Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

For the future of our environment

Radioactivity and Wind Farm Developments on peatlands

July 2025

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Radioactive Fallout in Scotland and Development of Windfarms

Overview

In recent months, SEPA has become aware of public concern in relation to disturbance of peatland areas by wind farm (or any other form of) construction and the potential for re-mobilisation of historic contamination from Chernobyl and other gaseous emissions. In response to this concern, SEPA has considered the published scientific data on, and reconsidered the potential impact from, key exposure pathways. Radiological dose assessments have been conducted considering potential exposure pathways and environmental concentrations of contamination of Cs-137 that would be necessary to breach the 1 millisievert limit as prescribed by the Environmental Authorisations (Scotland) Regulations 2018 (as amended) together with the dose constraints. In conclusion, SEPA does not regard that that potential resuspension of buried Cs-137 and other radionuclides arising from global deposition on peatlands in Scotland to pose a realistic risk to human health.

Background

The Chernobyl nuclear incident in April 1986 spread radioactive contamination across Europe, including the United Kingdom with upland areas being more susceptible to higher concentrations of radionuclides, including Caesium-137 (Cs-137) as the prime nuclide of concern.

Table 1: Selected radionuclides released by Chernobyl accident [1]

Radionuclide	Half-Life	Release (Exabecquerel)
Iodine-131 (I-131)	8.04 days	1.8
Caesium-134 (Cs-134)	2.06 years	8.5E-02
Caesium-137 (Cs-137)	30 years	4.7E-02
Strontium-90 (Sr-90)	29.12 years	1E-02
Plutonium-241 (Pu-241)	14.4 years	3E-03

Of the radionuclides released in the Chernobyl accident, in Scotland, Caesium-137 is the main contributor to radiation dose. Assessments conducted by the United Nations Scientific Committee on the Effects of Atomic Radiation showed that Cs-137 was responsible for approximately 75% of the effective dose during the first year following the accident in areas above 55 degrees North. Figure 1 shows the breakdown of radiation dose by pathway and by radionuclide.

