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Examining the Role of Banks in Financing Nuclear Power Programs for a Green Economy and Clean Energy Transition

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Abstract

Nuclear power programs have the potential to contribute to deep, multi-sector and economy-wide decarbonization as sources of reliable, low emissions intensity thermal and electrical energy. However, nuclear power projects are complex, capital-intensive ventures with significant financial risks associated with them. Therefore, financing has been a critical issue for these projects. To accelerate their deployment to meet clean energy transition targets of nations and institutions, financial institutions like banks can play a major role as a source of much needed long-term capital at potentially lower costs than from other sources. This is a virtuous cycle that benefits the banks as well because it represents a low carbon and sustainable investment opportunity for them. This can be a part of the suite of measures they take to divest from emissions-intense assets like fossil fuel plants, enable the clean and sustainable energy transition in power and industrial sectors, and avoid both physical and transition climate finance risks. This perspective study highlights the need for nuclear power for achieving global net zero emissions in a reliable and economically feasible manner, discusses typical cost elements of a nuclear power project, proposes some possible mechanisms for banks to support nuclear power program financing, and provides instances of how banks have already been involved in nuclear energy projects. The work is an attempt at creating awareness about the need for technology-agnostic evaluation and financing decision making by large financial institutions such as development, central and national banks, towards all applicable clean energy technologies.

Keywords: Banks, clean energy, energy transition, financing, nuclear power, responsible investment

INTRODUCTION

This study explores how climate change impacts banks and financial institutions, including the physical damage from severe weather and the difficulties brought by evolving climate regulations. We also explore how these changes impact developing countries and global financial stability. Finally, we talk about what financial institutions can do to manage these risks and support the shift to clean, renewable energy.

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IMPLICATIONS OF CLIMATE CHANGE FOR FINANCIAL INSTITUTIONS INCLUDING BANKS

The global clean energy transition is the most critical need for humankind to mitigate anthropogenic climate change and keep global temperature rising below 1.5°C as per the Paris Agreement of 2015. Climate change has been described as the biggest existential threat that mankind is facing today [1]. Additionally, it has been identified as a very significant risk factor for businesses and financial institutions, thereby posing a threat to global financial stability itself [2]. The climate related financial risk factors have a bi-directional effect on organizations. On one hand, it has been unequivocally established by the IPCC that greenhouse gas (GHG) emissions (most commonly carbon dioxide, methane, oxides of nitrogen) from industrial and business activities are the major and direct causes of climate change. On the other hand, the negative impacts from climate change including extreme weather events of rising frequency and severity themselves pose physical risks to various kinds of businesses by causing physical damage to infrastructure like buildings and roadways, and supply chain disruptions [3]. Yet another dimension is the climate transition risk, which has its origins in policy levers that may be implemented for climate change mitigation [4]. This includes for example, the impact of carbon taxes on carbon emissions intensive industries which will reduce their revenues and profitability directly, potentially creating non-performing or stranded assets and infrastructure. Additional impacts can be caused by the carbon border adjustment mechanism (CBAM) implemented by developed economies on import of carbon intensive products like steel, cement, and aluminium from developing countries where carbon pricing methods are weaker or not implemented at all. This too will have significant negative financial implications on the developing/emerging economies, which serve as exporters of these products to the industrialized world [5].

As businesses are impacted by various kinds of climate related risks, the effects spill over to the financial institutions associated with them, potentially leading to issues with financial stability. Some of the ways in which these can take place are for example, loss of profitability of an industry due to imposition of carbon taxes, which then causes an associated credit risk and a rise in the stranded and non-performing assets of banks which have invested in these carbon intense and heavy emitting industries. Thus, there is an urgent need for industry to transition to clean operations and for financial organizations and institutional investors to transition to green and sustainable investment opportunities across all these sectors. The loss of biodiversity and the availability of ecosystem services (such as regulation of water cycles, temperature regulating features of forestry, food provisioning, cultural and aesthetic value creation, etc.) due to climate change is yet another emerging risk; it has also created additional transmission paths for nature related financial risks to these institutions [6]; measuring, managing, and mitigating these risks has also emerged as another top priority for them.

