IAEA
International Atomic Energy Agency

Coal to Nuclear

Supporting a Clean Energy Transition

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Coal to Nuclear

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FOREWORD

Nuclear power is an attractive option for many countries looking to diversify their supply and secure reliable, affordable low carbon energy. Transitioning from coal-to-nuclear energy offers a strategic path aligned with sustainability and economic development goals, including energy security and environmental protection. Nuclear power plants generate valuable economic gains, including creating jobs and furthering economic growth, while supporting public health and the environment by mitigating harmful emissions.

Achieving a just transition requires benefits to be shared widely and equitably, taking into particular consideration coal dependent regions. Such transitions present significant opportunities in developing countries, provided that they are supported by adequate climate finance and the modernization of infrastructure. Several initiatives have been proposed, including some that have considered nuclear energy, in particular small modular reactors. Nuclear energy's low carbon emissions and high energy density make it an attractive option. So does the fact that repurposing existing coal plant sites for nuclear deployment can make use of current assets, such as grid connections, water access and skilled labour.

Thirty-one countries currently operate nuclear power plants, which combined produce about 9% of the world's electricity, amounting to almost a quarter of all low carbon power globally. More than 30 other countries, most of them in Africa and the developing world, are considering or already embarking on the introduction of nuclear power and are working with the IAEA to develop the necessary infrastructure to do so safely, securely and sustainably.

With the inclusion of nuclear energy in the Global Stocktake at COP28 and renewed global momentum behind it, including pledges to triple capacity by 2050, the world now faces an unprecedented opportunity.

Africa, with its vast potential and growing energy demands, is at a crucial juncture in its energy transition. The

Coal-to-nuclear transitions are not simply technological swaps; they are opportunities to drive clean growth, foster social equity and secure a resilient energy future. Strategic action today can unlock a sustainable future for generations to come.

IAEA is committed to supporting the continent's ambition to harness nuclear energy for sustainable growth.

With the growing interest in nuclear power in Africa and the recent decision by the World Bank to re-engage with nuclear energy for development, in partnership with the IAEA, countries now have a critical opportunity to access an expanding pool of global resources and support for their nuclear power ambitions.

Realizing the full potential of nuclear projects calls for a strong policy framework that fosters collaboration between governments and private sector stakeholders — government support is essential to mobilizing the necessary private sector capital and addressing barriers.

The IAEA welcomes South Africa's invitation to support its G20 Presidency in 2025, particularly in advancing the agenda of the Energy Transition Working Group.

This publication, developed in partnership with the South African Presidency, offers valuable insights into the potential of nuclear energy in enabling a just transition to clean energy while boosting economic development and industrialization.

Drawing on the operating experience of South Africa, as well as several African countries that are actively embarking on new nuclear power programmes, this publication also examines key considerations for integrating nuclear energy into national energy strategies.

I am confident the following pages will illuminate for stakeholders the transformative role nuclear energy can play for the world, and particularly Africa, empowering its people, strengthening its economies and supporting a cleaner, more resilient and prosperous future.

IAEA Director General

RAFAEL MARIANO GROSSI

INTRODUCTION

The global energy landscape is undergoing a fundamental transformation. As South Africa assumes the Presidency of the G20, we do so with full recognition of the responsibility to lead a coherent, inclusive and pragmatic energy agenda that meets the developmental needs of the present while advancing climate action commitments. In this context, nuclear energy emerges not merely as an option but as an essential pillar in our energy mix to support both national resilience and global decarbonization.

This IAEA publication on coal-to-nuclear transitions is both timely and necessary. It affirms a practical pathway for countries, particularly those with established coal infrastructure, to accelerate their energy transitions while retaining grid stability, enabling industrialization and safeguarding jobs. The principle of additionality must guide this transition. Nuclear energy must be seen not as a replacement for renewable energy sources, but as a complementary and sovereign choice to secure dispatchable, low-emission baseload power within a balanced energy system.

In South Africa, this principle is especially important. Our Integrated Resource Plan (IRP), currently under review, will address the urgent need to replace approximately 19 GW of coal-fired generation scheduled for decommissioning by 2035. This transition presents both a challenge and an opportunity. With the majority of our coal plants situated in Mpumalanga, which remains the backbone of the national grid, we are compelled to prioritize options that optimize existing infrastructure.

Repowering these sites with nuclear energy, particularly small modular reactors, aligns with national policy and fiscal imperatives. It enables us to reduce the cost and environmental burden of building new long-distance transmission lines, maintains grid stability in a constrained system, and supports regional economic revitalization. Our experience with the Komati repowering project underscores a critical lesson: the removal of baseload power without adequate replacement has deep socio-economic consequences for workers, communities and supply chains. A coal-to-nuclear programme offers a just transition alternative that safeguards livelihoods while advancing a cleaner energy future.

Nuclear power, on a levelized cost of electricity basis over the full life cycle, offers a competitive and predictable price trajectory when compared to other dispatchable sources. It also meets the requirements of long-term system adequacy, contributing to decarbonization without sacrificing reliability. The Department of Electricity and Energy welcomes the recent policy shift by the World Bank to consider nuclear energy within its financing framework. This decision signals growing international acceptance of nuclear energy's role in meeting global climate targets while addressing the development needs of the Global South.

In South Africa, we intend not only to expand our nuclear programme, but also to reassert our historical leadership in nuclear technology development and innovation. Our legacy in developing high-temperature, gas-cooled reactor designs, through the Pebble Bed Modular Reactor (PBMR) project, places us in a strong position to support the deployment of new nuclear technologies adapted for coal site repowering.

We therefore view the coal-to-nuclear transition as not simply a technological option, but a strategic imperative. It supports the following critical national objectives:

- Retaining and repurposing transmission and auxiliary infrastructure in existing coal plant sites, thereby reducing new build costs.
- Supporting industrialization and inclusive growth through high value employment and local manufacturing opportunities.
- Maintaining grid resilience with dispatchable, low-emission baseload capacity.
- Attracting sustainable private capital into the nuclear sector through investor-friendly small modular reactor platforms.
- Advancing energy equity and long-term cost competitiveness in a constrained fiscal environment.

As we prepare to host the IAEA's launching of this publication on the margins of the 4th Energy Transitions Working Group (ETWG) and Ministers Meetings during October 2025, South Africa reaffirms its commitment to multilateralism and to working with like-minded partners across the G20 and the broader Global South. The transition from coal to nuclear is not about abandoning our energy past, but about building a secure and inclusive energy future. It is about maintaining the right of developing economies to determine their own pathways based on national circumstances, without compromising our global responsibilities.

I extend my appreciation to the IAEA for this critical initiative and commend this publication to policymakers and practitioners alike. It is my firm belief that this work will provide a clear and credible blueprint for a just, secure and sustainable energy transition.

Minister of Electricity and Energy
Republic of South Africa

KGOSIENTSHO RAMOKGOPA

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EXECUTIVE SUMMARY

Initially advanced by trade unions in the 1990s to safeguard workers impacted by environmental regulations, the concept of a ‘just transition’ has progressively evolved to encompass the broader socio-economic dimensions of climate policy and action. In 2024, under Brazil’s G20 Presidency and in collaboration with UN-Energy, the Just and Inclusive Energy Transition (JIET) Compact was launched to drive global momentum for an equitable and inclusive energy transformation.

Building on these efforts and on a wide range of national studies exploring transitions from coal-to-nuclear energy, this publication explores the strategic role of nuclear energy in enabling a just, clean energy transition that fosters economic development and industrialization. Specifically, it underscores the potential of transitioning from coal-to-nuclear energy as a strategic approach to expand equitable access to energy, strengthen economic resilience and reduce greenhouse gas emissions.

Repowering coal plants with nuclear energy can deliver reliable, dispatchable power while advancing workforce and economic development, as well as environmental objectives. However, low and middle income countries could face barriers such as financing constraints, outdated grid infrastructure and the relatively young age of many coal power plants, which still have substantial invested capital yet to be recouped by investors. This contrasts with high income countries, which often deal with aging coal plants that are closer to retirement. The inclusion of nuclear energy in sustainable investment frameworks is helping to address these concerns by building investor confidence and reinforcing the relevance of nuclear energy in just and inclusive energy transitions.

Key Benefits

- **Economic growth:** Nuclear power can increase gross domestic products, labour income and employment by generating direct benefits from plant operations, indirect benefits through supply chains and induced effects from increased community spending.

- **Job creation and workforce transition:** A high percentage of coal power plant jobs can transition to nuclear power plant jobs with minimal reskilling. Nuclear power offers long term, high skilled jobs with average wages higher than in other energy sectors.

- **Public health and environment:** Replacing coal with nuclear energy improves air quality by reducing harmful emissions (e.g. CO_2, SO_2, NO_x and PM2.5), significantly decreasing the numbers of premature deaths and health related burdens — especially in low and middle income countries.

- **Sustainable development alignment:** A coal-to-nuclear transition contributes to several Sustainable Development Goals (SDGs), including quality education (SDG4), affordable and clean energy (SDG7), decent work and economic growth (SDG8) and climate action (SDG13).

Technical Considerations

- **Site selection:** Site suitability is critical, including space for infrastructure, cooling water availability and permitting, and environmental impacts of decommissioning the coal power plant.

- **Existing infrastructure:** Reusing existing coal power plant infrastructure, such as grid connections and cooling systems, can reduce costs but could require upgrades.

- **Plant features:** Advanced reactors, especially small modular reactors, align well with coal power plant characteristics (including temperature and pressure conditions) and grid compatibility. However, water usage and cooling needs must be evaluated, by assessing different types of cooling technologies, from once-through to dry cooling, to minimize water withdrawal or consumption.

Financing Coal-to-Nuclear Transitions

- **Investment needs:** Nuclear projects require long-term policy support and sound financial planning to derisk investment — this is especially crucial for low and middle income economies that face significant challenges such as limited access to climate finance and an outdated grid infrastructure.

- **Just Energy Transition Partnerships:** These partnerships are international collaboration mechanisms designed to support clean energy transitions in coal-dependent low and middle income countries through grants, loans and investments; although the primary emphasis of them is still renewable technologies, these partnerships could also represent a potential source of financing for nuclear energy initiatives.

Implementation Guidance

- **Clean energy strategies:** These increase financial support for nuclear energy projects through public-private partnerships and multilateral development banks, prioritizing nuclear energy as a dispatchable energy source in energy transition strategies and sustainable investment taxonomies, especially in coal dependent regions.

- **Stakeholder engagement:** The success of just energy transitions can be improved by ensuring adequate funding for worker retraining, pensions or compensation for retirees, while developing local supply chains to support communities affected by the transition.

- **The IAEA strategic tools:** The IAEA's Extended Input Output Model for Nuclear Power Plant Impact Assessment (EMPOWER) can support data driven planning and macroeconomic impact assessment of nuclear projects, including small modular reactors, as well as other power plants; additional IAEA methodologies and tools are available to interested Member States to support energy system analyses and the assessment of the suitability and sustainability of a nuclear power transition.

CONTEXT

Originally coined by trade unions in the 1990s to support workers affected by environmental policies, the concept of ‘just transition’ was framed mainly as a workforce-related issue in the Silesia Declaration at COP24 and now encompasses broader climate-related economic and social impacts [1]. In 2024, under the G20 Brazil Presidency and in collaboration with UN-Energy, the Just and Inclusive Energy Transition (JIET) Compact was launched [2]. The Compact is grounded in ten principles developed by the Energy Transition Working Group aiming to promote equitable energy access, social dialogue, human rights and sustainable economic growth [3]. One of its main goals is to mobilize support, encourage practical action and broaden participation to ensure a fair, affordable and inclusive global energy transition.

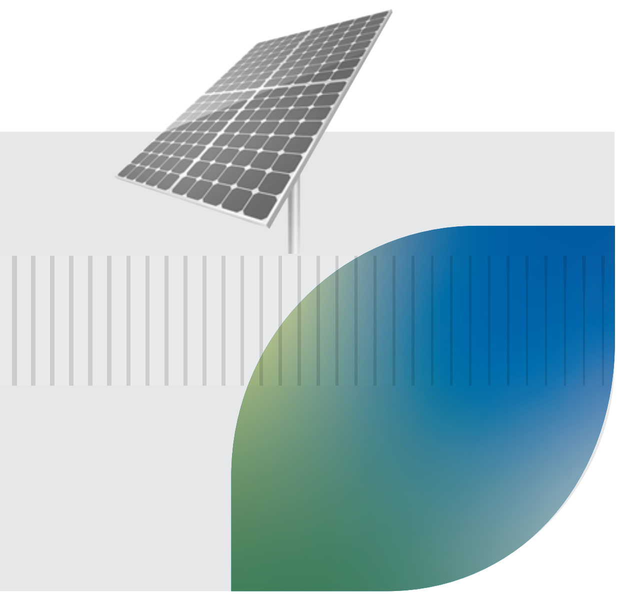
This publication builds on these efforts, as well as on several national studies on coal-to-clean transitions, and responds to South Africa’s invitation to the IAEA to support its 2025 G20 Presidency— particularly in advancing the agenda of the Energy Transition Working Group. Developed in partnership with the South African Presidency, it provides strategic insights into the role nuclear energy can play in supporting a just, clean energy transition that fosters economic growth and industrial development.

A separate IAEA publication, called Outlook for Nuclear Energy in Africa [4] and released in July 2025 in support of the G20 Presidency, examines the opportunities and challenges associated with expanding nuclear energy across Africa.

Coal-to-nuclear energy transitions present a strategic opportunity for policymakers to meet rising global demand for equitable energy access, while enhancing national economic performance, supporting workforce stability and advancing environmental and health outcomes. Such transitions align with sustainable development priorities and offer actionable pathways for inclusive, low-carbon economic growth. Moreover, repowering coal power plants (CPPs) with nuclear technology presents notable advantages in terms of energy security. Unlike other clean energy sources — particularly variable renewable sources — nuclear energy provides a stable, dispatchable supply of energy, which is critical for maintaining grid reliability and stability, and powering the economy. Nevertheless, such a change requires careful technical consideration with respect to site suitability and the reuse of existing infrastructure and plants’ operational features, including cooling solutions.

To date, about half of the G20 members, and countries invited to the G20 in 2025, include nuclear power in their energy strategies, recognizing its potential to provide clean and reliable energy. Many G20 countries are heavily dependent on fossil fuels, particularly coal, accounting for over 90% of the world's coal-based electricity. This reliance highlights the scale of the challenge in shifting to cleaner energy sources and underscores the importance of exploring all available low carbon options, including nuclear energy. As these economies seek pathways to cleaner energy while maintaining reliability, nuclear power is emerging as a viable option for coal-to-clean transitions. Moreover, nuclear energy is increasingly acknowledged in sustainable investment taxonomies, which can help to support investor confidence. However, challenges remain for financing nuclear projects, especially in low and middle income countries, requiring substantial government support and private sector investment. A key barrier for clean energy transitions in these countries is limited access to climate finance, coupled in some cases with relatively young CPPs and in most cases an outdated grid infrastructure. With 89% of global coal capacity in low and middle income countries, early retirement poses financial risks, such as the management of stranded assets. These points underscore the critical role of clean, dispatchable energy sources, such as nuclear energy. Through the adoption of appropriate policies, financing mechanisms and stakeholder engagement strategies, nuclear energy can contribute not only to grid reliability but also to economic resilience, workforce development and environmental sustainability.

This publication explores the macroeconomic and socio-economic implications of a just transition from coal-to-nuclear energy, including potential impacts on gross domestic product (GDP) and employment. It also examines technical considerations related to repowering CPPs with nuclear technologies, such as small modular reactors (SMRs), and reviews relevant developments and initiatives. The publication also outlines the IAEA support services in areas such as macroeconomic and environmental assessments and facilitating the implementation of coal-to-nuclear projects with the intention to assist policymakers evaluate the role of nuclear energy in advancing a fair, inclusive and cost-effective energy transition. In conclusion, the publication provides an overview of sustainable development strategies, with a focus on national policy initiatives aimed at expanding into emerging clean energy technology markets beyond fossil fuels.



Coal-to-nuclear energy transitions present a strategic opportunity for policymakers to meet rising global demand for equitable energy access, while enhancing national economic performance, supporting workforce stability and advancing environmental and health outcomes.