[1] Briefing European Parliamentary Research Service

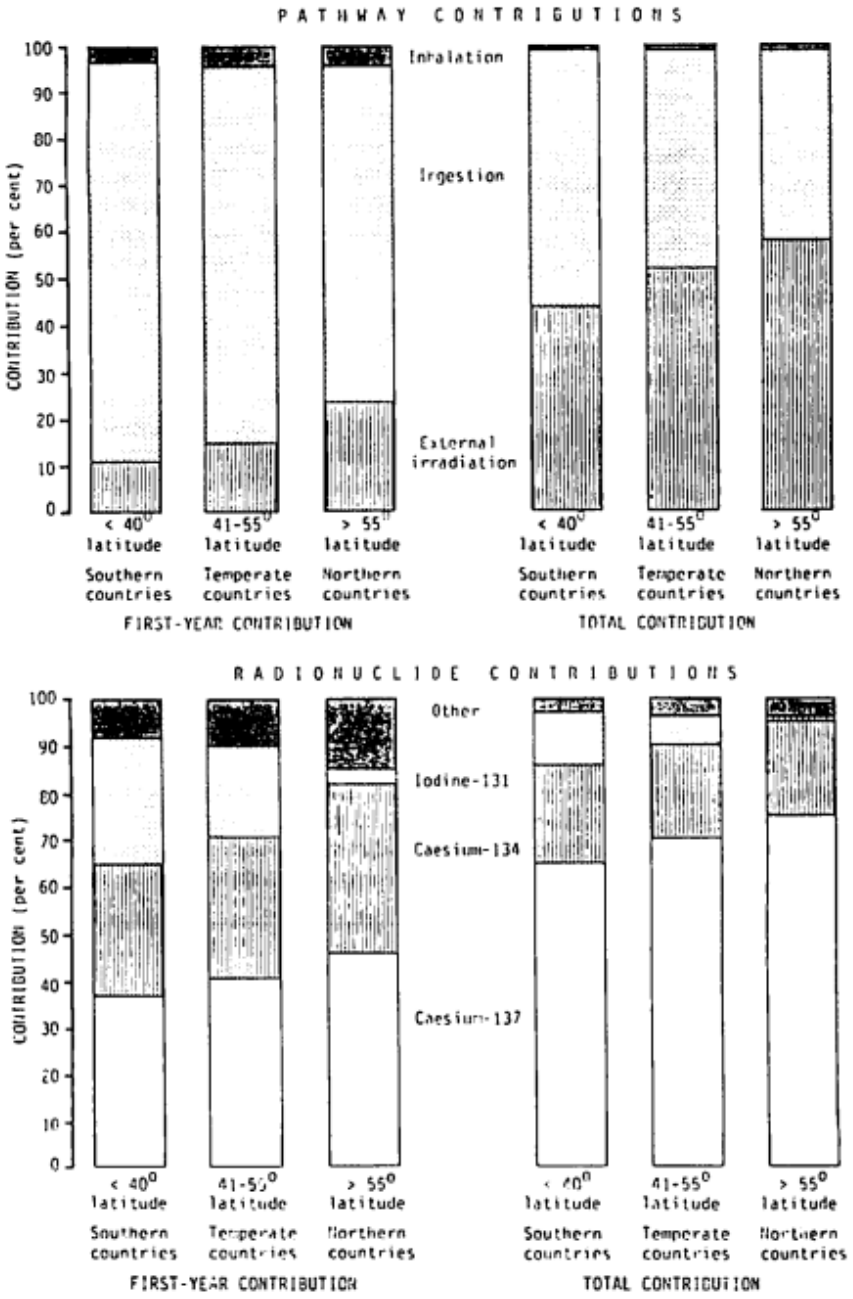

Figure 1: Pathway and Radionuclide Contribution to the first-year effective dose equivalent (1988 UNSCEAR Report [2])

As Scotland's environment regulator, SEPA are responsible for ensuring that no member of the public receives a radiation effective dose of 1 millisievert per year from all permitted sources under the Environmental Authorisations (Scotland)

[2] UNSCEAR 1988 Report - Annex D

Regulations 2018 [3] (as amended). Alongside this, as part of our duties, SEPA undertake a comprehensive environmental radioactivity monitoring programme throughout Scotland. The monitoring is primarily focussed on the impacts of large sources of radioactivity, such as nuclear licensed sites like Dounreay and Sellafield; however, SEPA also undertake background monitoring (water, milk, crops, diet etc) to provide additional data. All of the results are published each year in the Radioactivity in Food in the Environment [4] report.

Chernobyl and regional monitoring were contained as a separate chapter (normally Chapter 7 or 8) of the report for many years. SEPA are aware of the restrictions on livestock sales up until clearance in 2012 in the UK, although the last farms in Scotland were de-restricted in 2010.

Dose Assessment Parameters

Hazard is the harm that an object poses to an individual. Risk is the probability of that hazard causing harm. These are two different concepts that SEPA consider in our radiological assessments.

Using extreme values for dose assessments provides additional layers of protection and takes a very conservative approach. SEPA is directed to utilise the dose coefficients from the International Commission on Radiation Protection (ICRP), particularly those published in ICRP 119[5]. Rates of inhalation, ingestion and dose coefficients are provided in Tables 2, 3 and 4.

[3] Environmental Authorisations (Scotland) Regulations 2018 | Scottish Environment Protection Agency (SEPA)

[4] Radioactivity in Food and the Environment (RIFE) reports

[5] ICRP 119 - Compendium of Dose Coefficients based on ICRP Publication 60

Table 2: Inhalation and Ingestion Rates

Age Group	Inhalation rate (litres/year)	Ingestion Rate Basis of beef	Ingestion Rate of beef (kg/y)
1-year old	1.9E+06	20% adult rate	20
10-year old	5.6E+06	70% adult rate	70
Adult	8.1E+06	100% adult rate	100

Note: Inhalation values based on ICRP 119. Highest adult consumption of beef across EU countries in 1995 was France at 29 kg/y. Value of 100 kg/y is set as an extreme value. Ratios based on ICRP 119. (Source European Commission, SEC(97) 819 final, Situation and Outlook, Beef Sector - 3483.pdf (https://aei.pitt.edu/3483/1/3483.pdf) (ICRP 119, 2012)