Climate change therefore poses multi-dimensional, material, physical and transition risks for banks as well [7], affecting their valuation and financial performance [8] and the stability of the financial system. It is critical for them to consider the carbon footprint of their portfolios [9], reduce their exposure to various climate related risks by investigating avenues for divesting from fossil-fuel and emissions-intense economic activities and associated assets on one hand and contribute to the energy transition by financing those activities that are sustainable, low emissions and with the potential to create several positive ripple effects throughout the economy at large, and contribute to creation of high macro-economic multipliers [10]. This sentiment is also echoed in the Principles of Responsible Banking (PRB) and Principles of Responsible Investing (PRI) formulated by the United Nations Environmental Program, to encourage greening of the portfolio of assets of banks and other financial institutions by finding alternate, sustainable investment opportunities and phasing out involvement in emissions-intense activities and assets [11]. It is also embodied in the various transition plans being formulated by banks and other financial institutions to manage climate related financial risks, which can lead to system wide financial instability [12]. Thus, it is imperative for banks to begin assessing those emerging investment avenues involving assets that they might not have considered so far to green their own portfolios, while enabling the green transition for other sectors as well; this is what voluntary initiatives such as the Network for Greening the Financial System hope to foster among banks [13]. This perspective piece addresses one such emerging opportunity for banks, their involvement in funding, financing, and refinancing nuclear power programs as a means of greening their portfolio of assets and supporting the clean energy transition for the electricity sector and beyond.

ROLE OF NUCLEAR POWER IN CLIMATE CHANGE MITIGATION AND ADAPTATION

It is well accepted now that one of the most important levers to decarbonize various fossil fuel dependent sectors is clean electrification (e.g., transportation, domestic and industrial heating). Thus, there will inevitably be a massive increase in electricity demand at the global level, compared to the present level of reliance on electricity. To meet this growing demand, especially in developing economies and emerging markets, there is a need for deployment of a judicious mix of all clean electricity generation technologies such as renewables, fossil fuel with carbon capture and nuclear power. While most nations have adopted rapid renewable energy capacity addition as part of the solution strategy, several assessments of the economics of decarbonization show that an affordable and economically viable, secure, and reliable energy transition will also require harnessing more nuclear power [14]. This understanding has created renewed interest in building and expanding the nuclear fleet. Recent geo-political instability and the renewed need for domestic energy security have also been drivers of this new stance towards nuclear power. Consequently, there has been a declaration from 25 national governments at the COP 28 meeting in November 2023, about aspirations to triple installed nuclear power capacity by 2050; in COP 29, November 2024, another six countries have also joined the declaration. COP 28 also saw the historic inclusion of nuclear power in the Global Stock Take report as one of the drivers of climate change mitigation [15]. The latest edition of the IEA World Energy Outlook 2024 identifies nuclear power as one of the essential technologies for the global net zero transition and widespread decarbonization [16]. Recent projections made by the International Atomic Energy Agency indicate that anywhere between 514 and 950 GW of nuclear installed capacity may be deployed globally by 2050 as part of the clean energy transition and rising energy demand [17].

However, economic and financial considerations have always plagued the deployment of nuclear power projects. Like many infrastructure projects, they are very capital-intense with most investments made during the initial construction phase, with long construction timelines and significant socio-political risk perception around these projects. The extent of investment is expressed using figures such as overnight construction costs of nuclear power plants, which have a wide range of values from $ 2000–3000/kW(e) in countries like India and China to as high as $ 10000–12000/kW(e) or more in new build projects in OECD countries, depending on reactor size and technology [18]. Interest accrued on the debt part of the capital investment during the construction phase (which may last from 6 to 10 years or more) is not included in overnight construction cost; consideration of these numbers adds substantially to the costs of nuclear projects. This factor also makes them more sensitive to interest rates than other energy projects. However, their marginal operating cost is very low as they use extremely energy dense nuclear fuel; fuel price sensitivity is consequentially low. To most institutional investors, including development, central and commercial banks, these projects have so far appeared to be risky investment opportunities. Owing to these factors, it has been nearly impossible to deploy them without significant dependence on government support and the investment of sovereign funds (both debt and equity) in the nuclear power sector. But the required scale of capital investment needed for deployment of nuclear power to enable the large-scale clean energy transition cannot be sustained by sovereign funds alone; new mechanisms of funding and financing these projects are crucial requirements. It is in this context that banks as a category of large, institutional investors can have a significant role to play in supporting nuclear new build projects, life extension of existing projects, creation of other infrastructure for a nuclear power program and in generally improving their financial characteristics by developing innovative, suitable financing mechanisms. This study discusses the nexus between greening of the banking sector and nuclear power, the general economic features of nuclear power and provides recommendations of a variety of methods by which banks can (and should) contribute to the growth of the nuclear energy sector and justifies the need and applicability of these initiatives.

