NUCLEAR INDUSTRY IN THE EU

Generates 26% of the EU’s electricity

Electricity generation by technology (% in 2019)

- Nuclear: 26%
- Gas: 19%
- Coal: 17%
- Wind: 13%
- Hydro: 12%
- Other sources of energy: 11%
- Biofuels: 5%
- Solar: 4%
- Oil: 2%
- Waste: 1%
- Oil: 2%
- Other sources of energy: 1%

Generates electricity in 13 countries:

- France: 70%
- Slovakia: 53%
- Hungary: 48%
- Bulgaria: 40%
- Belgium: 39%
- Slovenia: 37%
- Czech Republic: 37%
- Finland: 33%
- Sweden: 29%
- Spain: 22%
- Romania: 19%
- Germany: 11%
- Netherlands: 3%

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Creating jobs that drive employment and prosperity

The construction of one new reactor (EPR) in the EU generates up to 10,000 jobs in total.

The European nuclear industry supports 1 million jobs.

Operation of a nuclear reactor provides highly-skilled jobs for two generations of workers.

© nucleareurope - Source: Deloitte 2019
COMPETITIVENESS OF NUCLEAR ENERGY

Providing reliable energy...

Energy performance:

- Nuclear produces electricity at full power 85 to > 90% of the time thus enhancing security of supply.
- % of rated capacity factor:
  - Nuclear: 85-90%
  - Coal: 80%
  - Offshore Wind: 27-44%
  - Gas: 24-40%
  - Onshore Wind: 20-36%
  - Solar: 10-21%

...at prices you can afford

Comparison of median LCOE (levelized cost of electricity) for different technologies in Europe (7% discount rate):

- Nuclear (LTO, 20 years): 25 €/MWh
- Nuclear (LTO, 10 years): 28 €/MWh
- Onshore wind (>=1 MW): 49 €/MWh
- Solar (utility scale): 54 €/MWh
- Gas: 64 €/MWh
- Biomass: 68 €/MWh
- Reservoir hydropower: 71 €/MWh
- Nuclear (New Build): 73 €/MWh
- Off-shore wind: 74 €/MWh
- Geothermal: 102 €/MWh

* LCOE metrics are not sufficient to characterize the competitiveness of different power generating technologies. A comparison should include system costs, i.e. networks and flexibility costs in addition to the sole production costs.

Contributing to the EU's economy

- Direct impact: €94 bn
- Indirect impact: €357.4 bn

1 GW of installed nuclear capacity generates:

- €4 bn in EU GDP
- Nearly 10,000 jobs in the EU economy
- €3 bn annual household income in the EU
- Nearly €1 bn annual public revenues in the EU
- €9 bn annual investment throughout the EU
- €0.15 bn annual EU trade surplus
SECURITY OF ENERGY SUPPLY

Harnessing abundant natural resources

Identified resources of uranium are sufficient to support continued use and significant growth of nuclear for well over 120 years.

New reactor designs and recycling fuel could increase this to 1,000s of years.

Additional exploitable resources would extend this to well over 300 years.

Who supplies uranium to the EU?
Uranium resources are available from a diversity of suppliers (% for 2021)

- 22.99% Kazakhstan
- 19.69% Russia
- 24.26% Niger
- 14.31% Canada
- 1.36% Uzbekistan
- 0.17% Europe
- 0.04% South Africa
- 15.54% Australia
- 1.64% Other

Additional exploitable resources would extend this to well over 300 years.

Providing an independent source of energy at a stable price

1 Uranium fuel pellet produces as much energy as:

- 20 g Uranium fuel pellet
- 410 litres oil
- 350 m³ gas
- 400 kg coal

Identified resources of uranium are sufficient to support continued use and significant growth of nuclear for well over 120 years.

New reactor designs and recycling fuel could increase this to 1,000s of years.

The cost of nuclear power is less vulnerable to fuel price fluctuations.
NUCLEAR AND CLIMATE CHANGE

Generating almost half of the EU’s low-carbon electricity

Almost 50% of low-carbon electricity

Contributing to the fight against climate change by avoiding CO₂, SO₂ and NOx emissions

The amount of CO₂ emitted by nuclear energy is comparable to that of renewables.