Table 3: Inhalation Dose Coefficients

Age Group	Fast Inhalation Dose Co-efficient Cs-137 (Sv/Bq)	Medium Inhalation Dose Co-efficient Cs-137 (Sv/Bq)	Slow Inhalation Dose Co-efficient Cs-137 (Sv/Bq)
1 year old	5.4E-09	2.9E-08	1.0E-07
10 year old	3.7E-09	1.3E-08	4.8E-08
Adult	4.6E-09	9.7E-09	3.9E-08

Note: Fast, moderate and slow relate to the rates of absorption into blood. The f1 value for each is 1, 0.2 and 0.02, respectively, and is defined as the fraction of an ingested element absorbed directly into body fluids. (Source ICRP 119, 2012)

Table 4: Ingestion Dose Coefficients (Source ICRP 119, 2012).

Age Group	Ingestion Dose Coefficient Cs-137 (Sv/Bq)
1-year old	1.2E-08
10-year old	1.0E-08
Adult	1.3E-08

Dose Assessment Results

Table 5 details the calculated concentrations for the relevant pathways to deliver a dose of 1milliSievert (which is the equivalent of 1,000 microsieverts) per year.

Table 5: Calculated Cs-137 Concentration Required for 1,000 microSieverts (Public Dose Limit)

Age Group	Inhalation (Bq/m^3)	Ingestion (Bq/kg)	Pica (Bq/kg)
1-year old	97.5	4.20E+03	4.60E+04
10-year old	49.5	1.43E+03	5.50E+04
Adult	27.0	7.70E+02	4.25E+04

Note: Pica is the craving or consumption of objects that are not normally intended to be consumed. In this case we have assumed consumption of soil at 5,000 [6]mg/day.

[6] Exposure Factors Handbook Chapter 5 (Update): Soil and Dust Ingestion | Environmental Assessment | US EPA

These values are reviewed for each pathway below to demonstrate that such values have not been recorded in Scotland and as such people will not be exposed to greater than 1mSv.

Inhalation Pathway

The calculated concentrations for inhalation doses have not been measured in Scotland even during the Chernobyl incident. A potential inhalation pathway would be via resuspension of Cs-137 by excavation or wildfire. Wildfire would make the Cs-137 more available in the environment as it released from the soil, however as demonstrated by the dose assessment above, the concentrations necessary to result in a breach of the public dose limit are far in excess of those reported during the Chernobyl incident. Concentrations across Europe were much lower during the time of the incident and doses to those in the UK were estimated to be in the region of 40 microsieverts per year[7]. Examples of measured concentrations of Cs-137 in air following the Chernobyl and Fukushima incidents are given in Figure 2 and Table 6.

[7] UNSCEAR 1988 Report - Annex D

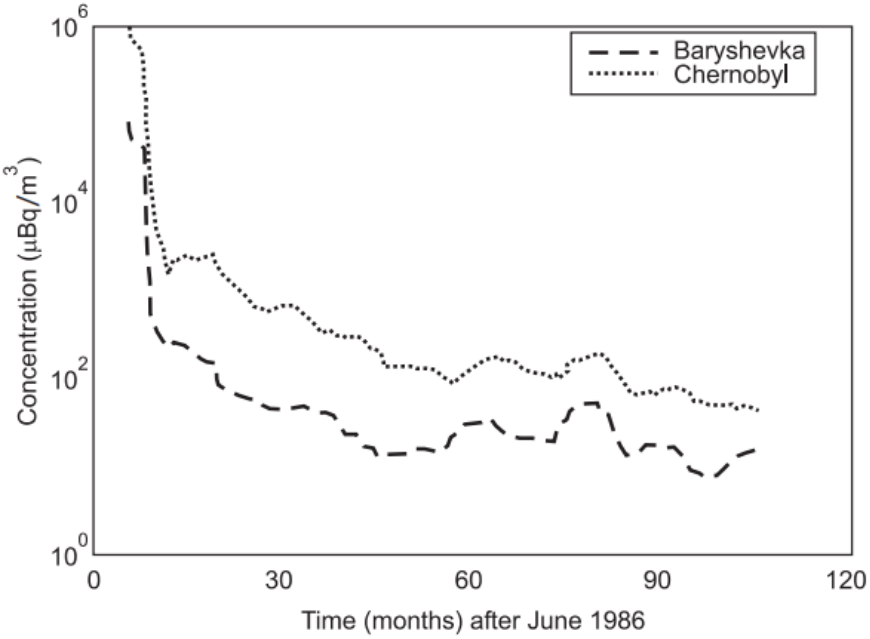

Figure 2: The concentrations of Cs-137 in air at Chernobyl and Baryshevka (~200 km distant) during 1986-1994[8].

