary needs of the structures of the Estonian Internal Security Service that are protected as state secrets have also not been considered. This is the subject of a separate analysis, which is presented separately on a need-to-know basis.

The exact costs for the Health Board and Ministry of Regional Affairs and Agriculture will be determined after the safety assessments have been evaluated by the national regulator to be established. It is also necessary to agree on the exact division of responsibilities and tasks in the Nuclear Energy and Safety Act. When drawing up the educational programmes, it is also necessary to further assess the need for supplementing the modules of the Academy of Security Sciences, as well as training for the entire emergency response structure, which concerns the employees of the Health Board, the Police and Border Guard Board and the Rescue Board, which should be approached as a whole.

In the future, it will also be possible to find solutions to cover costs outside the state budget – this means that it is worth looking for sources to cover the costs both through international cooperation formats (eg training) and through funding applications from different funds and bilateral cooperation formats (development of capabilities). The principles of dependence and reliability must also be carefully observed.

# 4.6 REVENUE TO THE STATE BUDGET FROM THE IMPLEMENTATION OF THE NUCLEAR ENERGY PROGRAMME

The revenues to the state budget from the implementation of the nuclear energy programme come from several sources, most of them being labour taxes. The tax revenues are conditional on the completion of the two reactors at the latest in year 11 of the nuclear energy programme. The tax revenue projection is different for the construction and operation periods and includes the tax revenue projection of the potential developer, Fermi Energia AS, during the development phase of the plant. The calculation of revenue takes into account tax revenue, possible state fees and toleration payments. The amount of the toleration payments has been calculated based on the Environmental Charges Act that will enter into force on 1 July 2023. In addition, from the start of electricity generation by the first reactor of the plant, payments will be made to the national fund for the final disposal of radioactive waste generated by the plant and for the decommissioning of the plant, which will be used only for the intender purposes and will need to be regulated accordingly. Therefore, these payments have not been included in the direct revenue of the state. In the calculation of state budget expenses, the costs of developing infrastructure for emergency planning are not yet included in this sub-chapter. The ratio of state budget expenses to revenue is shown in Figure 6.





### Ratio of national budget expenses to revenue in years 0–11 of the implementation of the nuclear energy programme



Figure 6. Ratio of national budget expenses to revenue in years 0–11 of the implementation of the nuclear energy programme (Source: NEWG)

Revenues to the state budget would start to exceed costs in the construction phase of the nuclear power plant starting from the 6th year of the nuclear energy programme. This is mainly due to the labour taxes paid on the project developer's growing personnel and the boost to regional economic activity from construction activities. After the 11th year, in the phase of the nuclear power plant's operation, public revenues would permanently exceed costs by at least €19 million. Even in the negative scenario, where state expenses would be twice as high as currently projected and revenues twice as low, revenues would already exceed expenses by at least €5.5 million at the beginning of the operational phase (Figure 7).

## Ratio of national budget expenses to revenue in the negative scenario in years 0–11 of the implementation of the nuclear energy programme

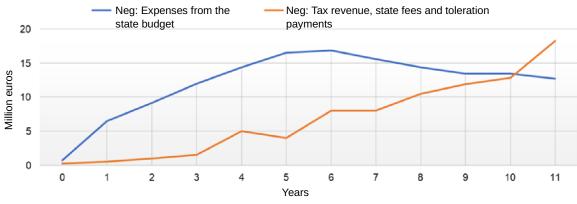


Figure 7. Ratio of national budget expenses to revenue in the negative scenario in years 0–11 of the implementation of the nuclear energy programme (Source: NEWG)

The construction of a nuclear power plant may also generate additional revenue through increased employment in the service sector, which provides services to plant workers and builders, such as catering, accommodation, security services, etc. Also, a nuclear power plant as a satellite facility could bring new investment in the form of energy-intensive industries. In some cases, nuclear power plants can attract educational and scientific tourism, as in other countries. Assuming that the plant is built on state land, there is the possibility of receiving revenue in the form of a land-use tax.





During the period of April 2021 to December 2023, €377,438 of public resources from the budget of the KeM/KLIM have been spent on the activities of the Nuclear Energy Working Group. In addition, €209,590 of the EU's Structural Funds have been used for the studies. In year 0 of the implementation of the nuclear energy programme, the estimated budgetary needs of the working group are €368,000, which will need to be allocated to the budget of the KLIM on the basis of a supplementary budget request. It is estimated that up to 30% of these costs can be covered by R&D funds, the US Department of State Project Phoenix and the IAEA's Technical Cooperation Programme.

One potential developer, Fermi Energia AS, aims to build a 600 MWe nuclear power plant by 2035 using private financing. Fermi Energia AS expects that 60% of the investment in the nuclear power plant and network construction (approx. €3 billion) would be borrowed capital and 40% equity capital.

The expenses from the state budget for launching the nuclear energy programme include the costs of the regulator, the legal framework, policy development and the creation of technical and emergency response capabilities, and the development of competences. In the years following the decision to introduce nuclear energy until the start of electricity generation in a nuclear power plant, the total cost from the state budget for the regulatory framework and education programmes would amount to €73 million at today's prices. The costs of developing emergency rescue and technical capabilities will be added to this. Expenses from the state budget can be reduced through various external funding programmes, in particular in cooperation with the IAEA, the US and Canada, as well as EU structural funds.

Revenues to the state budget, which include tax revenues, possible state fees and tolerance payments, would start to exceed the expenses in the construction phase of the nuclear power plant starting from the 6th year of the nuclear energy programme. After the 11th year, in the phase of the nuclear power plant's operation, public revenues would permanently exceed costs by at least €19 million.



# 5. LEGAL FRAMEWORK

Radiation sources are currently used in medicine, industry and research, and in radioactive waste management in Estonia. Therefore, the existing radiation protection legal framework in Estonia covers these practices. The current legal framework related to the use of radiation sources and the management of radioactive waste in Estonia is regulated by the legislation presented in Table 5, which should be taken into account when considering the development of an appropriate legal framework for the nuclear energy programme:

- 1. Government of the Republic Act
- 2. Electricity Market Act
- 3. Radiation Act
- General Part of the Environmental Code Act
- 5. Administrative Procedure Act
- 6. Emergency Act
- 7. Law Enforcement Act
- 8. Environmental Impact Assessment and Environmental Management System Act
- 9. Planning Act
- 10. Environmental Monitoring Act
- 11. Occupational Health and Safety Act

- 12. Road Transport Act
- 13. Waste Act
- 14. Rescue Act
- 15. Police and Border Guard Act
- 16. State Fees Act
- 17. General Part of the Economic Activities
  Code Act
- 18. Penal Code
- 19. Building Code
- 20. Environmental Charges Act
- 21. Equipment Safety Act
- 22. Strategic Goods Act

Table 5. Legislation to be taken into account in the development of the legal framework for the nuclear energy programme (Source: analysis Mapping the legal framework to start the nuclear programme).

The Radiation Act is the appropriate basis on which to regulate the current practices in Estonia. However, the Radiation Act is not a comprehensive regulatory framework for the nuclear sector. Also, the KeA, as the main regulatory authority, is not given sufficient powers and capacity by law to act as a national nuclear safety regulator. The procedure established under the Radiation Act does not cover all the areas necessary to regulate nuclear power plants and related spent fuel and waste management facilities. The existing legal and regulatory framework would not allow Estonia to meet its obligations under the various nuclear treaties and conventions to which it is a group. This is as well as obligations under EU regulations and directives, should a positive decision be taken to build a nuclear power plant and related installations in Estonia. A list of international conventions and treaties regulating the use and safety of nuclear energy to which Estonia is already a group is given in Table 6.

- Treaty on the Non-Proliferation of Nuclear Weapons – Estonia acceded on 7 January 1992 in London and on 31 January 1992 in Washington.
- The agreement of 5 April 1973 between the non-nuclear-weapon Member States of Euratom, Euratom and the Agency and its Additional Protocol – entered into force for Estonia on 1 December 2005.
- Convention on the Physical Protection of Nuclear Material and Nuclear Facilities and its Amendment – Estonia acceded on 9 May 1994 and it entered into force
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency – Estonia acceded on 9 May 1994 and it entered into force on 9 June 1994.
- Convention on Early Notification of a Nuclear Accident – Estonia acceded on 9 May 1994 and it entered into force on 9 June 1994 (no declarations).
- 1963 Vienna Convention on Civil Liability for Nuclear Damage – Estonia acceded





- on 8 June 1994. The amendment was ratified on 24 February 2009 and entered into force on 8 May 2016.
- International Convention for the Suppression of Acts of Nuclear Terrorism

   signed on 14 September 2005. Not ratified or in force.
- Convention on Nuclear Safety Estonia acceded on 3 February 2006 and it entered into force on 4 May 2006.
- The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management – ratified on 3 February 2006 and entered into force on 4 May 2006.

- on 9 May 1994 and it entered into force on 9 August 1994.
- Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage.
- Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention – Estonia acceded on 9 May 1994 and it entered into force on 9 August 1994.

Table 6. A list of international conventions and treaties regulating the use and safety of nuclear energy to which Estonia is already a party (Source: analysis Mapping the legal framework to start the nuclear programme)

As there are no nuclear power plants on the territory of Estonia, Estonia is not obliged to implement the provisions of the Convention on Nuclear Safety or the Joint Convention on the management of spent fuel and radioactive waste arising from their operation. The obligations set out in the Joint Convention on the management of radioactive waste have been relevant to the management of existing radioactive waste and to the practices and facilities in Estonia. Estonia has also made a political commitment to comply with the IAEA's Code of Conduct on the Safety and Security of Radioactive Sources and has notified the IAEA of its commitment to implement the guidelines on the import and export of radioactive sources and the guidelines on the management of spent radioactive sources.

#### 5.1 NUCLEAR ENERGY AND SAFETY ACT (TEOS)

On behalf of the NEWG, a mapping of the legal framework to start the nuclear energy programme, the legislative intent of the Nuclear Energy and Safety Act (TEOS) draft, the draft concept and its explanatory letter were prepared in 2023.

The use of nuclear energy is an internationally harmonised area of regulation. The main legal provisions derive from conventions and agreements, most of which Estonia has already acceded to. The purpose of commissioning the legislative intent of the TEOS draft was to obtain, as part of the analysis process, an overview of the necessary content of the law and the international obligations that the country needs to have clear knowledge of before deciding to introduce nuclear energy. The legislative intent of the TEOS and the draft concept commissioned by the NEWG are not a finished draft Act, but a concept on the basis of which the legislative sub-working group can continue its work in the event of a positive decision on the introduction of nuclear energy. One of the topics of the IAEA expert mission to Estonia in the last week of October was nuclear regulation, during which the NEWG's understanding of the drafting of a comprehensive nuclear law was assessed.

The overlap between the scope of the Radiation Act and that of TEOS, which in the most general terms is the use of ionising radiation, does not make it possible to distinguish the scope of both Acts completely. As a result, in some countries the entire regulation of ionising radiation (radiation protection)





and nuclear energy is combined in a single piece of legislation (eg the Czech 2016 Atomic Act). There are also countries where both radiation protection and specific matters of nuclear law are regulated with a narrower scope, so-called thematic legislation (eg a separate law on nuclear non-proliferation, (civil) liability for nuclear damage, etc).

In the process of mapping the regulatory framework, the following options for regulating nuclear energy were considered, based on the practice of other countries:

- 1. integration of the Radiation Act into TEOS;
- creation of a separate TEOS alongside the Radiation Act;
- 3. creation of a separate nuclear liability act in addition to the Radiation Act / TEOS.

Although one of the proposals of the IAEA INIR mission was to consider the creation of a single comprehensive law on radiation and nuclear safety, the NEWG decided to go ahead with the creation of the TEOS, which will include nuclear liability, alongside the Radiation Act. A similar solution is also common practice in other countries, including Finland. The rationale for maintaining the Radiation Act is to maintain the existing system of processing and issuing radiation practice licences and to avoid additional administrative burdens for licence holders. Although there are overlaps in the Radiation Act and the possible TEOS, it was decided to address this in the future by making references. One of the aims is to spare existing licence holders, the vast majority of whom are dentists using X-ray equipment, who would have to look for provisions applicable to their practices among the provisions governing the use of nuclear energy if a single unified legislation is adopted.

The scope of the TEOS is narrower than the Radiation Act, as it only covers specific issues related to nuclear energy:

- the nuclear fuel cycle, including nuclear facilities;
- nuclear safety;
- the physical protection of nuclear facilities and nuclear material against unlawful possession and use;
- nuclear non-proliferation;
- emergency planning.

The scope of the Radiation Act covers the whole field of ionising radiation in general (eg medical exposure, etc). Therefore, the radiation safety requirements of the Radiation Act also apply to the nuclear fuel cycle to the extent that the practices and material involved are at the same time also radiation practices and radiation sources and lead, for example, to the effects of ionising radiation on humans.

Since Estonia already has a Radiation Act that regulates and supervises radiation practices in accordance with European and international standards and the radiation practices actually carried out in Estonia, it is necessary to supplement Estonian law with specific rules for the introduction of nuclear energy.





# 5.2 LEGISLATION THAT NEEDS TO BE AMENDED TO IMPLEMENT A NUCLEAR ENERGY PROGRAMME, AND ADDITIONAL REQUIREMENTS RESULTING FROM CONVENTIONS AND EU DIRECTIVES

Amendments to existing legislation mainly concern nuclear safety and security issues, which include amendments to the Radiation Act (waste classification, physical safety management, licensing requirements). Following the ratification of the International Convention for the Suppression of Acts of Nuclear Terrorism, changes will have to be made to existing criminal law. With regard to nuclear liability, Estonia must follow the principles of the Vienna Convention (to which Estonia is already a party) in its national law, in particular in the Nuclear Energy and Safety Act (TEOS). At the moment, not all the principles have been implemented because there is no nuclear power plant on our territory. Estonia should also consider acceding to the Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage and/or the Convention on Supplementary Compensation for Nuclear Damage. At present, the first draft of TEOS is based on the Vienna Convention and its amending protocol.

EU directives the requirements of which for nuclear installations require further transposition and implementation:

- 1. Council Directive 2013/59/Euratom laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation;
- 2. Council Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations and its amendment, Council Directive 2014/87/Euratom;
- 3. Directive 2011/70/Euratom establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste.

For the development of specific amendments for legislation that needs to be amended or supplemented, a legislative sub-working groups under the leadership of the Ministry of Climate needs to be established, for which a budget (taken into account in the budget of the NEWG for year 0 of the implementation of the nuclear energy programme) needs to be planned, so that international nuclear law experts can be involved in its activities. The amendments are grouped by topic:

#### **Renewing the regulatory framework**

Amendments to the Electricity Market Act, the Rescue Act, the Regulation of the Government of the Republic *Procedure for Cooperation in the Preparation of Plans and the Bases for the Approval of Plans*, etc

#### Institutional changes

Amendments to the Government of the Republic Act, the statutes of the Environmental Board and other government agencies

#### Technical changes

Replacing references to the Environmental Board with references to the new authority.

The task of the legislative sub-working group is to ensure that the Nuclear Energy Act and its subsidiary legislation fit into the existing Estonian legal framework, that there are no conflicts with other existing legislation, and that the Estonian regulation is sufficient to regulate the field in its entirety and in compliance with international requirements.





# 5.3 ESTIMATED TIMETABLE AND COST FOR THE DEVELOPMENT OF A COMPREHENSIVE REGULATORY FRAMEWORK

Preparation of a nuclear regulatory package for submission to the Riigikogu in accordance with the Decree of the Government of the Republic No 180 of 22.10.2011 *Rules for Good Legislative Practice and Legislative Drafting* will probably take two to three years.

Legislative procedure of the draft regulatory package in the Riigikogu will take at least 6 months and up to 3 years.

The cost of drafting the whole regulatory package (including draft legislation, explanatory letters, impact assessments, public consultations and external expert assessments) ranges from €0.5 million to €1 million, depending on the volume of outsourced services. Part of the legislative costs can be covered using the resources of IAEA, in the context of which the revision of TEOS, seminars on nuclear law and nuclear liability for Estonian specialists and lawyers have been planned in 2024.

The NEWG has assessed the suitability of the country's existing legal framework and its compliance with international obligations. The current legal framework is generally suitable for launching a nuclear energy programme, but inadequate to regulate all activities. There is no need for major changes to the existing framework, but the adoption of the TEOS with its subsidiary acts is necessary. To this end, a legislative sub-working group will be established within the NEWG, under the leadership of KLIM, for which a budget will need to be planned to involve international nuclear law experts. On the basis of the Climate and Radiation Department of the KeA, it is appropriate to establish a nuclear regulatory body and to provide for its rights and obligations in approving planning and issuing permits. Legislative procedure of the draft regulatory package will take up to 3 years and will cost up to €1 million from the state budget, which can be reduced by limiting the volume of international cooperation programmes and outsourced services.



The implementation of non-proliferation measures aka safeguards is the fulfilment of an obligation under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) to use nuclear materials for peaceful purposes. The NPT was signed in 1968 and it entered into force in 1970. The Treaty has 191 contracting parties.

The Treaty is the cornerstone of the global nuclear non-proliferation and nuclear disarmament regime. The treaty is founded on three pillars: non-proliferation, disarmament and peaceful uses of nuclear technology. Under the treaty, the countries that officially possess nuclear weapons (the US, Russia, China, France, the United Kingdom)<sup>52</sup> undertake not to transfer them to any other country and not to contribute to an increase in the number of nuclear-weapon states. Non-nuclear-weapon states (all other NPT parties), on the other hand, commit not to acquire or produce nuclear weapons and to conclude safeguard agreements with the IAEA to ensure that nuclear energy is not used for anything other than peaceful purposes. The nuclear-weapon states, in turn, commit to negotiate in good faith to end the nuclear arms race in the near future<sup>53</sup>.

Safeguards can be defined as a set of technical measures that allow the IAEA to independently verify a state's commitment to use nuclear material for peaceful purposes in accordance with its international obligations, ie not to use nuclear material from peaceful nuclear activities for the production of nuclear weapons or other nuclear explosive devices. Safeguards include a combination of national and international nuclear material accountancy, physical protection measures and monitoring and control. The state must ensure that the government, as well as the plant owner/operator and the regulator, are prepared to meet all safeguard obligations as the project develops.

Broadly speaking, the implementation of safeguards at a national level involves three main elements:

- 1. imposing regulatory controls and supervision on nuclear material and related practices;
- providing information to the IAEA;
- 3. supporting the IAEA in verification activities.

A key activity in the implementation of safeguards is keeping records of nuclear material and the verification of data on site. The accounting for nuclear material requires a state to know and continuously monitor the location of all its nuclear material (including uranium and plutonium contained in unused or spent nuclear fuel), which means collecting data on the quantity, type, occurrence and location of nuclear material. To this end, a legal framework is needed to control the import, transport, possession, storage, use and export of nuclear material, as well as the construction, operation and decommissioning of nuclear facilities.

#### 6.1 IMPLEMENTATION OF SAFEGUARDS IN ESTONIA

From the point of view of nuclear safeguards, the Estonian legal framework consists of the Radiation Act, the Strategic Goods Act and international treaties. Estonia is already a party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and, as a member of the European Union, a party to the Euratom treaty, has joined<sup>54</sup> the Agreement in the implementation of Article III (1) and (4) of the NPT<sup>55</sup>

<sup>&</sup>lt;sup>55</sup> Agreement between Belgium, Denmark, the Federal Republic of Germany, Ireland, Italy, Luxembourg, the Netherlands, the European Atomic Energy Community and the Agency in implementation of Article III (1) and (4) of the Treaty on the Non-Proliferation of Nuclear Weapons



<sup>&</sup>lt;sup>52</sup> Today, India, Pakistan, North Korea and Israel number among the nuclear-weapon states.

<sup>53</sup> https://geneva.mfa.ee/treaties/

<sup>&</sup>lt;sup>54</sup> https://www.riigiteataja.ee/akt/954451 (in Estonian)



and its Additional Protocol<sup>56</sup>. While the Agreement calls for the establishment and maintenance of a state system of accounting for and control of nuclear material, the Protocol additional to the Agreement significantly enhances the IAEA's rights to control all peaceful uses of nuclear material in a country, allowing broader access to information on the country's nuclear energy programme and better access to facilities. In addition to the Treaties, Estonia is bound by the requirements of EU legislation, such as the European Commission Regulation (Euratom) No 302/2005 of 8 February 2005 on the application of Euratom safeguards<sup>57</sup>. Enforcement of the Agreement, the Additional Protocol and the European Commission Regulation will be ensured by the Ministry of Climate through the Environmental Board. Obligations related to accounting for nuclear material also stem from Regulation (EU) 2021/821 of the European Parliament and of the Council setting up a Union regime for the control of exports, brokering, technical assistance, transit and transfer of dual-use items<sup>58</sup>.

Estonia's commitments include accepting safeguards, cooperating with the IAEA and EURATOM to ensure that IAEA inspectors are able to carry out their duties, and notifying the IAEA if safeguarded nuclear material is used in practices not covered by safeguards. In assessing how well a country is implementing safeguards, the IAEA considers the data from the verification of a facility's records, such as the facility's key technical characteristics, nuclear material declarations, reports on practices involving nuclear material, imports and exports of nuclear equipment, facility's data obtained through electronic remote monitoring systems, and facility's inspection data.

The Radiation Act focuses on radiation protection and safety issues, covering the principles of applying for and deciding on the issuing of radiation practice licences, as well as transport permits for radioactive waste and spent nuclear fuel. To some extent, the law also deals with safeguards for nuclear materials. The control system of dual-use items, including those that are subject to safeguards, is governed by the Strategic Goods Act.

The KeA handles applications for radioactive waste and spent nuclear fuel transport and radiation practice licences, maintains a register of radiation sources and nuclear materials, and also fulfils safeguarding requirements, such as maintaining the state system for accounting for and control of nuclear material and reporting to Euratom and the IAEA.

Applications for import, export and transit permits for strategic goods, including dual-use items, are processed by the Strategic Goods Commission at the Ministry of Foreign Affairs. The Commission discusses and decides on matters relating to restrictions on the carriage of goods, the provision of services in connection with goods and the performance of transactions provided for in international legislation or legislation of the Government of the Republic imposing or implementing a sanction, taking into account the provisions of the International Sanctions Act.

The implementing authority for safeguards is also the Estonian Internal Security Service, which is under the Ministry of the Interior and manages the emergency response to a situation caused by the use of radiological, nuclear or explosive materials for criminal or terrorist purposes.

The Penal Code regulates the punishment of offences relating to radiation sources, while the Code of Criminal Procedure regulates the investigation and criminal procedure of criminal offences related to nuclear and radioactive material.

<sup>58</sup> https://eur-lex.europa.eu/eli/reg/2021/821/oj?locale=en



<sup>&</sup>lt;sup>56</sup> Protocol Additional to the Agreement between the Republic of Austria, the Kingdom of Belgium, the Kingdom of Denmark, the Republic of Finland, the Federal Republic of Germany, the Hellenic Republic, Ireland, the Italian Republic, the Grand Duchy of Luxembourg, the Kingdom of the Netherlands, the Portuguese Republic, the Kingdom of Spain, the Kingdom of Sweden, the European Atomic Energy Community and the International Atomic Energy Agency in implementation of Article III, (1) and (4) of the Treaty on the Non-Proliferation of Nuclear Weapons

<sup>&</sup>lt;sup>57</sup> https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32005R0302



There are no nuclear power plants, nuclear fuel cycle facilities or related practices in Estonia. The amount of nuclear material in Estonia is small, most of which (depleted uranium shielding containers, plutonium in old smoke detectors) is stored at the interim storage facility for radioactive waste site in Paldiski. In addition, two reactor compartments, both enclosed in reinforced concrete sarcophagi, are located on the same site, a legacy of the former Soviet nuclear submarine training centre. The spent nuclear fuel was removed from the reactors and taken back to Russia in 1994. Consequently, Estonia's current system of accounting for nuclear material is limited to the collection of data on nuclear material and practices that are not related to either the nuclear power plant or the nuclear fuel cycle. The system of accounting for and control of nuclear material is adequate to meet current needs.

A number of other international initiatives and programmes also help in the implementation of controls on the export and import of nuclear material. Estonia joined the Wassenaar Arrangement in 2005. The Arrangement aims to ensure greater transparency in the supply of conventional arms and dual-use items and technologies and to increase the responsibility of the member states of the Arrangement for such transactions to prevent the concentration of such goods and technologies in an aggressive state or to an aggressive end-user, and the consequent increase in the effects of instability. Through the EU's export control system, Estonia also complies with other laws and directives related to civil nuclear matters, such as the Missile Technology Control Regime (MTCR), which was originally designed to reduce the risk of nuclear proliferation by controlling the supply of equipment and technology that could be used in or developed for unmanned nuclear weapons delivery systems. Currently, the agreement is also focusing on reducing the proliferation threat of other weapons of mass destruction by controlling procurements that could contribute to the development of these weapons systems<sup>59</sup>. Estonia follows the guidelines of the Nuclear Suppliers Group (NSG), which aim to prevent the development of nuclear weapons under the guise of peaceful uses of nuclear energy. Member states of the Control Regime want to prevent the proliferation of nuclear weapons technology while enabling the use of nuclear energy for peaceful purposes. Based on the NSG guidelines, the export of the 'key components' for nuclear weapons to non-nuclear-weapon states will be restricted and controlled. During the transport of components, the physical protection of nuclear materials and the conditions for safe transport are ensured.

# 6.2 IMPLEMENTATION OF SAFEGUARDS IN THE NUCLEAR ENERGY PROGRAMME

Safeguards apply to all uses of nuclear material, whether in a conventional nuclear power plant or in an SMR. However, depending on the design of the SMR and the type of fuel used, the practical implementation of safeguards by the state and the IAEA may require the development of new approaches. Understanding and implementation of safeguarding requirements at both a national and SMR technology provider level is essential, and consultation with the IAEA should start already by the SMR design stage.

On behalf of the NEWG, Proxion Plan OY carried out a safeguard analysis in 2023 (Annex 5) with the aim of mapping the needs for upgrading the existing state system of accounting for and control of nuclear material for the implementation of the nuclear energy programme. The analysis showed that Estonia has acceded to all international treaties necessary for the implementation of safeguards and has established a state system of accounting for nuclear material. Legislation addresses safeguards for nuclear materials to some extent, but not sufficiently. The introduction of nuclear energy will require changing the system, sectoral legislation and guidelines. Adequate and competent staff to deal with safeguarding requirements at both a national and plant operator level must also be ensured.

<sup>&</sup>lt;sup>59</sup> https://www.vm.ee/sanktsioonid-ekspordi-ja-relvastuskontroll/strateegiliste-kaupade-kontroll/riiklikud (in Estonian)





International cooperation with other countries operating SMRs is essential for the effective implementation of the safeguards. When introducing SMRs, the following factors must be taken into account in implementing safeguards:

- 1. SMRs may use innovative systems and technologies that need to be taken into account in safeguards;
- the length of reactor operating cycles, which may deviate from the normal 12–18-month cycle, which in turn affects the reporting of nuclear material and the inspection schedule. In most cases, the reactor is refuelled every 12–18 months;
- 3. possible innovative solutions for spent nuclear fuel management.

The legislation must also designate the main person responsible for safeguards, which could be the nuclear regulatory body to be established. During the IAEA INIR mission 23.–30.10.2023, Estonia was recommended to develop a plan to upgrade the state system of accounting for and control of nuclear material (SSAC).

In the event of a decision to introduce nuclear energy, the country will start implementing a nuclear energy programme. Establishing and enforcing a comprehensive nuclear law, the regulatory authority and framework, and choosing the plant owner/operator are among the main tasks of this phase. Guided by the IAEA publication *Enhancing National Safeguards Infrastructure to Support the Introduction of Nuclear Power*<sup>60</sup>, the following needs to be done at a national level:

- Begin declaring data on planned nuclear power deployments under Article 2.a.(x) of the Additional Protocol to the Agreement implementing Article III (1) and (4) of the NPT and thereafter submit an updated declaration annually to the IAEA. The KeA will be responsible for preparing and submitting the declaration until a new regulatory authority is established, whose responsibilities and duties will include dealing with and implementing safeguards.
- 2. Increase the administrative and technical competence of the regulator's staff and safeguards. The regulatory body must develop its own management system and ensure that roles, responsibilities, organisational structure and processes, including accounting for nuclear material, are well defined. Taking into account the size of the nuclear energy programme, the resulting complexity of the safeguard activities and the frequency with which they are carried out, it is necessary to analyse:
  - the human resources and competence requirements necessary for the implementation of safeguards, and the possibilities for their development;
  - requirements and needs of the state system in accounting for nuclear material, including software, data exchange between the regulator and the plant owner/operator, data exchange with international organisations, cyber security and defence issues;
  - legislation and guidance on safeguards, including who is responsible for implementing safeguards, the process for licensing a nuclear power plant and the requirements set out in the licence, requirements for procurement documents for parts of a nuclear power plant, import and export of nuclear material and equipment;

<sup>60</sup> https://www.iaea.org/topics/infrastructure-development/bibliography





the technical capability to carry out national supervision of nuclear material accountancy at the nuclear power plant, including instrumentation (hand-held instruments, laboratory equipment) and the competence to handle them.

The final phase of the development of the nuclear energy programme will involve the construction of a nuclear power plant and the start of electricity generation. The country must provide information to the IAEA in a timely manner, in accordance with its safeguard agreements. Responsibility for the collection, compilation and accuracy of data on the implementation of safeguards lies primarily with the plant owner/operator. During this phase, the IAEA will start on-site inspections and the regulatory authority and the owner/operator will have to prepare for IAEA's verification activities during the construction, commissioning and operation phases of the plant.

Safeguards are a set of technical measures that allow the IAEA to verify that nuclear material from peaceful nuclear practices is not used for nuclear weaponisation. Estonia has acceded to all international treaties necessary for the implementation of safeguards and has established a state system of accounting for nuclear material. To implement the nuclear energy programme, safeguard provisions need to be included in the legislation, guidelines need to be drawn up and a person responsible needs to be appointed.



The basic principles of radiation protection are derived from the ICRP<sup>61</sup> guidelines, which the IAEA takes into account when drafting its safety standards. The IAEA has laid down international Fundamental Safety Principles<sup>62</sup> with the overall aim of protecting people and the environment from the harmful effects of ionising radiation. This applies to any situation that poses a radiological risk and requires the use of safeguards and preventive measures. The safety principles apply to both existing and new facilities and practices throughout their lifetime. This includes nuclear facilities, the use of radiation sources, the transport of radioactive materials and the management of radioactive waste. The safety principles are the basis for establishing requirements and measures to ensure the safety of facilities and practices. This includes protective and safety equipment, such as any procedures and devices to keep human doses and risks as low as reasonably achievable and below prescriptive limits, as well as the means to prevent accidents and mitigate the consequences of potential accidents.

In Estonia, radioactive sources are mainly used in medicine, industry and research, and there is a capability to handle radioactive waste. Estonia's current national infrastructure for radiation protection and safety, based on Council Directive 2013/59/Euratom<sup>63</sup> and the IAEA Safety Standard<sup>64</sup>, is sufficient to carry out these practices. The Radiation Act lays down the basic safety requirements for the protection of human health and the environment against the harmful effects of ionising radiation, the rights and obligations of persons in using ionising radiation, the requirements for radiation practices, the organisation of state supervision for compliance with the requirements laid down in the Act and liability for failure to comply with the requirements. The KeA issues a radiation practices licence based on the radiation safety principles laid down in the Act - justification of the practice, optimisation of exposure and implementation of dose limits – and carries out national supervision of radiation practices. The KeA is responsible for maintaining registers in the field of radiation (dose register of exposed workers, register of radiation sources and nuclear material, register of radioactive waste). The application for and processing of radiation practice licences, monitoring, reporting and other obligations related to licences, and the storage of collected data are carried out in the Information System for Environmental Decisions (KOTKAS). The register of radiation sources and nuclear material is part of KOTKAS. The KeA has the technical means and resources to monitor current radiation practices. The KeA also carries out national radiation monitoring and manages the early warning system for radiation risks. In the national radiation monitoring programme air samples, surface water, drinking water, milk, food and soil samples are collected and analysed every year. The levels of gamma radiation in the air are constantly monitored. This is done using 15 automatic monitoring stations, 3 air filtering stations, a KeA laboratory for sample analysis, a mobile metering laboratory and inter-agency cooperation on sample collection. All samples collected under the national programme will be analysed at the KeA laboratory. The KeA also provides the measurement service of personal dosimeters on the basis of contracts. Both the laboratory and personal dosimeters measurement methods for samples are accredited according to ISO 17025:2017.

The aim of the National Radiation Safety Development Plan for 2018–2027 (KORAK) is to ensure the functioning and development of radiation protection in Estonia.

