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# NUCLEAR ENERGY: AN ESG INVESTABLE ASSET CLASS

September 2021

## Foreword

In 2020, the Economic Modelling Work Group (EMWG) of the Generation IV International Forum (GIF) convened a finance industry taskforce (the Taskforce) to consider the nuclear industry's ability to report against Environmental, Social and Governance data collection and accounting metrics (ESG), and therefore whether nuclear energy should be considered as an investable asset class; thereby allowing nuclear companies and projects to access climate finance. This report has been produced by the finance community for the finance community.

*Nuclear Energy: An ESG Investible* Asset Class has been developed from the discussions of the Taskforce, all of whom are listed in Appendix III of this report. The report could not have been produced without their valuable contributions, and the contribution and oversight of Fiona Reilly, Co-Chair of the EMWG and Chair of the Taskforce. GIF would also like to express its gratitude to the Nuclear Industry Association in the United Kingdom, the Canadian Nuclear Association, the Nuclear Energy Institute in the United States, Natural Resources Canada, and the Nuclear Innovation and Research Office and the National Nuclear Laboratory in the United Kingdom.

## Scope of the Report

This report has various sections:

- **Climate Financing and Responsible Investment:** Sets out the international policy framework and background around climate finance including the UN's Principles of Responsible Investment, the rise of ESG reporting and its role in accessing climate finance and the role of taxonomies and how they fit, or rather do not fit, with ESG reporting;
- **Low Carbon ESG Reporting:** Provides a very high-level overview of how low carbon energy companies and/or projects could report against ESG;
- **Nuclear Disclosures Against ESG:** Demonstrates the nuclear industry's ability to report against ESG and why it is an investable asset class, if projects and companies are established and managed well;
- **Appendix I Standard Metrics:** The Taskforce mapped the WEF ESG against relevant SASB and TCFD ESG to create a consolidated list of ESG, which are used in this report; and
- **Appendix II Consistent and Transparent Reporting:** Provides significantly more details and cross-references for the finance community and wider stakeholders to use when considering nuclear companies and projects reporting together with some analysis where other energy companies could follow the nuclear industry's lead in their ability to report against ESG.

It is hoped, and intended, that this report develops into a living document that is used by the finance industry as a reference and guide to use when considering nuclear companies and their assets.

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# List of abbreviations and acronyms

| | |
|---|---|
| $^{o}C$ | Degrees Celsius |
| AUM | Assets under management |
| BAT | Best available techniques |
| BEP | Best environmental practice |
| Bq | Becquerel |
| CAPEx | Capital expenditure |
| CCS | carbon capture and sequestration |
| $CO_2$ | carbon dioxide |
| c. | Circa/approximately |
| DAWN | Driving the Advancement of Women in Nuclear (Canada) |
| DGR | Deep geological repository |
| DNSH | do no significant harm |
| EC | European Commission |
| EPC | Engineering, procurement and construction |
| ESG | Environmental, social and governance data collection and accounting metrics |
| EU | European Union |
| FOAK | First of a kind |
| FSA | Fuel supply agreement |
| GBP | Green Bond Principles |
| Gen-III+/Gen-IV | Generation III+ or Generation IV (reactors) |
| GHG | Greenhouse gas (emissions) |
| G7 | The Group of Seven |
| GVA | Gross value added |
| GW | Gigawatt |
| HLW | High-level waste |
| ICRP | International Commission for Radiation Protection |
| ICRU | International Commission on Radiation Units and Measurements |
| IAEA | International Atomic Energy Agency |
| IEA | International Energy Agency |
| ICMA | International Capital Market Association |

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|---|---|
| ILW | Intermediate-level waste |
| IPCC | Intergovernmental Panel on Climate Change |
| JRC | Joint Research Centre (EU) |
| kw | Kilowatt |
| kWh | Kilowatt hour |
| LCA | Lifecycle assessment |
| LLW | Low-level waste |
| LTO | Long-term operation |
| mSv | Millisieverts |
| MWe | Megawatt electric |
| NDC | Nationally determined contributions (Paris Agreement) |
| NEA | Nuclear Energy Agency |
| NEET | (youth) not in education, employment or training |
| NEI | Nuclear Energy Institute (United States) |
| NOx | nitrogen oxide (NOx) |
| NOAK | Next of a kind/ $N^{th}$ of a kind |
| NPT | Treaty on the Non-Proliferation of Nuclear Weapons |
| OECD | Organisation for Economic Co-operation and Development |
| PRI | Principles for Responsible Investment (United Nations) |
| RO | Reverse osmosis |
| SASB | Sustainability Accounting Standards Board |
| SDGs | Sustainable Development Goals (United Nations) |
| SFAC | Sustainable Finance Action Council (Canada) |
| SOx | Sulphur oxide |
| SPV | Special purpose vehicle |
| TBq | Terabecquerel |
| $tCO_2e$ | Metric tonnes of carbon dioxide equivalent |
| TEG | Technical expert group |
| R&D | Research and development |
| TCFD | Task Force for Climate-Related Financial Disclosures |
| WEF | World Economic Forum |
| UN | United Nations |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VAT | Value added tax |
| VLLW | Very low-level waste |
| WANO | World Association of Nuclear Operators |
| WEF | World Economic Forum |

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| WNA | World Nuclear Association |

# Executive summary

In the last ten years, access to climate finance – focusing on creating a positive impact on global society through ethical, socially responsible and eco-friendly value - has become a major focus of the finance industry. Against the background of the United Nations (UN) Framework Convention on Climate Change, the Kyoto Agreement, and more recently the Paris Agreement, investors have sought to integrate ethics, governance, social value and environmental concerns into their investment strategies. This report has been drafted by the finance community for the finance community to use when considering whether nuclear assets are investable.

The UN Principles for Responsible Investment (PRI) set out principles which are linked to Environmental, Social and Governance data collection and accounting metrics (ESG) for the investment community. More than 3,657 investors have signed up to the PRI Principles. These investors are responsible for c. USD 104 trillion assets under management.

ESG have been adopted by the investment community, against which companies or projects report in order to demonstrate their credentials. In other words, ESG are integrated into the investment decision-making process such that each investment is analysed for the potential level of ESG risk and impact that it may have. The assessment is not a binary screening but considered as a balanced scorecard i.e., on balance does the company report well. The risk is that companies reporting are potentially unethical, lack governance, are not socially responsible and/or are not eco-friendly. ESG are not only used for screening investment opportunities but also for assessing a company's continuing performance.

ESG reporting is undertaken by individual companies and projects rather than by an industry as a whole. This report is, therefore, intended to provide guidance to the finance community and wider stakeholders on how nuclear assets could report against ESG, rather than removing the requirement for each company to report against ESG.

### What are ESG?

ESG are Environmental, Social and Governance data collection and accounting metrics.

Companies report on ESG to any investors/ financiers who are invested in their company / project; and/or any investors/ financiers they want to invest in their company/ project.

ESG are not a pass or fail test but a balanced scorecard against which financiers and investors assess their investments or assess whether they will invest, examining whether a company is well run, ethical socially responsible and eco-friendly.

The term ESG is often misused to refer to vague environmental, social and governance concepts rather than to data collection and accounting metrics.

Nuclear energy, in combination with renewables, is the only way for countries to meet their nationally determined contributions (NDC) under the Paris Agreement and their Net-Zero commitments. As Barclays noted in their report "*Nuclear for a decarbonized future*": "Nuclear's high load factors and reliability could make achieving net-zero affordable." (Barclays, 2021) Inconsistency in applying ESG reporting has nevertheless resulted in nuclear power having a higher hill to climb than other low-carbon energy sources.

This report establishes not only how nuclear energy, as an asset class, has the potential to report well against a wide range of ESG; it highlights the importance of wide ranging, consistent and standardised ESG reporting to determine the credentials of all energy companies across their lifecycles and throughout their supply chains. The report discusses how ESG fit within international frameworks, including the UN Framework Convention on Climate Change (1992), the Kyoto Protocol (1997) and the Paris Agreement (2015), and how ESG are linked to the Green Bond Principles, while examining the relationship between ESG and the various taxonomies and other policy documents being developed around the world.

To obtain the greatest benefit from the adoption of ESG, consistency is essential, not only in terms of the ESG, but also in terms of how assets are intended to report and therefore how the investment community should assess ethics, governance, social value and environmental concerns. Requiring all companies to report against ESG in a consistent manner will allow for a level playing field across technologies. In other words, ESG need to be applied consistently across asset classes.

One of the difficulties with ESG is that historically each institution has had its own set of ESG, and they are applied inconsistently. In 2020, the World Economic Forum (WEF) carried out a consultation and reported on the outcome of the consultation to propose a common set of ESG, with the aim of aligning mainstream reporting on performance against ESG. The Generation IV International Forum (GIF), and in particular the Taskforce, welcome the WEF 2020 consultation and report: “Towards Common Metrics and Consistent Reporting of Sustainable Value Creation”, (WEF, 2020). However, to address comments raised by the finance and energy industries, the WEF ESG have been mapped against the relevant standards of the Sustainability Accounting Standards Board (SASB) and the Task Force for Climate Related Financial Disclosure (TCFD) to create a consolidated list (see Appendix I), which is used through-out this report.

The WEF defined four pillars of ESG: Governance, Planet, People and Prosperity. Under each pillar there are a set of ESG (see further details below). A great deal of the focus (including on the part of those looking at taxonomies) is on the ESG covered by the Planet metrics – namely climate change, including greenhouse gas (GHG) emissions, and waste management and mitigation. However, ESG address a much larger range of metrics to produce a balanced scorecard.

The Taskforce assessed each ESG in the order that it was developed by the WEF. In doing so, it was recognised that for a truly complete reporting exercise, each asset should not only consider the full lifecycle of the asset but also the supply chains used during that lifecycle; there should be a move for all assets to reports on this full basis. Nuclear energy, as an asset class, has the ability to report well against many of the ESG identified in this report. It is, however, the responsibility of each company and each asset to develop and maintain the company and asset in a manner that will enable consistent reporting across the full scope of ESG.

## Governance

- The governance metrics are: governing purpose; the quality of the governing body, including board composition and remuneration; stakeholder engagement including buy-in, impact and process; ethical behaviour and anti-corruption, ethics and reporting; and risk and opportunity oversight including integrating risks and opportunities such as climate change risk.
- The governance metrics are largely asset specific including whether the governing purpose of the company is established and maintained, and whether the company is managed at the highest standards including having a strong and diverse board which is properly remunerated. As with the energy sector as a whole, the nuclear sector is improving its Board diversity credentials, but there is still more to be done.
- Open and transparent stakeholder engagement also falls within these metrics, an area where the energy sector as a whole would generally report well. Stakeholder mapping for the nuclear sector has always been wide ranging and continues to be monitored throughout the lifetime of the asset. Transparency and openness vis-á-vis a broad range of stakeholders is something that the nuclear industry has managed well, particularly in more recent years. Stakeholders with whom the nuclear industry liaises include governments and governmental departments, local and regional communities, schools and universities.
- The ethical behaviour and risk oversight and management metrics are wide-ranging and place obligations on a company in relation to not only its own behaviour but also its supply chain and lifecycle. Again, this is something the nuclear industry can report well. The industry has long been aware of its need to behave ethically and to manage and mitigate risks to the highest standards. The nuclear industry takes unethical behaviours very seriously and assesses not only its own company’s behaviour but that of the supply chains across the whole lifecycle. Although reporting on these metrics will be company-specific, nuclear companies often have gold standard training in place for all employees to ensure that best practice is understood for anti-bribery and corruption practices, what to look out for and how scenarios should be assessed; as well as money laundering processes and procedures and how inappropriate incidents should be reported within the company.
- Nuclear regulation also has a role to play in maintaining the highest standards of behaviour. The Knowledgeable Customer and Safeguards regimes, together with nuclear health and safety standards and Export Controls are

vital to regulatory compliance in nuclear corporate governance, helping to maintain both ethical behaviour and proper risk management.

## Planet

- The Planet metrics are: climate change including GHG; nature loss, including land use and ecological sensitivity; fresh water availability, including consumption and management; pollution; waste, including management & mitigation; and resources.
- The role of nuclear as a low-carbon technology is becoming widely accepted with many governments, philanthropists and even some environmental NGOs, recognising nuclear energy's role in meeting Net-Zero commitments. Different reports show how nuclear can report that its GHG emissions are comparable with wind projects and lower than solar projects.
- The area that is often cited as the concern for nuclear fission is around waste management and mitigation. However, it is becoming recognised that waste is a concern across the whole of the energy sector. There is more of a focus on the waste and emissions from technologies such as wind, solar and batteries. The more companies can address waste mitigation and management concerns the better. For a long time, nuclear has had processes and procedures in place to plan, manage and mitigate the waste arising from the plant including establishing funds to cover the costs of decommissioning the site, remediating the land and managing and mitigating waste. There is more that can be done, but nuclear leads the energy sector in decommissioning and the mitigation and management of waste. Solar companies are beginning to adopt similar waste management and mitigation measures, including pre-funding decommissioning and waste management. However, the wind sector only just beginning to consider how it should deal with decommissioning and management and mitigation of its waste. A consistency in approach across all technologies is vital.
- The remaining metrics under the Planet pillar relate to the nature use, including land and water, the effects on the environment and ecology through land use, pollution and emissions and also the resources utilised in the production of energy, and how those resources are maintained and not depleted.
- All energy projects will involve some loss to nature and the environment. The interrelationship between land use and energy is a complex balance. Energy is needed for the socio-economic development of regions and countries, but this needs to be balanced with the efficient and effective use of land, which is also needed for other activities including the production of crops and food. Therefore, the efficient use of land for the production of energy is an important factor to be considered. Consideration should be given to the average energy produced per kilometre of land – average wind farms produce 0.77MWh; average solar farms produce 1MWh and average small nuclear reactors produce 14.5MWh.
- All energy plant utilise water. Some use it and others consume it. Nuclear uses a lot of water and yet has little effect on the water it uses. It can also be used for desalination thereby helping to provide fresh water, where needed.
- Again, all energy projects create pollution to air, land and sometimes water. For land and air, when considering particulates matter, nitrogen oxide (NOx) and sulfur oxide (SOx), nuclear and onshore wind are similar. For water pollution, nuclear projects often perform better than renewables.
- Resources, created by nature, are scarce and need managing well. However nuclear resources are not at risk of being over-utilised (particularly when combined with the development in nuclear technologies) whereas other resources used in energy projects, including cobalt and lithium, are.
- The mining of resources is a key concern across a number of technologies. Uranium mining is undertaken under strict regimes, but this is not necessarily the case for other mining activities. All mining activities should report against ESG to ensure that mining is undertaken in an ethical and eco-friendly way, while maintaining proper governance and creating social value.

## People

- The People metrics are: dignity and equality, including diversity, inclusion, harassment, pay equality and pay gaps, wages levels and living wage, human rights, slavery and child labour; health and well-being including health & safety (workforce and third parties), nuclear safety and emergency management, incidents on sites, well-being and impact; and skills for the future including training, recording the number of unskilled vacancies and the impact on the company.

- Lack of diversity remains an issue for the energy sector as a whole. However, nuclear appears to be performing marginally better in relation to gender diversity but not in relation to wider diversity criteria, where it is similar to the rest of the energy industry. This is something the energy sector as whole needs to improve.
- Energy companies and projects should have well managed policies and procedures on pay and remuneration. The energy sector wants to attract bright and diverse individuals who can develop the industry and deliver high quality and high performing projects and companies. Further work is needed across the sector.
- Without proper checks and balances a company's activities could facilitate human rights abuses and other social and environmental abuses. Without mechanisms for employees and stakeholders to report potential abuses, companies might miss the opportunities to identify, mitigate and manage activities. The nuclear sector's focus on safety and compliance helps to mitigate some of these risks but investors will need to assess each company's reporting on these matters. This also extends to ensuring there are no risks of incidents of child, forced or compulsory labour across their supply chains. An explanation of labour practices across the whole supply chain need to be disclosed by the executive and the board. The elimination of child labour and forced labour requires companies to be open and transparent and to assess their supply chain ethics. Nuclear companies must investigate their supply chain in great detail to ensure regulatory compliance, which should protect against these practices. However, concerns are being raised in relation to the mining of rare earth, lithium and cobalt; there needs to be proper reporting against all mining activities across the energy sector to ensure ethical and eco-friendly practices, while maintaining proper governance and creating social value. Only through openness and transparency by businesses and financial institutions will these unethical practices be eradicated.
- The nuclear industry has long been at the forefront of both general health and safety management (particularly physical but also mental health) and also nuclear specific health and safety. The global nuclear industry takes health and safety incredibly seriously. The nuclear sector has a wide range of health and safety regulations and systems in place to protect not only its workers (direct employees and through-out supply chains) but also third parties.
- The energy sector is generally good at training and development, and at providing skills for the future. The nuclear sector has spent considerable time and effort in maintaining its skills and developing skills for the future (on existing and future technologies). The renewables sector is a newer industry and therefore has not has to consider maintaining skills for the future in the same way, and therefore any reporting will be more asset specific.
- In many countries, nuclear has had to invest heavily in upskilling. This is partially due to the hiatus in the construction of new nuclear power plants, in some parts of the world. Also, many people working on existing plants and sites are reaching retirement age and so the nuclear industry has had to spend considerable efforts to bringing in the younger generation, this is particularly true in Western countries. Companies have implemented training and apprenticeships to bring in new people to the industry across various skills to protect the industry for the future.

### Prosperity

- The Prosperity metrics are: wealth creation and employment; energy affordability; end-use efficiency and demand; grid resiliency; innovation in better products and services, including R&D spend and social value generated; and community and social vitality, including taxes paid and total social investment.
- These ESG focus on the wider impact of the project, how it impacts greater value add (GVA) across the region and the country, including how much tax the company pays and its social and wider investment, its impact on the wider energy market in terms of prices but also efficiency and demand and how it impacts the grid resiliency.
- Reporting against these ESG will largely be company or project specific. However, in terms of GVA and wider socio-economic impact, nuclear companies and projects have a wider and larger impact than other energy projects due to the scale of the projects, the number of direct and indirect long-term jobs created and the long-

life of the projects. The macro-economic effect of nuclear projects extends through the construction, operation and decommissioning phases, resulting in GVA and wider socio-economic impacts for over 100 years.

- In terms of energy affordability, end use and grid resilience, it is key to allow companies and projects to report on a level playing field. When considering the levelised costs of the projects and looking at the wider system costs associated with intermittent technologies, nuclear is competitive. Also nuclear helps with the resilience of the grid as a firm power source.
- Innovation is key to prosperity. R&D spend is seen as a basic indication of a company's attempts to innovate and therefore be fit for the future. It can also indicate the company's ability to adapt to new market conditions and to create further socio-economic benefits including delivery of SDGs. Nuclear R&D and innovation are continuous. The industry constantly looks to find better ways of delivering clean low carbon energy.
- These metrics consider the wider benefits of a company's activities through taxes paid and social investment. It takes into consideration the wider payments into the wider economy both from the company and as amplified through the life-cycle and the supply chain. These are company-specific, although all well run energy companies should be able to report well against these metrics.

Nuclear, as an asset class, has the ability to report at least as well as or better than other energy sources against all these ESG. Key to reporting is ensuring that companies and projects are established to the highest standards, as the industry generally does, but there is also an obligation on the investor community to ask all energy companies to report on the wide range of ESG to make sure all projects are considered on a consistent open and transparent basis. Nuclear projects are vital to countries meeting their NDCs and Net-Zero commitments. The investment community has an obligation to ask companies to report in consistent ways to provide nuclear the opportunity of accessing climate finance and making nuclear an investable asset class.

If countries have any chance of reducing carbon emissions, accelerating their actions and achieving Net Zero by 2050, they need to have available to them all low-carbon technologies including nuclear – however accessing private finance for nuclear projects remains a barrier. It is intended that this report can be utilised by the investment community to demonstrate that nuclear should be an investable asset class, whether each company or project measures up will be a matter for ESG reporting.

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# Introduction and background

## Nuclear and renewables combine to address climate change

In April 2021, the United States convened a meeting of 40 world leaders in a Virtual Summit on Climate.[1] The aim of the meeting was to rally the world in tackling the climate crisis and meeting the demands of science. The United States and other countries announced ambitious new climate targets.

More and more work is being undertaken by the scientific and policy communities to ascertain how these climate ambitions can be achieved. What is becoming clear, and highlighted in a 2019 report by the International Energy Agency, is that nuclear combined with renewables are the only way to meet our climate change obligations. As noted in the report: "Nuclear power and hydropower form the backbone of low-carbon electricity generation. Together, they provide three-quarters of global low-carbon generation. Over the past 50 years, the use of nuclear power has reduced CO2 emissions by over 60 gigatonnes – nearly two years' worth of global energy-related emissions." (IEA, 2019)

Bill Gates and other climate change philanthropists have long supported nuclear energy's role in the fight against climate change. "Nuclear energy will 'absolutely' be politically palatable…..That's because the need for clean energy is dire, and the operation of nuclear power plants produces no greenhouse gas emissions," Gates told Andrew Ross Sorkin on CNBC's "Squawk Box" (2021). However, Gates' support for nuclear is not new. In a 2018 blogpost, Gates said, "Nuclear is ideal for dealing with climate change, because it is the only carbon-free, scalable energy source that's available 24 hours a day" (Bill Gates, 2018, cited in Hayunga, 2021). Gates and other philanthropists are investing heavily in nuclear technologies in support of their belief in nuclear's role in addressing climate change.

Many countries are recognising that if there is any chance of them meeting their Net-Zero commitments then nuclear has to form part of their plans. Countries such as the USA, Canada, the UK, Argentina, Poland and France recognise that nuclear power combined with renewables is the only way to achieve Net Zero heat and power.

Despite the growing recognition of nuclear energy's role in Net-Zero, one of the biggest challenges facing global nuclear projects, whether Generation III+ or Generation IV, is access to financing and particularly climate finance. A number of issues have resulted in limited access to private sector investment for nuclear projects (and some companies). The issues include: the lack of long-term policy frameworks, the size of equity and debt needed, the large CAPEx, and the long-term development and construction periods as well as the challenges developing government backed off-take support for assets with such a long life. Small Generation III+ and Generation IV reactors are addressing a number of these concerns by taking much more of a product-based factory build approach, thereby producing more certainly on costs and delivery, and delivering at a significantly lower cost and in shorter timescales. There is much written on these issues so they are not being revisited in this report.

However, the issues have resulted in few investors having real experience with nuclear; this of itself breeds caution across the finance sector. Clear, transparent and standardised ESG reporting would allow nuclear to highlight its value in low carbon economic development.

1. For more information on this summit, see: www.state.gov/leaders-summit-on-climate/.

## International policy framework

The United Nations Framework Convention on Climate Change (1992) was a culmination of extensive work undertaken by the United Nations (UN) to address climate change. Article 2 sets out the objective of the convention and states:

> The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilizing of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (UNFCCC, 1992).

On 11 December 1997 the Kyoto Agreement to the United Nations Framework Convention on Climate Change was entered into force (the Kyoto Protocol). The Kyoto Protocol has been signed by 192 countries and promotes sustainable development activities. The Kyoto Agreement was seen as a landmark environmental treaty as it represented the first-time nations agreed to legally mandate country-specific emission reduction targets.

At the United Nations Climate Change Conference in Paris (COP 21), governments agreed to intensify their efforts against climate change. The Paris Agreement is a legally binding international treaty which was adopted on 12 December 2015 and entered into force on 4 November 2016. To date, 197 countries have signed the Paris Agreement.

Under the Paris Agreement, the parties agree to limit global warming to below 2 degrees Celsius (2°C), and preferably to 1.5°C (compared to pre-industrial levels). The parties aim to reach global peaking of greenhouse gas (GHG) emissions as soon as possible and to achieve a climate neutral world (Net Zero) by 2050. The Paris Agreement provides a framework for financial, technical and capacity building to support countries who need it. The financial aspects are the focus of this paper.

Unlike the Kyoto Protocol, which established a top-down legally binding emissions reduction target for developed countries only, the Paris Agreement requires all countries to reduce greenhouse gas (GHG) emissions – but countries set their own emissions targets in line with their development status and their economic and social transformation possibilities. Targets are set through Nationally Determined Contributions (NDCs). While the Kyoto Protocol includes penalties for noncompliance, the Paris Agreement does not. The Paris Agreement does however have robust systems of monitoring, reporting and assessing targets.

By 2020 countries submitted their plans for climate action, their NDCs. The UK was the first G7 country to pass a Net Zero emissions law in 2019. Sweden, France, Denmark, Hungary, Japan, South Korea, China, New Zealand and the USA have also passed laws formally establishing Net-Zero targets and similar legislation is proposed in the EU, Spain, Canada, Chile and Fiji. To date, 192 countries have filed their NDCs with the UN, and nations accounting for half of the world's economy have now committed to the emission reductions needed globally to aim to limit global warming to 1.5°C .[2]

The Paris Agreement reaffirms that developed countries should take the lead in providing financial assistance to countries that are less endowed and more vulnerable, while for the first time also encouraging voluntary contributions by other parties. Finance is needed for mitigation because large-scale investments are required to significantly reduce emissions. Finance is equally important for adaptation, as significant financial resources are needed to adapt to the adverse effects and reduce the impacts of a changing climate.

The 26th UN Climate Change Conference of the Parties (COP 26) is due to take place in Glasgow in the United Kingdom in November 2021. The aim of the conference is to accelerate action towards the goals of the Paris Agreement, as little has been achieved in the last five years.

2. A register of these NDCs can be found at: www4.unfccc.int/sites/ndcstaging/Pages/LatestSubmissions.aspx.

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# Climate financing and responsible investment

According to the United Nations, climate finance refers to:

> …local, national or transnational financing – drawn from public, private and alternative sources of financing – that seeks to support mitigation and adaptation actions that will address climate change. The Convention, the Kyoto Protocol and the Paris Agreement call for financial assistance from Parties with more financial resources to those that are less endowed and more vulnerable. This recognizes that the contribution of countries to climate change and their capacity to prevent it and cope with its consequences vary enormously. Climate finance is needed for mitigation, because large-scale investments are required to significantly reduce emissions. Climate finance is equally important for adaptation, as significant financial resources are needed to adapt to the adverse effects and reduce the impacts of a changing climate. (UN, 2021)

Against the background of the UNFCCC, the Kyoto Protocol and latterly the Paris Agreement, particularly in the last 10 years, investors have sought to integrate social and responsible investment concerns into their strategies, thereby focusing on creating a positive impact on global society.

The main focus of this report is ESG, which companies and projects report against for the investment community to determine whether investments meet their ethical, socially responsible and eco-friendly standards. In addition, the finance industry has developed the Green Bond Principles (GBP), which cross over significantly with ESG.

In addition to ESG and GBP, governments are developing taxonomies which are policy frameworks documents. The distinction between ESG and taxonomies is discussed in further detail below.

As ESG reporting becomes standardised, they should be at the forefront of determining whether companies and projects should be able to access climate finance i.e., can the company report a positive impact on global society through ethical, socially responsible and eco-friendly value creation. The Taskforce understands that the US Government is considering leading the way in this regard by not having a sustainable investment taxonomy but by requiring greater reporting against ESG.

## Environmental, Social and Governance (ESG)

ESG have been developed as a set of standards that socially conscious investors use to screen potential investments by asking companies and projects to report against them. They are an increasingly popular way for investors to evaluate companies in which they might want to invest. They can also help investors avoid companies that might pose a greater financial risk due to their environmental or other practices.

In years past, socially responsible investments had a reputation for requiring a trade-off on the investor's part, limiting the universe of companies that were eligible for investment, and also limiting the investor's potential profit. So-called "Bad" companies sometimes performed very well, at least in terms of their stock price.

More recently, however, some investors have come to believe that ESG have a practical purpose beyond any ethical concerns. By following ESG they may be able to avoid companies whose practices could signal a risk factor — as evidenced by BP's oil spill in 2010 and Volkswagen's emissions scandal in 2015, both of which rocked the companies' stock prices and resulted in billions of dollars in associated losses. Further, ethical companies are sacrificing profits in order to behave responsibly.

As ESG-minded business practices gain more traction, investment firms are increasingly tracking their performance. Financial services companies such as JPMorgan Chase, Wells Fargo, and Goldman Sachs have published annual reports that extensively review their ESG approaches and the bottom-line results. As noted in the Harvard Business Review's ESG spotlight from September 2020:

"…following the spread of COVID-19, most ESG funds outperformed their benchmarks. And when colleagues and I looked at data for more than 3,000 firms between late February and late March 2020 – when global financial markets were collapsing – we found that the ones the public perceived as behaving more responsibly had less-negative stock returns than their competitors." (Serafeim, 2020)

## UN Principles of Responsible Investment

The UN's Principles of Responsible Investment (PRI) set out principles linked to ESG for the investment community. In 2005, the United Nations Secretary General, Kofi Annan, invited a group of the world's largest investors to develop the PRI. The PRI were launched in 2006. Since then, 3657 asset owners, investment managers and service providers have become signatories. The PRI are a voluntary and aspirational set of investment principles that offer a menu for possible actions for incorporating ESG issues into investment practice. They were developed by investors for investors.

Signatories to the PRI agree to the following:

> "As institutional investors, we have a duty to act in the best long-term interests of our beneficiaries. In this fiduciary role, we believe that ESG issues can affect the performance of investment portfolios (to varying degrees across companies, sectors, regions, asset classes and through time).
>
> We also recognise that applying these Principles may better align investors with broader objectives of society. Therefore, where consistent with our fiduciary responsibilities, we commit to the following:
>
> - Principle 1: We will incorporate ESG issues into investment analysis and decision-making processes.
> - Principle 2: We will be active owners and incorporate ESG issues into our ownership policies and practices.
> - Principle 3: We will seek appropriate disclosure on ESG issues by the entities in which we invest.
> - Principle 4: We will promote acceptance and implementation of the Principles with the investment industry.
> - Principle 5: We will work together to enhance our effectiveness in implementing the Principles.
> - Principle 6: We will each report on our activities and progress towards implementing the Principles." (UNPRI, 2021a)

The *PRI 2020 Annual Report* records:

> Despite the pandemic, our signatory base has continued to grow over the past year. The collective AUM represented by PRI signatories increased by 20% from US$86.3 trillion to US$103.4 trillion as of 31 March 2020, representing 3038 signatories. (UNPRI, 2021b)

Their signatories have increased to 3657 since the publication of the report.

ESG is integrated in the investment decision making process, such that all types of investments are analysed for the potential level of ESG risk and impact it has. It should be noted the ESG are not a pass or fail test but are used as an assessment tool to consider the overall profile of a project or company.

In this paper we discuss nuclear's role in providing a leading low-carbon energy source and how it performs against a wide range of ESG.

## Standardising ESG

ESG broadly cover:

- Environmental metrics such as a company's energy use, waste, pollution, natural resource conservation, and treatment of animals;
- Social metrics including how a company manages relationships with employees, suppliers, customers, and stakeholders. These metrics can consider a company's relationships, its GVA and how socially responsible it is; and

- Governance metrics covers a company's governing purpose, its Board, its executive, diversity and inclusion and ethical behaviours.

No single company will successfully report against each ESG. Responsible and ethical companies are likely to produce a balanced scorecard. Equally, the balance of the metrics may change because of factors such as the country in which the company operates or is to operate, and wider development goals.

Historically, each financial institution has applied ESG in their own way. While there is a more consistent approach being developed and there is a move towards harmonisation, there is currently a lack of standardisation across ESG. Different institutions have defined different sets of metrics and each financial institution has had its own set of metrics. This includes the rating agencies Fitch, Standard & Poor's and Moody's, who have each have incorporated ESG into their credit rating methodologies.

As stated by the European Investment Bank, there is a need for a common language in climate finance, which could be developed through the ESG framework.

This lack of consistency and transparency has resulted in each financial institution and investor reviewing assets on different criteria. As a minimum, this has resulted in assets being reviewed in an inconsistent way and at worst it has allowed entities, including countries, to place much more stringent reporting metrics on some assets over others, allowing what has become known as "green-washing".

In January 2020, the World Economic Forum (WEF) issued a consultation, which was prepared in collaboration with Deloitte, EY, KPMG and PwC. The consultation proposes a common set of metrics and recommended disclosures that could be used to align mainstream reporting, and thereby reduce fragmentation and encourage faster progress towards a systemic solution, and ideally to produce an international accounting standard. Their objective was to amplify those standards rather than to create new standards all together.

The WEF reported on its consultation in September 2020 with the report *Measuring Stakeholder Capitalism: Toward Common Metrics and Consistent Reporting of Sustainable Value Creation* (WEF, 2020). The WEF common metrics fall under four pillars: Governance, People, Planet and Prosperity. A set of ESG sit beneath each pillar.

The Taskforce welcomes the WEF report and has adopted their metrics in this report. However, in discussions amongst the Taskforce it became clear that companies were also looking to the Sustainable Accounting Standard Board (SASB) and the Task Force for Climate Related Financial Disclosure (TCFD) standards. Views were expressed that SASB metrics are used more by corporates who have existing energy assets whereas TCFD is used more by the project finance community. The Taskforce mapped the WEF metrics with the SASB and TCFD metrics to take on board these views. This can be found in Appendix I.

The remainder of this report therefore adopts the ESG mapped in Appendix I, for the reporting. Any deviation from the common metrics will be identified.

## Green bond principles

The Green Bond Principles (GBP) were developed to enable capital-raising and investment for new and existing projects with environmental benefits. "The GBP are voluntary process guidelines that recommend transparency and disclosure and promote integrity in the development of the green bond market by clarifying the approach for issuance of a Green Bond" (ICMA, 2018). Many of the GBP align with ESG, and therefore in adopting the wide range of ESG investors will be able to determine whether assets are investable and eligible for both climate finance and Green Bonds.

The GBP sets out the guidelines for transparency, disclosure and reporting in order to promote the integrity of the green bond market as well as drive the provision of the information required by the market in order to promote greater capital allocation to eligible projects. The GBP were established by a consortium of investment banks, with the ongoing monitoring and development now migrated across to being managed by the International Capital Market Association (ICMA).

> Green bonds are any type of bond instrument where the proceeds will be exclusively applied to finance or re-finance projects with clear environmental benefits and which are aligned with the four core components of GBP:
>
> - use of proceeds – the utilisation of the proceeds of the bond for "green projects" which have to be sufficiently described in the legal documentation. Clear environmental benefits

need to be assessed and ideally quantified. The GBPs recognise several broad categories which are eligible for Green Bonds including climate change mitigation;

- process of project evaluation and selection – the issuer should outline the investment decision-making process to determine the eligibility of projects using the process for determining that a project is an eligible green project which includes how material environmental and social risks are to be managed;
- management of proceeds – the funds and proceeds need to be managed and tracked in an appropriate and transparent manner and independently audited; and
- reporting (pre-issuance and ongoing) – subject to confidentiality undertakings, reporting on an annual basis until the bond is fully allocated and then on a regular appropriate basis. (ICMA, 2018)

The focus on the use of proceeds seeks to guide issuers towards an integrated business model which incorporates greater environmental and social value components to their projects. The principles also recommend green bond issuers to undergo a third-party verification/certification to establish that the proceeds are funding projects that would produce an environmental benefit, however there is no formal certification for a bond to be labelled as “Green”.

While the GBP are voluntary and suggest broad “green” categories (developed by the private sector) and issuers are encouraged to consider these categories and the existing green bond standards, issuers can develop their own framework and ignore the principles. In considering acceptable categories and whether to issue a bond, the issuers can consider other initiatives, for example the Climate Bonds Initiative. It should be noted that while recognising nuclear energy’s low-carbon credentials, under the Climate Bond Initiative nuclear is in the “more work required” category i.e. not currently included but being contemplated and sitting with other technologies, including waste to energy, large hydro and carbon capture and sequestration (CCS).

Nuclear is included in the European Investment Bank Climate Action List of eligible sectors and eligibility criteria. However, the European Investment Bank (which has issued over nineteen billion euros (EUR 19bn) of green bonds over the last ten years, including a 30-year Climate Awareness Bond issued in June 2017), has still not issued any bonds for nuclear projects.

Alignment to the United Nations Sustainable Development Goals (SDGs) does not automatically mean that projects would align with the GBPs or ESGs. However, it is recognised by the United Nations and the International Atomic Energy Agency (IAEA) that nuclear plays an important role in the SDGs.[1] Further alignment of the SDGs, ESG and the GBPs can only assist in developing market acceptance of nuclear for the green bond and other financial markets.

## Taxonomies

### *General overview of taxonomies*

This section provides an overview of some of the taxonomy policies being developed around the world. Various taxonomies and policies are in different stages of development, and therefore, there are different levels of detail for different policy frameworks.

A taxonomy is intended to be a classification system created to help investors and companies make informed investment decisions on environmentally friendly economic activities. Sustainable finance taxonomies are being developed by governments to be used as tools to grow the clean economy of the future and improve the environmental performance of industries.

This is in contrast to ESG, which is the reporting methodology used by the investment community. Some countries, such as the US, are considering leading the way by not having a sustainable investment taxonomy but requiring greater reporting against ESG, The Taskforce supports this approach.

1. Further details on nuclear energy’s role in the SDGs can be found at: www.iaea.org/about/overview/sustainable-development-goals.

As a tool, taxonomies are policy documents which are intended to spur sustainable investment and improve market clarity and integrity. However, they are being used to assess activities to determine whether broad asset classes are "sustainable"[2] or not, and therefore whether they should be able to access climate finance. Each country has its own environmental and socio-economic objectives set out in NDCs and other documents, and as such, their respective taxonomies may differ. While a clear global policy framework would be helpful to the markets, such policies should not contravene another country's own jurisdiction to determine its own energy policy, nor should they be used to broadly assess technologies and assets. ESG should be used to assess assets and individual companies or projects to determine whether they are investable assets able to access climate finance. Unfortunately, taxonomies could be used to restrict access to climate finance. The roles of taxonomies and ESG need to be clarified.

It should be noted, governments are always free to set policy to favour some technologies over another or to disqualify a technology from being used in their jurisdiction. However, this political determination should not drive the designation of an activity as "sustainable and thereby investable. An efficient and effective policy should set standards for outcomes and remain technology agnostic. As such a fair taxonomy would adopt the ESG to determine access to finance, rather than attempting to predetermine "sustainability" and ethics by reference to asset classes.