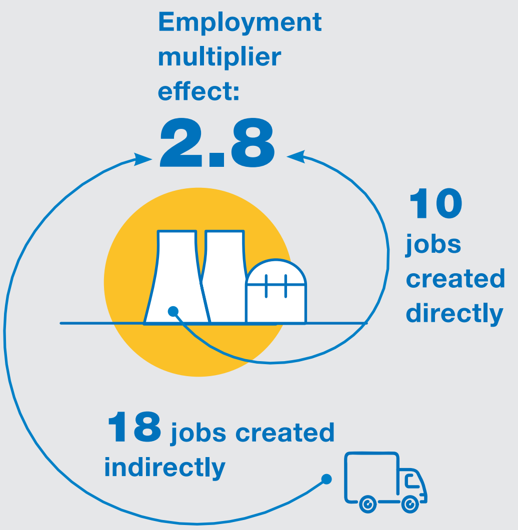
ECONOMIC AND SOCIAL IMPACTS OF COAL-TO-NUCLEAR TRANSITIONS

Power plants provide more than just electricity – they also deliver substantial economic benefits to host communities, including employment opportunities and boosting local economies through the household spending of their workers. Ensuring a just transition is essential in countries where the coal industry plays a major role in employment and local economic activity. The following sections examine the economic and social impacts of nuclear power, highlighting how its development can positively impact sustainable economic growth, employment and public health at the national and regional levels.

The Macroeconomic Impacts of Nuclear Power

A transition from coal-to-nuclear energy encompasses several macroeconomic considerations, including changes to GDP, employment and labour income. Studies analyzing the economic impacts of coal-to-nuclear transitions typically suggest that these transitions can lead to increased industry revenues, more job opportunities, higher incomes and broader economic growth [5].

Assessing the macroeconomic impacts of nuclear and other energy generation projects involves analyzing their effects on GDP, employment and income. The summation of these impacts is generally categorized as direct (occurring at the power plant level), indirect (arising within the supply chain level) and induced (resulting from broader community spending). The commonly applied analytical framework for such assessments is input-output models (IOMs), which capture the interactions between various economic sectors and estimate how changes in inputs or outputs of a sector influence others and the economy as a whole [6]. Gross domestic product, employment and income multipliers are used to analyze the magnitude of the impacts of external changes on the economic sectors (see Box 1).



BOX 1: Nuclear industry's investment multiplier concept in terms of employment in the southeastern USA

The southeastern states of the United States of America (USA), including Georgia, North Carolina, South Carolina, Tennessee and Virginia, compose a significant hub for the nuclear industry. In 2024, this region hosted 25 of the country's 93 operational nuclear reactors, contributing 26 287 MW (37%) to the region's net electricity generation and US $42.9 billion annually to the local economy. The industry supports 152 598 jobs and generates US $13.7 billion in labour income. It also delivers US $3.7 billion in state and local tax revenue. The nuclear industry has an employment multiplier effect of 2.8, meaning that for every 10 jobs created directly, another 18 jobs are created indirectly. Furthermore, the average wage in the nuclear supported workforce is 65.5% higher than the regional average. Future investments in new nuclear power are expected to drive significant economic growth, with each US $100 in revenue generating approximately US $200 in overall economic output [7].

Discussions among participants of the IAEA SMR School in Nairobi, Kenya, 5–9 May 2025.

The Human Footprint: Workforce Development

Transitioning from coal-to-nuclear power has significant socioeconomic implications for the local economy and workforce. Countries aiming to transition their energy systems require appropriate policies, financial support and workforce development. This shift can reduce reliance on coal imports, stabilize electricity prices and create socioeconomic opportunities by repurposing coal plant infrastructure and retraining workers. Nuclear energy can play a pivotal role in transitioning skilled workers from the coal sector to sustainable energy industries.

A transition from coal to nuclear can preserve the CPP workforce and even increase the local employment rate due to new jobs for the plant itself, the supply chain and the surrounding area [8]. A 2023 report by the U.S. Bipartisan Policy Center on transitioning retiring coal plants to nuclear power, particularly with SMRs, found that approximately 77% of CPP jobs can be transferred to nuclear power plant (NPP) operation without requiring new workforce licensing [9]. These estimates are based on a 2021 analysis in the USA of repurposing a CPP site with a 12-module NuScale SMR facility of 924 MW(e) [10]. Additionally, a 2022 study by the U.S. Department of Energy (USDOE) [8] estimated that such a transition (based on TerraPower and NuScale concepts) could lead to a net increase of over 650 permanent jobs in the region (two-thirds being indirect/induced), with NPP wages averaging 15% higher than CPP wages and 64% above the median hourly wage in the USA. For context, the original coal site in the case study employed around 150 workers before its closure. This underscores the nuclear industry's role in providing long term, high skilled and well paid employment opportunities with average wages that could surpass those in other energy technology industries by approximately 20% [11, 12].

Ensuring a smooth workforce transition from coal-to-nuclear energy requires coordinated efforts among utilities, nuclear operators, regulatory bodies, suppliers of products and services, governments, local communities, educational institutions and their related infrastructure. The IAEA can offer comprehensive support in human resources and workforce development, nuclear knowledge management and nuclear education and training [13].

The Socioeconomic Footprint: Air Pollution and Health

One of the key societal benefits of transitioning from coal to nuclear is a significant reduction in air pollution and carbon emissions. Coal emissions, including CO_2, SO_2, NO_x and PM2.5, are considered major contributors to air pollution and related health problems, especially in low and middle income countries. A 2017 study [14] showed that a business-as-usual scenario of coal-fired power development in Southeast Asia would triple the SO_2 and NO_x emissions by 2030, potentially causing close to 70 000 premature deaths by that year in the region.

Several countries have made significant efforts to replace coal use, particularly CPPs, with clean energy sources such as nuclear or renewable energy. One such example is China, where the Government has implemented numerous policies and plans since the early 2010s to reduce the country's reliance on coal. Several of these projects have focused on replacing coal with nuclear energy to provide district heating, industrial heat and steam for petrochemical industries, leading to observable reductions in CO_2, SO_2 and NO_x emissions [15–17]. A 2023 study estimated that a complete transition away from coal use in China, assisted by rapid nuclear energy development, would prevent 375 000 premature deaths and reduce the disability-adjusted life years (DALYs) by 8.90 million years, which could account for about half of the total premature deaths and DALYs caused by anthropogenic PM2.5 pollution [18].

The El Dabaa NPP is Egypt's first nuclear power facility currently under construction and is a strategic project that supports both national development goals and the United Nations Sustainable Development Goals (UN SDGs) (see Box 2). The NPP's contribution to the SDGs becomes especially significant when considered in the context of a transition away from fossil fuels. Coupled with their positive impact on resource management and environmental protection, coal-to-nuclear initiatives in low and middle income countries can help to meet multiple SDGs, including quality education (SDG4), affordable and clean energy (SDG7), decent work and economic growth (SDG8) and climate action (SDG13) [18–20].

One of the key societal benefits of transitioning from coal to nuclear is a significant reduction in air pollution and carbon emissions.

El Dabaa NPP construction site (courtesy of Nuclear Power Plants Authority of Egypt).

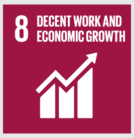
BOX 2: Contribution of El Dabaa NPP to the achievement of the UN SDGs

(Courtesy of Rosatom)

The El Dabaa NPP partnership with Rosatom (the State Atomic Energy Corporation of the Russian Federation) opens educational opportunities. More than 48 000 people have already been trained with the support of Rosatom (including higher education).

The El Dabaa NPP could provide approximately 20 million people (19% of the country's population) with electricity.

The El Dabaa NPP could generate approximately 13% of all electricity produced in Egypt (this will increase the volume of clean energy by almost two times[1]).



The construction of the El Dabaa NPP could contribute more than $5 billion[2] to Egypt's GDP (1.5% of the country's GDP[3]).

More than 70% of NPP construction workers (over 30 000 people[4]) could be from the local population of Egypt.

More than 230 local producers are involved in the El Dabaa NPP project.

The El Dabaa NPP could reduce greenhouse gas emissions by approximately 11 million tons CO_2 equivalent annually (5% of the current level[5]).

[1] After the nuclear power plant reaches its design capacity while maintaining the country's energy balance for other sources of electricity without changes (based on 2022 data).
[2] GDP growth calculation based on the research by Oxford Economics, which can be found at https://assets.publishing.service.gov.uk/media/5a7abae8ed915d71db8b217d/bis-13-633-the-economic-benefit-of-improving-the-uk-nuclear-supply-chain-capabilities.pdf
[3] Egypt's GDP according to International Monetary Fund data (accessed 2023).
[4] At the peak of the construction during 2025–2026.
[5] The share of Egypt's total greenhouse gas emissions from fuel combustion.

CONSIDERATIONS OF REPOWERING COAL POWER PLANTS WITH NUCLEAR POWER

Coal power plants can be repurposed as NPPs, by utilizing the site and the grid connection, and to even be repowered, which includes reusing additional site infrastructure, such as the cooling systems and the steam cycle [21]. The reuse of a CPP site can offer substantial benefits, but there are several key considerations that impact the viability of a coal-to-nuclear project [22, 23]. The following discussions on site selection, infrastructure assessment, technology compatibility and community engagement are not exhaustive, but provide a general overview of considerations for a coal-to-nuclear transition.

NPP Site Selection

Determining the suitability of the CPP site for use by an NPP is an important step in implementing a coal-to-nuclear project.

The size of the site needs to be able to accommodate the needed infrastructure for the selected NPP technology. If the site is large enough, it could enable development of the NPP to begin before decommissioning of the CPP, lessening or completely removing a gap in operations and electricity generation.

The location of the site must be suitable for an NPP. Nearby population density, industrial plants, natural hazards and other aspects of the site could be suitable for a CPP, but not for an NPP. Additional exclusionary and discretionary criteria will need to be evaluated to ensure the site will meet all requirements [24].

The existence of a cooling water supply is one of the most important site criteria for a coal-to-nuclear transition. The existing water supply must be able to meet the needs of the selected nuclear technology. In particular, the rights and permits to both use and discharge the water are among the most valuable assets in many jurisdictions due to the difficulty in recent years in obtaining new water utilization rights. The water permits could have to be re-obtained or modified from the existing CPP permits.

Decommissioning and clean-up of the existing CPP can require extensive resources and include environmental issues that could impact the NPP. Considerations could include soil and groundwater contamination, including both chemical and radiological. Additionally, coal ash and other waste products accumulated during the CPP lifetime could require remediation. Waste products could be converted into wallboard, concrete and other materials, removed from the site, or covered and stored in place.

Infrastructure Assessment

Coal power plant sites include infrastructure and equipment that could be repurposed by NPPs, and reuse of these systems could provide up to 35% in savings on construction costs [25]. However, the possibility of re-utilization of any of the infrastructure elements is dependent on several technical and regulatory aspects, such as the selected nuclear technology, layout of the site and condition of the equipment (Fig. 1).

The electrical equipment, including the transformers, grid connection, switchyard and related authorizations, are some of the most valuable infrastructure elements that could be repurposed for an NPP. The grid infrastructure needs to be assessed to ensure it can provide a sufficiently reliable electrical supply to an NPP, and depending on the size of the reactor, the equipment could need to be upgraded to be compatible.

In some cases, the existing cooling infrastructure could be reused, depending on the design and its compatibility with the selected reactor technology. Intakes and piping could be reused based on the site layout and the amount of water needed. Cooling towers, if existing in the CPP, will need to be evaluated for capacity and efficiency compatibility.

It may not be possible to fully re-utilize, without upgrades, both the electrical and cooling infrastructure unless a reactor technology with an efficiency and pressure and temperature conditions close to that of the CPP is selected. Alternatively, some of the heat output of the NPP could be utilized for purposes other than electricity generation, such as district heating, to reduce the necessary cooling load required during normal operation.

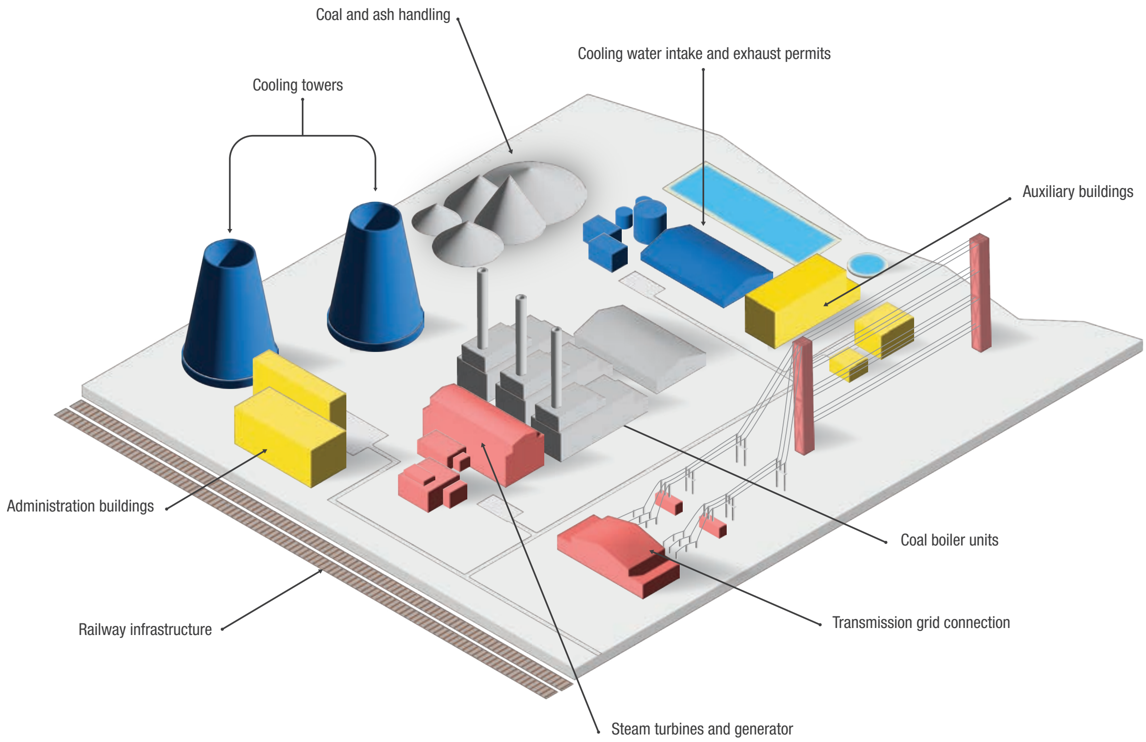


Fig. 1: The diagram shows the infrastructure of a CPP that could be repurposed for an NPP. Infrastructure that cannot be reused is shaded in grey—coal boiler units and coal and ash handling (reproduced from Ref. [26]).

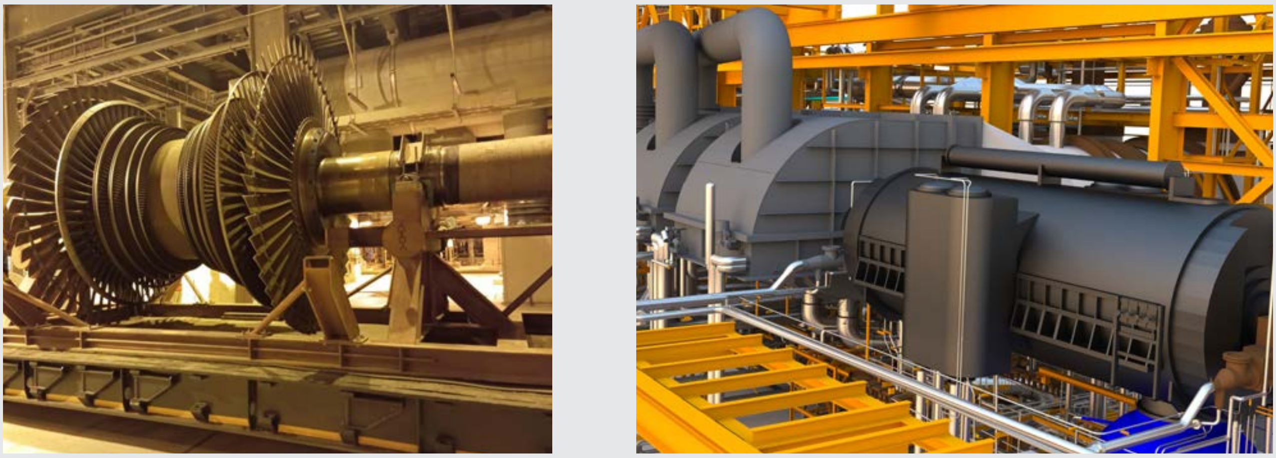


Fig. 2: Examples of CPP parts that could be reused for NPPs; a CPP turbine rotor (left) and a render of its outer casings (right) are shown (courtesy of Eskom).

The reuse of the CPP turbine island (Fig. 2) and balance of plant (BOP) systems for the NPP is dependent on several aspects. The nuclear steam supply system and turbogenerator systems would need to closely match the temperature, pressure, quality and other standards the CPP systems were designed for. Additionally, the systems would need to meet the applicable requirements based on each component's safety classification [27]. As safety-significant NPP and central turbine island components are manufactured to particular specifications under strict quality management requirements, reusing existing CPP components could require significant regulatory and engineering review, upgrade and modification, or may not be possible within the particular Member State's nuclear regulatory framework [28]. Some designs of advanced nuclear reactors include an intermediate heat storage system, which could mitigate these requirements, as the reused systems would be decoupled from the nuclear reactor.