KORAK has three annexes: the National Action Plan for Radioactive Waste Management, the National Radon Action Plan, and the Implementation Plan of the Development Plan. In addition to the technical means, the necessary and competent human resources must be ensured for the operation and

<sup>&</sup>lt;sup>64</sup> https://www.iaea.org/publications/8930/radiation-protection-and-safety-of-radiation-sources-international-basic-safety-standards



https://www.icrp.org/publication.asp?id=ICRP%20Publication%20103%20(Users%20Edition)

<sup>62</sup> https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1273 web.pdf

<sup>63</sup> https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013L0059&from=EN



development of the radiation safety infrastructure. There is no separate advisory body in the field of radiation protection in Estonia, but institutions can call on qualified radiation experts. Training courses for radiation protection professionals and radiation safety specialists are offered by a number of training organisations, including those run by qualified radiation experts. To increase training opportunities, an online course on basic radiation knowledge is planned under KORAK, ie developing modules and their content and selecting a suitable e-learning platform. The National Action Plan for Radioactive Waste Management proposes solutions for the systematic management of radioactive waste and its reduction in the Republic of Estonia. The action plan is limited to an assessment of the quantities of existing radioactive waste (including waste inherited from the Soviet era) and future radioactive waste generated in Estonia, and the management options. It does not include radioactive waste and spent nuclear fuel generated in a nuclear facility, as there are no nuclear power plants or practices and facilities related to the nuclear fuel cycle in Estonia.

## 7.1 RADIATION PROTECTION IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

On behalf of the NEWG, in 2023 STUK International OY, a company belonging to the Radiation and Nuclear Safety Authority in Finland, carried out a radiation protection analysis (Annex 5) with the aim of identifying the need for upgrading the existing radiation protection and monitoring system for the implementation of the nuclear energy programme. In the implementation of radiation protection principles, there is significant exposure to subjects such as nuclear safety, management, legal and regulatory framework, human resource development, location and supporting facilities, environmental protection, emergency planning, the nuclear fuel cycle and radioactive waste management. In its assessment, STUK International OY presented a total of 80 proposals for development needs in the field of radiation protection. Summarised by topic, the development needs are:

- 1. general requirements for the organisation<sup>65</sup>;
- developing legislation for the assessment of the safety of a nuclear power plant for each stage of its life cycle<sup>66</sup>;
- 3. developing radiation protection legislation for each stage of a nuclear power plant's life cycle;
- developing environmental surveillance, including radiation monitoring, legislation for baseline monitoring prior to the commissioning of a nuclear power plant, and implementation of monitoring;
- 5. developing legislative provisions and assessment of technical needs for the monitoring of radioactive effluent<sup>67</sup> from nuclear power plants (sampling equipment, measuring equipment for field and laboratory measurements, dose assessment methods and software);
- 6. developing legislation for dose assessment of technical needs (individual dosimeters, laboratory instruments, dose assessment methods and software);
- 7. developing legislation for radiation level measurements in the air and on surfaces in a nuclear power plant and assessment of technical needs (measurement methods, instrumentation);

<sup>&</sup>lt;sup>68</sup> Measurement, calculation and estimation of the absorbed dose of ionising radiation in the human body.



 $<sup>^{65}</sup>$  All organisations involved in the preparation and implementation of the nuclear energy programme

<sup>&</sup>lt;sup>66</sup> The life-cycle stages of a facility are site selection, design, construction, commissioning, operation and decommissioning, which are used to determine the application for and granting of a licence for each stage.

 $<sup>^{\</sup>rm 67}$  The planned and controlled release of gaseous or liquid radioactive substances.



- 8. developing legislation for the classification of control and monitoring areas, including the calculation of radiation shielding, and assessment of the technical needs for the calculation of radiation shielding (modelling and dose estimation software for the facility or its components);
- assessing radiochemical and chemical analysis methods and technical needs (sampling equipment, laboratory instruments);
- Developing legislative provisions for emergency planning and assessment of technical needs (sampling equipment, measurement methods, measuring equipment for field and laboratory measurements, dose assessment methods and software);
- 11. Developing legislative provisions for the management of radioactive waste and spent nuclear fuel and assessment of technical needs (sampling equipment, measurement methods, including measuring equipment for field and laboratory measurements).

In the event of a decision to introduce nuclear energy, the country has decided to launch the development phase of the nuclear energy programme. The assessment underlines that the launch of a nuclear energy programme will require the development of national expertise and the training of experts to meet the requirements for the implementation of a nuclear energy programme. These skills are essential both within the organisation of the holder of the operating licence and within the regulatory body, as well as in organisations providing technical support. Estonia has the advantage of being able to draw on the experience and lessons learned by other countries when creating its own system and rules. The development of the necessary capabilities will depend in part on the technology chosen. The main areas for the development of a radiation protection system are:

- Developing the Nuclear Energy and Safety Act guided by international fundamental safety
  principles and enforcing the act. The law must, among other things, describe the mandates
  and duties of the regulatory authority and the responsibilities of the plant owner/operator in
  the field of radiation protection.
- 2. Identification of potential topics for regulations and guidelines in the field of radiation protection, and the development and adoption of the regulations and guidelines.
- 3. Establishment of a new regulatory body as a government agency to manage all nuclear safety and radiation protection requirements:
  - It will include the functions and staff of the Climate and Radiation Division of the KeA and will be separate from the KeA.
  - The personnel requirements cover a range of areas, including radiation protection, with 2 specialists needed in the design phase, 8 in the construction and commissioning phase and 5 in the operation phase.

#### Next steps in radiation protection:

- 1. adopting legislation and regulations for the safe use of nuclear energy including binding requirements on radiation protection;
- developing additional knowledge on radiation protection and technical capacities to meet the needs of the nuclear energy programme, for example in cooperation with countries that already have a nuclear energy programme;
- 3. establishing national training programmes in Estonian universities to support the implementation of the nuclear energy programme.





Estonia has a national framework and capacity in the field of radiation protection. To implement the nuclear energy programme, additional radiation protection capacity needs to be developed to meet the needs of the nuclear energy programme.





### 8. REGULATORY FRAMEWORK

Current regulation in the field of radiation focuses on industrial, health and veterinary service providers, scientific and research institutions and the use of radiation sources by government agencies. Around three quarters of the 630 radiation practice licences issued in Estonia have been granted to healthcare providers, followed by industrial companies. The state-owned company A.L.A.R.A. AS manages radioactive waste resulting from the decommissioning of the former Soviet nuclear submarine training centre in Paldiski and from the past and present use of radiation sources in industrial, medical and research applications. Current activities are regulated by the KeA under the Radiation Act. The Climate and Radiation Department of the KeA performs regulatory tasks related to radiation protection, including issuing radiation practice licences and supervising compliance with them to ensure radiation safety. During previous IAEA expert missions, it has been found that, considering the existing radiation practices, the legal and regulatory framework established in Estonia to ensure radiation safety complies with the relevant IAEA safety standards.

The analysis commissioned by the NEWG on *Preparation of human resources development strategy* for the nuclear energy working group and mapping of the regulatory framework (Annex 5) assessed, among other things, the current tasks and responsibilities of the KeA compared to those of a nuclear safety regulator with a full nuclear safety, security and safeguards (3S) mandate. While the existing regulatory framework is adequate for the current use of radiation sources, the launch of a nuclear energy programme would significantly increase the complexity of regulated practices, requiring new functions and competences. The regulation of nuclear energy covers important issues of international and EU law, including non-proliferation and subjects related to nuclear security and safety. If a positive decision is taken on the introduction of nuclear energy, Estonia will need to improve the legal and regulatory framework that forms the basis for the implementation of the programme to bring it in line with international and EU obligations and IAEA standards.

## 8.1 REGULATORY FRAMEWORK FOR THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

One of the most important international requirements is the establishment of an independent nuclear safety regulatory body responsible for the implementation of the legal and regulatory framework and for the regulation of all nuclear energy and ionising radiation facilities and practices in Estonia. International standards and national practices for their implementation require the establishment of an independent body to oversee 3S aspects to ensure the safety of nuclear energy.

#### 8.1.1 NUCLEAR REGULATOR

Current international practice is moving towards a single regulatory body that will exercise control over the 3S areas for all practices using nuclear energy and radiation sources in a country. Bangladesh, Belarus, Turkey and the United Arab Emirates, which have recently launched new nuclear energy programmes, have set up a single regulatory body covering the 3S areas. In addition, a number of existing nuclear regulatory bodies have changed their policies to follow the same approach. For example, in the United Kingdom, the authority dealing with the security of civil nuclear facilities was once separate from the former Nuclear Installations Inspectorate, but now the Office for Nuclear Regulation, established in 2014, regulates the safety, security and safeguards of nuclear facilities in the UK. The Netherlands has recently centralised the 3S functions, which were previously split between several ministries, into a new regulatory body known as the ANVS. In Finland, STUK is the supervisory authority responsible for nuclear non-proliferation safeguards and physical protection under the Finnish Nuclear Energy Act. STUK is responsible for the management of the state system for accounting for





and control of nuclear material in Finland. It also monitors and regulates international trade and transport, storage and use, non-proliferation and physical protection aspects of nuclear material.

The NEWG assessed three alternative options for the creation of a new nuclear safety regulatory body:

- establishment of a new independent nuclear safety regulatory body with full 3S competence, involving the transfer of KeA's current radiological competence and resources under the Radiation Act to the new body;
- 2. extension of KeA's mandates to meet the requirements of a nuclear safety regulatory body;
- 3. establishment of a new authority with full 3S competence, except for the current KeA competence in the field of radiation protection under the Radiation Act, which would remain in place.

Considering the IAEA's recommendations and the practices of other countries, the preferred option is the establishment of a new, independent regulatory body with 3S mandates to supervise all practices related to the use of nuclear energy or radioactive materials in Estonia, which involves the transfer of the current KeA radiation competences and resources under the Radiation Act to the new regulator. The objectives and benefits of a nuclear safety regulatory body established by using the 3S approach are to:

- ensure independence from undue influence (political, functional and financial independence), which means functional separation from other bodies/organisations involved in the promotion and use of nuclear energy, decision-making on the basis of sound and transparent nuclear safety requirements, an appropriate budget, control over it and a sufficient number of qualified personnel;
- facilitate compliance with obligations under international treaties and EU law;
- ensure the role of the nuclear safety regulatory body in the national system;
- promote clarity of judicial competence and avoid gaps, overlaps and inconsistencies between different laws and areas of competence of the responsible bodies;
- we use a comprehensive framework legislation on nuclear energy setting out the mandate and powers, tasks and responsibilities of the nuclear safety regulatory body;
- simplify regulatory procedures for applicants and licence holders by providing a single point of contact, instead of having to apply for multiple licences from several responsible bodies;
- achieve synergies between the areas of safety, security and safeguards that will enhance the efficiency and effectiveness of regulatory tasks, recognising that the achievement of nuclear safety and nuclear security are practically and technically interlinked, as is the case for nuclear security and safeguards;
- gather the know-how, technical competence and institutional expertise of human resources in the nuclear safety regulatory body, which could ultimately lead to savings in human resources and budget;
- assemble the financial resources available for regulating the nuclear sector and facilitate the fulfilment of the international obligation to ensure that they are sufficient to fulfil the regulatory body's mandate.





# 8.2 FUNCTIONS AND RESPONSIBILITIES OF THE NUCLEAR SAFETY REGULATORY BODY

Different approaches have been used in national practices to define the functions and responsibilities of nuclear safety regulatory bodies. The laws of some countries contain a longer list of direct functions and responsibilities, while others rely on a shorter list of core functions and responsibilities. An essential condition is that the nuclear safety regulatory body must have all the competences necessary to carry out its mandate effectively. The main regulatory functions and responsibilities are the following:

- assisting the government in the development of national policies and measures to control regulated facilities and practices;
- 2. issuing the regulations, standards and guidelines necessary for the implementation of the national nuclear act;
- examining and evaluating applications for licences and other information submitted by authorised persons;
- 4. issuing, amending, suspending, renewing and revoking licences and setting the licensing conditions;
- 5. defining exemptions from regulatory control;
- 6. establishing and maintaining a national register of each radiation source, authorised person and nuclear material subject to safeguards;
- inspecting, monitoring and evaluating facilities and practices to verify compliance with the national nuclear act, regulations and licensing conditions;
- 8. taking enforcement action in the case of non-compliance;
- 9. informing and consulting the public and other stakeholders on regulatory processes;
- 10. cooperating with the IAEA;
- 11. cooperating with and advising other authorities or companies with competence in healthcare and safety, environmental protection, land use and planning, emergency response planning, security and the transport of dangerous goods;
- 12. exchanging information and cooperating directly with other national regulatory bodies and relevant international organisations;
- 13. carrying out research in areas related to its mandate.

The key requirements relating to the responsibilities and functions of the regulatory body, as defined in IAEA's safety standard No. GSR Part 1, are:

- The regulatory body should structure its organisation and manage its resources so as to discharge its responsibilities and perform its functions effectively; this should be accomplished in a manner commensurate with the radiation risks associated with facilities and activities.
- The regulatory body should perform its functions in a manner that does not compromise its effective independence.
- The regulatory body should employ a sufficient number of qualified and competent staff, commensurate with the nature and the number of facilities and activities to be regulated, to perform its functions and to discharge its responsibilities, and should obtain technical or other





expert professional advice or services as necessary, but this should not relieve the regulatory body of its assigned responsibilities.

- The regulatory body should establish formal and informal mechanisms of communication with authorised parties on all safety-related issues, conducting a professional and constructive liaison.
- The regulatory body should ensure that regulatory control is stable and consistent.
- The regulatory body should make provision for establishing, maintaining and retrieving adequate records relating to the safety of facilities and activities.
- The regulatory body should establish, implement, and assess and improve a management system that is aligned with its safety goals and contributes to their achievement.
- The regulatory body should obtain technical or other expert professional advice or services as necessary in support of its regulatory functions.
- The regulatory body should promote the establishment of appropriate means of informing and consulting interested parties and the public about the possible radiation risks associated with facilities and activities, and about the processes and decisions of the regulatory body.

# 8.3 STRUCTURE AND PERSONNEL OF THE NUCLEAR REGULATOR

The first step in the establishment of a nuclear safety regulatory body in Estonia is the adoption of a comprehensive nuclear act, which establishes the organisation as an independent legal entity, defines its functions and responsibilities and sets out the legal framework for the country's nuclear energy practices. It is then necessary for the Government of the Republic to appoint the Director General of the agency, who appoints other senior personnel. To ensure the national and international credibility of the new body, these individuals must have knowledge and practical experience in the field of nuclear energy regulation and be competent and able to work in the Estonian government sector.

The analysis commissioned by the NEWG took into account IAEA guidelines and international benchmarks for smaller nuclear energy programmes in preparing the assessments. Different organisational structures have been used by nuclear safety regulatory bodies in different countries. In the possible structure of the Estonian nuclear safety regulatory body shown in Figure 8, the main departments are competent in the fields of nuclear safety, radiation safety, security and safeguards. Each department will help to carry out regulatory tasks through common procedures, in line with current and planned nuclear and radiation practices.







Figure 8. Organisational structure of the nuclear regulator (Source: Analysis Preparation of human resources development strategy for the nuclear energy working group and mapping of the regulatory framework).

Based on the IAEA guidelines and the benchmarks of other national nuclear safety regulatory bodies overseeing small nuclear energy programmes, it is appropriate to set a target of around 80 members of personnel in the operational phase of a nuclear power plant. This target number includes existing personnel of the Climate and Radiation Department of the KeA who are expected to continue in their current functions but who will be transferred to the nuclear safety regulatory body, as well as the necessary management functions. The number of personnel shown in Table 7 does not include the current staff of the Climate and Radiation Department of the KeA, who will be merged into the new agency.

Function	Project development	Construction and commissioning	Operation
	Phase 2	Phase 3	After Phase 3
Nuclear safety	5	35	20
Radiation protection	2	8	5
Nuclear security	1	3	3
Safeguards	1	3	3
Programme Office	1	4	3
Supporting personnel <sup>69</sup>	8	20	18
Legal affairs	1	2	2
Management	5	8	8
Total	24	83	62

<sup>&</sup>lt;sup>69</sup> finance, procurement, human resources, training, IT, information management, quality management, stakeholder engagement, administration/office





Table 7. Number of personnel of the nuclear energy safety regulatory body (Source: Analysis Preparation of human resources development strategy for the nuclear energy working group and mapping of the regulatory framework).

The assessment also covers the support services needed to support the regulatory body, such as human resources, training, finance, IT, document and archive management, stakeholder engagement and management support. In Estonia, some administrative services are provided to ministries and agencies on a centralised basis through the State Shared Service Centre (SSSC). Some services may therefore be provided to the regulator through its centralised function. However, some of the areas listed above, such as stakeholder engagement, training, and management systems, require specific nuclear expertise and are an integral part of the effective functioning of the regulatory body. It must also be taken into account that the SSSC may not have the resources to support the regulator and hiring additional personnel would not result in overall cost savings. In the process of establishing the nuclear regulator, it will have to be decided which support services will be provided centrally and which will be an integral part of the regulatory body.

The regulatory body does not need to recruit specialists in each field, but to plan access to the necessary expertise. For example, it may be possible to outsource services to external experts in areas that are very specific and/or rarely used at a certain interval. The regulatory body should employ sufficient personnel to maintain the capacity of the 'informed customer' to recognise and specify the need for specific services and to assess the appropriateness of the products/services received. The regulator would preferably employ people with 2–10 years' experience in the field of engineering, natural sciences, science or technology in key positions. The competences, education and training requirements for the people working in the regulatory body are described in more detail in the analysis *Preparation of human resources development strategy for the nuclear energy working group and mapping of the regulatory framework* (Annex 5).

The personnel objective from the establishment of the regulator to the operation of the plant is shown in Figure 9.

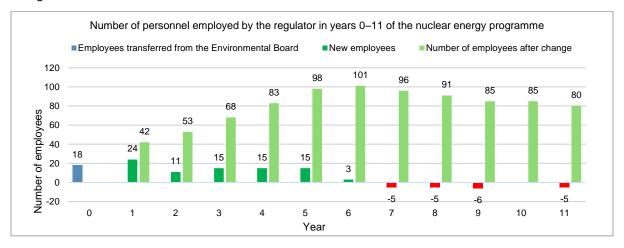


Figure 9. Nuclear regulator's personnel target for year 0–11 of the implementation of the nuclear energy programme (Source: NEWG)

The personnel need is the highest in the construction phase of the nuclear power plant, when, together with the employees of the Climate and Radiation Department of KeA, which will be integrated into the regulator, about 100 people would be employed. During the operational phase of a nuclear power plant, 80 people would work in the regulatory body.





### 8.4 ACTIONS TO ESTABLISH A REGULATOR FOR THE IMPLEMENTATION OF THE NUCLEAR ENERGY PROGRAMME

In the case of a positive decision on the introduction of nuclear energy, the NEWG must be given a mandate to prepare for the establishment of the regulator, with the aim of submitting a proposal for the establishment of the regulator within a timeframe set by the Government of the Republic or the Riigikogu. To do this, a subsidiary party should be set up within the NEWG, involving in particular the people who would work there if the regulator were established, in particular the key staff of the Climate and Radiation Department of the KeA. A total of 18 employees of the Climate and Radiation Department of KeA would join the regulator. In addition, in the establishment phase, persons performing priority functions – competence development manager, financial manager, quality manager – should be involved in the establishment of the regulator. Other key roles, including communication manager and international relations coordinator, can be filled by the existing personnel. Among other things, the subsidiary party would be responsible for preparing a draft amendment to the Government of the Republic Act, the drafting of the statutes of the nuclear regulator, the regulator's recruitment plan and budget estimations. Funding for preparatory activities also needs to be given to the subsidiary party, and this has been taken into account in the budget estimates for the subsequent NEWG activities.

### 8.4.1 LEGAL BASIS FOR THE CREATION OF A REGULATOR

In accordance with Article 8 of the Convention on Nuclear Safety<sup>70</sup> and Article 20 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management<sup>71</sup> and Article 5 (2) and (3) of Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations<sup>72</sup>, the regulator must be provided with the necessary legal powers, competences, financial resources and staffing to discharge its responsibilities. Measures must also be taken to ensure the separation between the regulator and the authorities responsible for the promotion and use of nuclear energy.

The analysis commissioned by the NEWG on *Mapping the legal framework to start the nuclear programme and updating the draft nuclear law and preparing the explanatory letter* recommended, in particular, the creation of the regulator under the Ministry of the Environment, with a view to separating it from the development of the energy sector. However, from 1 July 2023, the Ministry of the Environment and part of the Ministry of Economic Affairs and Communications, including the energy sector, were merged into the Ministry of Climate. Therefore, it would be advisable to consider the establishment of the regulator under the Ministry of Economic Affairs and Communications, to ensure separation from the development of the energy sector.

To establish the regulator, the first step is to initiate an amendment of the Government of the Republic Act. In addition, statutes will need to be drafted, which should follow the structure and functions of the body proposed in the analysis *Preparation of human resources development strategy for the nuclear energy working group and mapping of the regulatory framework* (Annex 5) commissioned by the NEWG. The proposal to establish a regulator should be accompanied by an estimated budget for at least three years until the choice of the site. During the process, a fixed-term director general of the regulatory body should be appointed, eg with a 5-year term.

All the recommendations on ensuring adequate funding, staffing and independence must be considered when drafting the statutes. Provisions to this effect should also be included in the draft TEOS.

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0087



<sup>&</sup>lt;sup>70</sup> https://www.riigiteataja.ee/akt/964536

<sup>71</sup> https://www.riigiteataja.ee/akt/958562



### 8.4.2 BUDGET OF THE REGULATOR

The regulator could start work within 6 months to a year of the mandate to establish it. In the early years, setting up the functionality of the regulator, preparing draft legislation and procedural aspects of the site selection process will be the focus of the regulator. Budgetary expenses for this period will mainly be related to personnel and administrative costs, outsourcing of analyses to external experts, development of capabilities, and will be in the range of €2.5 to €6 million for years 1 to 4. The regulator's budgetary needs are greatest during the construction phase of a nuclear power plant, when it employs experts with specific domain knowledge for a limited period. For this period, the regulator will have a budget of up to €5.7–7.1 million. During the operational phase of the nuclear power plant, the fixed costs of the regulator will remain within the budget of €5.4 million. An overview of the regulator's expenses by year is shown in Figure 10.

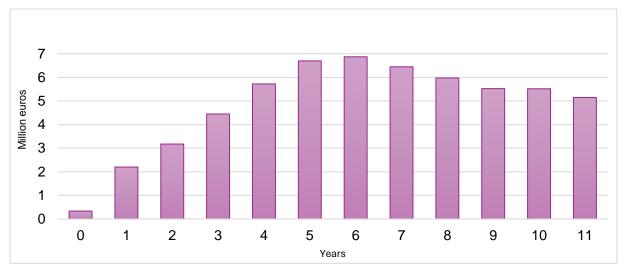


Figure 10. Expenses of the regulator for years 0–11 of the implementation of the nuclear energy programme implementation (Source: NEWG)

### 8.4.3 AN ALTERNATIVE APPROACH TO THE ESTABLISHMENT OF THE ESTONIAN NUCLEAR REGULATOR

As an alternative solution to reduce the expenses from the state budget, until the TEOS is adopted and the choice of the site of the nuclear power plant is confirmed, it is possible to consider the establishment of a regulator on the basis of and at the location of the Climate and Radiation Department of KeA. For this purpose, 4 additional positions should be created (competence development manager, chief financial officer, quality manager, coordinator for the establishment of a regulator) or, alternatively, these 4 experts could be included in the regulatory framework sub-working group of the NEWG under an authorisation contract, which would prepare the establishment of the regulator within about 6 months after receiving the mandate from the Riigikogu.

### Quality manager

The development of an IMS, which will be the basis for all regulator processes and their implementation.

### © Competence development manager

Developing training programmes for the positions of the regulator from recruitment onwards.

### **©** Chief financial officer

A forecast of the regulator's budgetary needs for the next 3 years – taking into account both the state and the applicant's contribution.





### © Coordinator for the establishment of a regulator

They would lead the preparations for the establishment of the regulator, support the developer of the IMS in the development of processes and the necessary guidelines, and provide the necessary input on the competence development side as well as for preparing the budget.

Existing resources can cover the following:

### Communications manager

They would be responsible for engagement, ensuring transparency and preparing a communication plan for the first years.

### International relations manager

Preparing and organising cooperation with the IAEA, neighbouring countries and the regulator of the country of origin of the plant.

Following the establishment of the regulator, employees from the Climate and Radiation Department together with the 4 additional posts created in the sub-working group of the NEWG and today's €1–1.1 million budget would move to the regulator. Once the regulator is in place, these people would be involved in site selection characterisation and design safety assessment, ie they would apply the IMS guidelines to the nuclear safety assessment of site selection.

In addition, once established, the regulator will need to recruit 4 additional employees immediately, who will need further training and will be responsible for the processing of the safety assessment of site selection. It is expected to be submitted to the regulator for assessment in about the 4th year after a positive decision on the introduction of nuclear energy (3 years after the establishment of the regulator), provided that in the 2nd year a regulation is adopted defining the criteria for the preparation of a nuclear safety assessment of the site selection of a nuclear power plant and the obligation to submit the safety assessment prepared on this basis to the regulator for assessment.

According to the above scheme, the preparations for the establishment of the regulator would require additional funding of around €0.6–0.7 million per year in years 1–4 and the regulatory framework sub-working group of the NEWG €0.1–0.15 million in year 0 of the implementation of the nuclear energy programme. This will allow for budgetary savings of €1.7–5.1 million per year in the initial years, but will probably result in a greater need for external experts in the site approval and construction phase, as well as a higher budget.

The advantage of such an approach would be that, if it becomes known before the site selection is confirmed that a nuclear power plant project is not economically feasible, the country would not yet have made a major investment in establishing a regulator. The additional staff and competences hired, the TEOS and the provisions relevant to the site selection process will in this case be used in the radioactive waste disposal site selection process. In other words, it would be an investment that the state would probably have to make one way or another to establish a final disposal site in Estonia by 2040 for the long-term safe storage of the sections of the nuclear submarine training reactors in Paldiski and other radioactive waste generated in Estonia.

In parallel, however, this scheme would also require the development of national competences and legislative expenditure.

The existing legislative and regulatory framework for nuclear and radiation safety in Estonia is generally adequate for current practices. Current international practice supports the creation of a single nuclear safety regulator with a full 3S mandate. The preferred option is the establishment of





a new independent nuclear safety regulatory body to oversee all 3S aspects of nuclear and radiation practices in Estonia. The nuclear regulatory body will incorporate the existing functions and staff of the Climate and Radiation department of the KeA, but will be a separate body from the KeA. Following the decision to move forward with the nuclear energy programme, a comprehensive nuclear law must be adopted swiftly, establishing a nuclear regulatory body in Estonia. Its top executives must be appointed and it must be provided with an adequate budget, including for hiring and training competent employees and external experts. Detailed consideration must be given to the mandates of other authorities with related or potentially overlapping responsibilities, giving them clear competences and establishing coordination mechanisms between the nuclear safety regulatory body and other authorities to ensure the smooth protection of the public and the environment.



# 9. ELECTRICAL GRID AND THE SUITABILITY OF NUCLEAR ENERGY FOR THE ESTONIAN ENERGY PORTFOLIO

### 9.1 ELECTRICAL POWER SYSTEM IN ESTONIA

Estonia's electrical grid (transmission network, Figure 11) consists of about 5,500 km of power lines (330 kV and 110 kV) and 155 substations. Cross-border AC connections to Latvia and Russia and direct current connections to Finland are connected to the domestic power network. Commercial flows are only possible on the Latvian and Finnish interconnections and the maximum capacities are 1,447 MW on the Estonian->Latvian, 1,259 MW on the Latvian->Estonian and 1,016 MW on the Estonian<->Finnish directions. There are currently three 330 kV lines connected to Russia, but there is no trade, and also in balance terms the Baltic States keep themselves in balance (zero balance) with Russia to minimise possible technical flows with the Russian electrical power system. In February 2025, it is planned to separate the Baltic electrical power system from the Russian frequency area and connect it to the Continental European frequency area, after which the Russian lines will also be technically completely disconnected from the Estonian electrical power system.

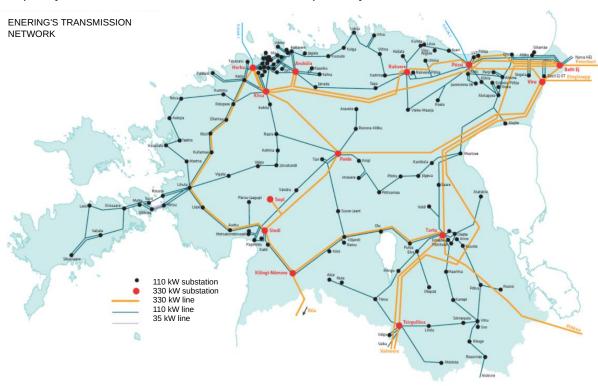


Figure 11. Estonian electricity transmission network (Source: Elering AS)

By joining the synchronous grid of Continental Europe, the Baltic system operators will be obliged to start managing the frequency of the Baltic power system in real time, using two types of reserves:

- frequency containment reserves (FCRs), which is a product with a 30-second reaction time;
- frequency restoration reserves (FRRs). The frequency restoration reserve is further divided into
  - automatic reserve (aFRR) with a response time of 30 s to 5 min;
  - manual reserve (mFRR) with an activation time of 12.5 min.





At present, manual frequency restoration reserve is used in the Baltic States to maintain the balance of the system. Therefore, from 2025 onwards, the need for reserves in the Baltics will increase and several new frequency reserve markets will be created. To cover Estonia's needs, the system operator estimates that 12 MW of FCR, 35 MW of aFRR for regulating up and down, 228 MW of mFRR for regulating up and 149 MW of mFRR for down are needed. These are the capacities that the system operator has to procure through the day-ahead power market to ensure the availability of reserves in the energy market, from which activations take place according to the needs of the electrical power system. Latvia and Lithuania will also acquire the corresponding reserves, and for the Baltic system as a whole, the reserves needed will be held and used jointly by the three countries.

The reserve requirements for the Baltic States are shown in Figure 12<sup>73</sup>.

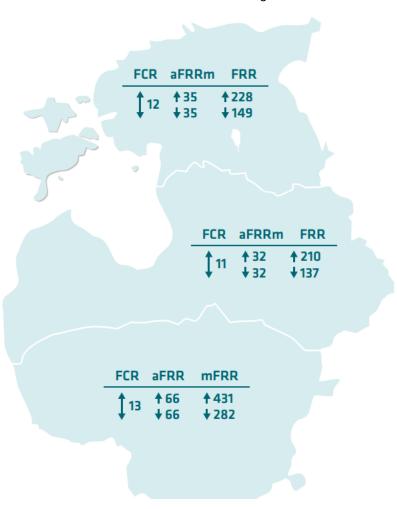


Figure 12. Baltic power system frequency reserve needs after synchronisation with the Continental European frequency area (Source: Elering)

### 9.2 CONSUMPTION AND PRODUCTION IN THE ESTONIAN ELECTRICAL POWER SYSTEM

Estonia's annual electricity consumption is  $\sim$ 8.6 TWh. By 2035, system operator Elering forecasts electricity consumption to grow to 11.3 TWh. This number may increase significantly due to the

<sup>&</sup>lt;sup>73</sup> https://www.elering.ee/sites/default/files/2023-12/Elering VKA 2023 5.pdf (in Estonian)





realisation of trends in the electrification of transport and heating of buildings or if energy-intensive industries grow in Estonia. For example, the transition of Estonia's entire current transport sector to electricity would mean an increase in electricity consumption of around 2 TWh.

While the annual volume of electricity consumption has been increasing year on year, the maximum peak consumption of electricity in winter has remained essentially unchanged over the past decade, ranging between 1,423 and 1,587 MW. The peak load of 1,587 MW was recorded more than ten years ago in the winter of 2010.

However, peak loads are also forecast to increase over the next decade. By 2035, Elering forecasts a peak load of 2018 MW, a 30% increase compared to the current peak. Elering AS consumption and peak load estimations for up to 2038 are shown in Table  $8^{74}$ .

Year	Annual consumption, TWh	Peak load, MW
2023	8.6	1,514
2024	9	1,591
2025	9.2	1,668
2026	9.3	1,705
2027	9.5	1,742
2028	9.7	1,779
2029	9.9	1,800
2030	10.3	1,829
2031	10.3	1,870
2032	10.5	1,910
2033	10.8	1,950
2034	11.1	1,984
2035	11.3	2,018
2035	11.7	2,075
2036	11.9	2,131
2037	12.3	2,187

Table 8. Electricity system consumption (MWh) and peak load (MW) estimations for up to 2038 (Source: Elering AS)

### 9.3 SECURITY OF SUPPLY

The security of supply (incl. production sufficiency) of the Estonian electricity system is analysed and ensured by Elering AS in cooperation with other EU transmission system operators. To assess the situation, annual European Resource Adequacy Assessments (ERAAs) are carried out for the next ten years and, if necessary, Elering will also carry out a regional National Resource Adequacy Assessment (NRAA), where it will be possible to look even more closely at the specificities and sensitivities relevant for the Baltic States than in the European assessment. For the 2023 Security of Supply Report, Elering

<sup>74</sup> https://www.elering.ee/sites/default/files/2023-12/Elering VKA 2023 5.pdf (in Estonian)



79



also included for the first time an NRAA analysis to model in more detail the system services needs in the Baltics.