The current lack of consistency in the definitions of "green" and "sustainable" investments across jurisdictions results in barriers to scaling up ethical, socially responsible and eco-friendly investment, rather than in supporting investment. Convergence towards commonly accepted definitions is key to maximising the effectiveness, efficiency and integrity of the market for sustainable finance.

Properly structured, taxonomies could greatly simplify the assessment of what is and is not socially responsible investment. Caution should be taken to not be too simplistic, as in their current forms taxonomies tend towards a pass or fail structure (i.e. an activity is environmentally "sustainable" or it is not). A broader qualitative assessment, as provided by ESG reporting, results in a wider and more structured approach, and continuous monitoring. Further as ESG reporting is done by an individual asset – the company or project - rather than attempting to undertake a broad assessment of an asset class, it is a much more focused exercise.

An additional issue with taxonomies applying to economic activities is how to apply this to companies. For instance, the regulation may determine an economic activity "X" to be a "sustainable" activity. Therefore, the financial equity and debt of a company solely involved in this activity will be considered as a sustainable investment. However, this activity may be undertaken by a company that is also involved in other activities, which are not considered activities eligible for climate financing. Therefore, finding a model to account for such real-world situations will increase the complexity of implementing taxonomies.

A recent report by the Organisation for Economic Co-operation and Development (OECD) entitled *Developing Sustainable Finance Definitions and Taxonomies* (2020) summarises and contrasts sustainable finance definitions and taxonomies in five jurisdictions: The European Union, People's Republic of China, Japan, France and the Netherlands. It lays out preliminary considerations for good design of taxonomies, which can support policy makers to develop and grow sustainable finance markets to help achieve environmental and sustainable development goals. It also identifies differences among the taxonomies in scope as well as commonalities. Other countries (such as Canada, Kazakhstan, South Africa and Indonesia) have also expressed interest in the development of sustainable finance taxonomies and are progressing towards this goal.

The most well-known taxonomy is the European Union (EU) Taxonomy Regulation adopted in June 2020 as the cornerstone of the EU Sustainable Finance Action Plan. It will be discussed further below.

### *EU taxonomy*

The EU Taxonomy is a list of economic activities with performance criteria for their contribution to six environmental objectives. This is as far as the taxonomies should go. However, the EU Taxonomy goes further in classifying assets classes as "sustainable" or not. Any asset omitted from the list is treated as not "sustainable". To be included in the proposed EU Taxonomy, an economic activity must contribute substantially to at least one environmental objective and do no significant harm to the other five, as well as meet minimum social safeguards. Technical screening criteria set requirements for determining substantial contribution and Doing No Significant Harm (DNSH).

2. Sustainability is a term that is not favoured by many in the finance community as it is unclear what it is intended to cover. It should link to the SDGs, but the term is greatly miss-used. ESG are wide ranging and companies need to be assessed against a broad range of ESG.

The six environmental objectives are:

- climate change mitigation;
- climate change adaptation;
- sustainable use and protection of water and marine resources;
- transition to a circular economy, waste prevention and recycling;
- pollution prevention and control;
- protection of healthy ecosystems.

The EU used a Technical Expert Group (TEG) to assess a large number of activities and determine if they meet the criteria set out above. For a long-time nuclear has been accepted as being one of the best technologies when assessed against all three scopes on GHG emissions (see more details below). However, there were concerns expressed by the TEG about nuclear not being able to meet the DNHP due to the waste it produces. Similar concerns about other technologies seem to be overlooked or at least discounted. However, following the initial TEG report, the EU appointed its Joint Research Centre (JRC) as the group of experts to assess nuclear under its sustainable finance taxonomy. In March 2021 the JRC issued its *Technical Assessment on Nuclear Energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation')* (EU, 2021) (hereafter the EU report), finding that nuclear does no more harm than other energy sources that were seen as sustainable. This report is now being considered by the EU commission to further debate nuclear's role in the EU taxonomy. In the meantime, a number of governments have expressed concerns about the role the EU is taking in trying to use the taxonomy to limit certain technologies such as nuclear.

The EU taxonomy is mandatory in the sense that financial market participants will be obliged to comply with the regulation when they want to market a financial product as "environmentally sustainable as per EU legislation". Financial products can still be issued with no reference to the EU taxonomy, if the issuer does not mention "environmentally sustainable" in its communications. The legislators' state that their intention is not to impose prescriptions on financial markets, but rather to spur the development of a market for "environmentally sustainable" investments as defined in the regulation. However, in practice the EU Taxonomy is being used to prevent financial institutions registered in the EU from investing in assets not listed as "sustainable" in the taxonomy wherever they are in the world.

### *United Kingdom*

The United Kingdom has announced that it is considering implementing a green taxonomy – a common framework for determining which activities can be defined as environmentally sustainable – to improve understanding of the impact on the environment of companies' activities and investments and support the UK transition to a sustainable economy.

### *Canada*

In May 2021, the government of Canada launched the Sustainable Finance Action Council (SFAC), recommended in the *Final Report on the Expert Panel on Sustainable Finance: Mobilizing Finance for Sustainable Growth* (Environment and Climate Change Canada, 2019), as a cross-departmental secretariat to advise and assist the federal government in implementing the panel's recommendations (Government of Canada, 2021). One of the potential SFAC work streams may relate to providing advice on defining transition finance.

Additionally, the Canadian Standards Association (CSA) is leading in the development of a Canadian transition finance taxonomy and has formed the Technical Committee for Transition and Sustainable Finance. The committee includes representatives from Canada's financial sector (including the major banks, pension fund managers, wealth and asset managers, insurance companies, rating agencies), Canada's natural resource sectors, and related industry stakeholders.

### *China*

As the largest economy in the world nowadays, China's efforts to develop sustainable finance definitions, build sustainable finance markets and shift investments from environmentally unsustainable to sustainable activities is essential to meeting the global environmental objectives.

In terms of financial regulation, China's core framework is the *Guiding Catalogue for the Green Industry* (Ministry of Ecology and Environment et al., 2019) established in 2016 and updated in 2019.

It consists of a list of eligible sectors and is based on both industrial policies and environmental considerations. The six categories of green industries listed in the catalogue are:

- manufacture of energy efficient equipment;
- clean production industry;
- clean energy industry;
- industry of ecology and environment;
- green upgrade of infrastructure;
- green services.

China has specifically included nuclear power under the category of clean energy industry.

### *Japan*

Rather than a "taxonomy", Japan's sustainable finance guidelines issued so far by the Japanese authorities are principle-based, containing metrics guidance but no thresholds.

Japan is an important player in the development of sustainable finance. It is the world's third largest economy and Tokyo is one of the main global financial centres home to some of the world's most powerful financial institutions.

> Japan's green bond guidelines provide an indicative, non-exhaustive sector list, including renewable energy, energy efficiency, pollution prevention and control, sustainable management of living natural resources and land use, projects for terrestrial and aquatic biodiversity conservation, projects for clean transportation, projects for sustainable water management, projects for climate change adaptation, projects concerning eco-efficient products, production technologies, and processes, and projects to newly build or renovate green buildings that not only are energy efficient but also address a wide range of issues for consideration such as water consumption or waste management.
>
> The guidelines recognize that some green projects may have incidental negative impacts on the environment, in addition to their intended environmental benefits. In such cases, the guidelines prescribe that those negative environmental impacts are evaluated by the issuers as limited compared to their environmental benefits, and that the issuers should include information regarding these negative impacts to investors so that the investors and market participants can appropriately evaluate these impacts.
>
> Issuers should inform investors of the environmental sustainability objectives they intend to achieve with the green bonds and the criteria for selecting the projects accordingly. Examples of environmental objectives are climate change mitigation, adaptation, and the conservation of biodiversity. For climate change mitigation, the criteria can be GHG emissions reductions (OECD, 2020).

### *South Africa*

In May 2020, the South African Government's National Treasury published the draft Technical Paper on "Financing a Sustainable Economy" with the aim of unlocking access to sustainable finance and stimulating the allocation of capital to support a development-focused and climate-resilient economy.

Since then extensive consultation with local and international stakeholders have resulted in a Draft Version of such a taxonomy for South Africa. The draft describes a national Green Finance Taxonomy for South Africa. It is divided into three main sections including,

- a Matrix that provides high-level view of eligible activities under each sector;
- a Catalogue that indicates basic attributes of the activities identified in the matrix, and maps the environmental objectives of each activity, and
- technical Screening Criteria to give in-depth information on the attributes and requirements for each eligible activity, including principles, metrics, and thresholds for substantial contribution to climate change mitigation and climate change adaptation.

This draft Green Taxonomy is clear on the applicability of wind, solar and hydropower but excludes mention of nuclear. The document is expected to be finalised and approved in 2022.

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# Low Carbon ESG Reporting

This chapter provides a high level overview of how nuclear and other low-carbon energy asset classes could report against the ESG identified in Appendix I. The following chapter (Nuclear Disclosures against ESG) addresses how nuclear can positively report against the ESG. Appendix II provides greater details on how nuclear and other energy sources could broadly report against ESG.

## Overview of energy companies / projects reporting

Pillar: **GOVERNANCE**


Table 1: General overview of how low carbon energy companies could report against the "Governance" pillar

| **Metric** | **Sub-metric/ comments** | **Comments** |
|---|---|---|
| Governing purpose | | Asset specific |
| Quality of governing body | Board composition, remuneration, | Asset specific |
| Stakeholder engagement | Buy-in, impact and process | Energy companies and projects generally have strong and wide stakeholder engagement. |
| Ethical behaviour | Anti-corruption, ethics and reporting | Energy companies and projects are generally considered to be ethical. However, the full lifecycle and supply chain should be considered. This is further complicated when considering the full system profile of assets, for example if renewables are using storage facilities to provide firm power. |
| Risk and opportunity oversight | Integrating risk and opportunity, including climate change risk | Asset specific |

# Pillar: **PLANET**


Table 2: General overview of how low carbon energy companies could report against the "Planet" pillar

| **Metric** | **Sub-metric/ comments** | **Comments** |
|---|---|---|
| Climate change | GHG emissions, scope 1, 2 and 3, including risk management and mitigation | When considering the full life cycle and the supply chain, nuclear energy and on-shore wind have similar greenhouse gas (GHG) emission profiles. However, when considering the wider system profile and assets used to provide storage, this evaluation becomes much more complex for some renewable projects. Reporting should be extended to consider how assets work together to provide firm power. |
| Nature loss | Land use and ecological sensitivity, and land use | Per kWh of power, nuclear energy reports better than solar, which in turn reports better than wind in terms of land use. |
| Fresh water availability | Consumption and management | Nuclear energy does not consume water but it does use large quantities of water. This may change with more advanced designs, particularly with Gen-IV technologies. Nuclear power can also be used for desalination to provide fresh water.<br><br>Solar uses little water except in manufacturing, but if solar panels break they can contaminate the watercourse.<br><br>Wind projects do not use water except in the manufacturing process, but off-shore wind farms do have an impact on the marine environment.<br>Each asset needs assessing on its own merits. |
| Pollution | Air and water, including NOx, SOx, particulate matter and lead | Nuclear energy can report well against pollution ESG. Renewables need to be assessed as individual assets. |
| Waste | Management and mitigation | All energy projects and companies produce waste and need to be decommissioned at the end of their lifetimes.<br>During its many years of existence, nuclear power has developed world class waste management and mitigation processes and procedures. Solar companies are beginning to manage and mitigate their waste using similar standards, but the wind industry has yet to establish proper processes and procedures for the management and mitigation of waste. |
| Resources | | Resource management is generally well-managed across energy projects. Some wind projects have been shown to be using balsa wood, and therefore such assets need assessing on an individual basis to ensure that the wood is ethically sourced. |

# Pillar: **PEOPLE**


Table 3: General overview of how low carbon energy companies could report against the “People” pillar

| **Metric** | **Sub-metric/ comments** | **Comments** |
|---|---|---|
| Dignity and equality | Diversity, inclusion, harassment, pay equality and pay gaps, wage levels and living wages, human rights abuses, including trafficking, slavery and child labour | Asset specific |
| Health and well-being | Health and safety (workforce and third parties), including nuclear safety and emergency management, incidents on-site, well-being and impact | Health and well-being across the energy sector is generally high. However, each asset will need to report to these high standards.<br>Nuclear energy has developed gold standard health and safety procedures, not only for nuclear safety and emergency preparedness but also for organisations as a whole, and across lifecycles. |
| Skills for the future | Training, number of unskilled vacancies and impact. | The energy sector is generally good at training and development, and at providing skills for the future. The nuclear sector has spent considerable time and effort in maintaining its skills and developing skills for the future (on existing and future technologies).<br><br>The renewables sector is a newer industry and therefore has not yet had to consider maintaining skills for the future (although they have had to develop a workforce from scratch), and therefore it will be more asset specific. |

## Pillar: **PROSPERITY**

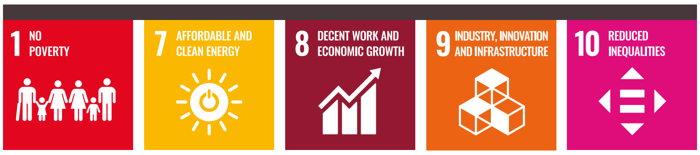



Table 4: General overview of how low carbon energy companies could report against the “Prosperity” pillar

| Metric | Sub-metric/ comments | Comments |
|---|---|---|
| Wealth creation and employment | Number of jobs, economic contribution, financial investment, Infrastructure investment, significant economic impact | All energy projects create jobs and wealth, particularly during the construction period.<br><br>Nuclear plants operate for 60 to 100 years and create significant and highly paid jobs at the plant itself, while also creating positive socio-economic impacts on the regions where they are built. These plants thereby create well-paid employment not only during the construction period but for the 60 to 100 years of operation, as well as through decommissioning.<br><br>The operation and maintenance of wind and solar projects can vary, and the plant life is much shorter. Wealth creation and employment therefore becomes more asset specific. |
| Energy affordability | Residential, commercial and industrial, number of disconnections and external factors | When considering the cost of the plant and therefore the energy generation, nuclear energy can be perceived as having higher costs than those for other energy assets, particularly when considered over a shorter period than the life of the asset. However, when considering affordability against a levelized cost across the life of the asset, capacity factors and any associated system costs, energy affordability is in fact similar to renewable projects. |
| End-use efficiency and demand | Percentage of electric utility revenues, percentage of load served by smart grid technology and customer savings from efficiencies | As a firm power source, nuclear power can often report better in terms of end use efficiency and demand. However, this will largely be asset specific for all three technologies. |
| Grid resiliency | Number of incidents and disruptions | As a firm power source, nuclear power often reports well as it causes little disruption to the grid.<br>Intermittent power sources that are weather dependent, such as wind and solar, can be more challenging. |
| Innovation in better products and services | R&D spending and social value generated | The nuclear industry invests significantly in R&D in an effort to find better products for the future.<br>The renewables industry is a newer industry and therefore R&D spending will be much more company specific. |
| Community and social vitality | Tax paid and total social investment | Energy companies and projects tend to report well against community and social vitality metrics. |

# Nuclear disclosures against ESG

This chapter considers nuclear energy as an asset class, and how nuclear companies and projects could report against the ESG identified in Appendix I. This section is the main focus of the report on how **nuclear energy is an ESG investable asset class**. Appendix II provides greater detail on the reporting against each ESG, including what each metric is intended to cover.

## Governance: SDGs 12, 16 and 17

### *Governing purpose*

Although this metric is very company-specific, many nuclear companies nonetheless clearly articulate their governing purpose as a utility, a generating company, a technology company, an operating company and/or a development company.

When special purpose vehicles (SPVs) are established for a specific purpose, to develop and construct an asset such as a new nuclear plant, their governing purpose is very clearly established from the offset.

A clear governing purpose, set out in the company's documentation, is vitally important. Equally the company needs to be run to deliver its governing purpose.

These roles have become a little confused in recent years with nuclear technology companies becoming shareholders in development companies. However, on the rare occasion this has happened, the governance procedures have been well established and maintained to ensure that an appropriate delineation of roles is maintained. The company's role as shareholder and the company's role as contractor selling their technology to the development company need to be separated to ensure that the correct governance is maintained.

Nuclear regulation also has a role to play here. With the strict requirements around the "Controlling Mind" of a company and also the "Knowledgeable Customer" that are vital to regulatory compliance in nuclear corporate governance, and while these do not strictly apply before a nuclear company is operational (having radioactive material on site), many companies adopt processes and procedures to follow these principles before they are strictly required to do so. They have also very frequently developed plans to ensure compliance during the life of the asset.

Nuclear projects and companies are often key to the socio-economic development of communities and countries. With the long-term nature of nuclear assets (a lifecycle of c. 100 years) they promote the long-term sustainable success of the company, generating value for shareholders and contributing to wider society as set out in this paper. There is an emerging focus on boards signing up to their own ESG statement to show how they will deliver their governing purpose in line with ESG across the lifecycle. The board should establish how the company proposes to fulfil its governing purpose through ESG means. More and more companies, including nuclear companies, should adopt this best practice.

The Taskforce noted that there could be improvement in some company's boards needing to ensure that the company's purpose, values and strategy are aligned to the corporate culture and to workforce policies and practices. The nuclear industry has stringent policies and practices but sometimes the leadership does not flow up to the board.

The number of stakeholders in any energy project, but particularly in nuclear projects, are extensive and complex and need to buy into the company purpose, and then they need to be kept informed of developments within the company. This is especially true in any new build project where the local community, local government and central governments will need to align for the project to move ahead.

Stakeholder mapping for the nuclear sector has always been wide ranging. Being transparent and open with a broad and wide range of stakeholders is something the nuclear industry has, in more recent years, managed well. Stakeholders the nuclear industry liaises with include governments and governmental departments, local and regional communities, schools and universities.

All material stakeholders need to buy into the company's governing purpose. Nuclear companies need to identify and manage all material issues that could affect stakeholders – which they are used to doing. Due to the misconceptions around nuclear, the sector has to go further than many other sectors in managing stakeholders and dealing with perceived concerns.

With the additional regulatory and stakeholder impact on nuclear companies, the quality of the company's governing body (both the board and the executive) are key to the successful performance of a company. The processes and procedures required to manage nuclear regulatory compliance are far-reaching, resulting in gold standard processes and procedures being adopted (sometimes to the financial detriment of the company), which needs to be considered. If other companies were to adopt such strict and stringent processes and procedures it would likely result in an increase in project and company costs.

Due to governance and regulatory oversight the composition of the board and its committees is a key concern. The challenge provided by the non-executive to the executive team is also good practice that many nuclear companies adopt from early in the company's existence. Some companies go further in having:

- a well-constituted board;
- independent, non-executive directors to provide oversight;
- a supervisory/advisory board to provide wider supervision and advice to the company. While this may be best practice, it also adds further costs and therefore needs to be considered against the additional value provided to the company.

Energy companies tend to remunerate reasonably well. Capital projects generally remunerate better to reflect the risks being undertaken in trying to get the project developed. The nuclear sector recognises the importance of its people and seeks to compensate them well. Capital project remuneration packages also tend to include success fees and bonuses linked to the milestones achieved. While corporates also link bonuses to milestones, they are often lower, reflecting the level of risk involved.

Whether an individual company has met these milestones will be a matter of due diligence, however the gold standard adopted by many in the nuclear sector should set the standards that others should aspire to.

### *Quality of governing body*

The capabilities, thinking, experience and perspectives of board members are key to the successful operation of a company. Much has been written in recent years about the importance of diversity of the individuals and diversity of thought. The WEF research examining public companies across multiple jurisdictions found that companies with higher diversity financially outperform their peers.

A diverse and inclusive board and workforce brings out the best in its people and the company as a whole can then better understand the needs of its customers. It is also better equipped to manage risk and exhibits responsibility for the organisation. Diversity of thought also provides the most fertile environment for innovation and disruption, allowing the company the ability to quickly pivot to meet changing demands.

Gender diversity is one form of diversity. In April 2020, PwC conducted a survey on powerful women[1] looking at women in energy companies and found that 38% of UK energy companies have no women on the board and only 21% of board positions in UK energy companies were held by women, with only 13% of executive board positions across the UK energy companies being held by women. The nuclear industry performs slightly better than the other parts of the energy industry, including renewables, in terms of gender diversity, but it is marginal. Some of the Canadian nuclear companies report extremely well on gender diversity on their boards and Canada has implemented the Equal by 30 programme[2] and Driving the Advancement of Women in Nuclear (DAWN) to advance the participation of women in the clean energy transition and to close the gender gap.

Human Resources Canada has also implemented a Diversity and Inclusion[3] programme to foster diversity and inclusion within all organisations. The programme represents the right for diversity and inclusion of under-represented groups in the electricity sector, including women and Canada's indigenous population. The Diversity

1. For more information on this survey, see https://powerfulwomen.org.uk/board-statistics-by-company/.
2. For more information on this programme, see: www.equalby30.org/en/splashify-splash.
3. For further information, see: https://electricityhr.ca/workplace-solutions/diversity-inclusion/.

and Inclusion programme works with the Canadian Council for Aboriginal Business [4] to consider corporate performance in Aboriginal relations. Further, the Canadian BlackNorth Initiative[5] seeks to end anti-black systemic racism – over 450 companies have signed up to the initiative. These programmes also work with Nuclear Against Racism,[6] under which the nuclear industry has pledged to agree to stand in solidarity with black and indigenous communities, and people of colour across the world.

In the UK, the revisions to the Nuclear Sector Deal will further address diversity and inclusion across the nuclear sector. The focus is likely to be on diversity of thinking and diversity of socio-economic backgrounds. There are also likely to be regional targets around cultural diversity to reflect the cultural diversity in different regions of the UK. The UK has also established a not-for-profit initiative, called Inclusion and Diversity in Nuclear (IDN),[7] with the aim of creating an inclusive and diverse industry.

Even with all these initiatives, and others, diversity remains a challenge. There are many considerations to developing diversity policies and procedures and some will be country and even regionally specific. The UK is considering the approach in its revisions to the Nuclear Sector Deal and not only looking at diversity of thinking together with cultural, racial, sexual orientation, gender, disability and socio-economic diversity, but also looking at different targets based on the socio-economic and cultural diversity in each region rather than trying to consider the country as a whole. The energy sector as a whole has a long way to go before it can be seen as truly diverse. Whether a company is inclusive and diverse is a matter for investors' due diligence and for a company's reporting.

Organisations need to be purpose-led. The ability to achieve milestones provides a useful mechanism to assess whether the board and its management have the ability to oversee the company and to deliver the stated purpose. It provides as indication of the board and executives ability to guide and lead the company.

It is important that projects run to time and to budget. In the West, infrastructure projects' ability to run to time and to budget has historically been a problem for large projects, including nuclear projects. As nuclear moves to more of a product-based approach (minimal on-site construction time) with the majority of the kit being factory built, this should improve dramatically. Also, with smaller reactors the project schedule will be shorter and less complex and therefore it should be easier to maintain milestones. Some smaller reactors are showing construction periods of only two to three years. As technologies advance, reactors will become more product-based and therefore construction periods will be shorter. This is an area that the nuclear industry needs to keep under constant watch and develop methods to keep to time and to budget. However, delays and cost overruns are not just the domain of the nuclear industry. Major megaprojects, including renewables, face the same challenges.

The company's remuneration policy needs to reflect both the company and the project. Energy projects are vital to society and important for the socio-economic development and regeneration of regions and countries. The remuneration policy, performance criteria, appraisal and assessment processes and performance incentives should reflect the delivery of the stated purpose as well as the importance to society of these projects.

Nuclear companies generally pay well and above the market rate, reflective of the importance of their Board and staff. However, due diligence will assess the specifics of a company against the wider country profile. The 2019 Oxford Economics report, *Nuclear power pays: Assessing the Trends in Electric Power Generation Employment and Wages* (2019) indicates that in average jobs in nuclear energy are 20% better paid than in fossil fuel generation, and 30% better than wind and solar generation, directly demonstrating the higher education in nuclear as well as a higher potential for premium activities and jobs.

### *Stakeholder engagement, including buy-in, impact and process*

Stakeholder engagement and assessing the impact of the company on stakeholders is something the energy industry, and particularly the nuclear industry, is used to doing. When developing new projects, energy companies engage with a wide range of stakeholders in bringing the project to fruition. These stakeholders will include: the government, the planning authorities, regulators, local communities, schools, universities and off-takers. To develop these projects, various hurdles will need to be overcome to reach financial close, including raising finance, getting all the relevant planning, environmental, and licensing approvals and consulting with communicates and wider

4. See: www.ccab.com/programs/progressive-aboriginal-relations-par/.
5. See: https://blacknorth.ca/the-pledge/.
6. See: www.nuclearagainstracism.com.
7. See: www.niauk.org/media-centre/member-news/inclusion-diversity-nuclear/.

stakeholders. This is even more stringent on nuclear projects where there are additional regulatory requirements to meet before a project can move ahead.

Established energy companies maintain their relationships with stakeholders but not to the same extent as capital projects SPVs. Nuclear companies tend to maintain relationships with wider stakeholders as a matter of course as they are part of the community for such a long period of time and they often work with a whole range of stakeholders to maintain their position in the community. Nuclear can be a controversial topic for some stakeholders and nuclear companies work hard to maintain their relationships. Nuclear companies often understand well their impact on different stakeholders and the importance to their business of maintaining those relationships.

Again, whether a company can report well against this metric will depend on the individual company and how well they have identified the material issues and engaged with a wide enough group of stakeholders.

### *Ethical behaviour*

Bribery and corruption undermine stakeholder trust and are linked to fraudulent behaviour, misconduct, lack of governance and due process, misallocation of capital, illegal behaviour and human exploitation. In short, bribery and corruption fundamentally undermine businesses and all ESG.

The nuclear industry takes unethical behaviours very seriously and assesses not only its own company's behaviour but that of the supply chains across the whole lifecycle. Although this will be company-specific, nuclear companies often have gold standard training in place for all employees to ensure that best practice is understood for anti-bribery and corruption practices, what to look out for and how scenarios should be assessed; as well as money laundering processes and procedures and how inappropriate incidents should be reported within the company.

Anti-corruption and bribery training is vital for the development and understanding of employees and to ensure that they understand the latest developments in anti-corruption and bribery prevention. However, training is not the be-all and end-all to protect the company and its reputation. Companies also need to invest in processes and procedures (including reporting) to ensure the highest levels of governance around anti-corruption and anti-bribery systems.

In addition, companies should train people, and have processes and procedures in place, to assess their supply chains and potential supply chains in order to look out for unethical or illegal behaviour, whether that relates to people (human trafficking, fraudulent behaviour) or financial practices. Implementing gold star processes and procedures helps to prevent corruption and bribery in organisations. Companies need to be aware of not only the local laws that apply to the company but also other laws, legal systems and regulations that have an impact. Monitoring is a key element of such processes.

Companies need to be able to assess and report unethical issues and need processes and procedures which facilitate reporting. Unethical behaviour needs to be prevented and remedied. Whistleblowing procedures need to be established to allow reporting of unethical behaviour without consequence on the reporter. Having such procedures in places helps to evidence proper governance and control by the board and the executive.

Energy is vital to countries' socio-economic development. Energy projects are developed throughout the world and investors need to be confident that concessions and contracts have been awarded in a professional, appropriate and ethical way. Corruption is a major concern for all energy projects, particularly in climate and green projects (where "green washing" can occur) or projects where resource such as forest are in issue. Corruption is a major issue for energy projects. With nuclear projects, due to the international oversight provided by organisations such as the International Atomic Energy Agency (IAEA), it is more difficult for unethical practices at a government level to exist, although it is possible and should be reviewed as part of any reporting and ESG assessment.

Nuclear technology is subject to two main regimes in order to ensure its use for peaceful purposes in energy, medicine and science. These are international safeguards and export controls. There are international and domestic standards around safeguarding of nuclear matters in place to ensure that nuclear materials are not misappropriated or used for illegal purposes. International safeguards exist to ensure that nuclear material cannot be diverted for non-peaceful uses and consist of a system of nuclear material accountancy by the operator of an installation and reporting to the national safeguards body, and ultimately the IAEA. Verification of accountancy figures, remote monitoring and sealing of inventories are all carried out, and backed up by periodic inspections from the national safeguards responsible authority and/or the IAEA to provide independent verification.

Equally there are complex and detailed international and national export controls as well as international and national practices in place to ensure that a wide range of materials (nuclear or other) cannot be misappropriated for nefarious purposes. Although many countries have export controls in place for a wide range of materials, the list of items on the export controls list are significantly higher for the nuclear industry. Export controls cover a variety of areas from nuclear, aerospace, communications, materials and weapons. They are intended to aid countries in discharging their obligations. Through numerous treaties, export controls place restrictions on the export of components, documentation, knowledge and training. For certain nuclear technologies, prior to export, exporters will have to obtain an export licence from their country's recognised authority and satisfy them that the technology, component or knowledge will not be diverted for purposes other than the peaceful exploitation of nuclear technology, and will not threaten the security of nations or contribute to the oppression of persons in the country of import. Importers are required to satisfy the exporting country's export authority that the materials will not be diverted anywhere other than their intended use.

Due to international oversight, countries that do not implement gold standards in relation to safeguarding and export controls are likely to be criticised by the market for failing to implement proper standards. This will equally apply to companies that do not have the current controls in place.

### *Risk and opportunity oversight*

This metric relates to a company's overall risks and opportunities. The onus sits with the board and the executive to have oversight of all the risks and opportunities. Risk registers should be maintained. The primary responsibility for maintaining registers and managing risks and opportunities lies with the executive, but the board must maintain oversight. The risks and opportunities must be appropriate for the organisation and not extend past the risk appetite of the company. The risks and opportunities should be wide enough to cover its stakeholders and the wider community. The risks should include ESG including environmental risks such as GHGs and climate change (see the Planet section below). The risk register must develop and adapt over time, including but not limited to an energy company transitioning from a development company, to a construction company, to an operational company and finally through to decommissioning. The risks and opportunities at each stage will be different.

Nuclear companies often have gold standard process and procedures in place to manage risks, particularly those around nuclear risks and health and safety. Health and safety varies across jurisdictions, and whether a company meets this metric will be company- and country-dependent and will be weighted accordingly. The standards of health and safety, generally whether in nuclear or other energy projects, varies across the globe. Investors will assess the projects on their culture, processes and procedures, including the board's oversight.

Nuclear regulations provide for nuclear licenses to be in place for the construction, operation and decommissioning of the plant. The precise details depend on jurisdiction. However, under internationally agreed norms, the licensee has to be the Controlling Mind and Knowledgeable Customer for the site.

The Controlling Mind is a legal concept has its origins in health and safety law relating to corporate manslaughter. In nuclear projects, it relates to the health and safety responsibilities in respect of risk management on a nuclear site. Under nuclear site licenses, the site licensee is responsible for health and safety and the overriding risk management of the site (the precise details of this will depend on the jurisdiction). The site licensee needs to be the "Controlling Mind" of all safety, security and safeguarding issues on the site. In relation to those areas, it cannot be constrained by the owner of the nuclear power plant or even the operator's parent company, shareholders or investors. This can adversely affect the ability of investors to enforce their rights in a traditional project finance way. This in turn can affect the structure of the project. The Controlling Mind principle does not mean that the site licensee takes over others responsibility on the site or is the only entity responsible for health and safety and risk management on the site i.e. owners, operators and contractors still have to comply with their contractual and legal responsibilities. However, the site licensee has to have an understanding of all work being undertaken on the site. The precise details of this will depend on each jurisdiction.

In addition to the Controlling Mind principle is the Knowledgeable Customer. A site licensee is expected to have the capability, within its own organisation, in terms of staffing and expertise, to understand the safety case for all the nuclear facilities on the site and the limits under which it must be operated. A nuclear licensee needs to understand the safety significance of any work undertaken by contractors and to oversee and take responsibility for each contractor's activities, including ensuring that the contractor's staff are suitably qualified and experienced to carry out their nuclear safety duties. This means that major contracts which affect the safety, security or safeguarding of the plant, including the EPC Contract and the Fuel Supply Agreement (FSA), must sit with the licensed entity i.e., the licensed entity needs to have control of those contracts to be able to fulfil its Knowledgeable Customer obligations.

Nuclear safety culture is defined as "the core values and behaviours resulting from a collective commitment by leaders and individuals to emphasise safety over competing goals, to ensure protection of people and the environment" (WANO, 2013). Nuclear companies should have detailed processes and procedures for managing health and safety and risk through-out the company and at every level of the organisation.

However nuclear companies' focus on nuclear risks and health and safety may be to the detriment of other risks such as delays and cost overruns in construction projects. These risks are large risks for the finance community and should not be underestimated as they have a direct impact on rates of returns. Delays and cost overruns are also true of other parts of the energy sector and therefore nuclear should not be discriminated against for this. In fact, it could be argued that other players in the energy sector should also improve their performance on sector-specific risks, and health and safety.

Therefore, a balanced and cross-board approach to risk, and risk mitigation and management, needs to be established and one risk should not be overly focused on to the detriment of other risks. All risks need to be managed and no company or project should be exempted from managing risks through perception or bias. Much can be learnt from the way nuclear manages and mitigates its risks.

## Planet: SDGs 6, 7, 12, 13, 14 and 15

### *Climate change*

The role of nuclear as a low carbon technology is becoming widely accepted.

As identified in the *Canadian Nuclear Factbook 2020*, "Today by displacing the use of coal and natural gas, nuclear power helps avoid about 2.2 billion tonnes of $CO_2$ emissions annually. This is the same as taking about 480 million passenger vehicles off the road – or nearly half of all the passenger vehicles in the world." (CNA, 2020)

In January 2016, the Public Service Commission of the state of New York ruled that the state's Clean Energy Standard (CES) portfolio must include nuclear power plants among its non-carbon-emitting generation resources.

In the "Agreement Between the Government of the United Kingdom of Great Britain and Northern Ireland and the European Atomic Energy Community for Cooperation on the Safe and Peaceful Uses of Nuclear Energy", signed on 31 December 2020, it was noted:

> NOTING the United Kingdom's commitment to developing and deploying nuclear energy as part of its diversified and low-carbon energy mix;
>
> DESIRING to make long-term cooperative arrangements in the field of peaceful and non-explosive uses of nuclear energy in a predictable and practical manner, which take into account the needs of their respective nuclear energy programmes and which facilitate trade, research and development and other cooperative activities between the United Kingdom and the Community;" (EU, 2020)

On the global stage, the potential role of nuclear in reducing carbon impacts from power generation was a central theme of the COP21 summit in Paris. During the event, Loreta Stankeviciute – Energy Economist at the IAEA – stressed that "nuclear energy should be considered on equal footing with other low-carbon energy sources in weighing the energy options for mitigating climate change, in recognition of its broader potential for contributing to sustainable development".

Stankeviciute was speaking at a session hosted jointly by the IAEA and the Nuclear Energy Agency, which has also consistently highlighted the credentials of nuclear power as a way to drive carbon emissions out of the generation mix.

As the NEA's report, *The Role of Nuclear Energy in a Low-carbon Energy Future* (2012), states:

> The generation of electricity from nuclear power does not result in any direct emissions of CO2, the most important of the greenhouse gases thought to be responsible for global warming. As with all energy sources, there are some indirect emissions; these result mainly from fossil fuel use for operations in the nuclear fuel cycle. The exact level of these indirect emissions varies according to location and the technologies used, but studies described in this report show that even in the highest

> cases they remain more than an order of magnitude below the direct emissions from fossil fuel generation, and are comparable to the indirect emissions from most renewable energy sources. (NEA, 2012)

This message was further amplified during a 2020 NEA webinar and in an NEA Policy Brief (NEA, 2020a) entitled "Building Low-Carbon Resilient Electricity Infrastructures with Nuclear Energy in the Post-COVID Era,[8]" and again in recent IEA reports: *Net Zero by 2050: A Roadmap for the Global Energy Sector* (2021), and *Nuclear Power in a Clean Energy System* (2019) and *Nuclear Power in a Clean Energy System (2019).*

GHG emissions have been identified as one of the primary causes of climate change, and therefore key to the mitigation of climate change. GHG emissions is one of the main metrics for ESG across a number of reporting bodies. Over the past ten years, businesses associated with high emissions have fallen out of favour as the markets have moved towards low carbon economies.

There remain difficulties in adequately measuring emissions. However, scope 1, 2 and 3 reporting has been developed. These are defined by the Task Force on Climate-Related Financial Disclosures (TCFD) as:

- Scope 1 refers to all direct GHG emissions.
- Scope 2 refers to indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3 refers to other indirect emissions not covered in scope 2, that occur in the value chain of the reporting company, including both upstream and downstream emissions.

There are also challenges about the accuracy of the reporting against these metrics and also there is a bias towards certain technologies who often only report against scope 1 and sometimes scope 2. Some nuclear companies are beginning to report on scope 1,2 and 3. Requiring companies to report on all 3 scopes would create a level playing field across technologies. Looking at the lifecycle emissions provides a more accurate view of technologies and their overall impact on climate change.

For a nuclear plant, many of the emissions are associated with the upstream supply chain – particularly the mining of uranium and the enrichment and fuel fabrication processes. In certain configurations with high grade ore or no enrichment or centrifuge-based enrichment the emissions from a nuclear lifecycle are the same as those from an on-shore wind farm (i.e., lower than an off-shore wind farm).

Appendix II references three reports on GHG emissions, comparing different technologies. These reports are:

- The Hatch report (2014) was commissioned by the Canadian Nuclear Association to consider lifecycle emissions from different technologies employing a lifecycle assessment (LCA) overview methodology (for further details see page 83). The LCA meta-analysis is a cradle-to-gate study spanning resource extraction to the production of electricity at the point (or gate) of delivery to the electricity grid. The study encompasses all upstream and downstream processes associated with the generation of 1 kWh of electricity, excluding transmission and distribution losses, and considers two dimensions of the lifecycle:
  - Supply chain – processes corresponding to the ongoing operation of the power generation facility, including the upstream systems associated with fuels and consumables and downstream systems associated with the management and disposal or waste; and
  - Lifespan – processes corresponding to the entire lifetime of the power plant from inception to eventual decommissioning, not otherwise captured in the day-to-day operation of the plant;
- The Intergovernmental Panel on Climate Change (IPCC) synthesised evidence from a comprehensive review of published Life Cycle Assessments (LCAs) covering all regions of the world, to produce a comparison of carbon dioxide emissions from different electricity generation technologies; and
- An article in *Nature Energy* (Pehl et al., 2017) measured the full lifecycle GHG emissions of a range of sources of electricity out to 2050.