AN OVERVIEW OF NUCLEAR POWER PLANT ECONOMICS

The economics of nuclear power production are mainly governed by the reactor type or technology (e.g., light water-cooled reactor or heavy water reactor or a non-water-cooled reactor), reactor size or power producing capacity (e.g., micro-modular reactor with power rating up to 10–20 MW, a 300 MW small, modular reactor with power rating up to 300 or a 1000 MW large reactor), origination of technology (i.e., whether imported or indigenous), the associated fuel cycle and its nature (i.e., using metallic, oxide, carbide or nitride fuels or molten salt fuels, adopting an open or closed fuel cycle to allow recycling and recovery of values from used nuclear fuel, etc.) and the available sources of funds, and the selected capital structure of the project. Some estimates state that a typical project has over 220 expenditure items [19]. The capital intensity of a nuclear power project is highest during the initial construction phase. Depending on construction time and the debt component of the financing structure of the project, debt servicing or the interest accrued during reactor construction is a substantial portion of the investment needs. As a result, these projects are also more interest rate sensitive than other energy sector projects. Among the other pre-project costs of the project, design and engineering costs, regulatory licensing fees and obtaining various clearances, land acquisition, compensatory payments to project-affected people and so on are important components.

A noteworthy feature of these projects is that they are much less sensitive to fuel price and its volatility, due to the very high energy density of nuclear fuel and the need for a very small amount of fuel to produce a given amount of power. This is unlike the production of electricity from fossil fuels like natural gas and coal where a substantial part (70–85% for fossil power plant, compared to 25–30% for the nuclear power plant [18]) of the life cycle or levelized costs of electricity production (LCOE) is made up of fuel charges, while the initial capital investment to construct the plant makes up a much smaller share in these projects [20].

The legal framework surrounding nuclear power in most cases places the entire liability arising out of any nuclear accident on to the reactor owner and/or operator, as per international conventions. In some countries, the liability is shifted to the suppliers of major equipment and systems, should it be clearly identified that any accident situation occurred due to the failure of these components. Nuclear insurance taken as a part of these liability clauses is generally done through a pool of insurance companies, like the Nuclear Electric Insurance Limited, American Nuclear Insurers and Swiss Re. The insurance premium is thus another substantial element of cost associated with the project. It is reasonable to expect that this component will be much higher than that of an equivalent capacity fossil fuel power plant.

The contribution of major cost elements to the overall project costs associated with a representative large nuclear power project in the USA is shown in Figure 1 (using reported data [21]). Financing costs are not included in this graphic. The reactor *per se* is seen to contribute to about 20% of the project cost.

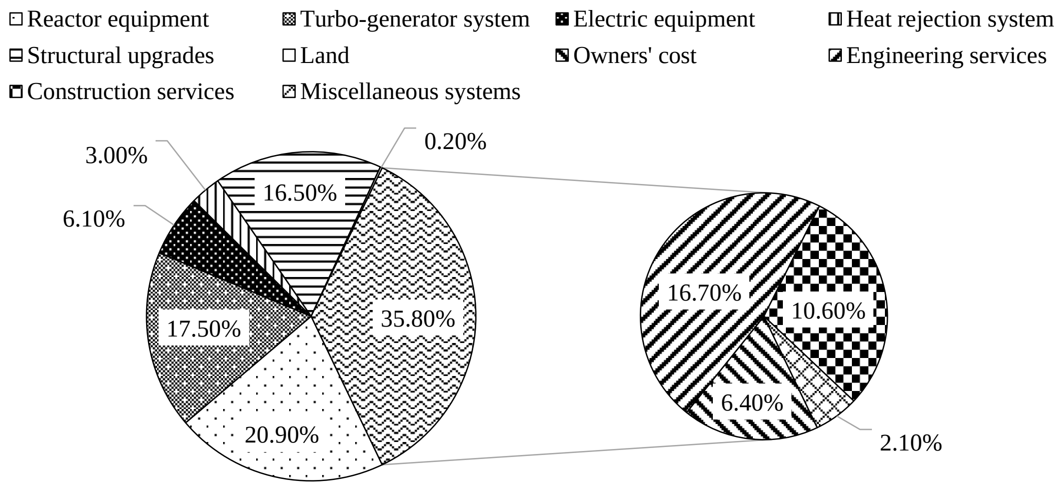

Figure 1. Major cost elements in a typical large nuclear power reactor project in USA in 1980 (based on data obtained from DOE, 1980 [21]).

Table 1. Compilation of cost estimates of various types of nuclear power plants from recent literature [23].