Transportation access via road, rail and/or waterways is likely well developed at a retiring CPP and could be utilized for both construction and operation of an NPP. Additional infrastructure elements could be reused in a coal-to-nuclear transition, such as existing utilities, site emergency services and office buildings.

Technology Compatibility

Given that many CPPs are nearing retirement, nuclear reactor technologies could present a suitable option for their replacement. In South Africa, 12 of the total 18 CPPs, with a total capacity of nearly 19 GW(e), are slated for retirement by 2035, including three where all units are already shut down (Fig. 3). These 12 CPPs consist of 81 units (36 units have been shut down) and have unit sizes that range from 30 MW(e) to 600 MW(e). These plants have efficiencies between 33% and 38% and power ramp rates between 16% and 40% per hour [29].

Small modular reactors are typically classified as reactors with power levels of less than 300 MW(e), and plants deployed with single or multiple units are available. Efficiencies of SMRs range from 30 to 33% for light water reactors (LWRs) and increase to 40–44% for high-temperature, gas-cooled reactors (HTGRs) [30]. Additionally, there are many advanced reactor designs with power levels greater than 300 MW(e) that would be suitable to replace CPPs, or several smaller SMRs could be deployed at a previous CPP site to match the desired power level, steam conditions and/or unit sizes (see Table 1).

Coal Plants in South Africa

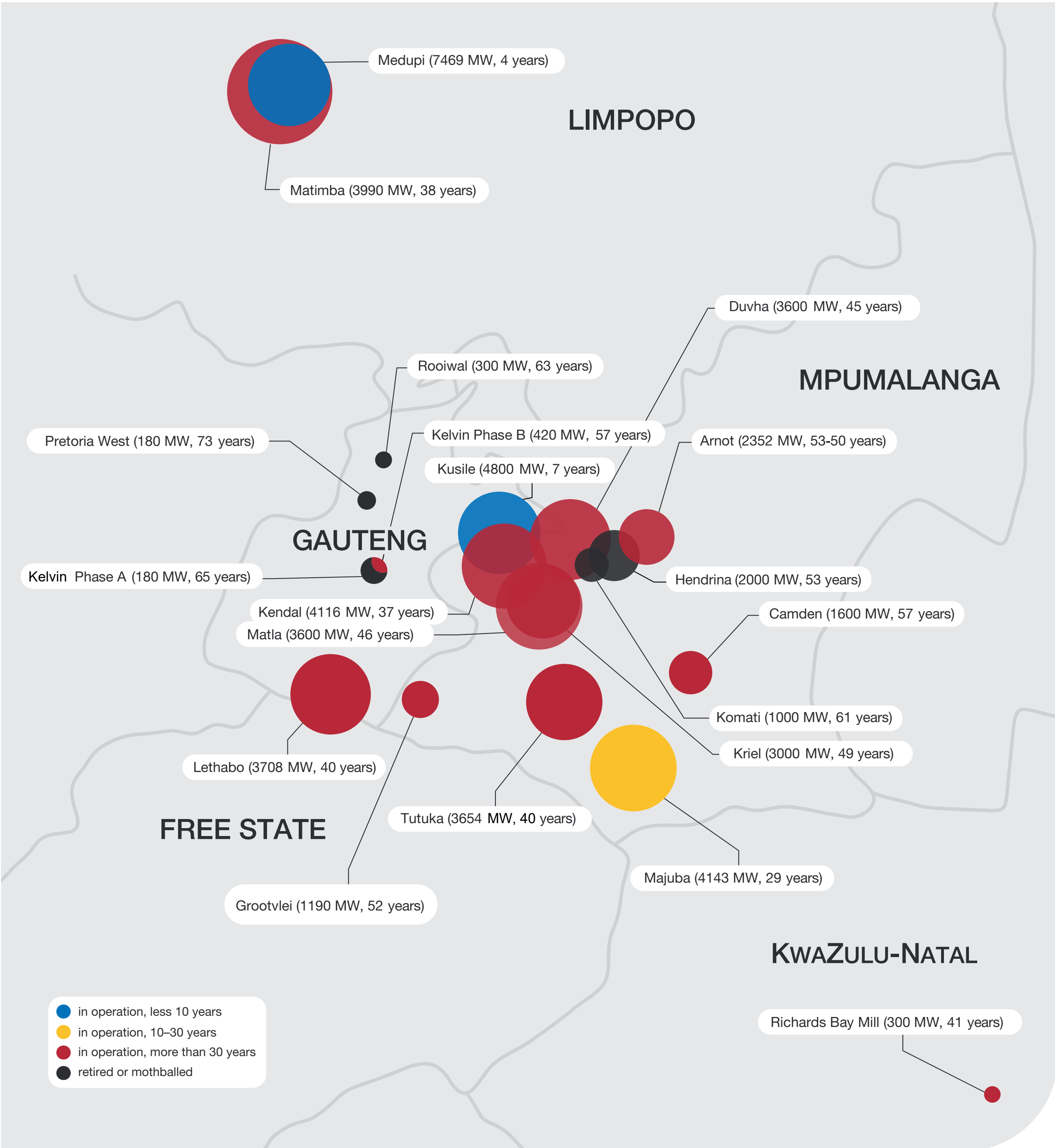


Fig. 3: The map illustrates the distribution, operating status and age, and generation capacity of CPPs across South Africa (data from Global Energy Monitor, accessed July 2025).

Koeberg NPP near Melkbosstrand, South Africa.

The ramp rates of many advanced designs can easily achieve the performance of the current fleet of coal plants. Technologies with higher outlet temperatures (such as HTGRs and molten salt reactors) can also match the typical steam conditions of CPPs, facilitating good matches in the grid sizes, water uses and possibly the power turbines and other parts of the BOP systems. To further reduce water consumption, some advanced reactor technologies can utilize dry cooling, which uses air to remove heat, while wet cooling uses water [31]. This cooling technique is also utilized at some CPPs (such as at the Matimba Plant in South Africa), although this process negatively impacts the efficiency of the plant when compared to wet cooling. Currently, the Bilibino NPP, a plant consisting of three operational 12 MW(e) reactors (and one shutdown 12 MW(e) reactor) in the Russian Federation, is the only dry cooled NPP in the world [32]. Advanced reactor technologies can offer many other advantages, such as smaller footprints, advanced manufacturing, flexible operation, passive safety systems, long refuelling cycles and reduced construction costs [30].

	Electrical Capacity (MW(e))	Thermal Efficiency	Temperature* (°C)	Pressure** (MPa)
SOUTH AFRICA LETHABO CPP UNITS	618	37.8%	535	16.1
WATER COOLED SMR	6–366	25–35%	110–330	Up to 7.4
GAS COOLED SMR	3–300	33–53%	700–950	Up to 16.5
MOLTEN SALT SMR	8–300	40–50%	625–800	Up to 25.7
LIQUID METAL-COOLED, FAST-NEUTRON SMR	10–345	33–43%	450–550	Up to 18

* Temperature provided for SMR technologies indicates core coolant outlet temperature; temperature provided for the CPP is the steam temperature.

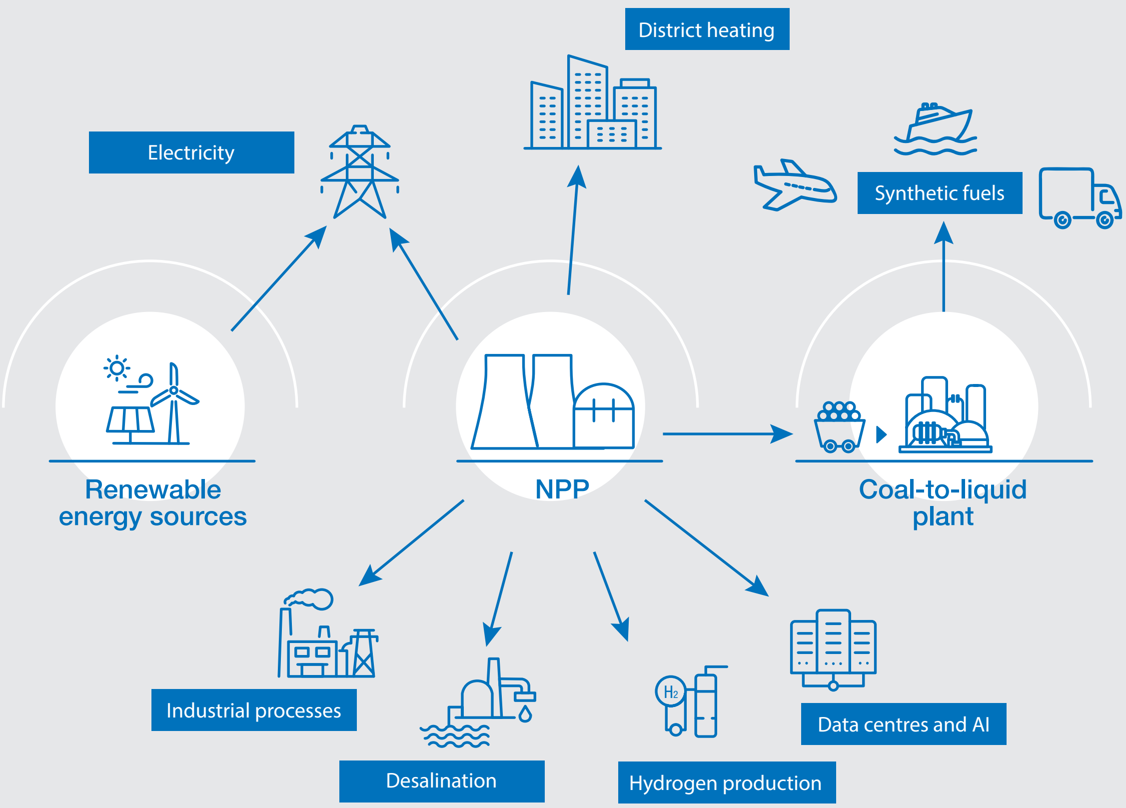
** Pressure provided for SMR technologies indicates secondary nuclear steam supply system operating pressure; pressure provided for the CPP is the steam pressure.

Table 1: Comparison of CPP and NPP technical characteristics [33, 34]

In addition to providing power to grids to replace CPPs, the nuclear reactors can be used for cogeneration, the generation of both electricity and heat. The heat produced from nuclear energy can be used for many applications beyond electricity production, including district heating, desalination, hydrogen production and providing heat for industrial processes [35]. Nuclear reactors replacing CPPs can also be part of larger industrial hubs and energy systems integrating nuclear and renewable technologies to support further decarbonization, providing both electricity and non-electric products. These integrated facilities can provide flexibility for the grid, optimize the use of investment capital and reduce greenhouse gas emissions (see Box 3) [36].

BOX 3: Nuclear energy decarbonizing large industrial hubs

Coal liquefaction is an important example of an industrial process that could utilize nuclear energy to reduce the carbon footprint of the production of synthetic liquid fuels. Coal-to-liquid plants, such as the coal-to-liquid Sasol plant in Secunda, South Africa, continue to explore ways to reduce CO_2 releases to the environment. Nuclear energy can provide decarbonized electricity, high temperature steam and hydrogen to be used in the manufacturing of synfuels, thus helping to decarbonize hard-to-abate sectors, such as aviation and maritime transport, while still making use of existing coal resources [37].



Engagement with Local Communities

Local community support for a just transition can be strengthened through the provision of sufficient funds for retraining workers, pensions or other retirement compensations, and the establishment of local supply chains. For example, the closure of the Komati CPP in South Africa was facilitated by a US $497 million loan from the World Bank Group, with an estimated US $47.5 million allocated to creating new opportunities for affected workers and communities [38]. Active involvement of local stakeholders, including civil society and non-governmental organizations, in the planning, decision-making and implementation process is necessary to promote transparency and accountability and ensure tangible economic and social benefits.

The Komati CPP experience underscores the value of early planning, active community involvement and securing funding in advance to ensure a successful just energy transition (see Box 4). Lessons learned, such as separating plant operations from site repurposing, investing in workforce skills development and promoting economic diversification, are being applied by Eskom (an electricity public utility in South Africa) at other sites, such as Grootvlei and Hendrina. Achieving a just transition requires a balanced focus on both repowering and repurposing, supported by strategic planning and robust collaboration. Ongoing development and coordinated localization efforts, backed by all stakeholders, are essential for long term impact.

BOX 4: Insights from the Komati experience

(Courtesy of Eskom)

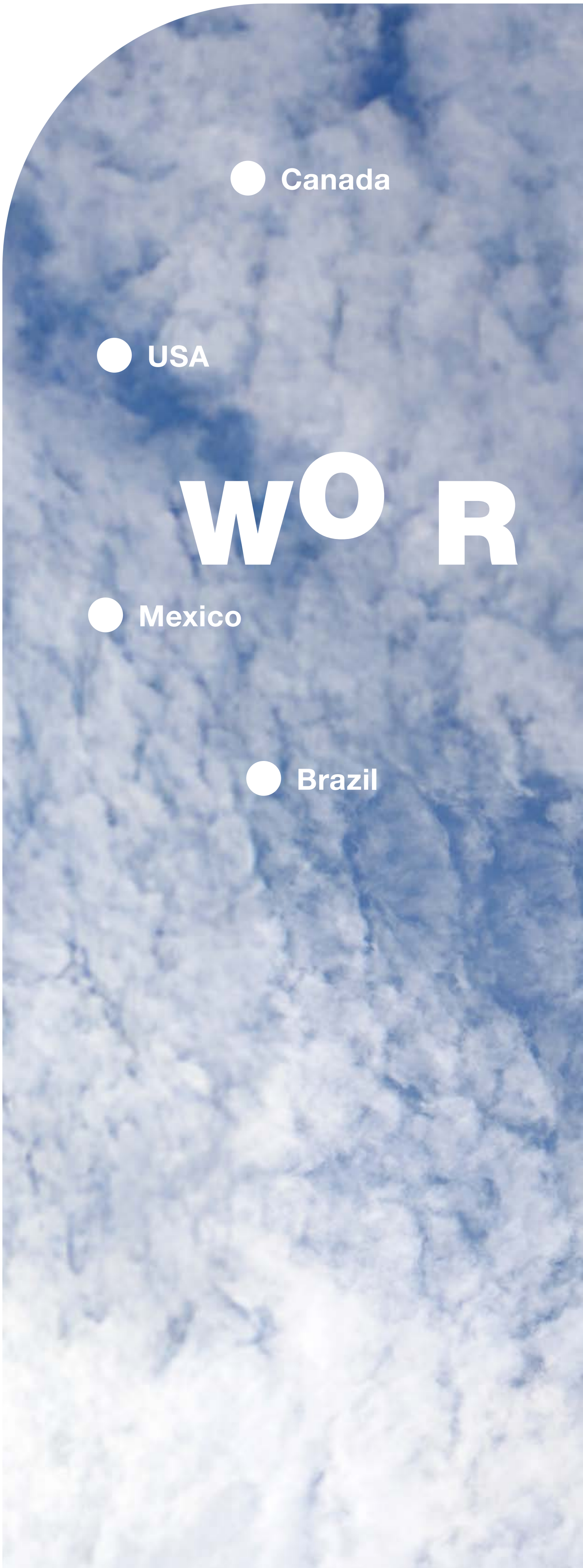
PARTNERSHIPS	All affected parties need to share experiences and collaborate to achieve a truly just transition.
FUNDING	Economic diversification is key and must align with supply and demand principles at the site and adjacent sites.
PLANNING	Upfront preparatory work is critical in identifying impacts and supporting project design and implementation strategy.
REPOWERING AND REPURPOSING	Repowering provides construction jobs, but repurposing has the potential to contribute to socio-economic development. Repowering alone is insufficient to drive a just transition.
TRAINING	Community, staff and contractor upskilling and reskilling are identified as key to delivering a just transition.
SOCIAL DIALOGUE	Community engagement is critical, with localization needing preferential materials, efforts and skills supported by all stakeholders.