The table below shows the findings of these three reports.

8. To watch the NEA webinar, see: www.oecd-nea.org/jcms/pl_34301/webinar-building-low-carbon-resilient-electricity-infrastructures-with-nuclear-energy-in-the-post-covid-19-era.

Table 5: Statistical Mean Total Lifecycle GHG Emissions for various sources of electricity

| Technology | Hatch | IPCC | Nature Energy |
|---|---|---|---|
| Nuclear power plant | 18.5 ± 1.7g$CO_2$e/kWh | 16g$CO_2$/ kWh | 4g$CO_2$e/kWh |
| On-shore wind turbine | 10.5 ± 0.9g$CO_2$e/kWh | | 4g$CO_2$e/kWh |
| Solar | | | 6g$CO_2$e/kWh |
| NGCC power plant* | 478 ± 10g$CO_2$e/kWh | | 78g$CO_2$e/kWh |
| Coal | | | 109g$CO_2$e/kWh |
| Hydro | | | 97g$CO_2$e/kWh |
| Bioenergy | | | 98g$CO_2$e/kWh |

*Current NGCC plant and coal production is typically in the range 400- 900+. The figures in the table assume the projects have been fitted with carbon capture and sequestration (CCS). KWh = kilowatt hour; NGCC = natural gas combined cycle. Source: Adapted from Hatch (2014), IPCC (2007) and (Pehl et al., 2017)

Reporting needs to be consistent and cover all three scopes for all technologies. Across the lifecycle, nuclear is on a par with on-shore wind and below solar and off-shore wind (although these reports do not specifically deal with off-shore wind, the cabling and converter stations [if any] increase the emissions to higher than on-shore wind projects). All low-carbon technologies are well below fossil fuel sources.

### *Nature loss*

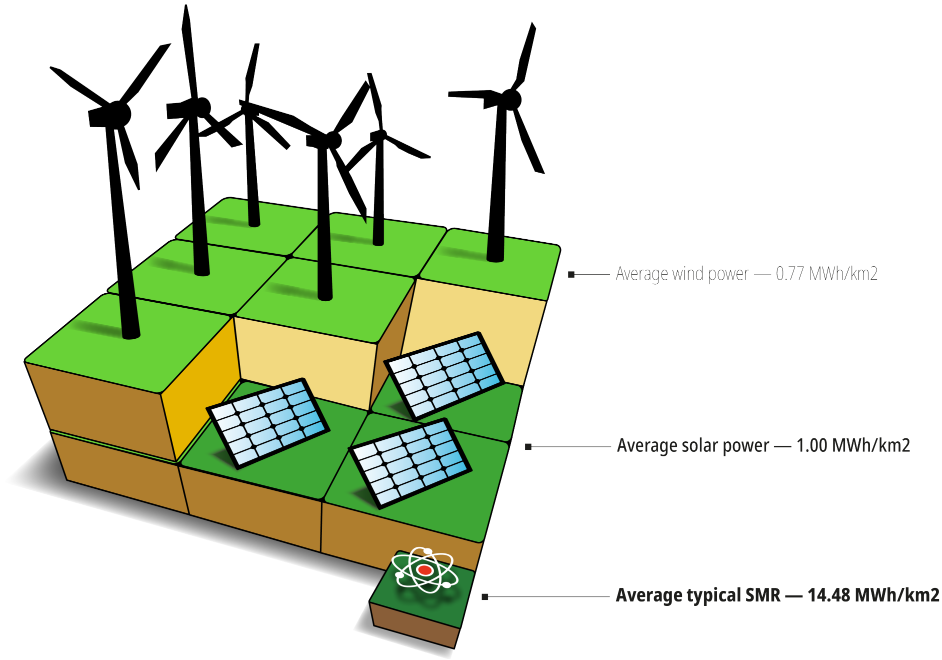
Reporting on the area of land owned, leased or managed by the company, together with adjacent land that is impacted by the company's activities, and in particular protected areas or key biodiversity areas, is vital to being able to assess the impact of any energy source.

Key biodiversity areas provide recognised ways of identifying sites contributing significantly to biodiversity. Protected areas or zones are recognised as areas of ecological importance. Any activities in such areas indicate heightened risk of environmental damage, adverse impacts on biodiversity or ecology and therefore risk to reputation.

The interrelationship between land use and energy is a fascinating balance. Energy is needed for the socio-economic development of regions and countries, but this needs to be balanced with the efficient and effective use of land, which is also needed for other activities, including the production of crops and food. Therefore, the efficient use of land for the production of energy is an important factor to be considered. As highlighted in Figure 1 below,

- An average wind farm produces 0.77MWh per square kilometre of land;
- An average solar farm produces 1MWh per square kilometre;
- whereas a small modular reactor (SMR) produces up to 14.5 MWh per square kilometre of land.

Figure 1: Land use of nuclear, solar and wind




Source: GIF

It should be noted that this reporting only takes into account the plant itself. For technologies which do not produce firm power the wider system profile should be considered to provide the comparable figures.

Like many other infrastructure projects, the development of any energy plant could have an impact on sensitive species and habitats. The impact will depend primarily on the site where the plant is deployed, but when considering the land to be utilised, a nuclear plant of similar size is likely to have a smaller impact than a renewable plant of equal size. Consideration should also be given to any plant and other carbon sinks that are removed to allow the development, and any plants or trees planted by the asset developer to help to balance out the impact on the environment. A developer of any energy plant is required to provide sufficient information (including in relation to avoidance and mitigation measures) in order for an assessment to be made. This includes any off-shore impacts, whether it is an off-shore wind farm or the outlet pipe for cooling water from a nuclear plant. An environmental impact assessment would need to be undertaken to determine the specific impacts on a particular site.

### *Fresh water availability*

Energy projects need to be considered in terms of their freshwater consumption. This is particularly relevant in water-stressed areas where there is a risk of a negative social impact. However, this metric should consider a company's water stewardship as a whole.

The reporting of the units, used together with how water is managed, should be reported in a way that executives, the board and investors can easily understand. The report should include an assessment of the environmental impact of the water use.

In 2014, The Energy and Water in a Warming World Initiative produced a report entitled *Freshwater Use by U.S. Power Plants: Electricity's Thirst for a Precious Resource*. They found that:

> …the water profile of power plants in 2008 shows that:
>
> Power plants are thirsty. Every day in 2008, on average, water-cooled thermoelectric power plants in the United States withdrew 60 billion to 170 billion gallons (180,000 to 530,000 acre-feet) of freshwater from rivers, lakes, streams, and aquifers, and consumed 2.8 billion to 5.9 billion gallons (8,600 to 18,100 acre-feet) of that water. Our nation's large coal fleet alone was responsible for 67 percent of those withdrawals, and 65 percent of that consumption.

> Where that water comes from is important. In the Southwest, where surface water is relatively scarce, power plants withdrew an average of 125 million to 190 million gallons (380 to 590 acre-feet) of ground-water daily, tapping many aquifers already suffering from overdraft. By contrast, power plants east of the Mississippi relied overwhelmingly on surface water.
>
> East is not west: water intensity varies regionally. Power plant owners can reduce their water intensity—the amount of water plants use per unit of electricity generated. Plants in the East generally withdrew more water for each unit of electricity produced than plants in the West, because most have not been fitted with recirculating, dry cooling, or hybrid cooling technologies. Freshwater withdrawal intensity was 41 to 55 times greater in Virginia, North Carolina, Michigan, and Missouri than in Utah, Nevada, and California. Freshwater consumption intensity was similar in those sets of states.
>
> Low-carbon electricity technologies are not necessarily low-water. On average in 2008, plants in the U.S. nuclear fleet withdrew nearly eight times more freshwater than natural gas plants per unit of electricity generated, and 11 percent more than coal plants. The water intensity of renewable energy technologies varies. Some concentrating solar power plants consume more water per unit of electricity than the average coal plant, while wind farms use essentially no water. (Averyt et al., 2011)

The exact water use will be project-specific, especially as some assets consume water whereas others (e.g. an operating nuclear or hydropower plant) simply use it and replace it. However, water consumption should also be assessed together with desalination and the creation of potable water for those countries where this is needed.

Nuclear plants can be used for desalination and the creation of potable water and can help to off-set the impact of water consumption, particularly in water-stressed areas. The technology has been proven for desalination, principally in Kazakhstan, India and Japan. According to the World Nuclear Association (WNA), the costs of desalination by nuclear plants is much the same as fossil-fuel plants that do the same – c. USD 70 to 90 cents per cubic metre. This cost may drop with some of the advanced high temperature reactors in development. Whether countries chose to take the benefit of this option in nuclear plant is yet to be seen and will depend on the economics and other developments in each country.

### *Pollution*

Many governments have been legislating for decades to try to reduce pollution generally, including energy projects. Renewable energy plants and nuclear plants are recognised as plants that have much reduced pollution across the supply chain.

The impact of air pollution needs to be assessed across the supply chain. This should include nitrogen oxide, sulphur oxides, particulates, lead and mercury as well as other air emissions. The reporting needs to provide a meaningful assessment of the impact of air pollution and the impact on air quality.

Hatch's lifecycle assessment showed wind and nuclear to have similar emissions:

Table 6: Statistical Mean Total Lifecycle Emission for nuclear and on-shore wind

| **Scenario** | PM* (g/kWh) | NOx (g/kWh) | SOx (g/kWh) |
|---|---|---|---|
| **On-shore wind turbine** | 0.015 ± 0.003 | 0.028 ± 0.003 | 0.025 ± 0.003 |
| **Nuclear power plant** | 0.008 ± 0.003 | 0.039 ± 0.006 | 0.023 ± 0.003 |

*PM = particulate matter.
Source: Adapted from Hatch (2014).

In the Annual Reviews "Life-Cycle Assessment of Electric Power Systems" (Masanet et al., 2013), the pollution from various plants was assessed. As can be seen in Table 7, nuclear and renewable projects have far fewer emissions than fossil fuels. Each different form of energy creates its own air pollution. For example, the manufacturing of cabling and the wind turbines for wind farms (particularly off-shore) produces air pollution (and water pollution). The table below outlines the emissions identified in the report.

Table 7: Range of electric power technology emissions

| Environmental exchange | | Sulphur dioxide ($SO_2$) (mg/kWh) | NOx (mg/kWh) | PM (mg/kWh) |
|---|---|---|---|---|
| **Coal** | Hard coal | 530-7 680 | 540-4 230 | 17-9 780 |
| | Lignite | 425-27 250 | 790-2 130 | 113-947 |
| **Natural gas** | Combined cycle | 1-324 | 100-1 400 | 18-133 |
| | Steam turbine | ~0-5 830 | 340-1 020 | ID |
| **Nuclear energy** | | 11-157 | 9-240 | ~0-7 |
| **Bioenergy** | | 40-940 | 290-820 | 29-79 |
| **Solar** | PV | 73-540 | 16-340 | 6-610 |
| | Concentrated | 35-48 | 54-160 | 7-26 |
| **Geothermal** | | ~0-160 | ~0-50 | 1.3-50 |
| **Hydropower** | Reservoir | 9-60 | 3-13 | 0.1-25 |
| | River | 1-6 | 4-6 | |
| **Ocean** | | 64-200 | 49 | 15-36 |
| **Wind** | | 3-88 | 10-75 | 1-14 |

Source: Adapted from Masanet et al. (2013).

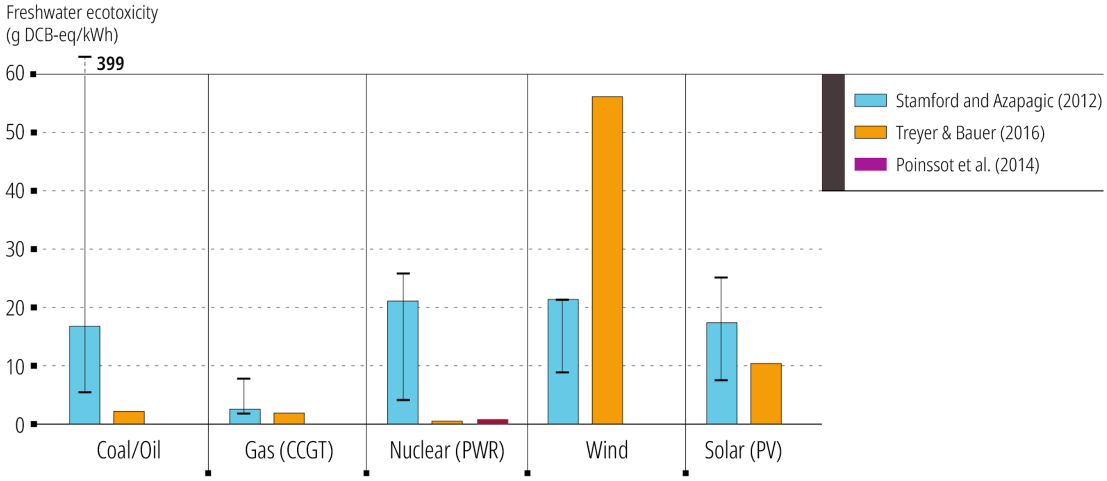
There is a unique connection between the use of water and the production of energy. Energy production across the supply chain creates water pollution. The impact of energy projects on water varies from technology to technology and from project to project. Companies need to report in an accessible way the impact of water pollution, including excess nutrients, heavy metals and other toxins.

The EU report from the JRC (EU, 2021) considers water ecosystems and the damage caused by various energy technologies and reports that:

> Water ecosystems are also damaged by toxic chemical releases, including heavy metals, volatile organic compounds (VOCs) and particles. Various ecotoxicity indicators have been used in sustainability assessments to compare technologies in terms of the toxic damage potential of their lifecycle chemical emissions.
>
> Freshwater aquatic ecotoxicity potential (FAETP) refers to the impact on fresh water ecosystems, as a result of emissions of toxic substances to air, water and soil. Marine ecotoxicity refers to impacts of toxic substances on marine ecosystems. Both indicators are expressed as grams 1,4-dichlorobenzene equivalents/kWh (g 1,4-DCB-eq/kWh).
>
> Stamford & Azapagic […], as well as Treyer & Bauer […], compared both fresh water and marine ecotoxicity potentials of several electricity generating technologies. The results are provided in the figures below.
>
> With regard to freshwater ecotoxicity, nuclear energy is again the best performer according to Treyer & Bauer, whereas the results of Stamford & Azapagic rank natural gas as best, with the other technologies fairly evenly matched, although nuclear has the potential to be comparable with gas according to the sensitivity studies. The data of Poinssot et al. again compare very well with the data of Treyer & Bauer and the lower bound data of Stamford & Azapagic. Concerning nuclear, the bulk of the impact is due to metals such as vanadium, copper and beryllium coming from uranium mill tailings. Regarding marine ecotoxicity, nuclear is again ranked best (Treyer & Bauer – ReCiPe methodology) or second best (Stamford & Azapagic – CML methodology) along with natural gas. (EU, 2021)

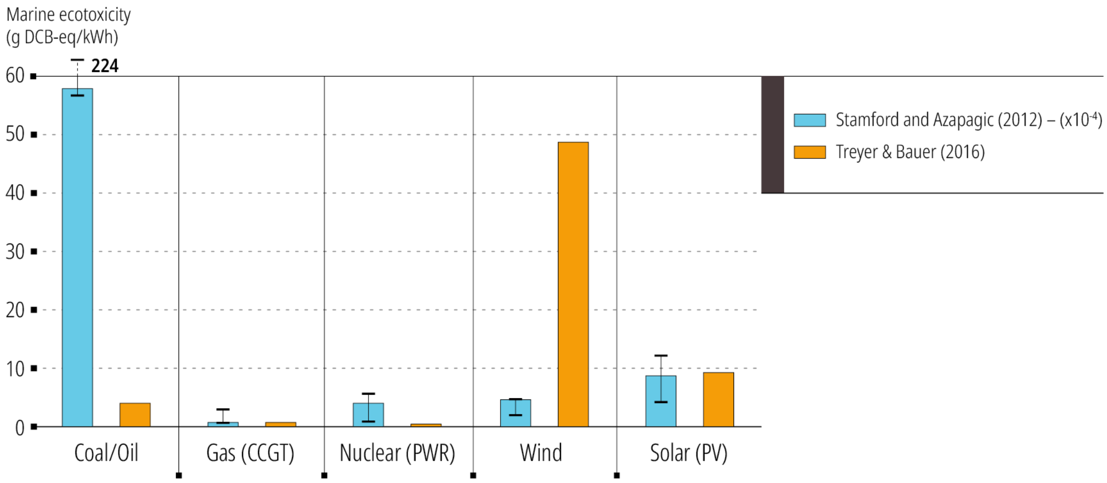
As such, nuclear power is one of the better energy technologies when considering pollution and water toxicity.

Figure 2: Freshwater ecotoxicity potentials of various electricity generation technologies




Source: Adapted from EU (2021)

Figure 3: Marine ecotoxicity potentials of various electricity generation technologies




Source: Adapted from EU (2021)

### *Waste, including management and mitigation*

All energy companies and projects produce waste. Waste needs to be reported, mitigated and managed. The metrics for waste have not been standardised and need to apply across industries and consider the whole of the supply chain across the project lifecycle. The reporting of waste arising from companies and projects needs to be meaningful and inciteful, and investors should ensure that they understand how companies and projects are managing and mitigating their waste.

Reporting on single use plastics is in its infancy, and standardisation is key to a fair and balanced reporting. However, this should be extended to include not only single use plastics but all plastics to ensure that those that can be recycled are recycled and managed.

For a long time, waste has been seen as an issue for all energy projects; however, more focus falls on waste arising from the nuclear industry. In response to this, the nuclear industry has developed the gold standard for reporting, mitigating and managing its waste. Lessons have been learnt through the management of waste arising from nuclear companies which should be applied across the energy sector and more widely (this is further discussed later in the report).

In line with best practices, nuclear power plants have to plan and pre-fund the decommissioning and waste management activities, for new plants. Generally, the funding is accumulated over the early life of the power plant and payments into the decommissioning and waste management fund can be the first payment out of the payment cascade i.e. before debt service. However, the payment is so small that it should not be a concern for lenders.

The objective of the planning and funding regimes is to ensure that nuclear operators make prudent provision for the full costs of decommissioning installations; and the full share of the costs of safely and securely managing and disposing of their waste; and that in doing so the risk of recourse to public funds is remote. Other energy producers, such as some solar companies, are beginning to follow this approach as it is recognised that plants need decommissioning and waste management plans.

Radioactive waste is managed in different ways. The IAEA defines low and intermediate level waste as waste with activity levels above clearance levels (i.e. unregulated levels) and thermal powers below 2kW/$m^3$.

The storage and disposal technology for dealing with low-level waste (LLW) is well-established. It is:

- the majority of solid radioactive waste by volume (c. 90%);
- the lowest activity category of radioactive waste;
- generally made up of materials such as plastics, glass, metal, paper and soil that have become contaminated by contact with radioactive liquids or powders; and
- produced by hospitals, research establishments and the nuclear industry.

Very low-level waste (VLLW) is a subset of the LLW category of radioactive waste, covering miscellaneous waste arising with very low concentrations of radioactivity. LLW and VLLW are either dealt with in LLW repositories or sent to landfill. Much of LLW and VLLW does not need to be disposed of in specialist facilities.

Intermediate level waste (ILW):

- arises from the reprocessing of spent fuel (most), from general operations and maintenance at nuclear sites, and from decommissioning;
- can include metal items such as reactor components (e.g. reactor pressure vessel components), and sludges, filters and resins from the treatment of radioactive liquid effluents.

Legacy ILW is typically being managed through a process of encapsulation in cement and packaged in stainless steel drums or higher capacity steel or concrete boxes as soon as reasonably practicable and placed into interim storage. Geological disposal is the preferred option for management of ILW in the long term, preceded by safe and secure interim storage.

High-level waste (HLW) is sometimes referred to but it encompasses spent fuel or waste materials which arise, should the spent fuel be reprocessed or recycled. Spent fuel is defined as “nuclear fuel that has been irradiated in and permanently removed from the reactor core”. Spent fuel is not categorised as waste, because it still contains uranium and plutonium which could potentially be separated through reprocessing and used to make new fuel (i.e. be an asset to the company). Fast reactors are being developed which can utilise these resources.

Spent fuel and waste also contain medical isotopes, including:

- Actinium-225 (Ac225), radium-223 (Ra223), Actinium-227 (Ac227) and lead-212 (Pb212), which are used for targeted alpha therapy. Currently, the production routes for these isotopes are typically via the "milking" of existing sources of nuclear materials that would otherwise be considered as waste. Given their position in decay chains, waste from nuclear fission can contain these isotopes (or their source isotopes);
- Yttrium-90 (Y90), which is used for beta irradiation therapy. The production route is the purification of strontium-90 (Sr90) from spent nuclear fuel for loading into an Sr90/Y90 generator;
- Xenon-133 (Xe133), which is an established diagnostic and is the only approved tracer for imaging the distribution and rate of exchange of air in the lungs. Xe-133 is a product of uranium-235 (U235) fission.

There are many more isotopes of interest for therapy, diagnostics, or combination in the form of theragnostics, some of which could be obtained from existing material, and others that might use existing material that can be irradiated (i.e. using a reactor or accelerator) to produce the isotope of interest.

Spent fuel is essentially fuel assemblies that have been "burnt" in the nuclear reactor, and the number of fuel assemblies depends on the size and life of the plant. The higher burn-up of the modern fuel means that an individual spent fuel assembly will have a higher heat output and external radiation compared with a fuel assembly discharged from nuclear reactors currently in use. Long-lived radionuclides remain thermally hotter and therefore require longer periods of cooling in interim storage. Interim storage of spent fuel can be carried out in a manner which causes a very low level of risk of detriment to human health and/or nature and/or the environment.

The current preferred method for the long-term management of spent fuel and HLW is placement in a deep geological repository (DGR), although none are currently operational. However, a number of countries are progressing deep geological repositories including Finland, Canada and the UK. The OECD NEA published a statement in 2008 which said that: "The overwhelming scientific consensus worldwide is that geological disposal is technically feasible" (OECD, 2008).

The NEA further noted that "Releases from engineered barriers would occur over thousands of years after disposal and would be very small. Additionally, these releases are diluted and slowed by the geological formation surrounding the repository and are further reduced by radioactive decay. The resulting potential radiological exposure in the biosphere would not represent, at any time, a significant increment above the natural background".

In respect of external dose rate, the encapsulation, transport and emplacement of high burn-up spent fuel can be shown to be feasible using existing technology applied in the management of vitrified HLW. In particular, the relevant IAEA dose rate limits for transport can be met after interim storage by providing a combination of a 14 cm thick stainless steel gamma shield surrounded by a 5 cm thick neutron shield.

Radioactive wastes are transported in accordance IAEA regulations and in accordance with domestic and regional agreements and directives. The packaging requirements for material containing radionuclides are dependent upon the radionuclide specific activity of the material, its form (solid, liquid or gas) and the total quantity of activity in the consignment.

The 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) and the OSPAR Radioactive Substances Strategy both aim to reduce discharges into the marine environment of the North-East Atlantic Region to levels where the additional concentrations above historic levels, resulting from such discharges, are close to zero.

It is important to note that while the ultimate objective of the OSPAR Convention is to reduce the concentrations in the marine environment, it does not prohibit the future development of the nuclear sector and the building of new reactors. OSPAR's Radioactive Substances Strategy acknowledges the need to take account of what is achievable and focuses on the delivery of the Convention's objectives through the application and use of BAT and BEP.

Non-radioactive waste is produced from operating and maintaining power plants, and includes laboratory chemicals and lubricating and fuel oils, which need safe management and disposal.

Hazardous waste is defined as waste with one or more properties that are hazardous to health or to the environment. Categories or generic types of hazardous wastes as well as the properties of hazardous waste are listed in directories such as the European Commission's Hazardous Waste Directive.

The volumes produced by new nuclear power stations is small in relation to the total volumes of such wastes produced generally. Amounts of non-radioactive hazardous waste arising from reactor construction and decommissioning are expected to be broadly equivalent to those arising from any major infrastructure, or power construction or demolition project and amenable to the normal waste minimisation techniques.

The treatment and disposal of waste is regulated in order to ensure the protection of the environment and human health, and is dealt with in accordance with the regulations applicable to non-nuclear sites.

Other low carbon energy projects create large amounts of waste which can be detrimental to people and the environment if not properly managed. This can extend to the lead in solar panels and the blades from wind farms. All waste needs managing properly and should be assessed against the highest international standards.

### *Resources*

In the long term, nuclear power is dependent upon the uranium resources (or other special nuclear material) being available. Special nuclear materials are defined in the international conventions.

According to *Uranium 2020: Resources, Production and Demand* (NEA/IAEA, 2020), "identified recoverable uranium resources, including reasonably assured resources and inferred resources at a cost of <USD 260/kgU (equivalent to USD 100/lb U-3O8) are sufficient for over 135 years, considering uranium requirements as of 2019. Exploitation of the entire conventional resource of about 15.3 MtU based on current demand would increase this to over 250 years. The conventional resources include reasonably assured, inferred, prognosticated and speculative resources but exclude secondary sources or unconventional resources, such as uranium from phosphate rocks."

With the development of advanced reactors and fast reactors uranium and other resources will be utilised more efficiently and therefore last for much longer than the 135 years highlighted in the NEA/IAEA report.

With fast-spectrum reactors operated in a "closed" fuel cycle by reprocessing the used nuclear fuel and recycling uranium and plutonium, the reserves of natural uranium may be extended to several thousand years. Therefore, the main current resource of nuclear power is not seen as a concern.

## People: SDGs 1, 3, 4, 5 and 10

### *Dignity and equality*

Organisations need to be built on a culture of respect, courtesy and professionalism. Without this foundation, employees and organisations will be unable to grow and develop.

Equality across the workforce and providing dignity to employees is a key metric for any modern business. Equity, dignity and inclusion irrespective of age, sexual orientation, gender, disability, race, ethnicity, origin or religion is key to good management and governance. Diversity of socio-economic background as well as diversity of thought is key to performance. Diversity attracts the best people to an organisation, including at the executive level, and provides the best environment for company growth and cohesion. All energy companies and projects need to work on improvements in diversity, equality and inclusion. The nuclear sector has shown developments in gender equality but there is still more to do.

As mentioned in the governance section, a number of countries are making strides towards gender and cultural diversity. Some of the Canadian nuclear companies report well on gender diversity on their boards, and Canada has implemented the Equal by 30 programme[9] and the Driving the Advancement of Women in Nuclear (DAWN) to advance the participation of women in the clean energy transition, and to close the gender gap in this field.

Human Resources Canada has also implemented a Diversity and Inclusion[10] programme to foster diversity and inclusion within all organisations. The programme represents the right for diversity and inclusion of under-represented groups in the electricity sector, including women and Canada's indigenous population. The Diversity and Inclusion programme works with the Canadian Council for Aboriginal Business[11] to consider corporate

9. For more information on this programme, see: www.equalby30.org/en/splashify-splash.
10. For more information on this programme, see: https://electricityhr.ca/workplace-solutions/diversity-inclusion/.
11. See: www.ccab.com/programs/progressive-aboriginal-relations-par/.

performance in Aboriginal relations. Further, the Canadian BlackNorth Initiative[12] seeks to end systemic anti-black racism – over 450 companies have signed the initiative. These programmes also work with Nuclear Against Racism,[13] under which the nuclear industry has pledged to agree to stand in solidarity with black and indigenous communities, and people of colour across the world.

In the UK, the revisions to the Nuclear Sector Deal will further address diversity and inclusion across the nuclear sector. The focus is likely to be on diversity of thinking and diversity of socio-economic backgrounds. There are also likely to be regional targets around cultural diversity to reflect the cultural diversity in different regions of the UK. The UK has also established a not-for-profit initiative called Inclusions and Diversity in Nuclear (IDN)[14] with the aim of creating and inclusive and diverse industry.

Energy companies and projects should have well managed policies and procedures on pay and remuneration through-out the organisation. The energy sector wants to attract bright and diverse individuals who can develop the industry and deliver high quality and high performing projects and companies.

A corporate's processes and procedures should also identify any pay gaps in the organisation to highlight unrepresented and disadvantaged groups. Pay gap analysis should identify inequality of pay, with is an obligation on the executive to monitor these areas to ensure that minorities are not disadvantaged. Wage levels and benefits should be assessed across the company to determine a fair distribution across the workforce; and against the living wage in their country to increase the socio-economic development of a region and a country.

Organisations should disclose the percentage of the workforce who are covered by collective bargaining agreements and should assess its supply chain to ensure they allow for freedom of associations and collective bargaining. These metrics and processes are seen to respect the rights of workers and human rights. It is important that companies promote these rights across their own workforce and through their supply chains.

Without proper checks and balances a company's activities could facilitate human rights abuses and other social and environmental abuses. Without mechanisms for employees and stakeholders to report potential abuses, companies might miss the opportunities to identify, mitigate and manage activities. Reporting the number of operations that have been subject to human rights reviews – both within the company and across the lifecycle and supply chain – is of key importance to organisations. Companies should also report any grievances raised and the type of grievances together with the number of operations and suppliers considered to be at risk of human rights abuses.

Companies need to ensure that there are no risks of incidents of child, forced or compulsory labour through-out their supply chains. An explanation of labour practices across the whole supply chain needs to be disclosed by the executive and the board. The elimination of child labour, forced labour and human trafficking requires companies to be open and transparent and to assess their supply chain ethics. Nuclear companies have to investigate their supply chain in great detail to meet regulatory requirements, which should protect against these practices. However, other energy sources also need to report correctly their supply chain activities, including the mining practices, for example around the mining of rare earth metals, lithium and cobalt. Only through openness and transparency by businesses and financial institutions will these unethical practices be eradicated.

### *Health and well-being*

Maintaining strong standards of health and safety and worker's rights can improve productivity and operational efficiency in businesses and enhance employee well-being, which in turn benefits the company as a whole. Proactive health and safety processes and procedures help to identify and mitigate potential risks. Health and safety not only relates to physical health and safety but also mental health and safety. Mental health and safety is becoming more of a focus in modern business. Mental health awareness together with access to medical and healthcare services helps to demonstrate a company's commitment to these important issues. Clear communication linked to processes of how workers access medical and healthcare services are also important metrics.

"Well-being is associated with numerous health, job, family, and economically-related benefits. [For example,] Higher levels of well-being are associated with decreased risk of disease, illness, and injury; better immune

12. See: https://blacknorth.ca/the-pledge/.
13. See: www.nuclearagainstracism.com.
14. See: www.niauk.org/media-centre/member-news/inclusion-diversity-nuclear/.

functioning; speedier recovery; and increased longevity. Individuals with high levels of well-being are more productive at work and are more likely to contribute to their community." (CDC, 2018)

"Mental health problems and stress can affect anyone, regardless of their position in the business. Therefore, physical and mental well-being should be made a high priority in the workplace. Worryingly, for many, this isn't the case. In the United Kingdom, 84% of managers acknowledge their responsibility in helping with employee mental health, but only 24% have any training in the area. Yet promoting well-being in the workplace can strengthen employee engagement, reduce the likelihood of poor mental health, and improve team happiness." (Murphy, 2020)

In the United Kingdom, an estimated 38.8 million working days were lost due to work-related ill health and non-fatal workplace injuries in 2019/2020.[15.] Deloitte reported in 2020 that poor mental health costs UK employers up to £45 billion a year; this is a rise of 16% since 2016 – an extra £6 billion a year.[16]

"US businesses lose up to $300 billion yearly as a result of workplace stress and only 43% of US employees think their employers care about their work-life balance" (AIS, 2019). It is reported that "83% of US workers suffer from work-related stress and over a quarter of employees are at risk of burn-out in the next 12 months."

"Canadian companies lose an estimated $16.6 billion in productivity per year due to workers calling in sick, as a result of mental health issues. This is a trend that many expect to increase in severity as more workers are reporting higher levels of stress and other mental health concerns (…) One in four workers has left their job due to work-related stress", according to a 2017 Monster Canada study. Similar statistics are available for other countries, the wellbeing of staff is becoming a bigger challenge and is reported to be getting worse.

The nuclear industry has long been at the forefront of both general health and safety management and also nuclear specific health and safety. The global nuclear industry takes health and safety incredibly seriously. The nuclear sector has a wide range of health and safety regulations and systems in place to protect not only its workers (employees and supply chain) but also third parties.

A company's processes and procedures should ensure that records are maintained for the following elements as a minimum:

- the number and rate of fatalities as a result of work-related injuries;
- the number and rate of high-consequence work-related injuries;
- the number and rate of recordable work-related injuries;
- the main types of work-related injuries;
- the number of hours worked.

Safety in the workplace can refer to both physical and psychological safety. In both instances, it means having a workplace that does not put employee's health and safety at risk, and that the health and safety of members of the public are not affected by the activities of the employer.

Radioactivity is managed through strict processes and procedures to ensure that not only the health and welfare of employees is maintained but also the health and safety of third parties – both on-site and off the site – is maintained. This extends to the general public. This potential radiological health detriment across various industries, including power, medicine and airlines, is mitigated by strict regulatory regimes. The regimes cover both emissions associated with normal operation and limits the possibility of a release radioactive material as the result of an accident.

The system of radiation protection that is used across Europe and worldwide is based on the recommendations of the International Commission for Radiation Protection (ICRP), and the International Commission on Radiation Units and Measurements (ICRU). The ICRP system of radiation protection is based on three fundamental principles: justification, optimisation and dose limitation. The principle of justification requires that any decision that alters the radiation exposure situation should do more good than harm. The principle of optimisation requires that the likelihood of incurring exposures, the number of people exposed and the magnitude of their individual exposure

15. www.hse.gov.uk/statistics/dayslost.htm.
16. www2.deloitte.com/uk/en/pages/press-releases/articles/poor-mental-health-costs-uk-employers-up-to-pound-45-billion-a-year.html.

should all be kept as low as reasonably achievable, taking into account economic and societal factors. The third principle of the ICRP's system of protection is that of dose limitation.

In the European Union, radiation protection legislation relating to ionising radiation derives from the Euratom Treaty. Its common objective is to establish uniform safety standards to protect the health of workers, patients and of the general public, and to ensure that they are applied.

Nuclear safety is probably one of the most talked about topics, both within the nuclear sector and in the general public. It is an area that all nuclear companies take extremely seriously and is a principal core value of businesses within the sector across the world.

Even though the occupational and public mortality and morbidity risks are lower than those of other power options, the perception of nuclear can far outweigh the reality. Misperceptions have resulted in the gold-plating of standards in the nuclear industry, in an attempt to manage these misperceptions. This can be to the detriment of projects moving ahead, and therefore, a balanced approach is required, as with other energy industries (Mckenna, 2011).

An IEA report on the environmental and health impacts of electricity generation put together existing studies to compare fatalities per unit of power produced for several leading energy sources (IEA, 2002). The agency examined the lifecycle of each fuel from extraction to post-use and included deaths from accidents and long-term exposure to emissions or radiation. Nuclear came out best, and coal proved to be the deadliest energy source.

The IAEA notes that national governments are responsible for regulations that govern how safety at nuclear facilities is maintained, as well as to reduce radiation risks, including emergency response and recovery actions, to monitor releases of radioactive substances to the environment and to regulate the safe decommissioning of facilities and disposal of radioactive waste. However, the IAEA, through the Department of Nuclear Safety and Security, works to provide a strong, sustainable and visible global nuclear safety and security framework for the protection of people, society and the environment. This framework provides for the harmonized development and application of safety and security standards, guidelines and requirements; but it does not have the mandate to enforce the application of safety standards within a country.

### *Skills for the future*

Skills improve a company's future and a wide and diverse range of skills are key to the success of a company. Training and skills also help to improve careers prospects and to improve human capital. When companies fail to invest in training and skills it can result in a detrimental effect on a company's performance. Training and development enhance a company's ability to attract and retain talent, which in turn helps the company to grow. Training needs to cover a wide range of hard and soft skills which can help with an individual's development.

Reporting should include: types of training and topics, paid educational leave, training or education pursued externally and reskilling of employees. Providing information on the investment in training is also important.

The rise in technology and development of companies' processes and procedures has resulted in skills gaps. It is vital that companies identify those skills gaps and seek to fill them. This is crucial not only at an individual company basis but also across industries, regions and countries. If the socio-economic development of a region is to be undertaken, a long-term strategy for filling skills gaps should be considered as training to fill future skills gaps begins in schools.

Companies should report on the number of unfilled skilled positions and report their strategies to hire and train candidates for these positions.

Training and innovation can have a direct impact on a company's performance and long-term value as well as employees on satisfaction. Companies should report on the investment made in training as a percentage of payroll and should analyse the effects of training and reskilling on the business.[17]

Nuclear has had to invest heavily in upskilling. This is partially due to the hiatus in the construction of new nuclear power plants. Also, many people working on existing plants and sites are reaching retirement age and so the nuclear industry has had to spend considerable efforts in bring on the younger generation. Companies have

17. The WEF recommends the Kirkpatrick Model, which evaluates four levels of training (Reaction – Learning – Behaviour – Results), each successive level representing a more precise measure of the effectiveness of a training program.

implemented training and apprenticeships to bring in new people to the industry across various skills to protect the industry for the future.

## Prosperity: SDGs 1, 8, 9 and 10

### *Wealth creation and employment*

These metrics are intended to consider the wider socio-economic development activities of the company and the company's impact on wider societal development. This is intended to be a more holistic approach that has recently been used by companies to consider their social impact.

Assessments of the wider socio-economic impacts of a particular activity typically consider the following:

- direct effects – the economic value created by the activity itself;
- indirect effects – the economic value created by the supply chain that is needed to serve the activity itself;
- induced effects – the impact on the wider economy by employees.

Government bodies conduct extensive analysis for their country or region of the interlinkages between different activities within the overall economy. Multipliers are produced to capture the effects of a company's activities on society. Multipliers can be either Type I or Type II. Type I multipliers capture the increment in economic value linked to indirect effects, but not induced effects. Type II multipliers capture the increment in economic value linked to indirect effects and induced effects.