According to the 2023 security of supply report, the security of electricity supply in Estonia will be ensured during the reference period (until 2033) (Figure 13), as the expected number of hours with limited service (4.5–4 h) is below the security of supply standard of 9 h per year established in Estonia.

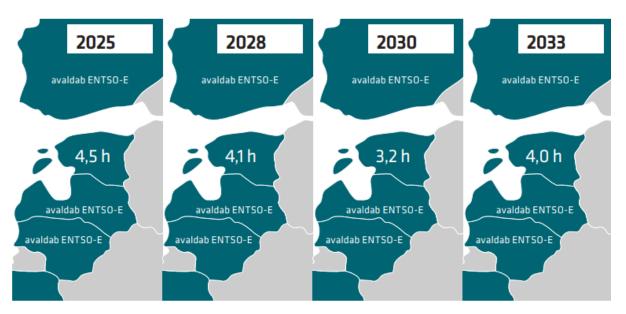


Figure 13. Results of the trans-European electrical power system generation adequacy and capability analysis in Estonia in 2023 (Source: Elering AS)

The regional analysis prepared by Elering, focusing on the situation in the Baltic States, has identified a security of supply problem in the years 2030 and 2033 (Figure 14), where the potential volume of hours with limited service exceeds the security of supply norm. Elering estimates that in 2030, in addition to the existing small power plants, about 800 MW of oil shale units and 250 MW of additional generation capacity (eg the Kiisa gas-fired emergency reserve power plant) will be needed.

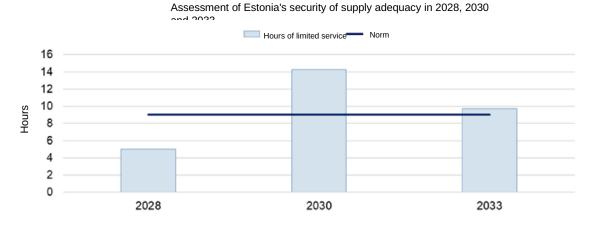


Figure 14. Results of the regional electrical power system generation adequacy and capability analysis for Estonia in 2023 (Source: Elering)

In addition, Elering has estimated that the problem may in fact emerge even sooner if Eesti Energia were to close more oil shale-fired power plants. According to the ERAA and NRAA analyses, Estonia will need to maintain around 1,000 MW of dispatchable capacity to ensure security of supply in 2028.





As the owner's expectation for the Narva oil shale-fired power plants expires at the end of 2026, the risk of capacity adequacy will in practice already arise in 2027. Therefore, it is important to be ready and implement a strategic reserve in Estonia already in 2027. From 2030 onwards, further additional dispatchable generation capacity will be needed in the region. On the one hand, this is to replace old generation capacity leaving the market, and on the other, to increase the capacity needed for fast frequency reserves, as large renewable generation capacities that will be connected to the grid need more reserves. Therefore, from a security of supply perspective, it is likely that from 2027 we will need a strategic reserve to extend the lifetime of Eesti Energia's oil shale-fired power plants instead of the current owner's expectation. From 2030 onwards, we will need more capacity to cover the growing need for reserves. This capacity can come, for example, against the market for reserves: either as an additional gas-fired power plant or through storage capacity. However, at the end of the life of oil shale-fired power plants, we will need more dispatchable generation capacity in the electrical power system that could replace oil shale. The likely options are gas-fired power plants (using biogas and hydrogen as fuel in the future) or nuclear energy. To some extent, storage and consumption management can also provide support. As of 2023, Elering has estimated the minimum amount of dispatchable capacity required to be 1,000 MW, but this value is expected to increase over time, depending on the growth in consumption and the connection of renewable energy to the system.

## 9.4 EXISTING GENERATING INSTALLATIONS IN THE ELECTRICAL POWER NETWORK

As of February 1, 2023, the total installed net generation capacity in Estonia is 1,706 MW, of which dispatchable capacity is about 1,110 MW (Table 9).

Power plant	Installed net capacity, 2022 MW	Installed net capacity, 2023 MW	Firm generation capacity, MW
Eesti Power Plant	866	866	652
Balti Power Plant	192	192	144
Auvere Power Plant	272	272	204
Iru Power Plant – gas unit	94	94	0
Iru Power Plant – municipal solid waste unit	17	17	
Põhja Thermal Power Plant	77	77	
Sillamäe Thermal Power Plant	23	23	
Tallinn Power Plant	39	39	110
Tartu Power Plant	22	22	110
Pärnu Power Plant	21	21	
Enefit	10	10	
Other industrial and cogeneration plants	75	73	
Sum	1,708	1,706	1,110

Table 9. Existing generating installations in the Estonian power network (Source: Elering AS)





### 9.5 CONNECTING NEW GENERATING INSTALLATIONS

The capacity of one production module to be connected to the Estonian electrical power system may not exceed 400 MVA<sup>75</sup>. In the case of capacity greater than this, more than one connection point must be installed at the transmission system operator's substation for connection and the production modules must be divided between the connection points<sup>76</sup>. This is due to the dynamics of the Baltic power system, where the largest element in the island mode that could go down is up to 400 MVA.

The connection requirements for production equipment have been harmonised at the European Union level – new generating installations will be connected to the network on the basis of Commission Regulation (EU) 2016/631<sup>77</sup> establishing a network code on requirements for grid connection of generators.

Pursuant to subsection 3 of § 19 of Regulation of the Government of the Republic *Network Code on the Functioning of the Electricity System*<sup>78</sup>, any new connection to the transmission network is established at the nominal voltage of 110 kV or 330 kV. Pursuant to subsection 5 of § 19 of the Network Code on the Functioning of the Electricity System, in the case where a new network connection is to be established or the consumption or production conditions of an existing network connection are to be modified, the configuration and technical parameters of the network are determined by the network operator. Due to the fact that the capacity of the 110 kV power network is generally not sufficient to accept capacities larger than 100 MW, generating installations with larger capacities than 100 MW must be connected to Elering AS's power network at a voltage level of 330 kV.

### 9.6 COSTS OF CONNECTING TO THE ELECTRICITY POWER NETWORK

Pursuant to subsection 3 of § 25 of the Network Code on the Functioning of the Electricity System, the expenditure made by Elering AS required to connect new consumption or production capacities is included in the connection fee. This means that the person wishing to connect the generating installation to the network must pay all the costs related to the connection. The exact costs depend on the specific location, or more precisely, on the capacities of the electrical power network at that location. The estimated cost of connection in a desired location is available from the Elering AS application<sup>79</sup>.

In addition, a deposit must be paid immediately to the network operator when applying for connection. Under the current law (§ 87¹ of the Electricity Market Act), the amount of the deposit is 38,000 EUR/MVA. The deposit is refunded to the market participant, or is counted towards their connection fee, only if they have commenced the generation of electricity using the appropriate generating installation within the required period, which is one year for solar panels, three years for offshore wind farms and two years for other technologies.

If the introduction of nuclear energy is authorised at a national level, it is likely that a separate requirement for timely completion of the generating installation will need to be introduced in the Electricity Market Act for nuclear energy, as it is a very different technology from the technologies considered in the current regulation (solar, wind, storage, gas), for which it is not realistic to require a

<sup>79</sup> https://vla.elering.ee/?lang=en.



<sup>&</sup>lt;sup>75</sup> https://www.elering.ee/sites/default/files/2023-12/Elering\_VKA\_2023\_5.pdf (in Estonian)

https://www.elering.ee/sites/default/files/public/Teenused/Liitumine/08%20-

 $<sup>\</sup>underline{\%20 Technical\%20 principles\%20 and\%20 solutions\%20 of\%20 the\%20 electrical\%20 installations\%20 of\%20 the\%20 transmission\%}{\underline{20 system\%20 operator}} \underline{2019.05.30.pdf.}$ 

<sup>77</sup> https://op.europa.eu/en/publication-detail/-/publication/1267e3d1-0c3f-11e6-ba9a-01aa75ed71a1/language-en.

<sup>&</sup>lt;sup>78</sup> https://www.riigiteataja.ee/akt/105072023243 (in Estonian)



plant completion requirement of 2 years from the completion of the connection point, which would apply under the current wording of the Act.

### 9.7 AMOUNT OF TIME SPENT ON CONNECTION

To connect to the network, the Network Code on the Functioning of the Electricity System requires the following particulars and documents:

- with respect to the electrical installation that is to be connected to the network, the decision
  establishing the spatial plan that allows such an installation to be erected, the conditions for
  designing that installation or the building permit for the installation, to show that the installation
  complies with the land use or building conditions of the spatial plan, or with the conditions for
  designing the installation, or with the building permit;
- 2. the decision made by the decision-maker referred to in the Environmental Impact Assessment and Environmental Management System Act, which proves that environmental impact has been assessed, or under which the assessment of such an impact is not required;
- 3. documents showing that the market participant who wishes to be connected to the network has a legal basis for using the registered immovable or building for which they wish a network connection to be established.

The time spent on these pre-connection activities depends on the duration of the planning procedures and impact assessments and can take years.

But currently, the process of speeding up the legislation on connections is underway, and in 2024 an amendment to the Network Code on the Functioning of the Electricity System will enter into force, according to which an application for connection can be submitted at an earlier stage, when the planning decision allowing the construction of an electrical installation to be connected to the grid has been made at the local government level. In addition, the environmental impact assessment decision and documents proving the right to use the registered immovable will no longer be required for filing an application for connection. However, in the end, all these documents are still required to build the generating installation. The aim is to allow the planning of the generating installation and the network to take place in parallel, and thus to speed up the overall connection process.

The precondition for the start of the construction works related to the connection is that Elering acquires the registered immovable necessary for the expansion of the substations and also obtains the right to use the utility line corridors of the overhead lines under construction. Before acquiring the property and obtaining the rights to use the overhead lines, it is necessary to:

- carry out planning and environmental impact assessments, the approximate time of which depends on the time spent on environmental studies and the assessment of other impacts, and the type of planning, and is 60–84 months, perhaps even longer when a nuclear power plant is built;
- prepare a route selection project and sign the land contracts, with an indicative timeframe of 18–24 months.

All of the above can be planned and the necessary land acquired at the same time. The timeframe for the construction related to the connection works is estimated at 2–3 years, once the necessary property has been acquired and rights of use obtained.





### 9.8 SUITABILITY OF NUCLEAR ENERGY FOR THE ESTONIAN ELECTRICAL POWER SYSTEM

All generating installations that meet the requirements (including technical, environmental, and safety requirements for connection, etc) with a connection capacity of less than 400 MVA can be connected to the Estonian electrical power system. SMRs would therefore be suitable for the Estonian electrical power system. A possible scenario for the deployment of nuclear energy in Estonia has been described in the analysis on climate-neutral electricity generation<sup>80</sup>, which concluded that oil shale, pyrolysis gas and nuclear energy are the most suitable energy sources for dispatchable generation capacities in the electrical power system. However, SMRs can be controlled in a more flexible way than oil shale-fired power plants. In addition, even when carbon capture is implemented, oil shale-fired power plants have higher greenhouse gas emissions over their lifetime than nuclear plants.

In the case of nuclear energy, reactors with a capacity of less than 400 MVA are suitable for Estonia. More important advantages are the ability to provide dispatchable capacity, in particular for the base load, which will be in high deficit following the closure of the shale plants. In addition, nuclear power plants can provide inertia to the system and also have the dispatchability to provide frequency reserves in a small amount and respond to market prices when needed.

If the introduction of nuclear energy is authorised at a national level, it is likely that a separate requirement for timely completion of the generating installation will need to be introduced in the Electricity Market Act, as it is a very different technology to the technologies considered in the current regulation (solar, wind, storage, gas), for which it is not realistic to require a plant completion requirement of 2 years from the completion of the connection point. Any person wishing to connect a generating installation to the grid must pay all the costs of connection, the exact amount of which depends on the specific location and the capacity of its electrical power network.

<sup>&</sup>lt;sup>80</sup> https://energiatalgud.ee/sites/default/files/2022-11/D8%20Final%20report%20-%20FINAL%2022.11.2022%20Clean.pdf.



84

### 10. HUMAN RESOURCE DEVELOPMENT

Only a small number of people in Estonia, except in organisations providing radiation protection and radioactive waste management services, have nuclear expertise. In general, the main competences in the fields of energy (including nuclear energy), radiation, physics and chemistry are available at the University of Tartu, Tallinn University of Technology (Taltech) and the National Institute of Chemical Physics and Biophysics (NICPB). In addition, medical radiation training is provided by Tartu Health Care College and Tallinn Health Care College. Vocational education centres offer education programmes and courses in mechatronics, construction, energy, engineering, etc.

In the case of government authorities, the national radiation and nuclear safety competence centre is the Climate and Radiation Department of KeA, which includes the Radiation Protection Bureau, the Radiation Monitoring Bureau, including the Radiation Laboratory, and the Climate and Ambient Air Bureau.

Relevant policies in this area (including on radiation-related issues) have been developed and designed by the Ministry of Climate.

The organisations responsible for responding to radiological incidents are the Rescue Board, the Health Board, the Police and Border Guard Board, the Internal Security Service and the Tax and Customs Board.

Responsibility for radioactive waste management, including development projects, lies with AS A.L.A.R.A., a state-owned company under the responsibility of the Ministry of Climate.

In the Estonian private sector, Fermi Energia AS has the main expertise in nuclear energy and it actively recruits specialists with relevant education and experience, trains its team members in cooperation with external partners, and organises seminars and visits to nuclear power plants for the representatives of the government, political parties and businesses.

Given the growing demand for radiation services, it is likely that only a limited number of employees will be immediately available for the future nuclear energy programme. Therefore, if the nuclear energy programme is approved, a domestic labour force with sufficient specialised knowledge and skills to implement phases 2 and 3 of the nuclear energy programme will not be available right away. An analysis of Estonia's current and projected labour force shows that there is and will continue to be a wide range of scientific, technical, managerial and administrative skills available for use in the implementation of the nuclear energy programme, although there is a shortage of engineers and related specialists in some sectors and this trend is set to continue.

### 10.1 FXISTING TRAINING PROGRAMMES

In Estonia, there are some initiatives, activities and curricula in higher education and vocational training that are more closely related to the nuclear field (nuclear safety, nuclear security, nuclear energy, safeguards, radiation protection, control systems, emergency planning, etc):

- Modern Nuclear Energy, taught by the Department of Electrical Power Engineering and Mechatronics of the Tallinn University of Technology, covering nuclear energy, nuclear power plants, nuclear fuel and nuclear safety;
- Experimental Methods in Nuclear Physics, taught by the Institute of Physics of the University of Tartu, covering the fundamentals of nuclear physics;
- Nuclear Technology Seminar, taught by the Institute of Technology of the University of Tartu, covering nuclear technology applications, nuclear waste and safety;





- Nuclear Power Plants: Problems and Challenges, taught by the Department of Energy Technology of the Tallinn University of Technology, covering nuclear energy, nuclear reactors and nuclear fuel;
- Reactor Physics, taught by Tallinn University of Technology and covering nuclear engineering, nuclear reactors, nuclear energy;
- Environmental Dosimetry and Radiation Protection, taught by the Department of Bio and Environmental Physics of the University of Tartu, covering radiation protection;
- From Cosmic Rays to the Nuclear Power Plant, taught by the University of Tartu Youth Academy, covering nuclear energy, nuclear safety and nuclear waste.

Estonia has training in radiation and nuclear safety (courses in educational institutions and specific training for people working in the field) and a system for recognising radiation experts. However, as Estonia has not used nuclear energy so far, the nuclear safety knowledge of Estonian specialists is limited and there are not enough human resources and competences to establish appropriate safety requirements and rules, to supervise the operator's activities, etc. The development of this area must therefore be a priority.

It is also important to note that there are activities, initiatives and training programmes in Estonia that are not directly related to the nuclear sector, but are relevant to the sector. For example, Tallinn University of Technology has a master's programme in Energy Conversion and Control Systems – although it is not designed for nuclear power control systems, it is in the field of study of control systems and therefore a place to find people with the right skills.

In addition, the University of Tartu, Tallinn University of Technology and the NICPB have proposed to develop, together with Estonian ministries, Estonia's capacity to provide nuclear energy education and research capabilities. For example, it would be important to develop competences in the fields of reactor technology and safety, nuclear power plant operation, radiation protection and the nuclear fuel cycle. While some of these competences are necessary for Estonia in any case (even if there is no nuclear power plant in Estonia), the extent of their possible development depends on the actual need, which in turn depends on the decision whether or not to build a nuclear power plant in Estonia.

Universities have also confirmed their interest and capacity to develop a comprehensive education programme on nuclear energy in Estonia. Universities aim to increase the number of student places in areas such as science, ICT, engineering, etc (these are also areas where various projections indicate that there will be a general need for more qualified people in the future) and to support Estonia's talent policy to attract students to Estonia and support graduates in staying and working in Estonia.

As many positions in nuclear power plants do not require higher education, it should be stressed that Estonian vocational education institutions also offer training related to the nuclear industry, have experience of working with local companies, and have the flexibility to develop and deliver the curricula and courses that the local nuclear energy programme needs. It is also clear that general nuclear topics are and would be important in relevant curricula, even if a nuclear energy programme is not launched in the near future, as graduates would be working in this field for decades and much could change in the energy sector during this time.

However, once the decision has been taken to launch a nuclear energy programme in Estonia, more attention should be paid to the specialties related to the nuclear industry. The Estonian Qualifications Authority has the competence in the framework of OSKA to analyse the need for specialisations and skills in the field, and also to draw up skills profiles and occupational standards for educational institutions as a basis for curricula development. Past experience has shown that Estonian vocational





education institutions are capable of making the necessary changes to meet the needs of local businesses. The cooperation of the Ida-Virumaa Vocational Education Centre with the local oil shale industry is a good example. Occupational qualification standards or skills profiles may need to be updated in the future and supplemented with the necessary competences. The experience of other countries shows that regulators generally supervise the recruitment and training of employees by the operating organisation, but do not issue a formal certificate.

At present, there are only a few courses on nuclear energy in Estonia and no in-depth training programmes on the subject. However, universities have shown that they are able and willing to set up such programmes if the government so decides and funds these developments.

It is also important to note that some R&D institutions (mainly NICPB and universities, the Institute of Physics at the University of Tartu) have been or are still engaged in research projects on or related to nuclear energy. Research projects have been funded, for example, by the Estonian Research Council or, in the case of international collaborative projects, by the European Commission. However, the number of research projects is limited, as is the number of researchers in the field. Research in the field (especially in the future, should a nuclear energy programme be launched) and R&D institutions can also be useful to the government (eg the regulatory body) to provide research results and recommendations that can be used for decision-making and relevant policy-making.

### 10.1.1 TRAINING ACTIVITIES OF THE NUCLEAR ENERGY WORKING GROUP

In the period of 2021–2023, the NEWG has also contributed to the development of core competences in Estonia, building on both domestic and international resources and partnerships. In addition to initiatives by educational institutions and the private sector, the NEWG, with the support of the US Department of State, has organised basic training courses on nuclear energy for Estonian specialists. At the beginning of 2022, Estonia started cooperating with the US in the framework of the FIRST programme. Training sessions focus on nuclear safety, security and safeguards. The development of a national infrastructure for nuclear safety, engagement and construction, financing and site selection of nuclear power plants are also addressed. More than 60 people from the public sector and NGOs, including the Estonian Green Movement and the Association of Estonian Cities and Municipalities, have been trained under the FIRST programme in the period of 2022–2023.

There is also ongoing cooperation between Estonian government agencies and the IAEA on training. In 2022, the framework agreement on technical cooperation between Estonia and the IAEA for the period of 2022–2027 was renewed and supplemented with a project on the development of nuclear competences. As part of the project, Estonian specialists have the opportunity to participate free of charge in training and seminars organised by the IAEA, which address the various sides of nuclear energy utilisation. In the period of 2021–2023, approximately 30 people from the KeA, the Ministry of Climate, the Ministry of Regional Affairs and Agriculture, the Ministry of Education and Research, Consumer Protection and Technical Regulatory Authority, AS A.L.A.R.A., Elering AS, the Estonian Environmental Research Centre, the University of Tartu, NICPB and Fermi Energia AS have participated in IAEA nuclear energy training courses of 1–5 weeks.





### 10.2 AVAILABLE HUMAN RESOURCES IN ECONOMIC SECTORS AND LABOUR FORCE PROJECTIONS

The main economic sectors in Estonia that use the skills needed for the deployment of nuclear energy in Estonia are the following, defined according to the statistical classification of economic activities in the European Union (NACE) codes (Table 10):

Sector	Number of people employed in the sector in Estonia according to OSKA
C: Manufacturing	<ul><li>5,560 engineers</li><li>2,915 chemical operators</li></ul>
C. Manufacturing	4,370 welders
D: Electricity, Gas, Steam and Air Conditioning Supply	1,090 electrical and energy engineers
	110 industrial engineers
	🧓 5,530 electricians
E: Water Supply; Sewerage, Waste Management and Remediation Activities	30 environmental specialists
	230 environmental surveillance specialists/analysts
	140 environmental chemistry and physics specialists
	90 laboratory technicians
F: Construction	2,660 engineers
	12,815 civil engineers
	2,670 construction machinery operators
M: Professional, Scientific and Technical Activities	6,845 researchers and engineers

Table 10. Sectors of the economy using the necessary skills for the introduction of nuclear energy (Source: analysis Human resources development strategy and mapping of the regulatory framework)

These sectors do not include all the people with the skills needed for the Estonian nuclear industry, but they are the most directly related sectors. Other sectors can also provide the necessary analysts, researchers and experts.

Many of the skills and competences needed in a nuclear power plant are similar to those needed for working in any other power plant. It is important to note this, since Estonia has extensive experience in building and operating power plants, including large oil shale-fired power plants. However, based on IAEA guidelines and the experience of countries with nuclear energy, there is a need to develop specific skills, competences and experience that Estonia currently lacks and that will need to be addressed if it is decided that Estonia will become a country with a nuclear power plant.

### 10.2.1 LABOUR MARKET PROSPECTS AND NEEDS

As the working-age population is projected to decline, it will generally be more difficult in Estonia to find the workforce needed. This problem is even greater given that the demand for engineers and other





skilled professionals is also increasing in other sectors, creating more competition for a potential nuclear energy programme.

To clarify the projection, it is important to note that the main positions providing the skills needed for Estonia's potential nuclear industry are:

- nuclear engineers;
- safety and environmental specialists;
- reactor operators;
- radiation protection specialists;
- chemists and physicists.

Another important group of skills needed is in the following positions:

- electricians;
- electrical engineers;
- chemical engineers;
- mechanical engineers;
- civil engineers.

In addition, carpenters, bricklayers, plumbers, sheet metal workers, heavy equipment operators and welders are needed for nuclear power plants and supporting infrastructure.

There is and will remain a shortage of engineers in the manufacturing sector, and it is recommended that consideration be given to the use of external labour to cover the need for engineers in the manufacturing industry. There is also a shortage of young people with vocational education.

In the electricity sector, the projected employment of electrical engineers will remain stable over the next five years, but the sector as a whole is training too few engineers and technicians. There will be a significant shortage of engineers, technicians and operators.

The number of environmental specialists and environmental chemistry and physics specialists is projected to remain stable over the next decade. It is important to bear in mind that many sectors need these specialists and the number of people with specific competences can be very small. For example, Estonia has the expertise and specialists to ensure national radiation safety, but not enough competent people in the field of nuclear safety to implement a nuclear energy programme.

The construction sector employs around 63,000 people. There are not enough engineering graduates to meet future labour force needs. Over the last five years, the number of applicants for construction specialties at higher education institutions has decreased by a quarter. At the same time, the demand for professionals with higher education is growing. The construction sector is obviously very important in the construction phase of a nuclear power plant. It is important to bear in mind that, although Estonia has no experience in building nuclear power plants and the number of people involved is not large, there are many construction companies in Estonia that have experience with complex and large-scale projects. Thus, given the size of the SMR and the rather limited need for (temporary) labour force (the number of workers would probably be a few hundred) for on-site construction, the necessary labour force and skills would be to some extent available on the Estonian domestic market. These could be used, for example, by subcontracting local companies to work on power plant facilities and/or components that do not require previous experience in building nuclear power plants. Overall, the Estonian industrial sector is experienced and can participate in the construction and maintenance of nuclear facilities.





For researchers and engineers in the professional, scientific and technical sectors, recent data projects a significant increase in employment (over 10%) over the next ten years. Based on data for 2017/2018, the sector employed 6,845 people and it is estimated that more than 1,000 additional specialists are needed to meet the existing overall demand.

### 10.3 PERSONNEL NEEDS AND COMPETENCE DEVELOPMENT OF THE NUCLEAR REGULATOR

Based on the IAEA guidelines and the experience of other countries with small nuclear energy programmes, the regulator will need at least about 80 permanent employees, including the current staff of the Climate and Radiation Department of the KeA, as well as the necessary management and corporate services.

A wide range of scientific, technical, managerial and administrative skills are and will continue to be available in the labour force in Estonia, although there is a shortage of engineers and related professionals in some sectors and this trend is expected to continue.

In preparation for the establishment of the regulator, a sub-working group on human resource development will need to be set up under the leadership of Ministry of Education and Research within the NEWG, who would prepare a roadmap for workforce planning and mitigation of shortages for the introduction of nuclear energy. A budget for outsourcing consultancy and analysis services, which has been taken into account in the NEWG budget estimates, must also be planned for the sub-working group.

In phase 2, the regulatory body must rapidly develop its organisation to prepare the regulatory framework for the nuclear power plant project. Key competences at this time include human resources and a strong talent management process for recruiting and training new employees, as well as other business support functions. It is assumed that the Estonian domestic labour market has the right skills and experience in the supporting areas.

At the same time, in phase 2, the newly established regulatory body will also need to hire experienced management and competent employees to set up and implement the necessary regulatory infrastructure for the nuclear power plant, including the regulator's own organisation, management processes and procedures, regulations and guidelines, and licensing process. It is not expected that personnel with relevant nuclear energy-related regulatory experience and skills will be widely available in the Estonian labour force in phase 2 of the programme.

The leading specialist of the regulatory body must have expertise in basic and applied science and technology, and the knowledge and skills to develop and implement regulatory procedures. These skills are usually acquired through a combination of university education, specialised training and at least five years of professional experience. In phase 2, a team of such individuals is needed to help develop the regulatory framework and organisation. Such skills are currently scarce in the labour market in Estonia and, given the preparation time needed to develop these skills, local employees will become available at the end of the third stage at the earliest.

### 10.4 PERSONNEL OF THE NUCLEAR POWER PLANT OPERATOR

The personnel of the nuclear power plant operator will be influenced by a number of factors, the most important of which is the choice of technology. The new small reactors are expected to be more personnel efficient compared to older technology, due to smaller power plants, simpler design





and passive safety systems that do not require operator intervention. However, personnel needs do not generally decrease in proportion to the size of the unit, so smaller units tend to suffer from a lack of economies of scale and employ more people per MW than larger units. So far, there is no real experience with the new small reactors to give a firm estimate of personnel needs.

Another factor to consider is that a new starting organisation will need more personnel during the initial deployment, training and settling-in period than an experienced organisation that has been using procedures and expertise for a longer period of time. Reliable production is key to the successful operation of a nuclear power plant, and to achieve this, an absolute minimum level of personnel is not necessarily the best solution.

Table 11 summarises the comparative data collected on the number of employees in existing small single reactor plants and the estimated number of employees provided by some small and medium reactor suppliers. Estimates by developers of small- and medium-sized reactors are generally significantly lower than the actual number of employees in operating nuclear power plants. Some of the estimations refer to on-site operating personnel and it is not clear to what extent they include the technical and operational support personnel that the owner/operator needs to manage the operation of the plant. To date, there are no examples of such small- and medium-sized reactor projects that provide data based on experience. Based on the available data, a small nuclear power plant could employ around 75–400 people.

	Nuclear power plant	Reactor type	Generation capacity	Personnel of the operator
LN	Nuclear power plants currently operating in the US and Europe	Light water reactor (LWR)	-	732 (median)
CURRENT	Krško, Slovenia	PWR	1 × 688 MWe	644
ರ	Point Lepreau, Canada	CANDU-6	1 × 690 MWe	850
	Borssele, Netherlands	PWR	1 × 485 MWe	~ 400
PLANNED	OPG DNNP	BWRX-300	1 × 300 MWe	210
	Nuscale VOYGR	iPWR	928 MWe	270
	GE Hitachi	BWR	1 × 300 MWe	75–150 (on-site personnel)
	Rolls Royce	PWR	1 × 470 MWe	302 (assigned to one reactor)

Table 11. Nuclear power plant personnel benchmarks (Source: Skepast&Puhkim, Steiger)

In phase 2, the owner/operator will need experienced personnel to manage the tendering and contracting process for the nuclear power plant and then to oversee the activities of the main contractor and the supply chain and to communicate with the regulator. The labour market in Estonia is unlikely to have personnel with the relevant nuclear experience.

The operating organisation will need to start its development activities in phase 3 early on, at the same time as the licensing and construction of the nuclear power plant. Around 15% of the labour force will not be required to have skills in the field of nuclear energy and may be available for immediate recruitment from Estonia, including in the following fields:





- administration;
- information technology (IT);
- documentary control and records management;
- finance:
- health and safety;
- human resources.

However, the operating organisation also needs to recruit CEOs with experience in the nuclear energy field and managers/leadership for functional areas, trainers and instructors on operations, operations mentors and experts leading each process and programme.

The head of the corporate services function of the owner/operator's organisation must have a university degree in business administration, have completed relevant training and have at least five years of experience in related positions. People with these skills are expected to be available in the general labour force in Estonia, so a short recruitment period of 3–6 months is expected.

Reactor operators usually have to undergo at least two years of classroom training and training on a simulator and on the job before they are allowed to work at a plant. There are currently no people in Estonia with these skills. However, if swift action is taken to set up the necessary training programme and facilities, including access to a simulator, the necessary personnel could be in place by the time they are needed for the commissioning and start of operation of a nuclear power plant at the end of phase 3.

### 10.5 HUMAN RESOURCES STRATEGY

Factors in determining the appropriate human resource strategies for the nuclear energy programme are the competences required in each role, the timeframe when people will be needed in the programme, the number of people needed, and the preparation time needed to develop the required knowledge and skills. Estonia has an educated labour force with general scientific, technical, managerial and administrative skills. However, the country currently lacks in-depth nuclear energy expertise. As a result, many of the nuclear energy skills are not available in the country to support the launch of the nuclear energy programme according to the planned timeline, and will have to be sought outside Estonia. At the same time, urgent action is needed to expand and develop public education and training programmes. More and more skilled local employees should become available in the future.

The above considerations show that the overall human resources strategy has two main strands, namely:

- recruiting personnel with skills in the field of nuclear energy from outside the country to fill
  critical management and expert functions and support the rapid launch of the programme
  according to the planned schedule;
- 2. developing Estonia's national capability to meet the long-term needs of the programme and ensure its sustainability.

An important part of the human resources strategy for the early years of the Estonian nuclear energy programme is the recruitment of external experts to fill the positions in the regulatory body and the organisation of the owner/operator that require significant experience, knowledge and skills in the nuclear energy field. For both the regulator and the owner/operator, priority should be given to the executive leadership, functional area leadership and management instructors who





supervise and mentor less experienced employees. Positions in the regulatory body that may be considered for the recruitment of foreign posted employees include the head of the operating unit, heads of department and senior specialists in each operating unit.

The WANO guidelines state that for the organisation of a nuclear power plant owner/operator, the priority and approximate order of recruitment should be as follows, with ideally the majority of candidates being qualified and experienced personnel with nuclear competences:

- executive leadership;
- functional area leadership;
- operations training personnel and instructors;
- operations mentors and management personnel;
- lead experts for each process and programme;
- plant operator and chemistry staff;
- all others.

If such a choice is difficult, alternatives should be sought. For example, leaders from non-nuclear fields could be supported by the involvement of senior, experienced nuclear advisors.

Another strategy to find the necessary expertise is to outsource work to qualified and experienced contractors. The choice of outsourced services depends on factors such as:

- the types of services needed whether they are one-off, temporary or long term;
- the difficulty of maintaining competence in the case of infrequent specific tasks;
- availability of skills and resources in Estonia;
- the availability and cost of external services;
- legal and regulatory requirements.