Comparison of average greenhouse gas emissions (grammes CO₂ eq/kWh)

Average lifecycle SO₂ and NOx emissions of different generation technologies

Hydrogen production

Hydrogen produced from nuclear is:

Low-carbon
Affordable as it can be produced constantly
Available 24/7 as it is not weather dependent

Nuclear-based hydrogen can help hard-to-decarbonise sectors reach their decarbonisation goals
NUCLEAR AND HEALTH

Protecting people from radiation

Average public exposure to radiation by sources*

<table>
<thead>
<tr>
<th>Source</th>
<th>mSv/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear power plant</td>
<td>0.0002</td>
</tr>
<tr>
<td>Nuclear medicine</td>
<td>0.03</td>
</tr>
<tr>
<td>Food</td>
<td>0.29</td>
</tr>
<tr>
<td>Cosmic</td>
<td>0.39</td>
</tr>
<tr>
<td>Soil</td>
<td>0.48</td>
</tr>
<tr>
<td>Radiology</td>
<td>0.62</td>
</tr>
<tr>
<td>Radon</td>
<td>1.3</td>
</tr>
</tbody>
</table>

* Rounded estimations of the effective dose to a person in a year (world average)
© nucleareurope - Source: UNEP, “Radiation effects and sources”, 2016

Saving people with nuclear medicine

Radiation and radioactive isotopes are used in the diagnosis and treatment of disease

1 person out of 2 will benefit from nuclear medicine during their life

© nucleareurope - Source: Belgian Nuclear Forum

Radioactive isotope production in the EU

Countries operating isotope production reactors in the EU

6 nuclear research reactors provide about 95% of the world’s Mo-99 or Lu-177 production.
4 of them are in the EU.

The most frequently used radioisotope is Technetium-99m for which the EU is the...

© nucleareurope - Source: RRDB 2022

© nucleareurope - Source: EURATOM Supply Agency 2019 and Nuclear Medicine Europe
RADIOACTIVE NUCLEAR WASTE

Sources of radioactive waste

- Nuclear Power Plants
- Industry
- Hospitals
- Research centres
- Universities etc...

On average, each year one person generates:

- **1.36 tonnes** of total waste
- **270 kg** Municipal solid waste
- **54 kg** Hazardous waste
- **54 g** Radioactive waste

Types of radioactive waste and their distribution per category (2016)

- **Very low level waste (VLLW)**
  - *E.g., concrete*
- **Low level waste (LLW)**
  - *E.g., scrap metal*
- **Intermediate level waste (ILW)**
  - *E.g., nuclear reactor components*
- **High level waste (HLW)**
  - *E.g., by-product of fuel reprocessing*

Applying a circular economy approach to radioactive waste

**REDUCE**
Reduction in the volumes of waste generated thanks to:
- Improved reactor design
- Improved reactor operation
- Improved fuel production

**REUSE**
Several technologies exist which enable the reuse of spent fuel. This saves up to around 25% of natural uranium resources, cuts final waste volumes by a factor of 5 and its long-term radiotoxicity by a factor of 10.

**RECYCLE**
Construction materials used in nuclear facilities can be fully recycled. Americium and plutonium can be recycled in space, medical and other applications.

**RESIDUAL**
Temporary storage:
Some countries use temporary storage in order to enable the future retrieval and reprocessing of the spent fuel.

**LONG-TERM DISPOSAL**
The nuclear sector is a leading example when it comes to the long-term disposal of radioactive waste thanks to, for example, the Deep Geological Repositories currently under development.

© nucleareurope - Source: OECD/NEA 2015 & The World Bank ‘What a Waste 2.0’ 2018
SUSTAINABILITY OF NUCLEAR

Raw materials use

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>REEs*</th>
<th>Cobalt</th>
<th>PGMs**</th>
<th>Lithium</th>
<th>Chromium</th>
<th>Zinc</th>
<th>Nickel</th>
<th>Copper</th>
<th>Aluminium</th>
<th>Uranium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>High</td>
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<td>Low</td>
<td>Low</td>
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<tr>
<td>Solar PV</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
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<tr>
<td>Solar CSP</td>
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<tr>
<td>Wind</td>
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<td>Hydro</td>
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<td>Bioenergy</td>
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<tr>
<td>Geothermal</td>
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<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>EVs and batteries</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
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<td>Low</td>
</tr>
</tbody>
</table>

* Rare Earth Elements
** Platinum Group Metals

Supply risk:
- High
- Moderate
- Low

Importance:
- High
- Moderate
- Low

Water use

Issues related to water consumption and potential thermal pollution of nuclear energy must be appropriately handled during the site selection, facility design and plant operation phases. Issues related to thermal pollution do not affect nuclear power plants located on coasts, that use seawater for cooling.

Biodiversity impact and land use

Land required by different energy sources to match the amount of electricity produced by a 1,800 MW nuclear power plant.