The reporting metrics expect companies to consider the jobs created during a defined period. For an established company that may be year on year; for a capital project that may be by phase of the project. Job creation is viewed as a key indicator of economic growth, and when taken together with remuneration and other processes and procedures indicates an ability of a company to attract talent. It is evidence of prosperity as it captures the ability of the company to support employment and growth in the region.

Energy new build projects always create direct, new jobs. However, different levels of new jobs are created through different phases. An analysis by the WNA on *Employment in the Nuclear and Wind Electricity Generating Sectors* (2020) shows that for a given installed capacity, nuclear power generates more than 3 times more jobs than wind power.

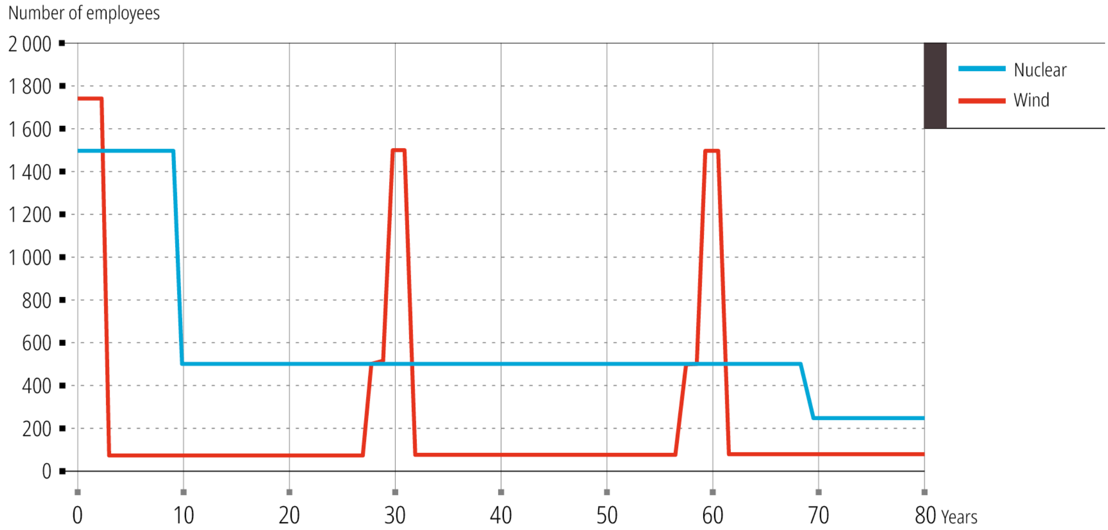
A 400 GW global nuclear fleet generates about 1.2 million direct and indirect jobs, or an average of 3000 jobs/GW (NEA, 2020b). These jobs are long-term, requiring higher levels of education. Such high-skilled employment with premium wages can result in significant spill-over investment into the local and regional economy.

The Canadian Nuclear Association's report on the *Benefits of Nuclear Energy for Canadians* reported:

> "The many Canadian organizations that make up the nuclear industry create high quality jobs and bring income to our Canadian communities. This study has assessed the number of jobs created and the impact on Canada's GDP with the following results:
>
> - The total number of jobs created across Canada is 76000
> - The total impact to the Canadian GDP is $17 Billion per year
> - The medical isotope industry with all its benefits to the health of Canadians creates 8500 jobs
>
> …The impact on Canada's economy in terms of GDP is $17 Billion per year." (MZ Consulting, 2019)

For example, the Hinkley Point C project in the United Kingdom will result in 25 000 employment opportunities, including over 1,000 apprenticeships during the construction phase and 900 permanent jobs onsite during the 60+-year life of the plant. UK companies will deliver a proportion of the construction contracts, and the project is estimated to contribute to the local economy in the region of GBP 1.5 billion during construction, and about GBP 40 million a year during operation. In contrast, 39% of all renewable energy jobs are in China (IRENA, 2019).

Figure 4: Employment for 1GWe capacity of nuclear and wind (construction; O&M; decommissioning)




Source: Adapted from NEA (2018, cited in NEA 2020b).

With the development of small light water and Gen-IV reactors and more of a product-based approach, the wider socio-economic development will come from not only the energy project itself but also the wider manufacturing development.

Capital expenditure (CapEx) is of particular relevance to capital projects. However, it is also relevant to established companies who are looking to grow and expand. When reporting on the wealth creation and employment metric, companies need to consider the CapEx minus depreciation as an indication of the company's overall investment strategy. In addition, the metric reporting includes the payback to shareholders by considering share buybacks and dividends.

Investment and payback are key indicators of a company's growth strategy and its ability to expand its operations and to create additional employment. Also, wealth creation from investment activities can be evidenced through the CapEx versus shareholder distributions.

The extent of any infrastructure investment and the services supported through it are an exceptional indication of growth. For a special purpose vehicle (SPV) established for a new infrastructure development, this is the main focus for the company. However, for an established company, new capital projects are evidence of growth. Any infrastructure development has an impact on the local communities and therefore on the socio-economic development of those communities. In kind and pro bono activities should not be discounted as they also have a wider benefit. This evidences a company's capital and other contribution to the wider economy.

Positive and negative impact on the wider economy need to be considered. The significance of the indirect economic impact should be considered in light of national and international benchmarks.  Socio-economic growth or decline needs to be considered to assess the wider and long-term impacts on society.

### *Energy affordability*

SDG 7 provides for access to affordable, reliable, sustainable and modern energy for all. Access to affordable, reliable and clean energy is crucial for achieving sustainable development goals, from eradicating poverty through to advancing health and education, facilitating industrial development and reducing greenhouse gas emissions. Since 1992, energy's role in meeting all of the SDGs has been identified; however, it is also important that energy be affordable and reliable to allow people access to other resources including schools, clean water and healthcare.

One of the challenges as the world moves to decarbonised energy is the need to reconsider the basis for pricing energy - as with many aspects of modern life – to include the consequences of previously ignored externalities – in this case the previously un-priced consequences of $CO_2$ pollution. Energy pricing and taxation varies significantly around the world with approaches varying on the extent of inclusion of sales tax or VAT, the extent to which time-of-day pricing passes on some elements of production price variability (itself derived from a manufactured wholesale market mechanism) and even the extent to which costs are fully passed on to consumers or covered by wider taxation systems. The net effect of this has been to disguise the true costs of energy in some cases and some early attempts at behavioural economics have rendered energy pricing a socially inconsistent tool. The challenge for most countries as they replace their entire primary energy creation systems will be one of the sheer speed needed to achieve Net Zero, and as a consequence, there will not be time for a near-perfect cost optimisation.

Low carbon energy, including wind, solar and nuclear, can provide the energy to ultimately achieve high living standards, good health, a clean environment and a sustainable economy. According to the latest IEA/NEA study on the *Projected Costs of Generating Electricity – 2020 Edition*, nuclear is the dispatchable low-carbon technology with the lowest costs. Only large hydro reservoirs can provide a similar contribution at comparable costs but are constrained by geography. Electricity produced from nuclear long-term operations (LTO) is highly competitive and is not only the least cost option for low-carbon generation – when compared to building new power plants – but for all power generation across the board, if carbon costs of USD 30 per tonne of $CO_2$ are taken into account for the emissions generated by coal- and gas-fired power plants (IEA/NEA, 2020).

There is the modern comparison of access to energy in developed countries as being as much of a human right as the right of access to virtually limitless supplies of clean water. Driving significant changes in demand through conventional pricing signals increasingly looks to be hard where it relies on human interaction. The drive to Net Zero is the biggest challenge rather than the need for more affordable technologies.

Nuclear power plants are a clear example of resilient facilities. The resilience of nuclear energy is the result of the combination of high levels of safety, operational flexibility and continuous learning from previous major events. By design, and beyond design, nuclear power plants are conceived following the principles of defence-in-depth: prevention, protection and mitigation (IAEA, 2016). This results in the implementation of redundant, independent and diversified safeguards designed to withstand external hazards. From an organizational perspective, nuclear facilities also incorporate emergency and contingency plans to rapidly identify critical activities and maintain normal operations with limited personnel.

Confronted with major disruptions in the past, the nuclear sector has been required to adapt profoundly, while always continuing to provide a stable supply of low-carbon electricity. Current nuclear systems and operations have been refined according to an evolving regulatory environment seeking the highest level of safety and reliability in the most diverse situations, including extreme weather events like those caused by climate change. The resulting nuclear governance models incorporate procedures and approaches that allow the continuous assessment of ongoing practices, the application of corrective measures and the integration of the latest knowledge available.

At the system level, a resilient low-carbon infrastructure requires a balanced and diversified power mix. Different technologies have different complementary roles in low-carbon electricity systems. Flexible power provision by plants that are dispatchable upon demand makes nuclear power an indispensable complement to wind and solar production in countries without large amounts of hydropower capacity. Furthermore, it also supports electric grid stability by providing valuable inertia, reactive capacity and voltage control to the system. Additional operational resilience can be obtained with strategic fuel stockpiles. One of the main advantages of nuclear power is the easiness of securing energy-dense uranium fuel for several years of operation.

### *Innovation in better products and services*

Innovation is key to prosperity. R&D spend is seen as a basic indication of a company's attempts to innovate and therefore be fit for the future. It can also indicate the company's ability to adapt to new market conditions and to create further socio-economic benefits, including delivery of SDGs. Nuclear R&D and innovation are continuous. The industry constantly looks to find better ways of delivering clean nuclear power. However, much R&D spend is funded by governments which is not directly applicable to this metric as it is not reflective of a company investing in its own future.

The R&D spend of an individual supply company or the supply chain will be subject to reporting on the relevant project. Accompanying the financial data should be a report on how the company is preparing for different scenarios and future proofing itself. This will allow investors to understand better how the company is protecting itself from innovation and disrupters in its industry.

There is considerable R&D spend across the nuclear sector. While much of this comes from countries and governments, there is more and more private equity being ploughed into small light water and Gen-IV technologies. Two examples of private sector investment are:

- Moltex Energy, which has raised significant financing from the private sector to help with the development of its molten salts technology;
- Bill Gates, who is a cornerstone investor in Terrapower, which is developing various technologies.

There are various other examples of the private sector and philanthropists investing in new nuclear technologies in the race to combat climate change.

### *Community and social vitality*

These metrics consider the wider benefits of a company's activities through its taxes paid and social investment. It takes into consideration the wider payments into the wider economy.

Total tax includes corporation tax, income taxes, property taxes, VAT, and other sales and payroll taxes. Reporting total tax paid provides global information on the company's contribution to governmental revenues through different forms of taxes, which in turn support governmental functions and public benefits.

This is intended to be an oversight of ESG efforts. This metric is intended to be a more inclusive definition of community investment. It seeks to capture the multiple ways in which companies can demonstrate their investments in social activities beyond traditional charity giving.

It provides an ability for companies to report on additional global tax collected by the company on behalf of other taxpayers – for example VAT and employee's tax. This allows companies to report on their further global contributions to government revenues. This includes reporting on the total tax paid and reported, and additional tax remitted by country for all of the company's significant locations. Companies may choose to supplement their reporting on tax paid.

The amount of tax paid and remitted by a company will depend on the company and any allowances permitted for areas such as R&D. The tax reporting should not differ depending on technology.

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# Appendix I. Standard ESG – World Economic Forum, Sustainability Accounting Standards Board (SASB) and Task Force on Climate-related Financial Disclosures (TCFD)

Figure 5: The 17 United Nations Sustainable Development Goals


Source: UN (2020)

## General

There is an urgent demand for consistency and comparability in sustainability reporting. To obtain the greatest benefit of adopting these metrics, there needs to be consistency not only of the metrics but also as to how assets are intended to report, and therefore how the investment community assesses whether companies are ethical, socially responsible and eco-friendly. They need to be applied consistently across asset classes.

### *World Economic Forum consultation on standardised metrics*

The Generation IV International Forum and the Taskforce welcomes the World Economic Forum's (WEF) 2020 consultation and report on a proposed conformed set of ESG. In this report the Taskforce has mapped the WEF metrics against the Sustainability Accounting Standards Board (SASB) and the Task Force for Climate Related Financial Disclosure (TCFD) standards to address concerns raised by the finance and energy industries. These mapped metrics have been use through-out this report.

### *Sustainable Accounting Standards Board – Different criteria for different industries*

The Taskforce recommended using the Electric Utilities and Power Generators Sustainability Accounting Standards from the SASB suite of metrics. These are more relevant to existing generators and transmission companies rather than new build, project finance or capital projects.

The SASB use of the term "sustainability" refers to corporate activities that maintain or enhance the ability of the company to create value over the long term. Sustainability accounting reflects the governance and management of a company's environmental and social impacts arising from the production of goods and services, as well as its governance and management of the environmental and social capitals necessary to create long term value. They identify a minimum set of criteria and do not include issues such as Board governance.

The SASB criteria apply to production and transmission of electricity only. They may not be sufficient when the energy assets are being used for other production such as medical, heat, hydrogen or synthetic fuels.

In addition to sustainability metrics, the SASB has activity metrics looking at:

- Number of residential, commercial and industrial customers served;
- Total electricity delivered to residential, commercial, industrial and other retail customers and wholesale customers;
- Length of transmission and distribution lines;
- Total electricity generated percentage by major energy source, percentage of regulated markets; and
- Total wholesale electricity purchased.

### *Task Force on Climate-related Financial Disclosure*

In June 2017, the TCFD released its final recommendations which provide a framework for companies and other organisations to develop more effective climate-related financial disclosures. The TCFD is supported by 110 regulators and government entities from around the world. These include Belgium, Canada, Chile, France, Japan, New Zealand, Sweden and the UK.

The TCFD is seeing governments embed the recommendations in policy and guidance and move towards requiring TCFD disclosures. These include:

- "New Zealand's Ministry for the Environment announced that the government plans to make climate-related financial disclosures mandatory for certain publicly listed companies and large financial institutions.
- The European Commission incorporated the TCFD recommendations into its *Guidelines on Reporting Climate Related Information* to support companies in disclosing climate-related information under the European Union's reporting requirements; and
- The United Kingdom's Financial Conduct Authority released a proposal for certain listed companies to state in their annual financial reports whether they made disclosures consistent with the TCFD recommendations." (TCFD, 2020)

The TCFD splits its recommendations and supporting recommended disclosures into: Governance, Strategy, Risk Management and Metrics and Targets. It focuses on climate-related disclosures and is not as wide as the World Economic Forum criteria. The TCFD criteria are more often used in the project finance world – so are more related to nuclear new build projects than SASB.

## Governance: SDGs 12, 16 and 17

| World Economic Forum | | SASB | | TCFD | |
|---|---|---|---|---|---|
| **Theme** | **Sub-theme** | **Topic** | **Metric** | **Recommendation** | **Supporting disclosure** |
| Governing purpose | Material stakeholder buy-in | | | | |
| Quality of governing body | Board composition | | | | |
| | Progress against strategic milestones | | | | |
| | Remuneration | | | | |
| Stakeholder engagement | Impact of material issues on stakeholders | | | | |
| | Process for engaging stakeholders | | | | |
| Ethical behaviour | Anti-corruption | | | Governance: disclose the company's governance around climate-related risks and opportunities. | Describe the board's oversight of climate-related risks and opportunities. |
| | Ethics and reporting | | | | |
| Risk and opportunity oversight | Integrating risk and opportunity | | | Governance: disclose the company's governance around climate-related risks and opportunities. | Describe management's role in assessing and managing climate-related risks and opportunities. |
| | | | | Strategy: disclose the actual and potential impacts of climate-related risks and opportunities on the company's businesses, strategy and financial planning where such information is material. | Describe the climate-related risks and opportunities the company has identified over the short, medium and long term. |

## Planet: SDGs 6, 7, 12, 13, 14 and 15

| World Economic Forum | | SASB | | TCFD | |
|---|---|---|---|---|---|
| **Theme** | **Sub-theme** | **Topic** | **Metric** | **Recommendation** | **Supporting disclosure** |
| Climate change | Greenhouse gas (GHG) emissions | GHG emissions and energy resource planning | 1) Gross global scope 1 emissions, percentage covered under; 2) emissions-limiting regulations; and 3) emissions-reporting regulations | Scope 1 refers to all direct GHG emissions.<br>Scope 2 refers to indirect GHG emissions from the consumption of purchased electricity, heat or steam.<br>Scope 3 refers to other indirect emissions not covered in scope 2, which occur in the value chain of the reporting company, including both upstream and downstream emissions. | |
| | Impact of GHG emissions | | GHG emissions associated with power deliveries | | |
| | Task Force on Climate-Related Financial Disclosure aligned reporting on material climate risks and opportunities | | Discussion of long-term and short-term strategy or plans to manage scope 1 emissions, emission-reduction targets, and an analysis of performance against those targets | Strategy: disclose the actual and potential impacts of climate-related risks and opportunities on the company's businesses, strategy and financial planning where such information is material. | Describe the resilience of the company's strategy, taking into consideration different climate-related scenarios, including a 2˚C or lower scenarios. |
| | | | 1) Number of customers served in markets subject to renewable portfolio standards (RPS); and 2) percentage fulfilment of RPS target by market | | |
| | Science-based targets to reduce GHG emissions | | | Risk management: disclose how the company identifies, assesses, and manages climate-related risks. | Describe how processes for identifying, assessing and managing climate-related risks are |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | integrated into the company's overall risk management. |
| | TCFD-aligned reporting | | | Metrics and targets: disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material | Disclose the metrics used by the company to assess climate-related risks and opportunities in line with its strategy and risk management process.<br>Disclose Scope 1, Scope 2 and, if appropriate, Scope 3 GHG emissions and the related risks.<br>Describe the targets used by the company to manage climate-related risks and opportunities and performance against targets. |
| Nature loss | Land use and ecological sensitivity | | | | |
| | Impact of land use | | | | |
| Fresh water availability | Fresh water consumption in water stressed areas | Water management | 1) Total water withdrawn; 2) total water consumed, percentage of each in regions with high or extremely high baseline water stress. | | |
| | | | Number of incidents of non-compliance associated with water quantity and/or quality permits, standards and regulations. | | |
| | | | Description of water management risks and discussion of strategies and practices to mitigate those risks. | | |

| | | | | | |
|---|---|---|---|---|---|
| | Impact on fresh water consumption | | | | |
| Air pollution | Fine particle matter | Air quality | Air emissions of the following pollutants: 1) NOx (excluding N2O); 2) SOx; 3) particulate matter (PM10); 4) lead (Pb); and 5) mercury (Hg); percentage of each in or near areas of dense population. | | |
| | Impact on air pollution | | | | |
| Water pollution | Nutrients | | | | |
| | Impact on water pollution | | | | |
| Solid waste | Single use plastics | | | | |
| | Impact on solid waste disposal | | | | |
| Resource availability | Resource circularity | | | | |

## People: SDGs 1, 3, 4, 5 and 10

| World Economic Forum | | SASB | | TCFD | |
|---|---|---|---|---|---|
| **Theme** | **Sub-theme** | **Topic** | **Metric** | **Recommendation** | **Supporting disclosure** |
| Dignity and equality | Gender pay equality | | | | |
| | Diversity and inclusion | | | | |
| | Pay equality and pay gaps | | | | |
| | Wage level | | | | |
| | Human rights review, grievance impact and modern slavery | | | | |
| | Risk of incidents of child, forced or compulsory labour | | | | |
| | Discrimination and harassment incidents and monetary losses | | | | |
| | Freedom of association and collective bargaining | | | | |
| | Living wage | | | | |
| Health and well-being | Health and safety | Workforce health and safety | 1) Total recordable incident rate; 2) fatality rate; and 3) near miss frequency rate | | |
| | Monetised impacts of work-related incidents on employees, employers and society | | | | |
| | Well-being | | | | |
| | | Nuclear safety and emergency management | Total number of nuclear power units, broken down by the US Nuclear Regulatory Commission (NRC) Action Matrix column | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | Description of efforts to manage nuclear safety and emergency preparedness | | |
| Skills for the future | Training | | | | |
| | Number of unfilled skilled positions | | | | |
| | Monetised impacts of training – increasing earning capacity as a result of training intervention | | | | |

## Prosperity: SDGs 1, 8, 9 and 10

| World Economic Forum | | SASB | | TCFD | |
|---|---|---|---|---|---|
| **Theme** | **Sub-theme** | **Topic** | **Metric** | **Recommendation** | **Supporting disclosure** |
| Wealth creation and employment | Number of jobs created | | | Strategy: disclose the actual and potential impacts of climate-related risks and opportunities on the company's businesses, strategy and financial planning where such information is material. | Describe the impact of climate-related risks and opportunities on the company's businesses, strategy and financial planning. |
| | Economic contribution | | | | |
| | Financial investment contribution | | | | |
| | Infrastructure investment and services supported | | | | |
| | Significant indirect economic impacts | | | | |
| | | Energy affordability | Average retail electricity rate for 1) residential; 2) commercial; and 3) industrial customers. | | |
| | | | Typical monthly electric bill for residential customers for 1) 500 kWh; and 2) 1 000 kWh of electricity delivered per month. | | |
| | | | Number of residential customer electric disconnections for non-payment, percentage reconnected within 30 days. | | |
| | | | Discussion of the impact of external factors on customer affordability of electricity, including the economic conditions of the service territory. | | |

| | | | | | |
|---|---|---|---|---|---|
| | | End-use efficiency and demand | Percentage of electric utility revenues from rate structures that 1) are decoupled; and 2) contain a lost revenue adjustment mechanism. | | |
| | | | Percentage of electric load served by smart grid technology. | | |
| | | | Customer electricity savings from efficiency measures by market. | | |
| | | Grid resiliency | Number of incidents of non-compliance with physical and/or cybersecurity standards or regulations. | | |
| | | | 1) System Average Interruption Duration Index; 2) System Average Interruption Frequency Index; and 3) Customer Average Interruption Duration Index, inclusive of major event days. | | |
| Innovation in better products and services | R&D spending ratio | | | | |
| | Social value generated and vitality index | | | | |
| Community and social vitality | Total tax paid | | | | |
| | Total social investment | | | | |
| | Additional tax remitted | | | | |
| | Total tax paid by country for significant locations. | | | | |

# Appendix II. Consistent and transparent reporting

## Governance: SDGs 12, 16 and 17

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Governing purpose | Material stakeholder buy-in |
| Quality of governing body | Board composition, progress against strategic milestones, remuneration |

### *Governing purpose*

The governing purpose should be clearly articulated in a company's documentation establishing the company, whether that be Articles of Association, Members Agreements or other. It is often forgotten that a company has its own legal personality, and that governing purpose is linked to that specific legal entity. The leadership team needs to be conscious of the "hat it is wearing", as well as the company and purpose, they are representing. The legal requirements for a company vary from jurisdiction to jurisdiction. However, the governing purpose of the company should be clearly established from the offset; and there is an emerging focus on boards signing up to their own ESG statement to show how they will deliver their governing purpose in line with ESG. Often companies start to expand their remit by drift rather than purposefully; they do this without being clear about the governing purpose of the company as the company evolves and without updating the company's documentation. The board statement should evolve in line with the company's governing purpose. According to the WEF, there is emerging evidence that purpose-led firms outperform their peers in terms of shareholder value and are better positioned to account for and deliver economic, environmental and social value.

This is often clearer with energy companies who have a clear governing purpose as a utility, a generating company, a technology company, an operating company and/or a development company. This is definitely easier for special purpose vehicles (SPVs) which are established for a specific purpose such as developing and constructing an asset (e.g. in energy, a renewable plant or a nuclear plant). However, confusion has arisen in recent years when technology companies (companies whose purpose is to develop and sell a technology) have invested in capital project development companies (i.e. SPVs established to develop and construct, and possibly to operate and decommission an energy asset), resulting in confusion in the market. This has been seen in the nuclear market. Clearer delineation of roles and transparency is required to maintain clear governing purposes.

The governing purpose should state how the company proposes to fulfil its governing purpose through economic, social and environmental means. The board of the company should promote the long-term sustainable success of the company, generating value for shareholders and contributing to wider society. This is particularly true of energy projects and companies who are often key to the socio-economic development of communities and countries. The board needs to ensure that the company's purpose, values and strategy are aligned to the corporate culture and to workforce policies and practices. It should also establish a framework of prudent and effective controls and ensure effective engagement with shareholders and stakeholders (see more on stakeholder management below).

### *Material stakeholder buy-in*

All material stakeholders need to buy into the company's governing purpose. The company will need to identify and manage all material issues that could affect stakeholders. The company will need to manage its stakeholders' expectations and understanding. This is further reason for a clearly defined governing purpose which meets ESG. The number of stakeholders in any energy project, but particularly in nuclear projects, are extensive and complex and stakeholder need to be kept informed of developments within the company. This is especially true in any new build project where the local community, local government and central governments will need to align for the project to move ahead.

Whether a nuclear or energy company has met this metric will depend on the individual company and will form part of investors' assessment of the company's reporting.

### *Quality of governing body*

The quality of the company's governing body (i.e. both the board and the executive) are key to the successful performance of a company.

However other key elements are the processes and procedures established for the board and for any board committees such as the audit committee, the remuneration committee etc… Finally, the differentiation and balance between the executive and non-executive team is a further key element in the overall quality of the governing body. As nuclear companies and projects tend to be long-term propositions, they often have not only independent non-executive directors to provide oversight and challenge but also advisory positions to provide support to the company.

### *Board composition*

The capabilities, thinking, experience and perspectives of the board members are key to the successful operation of the company. Much has been written in recent years about the importance of diversity of the individuals and diversity of thought. According to the WEF research, examining public companies across multiple jurisdictions has found that companies with higher diversity financially outperform their peers.

A diverse and inclusive board and workforce brings out the best in its' people and provides a better understanding of the needs of its customers. It is also better equipped to manage risk, and exhibits responsibility for the organisation. Diversity of thinking also provides the most fertile environment for innovation and disruption, allowing the company the ability to quickly pivot to meet changing demands.

Diversity remains a challenge for the energy industry as a whole. Gender diversity is only one area of diversity, but women are generally better represented than other groups identified by cultural, racial, sexual orientation or disability. However, the energy market is not a very diverse industry for women. The International Energy Agency (IEA) stated:

> Women's participation in the energy sector is below that of the broader economy and varies widely across energy sub-sectors. Despite making up 48% of the global labour force, women only account for 22% of the labour force in the oil and gas sector and 32% in renewables. These gender gaps in employment vary across the different energy sub-sectors.
>
> For example, based on labour force survey data for the European Union, we find that women's share of employment in energy sub-sectors perform poorly when compared with both the overall labour force (46%) and to other industrial sub-sectors. The lowest performing sub-sector, which is also energy-related, is mining of coal and lignite. (IEA, 2020)

In April 2020, PwC conducted a survey for Powerful Women[1] looking at women in energy companies and found that 38% of UK energy companies have no women on the board and only 21% of board positions in UK energy companies were help by women; with only 13% of executive board positions across UK energy companies held by women.

The nuclear industry is slightly better than the other parts of the energy industry, including renewables, in terms of gender diversity. Some of the Canadian nuclear companies report extremely well on gender diversity on their boards, with Canada having implemented the Equal by 30 programme[2] and the Driving the Advancement of Women in Nuclear (DAWN) to advance the participation of women in the clean energy transition and to close the gender gap.

Human Resources Canada has also implemented a Diversity and Inclusion[3] programme to foster diversity and inclusion within all organisations. The programme represents the right for diversity and inclusion of under-represented groups in the electricity sector, including women and Canada's indigenous population. The Diversity and Inclusion programme works with the Canadian Council for Aboriginal Business[4] to consider corporate performance in Aboriginal relations. Further, the Canadian BlackNorth Initiative[5] seeks to end systemic anti-black racism – over 450 companies have signed up to the initiative. These programmes also work with Nuclear Against

1. See: https://powerfulwomen.org.uk/board-statistics-by-company/.
2. See: www.equalby30.org/en/splashify-splash.
3. To learn more about this programme, see: https://electricityhr.ca/workplace-solutions/diversity-inclusion/.
4. See: https://www.ccab.com/programs/progressive-aboriginal-relations-par/.
5. See: https://blacknorth.ca/the-pledge/.

Racism,[6] under which the nuclear industry has pledged to agree to stand in solidarity with black and indigenous communities, and people of colour across the world.

In the UK, the revisions to the Nuclear Sector Deal will further address diversity and inclusion across the nuclear sector. The focus is likely to be on diversity of thinking and diversity of socio-economic backgrounds. There are also likely to be regional targets around cultural diversity to reflect the cultural diversity in different regions of the UK. The UK has also established a not-for-profit initiative called Inclusions and Diversity in Nuclear (IDN)[7] with the aim of creating an inclusive and diverse industry.

The energy sector as a whole has a long way to go before it can be seen as truly diverse. Whether a particular board composition is sufficient is a matter for each company's reporting.

### *Progress against strategic milestones*

Organisations need to be purpose lead. The ability to achieve milestones provides a useful mechanism to assess whether the board and its management have the ability to oversee the company and to deliver the stated purpose. It provides an indication of the ability of the board and executives to guide and lead the company.

Corporates should have a strategic plan for delivery of its purpose which should be measurable.

Capital Project SPVs will have a project plan, which will set milestones: 1) during the development period to financial close; and 2) during construction, which would link to investor draw-downs. Progress against the plan should be easily managed and reported on. Once operational, they will behave as an existing corporate with milestones for operation and outages. These are all very measurable. In addition, the impact on the wider socio-economic development of a region may be linked to a capital SPV milestones.

It is important that projects run to time and to budget. In the West, projects are often late and over-budget and historically this has been a problem for large nuclear projects. As nuclear moves to more of a modular and product-based approaches (i.e. minimal on-site construction time) with the majority of the plant being factory built, this should improve dramatically.

However, delays and cost overruns are not just the domain of the nuclear industry. Other energy projects are often over budget and delayed. According to one study on cost overruns and electricity infrastructure, "An analysis of 401 power plant and transmission projects in 57 countries suggests that costs are underestimated in three out of every four projects, with only 39 projects across the entire sample experiencing no cost overrun or underrun. Hydroelectric dams, nuclear power plants, wind farms and solar facilities each have their own unique set of construction risks." (Sovacool et al., 2014)

According to another study examining megaprojects, "Results show that construction costs were, on average, 97.53% above the initial estimates. The distribution that best fits the hydroelectric power plants costs overruns is the gamma distribution. For the delays, the construction completion time had an average increase of 74.28%, or 3.5 years." (Callegari et al., 2018)

### *Remuneration*

The company's remuneration policy needs to reflect the company and the project. Energy projects are vital to society and to the socio-economic development and regeneration for regions and countries. The remuneration policy, performance criteria, appraisal and assessment processes and performance incentives should reflect the delivery of the stated purpose and reflect the importance to society of these projects.

Having the right remuneration policy should reinforce the long-term value creation of energy projects. The remuneration of the board and executive can reinforce or impede long-term socio-economic development but the remuneration throughout the company is also important to support the value creation of the team. Without the correct remuneration policy, the company will not attract the current level of candidates and also will not raise the wage levels for any areas that they are trying to regenerate. Further, the structure should be transparent to allow the development of trust and openness for all stakeholders, both internal and external.

6. See: www.nuclearagainstracism.com.
7. See: www.niauk.org/media-centre/member-news/inclusion-diversity-nuclear/.

Energy companies tend to remunerate reasonably well. Capital projects generally remunerate better to reflect the risks being undertaken in trying to get the project developed. Capital project remuneration packages also tend to include success fees and bonuses linked to the milestones achieved. While corporates also link bonuses to milestones, they are often lower, reflecting the level of risk involved.

The nuclear sector generates a significant amount of high-skilled, high-paid and mostly local jobs for an extended period of time – often more than 60 to 80 years – including construction, operations and decommissioning (NEA, 2020b). An Oxford Economics study for the Nuclear Energy Institute (NEI) in the United States, entitled *Nuclear Power Pays: Assessing the Trends in Electric Power Generation Employment and Wages* (2019), indicated that in average jobs in nuclear energy are 20% better paid than in fossil fuel generation, and 30% better than wind and solar generation, directly demonstrating the higher education in nuclear as well as the higher potential for induced activities and jobs.

Whether a nuclear or energy company has met this metric will depend on the individual company and will form part of the company's reporting.

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Stakeholder Engagement | Impact of Material Issues on Stakeholders |
| | Process for engaging stakeholders |

***Stakeholder engagement***

The relationship between energy companies or projects and their stakeholders is important. Understanding the impact of the company on internal and external stakeholders is key to the success of the company. As companies move to more defined purposes with socio-economic development objectives, stakeholder engagement becomes more important. The criteria require the identification of a wide range of stakeholders and the impact the company's activities have on those stakeholders.

As stated by the International Atomic Energy Agency (IAEA) on its website regarding Stakeholder Engagement processes and guidance:

> "Involving a wide range of interested parties in the decision-making on nuclear power programmes can enhance public awareness, understanding and confidence. This is also important for those stakeholders that do not have a direct role in making those decisions.
>
> Member States often identify the effective communication with stakeholders, and their awareness and understanding, as one of the biggest challenges when initiating a nuclear power programme or undertaking related activities, such as uranium mining. Creating awareness and promoting understanding among the various interested parties, who do not only come from the nuclear industry or government institutions but also the media, local communities and non-governmental organizations, is essential to build mutual trust related to nuclear science and technology questions. Therefore, designing and implementing productive stakeholder involvement programmes starts with communication about energy policies and strengthening stakeholders' understanding of nuclear power, including its benefits and risks." (IAEA, Stakeholder Involvement, n.d.)

***Impact of material issues on stakeholders and process for engaging stakeholders***

Stakeholder engagement and management is something the energy industry, and particularly the nuclear industry, is used to doing. When developing new projects, energy companies engage with a large range of stakeholders in bringing the project to fruition. Stakeholders will include: the government, the planning authorities, regulators, local communities, schools, universities and off-takers. To develop these projects various hurdles will need to be overcome to reach financial close, including raising finance, getting all the relevant planning, environmental, planning and licensing approvals. This is even more stringent on nuclear projects where there are additional regulatory requirements to meet before a project can move ahead.

With established energy companies, they maintain their relationships with stakeholders. Nuclear companies tend to maintain relationships with wider stakeholders as a matter of course as they are part of the community for such a long period of time and they often work with a whole range of stakeholders to maintain their position in the community. Nuclear can be a controversial topic for some stakeholders and nuclear companies work hard to maintain their relationships. Nuclear companies often understand well their impact on different stakeholders and the importance to their business of maintaining those relationships.

Nuclear projects are encouraged to engage with a wide range of stakeholders and to work with them in relation to the role of the project or company in the wider community. This extends to not only the local stakeholders and local communities but to wider regional communities, indigenous people as well as to the schools, colleges and universities.

Again, whether a company has met this metric will depend on the individual company and how well they have identified the material issues and engaged with a wide enough group of stakeholders.

| World Economic Forum | | TCFD | |
|---|---|---|---|
| **Theme** | **Sub-theme** | **Recommendation** | **Supporting disclosure** |
| Ethical behaviour | Anti-corruption | Governance: disclose the company's governance around climate-related risks and opportunities | Describe the board's oversight of climate-related risks and opportunities |
| | Ethics and reporting | | |
| Risk and opportunity oversight | Integrating risk and opportunity | Governance: disclose the company's governance around climate-related risks and opportunities | Describe management's role in assessing and managing climate-related risks and opportunities |

### *Ethical behaviour*

Bribery and corruption undermine stakeholder trust and are linked to fraudulent behaviour, misconduct, lack of governance and due process, misallocation of capital, illegal behaviour and human exploitation. In short, they fundamentally undermine businesses and all ESG.

Ethical behaviour is brought into sharper focus in the energy sector and particularly in the nuclear sector. In the nuclear sector, employees are vetted to a higher standard because of them working with nuclear material on a nuclear site (see the Health and Safety section below).

### *Anti-corruption*

Anti-corruption and bribery training is vital for the development and understanding of employees and to ensure that they understand the latest developments in anti-corruption and bribery prevention. However, training is not the "be all and end all" to protect the company and its reputation. Companies also need to invest in processes and procedures (including reporting) to ensure the highest levels of governance around anti-corruption and anti-bribery systems. Implementing gold star processes and procedures helps to prevent corruption and bribery in organisations. Companies need to be aware of not only the local laws that apply to the company but also other laws, legal systems and regulations that have an impact. Monitoring is also a key element of such processes.

Energy is vital to countries socio-economic development. Energy projects are developed throughout the world, and investors need to be confident that concessions and contracts have been awarded in a professional, appropriate and ethical way. Corruption is a major concern for energy projects, particularly around renewable resources such as forests where deforestation is a concern, and in climate and green energy projects. Projects can, if mismanaged, lead to environmental degradation and destruction. Mismanaging natural resources can dramatically affect the livelihoods of local people who are dependent on those resources. Corrupt practices can undermine ecosystems and global resources and often affect the most vulnerable people. Investors need to ensure that projects are undertaken and maintained ethically and with the support of the local community, so as not to adversely affect the local environment and population.[8]

Projects can also be mismanaged through the lack of proper regulation and policy, and systems that do not allow any environmental impact to be assessed correctly. All energy projects need to assess the environmental impact of their project in great detail, including the impact on habitats. Nuclear projects are more diligent than

8. For more information on anti-corruption guidance in renewable resource sectors, see the U4 Anti-Corruption Resource Centre at: www.u4.no/topics/renewable-resources/basics.

renewables projects due to the additional regulatory requirements. Nuclear projects also assess the impact of radiation on the environment (even though the levels of radiation are very low) as well as the environmental impact on the resources and any effect on people. These projects are monitored not only by local regulators and stakeholders but also by international organisations such as the IAEA.

Companies need to ensure that not only are they and their projects complying with anti-corruption and anti-bribery practices but that their supply chains and through-out their lifecycles are also compliant. With the introduction of anti-bribery and corruption legislation in many countries and the consequences of poor practice in this area, energy companies have improved their reporting and monitoring for corruption and unethical practices.

### *Ethics and reporting*

Companies need to be able to assess and report ethical issues and need processes and procedures which facilitate reporting. Unethical behaviour needs to be prevented and remedied. Whistleblowing procedures need to be established to allow reporting of unethical behaviour without consequence on the reporter. Having such procedures in places helps to evidence proper governance and control by the board and the executive.