The use of outsourcing can help manage important but temporary tasks at these stages and allow organisations to focus on their longer-term needs. Outsourcing does not mean giving away responsibility. Both the regulator and the owner/operator need to ensure and maintain the capacity of an informed customer for the services they commission. Thus, each organisation must acquire the capability to specify the services required, select suppliers, monitor them and evaluate their performance.

Estonian institutions and companies are beginning to compete on the international market for nuclear expertise, which is in growing demand. Recruitment performance is influenced by factors such as salary ranges, residency requirements, prices and living standards, working language, working environment, career opportunities, etc. Thus, recruiting candidates from abroad and retaining them requires special attention and effort.

Establishing safety requirements and issuing licences require active cooperation with competent authorities in other countries with experience in regulating SMRs. Licensing requirements for small- and medium-power reactors are developed by, among others, the Finnish regulatory body STUK, the U.S. Nuclear Regulatory Commission, the Canadian Nuclear Safety Commission and the IAEA, which pools the expertise of Member States.





### 10.6 DEVELOPING NATIONAL CAPACITY

Education and training programmes need to be devised to develop skills and fill the capacity gaps to meet the personnel needs of the regulator and plant operator, and existing programmes need to be expanded to allow Estonian people to fill highly specialised positions.

National candidate sources and channels can be divided into three categories:

- those with no experience, coming directly from school, technical/vocational education institutions or universities;
- those with experience in related industries and some relevant skills and experience (eg electricity generation, petrochemicals, rail, aeronautics or other high risk/safety industries);
- those with experience and specific transferable skills (eg legal, financial, procurement, human resource management skills).

For the first group of candidates, it is essential that the government, the nuclear regulator and the owner/operator develop partnerships with academic and vocational institutions to develop programmes that are consistent with the professional and technical standards of the nuclear energy programme and the workforce plans of each organisation. While the human resource needs of the owner/operator and the regulator are different, they have enough in common to make cooperation on capacity building at a national level both feasible and beneficial.

Examples of important measures in this area:

- scholarships for graduates from secondary education to study in relevant international programmes;
- review existing curricula and, where necessary, develop additional postgraduate studies to train science and engineering students in the nuclear field. Alternatively, training at foreign universities where the capacity exists should be considered;
- develop and implement a comprehensive curriculum (eg micro-qualification) in cooperation between Estonian universities and research institutions or universities in countries experienced with nuclear energy;
- expand training opportunities through international cooperation, such as the US FIRST programme;
- take advantage of the training opportunities offered through the IAEA technical cooperation programmes;
- recognise the importance of vocational training on technology, and the need for such employees in the nuclear energy programme, develop appropriate training for technicians in the field of mechanics, electricity, instrumentation and control, radiation protection and reactor operation;
- implement training programmes by each organisation to enable employees to develop their work-related competences.

Recruiting candidates from related industries can mean competing with other employers and this needs to be reflected in recruitment and retention strategies. But even in these areas, it may be possible to develop strategic partnerships.





Caution should be exercised when hiring people from other industries as they may bring attitudes and behaviours that are not compatible with the safety culture of the nuclear industry<sup>81</sup>.

A successful nuclear energy programme requires many competences, and among these, management skills should be highlighted, as Estonia has no previous experience in managing nuclear industry projects. Thus, when designing programmes for developing national capacity, emphasis should be put on training in the area of managerial skills, taking into account the nuclear management training offered by the IAEA.

In addition, to develop Estonia's national capacity, it is important to consider the establishment of a research and development programme in the nuclear energy project, at the appropriate time. The programme would be hosted by a university or research institution in public law, and supported by both the regulator and the operator. Examples from other countries show that such nuclear R&D programmes, even if relatively small, can generate a certain number of highly educated specialists for the operator and regulator, as well as a centre of expertise in the country over time. As noted above, Estonian R&D institutions have the relevant expertise in this area and have shown a willingness to develop it further.

Overall, the development of national training, education and research programmes will require significant resources, but in the long term will bring many benefits in terms of ensuring a sustainable pool of specialists (including engineers, etc) for the local nuclear industry.

Establishing cooperative relationships between governments and technology suppliers, including the vendor country, operators in other countries using the same type of nuclear power plant technology and the regulator in the country of origin, can allow for the transfer of information and training that will benefit Estonians in gaining work experience in the field.

Practical measures could include, for example, the training of the personnel of a nuclear power plant in certified training centres in countries experienced in the use of the same technology.

The regulator, owner/operator and other organisations participating in the nuclear energy programme must develop workforce plans specific to their organisation. These workforce plans should take into account the training needs of personnel found through the abovementioned external and domestic channels, to enable them to develop the skills needed to perform their tasks and to support the development of the desired values and organisational culture.

The level and depth of training required will depend on the skills and experience of each employee and their role. Individual training needs should therefore be reflected in individual training and development plans, in line with the System Approach to Training (SAT). The training methods used are in line with the identified needs (eg training on how to perform routine operations and how to deal with emergency situations using training simulators, etc). Training of personnel is a priority and requires significant resources in each key organisation and needs to be planned and managed.

Also, it is important to integrate into workforce development plans the objective of having foreign specialists (including consultants and outsourced experts) train less experienced employees to increase local capacity to fill all the required positions in relevant organisations, such as the regulator. To fill senior posts in the nuclear regulatory body more quickly and in line with the planned timetable of the nuclear energy programme, consideration should be given to the possibility of a temporary derogation from the Civil Service Act, which provides for a nationality requirement for civil servants, or another legal solution for the recruitment of external experts. Outsourcing work, while retaining the in-house capacity of an intelligent client for certain tasks, such as the technical assessment of licence applications or

<sup>81</sup> https://www.iaea.org/publications/8121/managing-human-resources-in-the-field-of-nuclear-energy





construction management, can help both the nuclear safety regulatory body and the owner/operator to manage workloads and gain access to the necessary expertise.

### 10.7 FINANCING THE DEVELOPMENT OF NATIONAL CAPACITY

National budgets will need to be allocated to education and training programmes, research and development, and human resources development of regulatory bodies in the nuclear field.

Training of ministry and agency personnel, training of regulatory body's personnel, national scholarship programmes, training of specialists at Estonian universities (train-the-trainers), cooperation agreements with foreign universities for the training of specialists or the development of curricula to create appropriate training facilities in Estonia would be an expense from the state budget in the amount of €1.8 million per year during the construction phase of the plant and a fixed annual expense of about €1.4 million during the operation phase (Figure 15).

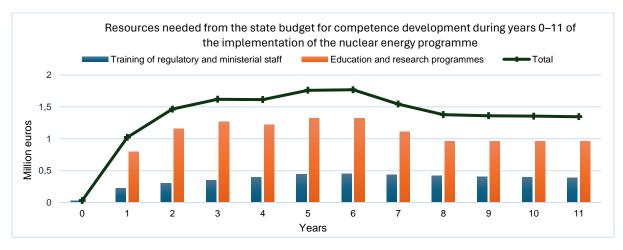


Figure 15. Expenses from the state budget for competence development during years 0–11 of the nuclear energy programme (Source: NEWG)

For some of the funding for the training, the European Union's Structural Funds could be used, which are targeted at R&D, education and vocational training, as well as projects related to energy and climate change. A large part of the basic competences can also be developed in cooperation with the IAEA, whose training possibilities are already actively used, and with other international nuclear organisations such as the OECD NEA. In addition, for the training of the personnel of the regulatory body, it is advisable to cooperate with regulators in large nuclear countries, such as the NRC in the US, which has established international expert exchange programmes to send its employees to work placements with experienced regulators.

The owner/operator of a nuclear power plant is responsible for organising and funding the training of its employees. To train a sufficient number of specialists for positions requiring higher education, the private sector can offer scholarship programmes for students to study nuclear education at foreign universities. To fill the positions requiring vocational education, the plant owner/operator can collaborate with vocational training centres, develop and finance the curricula needed by them, and submit training requests in line with expected labour needs. Cooperation agreements must also be concluded with the nuclear reactor supplier for the training of personnel to ensure that operators receive specific training in reactor technology. Private funding can also include joint projects and research and development activities.





Based on the IAEA guidelines and the experience of other countries with small nuclear energy programmes, the regulator will need about 80 permanent employees, including the current staff of the Climate and Radiation Department of the KeA, as well as the necessary management and corporate services. Based on available benchmarks related to the personnel of the owner/operator, including claims from some SMR suppliers, IAEA and WANO guidelines based on existing plants, and examples of smaller, stand-alone nuclear power plants, an estimated range from 75 on-site employees to around 400 per unit can be proposed. In the field of radiation protection and radioactive waste management, there are sufficient people and skills to meet the demands of existing practices. Efforts are being made to fill the shortage through training provided by the IAEA. Demand for radiation protection workers will increase in the near future with the planned decommissioning of the reactor sections of the former Paldiski nuclear submarine training centre. Therefore, there are a limited number of employees who can be reassigned to a new position within the nuclear safety regulatory body. Managers and senior level specialists in the nuclear safety regulatory body and the organisation of the owner/operator need both nuclear education, training and experience, which is not widely available in Estonia in the short to medium term. The solution would be a two-tiered human resources strategy that supports the rapid launch of the programme, bringing in external experts to support short-term needs while developing Estonia's national capacity to ensure the long-term sustainability of the programme. For the foreseeable future, external experts will be needed to fill leadership and main expert positions in key organisations and to train the next generation. Following the decision to move forward with the nuclear energy programme, urgent nationally coordinated action is needed to set up education and training systems for developing Estonian citizens to meet the needs of the nuclear safety regulatory body, owner/operator and other entities. This includes:

- scholarships to study abroad;
- b developing university curricula;
- vocational education for technologists and operators;
- IAEA technical cooperation training and missions;
- the FIRST programme or a similar programme to develop awareness of the principles of nuclear safety, security and safeguards;
- job-specific training.

The expense from the state budget for developing the competences would amount to  $\leq 1.8$  million per year during the construction phase of a nuclear power plant, and an annual fixed expense of around  $\leq 1.4$  million during the operational phase.



The implementation of a communication strategy is one of the tasks assigned to the NEWG by a memorandum of the cabinet of ministers in April 2021. The NEWG was tasked with drawing up a communication and engagement plan for dialogue with the public and stakeholders. All the agencies represented in the NEWG have their own public relations departments, whose tasks involve informing the public about the activities of the ministry. KeM/KLIM has coordinated communication on nuclear energy subjects, manages the NEWG website, reports on nuclear energy meetings on the ministry's social media pages and responds to media enquiries. In November 2022, the Ministry of the Environment organised a public information day on nuclear energy entitled 'Nuclear energy – good or bad?', which was broadcast live and is available to watch. A similar public event was organised by the Ministry of Climate in November 2023 entitled 'Nuclear energy – eve of Estonia's decision'. To inform the wider population, especially young people, negotiations have been held with the AHHAA Science Centre and the Energy Discovery Centre on the possibility of organising an interactive nuclear energy exhibition, if a positive decision is taken on the introduction of nuclear energy.

### 11.1 COMMUNICATION STRATEGY OF THE NUCLEAR ENERGY WORKING GROUP

To have a coordinated and comprehensive engagement and communication plan, the NEWG commissioned a communication strategy, which was completed in September 2022. The strategy included:

- 1. an analysis of the existing situation, including 8 focus group interviews;
- 2. the formulation of communication objectives;
- 3. the grouping of target groups and stakeholders;
- 4. key messages for different target groups, including Estonian- and Russian-speaking residents;
- 5. recommendations on the choice of information channels by target groups;
- 6. recommendations for the selection of speakers;
- 7. an action plan for the next period.

The strategy was prepared in accordance with the IAEA's guidance document *Stakeholder Engagement in Nuclear Programmes*<sup>82</sup>, in consultation with the IAEA's public relations and engagement specialist, and through participation in an IAEA technical meeting on communication. To implement the strategy, the NEWG agreed on a plan for the implementation of the communication strategy until 2023. The plan included information sharing on NEWG activities and nuclear energy subjects, responsible parties and stakeholders. The activities described included press releases, press conferences, articles, conferences and cooperation with various target groups and stakeholders. Public opinion surveys are important for the public debate, and they help identify key issues such as radioactive waste management or the risk of accidents and open communication. The main objectives of the communication strategy are shown in Table 12.

<sup>82</sup> https://www.iaea.org/publications/14885/stakeholder-engagement-in-nuclear-programmes



98



INFORM	RAISE AWARENESS	ENGAGE
<ul> <li>Explain to the public the tasks of the working group, the work process and the results of the analyses.</li> <li>Clarify the role of the state and the decision-making process, and the role of private companies and their options for</li> <li>Explain how the process of the introduction of nuclear energy is internationally regulated and supervised.</li> </ul>	<ul> <li>Provide factual information on nuclear energy.</li> <li>Balance and expand the debate on nuclear energy in Estonia.</li> <li>Address the risks associated with nuclear energy and explain how to mitigate them.</li> </ul>	<ul> <li>Establish a dialogue with citizens to understand their views on nuclear energy.</li> <li>Demonstrate national competence to explore the possibility of the introduction of nuclear energy.</li> </ul>

Table 12. The objectives of the communication strategy of the Nuclear Energy Working Group (Source: META Advisory)

### 11.2 PUBLIC OPINION STUDIES

The overall objective of the communication strategy implementation plan is to deepen the understanding of the potential role of nuclear energy in Estonia's energy policy and to ensure the involvement of key stakeholders in the decision-making process. In February 2022, the survey *Awareness of the field of nuclear energy and readiness for its adoption in Estonia* (Annex 5) commissioned by the NEWG was conducted among Estonian residents aged 15–74. The aim of the survey was to get an overview of the awareness of different population groups in the field of nuclear energy, their expectations and fears, and the main sources of information related to the field. The study mapped:

- 1. the perceived potential of different ways of generating electricity and people's attitudinal preference for replacing fossil fuels produced from local coal;
- 2. general attitudes towards the introduction of nuclear energy;
- 3. people's assessment of their knowledge of nuclear energy;
- 4. fears and expectations relating to the introduction of nuclear energy;
- 5. information needs in this area and preferred sources of information.

The results of the survey showed that **Estonian citizens have a positive attitude towards nuclear energy** – 59% support the introduction of nuclear energy, while 22% expressed opposition and 19% have not formed a position on the matter. More than half of the Estonian population consider themselves familiar with the general principles of nuclear energy generation, while slightly more than a third consider themselves unfamiliar with the field but are interested in learning more. In segments with a higher level of awareness, the percentage of those in favour of nuclear energy is higher. The biggest fear with nuclear energy is the potential environmental risk associated with radioactive waste management. This is also the area where information needs are greatest. As a source of information in the field of nuclear energy, preference is given to television, radio and thematic websites.

In February 2023, a public opinion monitoring survey<sup>83</sup> conducted by the Government Office also examined public attitudes towards the introduction of nuclear energy. The idea was supported by 75% of the country's population, while 17% were opposed in principle and 8% had not yet formed a position.

<sup>83</sup> https://riigikantselei.ee/uuringud (in Estonian)



99



In April 2023, a public opinion survey carried out by Norstat Eesti AS showed a 60% support rate for the introduction of nuclear power, while 25% of respondents were against it.

A follow-up survey in November 2023 showed 57% support for nuclear energy, 27% against and 16% had no position on the issue.

An overview of the 2022–2023 studies is shown in Figure 16.

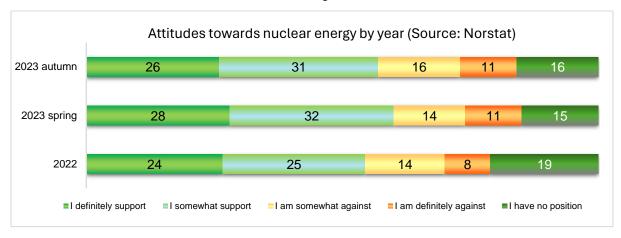


Figure 16. Attitudes towards nuclear energy by year (%, N= all respondents) (Source: Norstat)

### 11.3 COMMUNICATION AND ENGAGEMENT ACTIVITIES

The planned communication activities of the NEWG gained momentum at the end of 2022, when the NEWG communication strategy and its implementation plan were finalised and the target groups and stakeholders were mapped (Figure 17). The communication strategy provided a framework for further outreach activities to be more proactive, to provide factual information to the public through different dimensions, to address nuclear energy risks and explain mitigation options, as well as to organise engagement events and better coordinate activities with the authorities who are members of the working group.



Figure 17. Target groups and stakeholders of the Nuclear Energy Working Group (Source: META Advisory)





Communication activities in 2021 focused on sharing information about the creation of the working group and mostly responding to requests from journalists. The spokespersons were the Minister of the Environment and the NEWG coordinator. Among the publications, Virumaa Teataja, Delfi, Postimees, ERR news (both TV and radio and in Estonian and Russian), Põhjarannik, Stolitsa covered the topic more actively.

The 2022 communications were about the government's decision to accelerate the process of the final report on the introduction of nuclear energy, the NEWG presented the results of the public opinion survey and informed about the interim report. Alongside the NEWG coordinator, the leader of the working group took up the role of spokesperson and gave interviews and produced opinion pieces to explain the working group's activities and the national decision-making process for the introduction of nuclear energy. In addition to stakeholders and the general public, journalists covering the subject were invited to the nuclear energy information day in November 2022. NEWG activities were also promoted in the Russian-language media.

At the beginning of 2023, the publication of scheduled articles on subjects related to nuclear energy, eg nuclear waste, was launched. The press conference and presentation of the report on the spatial analysis of potential sites for a nuclear power plant and a spent nuclear fuel final disposal site in April 2023 received more media and public attention. The day before the press conference, a preview was organised for municipal representatives. In addition to state authorities, the members of the sub-working group on spatial planning, which was established to carry out the analysis of the sites, included the Association of Estonian Cities and Municipalities and the Estonian Council of Environmental NGOs, which was represented in the working group by the Estonian Green Movement. In May 2023, five meetings with municipal representatives and local residents were organised in the areas resulting from the analysis to inform the public about the results of the analysis, planned activities and processes, which also received extensive media coverage in regional newspapers. The results of a public opinion survey commissioned by the NEWG were also presented in the spring.

The human resources strategy and the results of the radioactive waste analysis were communicated as the most important studies. In order to inform Russian-speaking journalists, a media briefing organised by the Communication Unit of the Government of the Republic of Estonia that focused on the results of the spatial analysis was attended. The new head of the working group also published an opinion piece in July. The communication strategy identified the need to reach a variety of target groups, including women. To showcase women in the nuclear communication activities, a profile story about the coordinator of the nuclear working group appeared in the weekend newspaper LPs of the Eesti Päevaleht and Delfi.

In April 2023, a Nuclear Energy Support Group<sup>84</sup> was established in the Riigikogu, consisting of 23 members. The Support Group has been briefed on the activities of the NEWG, and its members and other members of the Riigikogu have taken part in nuclear study visits and NEWG events. In addition, reports on the activities of NEWG have been submitted to the Environment Committee and the Economic Affairs Committee of the Riigikogu.

The results of the analysis of the sub-working group on nuclear security and emergency preparedness were presented at a press conference in June 2023, providing an overview of whether and under which conditions the construction of a nuclear power plant in Estonia is feasible from the point of view of nuclear security and emergency planning.

<sup>&</sup>lt;sup>84</sup> https://www.riigikogu.ee/en/parliament-of-estonia/associations/association/212feb6b-2cc6-4c22-9756-dce98c799aeb/tuumaenergeetika-toetusruhm/



101



In August 2023, discussions on the potential of nuclear energy took place at the Opinion Festival in Paide, with the participation of NEWG representatives.

The main focus of the October coverage was on the IAEA expert mission. A visit with journalists to the Olkiluoto nuclear power plant and the Onkalo geological disposal site for spent fuel is also planned for early 2024.

According to the media analysis by Station, a total of 420 media reports related to the Nuclear Energy Working Group were published between April 2021 and December 2023. Active coverage was given by ERR, Virumaa Teataja, Delfi, Postimees, Maaleht, Eesti Ekspress, MK Estonia, Õhtuleht, Kanal 2, TV3, Kanal 7, Tallinna uudised, Pärnu Postimees.

Throughout these years, the activities of the NEWG have also been reflected in social media posts on the Facebook accounts of the Ministry of the Environment and the Ministry of Climate.

In terms of communication activities, the Estonian Green Movement has been the most active antinuclear group in Estonia, organising events, publishing articles, and creating online and social media pages. The representative of the Estonian Green Movement, who was appointed by the Estonian Council of Environmental NGOs to the sub-working group on spatial planning of the NEWG, has been given access to discussions, seminars and NEWG training. They also participated in a panel discussion at the NEWG information day 'Nuclear energy – good or bad' in November 2022.

### 11.4 COMMUNICATION ACTIVITIES IN THE IMPLEMENTATION OF THE NUCLEAR ENERGY PROGRAMME

Following a positive decision of principle, the main focus of communication activities will be on addressing the issues raised by the social debate. To this end, information days for target groups and stakeholders will be planned, and information materials explaining the objectives and implications of the nuclear energy programme will be produced. An update of the communication strategy, including the implementation of the communication activities for phase 2 of the nuclear energy programme, will need to be commissioned.

During phase 1, KeM/KLIM did not have specific employees for communication activities related to nuclear energy and the implementation of the communication plan was dealt with within the general communication activities of the ministry. At the beginning of phase 2, it is important to involve a communication partner who can effectively support the communication of the introduction of nuclear energy. This includes the production of explanatory materials and participation in public events. This will ensure an open dialogue with different stakeholders and strengthen public awareness and understanding of nuclear energy.

The NEWG has developed a communication strategy to engage in dialogue with the public and stakeholders by involving different authorities. The public opinion surveys show a generally positive attitude towards nuclear energy among the Estonian public, but also concerns were expressed, in particular about radioactive waste management. The communication activities of the NEWG have included a number of media channels, public opinion monitoring surveys and the organisation of events to deepen the understanding of the potential of nuclear energy in Estonia's energy policy. The NEWG has continued to actively engage with different stakeholders by, for example, organising debates, information days and participating in public events. If the nuclear energy programme will be implemented, it is necessary to involve a specialised communication partner to ensure effective communication with different target audiences.





### 12. SITE AND SUPPORTING FACILITIES

From 2022 to 2023, an analysis was carried out on behalf of the sub-working group on spatial planning of the NEWG (Annex 5) to identify potential areas in the territory of the Republic of Estonia where a nuclear power plant and a radioactive waste final disposal site could be built.

When the work was commissioned, the task was to find answers to the following questions:

- 1. Could there be a nuclear power plant in Estonia, and where?
- 2. Could Estonia host a final disposal site for spent nuclear fuel and low-level radioactive waste generated at a nuclear power plant, and where?
- 3. How would nuclear fuel be managed? Including:
  - How would nuclear fuel be supplied to the plant?
  - How would transport between the nuclear power plant and the final disposal site take place?
- 4. What would be the socio-economic impact of the site of the plant on the local community, and how could potential negative impacts be reduced? Impact on the location of social infrastructure.
- 5. What are the recommendations for further action?
- 6. To what extent is the information gathered in the spatial analysis usable in the future?

In the course of the spatial analysis, exclusion criteria were used to identify potential areas for SMRs under the base and alternative scenarios (SMR with open or closed cooling system / alternative cooling), as well as potential areas for a geological disposal site of high-level radioactive waste (geological disposal on a large scale, disposal in deep boreholes) and for a near-surface disposal site for low- and intermediate-level radioactive waste.

The spatial analysis is based on existing map layers and data. In the course of the spatial analysis, the data was compiled into a GIS database and a map system was created, which contains data as of autumn 2022. In addition, a set of criteria used to identify potential sites was developed. The data compliant to the IAEA guidelines used in the spatial analysis will be available for use in the next phases of the site selection of nuclear facilities. Subsequent work will have to take into account the need to update the data.





### 12.1 SPATIAL ANALYSIS OF THE SITE OF AN SMR

The results of the spatial analysis of the possible sites of the SMR in the base and alternative scenarios are presented in Figure 18.

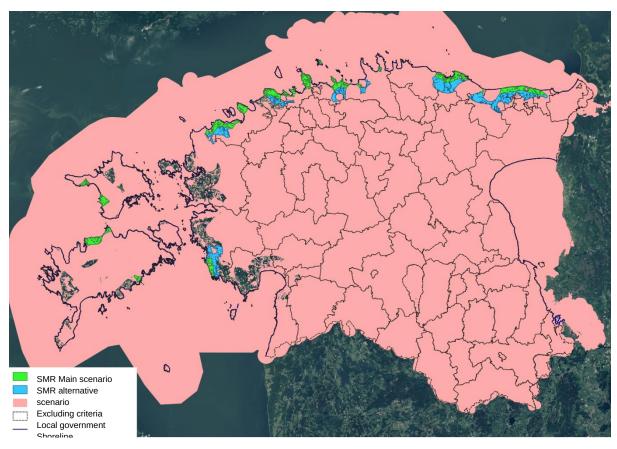


Figure 18. Results of the spatial analysis of the sites of an SMR (Source: Skepast&Puhkim, Steiger)

Under both scenarios, 16 potential areas were identified where building an SMR could be considered as a result of the exclusion criteria described. The number of potential areas may change in the future due to parallel processes. Possible areas in geographical order from east to west are:

#### 1. Toila

(partly in Toila Parish, Lüganuse Parish, Jõhvi Parish, Viru-Nigula Parish and Kohtla-Järve City, and to a lesser extent in Alutaguse municipality), the area delimited by the alternative scenario (29,200 ha) is larger than the area delimited by the base scenario (about 8,300 ha). In the alternative scenario as one plot (Toila), in the base scenario as two separate plots (Toila (approximately 8,025 ha) and Toila II (approximately 275 ha));

### 2. Kunda

(partly in Viru-Nigula Parish, Haljala Parish and Rakvere Parish), the area delimited by the alternative scenario (approximately 18,700 ha) is larger than the area delimited by the base scenario (approximately 6,120 ha);

#### 3. Loksa

(in Loksa City, partly on the territory of Kuusalu Parish) base scenario and alternative scenario with the same area (about 410 ha) and as a single separate plot;





### 4. Kuusalu

(in Kuusalu Parish), the area delimited by the alternative scenario (approximately 2,575 ha) is larger than the area delimited by the base scenario (approximately 430 ha), the area being a single plot in both scenarios;

### 5. Jõelähtme

(partly on the territory of Jõelähtme Parish and Kuusalu Parish), the area delimited by the alternative scenario (approximately 8,730 ha) is larger than the area delimited by the base scenario (3,800 ha). In both scenarios as two separate plots (Jõelähtme (base 3,740 ha; alternative 8,670 ha) and Jõelähtme II (alternative and base 60 ha));

### 6. **Prangli**

(Viimsi Parish) base scenario and alternative scenario with the same area (about 290 ha) and as a single separate plot;

### 7. Viimsi

(in Viimsi Parish and partly in Tallinn City), the base scenario and the alternative scenario with the same area (approximately 4,040 ha) and as a single separate plot;

### 8. Paljassaare-Kakumäe

(in Tallinn City and partly in Harku Parish), a base scenario and an alternative scenario with the same area (1,432 ha) and four separate plots: Paljassaare-Kakumäe (330 ha), Paljassaare-Kakumäe II (390 ha), Paljassaare-Kakumäe III (690 ha) and Paljassaare-Kakumäe IV (approximately 22 ha);

### 9. Harku Parish

(partly on the territory of Harku Parish, Saue Parish and Tallinn City), the area delimited by the alternative scenario (approximately 8,600 ha) is larger than the area delimited by the base scenario (approximately 3,930 ha), the area being a single plot in both scenarios;

### 10. Pakri Peninsula

(in Lääne-Harju Parish) base scenario and alternative scenario with the same area (approximately 2,480 ha) and as a single separate plot. It was decided to exclude the potential site during the spatial analysis, due to the position of the Ministry of Defence, communicated by letter No 12-4/22/163 of 17.01.2023, which does not consider it reasonable to plan nuclear facilities in the area (for internal use), the potential site will not be analysed in the next phases.

### 11. Alliklepa

(partly on the territory of Lääne-Harju Parish and Lääne-Nigula Parish), the area delimited by the alternative scenario (approximately 12,820 ha) is larger than the area delimited by the base scenario (approximately 6,170 ha), the area being a single plot in both scenarios;

#### 12. Suureranna-Ülendi

(in Hiiumaa Parish), the base scenario and the alternative scenario have the same area (approximately 1,080 ha) and are a single separate plot;

#### 13. Vanamõisa-Mänspe

(in Hiiumaa Parish), the base scenario (approximately 2,051 ha) and the alternative scenario (approximately 2,530 ha), as a single separate plot;

### 14. Murika-Panga

(in Saaremaa Parish), the base scenario (approximately 4,180 ha) and the alternative scenario (approximately 5,110 ha), as a single separate plot;





### 15. Turja

(in Saaremaa Parish), the base scenario (approximately 870 ha) and the alternative scenario (approximately 990 ha), as a single separate plot;

#### 16. Varbla

(in Lääneranna Parish), the area delimited by the alternative scenario (approximately 12,520 ha) is larger than the area delimited by the base scenario (approximately 2,690 ha), the area being a single plot in both scenarios.

Potentially suitable sites may change because of further research, knowledge (eg as technological circumstances become clearer) or in the planning process.

### 12.2 FINAL DISPOSAL SITES FOR RADIOACTIVE WASTE

The need for a disposal site for radioactive waste will arise at the end of the plant's lifecycle, ie about 50–60 years after the plant starts operating. Until then, radioactive waste will be temporarily stored on site at an interim storage facility and, if possible, spent nuclear fuel will be reprocessed and reused. Taking into account the time perspective, the spatial analysis of both final disposal sites (the geological disposal site for high-level radioactive waste and the disposal site for low and intermediate-level radioactive waste) is more general than the spatial analysis of the SMR.

To a large extent, the areas potentially suitable for SMRs also overlap with the non-excluded areas for radioactive waste disposal sites, as the exclusion criteria (eg geological and environmental criteria) are the same. Therefore, final disposal sites can mostly be located in the same areas where SMRs can be located. Radioactive waste disposal sites, on the other hand, do not require the availability of cooling water, so they can be located inland, and the potential areas are significantly larger compared to those suitable for SMRs (Figure 19).







Figure 19. Potential sites for the final disposal of radioactive waste. Areas excluded for the construction of the final disposal site are marked in red (Source: Skepast&Puhkim, Steiger)

### 12.3 NUCLEAR FUEL TRANSPORT

For each potential site, the space analysis also analysed the infrastructure options for supplying the plant with nuclear fuel and for transporting radioactive waste between the SMR and the disposal site. According to the expert group, the supply of fuel to the plant is likely to take place by maritime transport. When Rail Baltica is completed, it will be possible to bring nuclear fuel to Estonia using rail transport from the south. The final transport of fuel and waste, either to the plant site or from the plant to the final storage site, would be by road. In the current foreign policy context, it is not appropriate to analyse the possibilities for transporting nuclear fuel from Russia from the east. However, this would be possible for potential sites on the northern coast, using predominantly rail transport (Tallinn-Narva direction), combined with road transport where necessary. Air transport is not the preferred method for transporting nuclear fuel and radioactive waste.

The construction of the plant and the disposal site will require, depending on the location of the structures, the construction or upgrading of the existing infrastructure network (mainly the road network) to transport SMR components and other construction materials, and to later operate the plant and the disposal site. The new road network will be built or upgraded as part of the construction of these facilities. The new road network is also suitable for the subsequent transport of nuclear fuel and radioactive waste, and the construction of separate new roads for the transport of radioactive material is unlikely to be necessary. Transport options for nuclear fuel and radioactive waste were analysed for each potential area separately.





### 12.4 SOCIO-ECONOMIC IMPACT OF A NUCLEAR POWER PLANT ON THE LOCAL COMMUNITY

The potential socio-economic impact of a nuclear power plant was considered through two aspects. Firstly, the places where the workers of the plant and their families could live, along with the impact on the housing fund in the area, were looked at. Secondly, the impact of the station on the local community was estimated.

The analysis compares the incomes of the residents of local municipalities in the potential area, the number and proportion of taxpayers, the proportion of employees and turnover in economic units by sector and business activity, and the proportion of the business sector in employment. The financial indicators of the municipalities were also compared. The analysis identified the impact on regional inequalities for different indicators in the case of a nuclear power plant being built in the region.

In socio-economic terms, the most positive impact of building a nuclear power plant would be in declining areas with a lower than median income further away from the capital – Varbla, Loksa, Kunda and Toila. Regional disparities between different areas of Estonia would be further increased if a nuclear power plant were to be built in one of the potential sites in the region of the capital.

At the same time, the spatial analysis analysed the availability of the main public services (nursery schools, schools, leisure facilities) in each municipality in the potential area, and the trends in the possible changes in the provision of each service in relation to the demographic developments in the area and in the event of a nuclear power plant being built there with associated job opportunities.