- Wind: 437 km²
- Solar: 56 km²
- Nuclear: 4 km²

Environmental Impact Assessments are carried out on nuclear sites during different stages of the lifecycle to make sure that the impact on biodiversity is minimal.
The civil nuclear industry supports around 1.3 million jobs in Europe (EU and nucleareurope non-EU members)

<table>
<thead>
<tr>
<th>Country</th>
<th>Direct jobs</th>
<th>Indirect jobs</th>
<th>Total of direct and indirect jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>48,200</td>
<td>31,000</td>
<td>79,200</td>
</tr>
<tr>
<td>Germany</td>
<td>106,900</td>
<td>31,000</td>
<td>137,900</td>
</tr>
<tr>
<td>Hungary</td>
<td>15,200</td>
<td>6,300</td>
<td>21,500</td>
</tr>
<tr>
<td>Romania</td>
<td>12,600</td>
<td>8,900</td>
<td>21,500</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>11,200</td>
<td>18,400</td>
<td>29,600</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>32,900</td>
<td>20,400</td>
<td>53,300</td>
</tr>
<tr>
<td>Finland</td>
<td>32,900</td>
<td>20,400</td>
<td>53,300</td>
</tr>
<tr>
<td>Sweden</td>
<td>64,500</td>
<td>40,400</td>
<td>104,900</td>
</tr>
<tr>
<td>Poland</td>
<td>4,700</td>
<td>3,500</td>
<td>8,200</td>
</tr>
<tr>
<td>Slovenia</td>
<td>5,400</td>
<td>3,500</td>
<td>8,900</td>
</tr>
<tr>
<td>Slovakia</td>
<td>16,700</td>
<td>10,200</td>
<td>26,900</td>
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<tr>
<td>United Kingdom</td>
<td>111,000</td>
<td>84,100</td>
<td>195,100</td>
</tr>
<tr>
<td>France</td>
<td>457,200</td>
<td>277,100</td>
<td>734,300</td>
</tr>
<tr>
<td>Spain</td>
<td>74,500</td>
<td>43,700</td>
<td>118,200</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>111,000</td>
<td>84,100</td>
<td>195,100</td>
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<tr>
<td>UK</td>
<td>111,000</td>
<td>84,100</td>
<td>195,100</td>
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<tr>
<td>Netherlands</td>
<td>21,000</td>
<td>19,000</td>
<td>40,000</td>
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<tr>
<td>Norway</td>
<td>64,500</td>
<td>40,400</td>
<td>104,900</td>
</tr>
<tr>
<td>Switzerland</td>
<td>6,500</td>
<td>4,000</td>
<td>10,500</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1,185,300</td>
<td>790,500</td>
<td>1,975,800</td>
</tr>
<tr>
<td>Europe total</td>
<td>1,274,900</td>
<td>790,500</td>
<td>2,065,400</td>
</tr>
</tbody>
</table>

Direct jobs: Direct employment in nuclear power plants and the nuclear supply chain.
Indirect jobs: Employment deriving from the nuclear industry activities, including both employees in other affiliated economic sectors and additional employment in the economy resulting from expenses of direct employees and employees in other economic sectors.

Source: Deloitte 2019
### Operational nuclear reactors in Europe (EU and nucleareurope non-EU members)

#### Nuclear share of electricity (% in 2020)

- **France**: 70% (56 reactors - 61,370 MW)
- **53% Slovakia**: 4 reactors - 1,865 MW
- **51% Ukraine**: 15 reactors - 13,107 MW
- **48% Hungary**: 4 reactors - 1,916 MW
- **40% Bulgaria**: 2 reactors - 2,006 MW
- **39% Belgium**: 6 reactors - 4,936 MW
- **37% Czech Republic**: 6 reactors - 3,934 MW
- **37% Slovenia**: 1 reactor - 688 MW
- **33% Finland**: 5 reactors - 4,394 MW
- **32% Switzerland**: 4 reactors - 2,960 MW
- **29% Sweden**: 6 reactors - 6,885 MW
- **22% Spain**: 7 reactors - 7,121 MW
- **19% Romania**: 2 reactors - 1,300 MW
- **14% UK**: 11 reactors - 6,848 MW
- **11% Germany**: 3 reactors - 4,055 MW
- **3% Netherlands**: 1 reactor - 485 MW

#### Reactors currently under construction

- **France**: 1 reactor - 1,630 MW
- **Hungary**: 2 reactors - 2,400 MW
- **Slovakia**: 2 reactors - 880 MW

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