Nuclear technology is used for peaceful purposes in energy, medicine and science. Two predominant regimes are deployed to ensure ethical behaviour and reporting in the energy industry and particularly the nuclear industry. These are the safeguards regime and the export controls regulations.

The nuclear safeguards regime has been in place since the 1960s and is the gold standard for safeguarding. The regime is based on a number of international conventions and international agreements including: the IAEA Safeguards System, the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the Convention on the Physical Protection of Nuclear Material and Nuclear Facilities. The renewables industry is beginning to establish their own safeguards regimes to protect the environment and resources from improper use. These are in the early stage of development.

The *IAEA Safeguards Glossary* provides that the purpose of safeguards is:

> "… to verify that commitments made by States under safeguards agreements with the IAEA are fulfilled. It is therefore necessary to define the objectives of safeguards in technical terms relevant to each type of safeguards agreement so that safeguards can be applied in an effective manner." (IAEA, 2001)

International safeguards regimes exist to ensure that nuclear material cannot be diverted for non-peaceful uses. They consist of a system of nuclear material accountancy by the licensee operator of an installation and reporting to the national safeguards body, and ultimately to the IAEA. Verification of accountancy figures, remote monitoring and sealing of inventories are all carried out, backed up by periodic inspections from the national safeguards responsible authority and/or the IAEA to provide independent verification.

The IAEA sets out examples of non-compliance as follows:

> "(a) Under an INFCIRC/153-type safeguards agreement, the diversion of nuclear material from declared nuclear activities, or the failure to declare nuclear material required to be placed under safeguards;
>
> (b) Under an INFCIRC/66-type safeguards agreement, the diversion of the nuclear material or the misuse of the non-nuclear material, services, equipment, facilities or information specified and placed under safeguards;
>
> (c) Under an additional protocol based on, the failure to declare nuclear material, nuclear activities or nuclear related activities required to be declared under Article 2;
>
> (d) Under all types of agreement, violation of the agreed recording and reporting system, obstruction of the activities of IAEA inspectors, interference with the operation of safeguards equipment, or prevention of the IAEA from carrying out its verification activities." (IAEA, 2001)

Export controls apply to a wide range of projects across a variety of areas from nuclear, aerospace, communications, materials and construction. For the energy industry, and particularly for the nuclear industry, export controls play a large part in ensuring information and products are not misappropriated for unethical purposes. Intended to aid countries in discharging their obligations under numerous international treaties (such as the NPT for nuclear technology), export controls place restrictions on the export of components, documentation, knowledge and training on such particular items and areas. For certain nuclear technology, prior to export, exporters will have to obtain an export licence from their county's recognised authority and satisfy them that the technology, component or knowledge will not be diverted for purposes other than the peaceful exploitation of nuclear technology and will not threaten the security of nations or oppression of persons in the country of import. Importers are required to satisfy the exporting country's export authority that the materials will not be diverted for anything other than their intended use.

The nuclear industry and the wider energy industry need to maintain ethical behaviour with strong reporting principles. The nuclear industry leads the way in this regard and the renewables industry is seeking to establish its own policies and practices.

### *Risk and opportunity oversight, and integrating risk and opportunity*

This metric relates to a company's overall risks and opportunities. Risk registers should be maintained. The primary responsibility to maintaining the managing risks and opportunities lies with the executive, but the board must maintain oversight. The risks and opportunities must be appropriate for the organisation and not extend past the risk appetite of the company. The risks and opportunities should be wide enough to cover its stakeholders and the wider community. The risks should include ESG including environmental risks such as GHG emissions and climate change (see the Planet section below). The risk register must develop and adapt over time, including but not limited to any energy company transitioning from a development company, to a construction company, to an operational company and finally through to decommissioning. The risks and opportunities at each stage will be different.

The standards of health and safety generally, whether in nuclear or other energy projects, vary across the globe. Investors will assess the projects on their culture, processes and procedures, including the board's oversight. All energy projects should have gold standard levels of health and safety and risk management on their sites (see the Health and Safety section below).

Nuclear regulations provide for nuclear licenses to be in place for the construction, operation and decommissioning of the plant. The precise details depend on jurisdiction. However, under internationally agreed norms, the licensee has to be the "Controlling Mind" and the "Knowledgeable Customer" for the site.

The Controlling Mind is a legal concept that has its origins in health and safety law relating to corporate manslaughter. In nuclear projects, it relates to the health and safety responsibilities in respect of risk management on a nuclear site. Under nuclear site licenses, the site licensee is responsible for health and safety and the overriding risk management of the site (although the precise details of this will depend on the jurisdiction). The site licensee needs to be the "Controlling Mind" of all safety, security and safeguarding issues on the site. In relation to those legal requirements, the site licensee cannot be constrained by the owner of the nuclear power plant or even the operator's parent company, shareholders or investors. This can adversely affect the ability of investors to enforce their rights in a traditional project finance way. This in turn can affect the structure of the project. The Controlling Mind principle does not mean that the site licensee takes over others responsibility on the site or is the only entity responsible for health and safety and risk management on the site i.e. owners, operators and contractors still have to comply with their contractual and legal responsibilities. However, the site licensee has to have an understanding of all work being undertaken on the site. The precise details of this will depend on each jurisdiction.

In addition to the Controlling Mind principle is the Knowledgeable Customer. A site licensee is expected to have the capability, within its own organisation, in terms of staffing and expertise, to understand the safety case for all the nuclear facilities on the site and the limits under which it must be operated. A nuclear site licensee needs to understand the safety significance of any work undertaken by contractors and to oversee and take responsibility for contractor's activities, including ensuring that the contractor's staff are suitably qualified and experienced to carry out their nuclear safety duties. This means that major contracts which affect the safety, security or safeguarding of the plant, including the EPC Contract and the Fuel Supply Agreement (FSA), must sit with the site licensee i.e. the licensed entity needs to have control of those contracts to be able to fulfil its Knowledgeable Customer obligations.

Nuclear safety culture is defined as "the core values and behaviours resulting from a collective commitment by leaders and individuals to emphasise safety over competing goals, to ensure protection of people and the environment" (USNRC, 2020). Nuclear companies should have detailed processes and procedures for managing health and safety and risk throughout the company and at every level of the organisation.

With these additional levels of compliance, the nuclear industry leads the way in health and safety. This can be costly for projects and increase the overall costs associated with the project. This therefore needs to be balanced as both health and safety and costs are risks that the nuclear industry, and the energy industry more widely, must consider. The challenge for the nuclear sector is that the levels of health and safety management are set at such a high standard, making the nuclear industry one of the safest industries in the world, that compliance is costly and sometimes overly constrained.

## Planet: SDGs 6, 7, 12, 13, 14 and 15

| World Economic Forum | | SASB | | TCFD | |
|---|---|---|---|---|---|
| **Theme** | **Sub-theme** | **Topic** | **Metric** | **Recommendation** | **Supporting disclosure** |
| Climate change | GHG emissions | GHG emissions and energy resource planning | 1) gross global scope 1 emissions, percentage covered under; 2) emissions-limiting regulations; and 3) emissions-reporting regulations | Scope 1 refers to all direct GHG emissions.<br>Scope 2 refers to indirect GHG emissions from the consumption of purchased electricity, heat, or steam.<br>Scope 3 refers to other indirect emissions not covered in scope 2, which occur in the value chain of the reporting company, including both upstream and downstream emissions. | |
| | Impact of GHG emissions | | GHG emissions associated with power deliveries | | |
| | Task Force on Climate-Related Financial Disclosure aligned reporting on material climate risks and opportunities | | Discussion of long-term and short-term strategies or plans to manage scope 1 emissions, emission-reduction targets, and an analysis of performance against those targets. | Strategy: disclose the actual and potential impacts of climate-related risks and opportunities on the company's businesses, strategy and financial planning where such information is material. | Describe the resilience of the company's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenarios. |
| | | | 1) Number of customers served in markets subject to renewable portfolio standards (RPS); and 2) percentage fulfilment of RPS target by the market | | |
| | Science-based target to reduce GHG emissions | | | Risk management: disclose how the company identifies, assesses and manages climate-related risks. | Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the company's overall risk management. |

| | | | | | |
|---|---|---|---|---|---|
| | TCFD aligned reporting | | | Metrics and targets: disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material. | Disclose the metrics used by the company to assess climate-related risks and opportunities in line with its strategy and risk management process.<br>Disclose scope 1, scope 2 and, if appropriate, scope 3 GHG emissions and the related risks.<br>Describe the targets used by the company to manage climate-related risks and opportunities and performance against targets. |

### *Climate change*

Greenhouse gas (GHG) emissions are the main cause of climate change and therefore a key focus for those considering climate finance. Over the past ten years, businesses associated with high emissions have fallen out of favour as the markets have moved towards low-carbon economies.

There remain difficulties in adequately measuring emissions. However, scope 1, 2 and 3 reporting have been developed. These are defined by the TCFD as:

- Scope 1 refers to all direct GHG emissions.
- Scope 2 refers to indirect GHG emissions from consumption of purchased electricity, heat, or steam.
- Scope 3 refers to other indirect emissions not covered in Scope 2 that occur in the value chain of the reporting company, including both upstream and downstream emissions. Scope 3 emissions could include: the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities (e.g. transmission and distribution losses), outsourced activities, and waste disposal.

Emissions are reported in metric tonnes of carbon dioxide equivalent ($tCO_2e$).

The TCFD are established as the primary framework for the disclosure of risk and opportunities relating to climate change, and particularly GHG emissions. Established companies are used to producing annual filings. It is recognised that this framework is also in line with the Paris Agreement. The WEF has included the TCFD metrics and the Climate Disclosure Standards Board, and the SASB have produced a joint TCFD implementation guide and a related set of good practices.

The Paris Agreement on climate change sets our long-term goals to limit the increase in global average temperature to 1.5°C. In addition, a number of countries have committed to be Net Zero by 2050. Alongside these developments, companies have published science-based targets consistent with the Paris Agreement and Net Zero objectives. These are seen as minimum reporting requirements for all companies.

### *Greenhouse gas (GHG) emissions*

There is scientific consensus that human activities are causing global climate change. The burning of fossil fuels, changes in land use and various industrial processes are adding GHG, particularly $CO_2$, to the atmosphere. $CO_2$ concentrations have increased by 40% since pre-industrial times, primarily from fossil fuel emissions and secondarily from net land use change emissions. The effects of these additional gases can already be seen (global average temperatures have risen by 0.75°C since about 1990) with consequences for both the environment and people's lives.

GHG emissions is one of the main metrics for ESG across a number of reporting bodies. GHG emissions have been identified as one of the primary causes of climate change and therefore key to the mitigation of climate change. There are challenges about the accuracy of the reporting against these metrics and also there is a bias towards certain technologies who often only report against scope 1 and sometimes scope 2. Some nuclear companies are beginning to report on scope 1,2 and 3. Requiring companies to report on all 3 scopes would create a level playing field across technologies. Looking at the lifecycle emissions provides a more accurate view of technologies and their overall impact on climate change.

Nuclear power stations produce very few carbon dioxide emissions directly from electricity generation. As set out in the *Technical Assessment on Nuclear Energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation')*: "…the TEG concluded that nuclear energy has near to zero greenhouse gas emissions…. The comparison of impacts of various electricity generation technologies (e.g. oil, gas, renewables and nuclear energy) on human health and the environment, based on recent Life Cycle Analyses (LCA) […], shows that the impacts of nuclear energy are mostly comparable with hydropower and the renewables, with regard to non-radiological effects." EU, 2021)

The role of nuclear as a low carbon technology is becoming widely accepted. In January 2016, New York Public Service Commission ruled that the state's Clean Energy Standard (CES) portfolio must include nuclear power plants among its non-carbon-emitting generation resources.

As identified in the *Canadian Nuclear Factbook 2020* (CNA, 2020). "Today by displacing the use of coal and natural gas, nuclear power helps avoid about 2.2 billion tonnes of $CO_2$ emissions annually. This the same as taking about 480 million passenger vehicles of the road – or nearly half of all the passenger vehicles in the world."

In the Agreement Between the Government of the United Kingdom of Great Britain and Northern Ireland and the European Atomic Energy Community for Cooperation on the Safe and Peaceful Uses of Nuclear Energy, signed on 31 December 2020, it was noted:

> NOTING the United Kingdom's commitment to developing and deploying nuclear energy as part of its diversified and low-carbon energy mix;
>
> DESIRING to make long-term cooperative arrangements in the field of peaceful and non-explosive uses of nuclear energy in a predictable and practical manner, which take into account the needs of their respective nuclear energy programmes and which facilitate trade, research and development and other cooperative activities between the United Kingdom and the Community; (EU, 2020)

On the global stage, the potential role of nuclear in reducing carbon impacts from power generation was a central theme of the COP21 summit in Paris. During the event, Loreta Stankeviciute – (Energy Economist at the IAEA) – stressed that "nuclear energy should be considered on equal footing with other low-carbon energy sources in weighing the energy options for mitigating climate change, in recognition of its broader potential for contributing to sustainable development".

Stankeviciute was speaking at a session hosted jointly by the IAEA and the Nuclear Energy Agency (NEA), which has also consistently highlighted the credentials of nuclear power as a way to drive carbon emissions out of the generation mix.

All forms of electricity generation have some carbon dioxide emissions associated with the energy used in the construction, operation and decommissioning of the plant. Nuclear has carbon dioxide emissions associated with energy use during mining; and also with extraction, enrichment, and the manufacture of its fuel. Like coal, energy is also used in management of the waste products from generation, resulting in carbon dioxide emissions.

In 2011, the Intergovernmental Panel on Climate Change (IPCC) synthesised evidence from a comprehensive review of published Life Cycle Assessments (LCAs) covering all regions of the world, to produce a comparison of carbon dioxide emissions from different electricity generation technologies. This showed that emissions from nuclear power stations (median figure of 16g$CO_2$/ kWh) are comparable to those from renewable resources, and significantly lower than those from electricity generated from fossil fuels.

In the Energy Systems chapter of its 2018 Report,[9] the IPCC stated:

> Renewable heat and power generation and nuclear energy can bring more significant reductions in GHG emissions. The information provided here has been updated from the data provided in SRREN, taking into account new findings and reviews, where available. The ranges of harmonized lifecycle greenhouse gas emissions 012), and 4 – 110 gCO2eq / kWh for nuclear power (Warner and Heath, 2012). The harmonization has narrowed the ranges down from 5 – 217 gCO2eq / kWh for PV, 7 – 89 gCO2eq / kWh for CSP, and 1 – 220 gCO2eq / kWh for nuclear energy. A new literature review for wind power published since 2002 reports 7 – 56 gCO2eq / kWh, where the upper part of the range is associated with smaller turbines (< 100 kW) (Arvesen and Hertwich, 2012), compared to 2 – 81 gCO2eq / kWh reported in SRREN. For all of these technologies, at least five studies are reviewed. The empirical basis for estimating the emissions associated with geothermal and ocean energy is much weaker. SRREN reported 6 – 79 gCO2eq / kWh for geothermal power and 2 – 23 gCO2eq /kWh for ocean energy (IPCC, 2011a). For ocean power, Figure 7.6 shows only the results of newer assessments, which range between 10 – 30 gCO2eq / kWh for tidal barrages, marine current turbines, and wave power (Walker and Howell, 2011; Kelly et al., 2012). For RE, emissions are mainly associated with the manufacturing and installation of the power plants, but for nuclear power, uranium enrichment can be significant (Warner and Heath, 2012). Generally, the ranges are quite wide reflecting differences in local resource conditions, technology, and methodological choices of the assessment. The lower end of estimates often reflects incomplete systems while the higher end reflects poor local conditions or outdated technology. (IPCC, 2018)

In the Energy Supply chapter of its 2018 Report,[10] the IPCC stated:

> Total life-cycle GHG emissions per unit of electricity produced from nuclear power are below 40 gCO2-eq/kWh (10 gC-eq/kWh), similar to those for renewable energy sources […]. Nuclear power is therefore an effective GHG mitigation option, especially through license extensions of existing plants enabling investments in retro-fitting and upgrading. Nuclear power currently avoids approximately 2.2–2.6 GtCO2/yr if that power were instead produced from coal […] or 1.5 GtCO2/yr if using the world average CO2 emissions for electricity production in 2000 of 540 gCO2/kWh […]. (IPCC, 2018)

The Canadian Nuclear Association commissioned a report by Hatch to consider the lifecycle emissions from different technologies. Hatch employed a LCA Overview methodology where they measured "the environmental impacts of a product by modelling the processes, materials consumed and emissions at each stage of the product lifecycle, extending beyond the conventional operational boundaries of any one company or process stage […]. The process of conducting an LCA is standardized under ISO 14040, consisting of a four-step process including goal and scope definition, inventory analysis, impact assessment, and interpretation" (Hatch, 2014). The Hatch report the lifecycle assessment for nuclear, wind and natural gas.

The LCA meta-analysis is a cradle-to-gate study spanning from resource extraction up to the production of electricity at the point (or gate) of delivery to the electricity grid. The study encompasses all upstream and downstream processes associated with the generation of 1 kWh of electricity, excluding transmission and distribution losses. The environmental impacts and emissions in this study were obtained taking into account two dimensions of their lifecycle:

- Supply Chain – processes corresponding to the ongoing operation of the power generation facility, including the upstream systems associated with fuels and consumables and downstream systems associated with the management and disposal or wastes.
- Lifespan – processes corresponding to the entire lifetime of the power plant from inception to eventual decommissioning, not otherwise captured in the day-to-day operation of the plant. The supply chain encompasses the extraction, production and transportation of raw materials (fuels and consumables) to the power plant, operations and maintenance, and the management of all waste associated with the activities of the power plant. The lifespan includes all the process stages required build and disassemble the power plant at the start and end of the plant's lifetime, including the extraction, production, transportation and application of materials and fuels used during construction,

9. www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter4-1.pdf.
10. www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter4-1.pdf.

as well as the disassembly and disposal or re-use of plant materials during decommissioning. Combined, the supply chain and lifespan represent the complete range of processes directly and indirectly required to generate electricity from each generation scenario.

Hatch's lifecycle assessment for GHG shows that wind and nuclear have similar emissions, and that both are significantly below gas plants:

Table 8: Statistical Mean Total Lifecycle GHG Emissions

| **Scenario** | GHG ($gCO_2$-e/kWh) |
|---|---|
| **On-shore wind turbine** | 10.5 ± 0.9 |
| **Nuclear power plant** | 18.5 ± 1.7 |
| **NGCC power plant** | 478 ± 10 |

Note: NGCC = natural gas combined cycle.
Source: Adapted from Hatch (2014)

Much of the emissions associated with windfarms are generated primarily during construction and decommissioning. Off-shore wind farms have higher emissions than on-shore windfarms due to the foundations, cabling and transport impact. This becomes more of a concern when one considers the short life of a wind turbine. The design life of many wind turbines is 20 years, but for many, particularly off-shore windfarms, they are taken out of service in 15 years or less. Further, due to the intermittent nature of wind and solar, wind and solar plant are being paired with batteries and other storage facilities to create a firmer power solution. The figures above do not take into consideration the GHG emissions associated with the battery production, which can be significant.

For nuclear plants, many of the emissions are associated with the upstream supply chain – particularly the mining of uranium and the enrichment and fuel fabrication processes. In certain configurations with high grade ore or no enrichment or centrifuge-based enrichment, the emissions from a nuclear lifecycle are the same as those from an on-shore wind farm (i.e. smaller than an off-shore wind farm).

The report further looks at a range of technologies within each group:

Table 9: Statistical Mean Total Lifecycle Emissions

| **Scenario** | GHG (g/kWh) Average Current Study | GHG (g/kWh) Range of reference study* |
|---|---|---|
| **On-shore wind turbine** | 10.5 ± 0.9 | 3-45 |
| **Wind (mix)** | | 3-41 |
| **Nuclear LWR** | 18.5 ± 1.7 | 3.7-110 |
| **Nuclear PWR** | | 3.7-110 |
| **Nuclear BWR** | | 4.6-17 |
| **Nuclear mix** | | 1.36-288.25 |
| **Nuclear mix** | | 3-35 |
| **NG (NGCC)** | 478 ± 10 | 360-720 |
| **NG (mix)** | | 380-1000 |

*The reference study refers to the literature Hatch used to compare the results of its study.
Note: LWR = light water reactor; PWR = pressurized water reactor; BWR = boiling water reactor.
Source: Adapted from Hatch (2014).

In 2017 an article in *Nature Energy* (Pehl et al., 2017) measured the full lifecycle GHG emissions of a range of sources of electricity out to 2050. The carbon footprint of solar, wind and nuclear were shown to be significantly lower than other sources, even after taking into account emissions during manufacture, construction and fuel supply. The study found each kilowatt hour of electricity generated over the lifetime of a plant has an emissions footprint of:

- nuclear – 4g$CO_2$e/kWh $CO_2$ equivalent (g$CO_2$e/kWh);
- solar – 6g$CO_2$e/kWh;
- wind – 4g$CO_2$e/kWh;
- coal CCS[11] – 109g$CO_2$e/kWh;
- gas CCS – 78g$CO_2$e/kWh;
- hydro[12] – 97g$CO_2$e/kWh;
- bioenergy[13] – 98g$CO_2$e/kWh.

Further details and analysis on the GHG emissions and the impact on climate change of nuclear power can be found in reports such as the report entitled *The Role of Nuclear Energy in a Low-carbon Energy Future* (NEA, 2012). The message was further emphasized during a 2020 NEA webinar and in the NEA Policy Brief entitled "Building Low-Carbon Resilient Electricity Infrastructures with Nuclear Energy in the Post-COVID Era (NEA, 2020a).[14]

What is clear from the various analysis cited above is nuclear power's low-carbon credentials and its vital role in the fight against climate change.

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Nature Loss | Land Use and Ecological Sensitivity |
| | Impact of Land Use |

### *Nature loss*

All energy generating technologies impact the environment in their vicinity. Whilst any emissions from a facility or installation are generally regulated by national laws, regional laws and regulations, facilities can still have an impact on the environment, landscape and ecology. This section describes the relative habitat and ecology impacts brought about by differing generating technologies.

The emphasis of this metric is on reporting the area of land owned, leased or managed by the company, together with adjacent land, which is impacted by the company's activities, particularly in protected areas or key biodiversity areas.

Key biodiversity areas provide recognised ways of identifying sites contributing significantly to biodiversity. Protected areas/zones are recognised as areas of ecological importance. Any activities in such areas indicate heightened risk of environmental damage, adverse impacts on biodiversity or ecology and therefore risk to reputation.

### *Land use and ecological sensitivity, and the impact of land use*

The land use should consider the whole of the supply chain, including commodities used. Consideration should also be given to areas used to supply the project and the impact on ecology across that supply chain. Companies should consider a sustainable certification programme and the impact of each significant element of the supply chain, in terms of land and resources used and the overall balance, taking into consideration the adverse production impact. The ESG credentials of businesses in the supply chain should be addressed in any procurement programme.

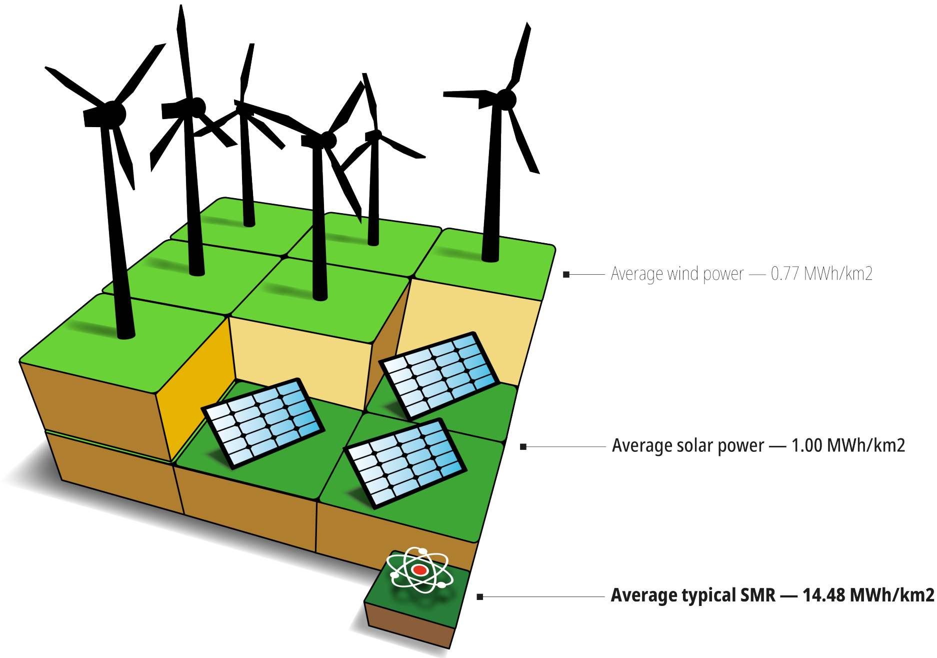
11. The figures for CCS are elevated for two reasons. First, upstream emissions during mining of coal or extraction of gas continue. Second, the study assumes that CCS only captures 90% of power plant $CO_2$. Higher capture rates are more costly and would not eliminate upstream emissions, equivalent to 23-42g$CO_2$e/kWh, still well above the numbers for nuclear, wind or solar.
12. The footprint for hydro is highly variable, the paper notes, with lifecycle emissions largely due to the rotting organic matter flooding the dam. This means certain sites should be avoided, in particular shallow dams in warm regions, with large variations in water levels.
13. For bioenergy, the footprint is also highly uncertain and variable, the paper says, depending on how the biomass is sourced and if it involves converting high-carbon stock land such as forests.
14. To watch the NEA webinar, see: www.oecd-nea.org/jcms/pl_34301/webinar-building-low-carbon-resilient-electricity-infrastructures-with-nuclear-energy-in-the-post-covid-19-era.

The interrelationship between land use and energy is a balance. Energy is needed for the socio-economic development of regions and countries, but this needs to be balanced with the efficient and effective use of land, which is also needed for other activities such as the production of crops and food. The efficient use of land for the production of energy is an important factor to be considered. The impact of land use needs to be assessed meaningfully by the energy company, it also needs to be presented to the Board, executive and stakeholders in an accessible way.

As highlighted in Figure 5 below:

- An average wind farm produces 0.77MWh per square kilometre of land;
- An average solar farm produces 1MWh per square kilometre;
- whereas a small modular reactor (SMR) produces up to 14.5 MWh per square kilometre of land.

Figure 5: Land use of nuclear, solar and wind




Source: GIF

Capacity factors need to also be considered in any assessment of land use. Each technology has different capacity factors. As can be seen from Table 10 below capacity factors can have a significant impact on electricity output:

Table 10: Capacity factor and land use for various electricity generating technologies

| Technology | Capacity factor[15] (%) | Electrical output (MWe per $km^2$) |
|---|---|---|
| Nuclear energy[16] | 90 | 17 164 |
| Off-shore wind[17] | 43 | 3 |
| Solar photovoltaic[18] | 9.2 | 9 |

Source: see footnotes

Both of these analyses only consider the direct land use associated with the plant itself rather than considering the supply chain across the lifecycle of the plant.

A report by the US Department of Energy, *Quadrennial Technology Review 2015: Enabling Modernization of the Electric Power System* (hereafter "the US report", 2015) recognises that there is no definite source for land use mapped against energy intensity and as a result metrics often have different units that are not always comparable. However, it provides the Representative Land Use Intensity Estimates shown in Table 11 and Table 12 below.

Table 11: Land use estimates for a variety of electricity generating technologies (power plants site only)

| Energy technology | m2/MW | System boundary (power plant site only*) |
|---|---|---|
| Biomass; direct-fired | 9 000-45 000 | Power plant site only |
| Coal | 270-8 000 | Power plant site only |
| Coal: CCS | 12 000 | Power plant site only |
| Nuclear energy | 6 700-13 800 | Low estimate is site only. High estimate includes transmission lines, water supply and rail lines, but does not include land used to mine, process or dispose of waste. |

Source: Adapted from US Department of Energy (2015)

15. Nuclear capacity factor taken from American Nuclear Society Nuclear News 2021 five-year capacity factor average for US fleet. Off-shore wind capacity factor lifetime average from Ofgem and Elexon data. Solar PV capacity factor taken from long-term patterns of European PV output using 30 years validated hourly re-analysis and satellite data, S Pfenninger & I Staffell.
16. Average of UK generating fleet: Sizewell B, Torness, Hunterston B, Hinkley Point B, Dungeness B, Hartlepool, Heysham I and Heysham II and new build at Hinkley Point C. All are AGRs with the exception of Sizewell B and Hinkley Point C (PWRs). Electrical output obtained from UK regulator website onr.org.uk and site footprint obtained from Google Maps area calculator.
17. Average of UK off-shore wind farms at: Hornsea One, East Anglia One, London Array, Race Bank, Rampion, Walney Extension, West of Duddon Sands, Gwynt Y Môr, Sheringham Shoal and Humber Gateway. Electrical output from wind farm developer's respective websites.
18. Average of UK Solar PV farms at: Shotwick, Stonebarrow, Burnaston, RAF Lyneham, New Mains of Guynd, Owls Hatch, Westmill, QEII Reservoir, Prestop Park and Rhosygilwen Estate. Electrical output obtained from developer's website. Area calculated from Google Maps area calculator.

Table 12: Land use estimates for a variety of electricity generating technologies (energy resource extraction area and power plant site)

| Energy technology | m2/MW | System boundary<br>Energy resource extraction area plus power plant site |
|---|---|---|
| Biomass gasification | 3 000 000 | Site and crop area. Area used, primarily driven by biomass productivity and power plant efficiency. |
| Coal (site and upstream) | 40 000 | Site and strip mining included |
| Geothermal: hydrothermal | 1 200-150 000 | Low estimate is for the site only. Upper estimate includes well-field and plant. |
| Geothermal:<br>hot dry rock | 4 600-17 000 | Includes well-field and plant |
| Hydropower: reservoir | 20 000-10 000 000 | Site of generators and reservoir |
| Solar: PV | 10 000-60 000 | Site of PV system, which includes the area for solar energy collection. PV systems on pre-existing structures have essentially no net increase in land use. |
| Solar: thermal | 12 000-50 000 | Site of concentrating solar thermal system, which includes the area for solar energy collection. |
| Wind | 2 600-1 000 000 | Low-end value is for the site only, which includes the physical footprint of the turbines and access roads. The high-end value includes the land area between turbines, which is typically available for farming or ranching. |

*Does not consider energy resource mining or collection, processing or transport area, or land used for waste disposal.
Note: CCS = Carbon capture and storage; PV = photovoltaic.
Source: Adapted from US Department of Energy (2015)

Like many other infrastructure projects, the development of any energy plant will have an impact on sensitive species and habitats. The impact will depend primarily on the site where the plant is deployed. However, when considering land utilisation, a nuclear plant will have a smaller impact than a renewable plant of equal power.

A developer of any energy plant is required to provide sufficient information (including in relation to avoidance and mitigation measures) of its impact on land, habitats and species in order for a proper assessment to be made. This includes any off-shore impacts, whether an off-shore wind farm or the outlet pipe for cooling water from a nuclear plant. An environmental impact assessment would need to be undertaken to determine the specific impact on a particular site.

These assessments aim to identify sites in the first instance where there are no impact or a minimal impact on the environment and local ecology. Where impacts are inevitable, suitable mitigation to compensate are required to be agreed and demonstrated prior to consent for construction being granted. For example: all applications to build nuclear power stations within the EU are subject to the EU Directive on the assessment of the effects of certain plans and programmes on the environment (known as the Strategic Environmental Assessment Directive (2001/42/EC)). The Directive specifically refers to effects on people, fauna and flora, soil, water, air, climate, the landscape, material assets and cultural heritage, and the interaction between them. All applications must include an Environmental Statement from the applicant describing the likely significant effects of the proposed project on the environment and the measures envisaged for avoiding or mitigating significant adverse effects. When considering cumulative effects, the environmental statement should provide information on how the effects of the applicant's proposal would combine and interact with the effects of other development, including projects for which consent has been sought or granted, as well as those already in existence.

Acquisition and maintenance of land can be a key issue for plants or installations and the smaller the land area required, generally the easier the process of siting and construction, which presents potentially less of a commercial risk as the project progresses. The siting of new nuclear power stations takes into account the implications of climate change, including the possibility of more severe weather patterns and rising sea levels. This is in addition to other postulated events that could impact the safety of the plant, both man-made and natural such as extreme weather events.

| World Economic Forum | | SASB | |
|---|---|---|---|
| **Theme** | **Sub-theme** | **Topic** | **Metric** |
| Fresh water availability | Fresh water consumption in water stressed areas and the impact on fresh water consumption | Water management | 1) Total water withdrawn; 2) total water consumed, as well as the percentage of each in regions with high or extremely high baseline water stress. |
| | | | Number of incidents of non-compliance associated with water quantity and/or quality permits, standards, and regulations. |
| | | | Description of water management risks and discussion of strategies and practices to mitigate those risks. |

### *Fresh water availability*

Where relevant, energy projects need to be considered in terms of their freshwater consumption. This is particularly relevant in water-stressed areas where there is a risk of negative social impact. However, this metric should consider a company's water stewardship as a whole.

### *Fresh water consumption and water management*

The reporting of the units used together with how water is managed should be reported in a way that executives, the board and investors can easily understand. The report should include an assessment of the environmental impact of the water use.

In 2014, the Energy and Water in a Warming World Initiative produced a report entitled *Freshwater Use by U.S. Power Plants Electricity's Thirst for a Precious Resource*", and found that:

> …findings on the water profile of power plants in 2008 show that:
>
> Power plants are thirsty. Every day in 2008, on average, water-cooled thermoelectric power plants in the United States withdrew 60 billion to 170 billion gallons (180,000 to 530,000 acre-feet) of freshwater from rivers, lakes, streams, and aquifers, and consumed 2.8 billion to 5.9 billion gallons (8,600 to 18,100 acre-feet) of that water. Our nation's large coal fleet alone was responsible for 67 percent of those withdrawals, and 65 percent of that consumption.
>
> Where that water comes from is important. In the Southwest, where surface water is relatively scarce, power plants withdrew an average of 125 million to 190 million gallons (380 to 590 acre-feet) of groundwater daily, tapping many aquifers already suffering from overdraft. By contrast, power plants east of the Mississippi relied overwhelmingly on surface water.
>
> East is not west: water intensity varies regionally. Power plant owners can reduce their water intensity—the amount of water plants use per unit of electricity generated. Plants in the East generally withdrew more water for each unit of electricity produced than plants in the West, because most have not been fitted with recirculating, dry cooling, or hybrid cooling technologies. Freshwater withdrawal intensity was 41 to 55 times greater in Virginia, North Carolina, Michigan, and Missouri than in Utah, Nevada, and California. Freshwater consumption intensity was similar in those sets of states.
>
> Low-carbon electricity technologies are not necessarily low-water. On average in 2008, plants in the U.S. nuclear fleet withdrew nearly eight times more freshwater than natural gas plants per unit of electricity generated, and 11 percent more than coal plants. The water intensity of renewable energy technologies varies. Some concentrating solar power plants consume more water per unit of electricity than the average coal plant, while wind farms use essentially no water. (Averyt et al., 2011)

While solar and wind plants do consume water, they use significantly less water than nuclear plants. However most of the water used in nuclear plant is used rather than consumed. A 2019 review of the water use of electricity technologies emphasised the challenges of determining the water consumed across various technologies and concluded that: "The results show that photovoltaics, wind power, and run-of-the-river hydropower consume relatively little water, whereas reservoir hydropower and woody and herbaceous biomass can have an extremely large water footprint. The water consumption of power production can differ greatly across countries due to different geographic conditions." (Jin et al., 2019)

The exact water use or consumption will be project-specific. However, water consumption should also be assessed with desalination and the creation of potable water for those countries where this is needed. Desalination and potable water can help to offset the impact of water use, particularly in water-stressed areas.

Fresh water is a major priority in sustainable development, it is estimated that one fifth of the world's population does not have access to safe drinking water,[19] and that this proportion will increase due to population growth relative to water resources. The worst affected areas are the arid and semi-arid regions of Asia and North Africa. "Wars over access to water, not simply energy and mineral resources, are conceivable" (WNA, 2020a). Where freshwater cannot be obtained from streams and aquifers, desalination of sea water or groundwater is required.

A report in 2002 from the UNESCO said that the freshwater shortfall worldwide was then running at some 230 billion m3/yr and would rise to 2,000 billion m3/yr by 2025. A report in January 2015 from the World Economic Forum highlighted the problem and said that "shortage of freshwater may be the main global threat in the next decade." (Ali, 2018)

Desalination is a very energy intensive process often contributing to increased levels of GHG, as the vast majority of desalination plants use fossil fuel sources. Current information on desalination shows that "only 1% of total desalinated water is generated from renewable sources" (IEA/IRENA, 2012). The use of fossil fuels is also vulnerable to volatile global market prices as well as logistical supply problems in remote and island communities. Until now, the majority of desalination plants have been located in regions where there is a high availability of low-cost energy. While renewable production is increasing, the demand for desalinated water in energy-importing countries such as India, China and small islands is also increasing.

According to the IEA/IRENA (2012), "there are two broad categories of desalination technologies. Thermal desalination uses heat to vaporise fresh water, while membrane desalination (reverse osmosis) uses high pressure from electrically-powered pumps to separate fresh water from seawater using a membrane". Reverse Osmosis (RO) needs about 6 kWh of electricity per cubic metre of water, while thermal distillation processes require heat at 70°C-130°C or 25 kWh/$m^3$ to 200 kWh/$m^3$. (Hore-Lacy, 2007)

However, the purity of the water produced from RO is not as high as with thermal distillation techniques and the cost-effectiveness of RO depends highly on any required chemical pre-treatment of the feed-water.

Nuclear plants can be used for desalination and the creation of potable water. The technology has been proven for desalination, principally in Kazakhstan, India and Japan. According to the World Nuclear Association (WNA), the costs of desalination by nuclear plant is much the same as fossil-fuel plant that do the same – c. 70 to 90 US cents per cubic metre. This cost may drop with some of the advanced high temperature reactors in development. Whether countries will widely choose to take the benefit of this option in a nuclear plant is yet to be seen and will depend on the economics and other developments in each country.