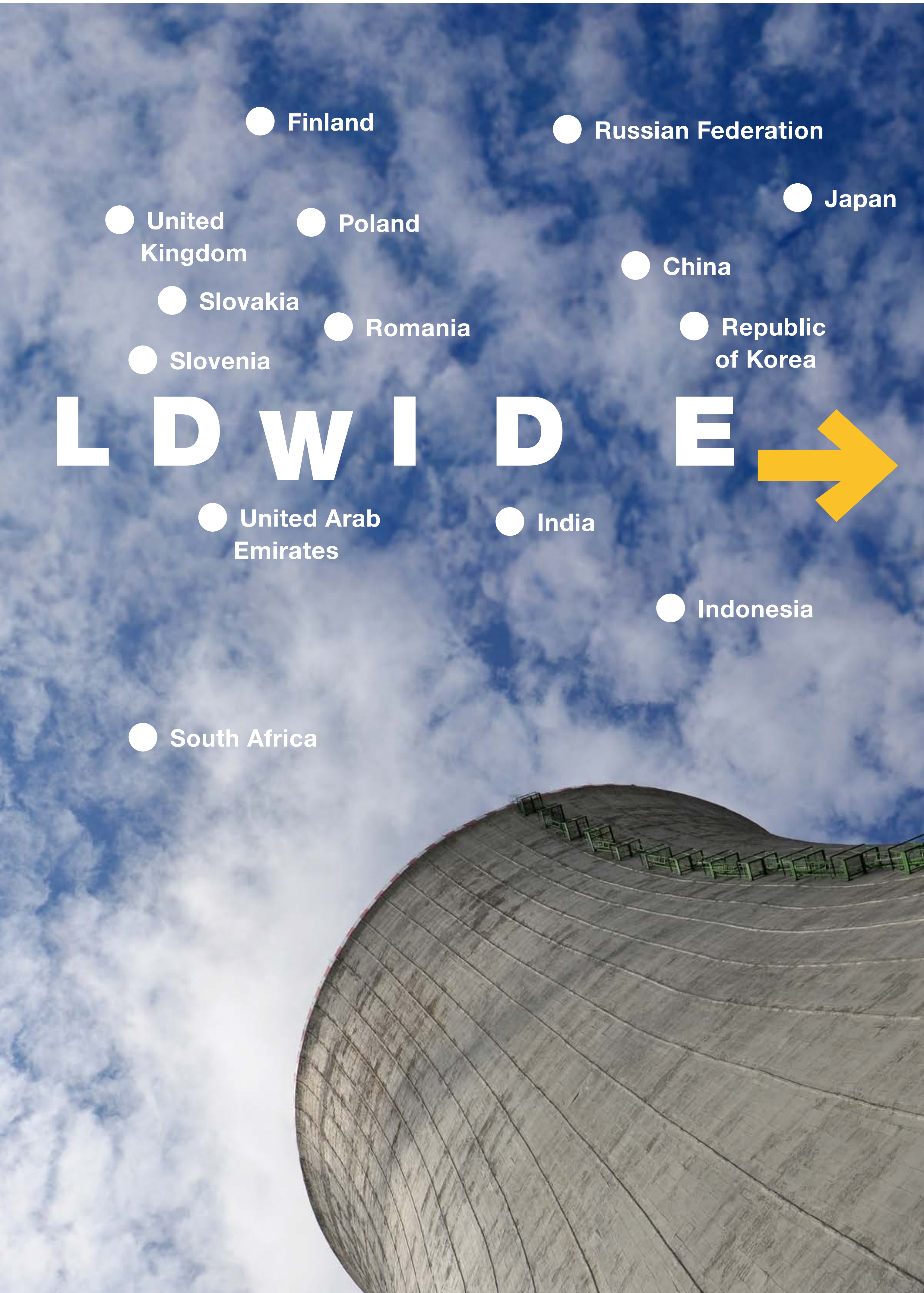
IAEA Director General Rafael Mariano Grossi with Mayors attending the International Conference on Stakeholder Engagement for Nuclear Power Programmes 2025 at the IAEA headquarters in Vienna, Austria, May 2025.

The overall effects of the transition on the coal industry, especially on coal mining communities, are not analyzed in depth in this study but would also require thorough consideration. It is important to highlight that many countries rely heavily on fossil fuel exports or domestic supply for economic stability and employment. For example, the International Energy Agency (IEA) has estimated that the coal sector employs 3.4 million people in China, 1.4 million in India and 470 000 in Indonesia [39]. When indirect employment is included, India alone has nearly 20 million people dependent on coal [40]. While such industries bring economic benefits, they leave communities highly vulnerable to mine closures or policy driven transition, often requiring re-skilling and coordinated job creation efforts. Research suggests that for many coal mining towns, coal is central to their identity, making the social and cultural transition as important as the economic one [39, 41]. A recent publication from the Asian Development Bank (ADB) [42] indicates that energy transition challenges are not limited to coal — similar disruptions could occur with petroleum, liquified natural gas or outdated renewable technologies — and governments will need to act early in coordination with regional authorities, to diversify economies and prevent future mono-industries in vulnerable regions.

EXAMPLES OF FOSSIL-TO-NUCLEAR PROJECTS WORLDWIDE

Many countries around the world are increasingly exploring nuclear power, and SMRs in particular, as an alternative to fossil fuels to fulfil their energy needs, diversify and secure their energy supply, support sustainable economic growth and achieve increasingly ambitious climate targets. In recent years, numerous countries have been actively conducting assessments to explore the feasibility of transitioning their energy systems from fossil based to nuclear energy systems for heat and electricity production, including among others Brazil, Canada, China, Finland, India, Indonesia, Japan, Mexico, Poland, the Republic of Korea, Romania, the Russian Federation, Slovakia, Slovenia, the United Arab Emirates, the United Kingdom and the USA. The following sections outline several of these fossil-to-nuclear case studies and initiatives.





Finland

Russian Federation

Japan

United Kingdom

Poland

China

Slovakia

Romania

Republic of Korea

Slovenia

L D W I D E

United Arab Emirates

India

Indonesia

South Africa

The Potential for a Coal-to-Nuclear Transition

In 2017, the Government of Brazil incorporated the Paris Agreement into national law through Presidential Decree No. 9073 of 2017. By 2022, discussions surrounding the just energy transition for Brazil's coal sector gained national attention, culminating in laws that established the Just Energy Transition Program. In this evolving context — and drawing on coal-to-nuclear initiatives of Eastern European countries and the USA — the Brazilian Association for the Development of Nuclear Activities (ABDAN) conducted a study in 2024 to assess Brazil's potential for transitioning CPPs (Fig. 4) to NPPs using SMRs.

In the study's first phase, ABDAN identified all 12 CPPs in Brazil, including four belonging to a single complex, with a combined capacity of 3.1 GW. Then, based on the location of each plant, an individual analysis was conducted to identify and specify the existing infrastructure (transportation, grid connection, water intake and treatment, etc.), proximity to population centres, geographic and socioeconomic factors, operational time, capacity factors and ownership details. By comparing these data, the plants were ranked according to the potential of each site for a coal-to-nuclear transition, with special consideration given to the proximity to natural gas and transportation infrastructure.

The study concluded that 9 out of the 12 plants have potential for a coal-to-nuclear transition. However, two of these plants were deemed economically unfeasible due to their proximity to existing natural gas infrastructure.

Given that 86% of Brazil's electricity mix is composed of renewable sources [43], replacing the existing CPPs with SMRs would further reduce emissions while enhancing resilience, inertia and the overall stability of the national power grid.

(Courtesy of ABDAN)

Fig 4: Two coal-fired power plants located in Brazil (courtesy of ABDAN).

Eliminating Coal-Fired Electricity Generation

Eliminating coal in the province of Ontario, Canada represents the largest action to reduce greenhouse gas emissions in North America. Jointly, the Ontario Ministry of Energy, Ontario Power Generation (OPG) — a Crown corporation and Ontario's largest electricity generator— and the Independent Electricity Systems Operator took a staged approach to coal reduction to support the clean energy transition. From 2001–2015, the province closed five coal-fired generating stations and passed two pieces of legislation to demonstrate its commitment to eliminate coal: Cessation of Coal Use Regulation (2007) and Ending Coal for Cleaner Air Act (2015).[1]

Nuclear energy played a critical enabling role for Ontario to eliminate the use of coal power to generate electricity (Fig. 5). In 2003, coal accounted for 25% of the province's electricity; by 2014, that figure dropped to zero. Nuclear energy replaced most of coal power, providing a reliable, low-emission alternative.

As of 2024, nuclear power provides approximately 51% of Ontario's electricity and 15% of Canada's total generation. With electricity demand rising and decarbonization goals in focus, Ontario and OPG are expanding nuclear capacity—advancing SMR projects, leading the G7 in SMR deployment and assessing opportunities for new large-scale reactors. OPG is advancing plans to build up to four SMRs at the Darlington site, with construction of Unit 1 underway, according to the Conference Board of Canada. The project could contribute CAD $38.5 billion to Canada's GDP and support over 3700 full-time jobs annually over a 65-year period. OPG estimates that each 300 MW SMR could reduce CO_2 emissions by 0.3–2 Mt per year.[2]

(Courtesy of OPG)

BWRX-300 SMR
(a light-water-cooled, boiling-water reactor)

GE Hitachi Nuclear Energy, USA and Hitachi-GE Nuclear Energy, Japan

300 MW

electricity

Fig. 5: Bruce Nuclear Generating Station, Ontario, Canada (courtesy of Bruce Power).

[1] Access the text of Cessation of Coal Use Regulation (2007) and Ending Coal for Cleaner Air Act (2015) at https://www.ontario.ca/laws/regulation/070496 and https://www.ontario.ca/laws/statute/s15025

[2] For more information, please visit OPG's website at https://www.opg.com/

The Haiyang District Heating Project

The Haiyang NPP District Heating Project replaces the steam generated by 12 coal fired boilers in Haiyang, China with steam extracted from two nuclear power units of 1170 MW, while simultaneously achieving the transformation and upgrading of the district heating infrastructure (Fig. 6). The expansion of the district heating network in the future in the cities of Haiyang and Rushan, with new heating pipelines and heat source distribution centres will further promote long-distance heating pipelines and cross-regional interconnection, as well as increase the stability and reliability of heating.

The heating quality in Haiyang has already improved significantly, while the heating prices for residents have decreased from 22 yuan/m^2 to 21 yuan/m^2, a total reduction of about 6 million yuan per heating season. In addition, as workers now maintain heat exchange stations and pipelines instead of operating coal-fired boilers, this has resulted in a cleaner work environment with improved health conditions.

The Haiyang NPP District Heating Project has served as a clean heat source of 14.32 million GJ for six heating seasons, saving 1.29 million tons of raw coal consumption and reducing carbon dioxide emissions by 2.37 million tons. Compared with the air quality during coal-fired heating, the air quality in Haiyang and Rushan has significantly improved: the average concentration of PM10 in Haiyang decreased by 43% during the heating season and in Rushan by 8.7%. Moreover, the nuclear heating system effectively recovers the heat that was originally to be discharged into the environment; as a result, during the heating season the ocean area around the Haiyang Nuclear Power that has a temperature rise of two degrees Celsius has decreased by 41 hectares. Furthermore, the combined heat and power supply of nuclear power units can increase the thermal efficiency from 36.69% to 55.9%.

(Courtesy of SNERDI)

AP1000 large reactor
(a light-water-cooled, pressurized water reactor)

Westinghouse Electric Company, USA

1170 MW (two reactors)

district heating

Fig. 6: The map depicts the Haiyang NPP district heating network (courtesy of SPIC Haiyang NPP).

The LDR-50 Project

Heat-only SMRs (e.g. Steady Energy's LDR-50) offer a cost-effective way to decarbonize heating in areas with district heating systems serving individual households and businesses. In countries such as Denmark, Finland and Sweden, district heating supplies approximately 50% of space heating needs (including hot potable water) — and up to 90% in bigger cities such as Helsinki, Finland. Interest in heat-only SMRs is growing among utilities in Finland, with three projects underway in the cities of Helsinki, Kuopio and Kerava. Kuopion Energia is conducting environmental impact assessments and zoning processes, while Helsinki's local utility, Helen, is tendering for potential suppliers to replace its combustion-based heat assets (fossil fuels and biomass) with nuclear heating plants together with heat pumps and electric boilers. The aim of these utilities is to control production costs, reduce CO_2 emissions, increase security of supply and limit the consumption of natural resources, such as forest-based biomass.

Steady Energy aims to have its heat-only LDR-50 reactor ready for construction by 2028 (Fig. 7). The company has successfully closed a €32 million funding round in July 2025 and will now begin constructing a full-scale pilot plant [44]. The reactor design, started in 2020 under Finland's Technical Research Centre (VTT) and taken over by Steady Energy in May 2023, involves 40 in-house experts and over 200 professionals from organizations across Europe.

Key partners include Tractebel, Fortum, VTT, LUT University, Sweco and Framatome. To speed up licensing, Steady Energy will start construction of a full-size pilot plant in the turbine hall of a recently decommissioned CPP in downtown Helsinki. Using electric heating instead of nuclear fuel, the facility will test operational systems and help establish supply chains for future plant construction. Steady Energy aims to start construction of 80 LDR-50 units by 2040, potentially creating 700 direct full-time employees for an individual unit. A rough estimate for the 80-unit target would be around 56 000 full-time employees over the next 15 years across areas such as design, construction and component manufacturing.

(Courtesy of Steady Energy)

LDR-50 SMR
(a light-water-cooled, pressurized-water reactor)

Steady Energy, Finland

50 MW

district heating

Fig. 7: Steady Energy's heat-only nuclear facilities are built underground (courtesy of Steady Energy).

The NuScale Project

An SMR project that features six 77 MW modules of NuScale technology is expected to be located at the preferred site of Doicesti, Romania, which is approximately 100 km northwest to the capital Bucharest. The site, a former CPP decommissioned during the 2010s, was one of the main baseload energy producers for more than 50 years.

The nuclear energy company Nuclearelectrica (SNN) and the project company, RoPower Nuclear, are prioritizing proactive engagement with the Doicești coal community to ensure a just and beneficial energy transition. Their efforts include conducting public consultations and information sessions to foster transparency and address community feedback regarding the SMR project. Recognizing the skills of the local workforce, they are exploring partnerships with educational institutions to develop targeted retraining programmes for nuclear and SMR operations and maintenance. Furthermore, RoPower and SNN are actively investigating avenues for local economic diversification and engaging with local businesses to explore their potential roles in the SMR supply chain along with the Romanian nuclear industry association, Romatom.

The pre-selection of the Doicești site, a former CPP, was the subject of an IAEA Site and External Events Design (SEED) mission (Fig. 8). The IAEA experts commended SNN and RoPower for their comprehensive and transparent approach to the site selection process, highlighting the thorough consideration of relevant factors. This international recognition underscores the robust foundation upon which the SMR project is being developed. While the final site designation is contingent upon licensing by the National Commission for Nuclear Activities Control (CNCAN), the commitment to community engagement, coupled with the positive feedback from the IAEA SEED mission, demonstrates a responsible and well considered path towards deploying clean nuclear energy in Romania.

(Courtesy of M. Amuza)

NuScale Power Module™ SMR
(a light-water-cooled, pressurized-water reactor)

NuScale Power LLC, USA

77 MW

electricity

district heating

BEFORE

AFTER

Fig. 8: The Doicești site, formerly an old CPP, has been selected by Romania as the site for the country's first SMR (courtesy of E-INFRA).

Project Phoenix

Slovakia has received a grant under Project Phoenix, which is implemented under the U.S. Department of State's Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology (FIRST) Program to support the transition from CPPs to SMRs. The grant will fund a comprehensive feasibility study, including site and technology assessments, as well as an overview of financing, licensing and project management considerations. Several potential sites are currently under evaluation in Slovakia, including existing nuclear facilities, greenfield locations and former coal plant sites. One of the key focus areas is the former coal plant site in Vojany, located in eastern Slovakia — a region with a relatively high unemployment rate. According to recent localization studies, the construction of a single SMR unit could generate between 7700 and 9400 job-years (Fig. 9) and create 430 to 640 full-time jobs during the operational phase. These figures include direct, indirect and induced employment impacts. For the Vojany region specifically, the employment benefits could represent approximately 1% of the regional employment during construction and 0.7% during operation, highlighting the project's potential to significantly boost the local economy.

(Courtesy of Slovenské elektrárne, a.s.)

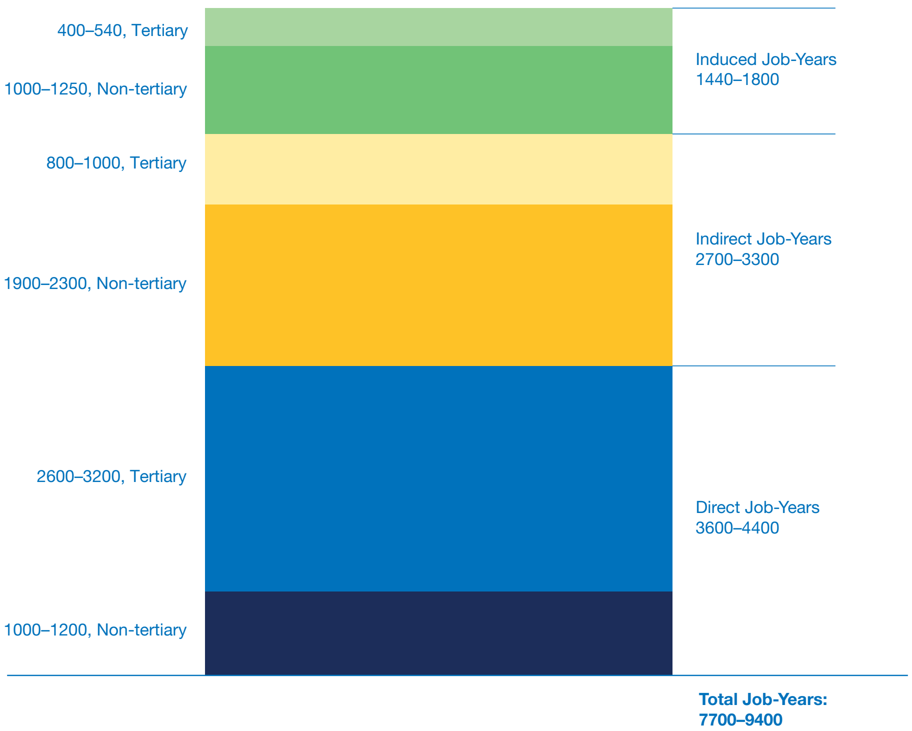


Fig. 9: The diagram shows potential employment categorized by education (non-tertiary and tertiary) and job type (direct, indirect and induced) during the construction phase in job-years (reproduced from Arthur D. Little Analysis conducted for Slovenské elektrárne, a.s.).