It was concluded that relatively less investment in social infrastructure is needed if the nuclear power plant is located close to a major centre (Harku, Jõelähtme, Paljassaare-Kakumäe, Prangli and Viimsi), and more quality services (entertainment, sports) are provided in these areas. In the case of areas further away from the larger centres (Alliklepa, Kunda, Kuusalu, Loksa, Murika-Panga, Sureranna-Ülendi, Toila, Turja, Vanamõisa-Mänspe and Varbla), the construction of a nuclear power plant will require investment in the provision of local public services, as the increase in jobs in the area may also significantly increase the number of residents who need these services. However, it is unlikely to increase the supply of quality services in these areas.

### 12.5 RECOMMENDATIONS FOR FURTHER ACTION FOR SITE SELECTION

The links between the IAEA's siting recommendations<sup>85</sup> and the Estonian planning system were analysed to provide recommendations for further action. The analysis outlines the planning phases at which the activities recommended by the IAEA should be carried out to reach the siting of a nuclear power plant and radioactive waste disposal site.

The spatial analysis commissioned by the sub-working group on spatial planning of the NEWG corresponds to the IAEA's site survey stage (Figure 20), which is the first part of the overall plant siting stage. Once the country has made a decision of principle to launch the activities necessary for the construction of a nuclear power plant, the potential sites identified in the spatial analysis based on available data should be screened against the IAEA guidelines to identify candidate sites.

<sup>85</sup> https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1690Web-41934783.pdf





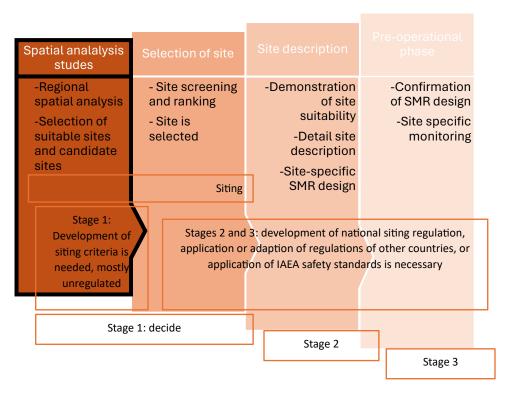


Figure 20. Stages in the selection of IAEA sites. The dark outline shows the current state of spatial planning (pre-selection of sites, ie selection of suitable areas) for the location of the Estonian nuclear power plant (Source: NEWG based on IAEA data)

Theoretically, it is possible to use several planning instruments (national designated spatial plan and, as a sequential process, county, comprehensive and detailed plan) for the construction of a nuclear power plant (including associated infrastructure) and a radioactive waste final disposal site. However, in view of the strong national and international interest, a national designated spatial plan should be preferred. The national designated spatial plan process combines the processes of finding the most suitable site and determining land use and construction conditions.

The IAEA recommends that a screening analysis of candidate sites for a nuclear power plant and a radioactive waste final disposal site may be carried out before the planning process is initiated. However, the selection of the most suitable site for a nuclear power plant (the site selection and description stage) will in any case be carried out during the planning process.

From 2022 to 2023, a spatial analysis was carried out on behalf of the sub-working group on spatial planning of the NEWG to identify potential areas on the territory of the Republic of Estonia where a nuclear power plant and a radioactive waste final disposal site could be built. The spatial analysis identified 16 potential areas for SMRs based on available data and exclusion criteria. In addition, potential areas for the geological disposal of high-level radioactive waste and for the near-surface disposal of low- and intermediate-level radioactive waste were identified. The number of potential areas may change in the future due to parallel processes.

In socio-economic terms, the most positive impact of building a nuclear power plant would be in declining areas with a lower than median income further away from the capital – Varbla, Loksa, Kunda





and Toila. Regional disparities between different areas of Estonia would be further increased if a nuclear power plant were to be built in one of the potential sites in the region of the capital.

Although in theory it is possible to use a number of planning instruments for the construction of a nuclear power plant and a radioactive waste final disposal site, in view of the strong national and international interest, a national designated spatial plan should be preferred.

For the design of a nuclear power plant and related facilities, an analysis may be carried out outside the planning process to screen candidate sites. The stage of selecting and describing the most suitable site for the nuclear power plant and for the radioactive waste disposal site must be carried out as part of the planning process.



### 13. ENVIRONMENTAL PROTECTION

The Nuclear Energy Working Group has mapped the suitability of the country's existing environmental protection framework and the need for changes, as well as the current and additional international commitments in the event of a possible launch of a nuclear energy programme. Environmental considerations have been taken into account in the initial spatial analysis.

### 13.1 LEGISLATION RELATED TO ENVIRONMENTAL PROTECTION

In the framework of the analysis *Mapping the legal framework to start the nuclear programme* (Annex 5), among other things, environmental legislation was mapped and a gap analysis was carried out. The relevant legislation includes:

- Environmental Impact Assessment and Environmental Management System Act (KeHJS)
   establishes the legal bases and procedures for assessing significant environmental impacts,
   as well as the environmental management and audit plan. The KeHJS defines nuclear
   activities as activities with a significant environmental impact that require a mandatory
   environmental impact assessment, for example the construction of nuclear power plants, the
   production and handling of nuclear fuel and the management and storage of radioactive
   waste.
- 2. The General Part of the Environmental Code Act (KeÜS) lays down rules for preventing and remedying environmental damage. This includes the general obligations of operators, the procedures for granting environmental permits and the 'polluter pays' principle, which requires the person responsible for environmental damage to bear the costs.
- 3. The Industrial Emissions Act (IEA) defines the energy industry as an activity of high environmental hazard, requiring detailed proceedings for the issuing of integrated environmental permits and setting general requirements for the operation of these industries.
- 4. The Water Act (VeeS) regulates the protection of water by setting requirements for limit values for pollutants discharged into water bodies and gives the right to impose individual conditions on applicants for a water permit or integrated permit.
- 5. The Waste Act (Waste Act) manages waste management, waste prevention and addresses health and environmental hazards from non-radioactive waste.

The current environmental acts and framework are broadly suitable for launching a nuclear energy programme and no major changes are needed. Attention needs to be paid to ensuring that the relevant laws contain references to the new nuclear regulator (considering the scope of its mandate), that licensing procedures (under the General Part of the Environmental Code Act) are linked to TEOS, and that the requirements under the Water Act for the discharge of cooling water from nuclear installations are reviewed.

The regulations setting out the substantive requirements for impact assessments also need to be revised and supplemented to include the environmental specificities of nuclear power plants.

### 13.2 INTERNATIONAL OBLIGATIONS

Estonia is subject to a number of international obligations in the field of environmental protection arising from agreements with other countries and international organisations.

The key points of reference for international environmental law include:





### The environmental policy of the European Union

As a Member State of the EU, Estonia is bound by the environmental legislation of the EU, including directives and regulations on issues such as air quality, water and waste management, and nature protection.

### UN conventions

Estonia is party to a number of UN conventions related to the protection of the environment, including the UN Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD). These conventions oblige Estonia to address climate change, biodiversity loss and other global environmental challenges.

#### Aarhus Convention

Estonia has signed the Aarhus Convention, which focuses on access to information, public participation and justice in environmental matters. The Convention ensures that citizens have access to information and can participate in decision-making processes.

### Espoo Convention

Estonia has an obligation to inform and consult with other countries if a planned project may have a significant impact on the environment of another country. The Convention encourages cooperation between countries on environmental impact assessment and planning of environmental projects, especially where they may cross national borders and affect the environment of other countries.

#### Helsinki Convention

Estonia is a party to the Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention), which aims to prevent pollution and promote sustainable development in the Baltic Sea area.

### Oslo-Paris Convention

Estonia is a party to the Convention on Long-Range Transboundary Air Pollution, which deals with air pollution and its transboundary effects in Europe.

#### **RAMSAR Convention**

The Convention emphasises the protection and sustainable use of wetlands, including wetlands of international importance.

### **WATER OF THE PROOF OF THE PROO**

Estonia has designated certain areas as World Heritage sites under the UNESCO World Heritage Convention, confirming its commitment to protect these culturally and naturally important areas.

#### International Maritime Organization (IMO) Conventions

As a country bordering the sea, Estonia adheres to a number of IMO Conventions aimed at reducing marine pollution and promoting safe shipping practices.

These international commitments shape Estonia's approach to protecting the environment and guide policies, legislation and activities in this field to protect it.

From the point of view of the start of a nuclear energy programme, the conventions mainly impact the choice of location (environmental and nature protection exclusion criteria) and, due to the cross-border implications, the requirements of the Espoo Convention must be taken into account at a very early stage (the KeHJS is in line with the Espoo Convention).





### 13.3 STUDIES AND ANALYSES CARRIED OUT

The spatial analysis of the potential sites of a nuclear power plant and a spent nuclear fuel disposal site (Annex 5) was based on different criteria and scenarios resulting from the different possible parameters of the nuclear power plants. The spatial analysis criteria were divided into 11 groups, one of which was environmental protection. In developing the list of specific criteria and classifying the criteria as exclusionary or discretionary, the work was based on the legislation in force in Estonia, the IAEA guidelines, the input from the authorities involved in the process, as well as the input from the NEWG and its sub-working group on spatial planning to the expert group and the knowledge of the expert group.

The environmental criteria derive directly from legislation (mainly the Nature Conservation Act). Exclusion criteria are used to exclude unsuitable areas for which there are no feasible solutions to prevent undesirable or adverse effects. Discretionary criteria are criteria for which possible solutions exist to prevent issues, events, undesirable impacts or hazards, ie mitigation measures can be implemented (eg relocation of plants, preparation of a new green network plan to ensure the functioning and coherence of the green network).

Exclusion criteria include nature reserves and special management zones, types of habitats and protected species in Natura 2000 areas, key habitats, finding places of protected plants, fungi and mosses with buffer zones (protected categories I-II), finding places of animal species of protected category I and salmon rivers and water bodies affecting them.

Discretionary criteria in the selection of the location of nuclear facilities include the building exclusion zone of the shore or bank, limited management zones and limited-conservation areas, areas forming part of a green network, finding places of animal species of protected categories II and III and finding sites of plant species of protected category III with buffer zones. While these criteria do not exclude the possibility of the construction of a plant and disposal site in the first stage of spatial planning, the discretionary criteria will need to be addressed in further studies and in the selection of more specific candidate sites, and the manager of the protected area will need to be involved.

According to the results of the spatial analysis, taking into account, among other things, environmental and nature conservation restrictions, there are potentially suitable areas for a nuclear power plant and a spent nuclear fuel disposal site in Estonia. The planning system currently in place in Estonia, which includes both a strategic environmental assessment and a detailed environmental impact assessment for such facilities, is suitable for identifying more precise locations.

The substantive requirements and the specific requirements related to nuclear facilities of the environmental impact assessment need to be developed at the level of a regulation, in line with international guidelines and the practice of experienced countries. In the case of the strategic environmental assessment, the nuclear regulator will remain an important coordinator of the planning process and will provide input.

A review of the environmental impact assessment topics, including impacts specific to SMRs, was carried out by an environmental management and spatial planning consultancy firm Hendrikson & KO on behalf of Fermi Energia AS. This study is based on IAEA's publications such as Considerations for Environmental Impact Assessment for Small Modular Reactors<sup>86</sup> (IAEA TECDOC-1915, June 2020), Managing Environmental Impact Assessment for Construction and Operation in New Nuclear Power Programmes (IAEA Nuclear Energy Series No. NG-T-3.11)87 and Prospective Radiological

<sup>87</sup> https://www.iaea.org/publications/10391/managing-environmental-impact-assessment-for-construction-and-operation-in-newnuclear-power-programmes



<sup>86</sup> https://www.iaea.org/publications/14676/considerations-for-environmental-impact-assessment-for-small-modular-reactors



Environmental Impact Assessment for Facilities and Activities (IAEA Safety Standards Series No. GSG-10)88. Although not commissioned by the NEWG and not part of any public procedure, the work provides an overview of international requirements and practices in other countries.

Under the environmental impact assessment both siting and technological (ie cooling system) alternatives are compared. The impact assessment will also set out general mitigation and compensation measures where appropriate, as well as the conditions for in-use monitoring. Particular attention needs to be paid to the chemical and physical characteristics of the cooling water and the aquatic life in the receiving water body.

As a party to the Espoo Convention, Estonia has also been kept informed of nuclear power plant developments in our neighbouring countries. For example, information has been submitted to the Ministry of the Environment / Ministry of Climate on the planning of the 1,200 MW Hanhikivi nuclear power plant in Finland, on the activities involving the construction and operation of the first nuclear power plant in Poland with a capacity of up to 3,750 MWe, and on the environmental impact assessment of the Loviisa nuclear power plant in Finland. From an environmental point of view, the most significant impacts of a nuclear power plant are on the aquatic environment (in particular the heat release from cooling the reactor), ambient air quality (radioactive and non-radioactive air emissions), vibration and acoustic environment. There are also impacts related to waste management (radioactive waste and non-hazardous waste).

### 13.4 ENVIRONMENTAL IMPACT OF THE LIFE CYCLE OF A NUCLEAR POWER PLANT

The environmental impact of the life cycle of nuclear power plants varies depending on the type of reactor, the quality of the uranium ore, the degree of fuel enrichment and fuel reuse. Heavy Water Reactors (HWRs) have the highest environmental impact, mainly due to heavy water production. Fast neutron reactors (FBRs), on the other hand, have a smaller footprint, as they allow for full recycling of plutonium. The most heavily studied boiling water reactors (BWRs) and pressurised water reactors (PWRs) have the lowest environmental impacts, most of which are caused by uranium ore mining and nuclear fuel production.

Nuclear fuel enrichment plays an important role in terms of environmental impact, with centrifugation being preferable to gaseous diffusion, which requires more energy. Reduction of the quality of uranium ore increases the need for mining and enrichment, thereby increasing the environmental impact, especially at lower uranium grades.

Improving the efficiency of the nuclear fuel cycle and fuel reuse can significantly reduce the environmental impact. For example, France's nuclear fuel cycle, where spent fuel is reprocessed, is more environmentally friendly, saving natural uranium and reducing the need for geological disposal sites.

The analysis of the life cycle of nuclear energy shows that, although direct emissions from nuclear plants are marginal, attention needs to be paid to the environmental impacts of the whole process.

The carbon footprint of nuclear energy ranges from 1.43 to 122 gCO<sub>2</sub>-eq/kWh, with the average across all studies being around 20 gCO<sub>2</sub>-eq/kWh. This is comparable to the life-cycle emissions of other 'zero emission' alternative energy sources such as wind, solar, geothermal and hydro energy (11-53 g CO<sub>2</sub>-

<sup>88</sup> https://www.iaea.org/publications/12198/prospective-radiological-environmental-impact-assessment-for-facilities-andactivities





eq/kWh) and is significantly lower than the life-cycle footprint of fossil fuel energy (> 856 g CO<sub>2</sub>-eg/kWh)<sup>89</sup>.

### 13.5 NEXT STEPS IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

According to the conclusions of the IAEA INIR mission, all aspects related to environmental requirements that should be taken into account in the nuclear energy programme consideration phase are covered. In phase 2 of a nuclear energy programme, the need to complete the existing environmental legislation, as well as the division of responsibilities between the authorities for environmental issues related to the construction of a nuclear power plant, needs to be analysed. Both the new regulator and the KeA will need to develop the necessary skills, plan resources and ensure coordination between themselves. In the site selection process, a strategic environmental assessment (SEA) and an environmental impact assessment (EIA) need to be carried out, which will assess the impacts of the nuclear power plant on people and the environment. Issues to consider include:

- 1. movement and concentration of emissions in the environment;
- 2. characteristics and sensitivities of local flora and fauna;
- 3. local demographics and trends;
- 4. predominant land use;
- 5. use of water and possible need for cooling towers;
- 6. impact of construction activities on the local environment.

The results of environmental studies are taken into account when issuing permits and setting environmental requirements.

The NEWG has assessed the suitability of the country's existing environmental protection framework and its compliance with international obligations. The current environmental acts and framework are broadly suitable for launching a nuclear energy programme and no major changes are needed. In launching a nuclear energy programme, appropriate legislation (TEOS, subsidiary legislation) must be ensured, the substantive requirements – the specific requirements to a nuclear facility – of the environmental impact assessment must be established, and the rights and obligations of the nuclear regulator in approving plans and issuing licences must be laid down.

<sup>&</sup>lt;sup>89</sup> Life cycle analysis of nuclear energy, 2023, by the Department of Energy Technology of TalTech commissioned by Fermi Energia AS.



# 14. EMERGENCY PLANNING

A radiological emergency is a radiological situation resulting from a nuclear or radiological accident, a crime or other unexpected event, the control of which requires the application of urgent protective measures to protect human life and health, property or the environment.

## 14.1 ENSURING PREPAREDNESS FOR RADIOLOGICAL EMERGENCIES

Estonia is party to the conventions on nuclear safety, physical protection of nuclear material, early notification of a nuclear accident and assistance in the case of a nuclear accident or radiological emergency. Ensuring compliance with the relevant national and international obligations is the responsibility of the competent authority in the field of radiation safety – the Environmental Board (KeA).

According to the Emergency Act, the KeA is responsible for preparing an emergency response plan to plan and effectively implement risk assessments to assess the probability and possible consequences of a radiological emergency and preparedness, and for regularly reviewing these plans to ensure that they are relevant and up to date. In the event of a national or cross-border radiological emergency, the KeA manages the emergency response and organises risk communication.

The INES scale of nuclear and radiological events (Figure 22) was introduced in 1990 to describe events to the public in a rapid, understandable and uniform way across countries. According to the scale, they are divided into seven levels, with 4–7 being accidents and 1–3 being incidents. Events that have no significant association with radiation safety fall below the scale, ie level 0.

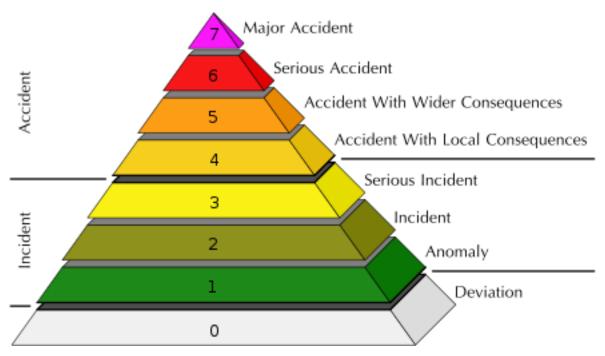


Figure 22. Scale of nuclear and radiological events (Source: NEWG based on IAEA)

Almost all accidents and incidents are caused by a simultaneous combination of several different actions or inactions. For example, accidents can be caused by disregard for safety measures, negligence, lack of attitude, nuclear safety culture, regulations, availability of necessary knowledge, technology and its use. An accident can also be caused by external factors for which there was insufficient preparation. Accidents with widespread consequences due to non-compliance with major and significant radiation safety requirements have also been addressed in IAEA publications.





For example, the *Chernobyl* accident in 1986 and the *Fukushima Daiichi* accident in 2011 are considered INES 7 accidents. Although both accidents resulted in large releases of radioactive material and had significant impacts on both the population and the environment, the *Fukushima* accident is estimated to have released about ten times less pollution than the *Chernobyl* accident. Nor did anyone in *Fukushima* receive a dose of radiation that would have caused radiation sickness.

Unfortunately, history confirms that smaller accidents have not led to significant changes in the radiation safety system. For example, the final report of the *Three Mile Island* (INES 5) accident in 1979 listed all the important aspects of a modern safety culture, but it was only after the *Chernobyl* accident that the concept of a safety culture was widely adopted. Safety culture refers to a set of characteristics and attitudes of organisations and individuals that confirm that safety and security issues are given priority because of their importance. Although the most prominent cause of the *Fukushima* nuclear accident is considered to be the devastating impact of the natural disaster on the safety systems of the nuclear facility, there were other causes. An analysis of the consequences of the accident has shown that an even more systematic approach to safety and security is needed to ensure the safety of nuclear power plants, taking into account human, technical and organisational factors, as well as the complexity of the relationships between them.

An INES 6 accident happened in 1957 in the Soviet Union, at a plant in Kyshtym, where nuclear fuel was being reprocessed. The failure of the cooling system of the containers for storing radioactive waste, ignored for a long time, resulted in a temperature rise to a level where a severe explosion occurred as a result of chemical reactions inside the containers. As a consequence of the accident, the inhabitants of the villages around the plant, contaminated with radioactive substances, had to be evacuated. There are also a number of important reasons in this accident that created the conditions for the situation. For example, in this case, there was almost malicious negligence and disregard for safety measures and the necessary rules.

Accidents of INES 5 severity also do not happen often. The most famous of these, for example, are the 1979 *Three Mile Island* accident in the USA and the 1957 *Windscale* fire in the UK. The *Three Mile Island* accident began in the early morning hours of 28 March 1979, when one of the reactors at the nuclear power plant suffered a failure of its feedwater pump. Automatic safety systems were immediately triggered, stopping both the turbine generator and the reactor itself. However, due to a combination of improper closing of the valve to release the excess pressure from the piping and faulty gauges on the instrument panel, the operator did not realise that the reactor was no longer receiving sufficient cooling water. Even though the core of the overheated reactor partially melted, no significant amount of contamination was released into the environment. The importance of the human factor was stressed as the main cause of the accident, but significant shortcomings were also found in the design of the control room, training and procedures.

In addition to the reactor accidents, there is the case of the 1987 accident in Goiânia, Brazil, involving a radiation source from a radiotherapy device, where, as a result of negligence, criminality and ignorance, 4 civilians died and a significant amount of radioactive material was released into the environment.

The list of INES 4 to INES 1 cases is somewhat longer, but in these cases the consequences of the accidents were more localised and resulted from one or more factors. However, the current incidence rates of many of the incidents and major accidents that occurred in the middle of the last century have become very low due to developments in the sector as a whole.

Despite the fact that nuclear energy has been clouded by some significant accidents, the ability of the industry to learn from its mistakes and the efforts and investments made to continuously improve nuclear and radiation safety are remarkable. Numerous breakthroughs in nuclear technology and in the





use of radioactive materials in medicine, research and industry have meant that radioactive sources are still indispensable in some functions. While there are a variety of noteworthy radiological practices in Estonia, the readiness to respond to incidents with transboundary impacts is of much greater strategic importance in the emergency context. This kind of risk assessment and disaster preparedness also covers the response to smaller local situations.

To reflect Estonia's current preparedness and capacity needs, the specificities of nuclear power plants in neighbouring countries have been thoroughly analysed in the risk analyses of radiological accidents with cross-border implications. A list of nuclear power plants closer than 500 km to Estonia can be found in Figure 23. It contains information on the location, name, type, age, capacity and distance of each reactor from both the Estonian border and Tallinn.

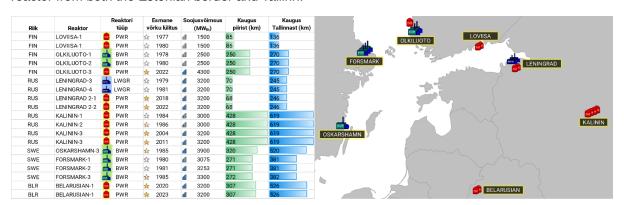


Figure 23. Nuclear power plants in neighbouring countries closer than 500 km from the Estonian border (Source: Environmental Board)

### 14.2 SAFETY OF NUCLEAR POWER PLANTS

Water-cooled reactors currently account for more than 95% of all civil power reactors in the world. In addition, most of the nuclear reactors under development and in construction (including SMRs) are water-cooled. In the risk assessment, one type of reactor cannot be considered to be more dangerous simply because it has been involved in accidents in the past, but the light water graphite reactor (LWGR, or *reaktor bolshoy moshchnosty kanalny* aka RBMK in Russian), for example, is the same type of reactor that had a significant accident in 1986 at *Chernobyl*.

The second accident, which was much smaller in scale but still significant, was a boiling water reactor (BWR) type accident in 2011 in *Fukushima*, Japan.

A significant accident also occurred with a pressurised water reactor (PWR) in 1979 at the *Three Mile Island* nuclear power plant in the USA. The consequences of the accident were very small compared to accidents with LWGR and BWR type reactors.

Figure 23 contains information on the time of the initial network connection of the reactors. It cannot be argued that the older the reactor, the more dangerous it is, because the causes and the circumstances of each accident have been very different. However, the newer technology has taken into account all the mistakes made in the past, and the safety measures in the new reactors are better and duplicated. To ensure the safety of reactors under any hazardous conditions, a significant number of passive solutions have been developed to ensure stable and safe operation without human intervention. The capacity of a nuclear reactor is directly expressed by the thermal output from the reactor by steam. In short, a more powerful reactor is also a bigger reactor with more fuel. With more powerful and larger reactors, there is a risk that higher levels of radioactive substances could be released into the





environment in the event of an accident. Again, it cannot always be said that this is a greater risk, but an accident involving the release of large quantities of radioactive substances into the environment can have more serious consequences. The distances from both the Estonian border and the capital serve a metaphorical purpose in the sense that distance from the accident site is generally a factor that rapidly reduces the magnitude of the hazard, but the actual distance and speed of dispersion depend on weather conditions. As an accident with a more powerful reactor can lead to more severe consequences, the risks associated with more powerful reactors can be considered more significant in some situations.

One of the main safety indicators for nuclear power plants is the calculated frequency of the likelihood of occurrence of core damage or meltdown. The US nuclear regulator NRC requires reactor designs to meet a theoretical core damage frequency of 1/10,000 years, but modern designs go well beyond this requirement, with a practical figure of 1/1 million years for plants currently in operation and 1/10 million years for plants to be built in the next decade. Although this calculated core damage frequency has been one of the main metrics for assessing reactor safety, European regulators mostly prefer a deterministic approach, focusing on the consequences of different scenarios. However, a probabilistic safety analysis is also carried out, requiring new reactor designs to have a core damage frequency of 1 per million years.<sup>90</sup>

Due to a number of characteristics, SMRs are considered to be safer than traditional large, over 1,000 MWth nuclear power plants. They are often designed to use passive safety systems that do not require active intervention or power supply to ensure cooling in the event of a failure. Because SMRs are smaller, they contain less radioactive material, which in turn reduces the spread of pollution and the scale of intervention required in the event of an accident. Building the modules in a factory allows for better quality control than in a traditional nuclear power plant. Some SMR designs foresee placing the reactors underground, providing additional protection against external and military attacks. Thanks to their smaller size and simpler design, evacuation plans can be simpler and the response faster. However, it should be noted that the safety of any nuclear reactor ultimately depends on its design, construction, operation and maintenance. SMRs, like large nuclear power plants, have to comply with strict safety standards. In addition, it should be noted that SMR technology is new and data on their long-term reliability is still limited.

### 14.3 RADIOLOGICAL EMERGENCY RESPONSE, EVENT MANAGEMENT AND MONITORING

The KeA is also the point of contact in the communication with the IAEA and the European Commission. This role entails a regular obligation to participate in international exercises simulating the transmission and reception of warning information, organised by both the IAEA and the European Commission. Exercises of varying levels and with different needs are held regularly and actively participated in.

All the Member States of the EU are obliged to comply with the requirements of the Treaty establishing the European Atomic Energy Community (Euratom). To this end, each country must have the necessary means to continuously monitor the levels of radioactivity in air, water and soil and to comply with basic radiation safety standards. This is in addition to the periodic obligation to transmit monitoring data to the European Commission. According to the Environmental Monitoring Act, which regulates the performance of radiation monitoring, the KeA is responsible for the implementation of the radiation monitoring subsidiary programme of national monitoring.

https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx



<sup>90</sup> https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx



To fulfil its national and international obligations, the KeA's Climate and Radiation Department has a gamma-ray spectrometry laboratory (Photo 3), a mobile laboratory (Photos 4 and 5) and an early warning system (Photo 6). The main objective of the laboratory is to carry out analyses of samples collected in the framework of the national radiation monitoring programme and to provide laboratory analysis services. The latter is important both to maintain unique competences and to cover costs. The laboratory is accredited as a testing laboratory, meeting the requirements of ISO 17025:2017 in the field of gamma spectrometric analysis. The laboratory regularly participates in international comparative analyses to ensure and monitor quality.



Photo 3. The Environmental Board's stationary laboratory. Photos 4 and 5. Mobile laboratory (Source: Environmental Board)

Estonia's monitoring network warning early of radiation risk consists of 15 automatic radiation monitoring stations that measure the gamma radiation level in the air in real time. In addition to measuring the total gamma-ray dose rate, the stations also identify radionuclides and assess the dose radiation caused by various radionuclides. Automatic stations are important for detecting potential cross-border radiological effects, but the KeA also monitors airborne particle concentrations in Harku, Narva-Jõesuu and Tõravere to detect very small changes in ambient air (Figure 24 and Photo 6).

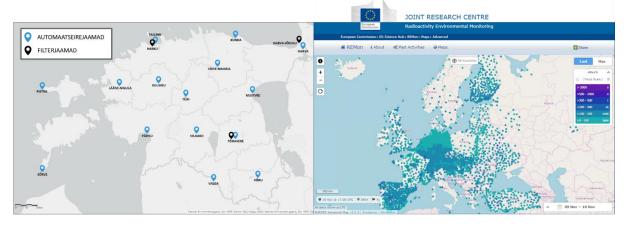


Figure 24. Estonian monitoring stations are part of a network covering the whole of Europe. The European Commission's public platform also makes monitoring data available to the public (Source: Environmental Board and EURDEP)

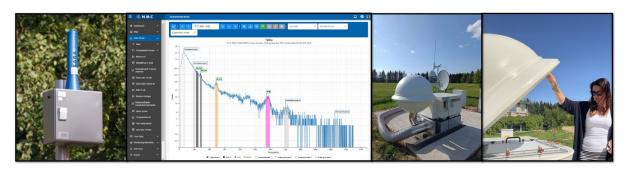


Photo 6. Early warning systems include automatic monitoring stations and filter stations (Source: Environmental Board)





The presence of fixed monitoring stations is very important, but does not give an indication of the gamma radiation levels in the areas between the stations. To address this shortcoming, KeA also has mobile systems with the capability to measure and map gamma radiation levels. Although the mobile laboratory is not a substitute for a national radiation laboratory, it also provides an opportunity to carry out an initial analysis of the monitoring samples at the site of interest and to provide a first assessment of the situation. In a real-life situation, this solution can be further enhanced by the decision support computer software program ARGOS. Although its uses include the estimation of potential risk areas and their extent, its use in emergency situations, where actual measurement data is not yet available, is essential for better planning of intervention activities. For example, the software allows modelling of the movement of radioactive contamination in a similar way to the conventional movement of air masses, taking into account the specifics of the migration of different radionuclides and the most recent weather forecast data provided by the Environment Agency.

Although the systems managed by the KeA and the resources needed for radiation monitoring are currently sufficient to assess and identify radiation hazards and to warn the public of potential emergencies, including radiological accidents originating from outside Estonia, the response to domestic radiological events and international nuclear accidents requires continued development and broader national cooperation.

Success in dealing with radiological incidents also has a role to play in raising public awareness. In 2018, the Government of the Republic designated the KeA as the authority responsible for risk communication in national and cross-border radiological emergencies. Although a number of actions have followed, the results are not easy to measure. Risk communication is not lacking in today's context, but a more comprehensive approach will certainly require additional resources to existing experts. Increased awareness and preparedness for emergencies does not come overnight and requires consistent information and education about potential hazards, the consequences of accidents and appropriate codes of conduct.

The successful response to and management of a radiological emergency requires a combination of activities from the different agencies involved. This means that everyone needs to be aware of and understand that continuity in both maintaining and updating knowledge is necessary to ensure emergency planning. The same applies to the provision and maintenance of protective equipment and radiation measurement equipment for any emergency. Particular attention must also be paid to mitigating security threats.

The capacity of the Rescue Board to decontaminate the scene of an incident from chemical, including radioactive, contamination of people, equipment and, to some extent, the site, has improved in recent years. However, the decontamination capacity of AS A.L.A.R.A., which supports the Rescue Board in these activities, has not developed to the same extent. To improve the state's preparedness for deactivation of contaminated sites, it would be necessary to partially renew the measuring and decontamination equipment of the state-owned company<sup>92</sup>. Decontamination capacity has also improved in several Estonian hospitals in recent years, for example, by ensuring that contamination on patients can be identified as well as cleaned up. However, here too, it is important to ensure that, in addition to the core responsibilities of the agencies, there is a continuous improvement in emergengy planning through the maintenance, repair and regular updating of equipment and facilities, with competent and trained experts who know how to use the systems and equipment and are well-versed in the additional knowledge and responsibilities associated with emergencies.

One of today's minimum requirements for the continuity of operations of emergency services is to ensure uninterrupted performance of their tasks for at least 168 consecutive hours. However, meeting

<sup>92</sup> https://kliimaministeerium.ee/elurikkus-keskkonnakaitse/kiirgus/kiirgusohutuse-riiklik-arengukava-2018-2027 (in Estonian)





this requirement is currently beyond the capabilities of several key agencies involved in responding to radiological emergencies. Also, many of the agencies involved do not have a 24/7 response capability. For example, due to a lack of resources, the response capacity of AS A.L.A.R.A. has today been resolved at 13/7. In the worst case, this level of responsiveness is not sufficient to deal with a radiological emergency, but is still somewhat acceptable in today's circumstances.