Small and medium-sized nuclear reactors are suitable for desalination, often with cogeneration of electricity using low-pressure steam from the turbine and hot sea water feed from the final cooling system. The main opportunities for nuclear plants have been identified as the 80-100 000 $m^3$/d and 200-500 000 $m^3$/d ranges (IAEA, 2009). US Navy nuclear powered aircraft carriers reportedly desalinate 1 500 $m^3$/d each for use onboard.

The cost of desalination from fossil fuels is USD 0.64/$m^3$ – USD 2.00/$m^3$, with nuclear energy being slightly lower at USD 0.50/$m^3$ – USD 1.48/$m^3$ (IAEA, 2007). The cost of desalination from renewables is, as shown in Table 13 below, greater at USD 1.3/$m^3$ – >USD 10/$m^3$ (World Bank, 2019). It should however be noted that while the cost of renewable desalination is more expensive, it can compete in remote regions where the cost of energy transmission and distribution is higher than the cost of distributed generation.

19. For more information, see the United Nations Department of Economic and Social Affairs International Decade for Action "Water for Life" web page at: www.un.org/waterforlifedecade/scarcity.shtml.

Table 13- Comparative costs for common renewable desalination*

| | Technical capacity | Energy Demand (kWh/ m$^3$) | Water cost (USD/ m$^3$) | Development stage |
|---|---|---|---|---|
| Solar stills | < 0.1 m$^3$/d | Solar passive | 1.3 – 6.5 | Application |
| Solar – Multiple Effect Humidification | 1 – 100 m$^3$/d | thermal: 100<br>electrical: 1.5 | 2.6 – 6.5 | R&D Application |
| Solar – Membrane Distillation | 0.15 – 10 m$^3$/d | thermal: 150 - 200 | 10.5 – 19.5 | R&D |
| Solar/CSP – Multiple Effect Distillation | > 5000 m$^3$/d | thermal: 60 – 70<br>electrical: 1.5 – 2 | 2.3 – 2.9<br>(possible cost) | R&D |
| Photovoltaic – Reverse Osmosis | < 100 m$^3$/d | electrical: BW:<br>0.5 – 1.5<br>SW: 4 – 5 | BW: 6.5 – 9.1<br>SW: 11.7 – 15.6 | R&D Application |
| Photovoltaic – Electrodialysis Reversed | < 100 m$^3$/d | electrical: only<br>BW : 3 – 4 | BW: 10.4 – 11.7 | R&D |
| Wind – Reversed Osmosis | 50 – 2000 m$^3$/d | electrical: BW:<br>0.5 – 1.5<br>SW : 4 – 5 | units under 100 m$^3$/d,<br>BW: 3.9 – 6.5<br>SW: 6.5 – 9.1<br>About 1,000 m$^3$/d,<br>2 – 5.2 | R&D Application |
| Wind – Mechanical Vapor Compression | < 100 m$^3$/d | electrical: only<br>SW : 11 – 14 | 5.2 – 7.8 | Basic Research |
| Wind – Electrodialysis | - | - | BW: 2.0 – 3.5 | - |
| Geothermal – Multi Effect Distillation | - | - | SW: 3.8 – 5.7 | - |

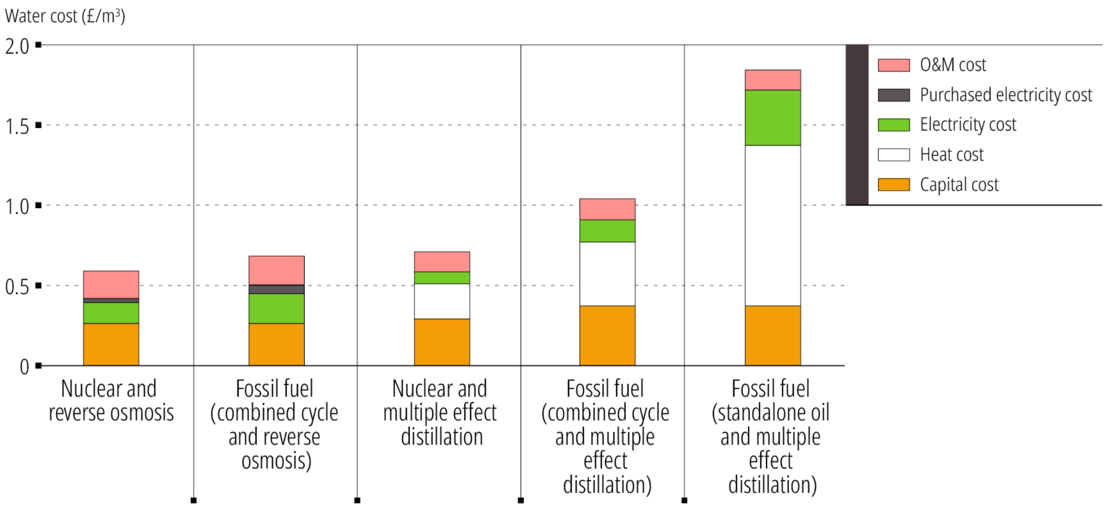
* The cost of fossil fuel desalination is ~USD 1.00 USD/m$^3$.
Note: BW = Brackish Water; SW = Sea Water.
Source: Adapted from IEA/IRENA (2012)

In December 2015, the "Global Clean Water Desalination Alliance – $H_2O$ minus $CO_2$ initiative was launched at the COP 21 climate talks in Paris “to seek solutions that will substantially reduce the projected increase in $CO_2$ emissions from the desalination process, as global demand for drinking water continues to grow” (WaterWorld, 2015). The call was part of the alliance's aim to tackle the water-energy nexus and climate change.

A French study for Tunisia compared four nuclear power options with combined cycle gas turbine and found that nuclear desalination costs were about half those of the gas plant for thermal technology and about one-third less for RO (Nisan et al., 2007). Also, the cost of water produced through nuclear desalination is less volatile than fossil fuel production as most of the cost is capital investment rather than dependent on fuel costs.

Using lifetime levelised unit costs to compare combinations of energy source and type of desalination plant, the Royal Society (2020) calculated that nuclear energy with RO technology is the cheapest option as can be seen in Figure 6 below.

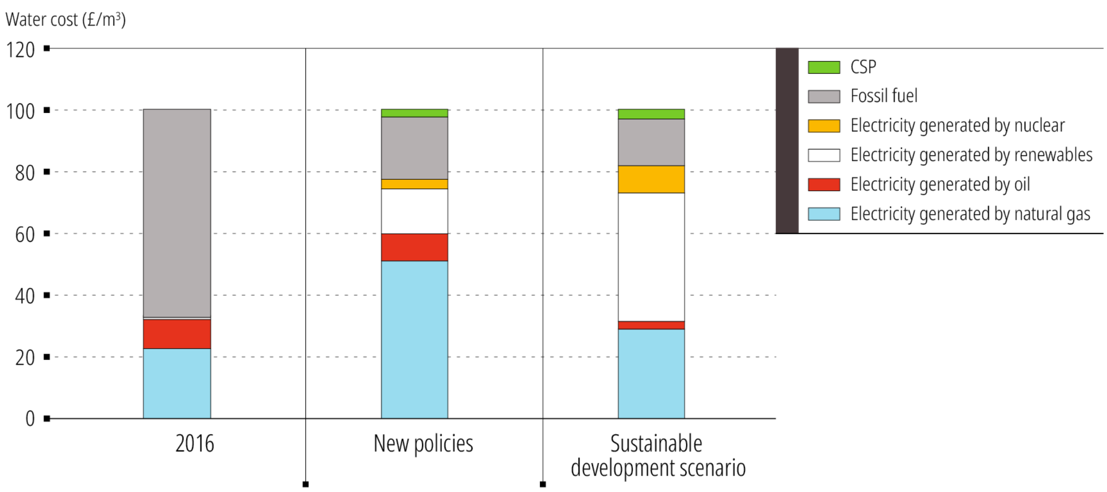
Figure 6: Cost of desalinated water by fuel and process




Source: Adapted from The Royal Society (2020).

In the IEA outlook to 2040 produced in 2019, "the production of desalinated seawater in the Middle East is projected to increase almost fourteen-fold to 2040, and there is a concerted shift towards membrane-based desalination in both IEA New Policies Scenario (NPS) and Sustainable Development scenarios (SDS)" (Walton, 2019), as can be seen in Figure 7 below. The IEA shows that the rapid phase-out of subsidies for fossil fuels in the SDS results in a higher share of water production from membrane-based and solar power desalination in 2040 than in the NPS. The policy choices taken in the SDS also lead to the deployment of more renewable and nuclear production, which account for over half of power generation by 2040. This shift not only reduces carbon dioxide emissions and local air pollutants, but also allows for more effective management of the region's energy and water needs.

Figure 7: Water production from seawater desalination in the Middle East by input fuel and scenario 2016-2040




Source: Adapted from Walton IEA Commentary (2019).

With over a fifth of the world estimated to not have access to fresh water and a shortfall predicted of over 2 000 billion m³/yr within the next five years, there is a growing need for methods that will cost effectively produce potable water, while also considering the production method and carbon emissions. As shown, nuclear energy offers a solution which is cost comparable to current fossil fuel production methods whilst not contributing to climate change.

| World Economic Forum | | SASB | |
|---|---|---|---|
| **Theme** | **Sub-theme** | **Topic** | **Metric** |
| Air pollution | Fine particle matter and impact on air pollution | Air quality | Air emissions of the following pollutants: 1) NOx (excluding N2O); 2) SOx; 3) particulate matter (PM10); 4) lead (Pb); and 5) mercury (Hg); percentage of each in or near areas of dense population. |
| Water pollution | Nutrients and impact on water pollution | | |

### *Pollution*

### *Air pollution and quality*

The impact of air pollution needs to be assessed across the supply chain. This should include nitrogen oxide, sulphur oxides, particulates, lead and mercury, as well as other air emissions. The reporting needs to provide a meaningful assessment of the impact of air pollution, or impact on air quality.

### *Fine particle matter and the impact on air pollution*

Air pollution from coal-fired power plants is linked with asthma, cancer, heart and lung ailments, neurological problems, acid rain, as well as climate change and other public health impacts. Many governments have been legislating for many decades to try to reduce pollution generally, including that from energy projects. Renewable energy plants and nuclear plants are recognised as plants that have much reduced the pollution across the supply chain.

In the "Life-Cycle Assessment of Electric Power Systems", the pollution from various power plants was assessed (Masanet et al., 2013). Their data can be found in the table below.

Table 14: Ranges of electric power technology emissions and resource-use factors (per unit generation)

| Environmental exchange | Coal | | Natural gas | | | |
|---|---|---|---|---|---|---|
| | **Hard coal** | **Lignite** | **Combined cycle** | **Steam turbine** | **Nuclear** | **Bioenergy** |
| $SO_2$ (mg/kWh) | 530-7 680 | 425-27 250 | 1-324 | ~0-5 830 | 11-157 | 40-940 |
| NOx (mg/kWh) | 540-4 230 | 790-2 130 | 100-1 400 | 340-1 020 | 9-240 | 290-820 |
| PM (mg/kWh) | 17-9 780 | 113-947 | 18-133 | ID | ~0-7 | 29-79 |

| Environmental exchange | Solar | | | Hydropower | | | |
|---|---|---|---|---|---|---|---|
| | **PV** | **Concentrated solar power** | **Geothermal** | **Reservoir** | **River** | **Ocean** | **Wind** |
| $SO_2$ (mg/kWh) | 73-540 | 35-48 | ~0-160 | 9-60 | 1-6 | 64-200 | 3-88 |
| NOx (mg/kWh) | 16-340 | 54-160 | ~0-50 | 3-13 | 4-6 | 49 | 10-75 |
| PM (mg/kWh) | 6-610 | 7-26 | 1.3-50 | 0.1-25 | | 15-36 | 1-14 |

Source: Adapted from Masanet et al. (2013).

As can be seen in the above table, nuclear and renewable projects have far fewer emissions than fossil fuels. Each different form of energy creates its own air pollution. For example, the manufacturing of cabling and the wind turbines for wind farms (particularly off-shore) produces air pollution (and water pollution).

According to the Hatch report (also see Table 15 below):

> The results of this process showed that GHG and NOx emissions from natural gas combined cycle (NGCC) generation greatly exceeded the wind and nuclear lifecycles […]. The variation in PM and SOx emissions by comparison are less pronounced […]. The lowest range of emissions corresponds to nuclear generation followed by wind and natural gas.
>
> SOx emissions from the wind and nuclear lifecycle exceed the emissions from NGCC and wind-NGCC generation. The construction and upstream fuel supply chain are the dominant sources of SOx emissions from wind and nuclear, respectively, and may be related to emissions from coal-derived electricity consumption or manufacture of intermediate products such as steel.
>
> The total emissions from the nuclear and wind power lifecycles were similar. Onshore wind power, on average, is a slightly more GHG efficient option than nuclear power over its lifecycle. The distribution of wind LCA data resides in the lower band of the range of nuclear power technologies considered. Of the nuclear power lifecycle, technologies that do not use diffusion-based enrichment produce similar emissions to onshore wind power. Average emissions of PM, SOx and NOx are comparable over the lifecycle of wind and nuclear power. No discernible difference in the statistical mean total lifecycle emissions of wind and nuclear power were observed. (Hatch, 2014)

Table 15: Statistical Mean Total Lifecycle Emissions for nuclear and on-shore wind

| Scenario | PM (g/kWh) | NOx (g/kWh) | SOx (g/kWh) |
|---|---|---|---|
| On-shore wind turbine | 0.015 ± 0.003 | 0.028 ± 0.003 | 0.025 ± 0.003 |
| Nuclear power plant | 0.008 ± 0.003 | 0.039 ± 0.006 | 0.023 ± 0.003 |

Source: Adapted from Hatch (2014).

### *Water pollution*

Companies need to report the impact of water pollution, including excess nutrients, heavy metals and other toxins as detailed below.

### *Nutrients and impact on water pollution*

Again, this need to be reported in a way that is accessible for the executives, the board and the investors. This should include as much information on the water impact across the supply chain, and not simply from the plant itself.

There is a unique connection between the use of water and the production of energy. Energy production across the supply chain creates water pollution. The impact of energy projects on water varies from technology to technology and from project to project.

A nuclear plant often discharge water used in the plant. This can result in minor increases in the temperature of the sea or other water source where the water is discharged. This has little long-term effects.

By contrast off-shore wind farms have an impact on water pollution, as well as on marine mammals and birds. An article in *Aquatic Biosystems* entitled “Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future” (Baily et al., 2014) looked at the potential effects of off-shore wind farm construction and operation, demonstrating that these effects differ from project to project and according to how the wind farm interacts with the species. Many studies have considered the effects on marine mammals and birds. The areas of concerns include: transportation of equipment to the site, pile driving, cable burial, as well as cable production and blade manufacturing impacts on water pollution and temperature. Environmental impacts include sound pollution, air pollution and water pollution. In addition, the alternating current (AC) or direct current (DC) cables also emit electromagnetic fields which may have an impact on species.

The EU report from the JRC (EU, 2021), *Technical Assessment on Nuclear Energy with respect to the ‘do no significant harm’ criteria of Regulation (EU) 2020/852 (‘Taxonomy Regulation’)*, considers water ecosystems and the damage caused by various energy technologies and reports:

> Water ecosystems are also damaged by toxic chemical releases, including heavy metals, volatile organic compounds (VOCs) and particles. Various ecotoxicity indicators have been used in

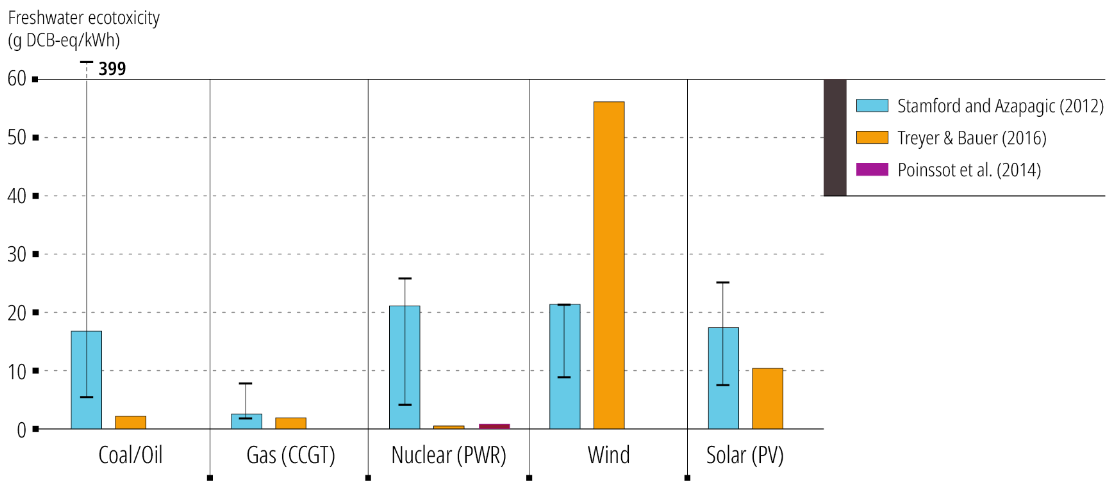
sustainability assessments to compare technologies in terms of the toxic damage potential of their lifecycle chemical emissions.

Freshwater aquatic ecotoxicity potential (FAETP) refers to the impact on fresh water ecosystems, as a result of emissions of toxic substances to air, water and soil. Marine ecotoxicity refers to impacts of toxic substances on marine ecosystems. Both indicators are expressed as grams 1,4-dichlorobenzene equivalents/kWh (g 1,4-DCB-eq/kWh).

Stamford & Azapagic […], as well as Treyer & Bauer […], compared both fresh water and marine ecotoxicity potentials of several electricity generating technologies. The results are provided in the figures below.

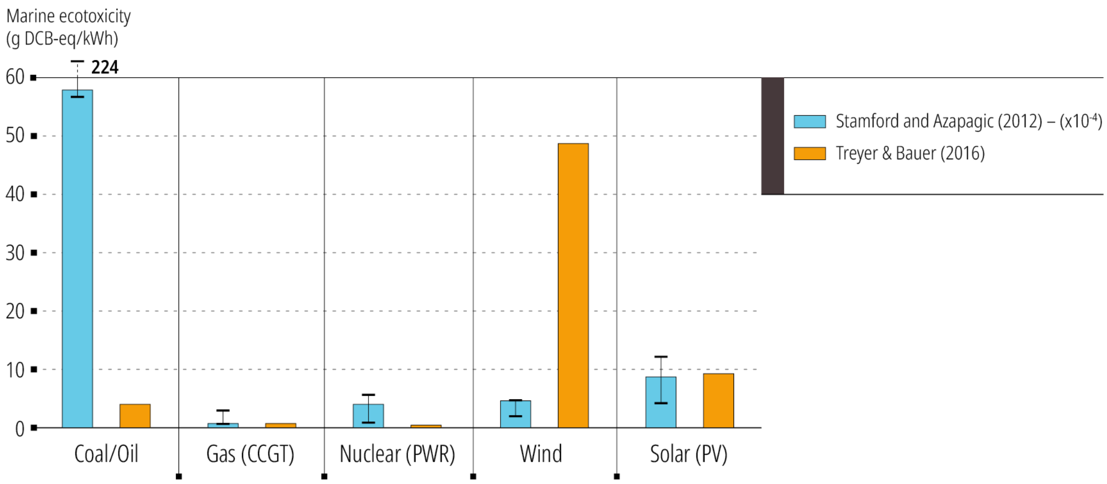
With regard to freshwater ecotoxicity, nuclear energy is again the best performer according to Treyer & Bauer, whereas the results of Stamford & Azapagic rank natural gas as best, with the other technologies fairly evenly matched, although nuclear has the potential to be comparable with gas according to the sensitivity studies. The data of Poinssot et al again compare very well with the data of Treyer & Bauer and the lower bound data of Stamford & Azapagic. Concerning nuclear, the bulk of the impact is due to metals such as vanadium, copper and beryllium coming from uranium mill tailings. Regarding marine ecotoxicity, nuclear is again ranked best (Treyer & Bauer – ReCiPe methodology) or second best (Stamford & Azapagic – CML methodology) along with natural gas. (EU, 2021)

Figure 8: Freshwater ecotoxicity potentials of various electricity generation technologies




Source: Adapted from EU (2021)

Figure 9: Marine ecotoxicity potentials of various electricity generation technologies




Source: Adapted from EU (2021)

As such, nuclear energy is one of the better energy technologies when reporting on the impacts of water pollution and water toxicity.

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Solid waste | Single use plastics |
| | Impact on solid waste disposal |

### *Waste*

Waste needs to be reported, mitigated and managed. The metrics for waste have not been standardised and need to apply across industries and consider the whole of the supply chain across the project lifecycle. The reporting of waste arising from companies and projects needs to be meaningful and inciteful, and the lack of reporting of waste from some companies should not be overlooked.

For a long time, waste has been seen as an issue for all energy projects. Waste needs to be reported but it is also key that it is mitigated and managed. This applies to plastic and all other waste arising from the plant. The metrics for reporting waste management have not been standardised and needs to apply across industries. As set out in depth below, the nuclear has accounted for and managed its waste for many years and will continue to do so. Lessons have been learnt through the management of waste arising from nuclear companies which can be applied across the energy sector and more widely.

### *Single use plastics*

Reporting on single use plastics is in its infancy and standardisation is key to a fair and balanced reporting. However, this should be extended to include not only single use plastics but all plastics to ensure that those that can be recycled are recycled and managed.

### *Solid waste*

The reporting of waste arising from companies and projects needs to be meaningful and inciteful, and the lack of reporting of waste from some companies should not be overlooked. The waste arising from the whole of the supply chain and across the lifecycle needs to be considered and not simply the waste arising from the energy plant itself. The impact, mitigation and management of all waste needs to be reported.

### *Radioactive waste*

Despite waste being an issue for the whole energy industry, more focus falls on waste arising from the nuclear industry. However, in response to this, the nuclear industry has developed the gold standard for reporting, mitigating and managing its waste. Lessons have been learnt through the management of waste arising from nuclear companies which should be applied across the energy sector and more widely.

Before assessing how energy projects deal with radioactive waste, radiation needs putting in context.

The Hatch report for the Canadian Nuclear Association sets out the radioactivity of some selected common materials (see Table 16 below).

Table 16: Radioactivity of selected materials

| Source | Radiation |
|---|---|
| 1 adult human (65 Bq/kg) | 4 500 Bq |
| 1 kg of coffee | 1 000 Bq |
| 1 kg of brazil nuts | 400 Bq |
| 1 banana | 15 Bq |
| The air in a 100 sq metre Australian home (radon) | 3 000 Bq |
| The air in many 100 sq metre European homes (radon) | Up to 30 000 Bq) |
| 1 household smoke detector (with americium) | 30 000 Bq |
| Radioisotope for medical diagnosis | 70 million Bq |
| Radioisotope source for medical therapy | 100 000 000 million Bq (100 TBq) |
| 1 kg 50-year-old vitrified high-level nuclear waste | 10 000 000 million Bq (10 TBq) |
| 1 luminous Exit sign (1970s) | 1 000 000 million Bq (1 TBq) |
| 1 kg uranium ore (Canadian, 15%) | 25 million Bq |
| 1 kg uranium ore (Australian, 0.3%) | 500 000 Bq |
| 1 kg low level radioactive waste | 1 million Bq |
| 1 kg of coal ash | 2 000 Bq |
| 1 kg of granite | 1 000 Bq |
| 1 kg of superphosphate fertilizer | 5 000 Bq |

Bq = becquerel; TBq = Terabecquerel.
Source: Hatch (2014).

As the EU report states:

The analyses did not reveal any science-based evidence that nuclear energy does more harm to human health or to the environment that other electricity production technologies …. Management of radioactive waste and its safe and secure disposal is a necessary step in the lifecycle of all applications of nuclear science and technology (nuclear energy, research, industry, education, medical, and other). Radioactive waste is therefore generated in practically every country, the largest contribution coming from the nuclear energy lifecycle in countries operating nuclear power plants. Presently, there is broad scientific and technical consensus that disposal of high-level, long-lived radioactive waste in deep geologic formations is, at the state of today's knowledge, considered as an appropriate and safe means of isolating it from the biosphere for very long time scales. (EU, 2021)

It further indicates that:

Measures to ensure that radioactive waste does not harm the public and the environment include a combination of technical solutions and an appropriate administrative, legal and regulatory framework. Although there remain contrasting views, it is generally acknowledged, that the necessary technologies for geological disposal are now available and can be deployed when public and political conditions are favourable. No long-term operational experience is presently available as technologies and solutions are still in demonstration and testing phase moving towards the first stage of operational implementation. Finland, Sweden and France are in an advanced stage of implementation of their national deep geological disposal facilities, which are expected to start operation within the present decade. The radiological impact of nuclear energy lifecycle activities, including radioactive waste management and disposal, is regulated by law in the Member States, setting the maximum allowed releases and radioactivity exposure to the professionally exposed groups, to the public and to the environment. Respecting these limits, establishing the boundaries below which no significant harm is caused to human life and to the environment, is a precondition for any nuclear lifecycle activity to be authorized and is subsequently monitored by independent authorities. (EU, 2021)

There are different categories of nuclear waste and the volumes of particularly high-level waste are significantly less than many appreciate. These are:

- Low-level (LLW) and very low-level waste (VLLW) – 90% of the volume of waste, but containing less than 0.0003% of total radioactivity:
  - LLW represents:
    - the majority of solid radioactive waste in the UK by volume;
    - the lowest activity category of radioactive waste;
    - generally made up of materials such as plastics, glass, metal, paper and soil that have become contaminated by contact with radioactive liquids or powders;
    - produced by hospitals, research establishments and the nuclear industry.
  - VLLW is a subset of the LLW category of radioactive waste, covering miscellaneous waste arising with very low concentrations of radioactivity.
  - The storage and disposal technology for dealing with LLW is well-established. Landfill sites often take LLW and VLLW as the waste does not need to be disposed of in specialist facilities. However, where there are large volumes of LLW it is super-compacted to reduce its volume and sent for disposal at the LLW repositories, where it is packaged and encapsulated in cement and large steel containers, and placed in an engineered vault a few metres below the surface.
- Intermediate-level waste (ILW):
  - Arises from the reprocessing of spent fuel (most), from general operations and maintenance at nuclear sites and from decommissioning; and
  - it can include metal items such as reactor components (e.g. reactor pressure vessel components), and sludges, filters and resins from the treatment of radioactive liquid effluents.
  - Legacy ILW is typically being managed through a process of encapsulation in cement and packaged in stainless steel drums or higher capacity steel or concrete boxes as soon as reasonably practicable and placed into interim storage. Geological disposal is the preferred option for management of ILW in the long term; preceded by safe and secure interim storage.
- High-level waste is sometimes referred to but it encompasses spent fuel and waste materials which arise should the spent fuel be reprocessed or recycled. This document has assumed that spent fuel will not be reprocessed and therefore high-level waste is not separately considered.

In addition to radioactive waste, there is spent fuel:

  - Spent fuel are the fuel assemblies that have been “burnt” in the nuclear reactor; and the number of fuel assemblies depends on the size and life of the plant.
  - Spent fuel is not categorised as waste, because it still contains uranium and plutonium which could potentially be separated through reprocessing and used to make new fuel (i.e. be an asset to the company.) The latest generation of nuclear power plants are designed to extract more energy from the fuel by leaving it in the reactor longer for increased irradiation, otherwise known as “burn-up”. This results in fewer spent fuel assemblies. However, the exact number will depend on the size and life of the plant.
  - The higher burn-up of the modern fuel means that an individual spent fuel assembly will have a higher heat output and external radiation compared with a fuel assembly currently discharged from nuclear reactors currently in use. The long-lived radionuclides remain thermally hotter and therefore require longer periods of cooling in interim storage. Interim storage of spent fuel can be carried out in a manner

which causes a very low level of health detriment, and considers below the arrangements for ensuring the safe and secure disposal of spent fuel from new nuclear power stations.

Spent fuel and waste also contain medical isotopes, including:

- Ac225, Ra223, Ac227 and Pb212 which are used for targeted alpha therapy. Currently production routes for these are typically by “milking” existing sources of nuclear material that would otherwise be considered as waste. Given their position in decay chains, wastes from nuclear fission can contain these isotopes (or their source isotopes);
- Y90, which is used for beta irradiation therapy. The production route is purification of Sr-90 from spent nuclear fuel for loading into a Sr90/Y90 generator;
- Xe-133, which is an established diagnostic and is the only approved tracer for imaging the distribution and rate of exchange of air in the lungs in the USA. Xe-133 is a product of U-235 fission.

There are many more isotopes of interest for therapy, diagnostics, or combination in the form of theragnostics, some of which could be obtained from existing material, and others that might use existing material that can be irradiated (reactor or accelerator) to produce the isotope of interest.

***Transportation***

Radioactive wastes are transported in accordance with International Atomic Energy Agency (IAEA) regulations, and in accordance with domestic and regional agreements and directives. The packaging requirements for material containing radionuclides are dependent upon the radionuclide specific activity of the material, its form (solid, liquid or gas) and the total quantity of activity in the consignment.

Spent fuel is transported in a shielded transport flask designed to reduce external dose rates to the low levels required by the transport regulations and to provide containment of the radioactive material, both during normal transport conditions and conditions representing transport accidents involving fire and impact. ILW packaging meets transport regulatory requirements in order to give confidence that these wastes can ultimately be transported. LLW transport methods are well-established by both road and rail. LLW is routinely transported in packages that are designed, certified and transported by industry as permitted in the transport legislation.

According to a recent report by the NEA (2020), there is a strong international scientific consensus that deep geological repositories (DGRs) are a safe and effective approach to the permanent disposal of high-level wastes and spent nuclear fuel. Countries are successfully selecting sites for DGRs using open and transparent activities that involve stakeholders as equal participants in the decision process. Several countries are implementing these demonstrations and have shared their experiences. The first DGR will likely be in Finland, with operations beginning around 2023.

The NEA published a statement in 2008 saying that “The overwhelming scientific consensus worldwide is that geological disposal is technically feasible”. (OECD, 2008)

The NEA further noted that “Releases from engineered barriers would occur over thousands of years after disposal and would be very small. Additionally, these releases are diluted and slowed by the geological formation surrounding the repository and are further reduced by radioactive decay. The resulting potential radiological exposure in the biosphere would not represent, at any time, a significant increment above the natural background.” (OECD, 2008)

In respect of external dose rate, the encapsulation, transport and emplacement of high burn-up spent fuel can be shown to be feasible using existing technology applied in the management of vitrified HLW. In particular, the relevant IAEA dose rate limits for transport can be met after interim storage by providing a combination of a 14 cm thick stainless steel gamma shield surrounded by a 5 cm thick neutron shield.

The 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) and the OSPAR Radioactive Substances Strategy both aim to reduce discharges into the marine environment of the North-East Atlantic region to levels where the additional concentrations above historic levels, resulting from such discharges, are close to zero.

It is important to note that while the objectives of the OSPAR Convention ultimately aim to reduce the concentrations in the marine environment, they do not prohibit the future development of the nuclear sector and the building of new reactors. OSPAR’s Radioactive Substances Strategy acknowledges the need to take account of what is achievable and focuses on the delivery of the Convention's objectives through the application and use of best available techniques (BAT) and best environmental practice (BEP).

***Funded Decommissioning and waste management***

In line with best practice, nuclear power plants have to plan and pre-fund decommissioning and waste management activities. Generally, the funding is accumulated over the early life of the power plant, and payments into the decommissioning and waste management fund can be the first payment out of the payment cascade (i.e. before debt service). However, the payment is so small that it should not be a concern for lenders.

The objective of the planning and funding regimes is to ensure that nuclear operators make prudent provision for the full costs of decommissioning installations and the full share of the costs of safely and securely managing and disposing of their waste, thereby reducing the risk of recourse to public funds is remote.

### *Non-radioactive waste*

Non-radioactive waste is produced from operating and maintaining power plants and includes laboratory chemicals and lubricating and fuel oils, which need safe management and disposal.

Hazardous waste is defined as waste with one or more properties that are hazardous to health or to the environment. Categories or generic types of hazardous waste, as well as the properties of hazardous waste, are listed in directories such as the European Commission's Hazardous Waste Directive.

The volumes produced by new nuclear power stations is small in relation to the total volumes of such waste produced generally. Amounts of non-radioactive hazardous waste arising from reactor construction and decommissioning are expected to be broadly equivalent to those arising from any major infrastructure or power construction or demolition project and amenable to the normal waste minimisation techniques.

The treatment and disposal of waste is regulated in order to ensure the protection of the environment and human health, and is dealt with in accordance with the regulations applicable to non-nuclear sites.

### *Other low-carbon technology waste*

Waste management from wind farms consists largely of waste associated with turbine and cable management. As wind farms go further off-shore, and as cables transition from AC cabling to high voltage direct current (HVDC) cabling (to reduce losses over longer distances) there will also be the waste associated with the converter stations. The precise level of the waste will depend on the individual farm and will take into account factors including the size of the turbine blades and the turbine type.

There is little published data on the volumes of waste arising from wind and solar farms as the waste is generally not managed and is simply sent to landfills. Also, as the wind and solar industries rarely prefund decommissioning and waste management, the costs associated with decommissioning and waste management are not readily available. Combining wind and solar farms with storage such as battery storage to produce a firn power solution increases the waste produced, and that needs to be managed and mitigated. There is increasing commentary and a significant number of studies emphasising the beneficial environmental impact if the wind sector started recycling materials across its lifecycle.

However, we are beginning to see greater reporting of waste arising from different energy sources. In 2018, Michael Shellenberger wrote an article for *Forbes* entitled: "*If Solar* Panels *are So Clean, Why Do They Produce So Much Toxic Waste*." The article highlighted the challenges which are being identified across the globe by environmental scientists around waste arising from solar panels and waste management (Shellenberger, 2018). Solar panels often contain a series of toxic chemicals including plastics, heavy metals including lead, cadmium and antimony.

There is a growing concern that cadmium can be washed out of solar modules by rainwater, increasing the concerns for the environmental community. The concerns include leaching during use if the panels are broken, and also during decommissioning. Panels containing cadmium are beginning to be classified as hazardous waste and should be dealt with as such. However, despite this, panels containing cadmium are still being sent to landfills in some countries. These chemicals mean that the glass cannot be reused as float glass. Equally, the glass cannot simply be disposed of in landfill sites as the toxic chemicals are likely to leach into the soil and the water table.

Some solar panels have been disposed of by selling them to other countries who are willing to manage the lower performance of second-hand panels. This allows the original plant not to have to deal with the panels as they create a secondary market, and thereby the panels become someone else's problem and less developed countries become, as Michael Shellenberger describes them, "primary e-waste destinations". The United Nations Environment Program is aware of these and similar issues. In 2015, they estimated that 60-90 % of electronic waste was illegally traded and dumped on poorer nations. ESG, particularly if they include the full lifecycle, should be highlighting on this illegal activity and helping to prevent and stop it.

In 2015 California's Department of Toxic Substance Control called an industry meeting to discuss the growing problem of solar waste. They determined that deciding whether waste was hazardous or not is more difficult at the end of life and that it would be better to create a database where the panels, and therefore the waste, is tracked.

Following California's analysis, creating a system of decommissioning and waste management at the start of life, as nuclear new build projects now do, could help to solve some of the problems arising with solar waste. History has shown the energy industry the problems of not prefunding and planning for decommissioning and waste management, with the historic liabilities and allocation of liabilities to operators that we witnessed in the oil and gas industry.

In 2012 First Solar established a waste management fund and offered clients access to their waste management solutions. Some parties have raised concerns that regulating waste management and waste management funds would make projects uneconomic. However, it would simply put solar projects on the same basis as nuclear projects, thereby allowing parties, including investors, to access projects on an equal footing.

The International Renewable Energy Agency (IRENA) estimated in 2016 that there was about 250 000 metric tonnes of solar panel waste in the world and projected that this amount could reach 78 million metric tonnes by 2050. In its report entitled *End of Life Management, Solar Photovoltaic Panels*, the waste from photovoltaic panels is estimated as:

> At the end of 2016, cumulative global PV waste streams are expected to have reached 43,500-250,000 metric tonnes. This is 0.1%-0.6% of the cumulative mass of all installed panels (4 million metric tonnes). Meanwhile, PV waste streams are bound to only increase further. Given an average panel lifetime of 30 years, large amounts of annual waste are anticipated by the early 2030s. These are equivalent to 4% of installed PV panels in that year, with waste amounts by the 2050s (5.5-6 million tonnes) almost matching the mass contained in new installations (6.7 million tonnes). (IEA/IRENA, 2016)

The report continues to look at how solar panel waste should be mitigated and managed, and many of the suggestions are on a par with how nuclear waste is managed Further details on solar waste can be found in the links provided in the footnote below.[20]

Waste is not just a concern of solar and nuclear. Wind and battery farms also have their fair share of waste that needs to be managed and mitigated. In August 2019, the *Wall Street Journal* wrote on the challenges facing the renewables industry: "*If You Want 'Renewable Energy,' Get Ready to Dig - Building one wind turbine requires 900 tons of steel, 2,500 tons of concrete and 45 tons of plastic"* (Mills, 2019). The waste arising from the wind industry was also highlighted by *Bloomberg* in February 2020 in an article entitled "*Wind Turbine Blades Can't be Recycled, So They're Piling Up in Landfills"* (Martin, 2020).

What is clear is that the nuclear industry leads the way in waste management and decommissioning and waste funding. Other low-carbon technologies need to follow suit and make sure they manage and mitigate their waste. ESG reporting should help facilitate a consistent assessment.

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Resource availability | Resource circularity |

***Resource availability***

The resources required for any energy project are significant. The circularity metric for the company and its supply chain needs to be considered. According to the WEF, The Ellen MacArthur Foundation has developed the circularity transition indicators

20. See also: www.nytimes/com/2021/01/08/business/economy/china-solar-companies-forced-labor-xinjiang.html; and www.scmp.com/news/china/society/article/2104162/chinas-ageing-solar-panels-are-going-be-big-environmental-problem.

metrics to cover resource management (Ellen MacArthur Foundation, n.d.). Again, these need to be standardised across all energy projects.