The Natrium Project

Ensuring a smooth workforce transition will necessitate collaboration among the utilities involved in the transition, the local governments of the affected regions and the local educational institutions. An ongoing example of a coal-to-nuclear transition is the TerraPower LLC project in Kemmerer, Wyoming, USA. TerraPower has broken ground to build its first Natrium™ plant near the site of the Naughton CPP, which was originally planned to retire in 2026. This project is being completed in a joint effort with the U.S. Department of Energy's Advanced Reactor Demonstration Program (ARDP). The Natrium™ reactor is an advanced 345 MW sodium fast reactor coupled with a molten salt energy storage system, enabling a variable supply of electricity to the grid (Fig. 10).

A key advantage of selecting a site near the retiring Rocky Mountain Power's Naughton CPP in Wyoming is the availability of a highly skilled workforce, including experienced employees from the existing facility. Project estimates indicate that approximately 1600 workers will be required at peak construction, with approximately 200–250 workers needed once the plant becomes operational to support day-to-day activities, including plant security. These long term positions are expected to remain within the community for decades following the reactor's commissioning. TerraPower is working in close partnership with local community leaders and educational institutions to ensure a well-prepared workforce, and to support a smooth transition and maintain continuity for the community.

(Courtesy of TerraPower)

Natrium™ SMR
(a sodium-cooled, fast reactor with a molten salt energy storage system)

TerraPower, LLC, USA

345 MW

electricity

Fig. 10: Power grid lines in Wyoming, USA.

The New IAEA Fossil-to-Nuclear Collaborative Project

The IAEA will launch the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) collaborative project, Fossil-to-Nuclear during October 2025. This initiative will explore strategic energy system planning by applying the IAEA's INPRO methodology [45] and tools to support participating Member States in assessing the sustainability of their energy systems when repowering from fossil fueled plants to NPPs. Relevant stakeholders and communities could benefit from a better understanding and acceptance of the strategies and adopted approaches for repowering fossil fuel fired power plants.

INPRO is a membership-based project established in 2000 to support its members with long term planning and collaboration on innovative nuclear reactors. It has a steering committee comprised currently of 46 members plus the European Commission and additional observer countries (Fig. 11). Members can choose to be involved in the collaborative project. Interested States may apply to the IAEA Deputy Director General of the Department of Nuclear Energy for INPRO membership.

INPRO Members

>> highlighted the G20 Members (blue)
>> 2025 Invitees (green) highlighted

Argentina, Canada, China, Germany, India, Kingdom of the Netherlands, Russian Federation, Spain, Türkiye, EU	**2001**	10
Brazil, Republic of Korea, Switzerland	**2002**	13
Bulgaria, Pakistan	**2003**	15
Armenia, Chile, Czech Rep., France, Indonesia, Morocco, South Africa	**2004**	22
Ukraine, USA	**2005**	24
Belarus, Japan, Slovakia	**2006**	27
Belgium	**2007**	28
Algeria, Italy, Kazakhstan	**2009**	31
Poland	**2010**	32
Jordan, Egypt, Israel	**2011**	35
Malaysia, Romania, Viet Nam	**2012**	38
Kenya	**2013**	39
Bangladesh	**2014**	40
Thailand	**2015**	41
Mexico	**2016**	42
Ghana	**2021**	43
Uzbekistan	**2022**	44
Mongolia, Rwanda, Sri Lanka	**2024**	47

Fig. 11: Members organized by the year they joined INPRO, G20 Members are highlighted in blue, and 2025 invitees are highlighted in green.

Other Relevant Initiatives

Established in 2016, the **Repower Initiative** was created to identify a sustainable pathway for transitioning away from coal-fired power in Poland [46] (see Box 5). It has since expanded to support similar efforts in China, Indonesia and the Republic of Korea with an emphasis on a broader portfolio of clean replacement technologies, including nuclear energy.

The **World Economic Forum (the Forum)** recently developed a framework to support alignment on the actions and strategies required to enable nuclear power to scale at the pace needed to support growing demand for clean energy (Fig. 12). It includes the opportunity to repower retired CPPs with advanced nuclear technology and reusing existing grid connections and infrastructure to cut costs and timelines for new nuclear projects [47].

The **Gateway for Accelerated Innovation in Nuclear (GAIN)** initiative is a public-private partnership established in 2015 by the U.S. Department of Energy through the Idaho National Laboratory [48]. It provides technical, regulatory and financial support to accelerate the commercialization of advanced nuclear technologies assisting States, utilities and communities new to nuclear energy by connecting them with the expertise of national laboratories. It has conducted various activities on coal-to-nuclear transitions, including workforce planning and stakeholder engagement.

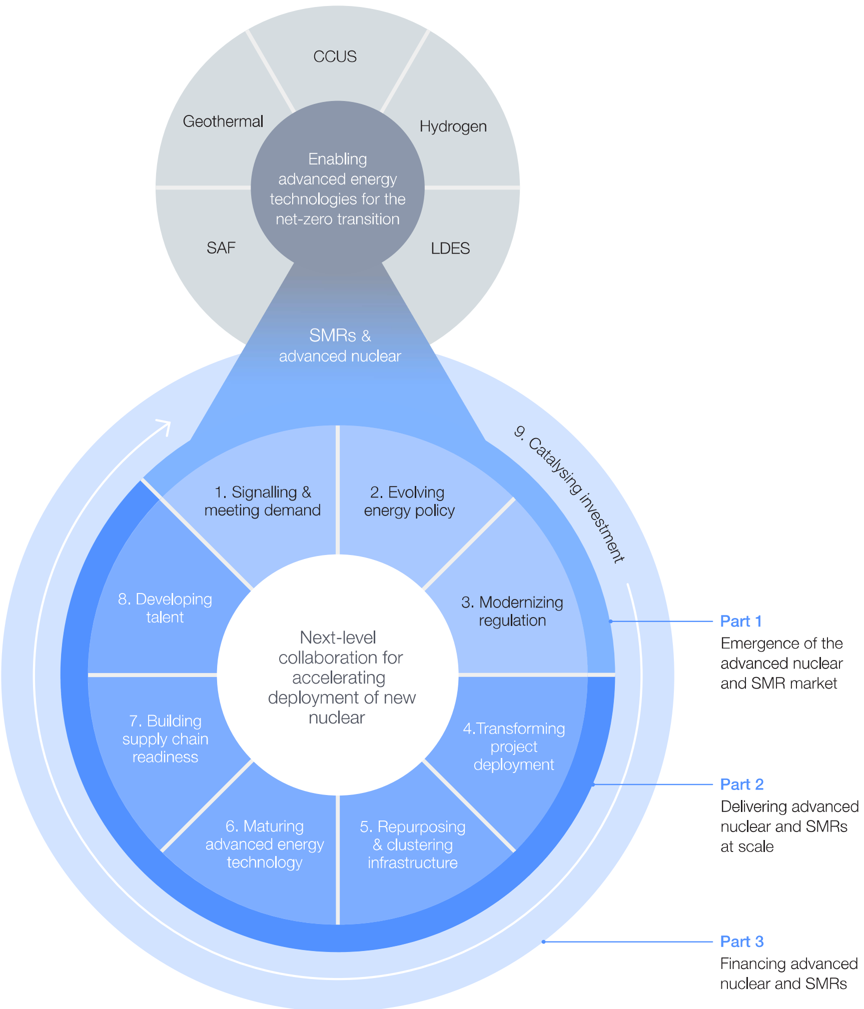


Fig. 12: The Forum framework for accelerating advanced nuclear and SMR deployment; CCUS: carbon capture, utilization and storage, LDES: long-duration energy storage, SAF: sustainable aviation fuels (reproduced from Ref. [47]).

Launched in 2017, the **Coal Regions in Transition Initiative (CRiT)** [49] serves as an open forum helping coal dependent regions across the European Union develop clean transition strategies that mitigate social impacts. The CRiT fosters a bottom-up approach, bringing together relevant stakeholders and other European Union and international initiatives to share knowledge and experiences while providing technical assistance to local communities. The **Just Transition Mechanism** [50] is the European Union's primary tool to support this initiative, aiming to mobilize around €55 billion from 2021 to 2027.

The **JUSTCOAL** project, led by the International Institute for Applied Systems Analysis (IIASA) and the Technical University of Vienna (TU Wien) with funding from Lower Austria's research promotion agency (GFF NÖ), focuses on the modelling framework to analyze regional clean transition policies, addressing socio-economic, political and technical dynamics along with potential disruptions such as technological and climate policy shifts [51].

BOX 5: Poland's initiatives to replace CPPs with a possible introduction of nuclear energy, especially SMRs

(Courtesy of the Silesian University of Technology)

Although Poland currently has no NPPs, the national Polish Nuclear Power Programme (PNPP) aims to develop 6–9 GW of nuclear capacity by 2040. Preparations are underway for the first plant in the Baltic municipality of Choczewo (Lubiatowo-Kopalino), which will comprise three AP1000 reactors. This site was among 27 listed in the original 2014 PNPP document, only four of which were connected to coal-fired power stations.

On 26 June 2025, the Government of Poland released an updated draft of its Nuclear Energy Program (PPEJ), reaffirming its dedication to nuclear power as a means of enhancing energy security, supporting decarbonization efforts and boosting industrial competitiveness. Among other elements, the draft outlines the proposed location for Poland's second NPP (EJ2), emphasizing the revitalization of coal-dependent regions in line with just transition objectives [52].

In recent years, the Polish scientific community has promoted the coal-to-nuclear transition — particularly through the DEsire project — as a means of decarbonization and just regional transformation. The initiative gained political support, with 'coal-to-nuclear' adopted as a motto by the Ministry of Industry. The tangible result was an update to PNPP 2025, which referring to the DEsire project, limited the number of potential locations for the next nuclear investment to four coal-related sites.

Bełchatów and Konin are the preferred sites, while Kozienice and Połaniec remain on the reserve list. Bełchatów is particularly noteworthy: it is home to Europe's largest CPP, which in 2023 produced 21.4 TW(h) of electricity and emitted approximately 26 million tons of CO_2. Together with the adjacent lignite mine, the complex employs nearly 8000 people.

IAEA TOOLS FOR EVALUATING COAL-TO-NUCLEAR TRANSITIONS

The IAEA developed several methodologies and tools that can support interested Member States in conducting comparative analyses of transitions from fossil fuels to nuclear power. These tools span across energy system analyses and planning [53] and assessing the suitability and sustainability of nuclear-based transitions, including economic, safety, waste management, proliferation resistance, infrastructure and environmental impacts [45].

Furthermore, the IAEA Milestones publication [54] details the activities to initiate and implement a new nuclear power programme and outlines the necessary infrastructure issues that need to be considered to facilitate the development of the nuclear power programme. Those infrastructure issues include 'soft' issues such as legal and regulatory frameworks and human resources and 'hard' issues such as electrical grids and supporting facilities. Some of those infrastructure issues are common to all electricity generation facilities, meaning that existing infrastructure from a decommissioned CPP could be re-used for an NPP on the same site.

Such analyses can support decision makers in designing effective policies and guiding the development of the energy sector and its connections to the economy and the society at large. The most relevant of these tools are described in the following sections.

The EMPOWER Tool: Assessing the Contribution of Nuclear Energy to Economic Development

The IAEA developed the extended IOM for sustainable power generation (EMPOWER) tool to support the activities of its Member States in quantifying the macroeconomic impacts of their nuclear power projects. The EMPOWER tool is an extended IOM that can assess the macroeconomic impacts of the construction and operation of nuclear and other power plants through four consecutive submodules, depending on data availability and analysis scope (Fig. 13). The economic feedback mechanisms in the tool include direct and indirect effects, induced effects, labour market response, feedback from financing (ex-ante and ex-post), and feedback from new power generation.

National case studies carried out by Member States participating in a coordinated research project on Assessing the National Economic Effects of Nuclear Programmes applied the EMPOWER tool in their analysis of the contribution of nuclear power to socioeconomic development [55]. Some Member States participating in a coordinated research project on Economic Appraisal of Small Modular Reactor Projects: Methodologies and Applications, which was closed in 2024, also assessed the macroeconomic impacts of constructing and operating SMRs using the EMPOWER tool. The objectives of these national case studies included assessing the macroeconomic impacts of deploying SMRs in relatively small economies and progressively deploying several SMRs in newcomer countries. Preliminary study results in both contexts indicate that the localization rate is an important determinant of the magnitude of the likely impacts on the economy.

EMPOWER Submodule ABCD

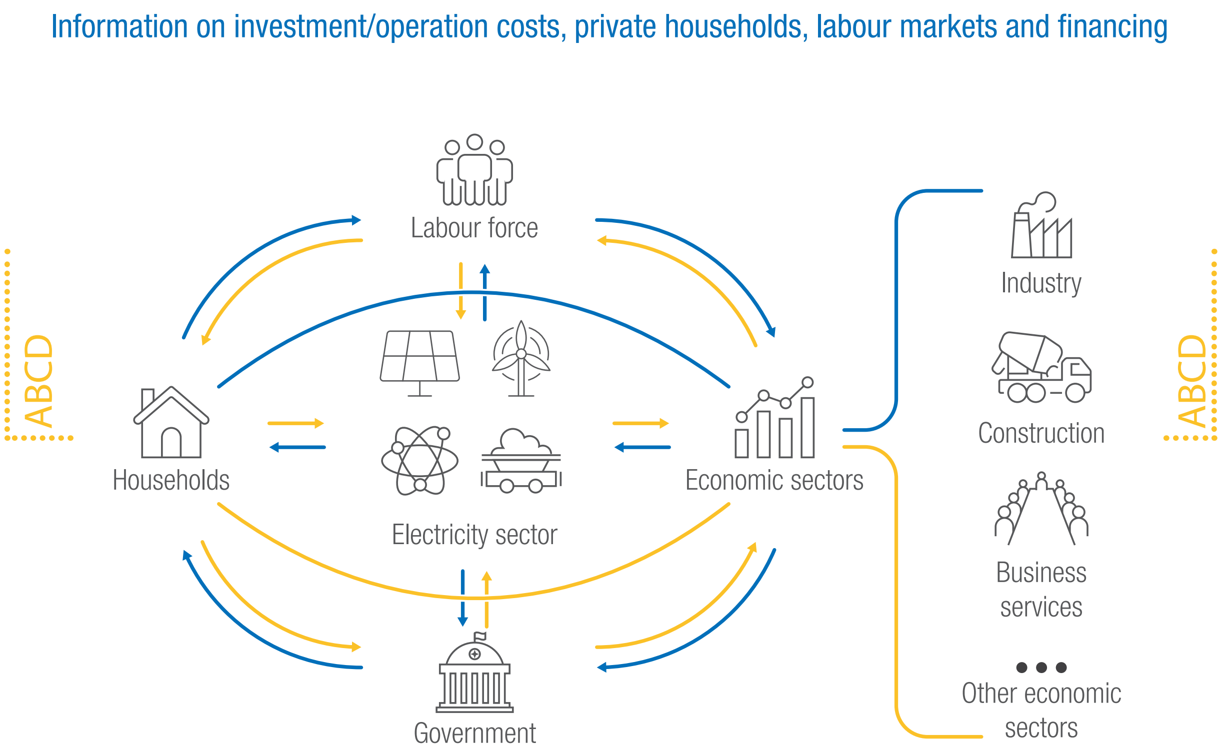


Fig. 13: Schematic representation of the EMPOWER submodule ABCD, which uses information on investment/operation costs, private households, labour markets and financing to assess macroeconomic impacts of the construction and operation of nuclear and other power plants (reproduced from Ref. [6]).

The Strategic Environmental Assessment for Nuclear Power Programmes

Strategic environmental assessments (SEAs) for energy strategies, policies and plans play a vital role in addressing key issues such as total energy demand, the energy mix and the role of nuclear energy. These assessments are followed by more specific environmental impact assessments, which evaluate project-level details, such as the construction of NPPs or spent fuel storage facilities.