Effective management of the aftermath of an accident requires a more effective ability to assess the damage caused by emergencies. This is a prerequisite for better crisis preparedness as well as for the rapid mobilisation of the additional resources needed for international assistance in response to an accident. The compensation mechanism is also somewhat insufficient.

Estonia has mutual assistance and cooperation agreements with the governments of Latvia, Lithuania, Finland, and Sweden regarding emergency prevention, preparedness and response. Intergovernmental agreements apply to cooperation in the field of rescue, including prevention, preparedness and response, and to offering mutual assistance in the event of an emergency or imminent threat thereof which may exceed the parties' domestic resources and capabilities to deal with the protection of people, the environment and property. Governments have appointed competent points of contact, which in Estonia is the Rescue Board, to perform the cooperation agreements. In addition to assisting neighbouring countries, the KeA is also ready to request additional sectoral assistance using the global platform RANET provided by the IAEA. The KeA has signed cooperation agreements with Finland and Latvia for a comprehensive exchange of information and cooperation.

## 14.4 EMERGENCY PLANNING IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

Under the leadership of the Ministry of the Interior, the sub-working group on nuclear security and emergency preparedness of the NEWG was convened in early 2023. The members of the working group, mainly experts with different areas of expertise, were tasked with analysing the initial report of the Centre for Defence and Security on nuclear security and emergency planning, which was completed in early 2023. As with many of the other studies commissioned, particular emphasis had to be placed on the requirements of the IAEA guidelines when reviewing this work. The revised and refined analysis was used as a basis for both the public summary (Annex 5) and for writing this chapter.

Responding to emergencies starts with broad-based preparedness. Even today, the state and the holders of the licences have emergency plans in place. Unfortunately, the approach is not the same in the implementation of a nuclear energy programme. Although there is much in common with the existing situation, the cooperation between the nuclear operator and the nuclear regulator in managing the consequences of a nuclear accident will be significantly more coherent, detailed, regularly updated and practised in cooperation between all parties as required. The causes, assessments and capabilities of the risks posed by emergencies and many other important safety and security details will continue to remain undisclosed under security considerations, but such a comprehensive analysis is essential for the implementation of a nuclear energy programme and will also provide important input for the development of emergency response plans.

As the nuclear energy programme continues, further investment will also be needed in the organisational capacity for evacuation or temporary relocation and in the development of cooperation procedures. However, the exact scope and extent of the evacuation capacity needs will only become clear in the future, at the latest during the licencing process, when the extent of the potential danger zones will be determined based on the technological solutions, reactor design and the corresponding assessments and practical needs. Planning zones include, for example, a preventive safeguard





implementation zone, within which the state must have the immediate capability to intervene in an emergency, even in the event of a hypothetical release of contaminants from a reactor. Unlike preventive interventions, the country must be prepared to carry out similar activities further away from the zone. In some cases, they may be carried out only after a contamination has occurred, but not always in the whole zone, but as a priority, for example downwind or in areas with foreseeable significant impacts.

To carry out the necessary procedures and coordinated inter-agency activities, it is necessary to prepare for periodic joint exercises. Unlike today, local authorities that would potentially be affected would also be involved in the crisis planning.

At this stage, it is not yet clear what the necessary conditions described in the legislation will be for the implementation of the measures for sheltering or evacuation. The Building Code, or other relevant legislation, should also establish specific requirements to ensure appropriate shelter for buildings in designated areas. Their establishment will be determined in the future based on further analyses, but also, if possible, on experience gained in the world.

As a whole, there is a need to raise the radiation safety awareness of all agencies involved in interventions and to ensure the preparedness of first responders to carry out emergency response activities in an environment with elevated radiation levels. Investing in knowledge is key as the nuclear energy programme continues.

Organising the response to a nuclear accident will be the responsibility of the new national nuclear regulator (currently the KeA), which will also be responsible for coordinating inter-agency cooperation, as is the case in terms of the existing preparedness. The implementation of the nuclear energy programme will require a sufficient number of trained experts, well-established internal and inter-agency procedures, plans and strategies for radiation monitoring, and even better technical oversight capabilities. A larger surveillance team is also needed for effective crisis communication and international communication.

Preparedness for possible domestic radiological events and international nuclear events needs to be further developed and more cooperation is needed. If the nuclear energy programme is launched, a significant investment in the development of evacuation management capacities and various cooperation procedures will also be needed. Existing radiation monitoring capacity also needs to be improved and significant changes need to be made to the radiation monitoring programme. This would be complemented by a monitoring strategy for both normal and emergency situations. Laboratory capacity and a relevant crisis management centre also need to be developed. It will be necessary to purchase personal protective equipment for the employees of the agencies involved in the intervention. In the area of food and drinking water safety, it will be necessary in the future to clarify the security of food and drinking water supply in different scenarios, and in the healthcare sector, to develop rules and guidelines for dealing with radiological emergencies and to equip hospitals with specific competences with the necessary medical equipment, medicines and primary means for the treatment of patients. To increase resilience, it is necessary to develop a holistic concept of decontamination capacity.

As a whole, there is a need to raise the radiation safety awareness of all agencies involved in interventions and to ensure the preparedness of first responders to carry out emergency response activities in an environment with elevated radiation levels. Investing in knowledge is key as the nuclear energy programme continues.



# 15. NUCLEAR SECURITY

The history of nuclear security dates back to the Cold War, during which time there was a nuclear arms race between the United States and the Soviet Union. At the time, the primary objective of nuclear security was to prevent the theft and sabotage of nuclear weapons. In the 1970s the focus of nuclear security shifted to the protection of nuclear power plants and other nuclear facilities. This issue has again resurfaced in the context of the war between the Russian Federation and Ukraine. Today, nuclear security is a global issue involving many countries and organisations. The IAEA is responsible for promoting nuclear energy worldwide, and it provides guidance and support to countries to help them develop and implement effective nuclear security measures.

The need for robust nuclear security measures has become more imminent as the global energy demand, and thus the risk of nuclear material being misused by terrorists, has increased. To protect nuclear material from theft or sabotage, several types of nuclear security measures can be taken: physical protection, material control and accounting, and personnel safety. Physical protection includes the use of barriers, and alarm and monitoring equipment to prevent unauthorised access to nuclear material. Control of and accounting for material includes the monitoring of nuclear material throughout its lifetime to prevent it from being lost or stolen. Personnel safety includes ensuring that persons with access to nuclear material are credible and have undergone background checks.

## 15.1 ENSURING NUCLEAR SECURITY IN THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

The potential construction of a nuclear power plant in the future must largely rely on mitigating security risks and on how we, as a country, are prepared to deal with the possible consequences of an emergency. The main objective of nuclear security is to prevent unauthorised persons from gaining access to nuclear materials or facilities. Both nuclear security and emergency planning cover the physical, cyber and personnel safety of nuclear materials and facilities, as well as the development and implementation of relevant legislation and other requirements. Nuclear security and emergency planning are closely interlinked and interdependent. If nuclear security measures are effective, the likelihood of an emergency is also reduced.

Much of the necessary nuclear security competence already exists in the country, but the main problem is the lack of top specialists in the field and their dispersion between different agencies. It is also necessary to take into account that the role of the state and the volume of work of agencies will increase significantly if a possible power plant is constructed. It is recommended to use the help of the IAEA International Physical Protection Advisory Service (IPPAS) to develop regulation, ensure supervision and training, and with a future-oriented view, proactively direct people to the appropriate training throughout the regulatory cycle, and later the monitoring cycle, for additional competence.

Most of the officials and public servants interviewed in the sub-working group's analysis emphasised the need to establish a nuclear security and emergency planning competency model and to increase expertise. Currently, Estonian curricula do not specifically address chemical, biological, radiological, and nuclear hazards (CBRN), and rescue curricula only include a small number of CBRN topics, mostly solely focusing on chemical accidents. In the future, the awareness of students in the field about CBRN will have to be significantly improved. It can also be seen as an opportunity to develop a single competence centre for all the agencies involved, including in international cooperation.

In addition to empowering the existing resources, it is also necessary to develop the capabilities, supplies and training opportunities required for the Defence Forces and the Police and Border Guard Board in the conditions of a hybrid or military threat.





It is important for Estonia to understand that the responsibility of the state is non-transferable and ensuring security is our priority. Although some nuclear security functions are performed by the operator of a nuclear facility, appropriate regulations are established and compliance is monitored by the state through the competent authority. The state must create or designate a competent authority responsible for the implementation of legislative and administrative regulation. This authority must have the necessary powers and competences, as well as sufficient financial and human resources to carry out the duties assigned to it. The state will establish a licencing system and a functionally and financially independent regulatory body with sufficient competence to assess licence applications and take decisions on safety, safeguards and security – this will require the establishment of a separate security and emergency section within the structure of the national regulator to be set up, and designated personnel.

The regulator must also have a plan for allocating additional human resources, if necessary, for the period of licensing, construction, commissioning and operation of the nuclear facility. The national crisis management plan must ensure that the designated competent authorities and authorised persons are prepared to respond to events related to nuclear security at a local, national and international level.

To increase overall crisis management preparedness, there is also an additional need to develop a crisis management centre specialised in radiological emergency management with secure and integrated ICT solutions, which could be established at the regulator to be created. The current arrangements are rather fragmented and a more central approach is needed to address potential events in the future. At the same time, Estonia has favourable prerequisites for creating a culture of nuclear security:

- security has been high on the agenda in society as a whole for some time, at least in the public debate;
- since 2010 comprehensive national defence has been systematically implemented, joint
  exercises are common and some of them have included CBRN, such as the larger EU
  CREMEX-2011 and CBRT-2019, and the last of the smaller ones, 'Sub-Regional Response',
  which took place in July 2022 at the Estonian Academy of Security Sciences.

NATO has developed its CBRN defence policy and updated it in 2022 while also taking into account the need to strengthen capabilities in the field due to the Russian Federation's military actions in Ukraine. The CBRN Defence Battalion is specially trained and equipped to respond to CBRN incidents and/or attacks against populations, territories or forces of NATO member states. The battalion not only trains for armed conflict, but also for responding to CBRN crises, where it supports civilian authorities. From an energy security perspective, the use of US nuclear technology would provide an opportunity to strengthen the collective security with the US, especially given that the US is our main security ally and a hub for energy innovation. Cooperation with the US will undoubtedly improve the security of the country as a whole.

Primary on-site physical protection and emergency response capabilities are the responsibility and duty of the nuclear power plant's operator. The requirements for background checks, physical fitness, training and more will be set by the national regulator that also checks compliance with them. The state must also establish the appropriate off-site response capabilities.

Daily use of the Defence Forces to ensure the physical security of the nuclear power plant is not feasible under Estonian conditions. Our reserve army system, the very unique training of the nuclear power plant's security team and conscripts, and the large-scale need for background checks do not support this. The Defence Forces may retain some warning functions, but employing them on a daily basis is not practical. In the future, it will be necessary to plan how the Defence Forces will be involved under





the conditions of an increased threat based on additional analysis. It is also not feasible to use the officials of the Police and Border Guard Board for the daily physical protection of the nuclear power plant. The training of the officials of the Police and Border Guard Board includes a great deal of competence, the acquisition of which is time-consuming, but not necessary for a member of the nuclear power plant's security team. As in the case of involving the Defence Forces, ways in which the Police and Border Guard Board will be involved in the conditions of an increased threat need to be planned based on additional analysis.

At the same time, the introduction of nuclear energy requires background checks and security checks of a large number of identified persons. The possible need for additional resources in agencies that perform security and background checks must be taken into account. The organisation of the background check, remuneration and other technical aspects need to be established and regulated in the follow-up analysis once the new national nuclear regulator is operational.

Much of the necessary nuclear security competence already exists in the country, but the main problem is the lack of top specialists in the field and their dispersion between different agencies. The implementation of the nuclear energy programme requires the establishment of a model of competence for nuclear security and emergency planning, and the enhancement of expertise. In addition to empowering the existing resources, it is also necessary to develop the capabilities required in the conditions of a hybrid or military threat. The state will create a nuclear regulator responsible for the implementation of legislative and administrative regulation related to nuclear security. There is a need to develop cooperation arrangements for national and cross-border transport of nuclear material. All of today's competent experts also need further training and cooperation opportunities to develop their expertise. Additional resources will be needed to carry out background and/or security checks during both the construction and operational phases.



The nuclear fuel cycle begins with the extraction of raw materials from the earth's crust, continues with refining, enrichment and processing into a suitable form, and use in the reactor, and ends with the storage, final disposal or reprocessing and reuse of spent fuel.

Nuclear power plants are usually fuelled by uranium (uranium dioxide) pellets, which are placed in special fuel rods. The fuel rods are grouped into specifically shaped fuel elements (fuel assemblies). When the reactor is activated, a controlled chain reaction is triggered in the fuel pellets inside the rods, resulting in a release of thermal energy.

As Estonia does not have a complete nuclear fuel cycle infrastructure, cooperation with international partners, including fuel suppliers, enrichment service providers and spent fuel management organisations, is essential. There is no uranium ore in Estonia that would be economically viable to mine, so imported ore must be used to produce fuel for a nuclear power plant.

### 16.1 NUCLEAR FUEL PRODUCTION (FRONT-END)

The world's largest uranium ore miners are Kazakhstan (about 40% of total world production), Canada (13%) and Australia (12%). Followed by Namibia, Niger and Russia. There are numerous fuel manufacturers for water-cooled reactors on the world market. Fuel production complexes in the Member States of the EU are located in Sweden (Westinghouse AB, Västeras), Germany (Framatome-ANF, Lingen), France (Framatome-FBFC, Romans; Orano, Malvési) and Spain (ENUSA Juzbado).

The ore necessary for the production of fuel (yellowcake,  $U_3O_8$  or triuranium octoxide) is purchased on the world market.  $U_3O_8$  is converted into gaseous uranium hexafluoride (UF<sub>6</sub>). UF<sub>6</sub> enrichment is mainly carried out by centrifugation or gaseous diffusion. The enriched UF<sub>6</sub> is converted into uranium dioxide (UO<sub>2</sub>), a black semiconducting solid with low thermal conductivity. The UO<sub>2</sub> powder is pressed under high pressure into pellets 7 mm in diameter and 10 mm high, which are then heat treated into uniform fuel pellets. The fuel pellets are enclosed in a metal rod and become a fuel rod. From there, the cluster of fuel rods in turn forms the fuel assembly<sup>93</sup>.

### 16.2 ENSURING SECURITY OF NUCLEAR FUEL SUPPLY

The Euratom Supply Agency's main task is to ensure security of supply of nuclear materials and nuclear fuel for all EU users. It caters for the needs of utilities producing nuclear energy, research reactors, producers of medical radioisotopes, and the nuclear supply chain industry. The ESA monitors the nuclear market and provides alerts on the trends that constitute a threat to the security of the EU's supply of nuclear materials for power and non-power uses. It may take actions on its own (eg memorandum of understanding with the United States for availability of specialised materials and fuel for research and medical uses) or it may propose measures to the European Commission.

The ESA is the only body that can sign contracts for supplying ores, source materials and special fissile materials in the EU, and it may refuse to conclude a contract. The agency's decisions with respect to the supply contract may be challenged before the Commission as checks and balances to the agency's powers.<sup>94</sup>.

<sup>&</sup>lt;sup>94</sup> https://european-union.europa.eu/institutions-law-budget/institutions-and-bodies/search-all-eu-institut



<sup>93</sup> https://world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/nuclear-fuel-cycle-overview.aspx



In 2014 the European Commission adopted a recommendation that new nuclear power plants not designed in the EU should have guaranteed fuel availability from more than one manufacturer. Several European nuclear power plants have different suppliers, but Russian-designed reactors in nuclear power stations in Bulgaria, the Czech Republic, Hungary, Slovakia and Finland have only one supplier – Rosatom-owned TVEL – making it one of the few Russian companies still allowed to operate in European territory<sup>95</sup>. The European Commission is helping the Czech Republic, Finland and Bulgaria to source suitable fuel from Westinghouse or French companies, following the example of Ukraine. Deliveries could be expected to start in 2024–2025. Slovakia has also signed a contract with Westinghouse to replace Russian supplies, but new supplies are expected to start in 2025. Currently, Hungary continues to use TVEL supplies and the construction of the Paks II nuclear power plant is underway and is expected to be completed in the early 2030s<sup>96</sup>.

The Euratom Supply Agency is also responsible for ensuring the security of supply of nuclear fuels, and mechanisms have been set up within the Union to supply fuel to nuclear power plants. For molten salt reactors and other reactors using alternative fuel, meeting the condition of more than one supplier may prove difficult. An option for mitigating risk is choosing a reactor type that uses the most common so-called conventional nuclear fuel in the world (U<sub>235</sub> or Pu<sub>239</sub> with up to 5% enrichment) that has many manufacturers on the market. In addition to nuclear fuel produced in the EU, fuel can also be supplied from third countries such as the US and Canada.

In November 2023, the price of one pound of U<sub>3</sub>O<sub>8</sub> was \$80, or about 161 €/kg<sup>97</sup>. In recent months, the price of uranium has been on an upward trend. Fuel accounts for 30–40% of the cost of operating a nuclear power plant<sup>98</sup>.

It would not be economically feasible to develop nuclear fuel production capacity (ie uranium enrichment, production of fuel assemblies) in Estonia under the current conditions. Nuclear fuel will therefore have to be supplied from foreign partners. The transport of enriched uranium and fuel assemblies to Estonia must comply with international regulations and safety requirements. Fresh nuclear fuel is mainly a source of  $\alpha$ -radiation, which is less penetrating than other forms of ionising radiation, such as  $\beta$ - or  $\gamma$ -radiation. This means that fresh fuel is less dangerous to handle and requires fewer safeguards for transport than spent nuclear fuel. However, strict safety measures must be taken when handling.

The lifetime of fuel assemblies for electricity generation varies depending on the fuel enrichment and the specific reactor type. On average, fuel assemblies have a lifetime of 18–24 months. The fuel in the reactor will not be replaced all at once. Spent nuclear fuel is stored for decades in purpose-built water-or air-cooled storage facilities, which are an integral part of the plant's design. This allows short-lived, high-heat-emitting, high-activity radionuclides to decay to a level where they can be further processed and packaged.

The final disposal of spent fuel requires a long-term solution. Possibilities include deep geological disposal or reuse in other countries where relevant technologies exist.

At the moment, the NEWG's considerations and proposals are based on the assumption that the state itself will not build the power plant, but that the private sector will do so, subject to international and national legislation, safety and security criteria and other requirements. Fermi Energia AS, which plans to build a nuclear power plant, aims to supply nuclear fuel through Vattenfall Nuclear Fuel AB, a subsidiary of Vattenfall AB (an investor in Fermi Energia AS). Vattenfall Nuclear Fuel AB currently

<sup>98</sup> https://world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx



<sup>95</sup> https://diplomaatia.ee/euroopa-tuumaenergeetika-on-haavatav/

<sup>96</sup> https://spectator.sme.sk/c/23217840/slovakia-dumps-russian-nuclear-fuel.html

<sup>97</sup> https://tradingeconomics.com/commodity/uranium



supplies fuel to five Vattenfall reactors in Sweden and has contracts with companies providing uranium mining, processing, enrichment and fuel fabrication services around the world<sup>99</sup>. Vattenfall Nuclear Fuel AB supplies standard boiling water reactor fuel (GNF2) for the Forsmark reactors (Photo 7).

For the supply of fuel for an Estonian nuclear power plant, a contract should be concluded between the developer of the plant and Vattenfall Nuclear Fuel AB. GNF2 is a conventional low enrichment fuel for a boiling water reactor, which does not require any additional measures for storage or transport compared to existing conventional nuclear power plants.

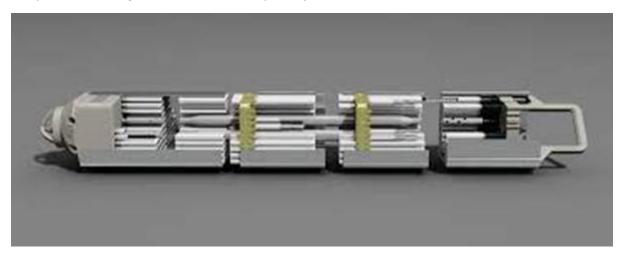


Photo 7. GNF2 fuel assembly (Source: Gevernova)

### 16.3 MANAGEMENT OF SPENT NUCLEAR FUEL (BACK-END)

After removal from the reactor, spent nuclear fuel is stored for decades near the plant in specially designed wet or dry storage facilities that are an integral part of the plant's design. Special safety and security measures must be in place at the storage facility, as well as radiation monitoring and continuous monitoring of the condition of spent fuel assemblies. Throughout the life of the storage facility, regulatory controls will also apply. The need for a disposal site for radioactive waste will arise at the end of the plant's lifecycle, ie about 50–60 years after the plant starts operating, although the expected lifetime of a modern nuclear power plant could be up to 80 years. For the final disposal of spent nuclear fuel, the solutions are either deep geological disposal, as in Finland and Sweden, or deep borehole technology. The first option is a mature technology, while the borehole solution, which is particularly suited for a nuclear energy programme with a small amount of waste, is still under development. The research and development of spent nuclear fuel recovery options is increasingly being studied from the viewpoint of the circular economy and waste reduction. For example, the European Partnership on Radioactive Waste Management EURAD-2 has been launched at the EU level, in which Estonia (University of Tartu) has also shown interest in participating.

At the request of Fermi Energia AS, NICPB carried out an analysis evaluating the technical and economic aspects of spent fuel disposal options. For programmes with a nuclear power plant capacity of less than 1,000 MW, it was found that deep borehole disposal could be economically preferable. For larger programmes, deep geological disposal, or a 'mine-type' solution, would be the preferred option. The management and storage of radioactive waste, including spent fuel, is discussed in more detail in Chapter 17.

<sup>99</sup> Fermi Energia AS input to the IAEA 23.-31.10.2023 INIR mission self-assessment report





Effective management of Estonia's nuclear fuel cycle requires thorough planning, international cooperation and high safety standards. The process includes fuel procurement, enrichment, transport, use in a nuclear power plant and spent fuel management. All these stages are governed by strict safety and environmental requirements. It would not be economically feasible to develop nuclear fuel production capacity (ie uranium enrichment, production of fuel assemblies) in Estonia under the current conditions. Nuclear fuel will therefore have to be supplied from foreign partners. The Euratom Supply Agency is responsible for ensuring the security of supply of nuclear fuels, and mechanisms have been set up within the EU to supply fuel to nuclear power plants. One supply risk mitigation option is choosing a reactor type that uses the most common so-called conventional nuclear fuel in the world that has many manufacturers on the market. In addition to nuclear fuel produced in the EU, fuel can also be supplied from third countries such as the US and Canada. Fermi Energia AS, which plans to build a nuclear power plant, aims to supply nuclear fuel through Vattenfall Nuclear Fuel AB.





### 17. RADIOACTIVE WASTE MANAGEMENT

Radioactive waste is defined as substances or objects containing or contaminated with radioactive substances, which have an activity or activity concentration higher than the exemption levels established by law and which are not intended to be used in the future. Radioactive waste is generated from a wide range of activities, eg in medicine, science and industry, and the activity and volume of radioactive waste generated varies widely. The radioactive waste generated can be in solid, liquid or gaseous form. Waste existing and generated in Estonia is mainly low- and intermediate-level solid waste. There is a small amount of liquid radioactive waste. Most of Estonia's radioactive waste dates back to the Soviet Union. Nowadays, the primary producers of nuclear waste are medical, industrial and research institutions holding a radiation practice licence.

The only operating facility for the management and interim storage of radioactive waste in Estonia is the former nuclear facility in Paldiski, managed by AS A.L.A.R.A., which is owned by the Ministry of Climate. The decommissioning of the two PWR reactor sections of the former Soviet nuclear submarine training centre in Paldiski will take place in the period of 2040–2050, and the radioactive waste disposal site in Paldiski, mainly for this purpose, is planned to be completed by 2040.

The public opinion surveys commissioned by the NEWG showed that the biggest fear of around 70% of respondents is the management of waste from the plant and the potential environmental risk it poses. Both those for and against nuclear power said they needed more information on nuclear waste.

### 17.1 REGULATION OF RADIOACTIVE WASTE

One of the most important international legal instruments for the management of radioactive waste is the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, which aims to protect the public and the environment from the dangers arising from civilian radioactive waste and spent fuel management. In the preamble to the Convention, the parties reaffirm that the ultimate responsibility for ensuring the safety of spent fuel and radioactive waste management rests with the state.

European Union legislation has a very strong influence on the setting of national requirements, the most important of which is Directive 2011/70/Euratom, the content of which coincides with that of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. This Directive establishes a European Community framework for the responsible and safe management of spent fuel and radioactive waste.

In the Republic of Estonia, the principles and obligations related to the management of radioactive waste are laid down in the Radiation Act. More detailed requirements to reduce the volumes of waste generated and to ensure the safe management of radioactive waste are established in the regulations issued under the Radiation Act, as well as in the radiation practice licences issued by the KeA to waste producers and operators.

The EU Directive 2011/70/Euratom requires all EU countries to have national policies for spent nuclear fuel and radioactive waste management and to establish and implement national programmes. Estonia has established an action plan for radioactive waste management in accordance with the directive<sup>100</sup>. The action plan will serve as a basis for the management of radioactive waste and aims to provide decision-makers and waste managers with concrete solutions for the systematic management of radioactive waste and the reduction of its quantities in Estonia. The plan describes the authorities

<sup>100</sup> https://kliimaministeerium.ee/elurikkus-keskkonnakaitse/kiirqus/radioaktiivsed-jaatmed (in Estonian)





authorised for the safe management of radioactive waste, the available and necessary technical and financial resources, and research and development activities. The action plan also sets out the subsidiary objectives, actions and expected results for the sector for up to 2050.

Prior to developing a strategy for the management of radioactive waste arising from a nuclear power plant, or supplementing the existing radioactive waste management plan, the legal framework within which waste management will take place needs to be established, together with a regulatory framework defining how waste management activities will be regulated. The government is responsible for setting up this framework and must designate an independent regulatory body to enforce waste management regulations. Here, it is important to develop waste management policies and strategies with all stakeholders.

In developing national policies and strategies for radioactive waste and nuclear fuel management, it is important to address the issues of radioactive waste exports and imports, spent nuclear fuel management, radioactive waste management and public information and engagement.

### 17.2 SPENT NUCLEAR FUEL OR NUCLEAR WASTE

The fuel in modern nuclear reactors consists of metal fuel rods containing small ceramic pellets of enriched uranium oxide. Fuel rods are grouped into fuel assemblies and placed in the reactor. After several years of use, the fuel rods are lifted into a cooling pool adjacent to the reactor, where the water acts as both a coolant and a radiation shield. Regardless of the strategy chosen, spent fuel management will always involve a period of time during which the fuel is temporarily stored in a pool near the reactor. Due to the radioactive decay of radioisotopes in the spent fuel, heat production from the fuel continues. For initial cooling and shielding, and prior to transport outside the facility, the spent fuel should be kept underwater in a cooling pool adjacent to the reactor immediately after removal from the reactor to allow for a significant reduction in both radiation and heat levels. The length of the storage period varies from a few years to several decades, depending on the capacity of the pool and also on the spent fuel management strategy. Storage allows short-lived isotopes to decay radioactively, resulting in a reduction of the amount of ionising radiation and heat emitted from the rods. Water cools the fuel and provides protection against ionising radiation from radioactive decay. Continuous cooling of the water helps to remove the heat released by the radioactive decay of spent fuel.

From there, the spent fuel is transferred to a wet storage or pool (Photo 8), separate from the reactor building, where it is stored until the end of the plant's lifetime, or to a dry storage facility, where the fuel rods are packed in steel and reinforced concrete containers (Photo 9). Whether to store spent fuel in wet or dry storage is a matter of choice, depending primarily on the waste management strategy, of which a cost-benefit analysis is one component.



Photo 8. Wet storage of nuclear waste in Sweden (Source IAEA). Photo 9. Dry storage in Switzerland (Source Zwilag)





From the beginning of nuclear power generation in 1954 to the present day, around 400,000 tonnes of spent nuclear fuel have been generated worldwide. A total of around 7,000 tonnes of spent fuel is generated annually by 442 reactors in the world<sup>101,102</sup>.

## 17.3 GENERATION AND MANAGEMENT OF RADIOACTIVE WASTE ARISING FROM THE IMPLEMENTATION OF A NUCLEAR ENERGY PROGRAMME

An analysis of radioactive waste management, storage and national policymaking in the operation of nuclear power plants was commissioned by the NEWG and carried out by Breitenstein-Solutions in 2023 (Annex 5). As small reactors suitable for Estonia are not yet used, the quantities of waste presented in the analysis are estimates based on the data of the GE Hitachi BWRX-300 reactor, considered to be conditionally suitable, and on the current experience of nuclear power plants.

The BWRX-300 reactor core contains 240 fuel assemblies and 36 fuel assemblies are replaced per year. The weight of one fuel assembly is 324 kg. A single reactor of a potential nuclear power plant in Estonia would likely generate 12 tonnes of spent fuel per year. If the lifetime of a nuclear power plant is 60 years, then a total of 720 tonnes of spent fuel per reactor would be generated during this period. Three such BWRX-300 reactors, with a total capacity of 900 MW, would produce about 35 tonnes of spent fuel per year.

If all the spent fuel assemblies generated during the year (from the three BWRX-300 reactors) were reprocessed, about 15 packages of solidified high-level radioactive waste (CSD-V<sup>103</sup> package volume: 180 litres, package mass: 489 kg, Photo 10) and about 18 packages of low- and intermediate-level radioactive waste (CSD-C<sup>104</sup> package volume 180 litres, mass 700 kg, Photo 11) would be produced. The reprocessing would also produce about 200 kg of plutonium per year, enough to produce 8–10 fresh mixed oxide (MOX) fuel assemblies. MOX fuel consists of up to 12% plutonium (of which 4-5% is fissile) and depleted uranium.

If all the spent fuel assemblies from the three reactors were reprocessed over a 60-year period, there would be between 2,900 and 3,350 CSD-V and about 3,600 CSD-C packages for disposal. A total of about 15 tonnes of plutonium would be produced.

<sup>&</sup>lt;sup>104</sup> Type of waste package for low- and intermediate-level radioactive waste of the French radioactive waste management company AREVA: CSD-C – Universal compacted standard canisters



https://www.iaea.org/newscenter/news/new-iaea-report-presents-global-overview-of-radioactive-waste-and-spent-fuel-management

<sup>&</sup>lt;sup>102</sup> In comparison, according to Statistics Estonia alone, 1,590,000 tonnes of hazardous waste, including mercury, cyanide, acids, asbestos, were generated in Estonia in 2021.

<sup>&</sup>lt;sup>103</sup> Type of waste packaging for fission products of the French radioactive waste management company AREVA: CSD-V – Universal vitrified standard canisters





Photo 10. Solidified high-level waste packaging. Photo 11. Packaging of low- and intermediate-level radioactive waste (Source: Zwilag)

As for the low- and intermediate-level radioactive waste generated at the plant, it is more difficult to estimate the quantities. The quantities depend to a large extent on the technical characteristics of the plant and the legal requirements for waste management. During the operation of the plant, this type of waste includes, for example, contaminated protective suits and filters in small quantities. The largest quantity of low- and intermediate-level radioactive waste is generated at the end of the plant's lifetime when it is dismantled. For the 1,000 MW boiling and pressurised water reactors, the quantities of plant scrap range from 5,000 to 10,000 m³. Most of them are very low in activity and the volume of waste can be reduced by various means, such as compaction. Low- and intermediate-level radioactive waste generated in a nuclear power plant must be disposed of in an above-ground and/or near-ground disposal facility, similar to the disposal facility to be constructed in Paldiski for the decommissioning of reactor sections at the Soviet Union's nuclear submarine training centre.

During the operational phase of a nuclear power plant, the owner/operator is responsible for the management and interim storage prior to disposal of spent fuel and other radioactive waste generated at the plant and must take this need into account in the plant design and human resources planning. A wet or dry storage facility for spent fuel and a storage facility for low- and intermediate-level waste must be designed. For the management and interim storage of low- and intermediate-level radioactive waste, an additional option is to analyse the possibilities for cooperation with a national radioactive waste management and storage company.

#### 17.3.1 CLOSED AND OPEN FUEL CYCLE

The state must decide between an open and closed fuel cycle, ie decide whether spent fuel is treated as waste that requires long-term storage and then disposal, or require it to be reprocessed.