In the long term, nuclear power is dependent upon the uranium resources or other special nuclear material being available.

According to *Uranium 2020: Resources, Production and Demand* (NEA/IAEA, 2020), "identified recoverable uranium resources, including reasonably assured resources and inferred resources at a cost <USD 260/kgU (equivalent to USD 100/lb $U_3O_8$) are sufficient for over 135 years, considering uranium requirements as of 2019. Exploitation of the entire conventional resource of about 15.3 MtU based on current demand would increase this to over 250 years. The conventional resources include reasonably assured, inferred, prognosticated and speculative resources but exclude secondary sources or potential unconventional resources, such as uranium from phosphate rocks or the vast amounts at low concentration in sea-water".

With fast-spectrum reactors operated in a "closed" fuel cycle by reprocessing the used nuclear fuel and recycling uranium and plutonium, the reserves of natural uranium may be extended to several thousand years. Therefore, the main resource of nuclear power is not seen as a concern.

The 2018 IPCC states:

> In the long term, the potential of nuclear power is dependent upon the uranium resources available. Reserve estimates of the uranium resource vary with assumptions for its use […]. Used in typical light-water reactors (LWR) the identified resources of 4.7 Mt uranium, at prices up to 130 US$/kg, correspond to about 2400 EJ of primary energy and should be sufficient for about 100 years' supply […] at the 2004 level of consumption. The total conventional proven (identified) and probable (yet undiscovered) uranium resources are about 14.8 Mt (7400 EJ). There are also unconventional uranium resources such as those contained in phosphate minerals, which are recoverable for between 60 and 100 US$/kg […]. If used in present reactor designs with a 'once-through' fuel cycle, only a small percentage of the energy content is utilized from the fissile isotope U-235 (0.7% in natural uranium). Uranium reserves would last only a few hundred years at current rate of consumption […]. With fast-spectrum reactors operated in a 'closed' fuel cycle by reprocessing the spent fuel and extracting the unused uranium and plutonium produced, the reserves of natural uranium may be extended to several thousand years at current consumption levels. In the recycle option, fast-spectrum reactors utilize depleted uranium and only plutonium is recycled so that the uranium-resource efficiency is increased by a factor of 30 […]. Thereby the estimated enhanced resource availability of total conventional uranium resources corresponds to about 220,000 EJ primary energy […]. Even if the nuclear industry expands significantly, sufficient fuel is available for centuries. If advanced breeder reactors could be designed in the future to efficiently utilize recycled or depleted uranium and all actinides, then the resource utilization efficiency would be further improved by an additional factor of eight […]. Nuclear fuels could also be based on thorium with proven and probable resources being about 4.5 Mt […]. Thorium-based fast-spectrum reactors appear capable of at least doubling the effective resource base, but the technology remains to be developed to ascertain its commercial feasibility […]. There are not yet sufficient commercial incentives for thorium-based reactors except perhaps in India. The thorium fuel cycle is claimed to be more proliferation-resistant than other fuel cycles since it produces fissionable U-233 instead of fissionable plutonium, and, as a by-product, U-232 that has a daughter nuclide emitting high-energy photons." (IPCC, 2018)

The WNA indicates in their website that: "The world's present measured resources of uranium (6.1 Mt) in the cost category less than three times present spot prices and used only in conventional reactors, are enough to last for about 90 years."

The use of natural resources is not only a concern for nuclear and uranium. It is clear that companies and projects need to report on all resources used. The US Report also highlights material requirements of various technologies (but again not all), as seen in Table 17 below.

Table 17: Range of material requirements (fuel excluded) for various electricity generation technologies

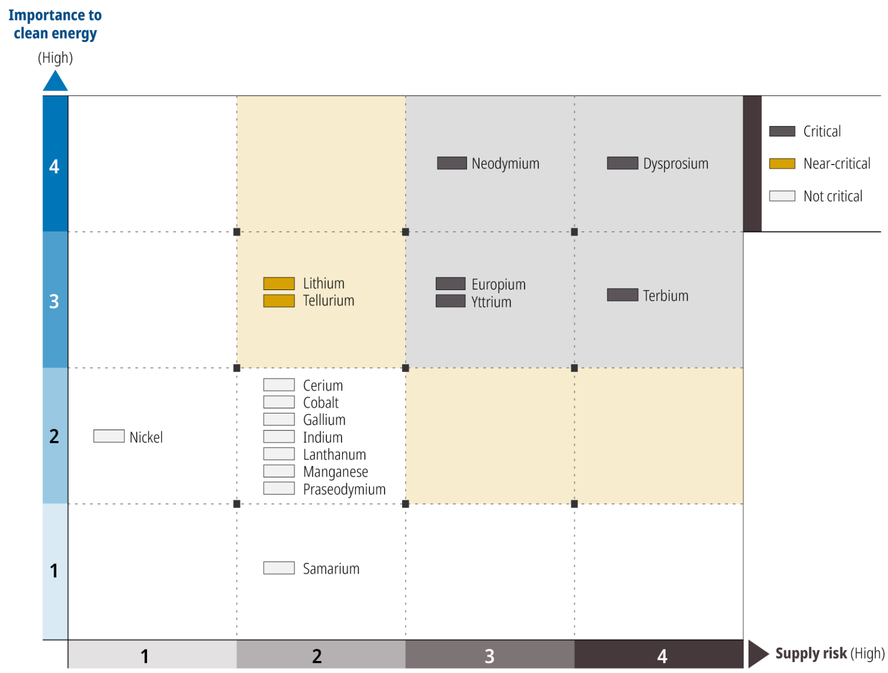
| Materials (tonne/TWh) | Generator only | | | | | Upstream energy collection plus generator | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coal | NGCC | Nuclear PWR | Biomass | | Hydro | Wind | Solar PV (silicon) | Geothermal HT binary |
| Aluminium | 3 | 1 | 0 | 6 | | 0 | 35 | 680 | 100 |
| Cement | 0 | 0 | 0 | 0 | | 0 | 0 | 3 700 | 750 |
| Concrete | 870 | 400 | 760 | 760 | | 14 000 | 8 000 | 350 | 1 100 |
| Copper | 1 | 0 | 3 | 0 | | 1 | 23 | 850 | 2 |
| Glass | 0 | 1 | 0 | 0 | | 0 | 92 | 2 700 | 0 |
| Iron | 1 | 1 | 5 | 4 | | 0 | 120 | 0 | 9 |
| Lead | 0 | 0 | 2 | 0 | | 0 | 0 | 0 | 0 |
| Plastic | 0 | 0 | 0 | 0 | | 0 | 190 | 210 | 0 |
| Silicon | 0 | 0 | 0 | 0 | | 0 | 0 | 57 | 0 |
| Steel | 310 | 170 | 160 | 310 | | 67 | 1 800 | 7 900 | 3 300 |

Note: NGCC = natural gas combined cycle; PWR pressurized water reactor; PV = photovoltaic; HT = high temperature.
Source: US Department of Energy (2015)

The US Report clearly does not cover all resources. Rare earth metals, cobalt, lithium and wood are materials which are not considered *The Economist* magazine ran an article in January 2021 raising concerns about balsa wood production for wind projects: "*A Worrying Windfall. The Wind-Power Boom Set off a Scramble for Balsa Wood for Turbines' Blades – with Unintended Consequences*" (2019). The list is endless but what is key is that full reporting is required.

The US report also identifies critical materials in the medium term (2105-2025), as shown in Figure 10.

Figure 10: Critical materials in the medium term (2015-2025)




Source: Adapted from the US Department of Energy (2012)

Some of these materials are controversial, and it is important in reporting to ensure that these materials are ethically sourced in an environmentally friendly way and fully reported.

## People: SDGs 1, 3, 4, 5 and 10

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Dignity and equality | Diversity and inclusion |
| | Pay equality and pay Gaps |
| | Wage level |
| | Human rights review, grievance impact and modern slavery |
| | Risk of incidents of child, forced or compulsory labour |
| | Discrimination and harassment incidents and monetary losses |
| | Freedom of association and collective bargaining |
| | Living wage |

### *Dignity and equality*

### *Diversity and inclusion*

Equality across the workforce and providing dignity to employees is a key metric for any modern business. Equity, dignity and inclusion irrespective of age, sex, gender, disability, race, ethnicity, origin, religion is key to good management and governance. Diversity of gender and culture as well as diversity of thought is key to performance. The WEF recognises that: "*Gender and ethnic/cultural diversity particularly within executive teams are closely correlated to both financial and non-financial performance and enhance stability of companies across the globe.*"

Diversity of thought, gender and culture attracts the best people to an organisation, including at the executive level, and provides the best environment for company growth and cohesion. The benefits of diversity, equality and dignity have been well documented. A 2019 book entitled *Rebel Ideas: The Power of Diverse Thinking* by Matthew Syed bring together many of the benefits of diversity of culture and thought to organisations.[21]

All energy companies and projects need to work on improvements in diversity, equality and inclusion. The nuclear sector has shown developments in gender equality but there is still more to do. The renewable sector has again shown progress but has more work to do. Also, the Nuclear Skills Strategy Group in the UK has joined forces with Women in Nuclear to ensure that the entire sector embraces diversity, and to build the business case for both diversity of people and thought. Further details can be found on their Commitment Page[22] and also in the *Nuclear Sector Gender Roadmap: A journey to a diverse and inclusive sector*.[23.]

The on-going safe operation of nuclear stations continue to support highly paid skilled jobs, as the station provides employment to local labour, which is required to meet local salary and wage compensation, and thereby support the local communities.

### *Pay equality, pay gaps and wage level*

Corporate policies, processes and governance should support equal basic pay and remuneration for all categories of employees. They help to promote equality across cultural, gender and backgrounds. They are shown to attract talent and to drive long-term competitiveness across companies and projects. Well-developed processes and procedures should maximise professional opportunities regardless of background, gender or culture. However, having well developed processes and procedures should not be the only metric required. How the processes and procedures are implemented and managed is also key to diversity and inclusion. This can include systems to mitigate unconscious bias.

Wage levels and benefits should be assessed across the company to determine a fair distribution across the workforce. Fair compensation and benefits contribute to the economic well-being of individuals, as they help with the socio-economic development of regions and countries. Too wide a gap between the pay of those at the top of an organisation and those at the bottom can highlight inequality across the workforce. Disclosure and transparency of wage and benefits has not been encouraged by various cultures but has been shown to be key to equality and development.

21. See: www.matthewsyed.co.uk/resource/rebel-ideas-the-power-of-diverse-thinking/.
22. See: www.nssguk.com/gender-commitment/diversity/.
23. See: www.nssguk.com/media/2017/nssg-win-sector-gender-roadmap_web.pdf.

A corporate's processes and procedures should also identify any pay gaps in the organisation to highlight unrepresented and disadvantaged groups. Pay gap analysis should identify inequality of pay, with an obligation on the executive to monitor these areas to ensure that minorities are not disadvantaged. The UK Government Equalities Office and the UK Chartered Institute of Personnel and Development have well established methodologies for undertaking a pay gap analysis.

Energy companies and projects should have well managed policies and procedures on pay and remuneration. The energy sector wants to attract people who can develop the industry and deliver high quality and high performing projects and companies.[24.] While due diligence on the company will identify any pay inequality and pay gaps, the energy industry, and particularly the nuclear industry, is well placed in relation to this metric. Energy companies want to attract the brightest and the best, and to do this they need to be awarding competitive salaries. As the Nuclear Energy Institute (NEI) states:

> The nuclear energy industry creates lasting, high-paying jobs for people from a wide range of fields and educational backgrounds. Recruiting from universities, community colleges, the military and the trades, nuclear power plants provide high-quality jobs to the whole community […]. Nuclear worker salaries are 20 percent higher on average than those of other electricity generation sources. The typical nuclear power plant creates $40 million in labor income each year. For every 100 nuclear power plant jobs, 66 more jobs are created in the local community. Nearly one in four nuclear workers are veterans. (NEI, 2021)

### *Human rights reviews, grievance impact and modern slavery and risks of incidents of child, forced or compulsory labour*

Without proper checks and balances, a company's activities could facilitate human rights abuses and other social and environmental abuses. Without mechanisms for employees and stakeholders to report potential abuses companies might miss the opportunities to identify, mitigate and manage activities. Reporting the number of operations that have been subject to human rights reviews both within the company and across the lifecycle and supply chain is of key importance to organisations. Companies should also report any grievances raised and the type of grievances together with the number of operations and suppliers considered to be at risk of human rights abuses.

Companies need to ensure that there are no risks of incidents of child, forced or compulsory labour across their supply chains. An explanation of labour practices across the whole supply chain need to be disclosed by the executive and the board, and reported on. The elimination of child labour, forced labour and human trafficking requires companies to be open and transparent and to assess their supply chain ethics. Only through openness and transparency by businesses and financial institutions will these unethical practices be eradicated.

The nuclear industry undertakes a considerable number of checks into the safety and security of its employees and contractors. Employees and many contractors need to be security cleared to allow them to work on the plant. Considerable checks are undertaken into both individuals and their companies. However, there is more that can be done on the wider supply chain and lifecycle of a nuclear plant.

In July 2019, the *Financial Times* published an article called "*Congo, child labour and your electric car*", raising concerns about child labour and the mining of cobalt for electric cars (Sanderson, 2019). This followed an article by Amnesty International called: "*Exposed: Child labour behind smart phone and electric car batteries*" (Amnesty International, 2016). In December 2019, a US court case was brought against Apple and Google (among others) over deaths related to Congolese child cobalt mining (Kelly, 2019). It is thus essential that mining practices are verified as part of the supply chain for a number of energy projects. Mining practices thus need to be diligenced as part of the supply chain for a number of energy projects.

In January 2021, the *New York Times* raised concerns about some solar companies in China using forced labour (Swanson, 2021). Investors, when considering ESG and investing in projects, need to undertake full lifecycle assessments to ensure that forced labour is not being used in the supply chain and that companies are fully reporting on all activities.

24. Further details on this subject can be found in *Global Reporting Standards (GRI)405* at www.globalreporting.org/standards/media/1020/gri-405-diversity-and-equal-opportunity-2016.pdf.

### *Discrimination and harassment incidents, and monetary losses*

Organisations need to be built on a culture of respect, courtesy and professionalism. Without this foundation, employees and organisations will be unable to grow and develop. Incidents of discrimination and harassment need to be reported and dealt with fairly and transparently, but without causing more distress to those subjected to the discrimination or harassment. Companies need to record and disclose any incidents and to try to eradicate the behaviours. In addition, companies need to report the monetary losses, including those due to legal proceedings or claims relating to such behaviours. Ideally, this should be broken down to identify the basis for the proceedings or claims and to highlight any failings within the organisations which have allowed such behaviours to grow.

Much will depend on the culture and reporting within an individual company. However, the energy industry as a whole and the nuclear industry in certain countries, are doing significant work to try to eradicate discrimination and harassment in all forms.

### *Freedom of association and collective bargaining*

Organisations should disclose the percentage of the workforce that is covered by collective bargaining agreements and should assess its supply chain to ensure they allow for freedom of associations and collective bargaining. These metrics and processes are seen to respect the rights of workers and human rights. It is important that companies promote these rights across their own workforce and through their supply chains.

The Unions in the UK energy industry have strong connections with both the workforce and with industry generally. Prospect alone represents over 14 000 individuals across the energy supply chain. Thousands of Unison members in the UK also work in the energy sector. In Canada, collective bargaining is established by law and highly regulated. There are two main unions who represent approximately 23 000 people across the electricity sector. The two unions are the Power Workers Union and the Society of United Professionals.

### *Living wage*

Companies should assess their wages not only internally but against the living wage in their country, and also as required to increase the socio-economic development of a region and a country. Levelling up to address disparities across regions is important to the creation of balanced societies and to deal with discrimination across areas. The living wage is a benchmark for responsible employers. However, because of energy's wider role in socio-economic development, all energy projects should be treating the living wage as the lowest denominator for any assessment.

Companies should regularly benchmark their wages to ensure that they are reflective of the market. The energy industry as a whole often pays a premium to attract the brightest and the best to the industry, and this is particularly true of the nuclear industry.

According to a report prepared by Oxford Economics (2019) and called *Nuclear Power Pays: Assessing the Trends in Electric Power Generation Employment and Wages*, the nuclear power generation industry employed nearly 48 400 workers in the US paying an average salary of USD 136 600. This exceeded average regional wages across the country and placed nuclear power as the highest paying industry in the electric power generation sector.

| World Economic Forum | | SASB | |
|---|---|---|---|
| **Theme** | **Sub-theme** | **Topic** | **Metric** |
| Health and well-being | Health and safety | Workforce health and safety | 1) Total recordable incident rate (TRIR); 2) fatality rate; and 3) near miss frequency rate (NMFR) |
| | Monetised impacts of work-related incidents on employees, employers and society | | |
| | Well-being | | |
| | | Nuclear safety and emergency management | Total number of nuclear power units, broken down by US Nuclear Regulatory Commission (NRC) Action Matrix Column |
| | | | Description of efforts to manage nuclear safety and emergency preparedness |

### *Health, safety and well-being*

There is a growing recognition that the well-being of employees is vital to successful businesses. Well-being extends to having a healthy work-life balance. Well-being is key to performance, productivity and success and contributes to a high performing organisation with employees who are socially integrated.

Maintaining strong standards of health and safety and wellbeing can improve productivity and operational efficiency across companies. Effective management of health and safety requires companies to understand the risks their work presents to employees, contractors and other third parties as well as to members of the public. In many countries this is enshrined in law. Countries have regulatory bodies; for example, in the US the Occupational Safety and Health Administration (OSHA) and the Health and Safety Executive in the UK provide guidance on effective ways of managing risks to health and safety for employers, employee representative groups and employees. On occasions when health and safety is not effectively managed, these bodies also have powers to enforce companies to improve health and safety, including, where necessary, through prosecution.

The wellbeing of employees and contractors is becoming more of a focal point as the importance of mental health and work-life-balance becomes more important.

### *Health and safety*

Employers should strive to create and maintain a safe workplace for their employees. Workplace safety should be a high priority for the board and the executive (and ultimately the shareholders) in all types of workplaces and industries. Safety is the responsibility of everyone in a company, with the board and the executive setting the policies and leading by example, but responsibility for safety lies with everyone working in the company. Companies are obligated to provide a safe working environment for their employees. Regardless of the type of work they perform, whether it's pouring concrete to repair heavily trafficked roads or pouring over accounts in the finance department, employees should never be in a position where their physical safety is in jeopardy.

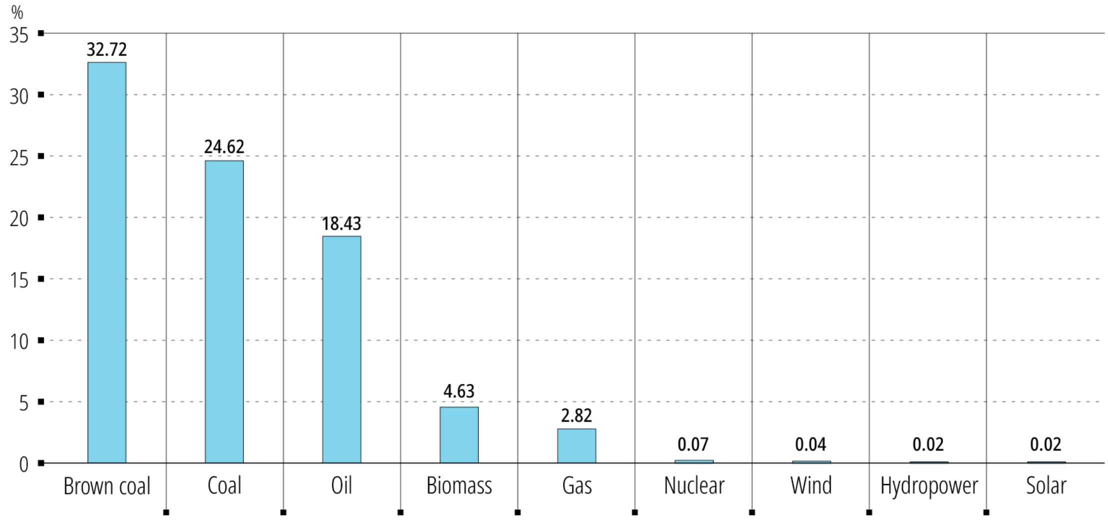
At its heart, workplace safety is the concept that employers must control recognised hazards in the workplace. This doesn't mean that a place of employment is completely free of all hazards, but rather that the risk associated with the hazards is reduced to an acceptable (or, reasonably practicable) level. Safety hazards can come from many sources, but the common ones are slips and trips, working from height, working in confined spaces, electricity, fire, and explosions, working with machinery and pressure systems.

Effective safety management requires open and transparent communication. Employees should feel empowered to raise any concerns they have and work with the company to develop and maintain practical and effective processes, procedures and controls to manage the risk.

In Europe and the UK there is a downward trend of workplace fatal injuries. The UK consistently has one of the lowest rates of fatalities. In the year 2019 to 2020, 111 workers were nonetheless killed at work.[25]

Death rates were considered by Our World in Data for various energy technologies. Nuclear is shown to be comparable with renewables, as shown in the Figure 11 below.

Figure 11: Death rates from energy production per TWh*




*Death rates are measured based on deaths from accidents and air-pollution perTWh
Source: Our World in Data

The health of employees is vital to the productivity and success of a company. Health includes both physical and mental health. In the year 2019 to 2020, 1.6 million working people in Great Britain suffered from a work-related illness and 38.8 million working days were lost due to work-related illness and workplace injury. These figures illustrate the impact on companies of health-related issues in the workplace.

The hazards and risks associated with occupational health are often harder to identify and therefore effectively control. However, occupational health issues such as cancer consistently account for many fatalities given their long latency. Health hazards can come from many sources, but the common ones are exposure to hazardous substances, manual handling and repetitive strain, noise, vibration, and exposure to chemicals, pollutants and radiation. Stress is also a key contributor to workplace absenteeism. Stress affects people differently and many external factors can contribute to stress in the workplace.

Energy companies generally operate to the highest health and safety standards. As Energy UK states on its website: "Maintaining Health and Safety standards across all activities is critical to the industry. From our generators through to our suppliers, our members are committed to the highest standards of health and safety. Whether through monitoring trends, developing best practice or guidance on regulation or legislation implementation, we work with members to ensure the energy industry's workforce is safe and healthy at work" (Energy UK, 2019).

Nuclear regulation is a mix of international and national laws. The International Atomic Energy Agency (IAEA) works to provide a strong, sustainable, and visible global nuclear safety and security framework for the protection of people, society, and the environment. This framework provides for the harmonized development and application of safety and security standards, guidelines, and requirements; but it does not have the mandate to enforce the application of safety standards within a country.

25. See more health and safety statistics at the UK Parliament, House of Commons Library website: https://commonslibrary.parliament.uk/research-briefings/sn04936/.

The EU cooperates with non-EU countries and international organisations on nuclear safety and in 2013, the European Commission signed a Memorandum of Understanding with the IAEA to further strengthen the cooperation through expert peer reviews, emergency preparedness and response, and other measures.

In 2014, Euratom amended the Community framework for the nuclear safety of nuclear installations directive, which requires EU countries to give the highest priority to nuclear safety at all stages of the lifecycle of a nuclear power plant through independent national regulatory authorities, peer reviews and re-evaluation for all nuclear power plants to be conducted at least once every ten years.

A key attribute of the nuclear sector is behavioural safety which is developed within individuals through training and observing others over many years such that good practice becomes the norm within staff and a subconscious level of high safety is implemented, rather than something that needs to be actively reinforced and seen as a “chore”. The World Association of Nuclear Operators (WANO) have also developed their principles of a healthy nuclear safety culture.

The system of radiation protection that is used across Europe and worldwide is based on the recommendations of the International Commission for Radiation Protection (ICRP) and the International Commission on Radiation Units and Measurements (ICRU). The ICRP system of radiation protection is based on three fundamental principles: justification, optimisation, and dose limitation.

The UK government issued the “Nuclear Emergency Planning and Response guidance”, which describes the UK response framework and associated capabilities that may be required in the event of a radiation emergency. The document discusses the importance of knowledge of radiation and its effects, and the importance of effective communication in a radiation emergency. In 2017, the UK government ran a consultation on revised requirements for radiological protection, which included a range of stakeholders from local authorities and industry to members of the public, professional bodies, and emergency services. In October 2018, the UK government responded to this by making a commitment to take steps to build on already robust radiological emergency preparedness and committed to implementing several enhancements.

As in other counties, regulation in the United States is robust. For example, the U.S. Nuclear Regulatory Commission (NRC) requires all nuclear plants to be able to withstand the most severe natural phenomena historically reported in a 200-mile area around each plant. All nuclear energy facilities in the United States are required to develop and test detailed emergency response plans to protect the public. The NRC reviews and approves these plans and also coordinates approval of these plans with the Federal Emergency Management Agency (FEMA). State and local agencies develop detailed plans for the population within the 10-mile emergency planning zone. Zones out to 50 miles are geared toward protecting public health along with monitoring and protecting the food supply. Nuclear facilities are also responsible for sampling water, milk, soil and crops within 50 miles of a plant (Exelon, 2020).

Whether international or national, best practice around health and safety is key to the energy industry as a whole. In the nuclear industry, there is one health and safety concern which attracts more than its fair share of focus – radiological health and safety. Nuclear companies go to extreme lengths to protect both employees and wider stakeholders, including the general public from exposure to ionising radiation.

Often communication in this area focusses on the management of incidents and the emergency response to accidents. However, any company involved in nuclear activities – whether that be power companies, medical companies (e.g. hospitals and radiological medical facilities) and even airlines – operate and maintain open and transparent processes and procedures to manage and mitigate exposure to radiation.

The release of radioactivity into the environment could occur through the planned release of gaseous and liquid discharges, through to an unplanned release of radioactive waste or as the result of an accident or terrorist incident. Public Health England, which regularly reviews the radiation exposure of the UK population, has calculated that the overall average annual dose to a member of the public from all sources of radioactivity is 2.7 millisieverts (a measure of dose and abbreviated as mSv) per year. Of this dose, about 84% is from natural sources, including cosmic radiation entering the earth’s atmosphere from space, and radiation from the radioactive materials that occur naturally in soils and rocks, about 16% from medical procedures such as X-ray equipment and about 0.2% from all other sources, including domestic smoke detectors and nuclear power plants.

Through its focus on health and safety, and particularly protecting all parties from exposure to ionising radiation, the nuclear power sector has become a leader in health and safety regimes. A 2002 review by the International Energy Agency (IEA) on the environmental and health impacts of electricity generation compared fatalities per unit of power produced for several leading energy sources. Nuclear companies’ processes and procedures such as open reporting, peer observation, independent verification, learning from experience and action tracking/resolution are key to sustaining a vigorous health and safety culture. The IEA examined the lifecycle of each fuel from extraction to post-use and included deaths from accidents as well as long-term exposure to emissions or radiation. Nuclear was reported to have the lowest impact of health, with coal having the highest impact on health. The low rates of conventional health and safety incidents in the nuclear sector are often attributed to the translation of nuclear, radiological safety principles being applied to general health and safety practice on site. In other words, the culture, systems and processes in place to facilitate effective nuclear, radiological safety are the same as those applied to general health, safety and environment.

The potential effects from radiation on the general public are constantly monitored. The Committee on Medical Aspects of Radiation in the Environment (COMARE) has, since 1986, investigated the incidence of childhood cancer and other cancers around nuclear sites. Its view is that "there is no evidence from this very large study that living within 25 km of a nuclear generating site in Britain is associated with an increased risk of childhood cancer". (UK Government, 2011)

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)[26] has been publishing reports on exposure to radiation from the whole nuclear fuel cycle since the 1970s. UNSCEAR's finding is that the dose rate to members of the public from uranium mining is low and would be imperceptible from variations of the normal background dose rate from natural sources.

UNSCEAR's finding is that:

> The average annual effective doses to workers in the nuclear fuel cycle are, in most cases, larger than the doses to those in other occupations; for the fuel cycle overall, the average annual effective dose is about 1.75 mSv. For the mining of uranium, the average annual effective dose to monitored workers in countries reporting data was about 4.5 mSv [for the most recent period considered (1990-1994)], and for uranium milling operations, it was about 3.3 mSv. There are, however, very wide variations about these average values, with doses of about 50 mSv being reported in some countries.

UNSCEAR's finding summarises detailed evidence presented in the report. From this evidence it is clear that these high doses are exceptional. In only one country and period (uranium mining in Gabon in the period 1985-1989) is the average annual effective dose to workers recorded as being over 20 mSv, at 21.0 mSv. In all other countries the average annual effective dose to workers is consistently below 20 mSv – and in most cases well below – and in most countries, including Gabon, the trend over the periods covered (from 1975-1979 to 1990- 1994) is downwards.

Across the world, therefore, UNSCEAR reported the exposure of employees to radiation for uranium mining and milling as, with some exceptions, well below the recommended ICRP annual limit applied in the UK of 20 mSv.

In August 2010, UNSCEAR published the first volume of its 2008 report entitled *Sources of Ionizing Radiation*, which includes, as Annex B, further consideration of "Exposures of the public and workers from various sources of radiation". (UNSCEAR, 2008)

The Organisation for Economic Co-operation and Development (OECD) conducted a study in 2000. Although its purpose was to compare options for the management of spent fuel, this involved looking at the radiation exposure caused by uranium mining. The study found that the dose levels to employees, although higher than for other stages in the nuclear fuel cycle, remained at levels similar to the averages reported by UNSCEAR, and therefore well below the recommended ICRP annual limit of 20 mSv. The study also found that doses to members of the public were "low compared to the pertinent regulatory limits, and also insignificantly low compared with exposures from natural background radiation". (OECD, 2000)

UNSCEAR looked at the average annual effective doses to workers in the nuclear fuel cycle and concluded that the average annual effective dose is about 1.75 mSv. For the mining of uranium, the average annual effective dose to monitored workers in countries reporting data was about 4.5 mSv, and for uranium milling operations, it was about 3.3 mSv. There are, however, very wide variations about these average values, with doses of about 50 mSv being reported in some countries. UNSCEAR reported the exposure of employees to radiation for uranium mining and milling as, with some exceptions, well below the recommended annual limit of 20 mSv.

In August 2010, UNSCEAR published its findings demonstrating that average annual effective doses have declined further since their previous report.

26. For more information on UNSCEAR announcements and reports, see at www.unscear.org/.

Average annual doses in uranium mining were down from:

- 4.5 mSv in 1990-1994; to
- 3.9 mSv in 1995-1999; and
- 1.9 mSv in 2000-2002.

For uranium milling, average annual doses were down from

- 3.3 mSv in 1990-1994; to
- 1.6 mSv in 1995-1999; and
- 1.1 mSv in 2000-2002.

The findings of these studies are therefore that the radiation exposure caused by uranium mining is high compared with other stages of the fuel cycle but in the vast majority of cases it is low in terms of impact on employee and members of the public and well below regulatory dose limits.

The Medical Exposure Directive (MED) deals with the health protection of individuals against the dangers of ionising radiation in relation to medical exposure. This is the main legal instrument dealing with the protection of patients undergoing diagnostic and therapeutic procedures which utilise ionising radiation. The MED aims at eliminating the practice of unnecessary medical exposures, and to this end, the principle of justification is central to the Directive. The scope of the Directive includes not only patients, but also other individuals exposed either directly or indirectly. This includes those exposed in occupational health surveillance, health screening, research, and medico-legal procedures. Passenger security scanning using ionising radiation is not addressed explicitly in the current text.

### *Well-being*

Well-being is associated with numerous health, job, family, and economically related benefits. Again, as an example, poor mental health costs UK employers up to £45 billion a year, this is a rise of 16% since 2016 - an extra £6 billion a year[27]. Higher levels of well-being are associated with decreased risk of disease, illness, and injury; better immune functioning; speedier recovery; and increased longevity. Individuals with high levels of well-being are more productive at work and are more likely to contribute to their community.[28]

"Mental health problems and stress can affect anyone, regardless of their position in the business. Therefore, physical and mental well-being should be made a high priority in the workplace. Worryingly though, for many, this is not the case. In the UK 84% of managers acknowledge their responsibility in helping with employee mental health, but only 24% have any training in the area. Yet promoting wellbeing in the workplace can strengthen employee engagement, reduce the likelihood of poor mental health, and improve team happiness." (Murphy, 2020)

According to the American Institute of Stress (2019), "US companies lose up to $300 billion yearly as a result of workplace stress and only 43% of US employees think their employers care about their work-life balance". It is also reported that "83% of US workers suffer from work-related stress and over a quarter of employees are at risk of burning out in the next 12 months". Canadian companies lose an estimated $16.6 billion in productivity per year due to workers calling in sick, as a result of mental health issues a trend that many expect to increase in severity, as more workers are reporting higher levels of stress and other mental health concerns. One in four workers has left their job due to work-related stress, according to a 2017 Monster Canada study.[29] Similar statistics are available for other countries, where the well-being of staff is a key challenge and is reported to be getting worse.

While initiatives in this area are generally not legal requirements, companies can gain increased productivity and impact positively on employee's health through activities, and promoting well-being in the workplace can strengthen employee engagement with a positive impact on health and safety management.

27. See "Poor mental health costs UK employers up to £45 billion a year", Deloitte at www2.deloitte.com/uk/en/pages/press-releases/articles/poor-mental-health-costs-uk-employers-up-to-pound-45-billion-a-year.html
28. www.cdc.gov/hrqol/wellbeing.htm.
29. www.mercer.ca/en/our-thinking/how-much-are-you-losing-to-absenteeism.html.

These initiatives often form part of a company's social and corporate responsibility efforts. Mental health awareness, together with medical and healthcare services, helps to demonstrate a company's commitment to these important issues.

Clear communication linked to processes of how workers access medical and health-care services are also important metrics.

In the OECD study *How's Life? 2020 Measuring Well-being,* 11 dimensions of well-being are examined, including income and wealth, work and job quality, housing, health, knowledge and skills, environment quality, subjective well-being, safety, work-life balance, social connections and civil engagement. While this study reported increases in well-being since 2010, many people are stating they feel more disconnected and 7% of people in OECD countries report very low life satisfaction and two thirds of people in OECD countries continue to be exposed to dangerous levels of air pollution. (OECD, 2020)

Studies benchmarking and measuring well-being across sectors are not commonplace, as the *Corporate Wellness Magazine* discusses in its article "Benchmarking Wellness Programs: How Does Your Program Measure Up?". According to this article:

> The search for benchmarks is a fluid process. The scientific literature is helpful in establishing benchmarks from visionary employers who have used sophisticated design, development, marketing, communication, implementation, and evaluation strategies to apply leading programs. The information to be obtained from the published literature is not typical though, because there is little incentive to publish poor results. To help others evaluate their wellness programs, we encourage you to make your findings public. As employers increasingly disseminate and discuss their findings, the knowledge required to improve program outcomes will grow for everyone, and the health and productivity of the U.S. workforce will improve along the way. (Musich et al., n.d.)

When looking specifically at the nuclear industry, while wellbeing is taken extremely seriously, finding impartial evidence to back this up is not easy. It is often integrated into wider health and safety policies.

### *Nuclear safety and emergency management*

The WEF did not identify this as a metric, presumably because it is seen to be very specific to nuclear companies and projects. However, the global nuclear industry is amongst the industries with the highest levels of health and safety and emergency management as demonstrated above. Other energy companies could learn from the nuclear industry in this regard. Standardisation of these highest levels across the energy, and other sectors, should be encouraged and developed.

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Skills for the Future | Training |
| | Number of unfilled skilled positions |
| | Monetized impacts of training – increasing earning capacity as a result of training intervention |

### *Skills for the future*

Skills improve a company's future, and a wide and diverse range of skills are key to the success of a company. Training and skills also help to improve careers prospects and to improve human capital. When companies fail to invest in training and skills it can result in a detrimental effect on a company's performance. Training and development also enhance a company's ability to attract and retain talent, which in turn helps the company to grow. Training needs to cover a wide range of hard and soft skills, which can help with an individual's development.

Reporting should include: types of training and topics, paid educational leave, training or education pursued externally and reskilling of employees. Providing information on the investment in training is also important.

The nuclear industry experienced a hiatus in building new power plants and bringing new people into the industry. Over a decade ago, skills for the future were recognised as a concern for the industry and considerable work has been undertaken to attract new people to the industry and to support future projects and companies. In the UK, the Nuclear Skills Strategy Group[30] (NSSG) was established:

- to bring together major employers, government, regulators and trades unions to address the sector's skills challenge;
- to ensure we can meet the demand for 100,000 skilled jobs needed in the UK – both skills for nuclear and nuclear skills;
- to build a more diverse workforce – including 40% female representation by 2030 (up from 22%);
- to grow our Subject Matter Experts, to replace those retiring and to ensure we lead innovation in new technology;
- to improve the mobility of skilled people, both within our sector and from other sectors; and
- to attract young people into the nuclear sector, increasing visibility in schools of careers in nuclear.

The NSSG has undertaken a review of the industry to assess the nuclear workforce. Its findings can be found in the report entitled *Nuclear Workforce Assessment* (2021). Similar activities have been undertaken in other countries. Some counties, such as China, have continued to build and to develop skols for the future through their nuclear new build programme.

### *Number of unfilled skilled positions*

The rise in technology and development of companies' processes and procedures has resulted in skills gaps. It is vital that companies identify those skills gaps and seek to fill them. This is crucial not only at an individual company basis but also across industries, region and countries. If the socio-economic development of a region is to be undertaken, a long-term strategy for filling skills gaps should be considered as training to fil future skills gaps begins in schools.

Companies should report on the number of unfilled skills positions, and on their strategies to hire and train candidates for these positions.

### *Training and monetized impacts of training*

Training and innovation can have a direct impact on a company's performance and long-term value, as well as on employees' satisfaction. Companies should report on the investments made in training as a percentage of payroll and should analyse the effects of training and reskilling on the business.[31.]

30. www.nssguk.com/.
31. The WEF recommends the Kirkpatrick Model, which evaluates four levels of training (Reaction – Learning – Behaviour – Results), each successive level representing a more precise measure of the effectiveness of a training program.