Table 6: Measured concentrations of Cs-137 in air for comparison

Area	Cs-137 Measurements (Bq/m^3)
Chernobyl, contaminated area of red forest during wildfires (2020)	7E-04[9]
Chernobyl (from Figure 2) 1986 – 94	1E-03 – 1
Fukushima (2011 at time of incident)	16[10]

[8] Environmental consequences of the Chernobyl accident and their Remediation: Twenty years of experience

[9] Estimation of Cs-137 emissions during wildfires and dust storm in Chernobyl Exclusion Zone in April 2020 using ensemble iterative source inversion method - ScienceDirect (700 microBq/m^3 maximum detected daily average volume concentration measured in Kyiv, 11 April 2020)

[10] Fukushima Nuclear Accident Update Log | IAEA

Therefore, SEPA conclude that the inhalation pathway arising from windfarm construction is not of regulatory concern as it does not represent a realistic risk to the public.

Ingestion Pathway

For the ingestion (contaminated foodstuffs) pathway, SEPA have demonstrated the Cs-137 concentrations required in food to reach the public dose limit based on an extreme consumption of 100 kg/y for meat for adults (Table 5). For comparison, the highest beef consumption in Europe was found to be in the region of 29 kg/y in France so the basis of SEPA's assessment is highly conservative (over three times this rate). The highest concentration of Cs-137 in Europe was found to be in reindeer meat in Finland in the aftermath of Chernobyl, where values of up to 720 Bq/kg[11] were found. Also in Finland, wild mushrooms measured on average 6,600 Bq/kg in 1986 and can contain up to 940 Bq/kg post-Chernobyl[12], however the concentrations in the UK now will be much less due to radioactive decay since 1986 and the distance from Chernobyl. It is also notable that wild food consumption rates will not reach 100 kg per year, so doses would be scaled accordingly. Given that the activity since 1986 has decayed by half, there is no realistic possibility that these concentrations would be seen in Scotland.

Calculated concentrations to reach the public dose limit in Table 5 demonstrate that such doses are not possible at this time.

Pica Pathway

The final dose assessment undertaken is for a condition known as pica. Pica is an extremely rare medical condition where an individual seeks to consume non-nutritional objects, such as coal and soil. US EPA gives a guideline value for 5,000 mg/day for a single habitual pica consumer. The dose is modelled as a deliberate consumption of contaminated soil on an annual basis (kg/y). This is considered an extreme and unlikely pathway of exposure and would have non-radiological

[11] Cs-137 concentration in reindeer and its fodder plants

[12] Radioactivity in sold natural produce | Säteilyturvakeskus STUK

consequences for the individual prior to any radiological exposure taking effect in this case.

The results in Table 5 show that an individual would need to consume soil at a concentration that has not been measured in Scotland, consistently for one year to reach the public dose limit. Given that the concentration has not been identified in Scotland and the fact that the condition is extremely rare, SEPA considers that deliberate ingestion of contaminated soil does not pose a realistic risk to members of the public in Scotland.

Additional Monitoring

In addition, SEPA is also undertaking a small sampling programme of peat soils at four locations across Scotland near to proposed windfarms to check that the environmental concentrations of Cs-137 are not as high as these extreme theoretical concentrations given in Table 5. If these results do not give cause for concern, SEPA will take no further action. SEPA have no reason to believe that our current assessments require us to take any action. This monitoring data will be published on our website and in the Radioactivity in Food and the Environment (RIFE) Report alongside other data from 2025 in October 2026.

Conclusions

For the reasons of:

(i) known measured concentrations being lower than those used in the SEPA dose calculation, and;

(ii) extreme rates used in modelling to breach the statutory dose limit,

SEPA believes that there is no realistic risk posed to the public by any Cs-137 contamination from either dry dust/wildfire release, inhalation, ingestion or deliberate soil consumption exposure as a result of any release due to windfarm construction in Scotland.

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