The primary objective of an SEA is to prevent, minimize or mitigate significant environmental impacts while promoting positive environmental and sustainability outcomes of policies, plans and programmes. As a key decision-support tool, the SEA helps ensure that policy and planning decisions are environmentally sound.

IAEA Nuclear Energy Series No. NG-T-3.17, Strategic Environmental Assessment for Nuclear Power Programmes: Guidelines [56], offers practical guidance for conducting SEAs, outlining tools for assessment and quality review throughout the process (Fig. 14). The SEA process includes eight core elements: screening, scoping, stakeholder engagement and public participation, assessment, reporting, decision making, monitoring and follow-up, and quality review. Central to the SEA for a nuclear power programme is the assessment itself, which runs in parallel with programme development and remains closely aligned throughout. Stakeholder engagement is essential for identifying and addressing public acceptance issues. Ultimately, the effectiveness of an SEA depends on its ability to feed its findings into decision making and guide subsequent developments, supported by continuous quality assurance — ideally carried out by an impartial external body.

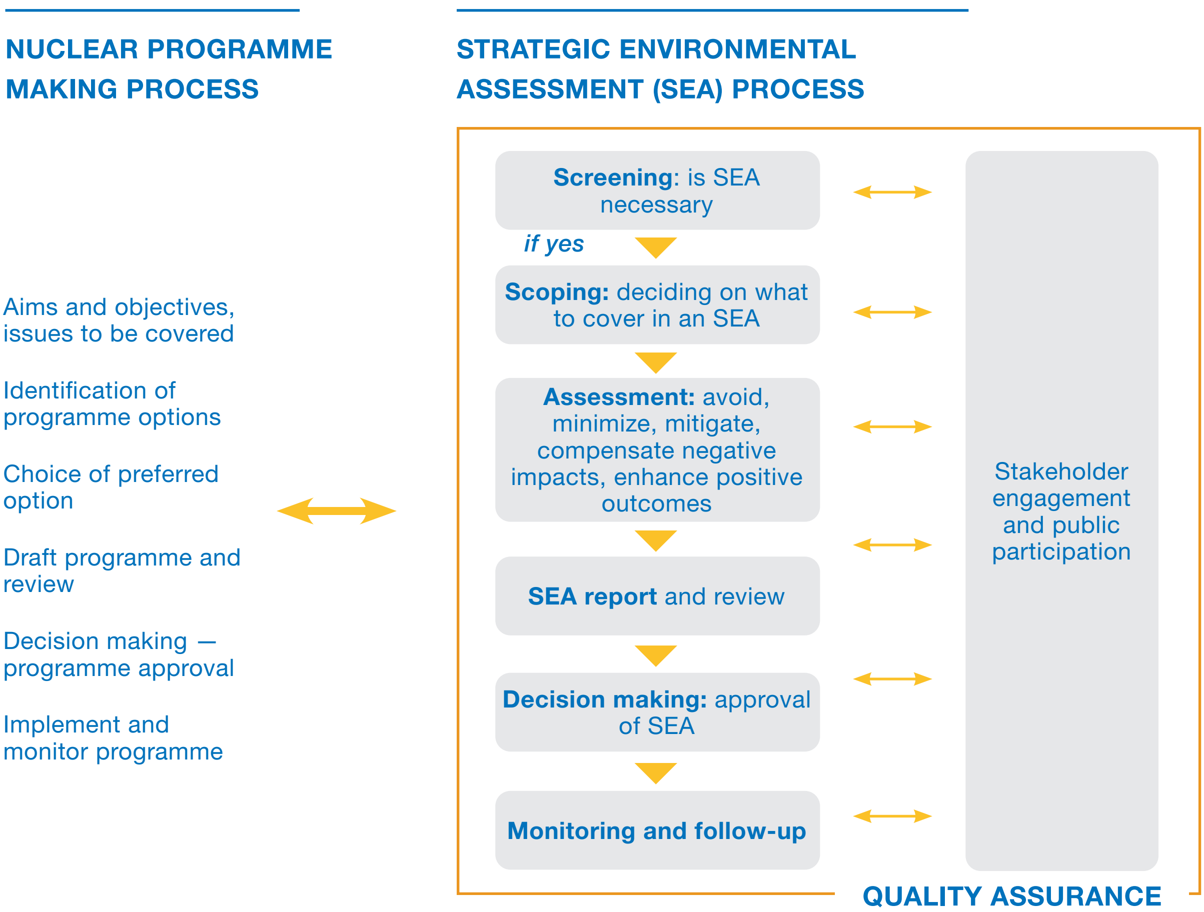


Fig. 14: The IAEA SEA process and integration with nuclear power programme preparation (reproduced from Ref. [56]).

The KIND-ET tool for Comparative Analysis of Energy Systems

In preparing fossil-fueled power plants for replacement with NPPs, States can conduct comparative analyses using the IAEA KIND-ET (Key Indicators for Innovative Nuclear Energy Systems) tool developed by INPRO (Fig. 15) [57]. The analysis uses multi-criteria comparative evaluations of nuclear energy systems (NESs). By setting high level objectives, identifying evaluation areas and key indicators, and then specifying the weighting factor, KIND-ET users can evaluate in terms of prospects, benefits and risks of NESs with distinct technologies under various circumstances. Tool outputs provide overall ranks considering NES performance and incorporating experts' and decision makers' preferences. The KIND-ET analyst can create scenarios using different weights for important evaluated factors and compare the rankings. The comparison of various nuclear technologies in NESs supports decision makers in setting priorities to achieve a clean energy transition.

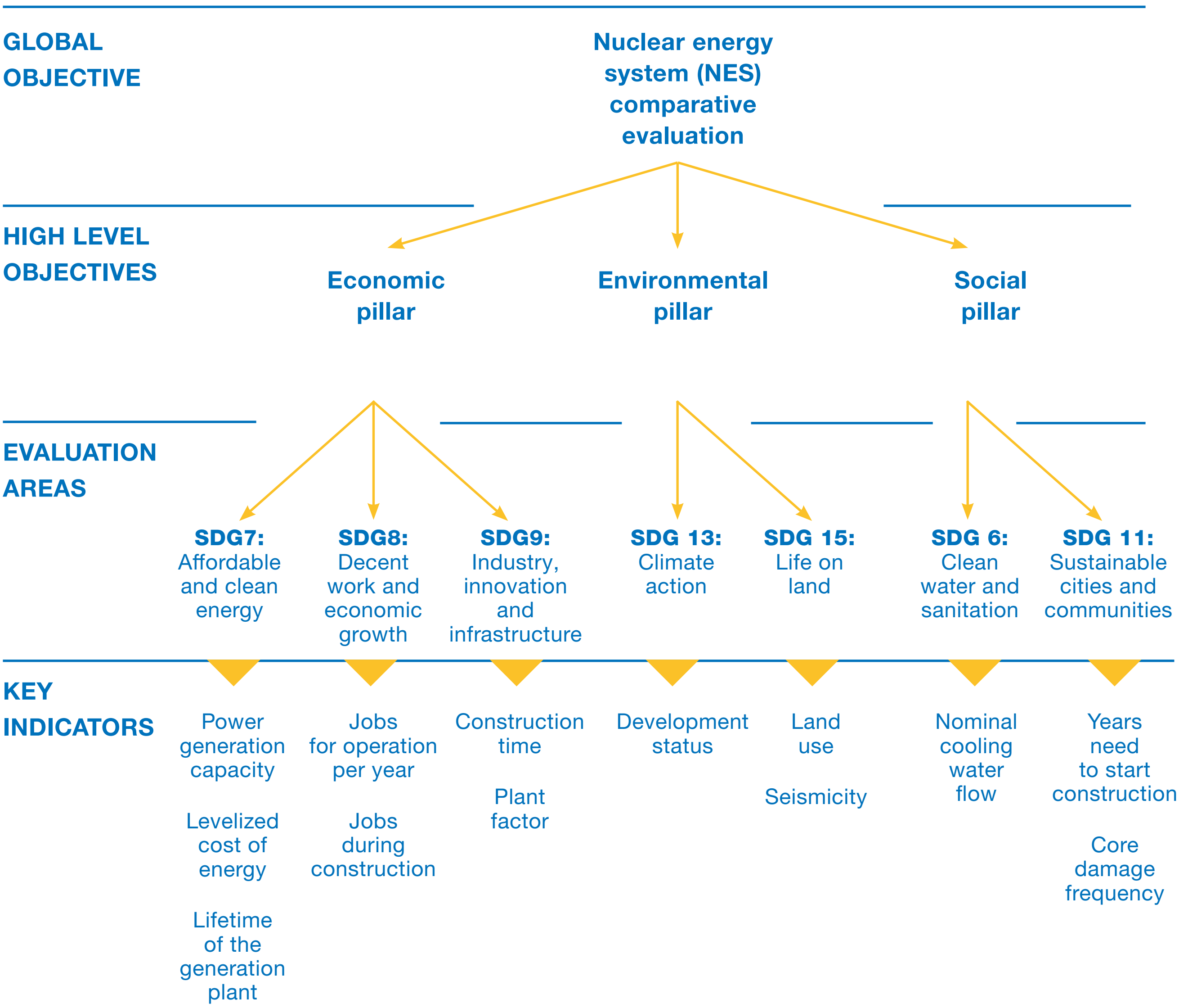


Fig. 15: The KIND-ET objectives tree (reproduced from Ref. [57]).

An example of KIND-ET's application is a case study performed by the National Autonomous University of Mexico (UNAM), which examined the deployment of three different SMR power plants (hereinafter referred to as SMR-1, SMR-2 and SMR-3) aimed at achieving a nuclear contribution of approximately 10 000 MW(e) to Mexico's energy mix by 2050. In this study, economic, environmental and social pillars were chosen as high level objectives (Fig. 16). The values for the key indicators were taken from publicly available information, and some of them were provided via direct communication with the vendors and their weights were assigned based on expert judgment and decision maker's preferences. Two scenarios with different prioritization of economic, environmental and social pillars were employed for the analysis (Fig. 16). The overall ranks for three different NESs obtained by KIND-ET could support identifying SMR scenarios which are in line with the sustainable energy development strategy of Mexico (Fig. 16).

IAEA Director General Rafael Mariano Grossi delivered remarks at the International Conference on Small Modular Reactors (SMRs) held at the IAEA headquarters in Vienna, Austria, October 2024.

KIND-ET Results for Three SMRs in Two Different Scenarios

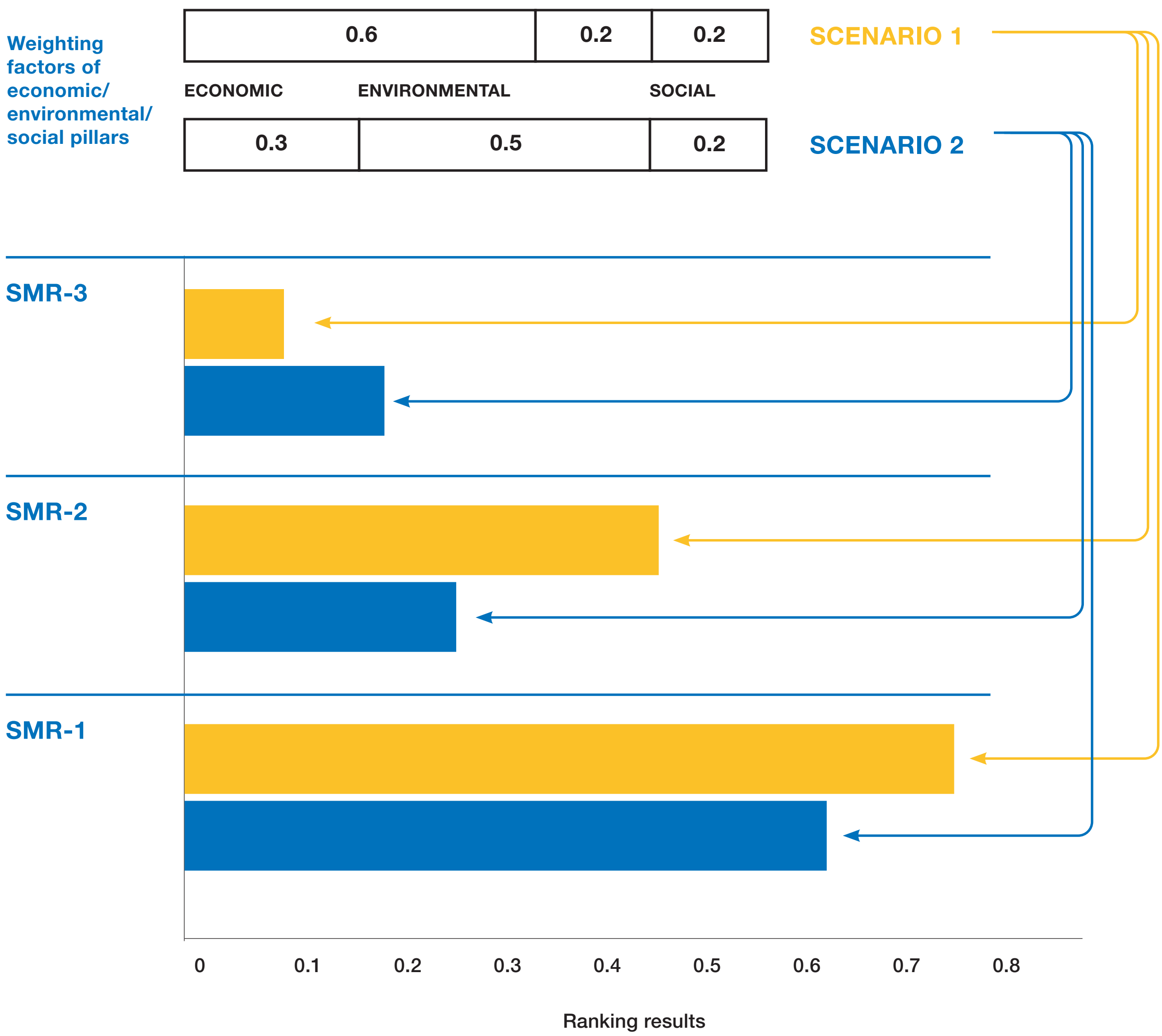


Fig. 16: The KIND-ET results for the three SMRs in two different scenarios (courtesy of the National Autonomous University of Mexico).

SUSTAINABLE DEVELOPMENT POLICIES SUPPORTING CLEAN TRANSITIONS

Effective policy frameworks are essential for creating a supportive environment that encourages investment and the development of clean energy technologies while ensuring that the shift away from fossil fuels is fair and inclusive. Financing a sustainable energy transition is critical to unlocking the capital needed to develop nuclear infrastructure and accelerate the move towards a low-carbon energy future. These sections focus on the key factors driving a successful transition from coal-to-nuclear energy, emphasizing the importance of enabling policy frameworks, Just Energy Transition Partnerships (JETPs) and sustainable financing.

Enabling Policy Frameworks for a Clean Energy Transition

To date, approximately half of G20 members, and countries invited to the G20 in 2025, reference nuclear energy in their most recent nationally determined contributions (NDCs) under the Paris Agreement or in their National Energy and Climate Plans (NECPs) submitted to the European Commission and include it as option in their long-term low emissions development strategies (LT-LEDS) (Fig. 17). Several of these G20 countries are among those most dependent on fossil fuels (particularly coal) for electricity production, and collectively, they produce over 90% of the world's coal-based electricity (Fig. 18).