## Prosperity: SDGs 1, 8, 9 and 10

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Wealth creation and employment | Number of jobs created |
| | Economic contribution |
| | Financial investment contribution |
| | Infrastructure investment and services supported |
| | Significant indirect economic impacts |

### *Wealth creation and employment*

These metrics are intended to consider the wider socio-economic development activities of the company and the company's impact on wider societal development. This is intended to be a more holistic approach than what has recently been used by companies to consider their social impact.

Assessment of the wider socio-economic impacts of a particular activity typically considers the following:

- direct effects – the economic value created by the activity itself;
- indirect effects – the economic value created by supply chain that is needed to serve the activity itself;
- induced effects – the impact on the wider economy by employees.

Government bodies conduct extensive analysis for their country or region of the interlinkages between different activities within the overall economy. Multipliers are produced to capture the effects of a company's activities on society. Multipliers can be either Type I or Type II. Type I multipliers capture the increment in economic value linked to indirect effects, but not induced effects. Type II multipliers capture the increment in economic value linked to indirect effects and induced effects.

Countries measure GVA in different ways. Standardised reporting would be helpful and could include:

- Employment Multipliers (direct and indirect jobs)
- Employment Effects – the effect of employment on the wider region/ country.
- Income (or Compensation of Employees) Multipliers and Effects – the effect of employment on wider income and compensation for employees.
- GVA multipliers – a ration of direct and indirect jobs and multipliers to calculate the change to the economy as a whole.
- GVA effects – changes to the wider economy from the final use.

Companies need to report on the specific GVA effects from their company and/or project.

### *Number of jobs created*

This metric wants companies to consider the jobs created during a defined period. For an established company that may be year in year, and for a capital project that may be by phase of the project. Job creation is viewed as a key indicator of economic growth, and when taken together with remuneration and other processes and procedures it provides an indication of the ability of a company to attract talent. It is evidence of prosperity as it captures the ability of the company to support employment and growth in the region.

Energy new build projects always create direct new jobs. However, different levels of new jobs are created through different phases. An analysis by the WNA (2020) shows that for a given installed capacity, nuclear power would generate more than three times more jobs that wind power.

In 2019, a Deloitte study (Foratom, 2019) found that for every euro spent in the nuclear industry, EUR 5 in the EU economy and EUR 3.6 of disposable income to the European households are generated, and every direct job created in the nuclear industry creates an additional 3.2 jobs in the EU economy as a whole. In the United States each dollar spent by an average nuclear power plant during one year of operation is estimated to trigger an additional USD 1.04 of output in the regional economy, USD 1.18 in the state and USD 1.87 at the national economy level (NEI, 2014).

With a global nuclear fleet of about 400 GW today, nuclear energy generates about 1.2 million direct and indirect jobs, or an average of 3 000 jobs/GW (NEA, 2020b). These jobs are long-term, highly educated, high-skilled employment with premium wages that result in significant spill-over investment into the local and regional economy. For example, the Hinkley Point C project in the United Kingdom will result in 25 000 employment opportunities, including over 1 000 apprenticeships during the construction phase, and 900 permanent jobs onsite during the 60-year life of the plant. UK companies will deliver about 64% of the construction contracts, and the project will contribute to the local economy GBP 1.5 billion during construction, and about GBP 40 million a year during operation. In contrast, 39% of all renewable energy jobs are in China (IRENA, 2019).

The Canadian Nuclear Association 2019 report on the "Benefits of Nuclear Energy for Canadians" states:

> The many Canadian organizations that make up the nuclear industry create high quality jobs and bring income to our Canadian communities. This study has assessed the number of jobs created and the impact on Canada's GDP with the following results:
>
> - The total number of jobs created across Canada is 76,000
> - The total impact to the Canadian GDP is $17 Billion per year
> - The medical isotope industry with all its benefits to the health of Canadians creates 8,500 jobs
> - …The impact on Canada's economy in terms of GDP is $17 Billion per year. (MZ Consulting, 2019)

### *Economic contribution*

This metric requires the consideration of direct economic value generated and distributed on an accruals basis, covering the basic components: revenue, operating costs, wages and benefits, payments to investors/debt and equity service, payments to government and community investment. It also takes into consideration any financial assistance received from government.

This is intended to provide a basic indication of how a company has created wealth for stakeholders. It provides an overview of the direct monetary value the company has created. This includes taxes paid to governments and therefore into the wider economy.

### *Financial investment contribution*

Capital expenditure (CapEx) is of particular relevance to capital projects. However, it is also relevant to established companies that are looking to grow and expand. This metric considers the CapEx minus depreciation as an indication of the company's overall investment strategy. In addition, the metric asks to consider the payback to shareholders by considering share buybacks and dividends.

Investment and payback are key indicators of a company's growth strategy and its ability to expand its operations and to create additional employment. Also, wealth creation from investment activities can be evidenced through the CapEx versus shareholder distributions.

### *Infrastructure investment*

The extent of any infrastructure investment and the services supported through it are an exceptional indication of growth. For a special purpose vehicle (SPV) established for a new infrastructure development, this is the main focus for the company. However, for an established company new capital projects are evidence of growth. Any infrastructure development has an impact on the local communities and therefore the socio-economic development of those communities. In kind and pro bono activities should not be discounted as they also have a wider benefit. This evidences a company's capital and other contribution to the wider economy.

### *Services supported significant indirect economic impacts*

Positive and negative impact on the wider economy need to be considered. The significance of the indirect economic impact should be considered in light of national and international benchmarks. Socio-economic growth or decline needs to be considered to consider the wider and long-term impacts on society.

| SASB | |
|---|---|
| **Topic** | **Metric** |
| Energy affordability | Average retail electricity rate for: 1) residential; 2) commercial; and 3) industrial customers |
| | Typical monthly electric bill for residential customers for: 1) 500 kWh; and 2) 1 000 kWh of electricity delivered per month. |
| | Number of residential customer electric disconnections for non-payment, and the percentage reconnected within 30 days. |
| | Discussion of impact of external factors on customer affordability of electricity, including the economic conditions of the service territory. |
| End-use efficiency and demand | Percentage of electric utility revenues from rate structures that 1) are decoupled; and 2) contain a lost revenue adjustment mechanism. |
| | Percentage of electric load served by smart grid technology. |
| | Customer electricity savings from efficiency measures by market. |
| Grid resiliency | Number of incidents of non-compliance with physical and/or cybersecurity standards or regulations. |
| | 1) System Average Interruption Duration Index (SAIDI); 2) System Average Interruption Frequency Index (SAIFI); and 3) Customer Average Interruption Duration Index (CAIDI), inclusive of major event days. |

### *Energy affordability*

SDG 7 provides for access to affordable, reliable, sustainable and modern energy for all. Access to affordable, reliable and clean energy is crucial for achieving sustainable development goals, from eradicating poverty through to advancing health and education, facilitating industrial development and reducing greenhouse gas emissions. Since 1992 energy's role in meeting all of the SDGs has been identified, however that energy needs to be affordable and reliable to allow people access to other resources including schools, clean water and healthcare.

Low-carbon energy – wind, solar and nuclear – can provide the energy to ultimately achieve high living standards, good health, a clean environment and a sustainable economy. Nuclear, wind and solar are also vital to countries abilities to meet their NDCs and Net-Zero commitments. Nuclear and renewables need to work together to provide system solutions.

### *Energy pricing – energy rates, typical bills, disconnections*

One of the challenges as the world moves to decarbonised energy is the need to reconsider the basis for pricing energy – as with many aspects of modern life – to include the consequences of previously ignored externalities – in this case the previously unpriced consequences of $CO_2$ pollution. Energy pricing and taxation varies significantly around the world with approaches varying on the extent of inclusion of sales tax or VAT, the extent to which time-of-day pricing passes on some elements of production price variability (itself derived from a manufactured wholesale market mechanism) and even the extent to which costs are fully passed on or covered by wider taxation systems. The net effect of this has been to disguise the true costs of energy in some cases and some early attempts at behavioural economics have rendered energy pricing a socially inconsistent tool.

Part of this has been a consequence of the different approaches to charging for energy usage to businesses and individuals with intricate market models, not always at the service of citizens. A simple example of this is where energy regulators' supervision of monopolistic elements of the energy system is predicated on reducing the cost to consumers over a short period of time when compared to asset lives. Others examples include systems such as that in Texas where the instantaneous energy price from an auction process is passed on directly to consumers, resulting in households being charged rates of up to USD 9/kWh in the cold snap of February 2021 – compared to the more normal USD 0.12/kWh – and consumers facing bills of USD 6 000 to heat normal-sized homes for a few days (Meyer et al., 2021).

As energy systems are entirely redesigned, and in many countries the entire primary energy provision is replaced, socially equitable pricing debates will return and the role of a "market" will increasingly become questioned. Historically, markets have set the price for energy and changes to the pricing were slow, with a focus by markets on bringing down the costs of energy. Over that period, the changes were generally slow enough and small enough to avoid wholesale problems with stranded assets, which the drive to Net Zero is already creating.

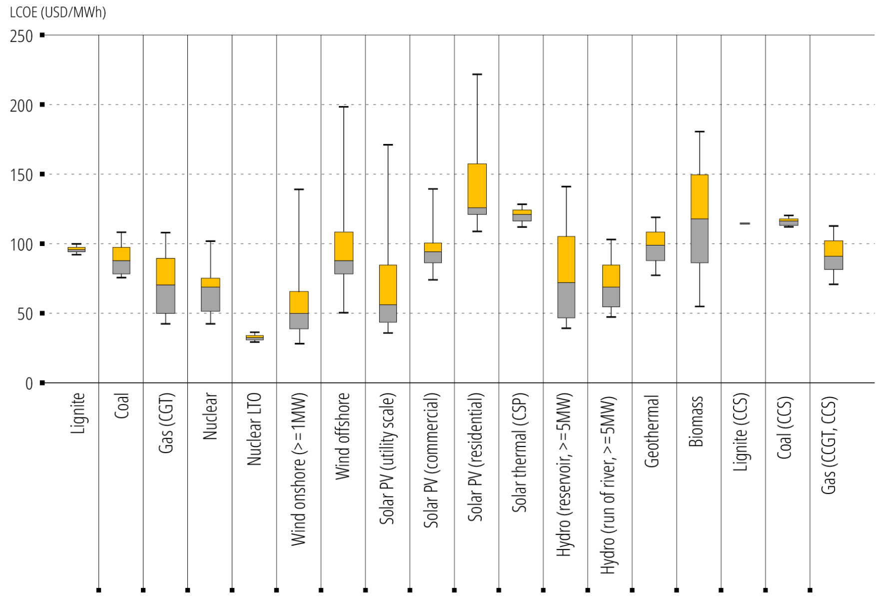
The challenge for most countries as they replace their entire primary energy creation systems will be one of the sheer speed needed to achieve Net Zero, and as a consequence there will not be time for a near-perfect cost optimisation. Equally, the risk of stranded assets will increase. So the question will have to be asked about the role of markets and indeed where many of the low-carbon electricity generation technologies are near zero marginal cost, there will be a question to be answered about what exactly ***is*** the role of a market in these circumstances. What is the objective of the market? How do markets deal with the complexities of consumer action "behind the meter" which can add to system-level complexity? To what extent can and will consumers react in a meaningful way to behavioural pricing signals in a world where, for the developed economies, energy is now seen as much as an individual right as clean water?

This could lead to more regulated energy markets, but where the regulatory control period is much longer. It could also lead to different approaches to so-called "Energy Poverty" which is a political construct that could perhaps be more fairly dealt with as an issue of welfare failure. The rapid pace and scale of change that achieving Net Zero will entail gives a perfect opportunity to revisit the entire basis for energy pricing. It is not impossible that the variety of responses to this may create fundamental differences in national economic competitiveness for the second half of the 20$^{th}$ Century, as well as further shifts in employment opportunities. An extreme example of the way energy pricing drives behaviour in the internet world is the movement in the physical location of Bitcoin mining where, given the huge energy costs of the technology as the number of bitcoins increases, has dominated the economics of the cryptocurrency for some years. The bulk of bitcoin mining now happens in China (65% at the time of writing) as a result of the relatively low energy costs with 35% of the total bitcoin mining happening in Xinjiang province. The rise in bitcoin mining malware affecting corporate systems is the other response to high energy needs – to steal the electricity from others.

According to the latest NEA/IEA study on the *Projected Costs of Generating Electricity* – 2020 Edition, nuclear is the dispatchable low carbon technology with the lowest costs. Only large hydro reservoirs can provide a similar contribution at comparable costs but are constrained by geography. Electricity produced from nuclear long-term operations (LTO) is highly competitive and is not only the least cost option for low-carbon generation – when compared to building new power plants – but for all power generation across the board if carbon costs of USD 30 per tonne of $CO_2$ are taken into account for the emissions generated by coal and gas-fired power plants (IEA/NEA, 2020).

Energy generation costs from nuclear differ significantly between existing reactors and those being constructed (or planned). Figure 13 shows that existing nuclear reactors globally (Nuclear Long Term Operation or LTO) produce electricity cheaper than all other forms of electricity generation (IEA/NEA, 2020). This provides a benchmark which new nuclear should target.

Figure 13: Electricity costs by technology




Source: Adapted from IEA/NEA (2020)

### *End-use efficiency and demand*

First, there is the modern comparison of access to energy in developed countries as being as much of a human right as the right of access to virtually limitless supplies of clean water. Driving significant changes in demand through conventional pricing signals increasingly looks to be hard where it relies on human interaction. It currently seems more likely that more sophisticated "behind the meter" use of internet of things (IoT) technology and smartness built into some appliances may provide some route forward. However, there are still likely to be limits to this sort of market behaviour in developed countries for the really large energy use – heat and air conditioning. Both are examples of energy use where the limits to markets for many families, other than those in more deprived circumstances, will be constrained and there is a material risk that behavioural economics approaches could result in unintended discriminatory consequences for the wrong parts of society. While a tough drive on energy efficiency in the design and manufacture of energy-consuming appliances will become ever more necessary, and while the rapidly increasing recognition of the need to hit Net Zero amongst the younger segment of society grows, there is a school of thought that "*demand side response is a polite phrase for supply side failure*".

There are bigger issues in end-use efficiency which will have to be taken into account in energy systems redesign. In many countries, a very significant amount of energy is delivered to end users – whether domestically or industrially – down large gas pipes. If that transportation mechanism cannot be re-purposed – e.g. by converting to deliver about three times the volume of hydrogen – there will have to be radical changes in the transportation of primary energy. In the extreme case for countries such as the UK, Japan and many in Europe where natural gas is currently a large vector, failure to repurpose the gas system will probably require a complete rebuild of the electricity distribution system. There is currently no social licence for this nor are citizens and industry remotely prepared for the large physical changes which would result.

The one point which has to be borne in mind throughout the drive to Net Zero is that the biggest challenges will not be the need for new technology. They will be the practicalities of the necessary physical change – whether building new sources of low-carbon primary energy or its transportation to end users. This pace and scale of change which society will need to welcome – or at least tolerate – is not something for which current generations are prepared.

### *Grid resilience*

There are two major contexts in which to consider the resilience of electricity grids – overall capacity factors and frequency stability.

Frequency stability is a critical issue for electrical grids – not because of the impact on timekeeping as is often assumed, but because of the safety consequences of even quite small but sudden shifts in frequency on end users. Sudden shifts in frequency can, and does, damage or destroy electrical equipment from distribution assets to electric motors, whether in industrial settings or in homes – such as washing machines, dishwashers and fridges. Frequency itself is not constant across a grid but is dependent on the relationship between supply and demand – as the demand approaches the limits of what's possible to supply, frequency drops and when generating equipment or connections fail, the drops in frequency can be profound and damaging. To provide protection against this, grid operators have a variety of tools at their disposal including standby conventional generation assets, batteries and invertors for quick response and ultimately demand side response and load shedding (i.e. disconnection of users). The more that generation suffers from intermittency, the more the grid needs additional protection against that intermittency. While grids have evolved to deal with a host of potential problems historically, the addition of inherently intermittent supply has inevitably complicated frequency stability. At lower levels of intermittent supply penetration, grids can and do adapt well but there comes a point where the economics of "Band-Aid" solutions becomes unacceptable and, at a national level, uncompetitive. As decarbonisation gathers pace, for most countries it will mean the replacement of much – and in some cases such as the UK and Japan – all of the primary energy production. At that point, anything less than a full and proper system (re)design[32] will be both economically and practically sub-optimal. The reliance on Darwinian evolutionary market-led solutions to smaller pace and scale of changes to a country's electrical system is extremely unlikely to provide a good answer for most countries and states cannot avoid ensuring that redesign is done in the national interest.

Capacity factors are a related issue. While sudden relatively small shifts in frequency can damage a range of equipment, to protect against that the ultimate measure is major curtailment of grid power which not only has a major impact on the lives of the customers but bringing a grid back from a major shutdown is both a complex and slow procedure – as the problems in Texas in February 2021 showed all too well. Amongst other challenges, part of what has emerged from that event was the consequences of the local energy regulator – ERCOT – in maintaining total independence from US Federal Standards including those of resilience. To quote the Washington Post, the failure of the system was "… *a financial structure for power generation that offers no incentives to power plant operators to prepare for winter. In the name of deregulation and free markets, critics say, Texas has created an electric grid that puts an emphasis on cheap prices over reliable service*." (Englund, 2021). The short-term impact of the collapse of the electricity system saw the wholesale price of electricity in Houston go from USD 22 a megawatt-hour to about USD 9 000. Meanwhile, 4 million Texas households were without power and 57 deaths have been attributed to that failure, the majority from hypothermia. An academic commentator Edward Hirs, an energy fellow at the University of Houston, said the disinvestment in electricity production in Texas reminded him of the last years of the Soviet Union or of the oil sector today in Venezuela. Modern societies now rely on uninterrupted supplies of energy whether to protect from extremes of weather as populations move to less habitable areas, or as populations move to mega-cities where the dependence on energy for survival increases markedly from older community structures in smaller towns and village. Modern societies also rely on uninterrupted supplies of energy for an increasingly data-driven world. The adaptation of communities to the changed nature of work and day-to-day existence in response to the COVID-19 pandemic has further exaggerated dependence on the energy system.

This again returns to the issue of the need for a proper system design for the electricity grid to ensure resilience for citizens and that there is proper accountability for the creation of that system design but then for its operation and maintenance.

There is also, of course, those communities for whom grid connections are unfeasible and just as they have gone from no telecommunications straight to mobile telephony and wireless internet access, electrification for the first time, or the decarbonisation of existing electricity supplies will be a different challenge. Cases such as remote communities in Canada where local generation is currently provided by diesel generation (in some cases with fuel supplies actually flown in) are but one example. The drive to provide low-carbon energy to the developing world is also a critical challenge and, in a world where, with low cost of capital, nuclear power can be competitive with the

32. See the National Engineering Policy Centre and Royal Academy of Engineering brochure: "Net Zero: A systems perspective on the climate challenge" at https://bit.ly/3rsMoyc.

cost of renewable power, leadership on a global scale is essential to avoid the developing world relying on fossil power as their route to increasing economic prosperity.

Nuclear power plants are a clear example of resilient facilities. The resilience of nuclear energy is the result of the combination of high levels of safety, operational flexibility and continuous learning from previous major events. By design, and beyond design, nuclear power plants are conceived following the principles of defence-in-depth: prevention, protection and mitigation (IAEA, 2016).[33] This results in the implementation of redundant, independent and diversified safeguards designed to withstand external hazards. From an organizational perspective, nuclear facilities also incorporate emergency and contingency plans to rapidly identify critical activities and maintain normal operations with limited personnel.

Confronted with major disruptions in the past, the nuclear sector has been required to adapt profoundly, while always continuing to provide a stable supply of low carbon electricity. Current nuclear systems and operations have been refined according to an evolving regulatory environment seeking the highest level of safety and reliability is the most diverse situations, including extreme weather events like those caused by climate change. The resulting nuclear governance models incorporate procedures and approaches that allow the continuous assessment of ongoing practices, the application of corrective measures and the integration of the latest knowledge available.

At the system level, a resilient low-carbon infrastructure requires a balanced and diversified power mix. Different technologies have different complementary roles in low-carbon electricity systems. Flexible power provision by plants that are dispatchable upon demand makes nuclear power an indispensable complement to wind and solar production in countries without large amounts of hydropower capacity. Furthermore, it also supports electric grid stability by providing valuable inertia, reactive capacity and voltage control to the system. Additional operational resilience can be obtained with strategic fuel stockpiles. One of the main advantages of nuclear power is the easiness of securing energy-dense uranium fuel for several years of operation.

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Innovation in better products and services | R&D spending ratio |
| | Social value generated and vitality index |

### *Innovation in better products and services*

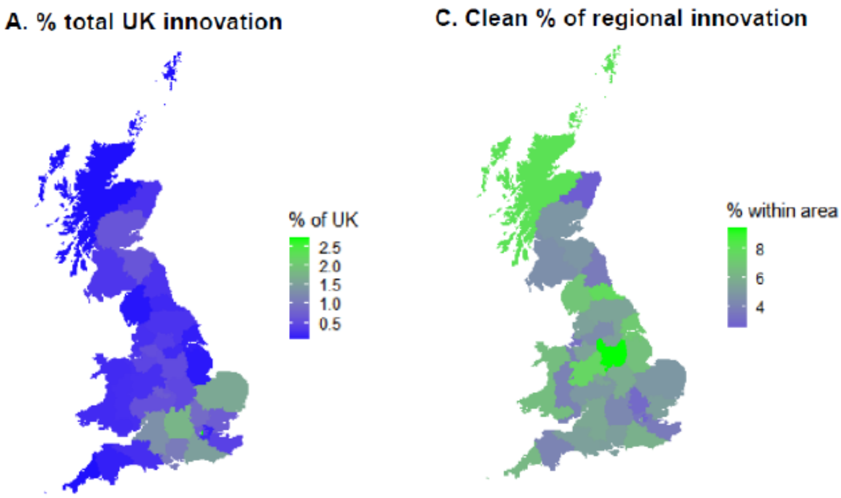
Innovation is a key enabler for prosperity. Investing in research and development is seen as a key indicator of a company or nation's attempts to innovate. This innovation in better products and services supports:

- the ability to adapt to new market conditions;
- the capacity to create a long-term sustainable business model.
- the possibility to create further socio-economic benefits, including the delivery of SDGs.

Investing and supporting R&D can result in positive externalities known as spillovers, which occur when innovations and ideas flow beyond the organisation conducting R&D. These societal benefits can in turn lead to new innovation and wealth creation through increased GVA and supported jobs. Societal returns on R&D are generally estimated to be two to three times larger than private returns (Frontier Economics, 2014), while clean technology R&D has historically provided an additional 40% in social returns when compared to other conventional technologies (Rydge et al., 2018). Furthermore, clean innovation can play a significant role in assisting with economic regeneration. This can be seen in Figure 12 below (Martin et al., 2020).

33. For more information on the safety of nuclear power plants and design, see the 2016 IAEA report in the IAEA Safety Standards series, *Safety of Nuclear Power Plants: Design – Specific Safety Requirements, IAEA Safety Standards Series, No. SSR-2/1 (Rev. 1)* at www-pub.iaea.org/MTCD/Publications/PDF/Pub1715web-46541668.pdf.

Figure 12: Distribution of patenting across Great Britain

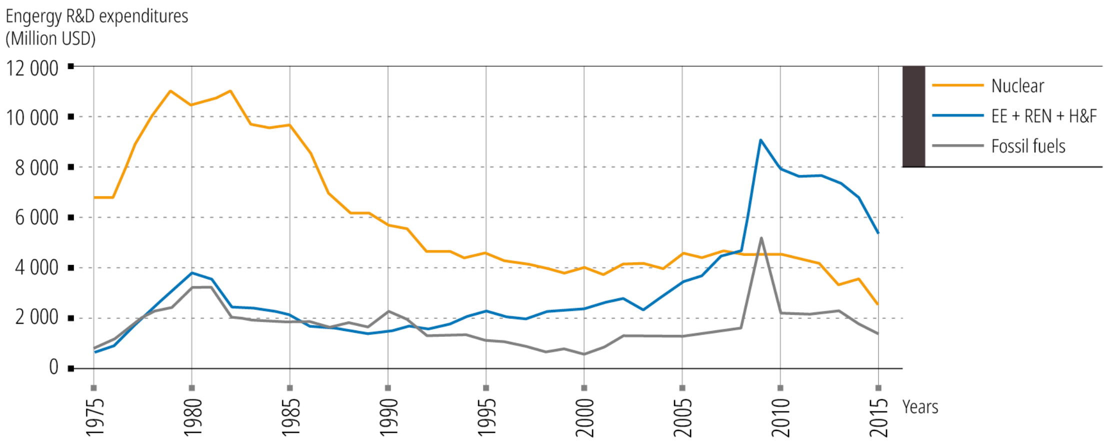



Source: Martin et al. (2020)

According to the IEA report, *Nuclear Power in a Clean Energy System* (2019), “a range of technologies, including nuclear power, will be needed for clean energy transitions around the world […] The biggest barrier to new nuclear construction is mobilising investment [...] A collapse in investment in existing and new nuclear plants in advanced economies would have implications for emissions, costs and energy security. Taking nuclear out of the equation results in higher electricity prices for consumers.”

Nuclear R&D has decreased materially in relative terms since the 1970s as investment has become more diverse. The IEA estimates that 20% of the public R&D energy budget was invested in nuclear technologies in 2015, down from nearly 73% of the public R&D energy budget in 1975. Over the same period, investment in energy efficiency and renewables increased markedly, with each attracting similar shares of total energy R&D to nuclear in 2015 (WNA, 2018).

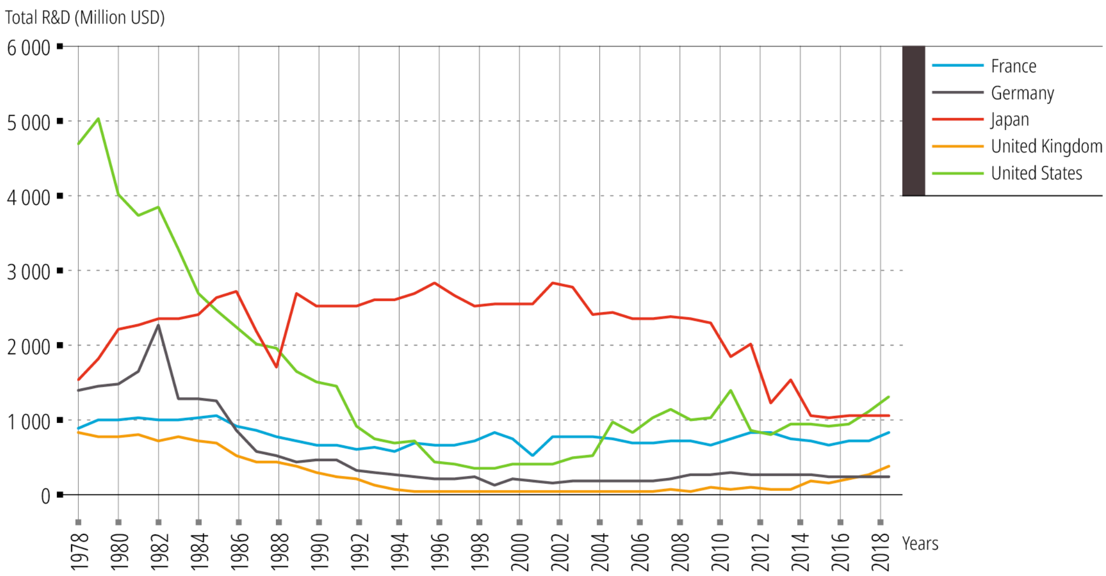
Figure 14: IEA Energy R&D Expenditures




Source: Adapted from WNA (2018).

Figure 15 below shows the reducing R&D investment in nuclear, by nation. (NIRAB, 2020)

Figure 15: Civil nuclear R&D spent by country from 1978 to 2018




Source: Adapted from NIRAB (2020)

The reduction in nuclear R&D is a contributory factor in why new nuclear build programme costs significantly exceed energy costs from existing nuclear sites (as shown in Figure 13). However, with new (i.e. advanced) nuclear technologies emerging, innovation across the sector is now accelerating.

The IAEA states:

Global interest in small and medium sized or modular reactors has been increasing due to their ability to meet the need for flexible power generation for a wider range of users and applications and replace ageing fossil fuel-fired power plants. They also display an enhanced safety performance through inherent and passive safety features, offer better upfront capital cost affordability and are suitable for cogeneration and non-electric applications. In addition, they offer options for remote regions with less developed infrastructures and the possibility for synergetic hybrid energy systems that combine nuclear and alternate energy sources, including renewables.

Many Member States are focusing on the development of small modular reactors, which are defined as advanced reactors that produce electricity of up to 300 MW(e) per module. These reactors have advanced engineered features, are deployable either as a single or multi-module plant, and are designed to be built in factories and shipped to utilities for installation as demand arises.

There are about 50 small modular reactor (SMR) designs and concepts globally. Most of them are in various developmental stages and some are claimed as being near-term deployable. There are currently four SMRs in advanced stages of construction in Argentina, China and Russia, and several existing and newcomer nuclear energy countries are conducting SMR research and development (IAEA, n.d.).

A recent American Nuclear Society Task Force stated:

> Dozens of nuclear technology companies are designing advanced reactors that will reshape how we think about nuclear power. Backed by a recent and unprecedented surge of private investment in nuclear technologies, they recognize the market needs of a zero-carbon energy future. Some of these new reactor designs will eventually be licensed and constructed. What is not yet clear is whether they will be deployed at a scale and a pace that will rapidly impel the United States to a clean energy future. Commercialization is not the finish line, but it will usher in a new kind of energy system—one that can be served by clean, reliable nuclear energy in a range of reactor sizes and types that share the grid with other low carbon or carbon-free technologies. Federal investments in nuclear research and development are critical to lower costs and reduce the time to deployment, while building momentum to catalyse more private investment, more research, and more innovation. United momentum is key to deriving maximum benefit from nuclear technologies and securing America's clean energy future. (ANS, 2021)

Without innovation in new products and services nuclear sites above will progressively support less employment through the nuclear decommissioning phase.

New build plants have a typical operational life of 60 years (excluding any potential lifetime extensions). When construction and decommissioning are included, a nuclear programme can support three to five generations. This multi-generational support drives large economic and social value with both direct and indirect local employment and integrated communities.

Companies need to report on their innovation and social value creation to show that they are investing in the future of the company, the industry and the wider community.

| World Economic Forum | |
|---|---|
| **Theme** | **Sub-theme** |
| Community and social vitality | Total tax paid |
| | Total social investment |
| | Additional tax remitted |
| | Total tax paid by country for significant locations |

### *Community and social vitality*

These metrics consider the wider benefits of a company's activities through taxes paid and social investment. It takes into consideration the wider payments into the wider economy. These are all company specific

### *Total tax paid*

Total tax includes corporation tax, income taxes, property taxes, VAT, and other sales and payroll taxes. Reporting total tax paid provides global information on the company's contribution to governmental revenues through different forms of taxes, which in turn supports governmental functions and public benefits.

### *Total social investment*

This is intended to be an oversight of sustainability and ESG efforts. This metric is intended to be a more inclusive definition of community investment. It seeks to capture the multiple ways in which companies can demonstrate their investments in social activities beyond traditional charity giving.

### *Additional tax remitted*

This metric provides an ability for companies to report on additional global tax collected by the company on behalf of other taxpayers – for example VAT and employee's tax. This allows companies the opportunity to report on their further global contributions to government revenues.

### *Total tax paid by country for significant locations*

This metric allows companies to report on the total tax paid and reported, additional tax remitted by country for all of the company's significant locations. Companies may choose to supplement their reporting on tax paid.

### *Energy companies*

The amount of tax paid and remitted by a company will depend on the particular company and also any allowances permitted for areas such as R&D. The tax reporting should not differ depending on technology.

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## Appendix III. The Taskforce

| | |
|---|---|
| Chair | **Fiona Reilly**, Co-chair of the GIF Economic Modelling Working Group (EMWG)<br>FiRe Energy Ltd |
| Secretariat | **Michel Berthélemy**<br>Nuclear Energy Agency<br><br>**Gina Abdelsalam**<br>Nuclear Energy Agency<br><br>**Robert Alford**<br>Nuclear Innovation and Research Office |
| Taskforce members | **Anne Crepin**<br>Société de FInancement Local (SFIL) |
| | **Milt Caplan**<br>MZ Consulting Inc. |
| | **Alec Cheng**<br>Ontario Power Generation |
| | **Chris Gadomski**<br>Bloomberg |
| | **Arthur Hyde**<br>Segra Capital |
| | **Emily Johnston**<br>Bruce Power |
| | **David Kaposi**<br>Ontario Power Generation |
| | **Craig Lester**<br>Department of Business, Energy and Industrial Strategy |
| | **Darryl Murphy**<br>Aviva Investors |
| | **Matthew Toolan**<br>Bank of Ireland |
| | **Laughlan Waterston**<br>Sumitomo Mitsui Banking Corporation |
| | **Tim Purvis**<br>Bruce Power |

# Appendix IV. Glossary

| Term | Definition |
|---|---|
| Bond | A negotiable certificate evidencing indebtedness. |
| Capital markets | The markets for medium- and long-term instruments, predominantly bonds, notes and other equities and commodities. |
| Capital project | A long-term project to build or develop a capital asset. |
| Controlling Mind | The nuclear licensee's obligation to be responsible for all safety, security and safeguarding issues at a nuclear site. |
| Credit committee | An investor's internal committee, whose job it is to scrutinise investments and to confer authority on individuals within the investor to act. |
| Debt | Capital loaned to a company on a repayable basis, and on which interest is due and payable. |
| Debt equity ratio | The ratio of debt to equity in a commercial enterprise. A measure of the financial stability of a company and its ability to increase its level of total borrowing. |
| Development company | A company, often a special purpose vehicle (see below), established to develop a capital project for commercial use, i.e. to sell power. It will be the owner of the asset, the procurer of the technology, and it is likely to be the holder of any licences and approvals, as well as the counter-party to any off-take agreements. |
| Equity | Cash or assets given to a company in exchange for an equity interest or as part of an ongoing obligation, or capital commitment, to fund the entity. There is no obligation to repay the equity, but it usually attracts a higher rate of return. An investor would extract its equity by selling its shares. |
| ESG | Environmental, social and governance data collection and accounting metrics. |
| EU report | The JRC Science for Policy report, Technical Assessment of Nuclear Energy with respect to the "do no significant harm" criteria of Regulation (EU) 2020/852 |
| Export controls | Legislation and regulation implemented by governments to control the export of materials, including:<br>dual-use items, software and technology, goods for torture and radioactive sources<br>export controls: military goods, software and technology. |
| Green Bond Principles/ GBP | The principles developed to enable capital raising for, and investment in, new and existing projects with environmental benefits. They were established by a consortium of banks and are monitored and developed by the International Capital Market Association. |
| Generation III+ | Generation III+ designs offer significant improvements in safety and economics over Generation III advanced reactor designs. |
| Generation IV | Generation IV reactors are a set of advanced nuclear reactor designs that are currently being developed. The Generation IV International Forum is co-ordinating research and development on six selected designs, which are expected to be ready for deployment by 2030. A number of private companies are developing Gen-IV designs. |
| Gross value added/ GVA | Gross value added to the economy and society by companies and projects including indirect jobs (employment and multipliers) and the wider benefits to the regional economy through direct and indirect jobs. Different governments have different definitions of GVA. |
| Hybrid capital | Capital loaned to a company, which may attract some equity benefits such as the ability to defer or cancel interest payments and the ability to convert to shares. |

| | |
|---|---|
| Knowledgeable Customer | A nuclear licensee is expected to have the capability, in terms of staffing and expertise within its own organization, to understand the safety case for all the nuclear facilities on-site and the limits under which it must be operated. A nuclear licensee needs to understand the safety significance of any work undertaken by contractors and to oversee and take responsibility for the contractor's activities, including ensuring that the contractor's staff are suitably qualified and experienced to carry out their nuclear safety duties. This means that major contracts that affect the safety, security or safeguarding of the plant, including the engineering, procurement and construction contract and the fuel supply agreement, must sit with the licensed entity, i.e. the licensed entity needs to have control of those contracts to be able to fulfil its knowledgeable customer capability. This is known as the intelligent customer in some jurisdictions. |
| Nationally Determined Contributions/ NDCs | Each countries' commitments and targets to reduce greenhouse gas (GHG) emissions that are established in the nationally determined contributions (NDCs). |
| OSPAR Convention 1992 | The Convention for the Protection of the Marine Environment in the North-East Atlantic |
| OSPAR Radioactive Substances Strategy | The OSPAR Commission's strategic objectives with regards to radioactive substances, to prevent pollution of the OSPAR marine area. |
| Safeguards | The IAEA Safeguards are a system of inspections and verifications of the peaceful use of nuclear materials as part of the Nuclear Non-Proliferation Treaty, supervised by the IAEA. States access these measures through the conclusion of Safeguards Agreements. |
| Special purpose vehicle/ SPV | A company established for a specific project or venture. |
| The Taskforce | The taskforce convened by the Economic Modelling Working Group of the Generation IV International Forum to assist with this report. The members of the taskforce are set out in Appendix III. |
| Technology company | A company with responsibility for developing a technology. This company is likely to take the design from a theoretical or paper design through to feasibility studies and possibly to prototype development. |
| US report | The US Department of Energy's 2015 Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities. |

## THE GENERATION IV INTERNATIONAL FORUM

Established in 2001, the Generation IV International Forum (GIF) was created as a co-operative international endeavour seeking to develop the research necessary to test the feasibility and performance of fourth generation nuclear systems, and to make them available for industrial deployment by 2030. The GIF brings together 13 countries (Argentina, Australia, Brazil, Canada, China, France, Japan, Korea, Russia, South Africa, Switzerland, the United Kingdom and the United States), as well as Euratom – representing the 28 European Union members – to co-ordinate research and development of these systems. The GIF has selected six reactor technologies for further research and development: the gas-cooled fast reactor (GFR), the lead-cooled fast reactor (LFR), the molten salt reactor (MSR), the sodium-cooled fast reactor (SFR), the supercritical-water-cooled reactor (SCWR) and the very-high-temperature reactor (VHTR).

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