If Estonia decides in favour of a closed fuel cycle, France would be the only potential fuel reprocessor in Europe. However, the complex and costly transport of nuclear material is something to be considered in regard to reprocessing, and a buyer for the MOX fuel made from spent fuel would also have to be found if we do not have a use for such fuel ourselves. After reprocessing, a small amount of waste that cannot be recycled would be returned to the state, and we would still have to find a way to dispose of it.

For an open fuel cycle, the analysis proposes three options for the disposal of spent fuel:

- 1. the establishment of a deep geological disposal site, similarly to Finland and Sweden;
- 2. the construction of a final disposal site using the borehole method, where waste is placed in special containers 1–3 km underground;





3. participation in the construction of a regional disposal site.

The options for a deep geological disposal site and a borehole disposal site have been addressed in the Spatial analysis of the potential sites of a nuclear power plant and a spent nuclear fuel disposal site commissioned by the sub-working group on spatial planning (Annex 5). The construction of a borehole disposal site is still in the experimental phase, with the first test facility being set up by Deep Isolation in Texas in the US<sup>105</sup>. To analyse the feasibility of implementing a regional disposal site project in Europe, an ERDO Association has been set up with nationally appointed representatives from Slovenia, the Netherlands, Denmark, Norway, Italy, Croatia and Belgium.<sup>106</sup>

Estonia is advised to keep its spent nuclear fuel management options open. In today's situation, reprocessing of small quantities of spent nuclear fuel may not be the first choice economically and under international agreements, but the option of reprocessing should not be legally restricted as it may still be feasible in the future. Therefore, the design of the proposed SMR could technically foresee the use of MOX fuel.

### 17.4 ENSURING THE LONG-TERM SAFETY OF SPENT NUCLEAR FUEL

Although the quantities of waste requiring disposal are small, it must be borne in mind that spent nuclear fuel in its uncontained form is dangerous to humans, and even a few minutes' exposure to fuel right after it is removed from the reactor would mean certain death. As a result, the management of spent fuel is subject to the highest safety standards, and there have been no known fatalities related to waste management in the almost 70-year history of nuclear energy. Spent nuclear fuel radiation levels will start to decline rapidly, but it will never completely lose its radioactivity due to the extremely long half-life of the isotopes in its composition. However, spent nuclear fuel remains dangerous to humans on direct exposure for hundreds, not thousands, of years, and would then only pose a health risk if it entered the body, eg by ingestion. The natural decrease in radioactivity of waste is due to the radioactive decay of the radioisotopes it contains. High-level radioactive waste reaches the radioactivity level of the originally extracted ore within 1,000–10,000 years<sup>107</sup>.

### 17.4.1 FUND FOR RADIOACTIVE WASTE DISPOSAL AND DECOMMISSIONING OF THE PLANT

The recovery of waste generated by a nuclear power plant must not be left to the state or future generations at the end of a plant's lifetime. This is why funds for decommissioning (dismantling) and waste disposal will be raised as soon as the plant is operational. In most of countries generating nuclear energy, it is one of the components of the electricity price. If the decision is made to build a nuclear power plant, a waste management and decommissioning fund fee should also apply in Estonia to the operator of the nuclear power plant.

After a thorough geological investigation and safety assessment, a disposal site will be built to ensure the safety of the waste for millennia. The funds will be collected in the form of periodic cash payments and kept in a national radioactive waste disposal and decommissioning fund, the assets of which are separate from the state budget and from which disbursements may be made only for the

 $<sup>{\</sup>color{blue} \underline{\text{https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-wastes-myths-and-realities.aspx} \\$ 



<sup>105</sup> https://www.deepisolation.com/

<sup>106</sup> https://www.erdo.org/



decommissioning of a nuclear facility after its decommissioning or, to a limited extent, for the financing of the development of related research or technologies. The state must establish a legal framework for the establishment and management of the fund on a 'polluter-pays' basis.

The number of payments to the fund and the disbursements from the national decommissioning fund are decided by the regulator. The amount of the payments will be determined on the basis of the estimated cost of the waste disposal and decommissioning of the plant. The most common mechanism for raising money for the fund is to tax the electricity produced by a nuclear power plant. For example, 0.1 cents/kWh in the US, 0.14 cents/kWh in France or 0.2 cents/kWh in Romania. Other examples include flat annual fees (in Korea) or payments proportional to the volume of waste generated (in Belgium)<sup>108</sup>.

The methodology for estimating the size of the reserve, the detailed conditions and procedures for contributions to and withdrawals from the national fund and the management, allocation and use of the assets are to be laid down in a subsidiary act of TEOS. The size of the reserve must be determined based on the fundamental principles of the use and decommissioning of nuclear facilities and the storage of nuclear waste, and the principle that there are sufficient resources in the national fund at any given time to cover the costs. The initial amount of the reserve for each calendar year of the expected lifetime of each nuclear facility should be determined by the regulator in the conditions of the operating licence

The amount of the reserve must cover:

- the cost of decommissioning the nuclear facility;
- 2. the costs of the disposal of spent nuclear fuel, radioactive sources or radioactive waste arising from the operation of a nuclear facility;
- 3. the expected costs of disposal of spent nuclear fuel or nuclear waste during the expected lifetime of the nuclear facility and decommissioning;
- 4. research and development costs of the licensee;
- 5. the estimated costs necessary for the supervision of waste management;
- 6. the cost of administering the national fund.

The owner/operator of a nuclear power plant has to submit to the regulator an initial estimation of decommissioning costs and to update it regularly thereafter, the frequency of which is set by legislation. According to international practice, the first update is usually made five years after the first estimate of decommissioning costs. If the regulator determines that the amount of the decommissioning reserve does not cover the costs of decommissioning the nuclear facility or the radioactive waste disposal site, it has the right to increase the amount of the reserve. The fund is registered in the national register of state and local authorities in accordance with the procedure laid down in the statutes of that register. The fund is guided in its activities by TEOS, the fund's statutes and other legislation. The statute is approved and amended by the Government of the Republic on the proposal of the Minister responsible for the field.

Radioactive waste existing and generated in Estonia is mainly low- and intermediate-level solid waste. Most of Estonia's radioactive waste dates back to the Soviet Union. Nowadays, the primary producers of nuclear waste are medical, industrial and research institutions holding a radiation

 $<sup>\</sup>frac{108}{\text{https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx}{\text{https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx}{\text{https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx}{\text{https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx}{\text{https://world-nuclear.org/information-library/nuclear-fuel-cycle/n$ 





practice licence. The only operating facility for the management and interim storage of radioactive waste in Estonia is the former nuclear facility in Paldiski, managed by AS A.L.A.R.A., which is owned by the Ministry of Climate. The decommissioning of the reactor sections of the former Soviet nuclear submarine training centre in Paldiski will take place in the period of 2040–2050, and the radioactive waste disposal site in Paldiski, mainly for this purpose, is planned to be completed by 2040.

Prior to developing a strategy for the management of radioactive waste arising from a nuclear power plant, or supplementing the existing radioactive waste management plan, the legal framework within which waste management will take place needs to be established, together with a regulatory framework defining how waste management activities will be regulated.

An analysis of radioactive waste management, storage and national policymaking in the operation of nuclear power plants was commissioned by the NEWG. According to the analysis, a single reactor of a potential nuclear power plant in Estonia would likely generate 12 tonnes of spent fuel per year. If the lifetime of a nuclear power plant is 60 years, then a total of 720 tonnes of spent fuel per reactor would be generated during this period. During the operational phase of a nuclear power plant, the owner/operator is responsible for the management and storage prior to disposal of spent fuel and other radioactive waste generated at the plant and should take this need into account in the plant design and human resources planning.

The state must decide between an open and closed fuel cycle, ie decide whether spent fuel is treated as waste that requires long-term storage and then disposal, or require it to be reprocessed. For an open fuel cycle, the analysis proposes three options for the disposal of spent fuel:

- 1. the establishment of a deep geological disposal site, similarly to Finland and Sweden;
- 2. the construction of a final disposal site using the borehole method, where waste is placed in special containers 1–3 km underground;
- 3. participation in the construction of a regional disposal site.

It is recommended to keep spent nuclear fuel management options open. In today's situation, the reprocessing of small quantities of spent nuclear fuel may not be the first choice, but the option of reprocessing should not be legally restricted.

Low- and intermediate-level radioactive waste generated in a nuclear power plant must be disposed of in an above-ground and/or near-ground disposal facility, similar to the disposal facility to be constructed in Paldiski for the decommissioning of reactor sections at the Soviet Union's nuclear submarine training centre.

To ensure that the recovery of the waste generated by a nuclear power plant is not left to the state and future generations, a waste management and decommissioning fund fee should be imposed on the operator of a nuclear power plant if a decision is taken to build a nuclear power plant in Estonia.



The construction of a nuclear power plant offers opportunities for the local industrial sector to be developed and expanded. Nuclear energy programmes map out the extent to which a nuclear power plant could be built with the participation of local companies, taking into account the capacities already available, the technical services offered, the quality standards applied and the likely investments. The involvement of the local industry is essential in supporting a safe and reliable nuclear energy programme at the different stages of its development, from plant design to decommissioning.

Participation in the nuclear energy programme requires local industry to be able to meet strict quality requirements and standards and to develop and implement appropriate management systems and quality programmes. The experience of other countries has shown that industry's efforts to meet high quality standards are being transferred to other industrial sectors and are not limited to projects related to the nuclear energy programme. It is the responsibility of the state to develop policies and targets for the engagement of local industry, including possible support mechanisms for the development of industry capabilities to achieve an optimal level of nuclear expertise and experienced personnel to ensure the efficient and safe operation and maintenance of the plant. <sup>109</sup>

For projects that require large investments, greater involvement of local businesses will support growth and job creation. This rule also applies to projects that have never materialised or have been completed late and over budget. As long as money is spent locally, there is a good chance of inducing a positive macroeconomic impact<sup>110</sup>.

# 18.1 THE POTENTIAL OF ESTONIAN INDUSTRIAL FIRMS IN PARTICIPATING IN THE CONSTRUCTION OF A NUCLEAR POWER PLANT

To get an overview of potential service providers, Fermi Energia AS conducted a supply chain analysis in 2022. Information was collected from interviews with company representatives and/or from official company websites. Based on the analysis, companies from the following sectors would be most likely to be involved in the construction of a nuclear power plant and in the process of manufacturing its components:

- electrical equipment;
- 2. metal industry;
- 3. machinery and equipment;
- 4. construction;
- 5. architectural and engineering services;
- 6. technical testing and analysis services;
- transport services;
- 8. computers, electronic and optical products;
- 9. programming, information and communication services;
- 10. repair and installation of machinery and equipment.

The first four on the list would be the ones with the greatest potential for involvement in the construction of a nuclear power plant. About 30 companies registered in Estonia have the potential to participate in

https://nucleus.iaea.org/sites/INPRO/df15/IAEA/DARDOUR.pdf



<sup>109</sup> https://www-pub.iaea.org/MTCD/Publications/PDF/P1703 web.pdf



the construction of nuclear power plants in these fields. Several of them have been involved in the construction of nuclear power plants in Finland or have produced components for nuclear power plants in EU countries. In addition, furnishing of administrative buildings, utilities and environmental services, logistics services, etc would be involved on a smaller scale, as is the case in any other large-scale industrial project.

For participation in a nuclear power plant project compliance with the standards of the quality and environmental management system and the country of origin of the technology supplier with specific requirements, ISO standards, IEC standards, IAEA standards and specific requirements imposed by regulators are essential.

There are a number of companies in Estonia that produce steel structures, vessels and heat exchangers, which form a large part of the components of both thermal and power plants as well as nuclear power plants. In addition to ISO and IEC standards, there are also NATO-compliant industrial firms among local companies. In light of the above, Estonia is well placed to develop a local supply chain for the production of nuclear power plant components and to participate in the construction of a nuclear power plant.

### 18.2 THE ROLE OF THE STATE IN ENGAGING INDUSTRY

At the national level, there are no objectives or policies in place in Estonia for the involvement of industry at this stage of the construction of a nuclear power plant. The general objectives for the industrial sector are outlined in the document *Industrial Policy 2035*, which was prepared in August 2023 by the Ministry of Economic Affairs and Communications in cooperation with industry associations and businesses. The document addresses the issues that need more attention from policymakers for the comprehensive development of the Estonian industry as a whole. One of its aims is to ensure that industry is visible and valued as the main economic sector in Estonia and that industrial companies are considered in decision-making. Based on the objectives of the Industrial Policy document, the Ministry of Economic Affairs and Communications and the partners involved in the drafting of the paper agree on annual actions to implement them.<sup>111</sup>

To encourage involvement in the nuclear power plant project, the action plan should also include activities to support it. The IAEA, during the INIR mission 23–30.10.2023, also recommended Estonia to develop a national policy for the engagement of the local industrial sector in the implementation of the nuclear energy programme.

To engage the industrial sector, it is important to maintain to maintain openness throughout the project and to provide information and opportunity for making suggestions to local businesses (for example through professional associations). In terms of engagement, cooperation and information exchange with potential suppliers and local industry organisations, information seminars should continue to be organised, also by the state, and they should be involved in nuclear events. It is possible to use the facilities of the Estonian Business and Innovation Agency (EISA) (formerly known as KredEx and Enterprise Estonia) for the certification, qualification and development activities required for a nuclear power plant project. The EISA's objectives are to increase Estonia's international competitiveness, to develop entrepreneurship and the living environment, to attract foreign investments with high added value to Estonia and help recruit top-level international workers. Companies are offered grants, loans, venture capital, credit insurance and guarantees to support their development and secure expansion into foreign markets. Companies could also be supported by the Estonian Chamber of Commerce and

<sup>111</sup> https://www.mkm.ee/ettevotlus-ja-innovatsioon/toostus/toostuspoliitika (in Estonian)





Industry, which offers consultancy services in various areas of business, including legal services in export, foreign trade and customs, and EU consultancy.

At the ENEF meeting in Bratislava, Slovakia, in November 2023, the European Commission informed Member States about the preparatory work for the creation of the EU SMR Industrial Alliance.

The Alliance is expected to focus on the following:

### 1. Incentivising the market

Addressing the needs of energy-intensive industries and the solutions which SMRs can bring.

### 2. Financing

Analysing the possibilities for cost-sharing as well as financial support for individual projects.

### 3. Ensuring that the nuclear industry is well-equipped

This includes strengthening education & training to ensure a skilled workforce and upscaling the involvement of the EU supply chain in the development of SMRs.

### 4. Support for innovation, research and development

Identify what the needs are to establish relevant R&D programmes and facilities<sup>112</sup>.

Greater involvement of local businesses in the nuclear power plant project will support economic growth and job creation and create the conditions to ensure the efficient and safe operation of the nuclear power plant. Companies in the electrical equipment manufacturing, metal industry, machinery and equipment and construction sectors are most likely to be involved. To encourage participation, the *Industrial Policy 2035* action plan should also include activities to support this and continue to engage in open communication, cooperation and information exchange with companies on the deployment of nuclear energy.

https://www.nucleareurope.eu/press-release/european-commission-announces-creation-of-small-modular-reactor-alliance/



The IAEA guidelines assume that a nuclear power plant will be built using a turnkey contract (EPC), where the contractor will enter into a single contract with the contracting authority and carry out all phases of the project from design to construction. The contractor must be aware that special conditions apply to the procurement of the equipment and services for a nuclear power plant. The IAEA has developed a corresponding guidance document NP-T-3.21 *Procurement Engineering and Supply Chain Guidelines in Support of Operation and Maintenance of Nuclear Facilities* for Member States<sup>113</sup>. Specific conditions that apply include safety standards, quality control, certificates proving that products meet standards and requirements. This includes comprehensive documentation on the characteristics, testing and maintenance of the components, which must be available to the regulators and the plant operator. Compliance with these conditions must be checked by both the contractor and the contracting authority. Compliance with requirements is also checked and monitored by the regulator during the licencing process.

Procurement of goods, services and works related to nuclear power plants must comply with relevant EU legislation in the field of nuclear safety, security and radiation protection, as well as national laws and regulations. Procurement activities for nuclear power plants must ensure that the safety and security of personnel, the public and the environment are ensured and that the materials and technology used meet the highest standards.

## 19.1 CONSIDERING SECURITY RISKS WHEN CARRYING OUT PROCUREMENTS

In addition to quality and safety aspects, security aspects may also play an important role in the procurement of some components and equipment for use in a nuclear power plant, where some manufacturers or maintenance or support service providers may be excluded due to the high risk they pose. Provisions to this effect must also be included in national legislation. An example can be found in the Electronic Communications Act<sup>114</sup> subsection 1 of § 87³, which establishes that the hardware and software used in the provision of communications services in a communications network must not pose a risk to national security.

The main components of the reactor are expected to be supplied by the SMR manufacturer, who in turn may use several companies for their production. If the state has made a decision / implemented a policy on not allowing the use of components produced in certain countries (eg Russia) for the construction of a nuclear power plant, this requirement will be verified by the regulator during the review of the technical documentation for the construction of a nuclear power plant. A prior check of the tender documents must be carried out by the builder of the plant in this respect to exclude such bidders. A thorough check is also important for them in the subsequent licencing procedure, as any errors will extend the project implementation deadline.

While it is easy to rule out unfriendly countries for the components and fuel used in the construction of a nuclear reactor, it may be more difficult to rule out unfriendly countries for the non-nuclear components used in the plant, such as parts of the electronic equipment. In these cases, a risk assessment is required. Manufacturers from certain countries should be excluded for equipment that plays a key role in station security, eg surveillance cameras, routers, communication equipment.

https://www.riigiteataja.ee/en/eli/512012023003/consolide



<sup>113</sup> https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1725 web.pdf



### 19.2 PUBLIC PROCUREMENT

In addition to the contracting authority and the contractor of the nuclear power plant, services related to the implementation of the nuclear energy programme must also be procured by state authorities, which follow the Public Procurement Act¹¹⁵ in this process. State authorities and state-owned companies base their procurement procedures on the Public Procurement Act and the legislation issued on the basis of it, the directives regulating public procurement, the case law of the European Union and the legislation regulating the internal organisation of the ministry. In the case of an external financier, the specific requirements imposed by these financial institutions will also be taken into account. Regardless of the expected value of the procurement, the general principles of the Public Procurement Act must be followed. The person involved in the procurement is obliged to avoid any conflicts of interest. The SSSC procurement unit carries out procurements in accordance with the operational model agreed between the SSSC procurement unit and the public authority. Small purchases of up to €29,999.99 excluding VAT are generally carried out by each institution itself according to the procedures for small purchases established within its institution.

In the process of considering the introduction of nuclear energy by the NEWG, public procurement was carried out in 2022–2023 for the following works:

- 1. Preliminary spatial analysis of potential locations for a nuclear power plant and a disposal site for spent nuclear fuel;
- 2. Preparation of a human resources development strategy and mapping of a regulatory framework;
- 3. Mapping the legal framework required to start the nuclear programme and updating the draft nuclear legislation.

Following a positive decision, at least the following public procurement procedures are likely to be necessary within 8 months:

- to create national policies;
- 2. to support legislative processes;
- 3. for communication and engagement activities;
- 4. to support the creation of a regulator and a system for issuing permits;
- 5. for human resources development.

In the later phases of the implementation of the nuclear energy programme, the procurement of services will be complemented by the procurement of laboratory equipment and rescue equipment. For some activities, it is also possible to use international cooperation instead of public procurement. For example, it is possible to work with the IAEA and/or the US and other national governments to establish a regulator and develop its staff.

Specific conditions apply to the procurement of equipment and services for a nuclear power plant. These are checked by the contractor, the contracting authority and the regulator during the licencing process. Security aspects must also be taken into account to avoid producers from unfriendly countries. The purchase of services and equipment needed by state authorities in the process of implementing the nuclear energy programme is governed by the Public Procurement Act.

<sup>115</sup> https://www.riigiteataja.ee/en/eli/503042023006/consolide





Table 13 shows the main activities of the different phases of the nuclear energy programme, together with their duration and budget.





Timeframe	PHASE 1: analysis and considerations before the decision						PHASE 2: preparatory work											PHASE 3: activities to implement the first nuclear power plant															
Year	0					1			2			3					5 6			6	7 8				9 10			11					
Quarter	I	Ш	III		IV	1	II I	II IV	1 11	III IV I	11 111		IV	ı	1 11 111	IV	ı	11 111	IV	1 11	III IV	1 11 1	II IV I	11 111	IV I	11 111	IV I	11 111 11	/ 1	Ш	III	IV	
	Final Report of NEWG					Procedure for the dra			ft Nuclear Energy and ty Act								IAEA SEED nission	IAEA INIR-2							IAEA INIR-3 mission			1					
	Decision of principle								Preparation of fu						further	ırther legislation																Start of electricity	
						E	Establishment a nuclear regulator			Nuclear safety assessmer by the regul									Building permit procedure			Regulatory supervision and control				Authorisation of use procedure Licence to load fuel Operati							
	c				Renewa the ompos the NE nd crea of sul working	ition EWG, ation b- ng	Spatial planning (IAEA site selection)														Construction of a nuclear power plant			ant									
															Developing emergency response and technical capacity																		
	Deve		national ( etences	core			Developing national competences: training of regulatory personnel, education programmes, emergency response and health sector competences.														Total up to												
Budget (state)													elopment	€127 million																			
Pos. scenario (30% savings)	rio €0.26 million €26.41 million + up to €12.66 million for the development of emergency response capacity €24.38 million + up to €25.32 million for the development of emergency response capacity												nergency	response	€88.03 million																		
Neg. scenario (30% increase)		€0.48	million				€49 million + up to €24.44 million for the development of emergency response capacity												€45.28 million + up to €47.02 million for the development of emergency response capacity										€166.22 million				

Table 13. Activities, timetable and budget for years 0–11 of the implementation of the nuclear energy programme (Source: NEWG)



#### 20.1 PHASE I: ANALYSIS AND CONSIDERATIONS

In phase I, the discussions initiated based on this report will take place in the Government of the Republic and the Riigikogu, followed by a first decision of principle on the introduction of nuclear energy. If the decision is positive and the country decides to start establishing a national infrastructure for the deployment of nuclear energy, the NEWG will continue to prepare for this. This requires the following:

#### 1. Government of the Republic needs to renew the NEWG's mandate

Mandating the establishment of a regulatory and legislative framework and setting deadlines for the submission of a proposal for the establishment of a regulator and a draft TEOS.

#### 2. Renew the composition of the NEWG

Adding representatives of additional agencies, national companies and universities as members. In addition, the interaction with the potential developer and input into the activities of the NEWG should be formalised through a memorandum of understanding.

#### 3. Establish sub-working groups for:

#### Legislative work

Drafting TEOS and its subsidiary acts and amending and supplementing other legislation under the leadership of the Ministry of Climate.

#### Human resources development

For the preparation of training programmes for the personnel of the regulator, educational programmes, additional training for emergency response and health workers under the guidance of the Ministry of Education and Research.

#### Preparing for the establishment of a regulator

Preparation of the draft amendment to the Government of the Republic Act, drafting of the statutes, establishment of the quality management system, preparation of the personnel recruitment plan, coordination of international relations and assistance in the management of the Environmental Board.

In phase I, the development of national core nuclear capabilities will continue in cooperation with the IAEA and the US FIRST programme.

#### 20.2 PHASE 2: PREPARATORY WORK

The preparatory phase lasts from the beginning of the first year of implementation to the beginning of the fifth year, or up to one year less in the case of an accelerated timetable. At the beginning of the phase, the establishment of the nuclear regulator will take place on the basis of the Government of the Republic Act, but the regulator will have operational competence after the adoption of the TEOS. Recruitment of personnel with key competences for the regulator will be launched, in line with the recruitment plan drawn up in phase 1.

In the first year of the implementation of the nuclear energy programme, the procedure for TEOS and its subsidiary acts and other draft legislation will be launched. The time required for the procedure of the draft TEOS – for the coordination of the drafting proposal, consultation with stakeholders, drafting, coordination and procedure in the Government of the Republic and the Riigikogu – is estimated at 33 months, 24 months in the case of an accelerated timetable.





A regulation establishing the criteria for the nuclear safety assessment of a plant site – requirements for design and site safety and for the manufacturer's and applicant's management and quality systems – should also be processed in the same timeframe as TEOS. It should also provide for the need for the nuclear safety assessment of the site to be approved by the regulator. The drafting and processing of the complementary legislation will start in parallel with the TEOS procedure, but will take 60 months, or 5 years, or 39 months in the accelerated timetable, or the full duration of phase 2, and will continue in phase 3. The lengthy legislative process relates, in particular, to the amendments to regulations and legislation required as the nuclear energy programme progresses, which are needed for site studies, safety assessments, the licensing process, preparation for construction activities, emergency planning, etc. The accelerated timetable will make greater use of outsourcing services from legal partners and international experts for the preparation of draft legislation.

In addition to national core competences, training of specialists in cooperation with foreign universities and developing the study programmes of Estonian universities and vocational training centres should start in phase 2. Also, a more comprehensive treatment of CBRN topics needs to be introduced into the curriculum of the Estonian Academy of Security Sciences.

At the beginning of this phase, spatial planning activities will also start under the Planning Act to identify the best site for the nuclear power plant. The national designated spatial plan process consists of two stages, and under the amendment to the Planning Act, which entered into force in March 2023, it is possible to waive the second stage. If the national designated spatial plan (second stage) is waived, it can be completed in 36 months or 3 years. An additional 24 months, or 2 years, is added for the detailed solution. During the spatial planning process, the role of the nuclear regulator will increase and the first licensing procedures will start, the first of which will be to approve the site selection.

When drawing up a national designated spatial plan, it is necessary to know the technology of the nuclear power plant to determine land use and construction conditions and to prepare a safety assessment. This requires the adoption of the necessary legislation for safety assessments (TEOS and its regulations). The choice of technology is also important for the development of emergency response capabilities to identify needs and develop specific capabilities. Technology/design safety assessment is part of the nuclear safety assessment. The preparation and validation of the safety assessment is carried out on a site-by-site basis in the planning process. On this basis, the site selection would also be approved by the regulator.

In the area of emergency response and health, activities will start in parallel with the technology selection and planning process, as in addition to technology, the need for capacity development will also depend on the resources available in the region where the plant is located and, in planning security aspects, on the distance from the national border.

As the planning of phase 2 activities will also follow the IAEA *Milestones*, it will be necessary to carry out an IAEA INIR-2 mission before the end of the phase 2 activities to assess the adequacy of the preparatory activities for the next phase and the implementation of the proposals of the first INIR mission. At the end of the planning process, it is recommended to carry out an IAEA Site and External Events Design Review Service (SEED) mission, the modules of which deal with site selection and its safety assessment. We would then move on to the next phase – phase 3.





## 20.3 PHASE 3: ACTIVITIES TO IMPLEMENT THE FIRST NUCLEAR POWER PLANT

Phase 3 starts with an application for a building permit from the regulator. The process of obtaining a building permit is estimated to take up to 24 months or 2 years. In parallel with the permit procedure, the applicant can carry out preparatory activities for the start of construction, such as earthworks, building supporting infrastructure, etc, at the approved site. The estimated duration of the construction of the nuclear power plant is 42 months, ie 3.5 years. According to SMR developers' estimations, construction of a plant on site could take up to 3 years. Compared to large nuclear power plants, the construction time for SMRs is expected to be significantly shorter, as the main components of the plant are delivered to the site in a prefabricated form and only require on-site assembly.

Once the construction is completed, it will be necessary to apply to the regulator for an operation permit for the plant. Given the length of the construction and the rigorous supervision and quality control of the construction by both the applicant and the regulator, it is estimated that it could be possible to process the permit to the point of issuance in 9 months. The completion of the activities set out in the commissioning plan approved under the operating licence (various tests, etc to demonstrate that the completed plant is of the required quality for commissioning) is followed by the procedures for the fuel use permit and the permit to start generating electricity, which are also necessary to start generating electricity, but the procedures of which have a short duration. This means that the time needed from the application for the permit to the production of electricity could be estimated at around 15 months, or just over a year.

The total duration of phase 3, from the application for a construction permit to the start of electricity generation, could then be estimated at around 7 years. Under an accelerated timetable, where the necessary permits are processed as many times as possible in parallel, the corresponding time taken would be 57 months or less than 5 years.

In parallel, activities to develop national competences, emergency response and health capacities would continue.

At the end of the phase, an INIR-3 mission should be carried out to assess the readiness of the infrastructure to operate the plant, in accordance with the IAEA *Milestones*. The sale of electricity generated by the plant to consumers could then start at the end of year 11 after the decision of principle taken at the beginning of the nuclear energy programme, or at the end of year 9 under an accelerated timetable.

#### 20.4 BUDGET FOR PHASES

Three scenarios have been taken into account in estimating budgetary needs:

- 1. a common scenario, in which public finances are planned according to budget estimations;
- 2. a positive scenario, with a 30% cost saving by maximising the use of international cooperation and EU structural funds;
- 3. a negative scenario where expenses to the state budget turn out to be 30% higher than planned.





The budget for phase 1 activities of €0.37 million (€0.26 million for the positive scenario and €0.48 million for the negative scenario) is proposed for the operation of the NEWG and its additional subworking groups, which are intended to outsource analyses and consultancy services and to cover the salary costs of additional personnel to coordinate the activities of the working group.

The expenses from the state budget for phase 2, the lion's share of which will be spent on manning the regulator and drawing up educational programmes, have a budget of €37.73 million (positive €26.41 million, negative €49 million). The costs of emergency response and technical capacity building will be additional to this, which cannot be realistically estimated at this stage and which are estimated in Table 13 on the basis of emergencies that may occur in large nuclear power plants of more than 1,000 MW. However, for SMRs, even under the most conservative scenarios, the costs of developing emergency response capacity are still expected to be several times lower.

The budget for phase 3 is €34.83 million (positive €24.38 million, negative €45.28 million). In this phase, key investments in emergency planning and capacity building in the health sector would take place. This is mainly in the form of the purchase of measuring equipment, laboratory equipment and specialised equipment.

Shorter timeframes and parallel procedures would provide some time savings, but would require the outsourcing of essential services and competences, which would not result in significant savings in total expenses from the state budget. At the same time, a shorter timetable, assuming that the desired technology is ready for construction in line with the timetable, would allow electricity generation to start earlier, bringing additional revenues to the state sooner than the original timetable.

In terms of the use of funds from the state budget, the biggest savings are likely to be made in emergency planning expenditure, which can be met using EU Structural Funds and international cooperation programmes. Also, most of the capacity-building activities are not exclusively related to the implementation of the nuclear energy programme, but are designed as activities to improve overall crisis preparedness, ie they would not only ensure the safety of the nuclear power plant, but also fulfil other objectives of protecting the population. Rather than developing very specific technical capabilities, national practice also includes the provision of technical assistance in emergencies on the basis of memoranda of understanding with neighbouring countries, given the cost of specialised equipment and the extremely low likelihood of its frequent use.