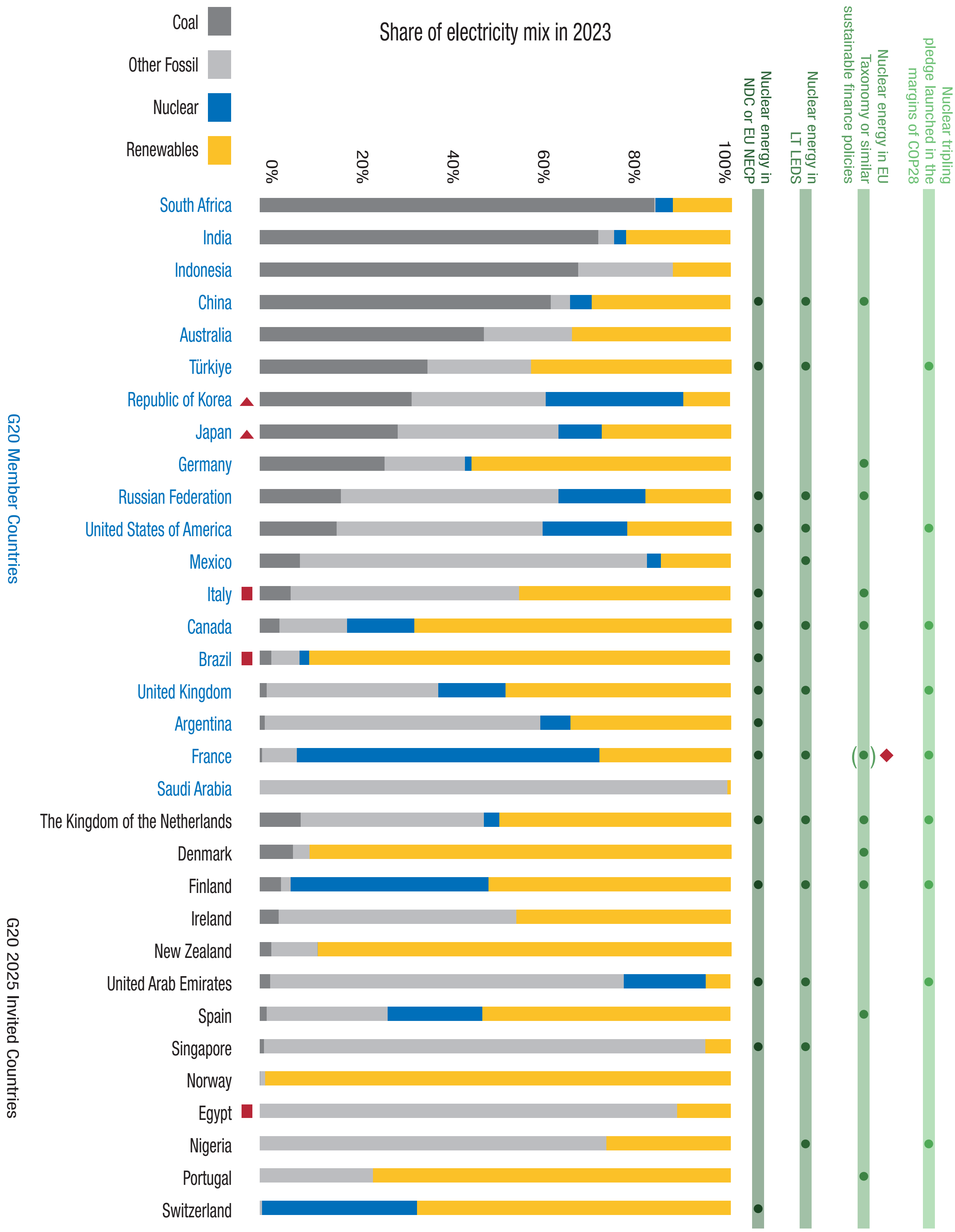
Nuclear energy is included in regional or national sustainable investment taxonomies, or similar frameworks, in about half of the countries within this group (Fig. 17). The recognition of nuclear energy in sustainable investment taxonomies (such as the European Union taxonomy for sustainable activities [58]) and national sustainable bond frameworks (such as those in Canada [59] and Japan [60]) is facilitating the acceptance of nuclear energy technologies and builds confidence among environmental, social, and governance (ESG) conscious investors. This inclusion could further catalyze the involvement of commercial financial institutions, where multilateral development banks (MDBs) could support financing of nuclear projects, particularly in low and middle income economies with limited financial market maturity and higher perceived investment risks [61].

Nuclear power is 'making a comeback' around the world, with small modular reactors (SMRs) becoming a potential gamechanger. Provided government support, innovation and new business models can bring down their costs, SMRs could account for over 10% of all new nuclear capacity globally by 2040. In this context, I very much welcome the IAEA report which offers a very important perspective, as the industry is looking to reduce costs. Repurposing or replacing former coal or gas power plants with SMRs may offer a promising solution for transitioning to low-carbon energy systems by making use of existing infrastructure. The latest IEA analysis* illustrates that SMRs are well-suited to replace retired coal facilities due to their comparable power output and the availability of existing infrastructure, such as grid connections and water resources. Such brownfield projects would not only lower land acquisition costs but also facilitate permitting processes, which both remain key roadblocks in many countries around the world.

**International Energy Agency, The Path to a New Era for Nuclear Energy, 2025 https://www.iea.org/reports/the-path-to-a-new-era-for-nuclear-energy*

International Energy Agency Executive Director

FATIH BIROL



▲ Republic of Korea (in 1st NDC from 03/11/2016; not mentioned in update of 23/12/2021); Japan (in 1st NDC from 08/11/2016 and 31/03/2020, not in update of 22/10/2021 or 18/02/2025); Egypt (in 1st NDC submitted 29/06/2017; not mentioned in update of 07/07/2022 or 2nd update of 26/06/2023).

■ Countries that have not communicated long-term low greenhouse gas emission development strategies (LT-LEDS).

◆ Refers to alignment with the EU Taxonomy, the French Ministry of Ecological Transition included nuclear power in France's Greenfin label, which establishes the criteria for labelling investments funds as green.

Fig. 17: Nuclear energy, climate change commitments and sustainable investment taxonomies in the G20 (as of August 2025).

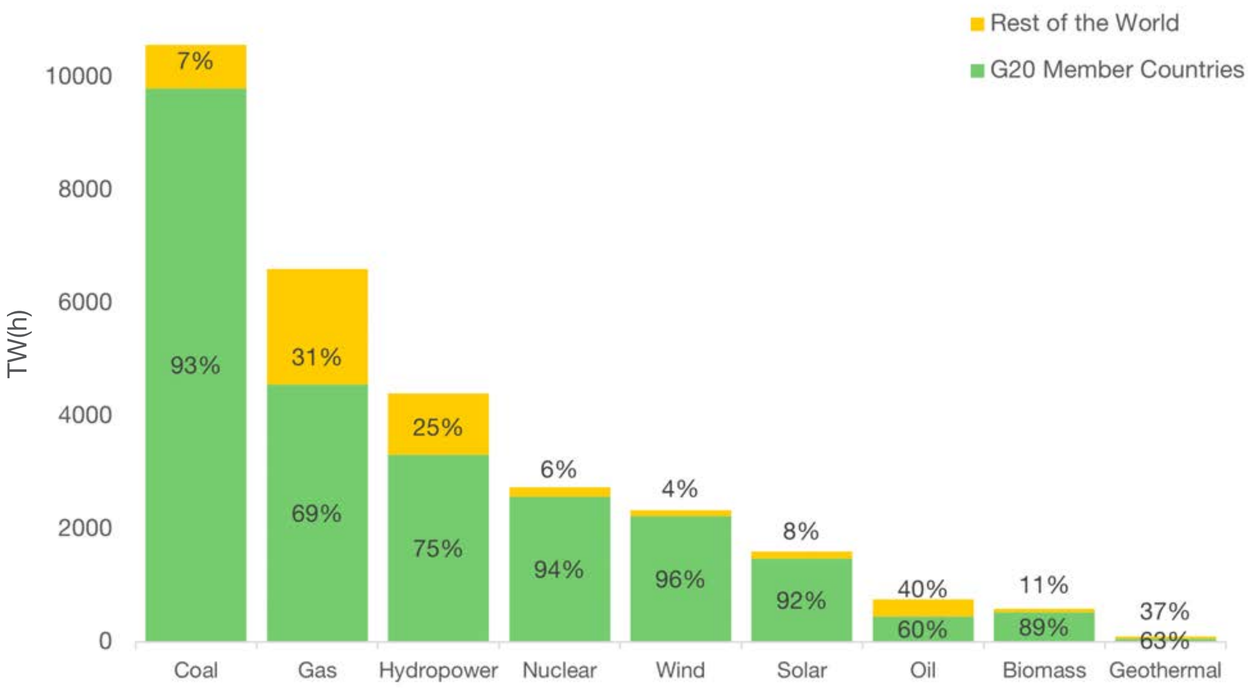


Fig. 18: Gross electricity consumption by energy source in the G20 in 2023 (data from Enerdata).

Just Energy Transition Partnerships

Just Energy Transition Partnerships serve as a multilateral platform for collaboration designed to support coal-dependent low and middle income countries in transitioning to clean energy in a way that is equitable, socially inclusive and economically viable. Just Energy Transition Partnerships focus on accelerating the energy transition by providing climate finance while ensuring the transition is socially and economically equitable [62]. According to the United Nations Framework Convention on Climate Change, 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" [63]. Just Energy Transition Partnerships combine various financial mechanisms, such as grants, concessional loans and equity investments, as well as risk-sharing instruments to mobilize private sector investment. The donor pool includes several high income countries and has expanded to include MDBs, national development banks and development finance agencies [64].

To date, the countries announced as partners in the JETPs are Indonesia, Senegal, South Africa and Viet Nam (see Box 6). While nuclear energy is referenced in all these JETPs – except for Senegal – either as an existing clean energy source or a potential long-term option, the focus remains on renewable technologies such as wind, solar and green hydrogen. In countries that include nuclear energy in their energy transition strategies, JETPs could serve as a potential financing source for nuclear energy projects. These partnerships play a crucial role in advancing climate objectives while also supporting energy access and sustainable development.

BOX 6: Insights into the South African JETP

(Courtesy of Eskom)

Announced in November 2021, the South African JETP is the first initiative of its kind aimed at supporting the country's decarbonization commitments outlined in its NDC and representing the fair contribution to achieving the goals of the Paris Agreement. The partnership initially committed to mobilizing US $8.5 billion in the first phase of financing, with the objective of reducing reliance on fossil fuels and cutting carbon emissions, while simultaneously promoting economic and social development through the decarbonization of key sectors, particularly the electricity sector [65].

ENABLERS OF A JUST TRANSITION

Obtaining and mobilizing affordable finance to enable investments in JETP projects	Leveraging collaboration to accelerate execution, catalyzing growth and securing offtake contracts	Expanding and strengthening the national grid to support a clean energy-based power system

Financing a Sustainable Energy Transition to Clean Energy: Opportunities and Challenges

The IAEA's high case nuclear capacity projections show nuclear capacity reaching 992 GW by 2050 — 2.6 times the 2024 level [66]. This projection aligns closely with the IEA estimates for reaching net zero in 2050 [67]. To meet this target, annual investment in nuclear energy would need to increase from an average of US $50 billion (2017–2023) to over US $125 billion [61]. The latest estimates for 2025 are approximately US $75 billion [68]. The tripling of the existing nuclear capacity, as pledged by 31 countries – including 11 G20 members and invitees (Fig. 17) — would require over US $150 billion per year. Mobilizing this level of investment will depend on nuclear projects being able to prove bankability by mitigating financial risks [61].

Nuclear projects are large-scale, capital-intensive infrastructure projects. When it comes to financing such projects, it is vital to ensure strategic planning and financial foresight. Financing nuclear power projects demands a balance between substantial upfront investments and long-term project sustainability. Historically, nuclear power projects were mainly financed by governments, with little involvement from the private sector. While attracting private sector capital is becoming more viable for nuclear energy projects, this involvement still requires government support to ensure the commercial funding needed in the next decades to enable sufficient and sustained deployment of nuclear power (Fig. 19) [61].

Nuclear new build projects are typically financed through a combination of government backing, public-private partnerships, offtake contracts and various other mechanisms, such as sustainable bonds (including green, social, sustainability, sustainability-linked and transition bonds) and infrastructure investment funds. Specifically for technically mature and scalable SMR designs, features such as lower upfront costs, shorter construction timelines, reduced project risk and quicker revenue generation could attract investors and lenders, thereby potentially reducing financing obstacles and lowering capital costs relative to conventional large-scale reactors [61].

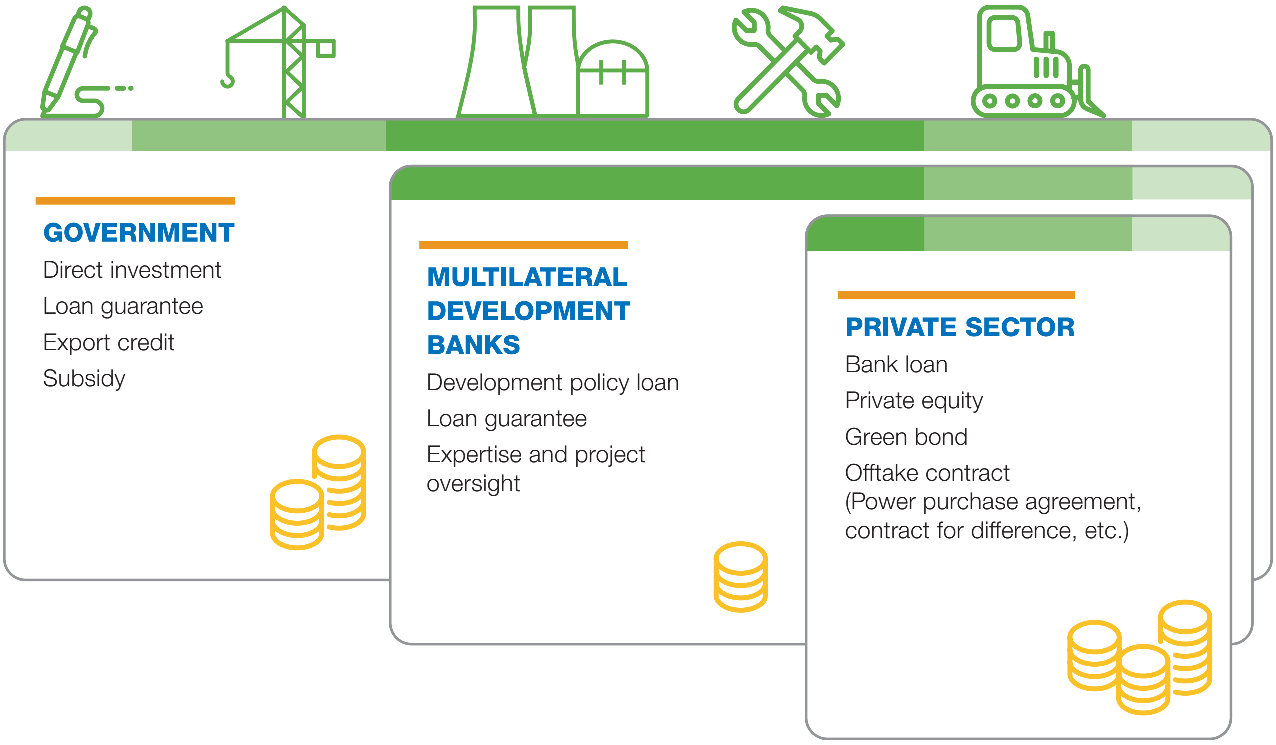


Fig 19: Nuclear power projects can be financed by governments, multilateral development banks and the private sector. Coins indicate debt/equity provided to nuclear energy projects in the future.

BOX 7: Financing pathways for new builds

- **GOVERNMENT BACKING:** Governments play a pivotal role in supporting and sustaining nuclear power initiatives through comprehensive energy planning. By offering direct investments, loan guarantees, subsidies and backing from export credit agencies (ECAs), they help to ensure financial stability and encourage private investments.

- **MULTILATERAL DEVELOPMENT BANKS:** MDBs can play an important role in financing coal-to-nuclear transitions by providing low cost capital and loan guarantees, policy support and project oversight. Recent discussions signal a shift toward a greater participation by MDBs in financing nuclear energy projects and supporting relevant capacity-building efforts. Notably, on 11 June 2025, the World Bank Group's board approved the removal of its longstanding ban on funding nuclear energy projects, marking a broader effort to address the growing electricity demand [69]. Additionally, on 26 June 2025, the World Bank Group and the IAEA signed a partnership agreement to support the safe, secure and responsible deployment of nuclear energy in developing countries, considering the projected doubling of energy demand by 2035 [70].

- **PUBLIC–PRIVATE PARTNERSHIPS:** Collaboration between public entities and private investors is a common approach in financing large-scale infrastructure projects, including nuclear energy projects. Public-private partnerships allow for the distribution of risks and responsibilities among participants while harnessing the strengths of each sector. When effectively managed, this model can provide a more resilient financial structure, mitigate uncertainties and enhance project feasibility.

- **OFFTAKE CONTRACTS**: Securing offtake agreements, such as power purchase agreements or the contract for difference scheme, with large scale users can ensure long-term revenue streams and strengthen investor confidence. These contracts offer stability in volatile market conditions and enhance the attractiveness of nuclear financing to investors. This model is currently not very common.

- **OTHER FINANCING INSTRUMENTS:** A range of financial instruments can be used to attract investments for nuclear power projects, including sustainable bonds, carbon credits and infrastructure funds. These instruments help diversify financing sources and reduce dependency on conventional bank loans, thereby enhancing resilience and flexibility of project financing.

IAEA Director General Rafael Mariano Grossi and World Bank Group President Ajay Banga during the signing of the agreement between the IAEA and the World Bank to support the safe, secure and responsible use of nuclear energy (courtesy of the World Bank Group).

The clean energy transition in emerging and developing economies has attracted support from both new public and private investors as well as development banks. This support has taken the form of direct loans with concessional terms, guarantees and insurances to improve credit and loan offerings for borrowing countries, and zero-interest grants. For instance, strong private sector involvement has enabled some countries of Latin America and the Caribbean to nearly triple their domestic climate finance, growing from US $13 billion in 2018 to US $32 billion in 2022 [71]. Although most MDBs have yet to include new nuclear investments in their portfolios — except for the recent case of the World Bank Group [72] —some state-backed development finance institutions have supported the financing of new nuclear projects. An example is the China Development Bank, which has provided Pakistan with preferential loans for its nuclear projects [73].

One of the main barriers to the clean energy transition in emerging and developing economies is the inadequate availability of climate finance, combined with the relatively young age of many CPPs. In contrast to high income countries such as Canada, the United Kingdom and the USA — where most CPPs are over 30 years old and largely depreciated — many facilities in emerging and developing economies have only become operational within the last two decades (Fig. 20). It is estimated that from the 2100 GW of global CPP capacity worldwide, 89% is in low and middle income countries, with Asia having 69% of the capacity (51% in China and 11% in India) [42]. The fact that these plants still have substantial invested capital yet to be recouped by investors is a significant obstacle to closing them early. However, continued operation in an evolving energy landscape — where coal is becoming less competitive compared to other energy sources — poses significant stranded asset risks [74].

When it comes to financing nuclear projects, it is vital to ensure strategic planning and financial foresight. Financing nuclear power projects demands a balance between substantial upfront investments and long-term project sustainability.

A recent publication from ADB [42] examines the various strategies for early retirement of plants and outlines five business models that can be applied: policy-based closure, buyout, repurposing, renewable swaps or a hybrid approach. Policy based closures can be accelerated through tools such as reverse auctions (e.g. rewards for early plant retirement), whereas buyout models offer investors a return by retiring coal assets early and investing in clean energy alternatives, which however requires significant capital and complex regulatory support. The hybrid model that blends elements of all approaches is cited as being often the most effective. Ultimately, tailored, multi-pronged approaches, backed by financing, centralized planning efforts and feasibility studies, regulation and just transition efforts, are essential to retiring CPPs at scale which entails high costs (i.e. cost associated with decommissioning, social transition and replacement infrastructure) but also offers economic and grid efficiencies (Box 8).

BOX 8: Bridging the gap — financial strategies for CPP phase-out

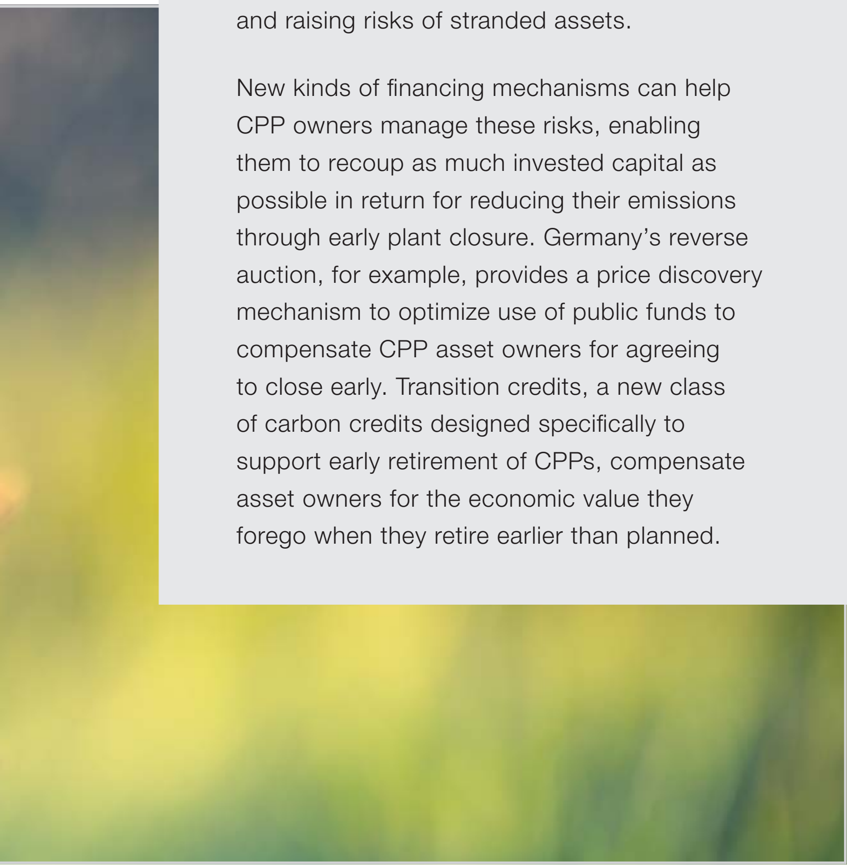
(Courtesy of the World Economic Forum)

Coal power plants are under pressure from tightening government policies, such as carbon pricing and stricter environmental controls, as well as growing competition from cheaper and increasingly available clean energy sources. These changing dynamics are putting economic pressure on CPPs, at the same time threatening revenue certainty and raising risks of stranded assets.

New kinds of financing mechanisms can help CPP owners manage these risks, enabling them to recoup as much invested capital as possible in return for reducing their emissions through early plant closure. Germany's reverse auction, for example, provides a price discovery mechanism to optimize use of public funds to compensate CPP asset owners for agreeing to close early. Transition credits, a new class of carbon credits designed specifically to support early retirement of CPPs, compensate asset owners for the economic value they forego when they retire earlier than planned.

Refinancing strategies, either through capital restructuring or assigning a CPP with cheaper debt, can also facilitate early plant closure while supporting an asset owner to manage growing revenue uncertainty and stranded assets risks. Refinancing works by reducing the cost of capital that an asset faces, thereby enabling the asset to realize the value it needs to from its CPP earlier than planned. As a result, the CPP can then close sooner.

Recent research by the Forum tested the use of refinancing as a strategy for early phase-out on ten CPPs in the Philippines [75]. It showed refinancing can result in CPPs closing early by an average of almost ten years, while delivering an early payout of up to 40% of a plant's remaining value which can be redirected towards clean energy investments.



Furthermore, existing power transmission and distribution infrastructure, which was designed for dispatchable energy sources, is often ill-equipped to integrate intermittent renewable sources such as wind or solar power. Upgrading and expanding these grids typically necessitates government funding or loans from development banks, which can pose both financial and energy security challenges. For example, South Africa's transition of the 1000 MW Komati CPP to renewable energy sources and storage (150 MW solar, 70 MW wind and 150 MW battery storage) — despite support from the World Bank Group — has not fully compensated for the loss of a stable power supply [76, 77]. In this context, investing in dispatchable, clean energy sources such as nuclear energy, which can deliver power output comparable to coal, offers a more reliable and practical alternative.

Sanmen NPP,
Zhejiang Province, China.

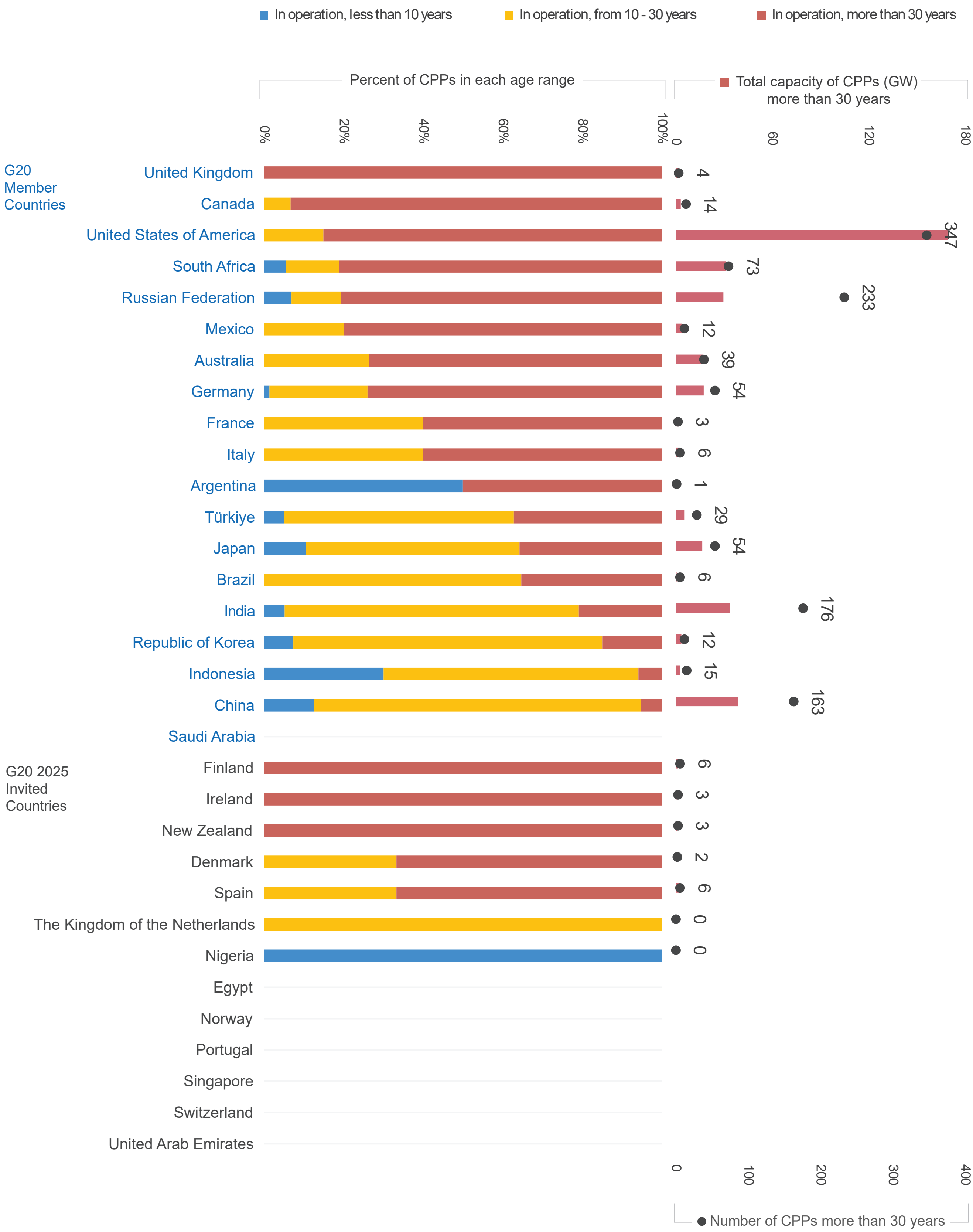


Fig. 20: Status of CPPs of G20 Members and 2025 Invitees (data from Global Energy Monitor, accessed May 2025). Note that Egypt, Norway, Portugal, Singapore, Switzerland, and the United Arab Emirates do not operate any CPPs.

CONCLUSIONS

The need to transition from high emission coal power to low carbon energy sources has never been more urgent. For coal dependent economies, this transition should not only reduce emissions but also sustain industrial development while ensuring energy security and economic growth of communities. Coal-to-nuclear transitions present a distinctive opportunity to achieve these multiple objectives simultaneously, offering governments a credible pathway to balance climate action with socio-economic development.

From a policy perspective, coal-to-nuclear transitions are not simply technical swaps but strategic interventions. Repurposing coal plant sites for nuclear power could allow governments to retain valuable coal-plant infrastructure including grid connections, water access and skilled labour. This reuse could significantly reduce upfront capital costs while maintaining parts of the socioeconomic fabric of coal dependent regions. At the same time, nuclear energy's attributes as a dispatchable, low-carbon baseload option can strengthen national capacity to achieve climate targets while ensuring security and affordability of energy supply.

Effective public policy is indispensable to mobilize investment, foster public trust and promote social equity. Establishing enabling regulatory frameworks — such as including nuclear energy in sustainable investment taxonomies, leveraging climate finance tools such as green bonds and transition credits, and acknowledging nuclear energy's role in long term strategies to deliver affordable, reliable and low emission electricity — can offer clarity and confidence to both domestic and international investors.

Financing remains one of the most significant challenges to large-scale deployment of nuclear energy, particularly in emerging and developing economies, making international cooperation and multilateral support essential. Just Energy Transition Partnerships, currently focusing mainly on transitions from fossil to renewable energy, provide a valuable platform for mobilizing grants, concessional loans and blended finance. Expanding their scope to include nuclear energy could help achieve a balanced mix of clean and reliable energy sources. Likewise, the recent partnership of the World Bank Group and the IAEA to support the safe, secure and responsible deployment of nuclear energy in developing countries marks a pivotal moment, opening new opportunities for SMR projects, including coal-to-nuclear projects, to access international development finance.

Equally essential for coal-to-nuclear transitions is a policy commitment to social equity and inclusivity. Targeted policies for reskilling workers from the fossil fuel industry, ensuring social protection, and local economic diversification, including establishing

Koeberg NPP near Melkbosstrand, South Africa.

local supply chains and manufacturing, can help ensure that the benefits of nuclear energy — secure, reliable, affordable low-carbon energy; long term, high skilled jobs; and improved public health through reduced emissions — are widely shared.

International collaboration can further strengthen the impact of national policies. The IAEA, through its suite of planning and assessment tools can support Member States build capacity and carry out technical and economic analyses to guide sustainable energy transitions and assess the potential role of nuclear energy.

In conclusion, coal-to-nuclear transitions offer governments a unique opportunity to deliver on climate commitments while supporting and promoting inclusive economic development. Moving forward, coordinated strategies that align technological innovation with policy support and community engagement while prioritizing nuclear energy within national energy strategies can help unlock the benefits of coal-to-nuclear transitions: achieving climate commitments, enhancing energy security, supporting sustainable development, and delivering a just transition for workers and communities. With strategic leadership and coordinated action, coal-to-nuclear transitions can become a cornerstone of the global clean energy agenda, enabling countries to chart credible pathway toward a just, secure and sustainable energy future.

For coal dependent economies, this transition should not only reduce emissions but also sustain industrial development while ensuring energy security and economic growth of communities.

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ABBREVIATIONS

BOP	balance of plant
DALYs	disability-adjusted life years
GDP	gross domestic product
HTGR	high-temperature, gas-cooled reactor
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles (of the IAEA)
IOM	input-output model
JETP	Just Energy Transition Partnership
LEDs or LTS	long-term low emissions development strategies
MDB	multilateral development bank
NDCs	nationally determined contributions
NES	nuclear energy systems
PM2.5 and PM10	particulate matter in the air, of particles with a diameter of 2.5 and 10 μm or less, respectively
SDG	sustainable development goal
SEA	strategic environmental assessment
SMR	small modular reactor

CONTRIBUTORS TO DRAFTING AND REVIEW

Afanasyeva, T.	International Atomic Energy Agency
Amuza, M.	Expert, Romania
Bartela, Ł.	Silesian University of Technology, Poland
Batra, C.	Steady Energy, Denmark
Chen, Y.	State Power Investment Corporation (SPIC), China
Clevesque, C.	Terrapower, LLC, United States of America
Cunha, C.	Brazilian Association for the Development of Nuclear Activities, Brazil
Dieguez Porras, P.	International Atomic Energy Agency
Dyabaza, J.	Eskom Holdings SOC Ltd, South Africa
Ganda, F.	International Atomic Energy Agency
Gavello, M.K.	International Atomic Energy Agency
Kanwar, S.	World Economic Forum, Switzerland
Lazerwitz, B.	International Atomic Energy Agency
Lion, P.	State Atomic Energy Corporation Rosatom, Russian Federation
Macpherson, W.	World Economic Forum, Switzerland
Makgae, L.	Department of Electricity and Energy, South Africa
Maphoto, K.	Department of Electricity and Energy, South Africa
Martin Del Campo Marquez, C.	National Autonomous University of Mexico, Mexico
Mbambo, Z.	Department of Electricity and Energy, South Africa
Mberia, N.	International Atomic Energy Agency
Melo, T.	Brazilian Association for the Development of Nuclear Activities, Brazil
Monale, E.M.	Department of Electricity and Energy, South Africa
Msabala, M.	Eskom Holdings SOC Ltd, South Africa
Mtwebana, N.	Eskom Holdings SOC Ltd, South Africa
Muranen, L.	Steady Energy, Finland
Nelson, P. F.	National Autonomous University of Mexico, Mexico
Nguyen, P.	International Atomic Energy Agency
Ontario Power Generation	Canada
Paillere, H.	International Atomic Energy Agency
Papadopoulou, M.	International Atomic Energy Agency
Paredes, L.	Brazilian Association for the Development of Nuclear Activities, Brazil
Pecko, S.	Slovenské Elektrárne, A.S., Slovakia
Reitsma, F.	International Atomic Energy Agency
Scherer, C.	International Atomic Energy Agency
Stenson, C.	World Economic Forum, Switzerland
Vu, T.M.	International Atomic Energy Agency
Wang, J.	Shanghai Nuclear Engineering Research & Design Institute (SNERDI), China
Wang, P.	State Nuclear Electric Power Planning Design & Research Institute (SPIC) CO, LTD, China
Young, S.	Terrapower, LLC, United States of America
Zhang, Z.	Shandong Nuclear Power Company Ltd., China

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Enquiries should be addressed to:
Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
tel.: +43 1 2600 22529 or 22530
email: sales.publications@iaea.org
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