# ANNEX 1: MEMBERS OF THE NUCLEAR ENERGY WORKING GROUP FOR THE PERIOD OF 2021–2023

	Name	Institution	Role	Membershi	p period
1.	Meelis Münt	Estonian Ministry of the Environment	chairman	directive 20.04.2021 No 1- 2/21/199; 20.04.2021	30.06.2023
2.	Harry Liiv	Estonian Ministry of the Environment	deputy chairman	20.04.2021	21.04.2022
3.	Antti Tooming	Estonian Ministry of the Environment	deputy chairman	directive 21.04.2022 No 1- 2/22/147, 21.04.2022	
4.	Reelika Runnel	Estonian Ministry of the Environment	coordinator	20.04.2021	
5.	Ilmar Puskar	Estonian Environmental Board	member of the working group	20.04.2021	
6.	Lauri Lugna	Ministry of the Interior	member of the working group	20.04.2021	21.04.2022
7.	Viola Murd	Ministry of the Interior	alternate member of the working group	20.04.2021	
8.	Priit Laaniste	Ministry of the Interior	alternate member of the working group	21.04.2022	
9.	Kaia Sarnet	Ministry of Finance	alternate member of the working group	20.04.2021	
10.	Tiit Oidjärv	Ministry of Finance	alternate member of the working group	20.04.2021	21.04.2022
11.	Katri-Liis Ennok	Ministry of Finance	alternate member of the working group	21.04.2022	27.08.2022
12.	Heddy Klasen	Ministry of Finance (from 1 July 2023, Ministry of Regional Affairs and Agriculture)	member of the working group	directive 27.08.2022 No 1- 2/22/285, 27.08.2022	





	ı		<u> </u>	ı	
13.	Tõnis Saare	Ministry of Justice	member of the working group	20.04.2021	
14.	Heddi Lutterus	Ministry of Justice	alternate member of the working group	20.04.2021	
15.	Indrek Reimand	Ministry of Education and Research	member of the working group	20.04.2021	21.04.2022
16.	Renno Veinthal	Ministry of Education and Research	member of the working group	21.04.2022	
17.	Katrin Pihor	Ministry of Education and Research	alternate member of the working group	20.04.2021	01.01.2023
18.	Margus Haidak	Ministry of Education and Research	alternate member of the working group	01.01.2023	
19.	Timo Tatar	Ministry of Economic Affairs and Communications	member of the working group	20.04.2021	
20.	Jaanus Uiga	Ministry of Economic Affairs and Communications	alternate member of the working group	20.04.2021	08.12.2022
21.	Rein Vaks	Ministry of Economic Affairs and Communications	alternate member of the working group	08.12.2022	
22.	Kristjan Prikk	Ministry of Defence	member of the working group	20.04.2021	01.06.2021
23.	Kusti Salm	Ministry of Defence	member of the working group	directive 01.06.2021 No 1- 2/21/261, 01.06.2021	
24.	Marti Magnus	Ministry of Defence	alternate member of the working group	20.04.2021	08.12.2022





25.	Asko Kivinuk	Ministry of Defence	alternate member of the working group	08.12.2022	
26.	Kaja Tael	Ministry of Foreign Affairs	member of the working group	20.04.2021	30.08.2023
27.	Andres Ideon	Ministry of Foreign Affairs	alternate member of the working group	20.04.2021	30.08.2023
28.	Katrin Saarsalu- Layachi	Ministry of Foreign Affairs	member of the working group	30.08.2023	
29.	Gert Siniloo	Ministry of Foreign Affairs	alternate member of the working group	30.08.2023	
30.	Marika Priske	Ministry of Social Affairs	member of the working group	20.04.2021	21.04.2022
31.	Sten Andreas Ehrlich	Ministry of Social Affairs	alternate member of the working group	20.04.2021	21.04.2022
32.	Aive Telling	Ministry of Social Affairs	member of the working group	21.04.2022	
33.	Kristi Suur	Ministry of Social Affairs	alternate member of the working group	21.04.2022	27.08.2022
34.	Ulla Saar	Ministry of Social Affairs	alternate member of the working group	27.08.2022	25.10.2023
35.	Triin Reisner	Government Office	member of the working group	20.04.2021	
36.	Kristi Talving	Consumer Protection and Technical Regulatory Authority	member of the working group	27.10.2022 No. 1- 2/22/381, 27.10.2022	





37.	Ingrid Teinemaa	Consumer Protection and Technical Regulatory Authority	alternate member of the working group	27.10.2022	
38.	Ahti Kuningas	Ministry of Economic Affairs and Communications	member of the working group	14.12.2023	
39.	Sandra Särav	Ministry of Economic Affairs and Communications	alternate member of the working group	14.12.2023	





# ANNEX 2: PROPOSALS AND RECOMMENDATIONS OF THE INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA) INIR MISSION 23.–30.10.2023.

In total, 12 proposals and recommendations (6 proposals, 6 recommendations) were made by IAEA experts on 8 thematic items. In addition, 3 good practices were identified. During the mission, 19 issues were assessed in accordance with IAEA guidance publication NG-G-3.1 (Rev.1) *Milestones in the Development of a National Infrastructure for Nuclear Power*:



Proposals and recommendations presented to the Nuclear Energy Working Group (NEWG) during the International Atomic Energy Agency (IAEA) expert mission to assess nuclear infrastructure (INIR mission).

Issue	(P) proposal (R) recommendation (G) good practice	Explanation	Activities planned
National position	S: The government could make clearer its commitment to nuclear safety, security and non-proliferation (3S).	The mandate given to the NEWG in April 2021 by the memorandum of the cabinet meeting of the Government of the Republic does address these issues, but it does not specifically highlight them.	In the event that the Riigikogu takes a positive decision on the introduction of nuclear energy, these three points will be clearly stated in the renewal of the NEWG mandate.
	S: The composition of the NEWG could be extended	At the moment, the NEWG members are the ministries, the KeA, TTJA	In the case of a positive decision, the NEWG will be extended in phase 2





		and the Government Office. Other state authorities and state- owned companies are involved through their respective ministries and through sub-working groups, which also include stakeholder representatives. However, NEWG members do not include the possible project developer or the network operator.	to include representatives of the most relevant institutions/stakeholders .
	E: Finalise the final report of the NEWG	The final report was not ready when the mission took place	Final report of the NEWG will be completed by the end of 2023
	S: Review the timetable for the implementation of the nuclear energy programme	Compared to the initial timetable for the preparation of the mission, there have been additions and changes to the planned activities, which need to be reflected in the timetable.	An updated list of activities, timetable and a corresponding scheme will be presented in the final report of the NEWG by the end of 2023.
		external experts to assist with final report, which supports in	_
Funding	E: Finalise the analysis of the budgetary resources needed from the national budget in the next steps and include it in the final report.	At the time of the mission, the inputs for the budgetary needs of all sectors had not yet been received and therefore the budget table presented was not comprehensive.	Input on budgetary needs will be received by the end of November at the latest and will be included in the final report of the NEWG.
Legal framework	E: To further analyse the potential advantages and disadvantages of two separate sectoral laws (Radiation Act and TEOS) compared to	According to the IAEA guidelines, the preferred solution is to have a comprehensive nuclear law regulating all areas of radiological activities. Under the plan of the NEWG, however, the	Since in practice in many countries of the world the Radiation Act and the Nuclear Act are separate pieces of legislation, including for example Finland, the NEWG does not see the





	one comprehensive law.	Radiation Act would remain in force in Estonia and a separate TEOS would be created alongside it, which would regulate only the use of nuclear energy and refer to the provisions of the Radiation Act for some issues.	need for a merger of the Radiation Act and TEOS in Estonia at the moment, as this would in turn require a reorganisation of the existing and functioning system. Further justification of our considerations will be provided to the IAEA.
Non- proliferation measures	S: Develop a plan for adding to the state system for accounting for and control of nuclear material (SSAC)	No detailed plan for upgrading the nuclear material accountancy system has yet been drawn up.	The need for a supplemented nuclear material accountancy system will arise in the next phases of the implementation of the nuclear energy programme. The plan will be prepared by the nuclear regulator in cooperation with the IAEA, EURATOM, the operator and stakeholders.
Regulatory framework	E: Position the new nuclear regulator within the national system in such a way as to ensure its independence and discretion over the content of regulations.	The regulator should not be subordinate to a ministry/agency that is also involved in the operation of power plants or the development of the energy sector, to avoid conflicts of interest. The regulator must also be empowered to draw up regulations in its field of activity and decide on their content.	The analyses of the NEWG have taken into account the possibility that the regulator would be established as a subsidiary agency of the Ministry of the Environment. However, due to the merger of ministries, the placement of the regulator needs to be further analysed. The regulator must be given veto power over the content of ministerial regulations, so that the ministry cannot change the content of regulators against the will of the regulator.





	S: Analyse options for	The regulator will be	In the case of a positive		
	establishing a regulator once TEOS enters into force	governed by TEOS, but as the process may take several years, it is already important to find a way to establish the regulator and recruit key personnel at this stage of the process.	decision, options for establishing a regulator and hiring key personnel will be analysed before TEOS enters into force.		
Human resource development	S: Launch a long-term human resources development strategy and a workforce management plan for key organisations	A capacity gap analysis and a human resources development strategy have been commissioned by the NEWG, but a detailed recruitment plan is needed for the followup, which includes information on when, in which institutions, with which competences and exactly how many specialists are needed.	Following a positive decision, a sub-working group on human resources development will be set up within the NEWG, under the leadership of the Ministry of Education and Research, to prepare a long-term human resources strategy.		
	regulator, where key com while also developing na	las been taken in recruiting the spetences are outsourced dur tional competences, which witation of the nuclear energy p	ing the start-up phase Il in turn support the		
Site and supporting facilities	S: More detailed thinking on the process for determining the criteria for site selection and licensing.	The materials submitted for the preparation of the mission described a site selection process based on the current national designated spatial plan process, which is due to be amended in the coming years.	A positive decision will be followed by a regulation on the criteria for the selection of the site. The final location must be confirmed by the nuclear regulator, which must be up and running at the time of confirmation.		
	H: The preliminary analysis of the sites also assessed the feasibility of establishing a geological disposal site for spent fuel, which will contribute to the implementation of the waste management part of the nuclear energy programme.				
Industrial involvement	E: Develop a national policy for the involvement of local industry in the	The current national industrial development plans and policy documents do not	In the event of a positive decision, find ways to involve local businesses in the implementation		





implementation of the nuclear energy programme. address the involvement of local industry in a possible nuclear programme.

activities of the nuclear energy programme.





#### 1. LATVIA

In recent years, Latvia has generated nearly two-thirds of its electricity from renewable energy sources, with hydropower accounting for the majority (55.6% of total electricity generation in 2022). Wind (3.8% of total electricity generation in 2022) and solar are also expected to be used to a lesser extent. Renewables accounted for 43.3% of total electricity generation in 2022 (a steady increase in recent years). Gas consumption has fallen by more than 42.2% over the last 10 years (and its share in the energy portfolio by 11.4 percentage points). In 2022, it accounted for 15.5% of total energy consumption. Latvia produces about 70% of the electricity it uses.

Latvia's targets are to further reduce the use of gas and increase the share of renewable energy. The national energy company Latvenergo wants to significantly increase its generation capacity and invest heavily in wind and solar energy in the next 5 years. One of the aims is to replace the declining share of natural gas with wind energy.

Although many politicians and entrepreneurs in Latvia have referred to the need for nuclear energy and the possibilities it offers, the actual steps taken have remained modest and rather reserved. Latvia has shown some interest in SMRs. In April 2022, the Latvia-US cooperation under the FIRST programme was announced. The cooperation project foresees an in-depth exchange of competences and knowledge in the field of workforce development, regulations and demonstration of new nuclear technologies, including SMR, to contribute to Latvia's energy independence and climate neutrality.

#### 2. LITHUANIA

Lithuania imports 70% of its electricity, meaning that its electricity production is small. Today, Lithuania generates 4 TWh of electricity, with a demand of 12 TWh. Local energy is mainly produced from biomass, but the share of other renewable energy sources is gradually increasing. In 2022, 15% of energy consumption resulted from renewable sources (12% wind and 3% solar), but in 2023 it is already 25% (20% wind and 5% solar). The goal is to generate all electricity from renewable energy sources by 2030 and to move from being an electricity-importing country to an electricity-exporting country.

The Lithuanian Parliament's spring session is expected to approve a new and ambitious energy strategy, which foresees 74 TWh of electricity from onshore and offshore wind and solar power in 2050. The vision also includes dispatchable capacities (gas and possibly nuclear). The government plans to make a decision on the introduction of SMRs in 2028. The construction of a new nuclear power plant has not been a serious topic since the closure of the Ignalina nuclear reactors.

#### 3. POLAND

Poland's electricity consumption is estimated to increase from 140 TWh in 2020 to 330–360 TWh in 2050. Poland still relies on fossil fuels for its energy production, which accounts for 85% of total energy production, including 70% from coal. The share of coal in electricity generation is expected to fall to 35% in 2030 and 8% in 2040. At the same time, the share of gas is projected to rise from 6% today to 15% in 2030 and to remain at the same level in 2040. Poland's new energy policy (PEP2040) foresees faster progress in the transition to renewables, while the ambition to phase out coal is reduced. The aim is not to become over-reliant on gas imports for energy production.





Renewable energy accounted for 17% of total energy production in 2022, well below the EU average. The main sources of renewable energy are onshore wind and biomass. PEP2040 foresees an increase in the share of renewable energy in electricity generation to 46.6% in 2030 and 50.8% in 2040, to be achieved through an increase in onshore wind capacity (from the current 9 GW to 20 GW) and the development of offshore wind farms.

The pressure to stop using coal is great and, in light of this, a political decision has been made to partially switch to nuclear power. Poland's first nuclear power plant was selected in September this year to be developed by US company Westinghouse. A 3,750 MW nuclear power plant will be built in 2026 in the Lubiatowo-Kopalino region. If the project develops without any obstacles, the target completion date is 2033. In addition to large reactors, there is also great potential for the development of SMRs in Poland, as they can be built on the sites of existing coal-fired plants and are planned to be financed by large industrial companies. It is projected that by 2040, nuclear power is expected to account for 22.6% of electricity generation.

#### 4. FINLAND

Finland's share of renewable energy in total energy consumption in 2022 was 42%, including woodfuel 28.5% (woodfuel for industry and energy production 12.8%, black liquor 11%, small-scale wood use 4.7%), hydropower 3.7%, wind 3.2%, other renewable energy 6.4% (including solar, biogas, heat pumps, biofuels). In the future, there will be a big push for onshore and offshore wind farms.

The share of nuclear energy in total consumption was 20.4% in 2022. The newest nuclear reactor, Olkiluoto 3, started full operation in spring 2023. There are no new announcements on the suspended Hanhikivi nuclear power plant project in Pyhäjoe, with the local authority working out how to proceed with the already partly developed area.

The establishment of SMRs, in particular to provide central heating, has been discussed, and there are research projects on the subject. As the current legislation is made with full-scale nuclear plants in mind, the Finnish Ministry of Economic Affairs and Employment plans to bring into force amendments to legislation to consider SMRs by 2026.

#### 5. SWEDEN

Biomass accounts for the largest share of Sweden's energy consumption (28%), followed by nuclear energy (27%) and oil and petroleum products (20%). Wind and nuclear energy capacity is to be increased, and work is also underway on hydrogen solutions. Hydropower production is already close to its maximum, experts say. Swedish electricity consumption is projected to grow from 137 TWh in 2022 to 373 TWh in 2050. Total energy consumption in Sweden is currently 508 TWh (as of 2020). The SMR subject is being analysed and considered as an alternative.

The Swedish government has replaced its previous target of 100% electricity from renewable sources by 2040 with a new target of 100% fossil-free electricity generation by 2040, paving the way for the continuation of nuclear power. Sweden plans to make a strong transition to nuclear energy and double nuclear energy generation by 2045. In 2024, two draft acts will be presented to Parliament, the energy and energy research act. The energy balance will be based on security of supply and not on the source of energy production. The Swedish parliament decided to phase out nuclear power in the 1980s (with the support of a referendum). In line with the decision, reactors have been shut down in stages. To date, 6 reactors are still in operation at three sites (Forsmark, Oskarshamn, Ringhals).





Since the end of last year, a number of analyses have been carried out on continuing with nuclear energy, including a cost-benefit analysis for new reactors commissioned from the national energy company Vattenfall. As Sweden was in the process of phasing out nuclear power, the implementation of the new policy would take time (regulation, permits) and be a costly investment. The government has promised to shorten the licencing process and additional investment, but despite this, the earliest deadline for opening new reactors is the 2030s.

#### 6. DENMARK

Denmark is one of the EU's leading producers and consumers of renewable energy. In 2021, renewable energy accounted for 46% of Denmark's total energy consumption, with liquid fuels accounting for 37%, gas for 12% and other fossil fuels for 6%. The share of renewable energy in electricity consumption was as high as 81%. With this figure, Denmark is the greenest electricity consuming country in the EU. Fossil fuels are still important in the transport sector in Denmark, where the share of renewable energy is close to 10%. Gas is mainly used for heating.

Denmark's target is to cut emissions by 70% by 2030 and reach climate neutrality in 2050, as agreed by the EU. By 2030, Denmark aims to switch to 100% renewable energy in electricity generation.

The most important source of renewable energy in Denmark is biomass (72%), which is mainly used to generate heat. However, if we look at electricity consumption alone, the share of wind energy is close to 50%. Increasingly, there are hours in the days in Denmark when all the electricity is generated by wind. Denmark already has 15 offshore wind farms with a total capacity of 2,300 MW, but there are plans to build more and with more capacity. The world's first offshore wind farm was established in Denmark back in 1991. Decisions to commit to renewable energy, and wind energy in particular, were made in Denmark as early as the 1970s, during the oil crisis, when the Danish energy economy was almost entirely dependent on imported oil.

In addition to the desire to get rid of oil dependency, Danes were also motivated to develop renewable energy by their anti-nuclear stance. Although nuclear power was also considered in Denmark in the 1970s, it is no longer a subject. Anti-nuclear sentiment tends to prevail in Danish society. In 1985, the Danish Parliament decided that no nuclear power plants would be built in the country. At the same time, the Danish company Seaborg Technologies is developing a 100 MW molten salt reactor on a floating barge, the first of which is expected to be completed in 2028<sup>116</sup>.

#### 7. NORWAY

Norway's total energy consumption (including the gas and oil industry on the Norwegian continental shelf) was 326 TWh in 2021. Of this, 138 TWh was electricity, 165 TWh fossil fuels, 16 TWh bioenergy and 7 TWh district heating (also partly based on bioenergy). Historically, electricity in Norway has been generated by hydroelectric power stations: In 2022, hydropower accounted for 86% of electricity generation and other generation for 14% (including 8% wind). Renewable energy accounted for 44% of total primary energy consumption. In 2050, 76% of primary energy consumption should come from renewable sources: wind, hydro, bio and solar. The main increase in the share of renewable energy will come from wind, with offshore wind being the most important. The share of gas used for hydrogen production, as well as for the oil and gas industry's own use, remains important.

<sup>116</sup> https://www.seaborg.com/the-reactor





Total energy consumption growth is not projected to be high, and is expected to remain at essentially the same level in 2050 as today. The increase in energy demand resulting from population and economic growth will be offset by improvements in energy efficiency from electrification. However, the growth in electricity consumption by 2050 is significant: 373 TWh compared to 145 TWh in 2022. Here, the lion's share of the increase will come from offshore wind: an estimated 136 TWh. This will certainly depend on technological developments and hydrogen demand. More conservative estimates suggest that by 2050. Norway's electricity consumption could be in the range of 190–232 TWh. However, both in relative and absolute terms, electricity consumption growth is significant.

Nuclear energy has a minimal share among Norwegian energy sources. During periods when Norway imports electricity, part of the energy may come from nuclear power plants in neighbouring countries. There are currently no plans to develop nuclear power plants in Norway. However, there is a strong lobby for the introduction of SMRi in the country (Norsk Kjernekraft), which has the support of a number of wind-sceptical municipalities. The major parties do not rule out discussing nuclear power, but the current energy minister does not consider nuclear power necessary for Norway. A recent analysis commissioned by the Confederation of Norwegian Employers found that SMR cannot be a viable alternative before 2050. This is due, among other things, to the high cost of energy produced by SMR compared to alternatives (onshore and offshore wind) and the debate would distract attention from the more important issue of wind energy development.

#### 8. GERMANY

Germany's goal is to achieve climate neutrality by 2045, and this is also reflected in the development of the electrical grid. A massive increase in renewable energy production is a key element in decarbonising the economy. Germany's electricity consumption is expected to grow from 600 TWh today to around 1,000 TWh in 2045. The electricity will need to be provided by onshore wind, solar, offshore wind, green electricity imports and green hydrogen power plants in the future. However, natural gas will continue to play an important role over the next few years, as German industry and private household heating relies on gas, and it will take time to replace it with renewable energy. In 2022, the share of renewable energy in total electricity consumption was 46%. The aim is to raise this to at least 80% by 2030, which will require the production of 600 TWh of green electricity. By 2035, almost all electricity generation must be from renewable energy and green hydrogen.

In terms of increasing offshore wind generation, the aim is to achieve a capacity of at least 30 GW by 2030, at least 40 GW by 2035 and at least 70 GW by 2045. To this end, planning and authorisation procedures have been sped up and the auction areas extended. In the development of onshore wind energy, the target is to make 2% of onshore land available for wind energy production. The target is to install 215 GW of solar capacity by 2030. The rules have been significantly relaxed to expand solar generation. A target of 10 TWh of geothermal heat has also been set for the coming years.

In April 2023, Germany's last three nuclear power plants ceased operation after an extension of four months due to the energy crisis. While all political parties have previously supported the abandonment of nuclear energy, the CDU/CSU, for example, have now strongly criticised the nuclear phase-out. The FDP's proposal to keep the last three plants in reserve did not find majority support in the Bundestag. A total of 1,900 containers of spent nuclear fuel in interim storage are awaiting disposal in Germany. A decision on the location of the final disposal site should be taken by 2031 at the latest. New investment in nuclear power is not considered to be prudent, but the FDP believes that investment in thermonuclear power is certainly an option for the future.

The last coal-fired power plants are scheduled to close by 2038 at the latest. At the end of 2022, a legal amendment was approved that obliges the end of lignite mining in the Rhine mining area by 2030. By





the end of 2023, the federal government wants to present a power plant strategy setting targets for the construction of dispatchable (hydrogen-fired) power plants to balance renewable energy.

#### 9. FRANCE

Nuclear power continues to dominate France's energy mix. At the beginning of 2022, 63% of energy production was nuclear, 8% wind, 11% gas, 10% hydro, 9% solar, 2% bio. France's energy strategy focuses on two main pillars: renewable and nuclear energy.

The most preferred renewable energy sources are solar, offshore and onshore wind. Solar energy production is set to increase 10-fold to over 100 GW by 2050. In terms of offshore wind, 50 offshore wind farms are expected to be built to generate 40 GW by 2050. Onshore wind currently produces 18.2 GW per year and is expected to double by 2050.

The national strategy for nuclear energy has changed: while a few years ago the aim was to phase it out, the plan is now to increase production to 360 TWh. The country has two main priorities on this subject: (1) no operational reactors in the existing nuclear fleet will be shut down (except for safety reasons) and the possibility of extending the lifetime of existing reactors beyond 50 years will be explored; (2) the construction of 6 EPR2 reactors and possibly 8 additional reactors. In addition, the state will contribute €1 billion to the development of more innovative reactors, including the NUWARD SMR.

The country's ambition is to phase out fossil fuels by 2050, while the latter, led by oil and gas, still account for 60% of energy consumption today. In this respect, two targets have been set: to halve the share to 42% in 2030 and 29% in 2035. This in turn will lead to an increase in electricity consumption. According to the electricity system operator RTE, France needs to produce 35% more electricity by 2050 and in 30 years' time electricity should account for more than 55% of French people's energy consumption. According to the French national electricity company EDF, this figure is underestimated. President Macron has, for example, mentioned that in the coming decades they must be ready to produce up to 60% more electricity than today, because electricity consumption is a growing trend.



### Expenses from the state budget (excluding emergency response and technical capacity) for years 0–11 of the introduction of nuclear energy

Year	Activity	Cost (€)	<b>Explanation</b>
	Analyses and consultancy services	150,000	Including considering the proposals of the IAEA INIR mission, partly funded by R&D.
	Legislation	100,000	Finding a legal partner for the legislative sub-working groups, commissioning draft regulations.
	Additional personnel	33,600	2 positions starting in the 4th quarter of year 0 with a salary fund of €4,200 per month per person (gross salary approx. €3,200).
0	Communication	55,000	Commissioning a communication strategy, information events and materials
	Human resource development	30,000	IAEA, FIRST training, with mission expenses, outsourced training from technical support organisations (TSOs).
	Total:	368,600	Possible sources of external funding: IAEA technical cooperation programme, US (FIRST, GTRI, NNSA, Phoenix), EU Structural and R&D Funds, fellowship programmes.
	Regulatory personnel	1 584,000	24 people with an average monthly salary of €5,500. No account has been taken of the existing staff (18 in) in the Environmental Board who would be transferred to the new regulatory body with the existing salary fund.
1	Human resource development	222,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
	Higher education programmes	800,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.





Administrative costs of the regulator	144,000	€500 per month per person for 24 people (based on Workland's business rates).
Analyses and consultancy services	250,000	
Additional personnel of NEWG	252,000	2 positions created in 2024 + 5 positions with a salary fund of €4,200 per month.
Total:	3,252,000	
Regulatory personnel	2,310,000	35 people with an average monthly salary of €5,500.
Human resource development	305,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
Higher education programmes	1,160,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.
Administrative costs of the regulator	210,000	Calculated at €500 per month per person for 35 people (Workland example)
Analyses and consultancy services	350,000	
Additional personnel of NEWG	252,000	5 positions with a salary fund of €4,200 per month
Total:	4,587,000	
Regulatory personnel	3,300,000	50 people with an average monthly salary of €5,500.
Human resource development	350,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
Higher education programmes	1,270,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the
	costs of the regulator  Analyses and consultancy services  Additional personnel of NEWG  Total:  Regulatory personnel  Human resource development  Administrative costs of the regulator  Analyses and consultancy services  Additional personnel of NEWG  Total:  Regulatory personnel of NEWG  Higher education programmes	costs of the regulator  Analyses and consultancy services  Additional personnel of NEWG  Total: 3,252,000  Regulatory personnel 2,310,000  Human resource development 21,160,000  Administrative costs of the regulator Analyses and consultancy services  Additional personnel of NEWG  Total: 4,587,000  Regulatory 33,300,000  Regulatory and consultancy services  Additional personnel of NEWG  Total: 4,587,000  Regulatory and analyses and consultancy services  Additional personnel of NEWG  Total: 4,587,000





			development of curricula to create training opportunities in Estonia.
	Administrative costs of the regulator	300,000	€500 per month per person for 50 people (based on Workland's business rates).
	Analyses and consultancy services	500,000	
	Additional personnel of NEWG	252,000	5 positions with a salary fund of €4,200 per month
	Total:	5,972,000	
	Regulatory personnel	4,290,000	65 people with an average monthly salary of €5,500.
	Human resource development	395,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
	Higher education programmes	1,220,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.
4	Administrative costs of the regulator	390,000	€500 per month per person for 65 people (based on Workland's business rates).
	Analyses and consultancy services	650,000	
	Additional personnel of NEWG	252,000	5 positions with a salary fund of €4,200 per month
	Total:	7,197,000	
5	Regulatory personnel	5,280,000	80 people with an average monthly salary of €5,500.
ວ	Human resource development	440,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.





Higher education programmes	1,320,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.
Administrative costs of the regulator	480,000	€500 per month per person for 80 people (based on Workland's business rates).
Analyses and consultancy services	500,000	
Additional personnel of NEWG	252,000	5 positions with a salary fund of €4,200 per month
Total:	8,272,000	
Regulatory personnel	5,478,000	83 people with an average monthly salary of €5,500.
Human resource development	449,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
Higher education programmes	1,320,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.
Administrative costs of the regulator	498,000	€500 per month per person for 83 people (based on Workland's business rates).
Analyses and consultancy services	450,000	
Additional personnel of NEWG	252,000	5 positions with a salary fund of €4,200 per month
Total:	8,447,000	
Regulatory personnel	5,148,000	83 people with an average monthly salary of €5,500.
	Administrative costs of the regulator  Analyses and consultancy services  Additional personnel of NEWG  Total:  Regulatory personnel  Human resource development  Higher education programmes  Administrative costs of the regulator  Analyses and consultancy services  Additional personnel of NEWG  Total:  Regulatory	Administrative costs of the regulator  Analyses and consultancy services  Additional personnel of NEWG  Total: 8,272,000  Regulatory personnel 449,000  Human resource development 1,320,000  Administrative costs of the regulator  Analyses and consultancy services  Additional personnel 252,000  Administrative costs of the regulator 498,000  Analyses and consultancy services  Additional personnel of NEWG  Total: 8,447,000  Regulatory 5,148,000





	Human resource development	434,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
	Higher education programmes	1,110,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.
	Administrative costs of the regulator	468,000	€500 per month per person for 78 people (based on Workland's business rates).
	Analyses and consultancy services	400,000	
	Additional personnel of NEWG	252,000	5 positions with a salary fund of €4,200 per month
	Total:	7,812,000	
	Regulatory personnel	4,818,000	73 people with an average monthly salary of €5,500.
	Human resource development	419,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
		419,000 960,000	_
8	development  Higher education		regulator training, scholarship programmes.  Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training
8	Higher education programmes  Administrative costs of the	960,000	regulator training, scholarship programmes.  Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.  €500 per month per person for 73 people (based
8	Higher education programmes  Administrative costs of the regulator  Analyses and consultancy	960,000 438,000	regulator training, scholarship programmes.  Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.  €500 per month per person for 73 people (based





9	Regulatory personnel	4,422,000	67 people with an average monthly salary of €5,500.
	Human resource development	401,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
	Higher education programmes	960,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.
	Administrative costs of the regulator	402,000	€500 per month per person for 67 people (based on Workland's business rates).
	Analyses and consultancy services	300,000	
	Additional personnel of NEWG	252,000	5 positions with a salary fund of €4,200 per month
	Total:	6,737,000	
	Regulatory personnel	4,422,000	67 people with an average monthly salary of €5,500.
		4,422,000 395,000	
	personnel Human resource		€5,500.  Training for staff of NEWG member institutions,
10	personnel  Human resource development  Higher education	395,000	€5,500.  Training for staff of NEWG member institutions, regulator training, scholarship programmes.  Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training
10	personnel  Human resource development  Higher education programmes  Administrative costs of the	395,000 960,000	€5,500.  Training for staff of NEWG member institutions, regulator training, scholarship programmes.  Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.
10	Personnel  Human resource development  Higher education programmes  Administrative costs of the regulator  Analyses and consultancy	395,000 960,000 402,000	€5,500.  Training for staff of NEWG member institutions, regulator training, scholarship programmes.  Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.





11	Regulatory personnel	4,092,000	62 people with an average monthly salary of €5,500.
	Human resource development	386,000	Training for staff of NEWG member institutions, regulator training, scholarship programmes.
	Higher education programmes	960,000	Training the specialists in Estonian universities (train-the-trainers), cooperation agreements with foreign universities to train specialists or the development of curricula to create training opportunities in Estonia.
	Administrative costs of the regulator	372,000	€500 per month per person for 60 people (based on Workland's business rates).
	Analyses and consultancy services	300,000	
	Additional personnel of NEWG	252,000	5 positions with a salary fund of €4,200 per month
	Total:	6,362,000	Remains a fixed annual cost during the lifetime of the plant
	For years 0–11 in total:	72,924,600	There will be additional costs for emergency response and technical capacity, capacity building of up to €54 million.





- 1. Tuumaenergia töörühma kommunikatsioonistrateegia, META Advisory Group OÜ (October 2022) (asutusesiseseks kasutamiseks);
- Julgeoleku ja hädaolukordadeks valmisoleku analüüs, tuumajulgeoleku ja hädaolukordadeks valmisoleku alltöörühm Rahvusvahelise Kaitseuuringute Keskuse SA materjalide põhjal (June 2023) (internal use only, public summary "<u>Tuumajulgeolek ja hädaolukordadeks</u> <u>valmistumine</u>");
- 3. Julgeoleku ja hädaolukordadeks valmisoleku analüüsi Lisa 1 "Kulude analüüs", tuumajulgeoleku ja hädaolukordadeks valmisoleku alltöörühm asutuste sisendi põhjal (December 2023) (internal use only);
- 4. <u>Tuumaenergia töörühmale inimressursside arendamise strateegia ja regulatiivse raamistiku kaardistamine</u>, Advokaadibüroo SORAINEN AS (March 2023);
- 5. <u>Õigusraamistiku kaardistamine tuumaprogrammiga alustamiseks</u>, TRINITI Advokaadibüroo AS (March 2023);
- 6. Tuumaseaduse eelnõu ajakohastamine, väljatöötamiskavatsuse ja seletuskirja koostamine, TRINITI Advokaadibüroo AS (November 2023), (internal use only);
- 7. <u>Tuumaelektrijaama ja kasutatud tuumkütuse lõppladustuspaiga potentsiaalsete asukohtade eelanalüüsi vahearuanne,</u> Skepast&Puhkim OÜ and OÜ Inseneribüroo STEIGER (December 2022);
- 8. <u>Tuumaelektrijaama ja kasutatud tuumkütuse lõppladustuspaiga potentsiaalsete asukohtade</u> eelanalüüsi lõpparuanne, Skepast&Puhkim OÜ and OÜ Inseneribüroo STEIGER (May 2023);
- Kasutatud tuumkütuse ja radioaktiivsete jäätmete käitlemise analüüs, Breitenstein-Solutions (July 2023);
- 10. Kiirguskaitse analüüs, STUK International OY, STUK International OY (July 2023);
- 11. Tuumamaterjali kaitsemeetmete analüüs, Proxion Plan OY (August 2023).
- 12. <u>Küsitluse Tuumaenergia valdkonna teadlikkus ning valmisolek selle kasutuselevõtuks Eestis aruanne</u>, Emor AS (April 2022)
- 13. <u>Küsitluse Eesti elanike teadlikkus tuumaenergiast ning valmisolek selle kasutuselevõtuks Eestis aruanne</u>, Norstat Eesti AS (May 2023)
- 14. <u>Küsitluse Tuumaenergia valdkonna teadlikkus ning valmisolek selle kasutuselevõtuks Eestis aruanne</u>, Norstat Eesti AS (October 2023);
- 15. IAEA INIR missiooni tulemuste aruanne (internal use only until 17 January 2024)

Study reports and additional supplementary materials are available on the website of the Ministry of Climate:

https://kliimaministeerium.ee/elurikkus-keskkonnakaitse/kiirgus/tuumaenergia-tooruhm