Study/data source	Type of reactor	Cost estimates	Remarks
Wealer *et al*., 2018 [26]	Gen III/Gen III+ water cooled reactors	*Overnight construction cost (OCC):* $ 4000 to $ 6000/kW(e) These figures exclude decommissioning and waste disposal costs, which are estimated to be an additional $ 1250–2000/kW(e)	The actual realized investments in US and European projects with similar reactors have been seen to be about $ 8000 to 10000/kW(e)
IEA and NEA, 2020 [27]	Gen III/III+ water cooled reactors	*OCC:* $ 2157–6920/kW(e) for new build plants *Fuel:* $ 5–14/MWh(e) *OM:* $ 10–26/MWh(e)	Data pertain to large reactors of 1000 MW or higher capacities, operating at 85% annual capacity utilization factor
Abou-Jaoude and Lin, 2023 [28]	i. PWR ii. HTGR iii. SFR iv. MSR v. Microreactor	i. Capex: $ 2850–7349/kW(e), Opex: $ 19–25/MWh(e) ii. Capex: $ 3000–9900/kW(e), Opex: $ 5–30/MWh(e) iii. Capex: $ 4241–5613/kW(e), Opex not reported iv. Capex: $ 3384–6113/kW(e), Opex: $ 34–60/MWh(e) v. Capex: $ 6575–65445/kW(e), Opex: $ 53–137/MWh(e)	Values from projects constructed prior to 2005 are not reported here; values included in this table are for different base years for the different technologies mentioned
Asuega *et al*., 2023 [29]	i. LW-SMR ii. GC-SMR iii. MS-SMR	*OCC* i. $ 4844/kW(e) ii. $ 4355/kW(e) iii. $ 3985/kW(e)	OCC is found to be most sensitive to cost of the reactor pressure vessel and reactor building for the first two types
Steigerwald *et al*., 2023 [30]	i. PWR type SMRs ii. HTR/HTGR type SMRs iii. SFRs iv. MSR and microreactors	*Constructions costs:* i. $ 2250–23188/kW(e) ii. $ 1550–5400/kW(e) iii. $ 2500–23035/kW(e) iv. $ 1950–5771/kW(e) *Fuel costs:* i. $ 5.31–6.23/MWh(e) ii. $ 8.63–19.29/MWh(e) iii. $ 23.86–113.05/MWh(e) iv. $ 8.94–29.55/MWh(e)	Estimates in this study are based on data supplied by reactor developers/manufacturers
Abou-Jaoude *et al*., 2024 [31]	i. SMRs	*OCC* i. $ 5500–10000/kW(e) in 2030, $ 2500–8000/kW(e) in 2040, $ 2000–6250/kW(e) in 2050 and fuel costs $ 10–12.1/MWh(e)	Meta analysis of reactor cost estimates was carried out in this study to arrive at the final projections for the next three decades
	ii. Large reactors	*OCC* ii. $ 5250–7750/kW(e) in 2030, $ 3000–7500/kW(e) in 2040, $ 2250–6000/kW(e) in 2050 and fuel costs $ 9.1–11.3/MWh(e)	
DAE, 2024 [32]	i. 700 MW indigenous PHWRs ii. 1000 MW VVER built in India with Russian cooperation iii. 500 MW sodium cooled fast breeder reactor/PFBR	*Capital costs are:* i. $ 1760–1930/kW(e) ii. $ 2918–4052/kW(e) iii. $ 1770/kW(e)	The figures are for India only and represent current sanctioned costs of the entire reactor projects, considering twin reactor units for all except the PFBR, including any escalation from initial sanctioned costs; does not include operating costs
World Nuclear Association, 2024 [33]	Gen III and Gen III+ reactors constructed in USA, Asia, and Europe, having net capacities between 950–1650 MW(e)	OOC ranges between $ 2157/kW(e) and $ 4250/kW(e) for the constructed reactors	Data from completed reactor construction projects have been presented

Study/data source	Type of reactor	Cost estimates	Remarks
Tassone *et al.*, 2024 [34]	i. Lead cooled fast reactors ii. Lead-bismuth eutectic cooled fast reactors	Capital investment requirements are: i. $ 2727/kW(e) to $ 8252/kW(e) ii. $ 1464/kW(e) to $ 27482/kW(e)	Concentrates only on one variant of the advanced Gen IV reactor types; most estimates are from projects at initial or detailed design stage, having various capacities, so there is very large heterogeneity in the estimates arrived at

A more recent study shows the bottom-up cost estimation of an innovative and inherently safe reactor concept and provides a more detailed distribution of the costs across various heads [22].

Table 1 summarizes some estimates of specific capital and operating costs of reactors of different technology classes [23]. As a general trend, lower costs have been observed in nuclear new build projects in China, Russia, India while higher costs have been reported from the projects in OECD countries, for the same reactor capacities or technologies [24].

Large reactors have exhibited economies of scale in deployment, thus lowering cost per unit of power produced. However, currently there is also tremendously growing interest in developing smaller and modular reactors (SMRs) with enhanced safety features to reduce the total capital investment needs and associated risks, reduce construction time by factory fabricating the systems and components and reducing on site work, and making them more suitable for deployment where large reactors may not be feasible (e.g., within energy intensive industrial complexes as captive power plant, close to urban demand centers due to a smaller exclusion zone, in countries with smaller power grids and with energy demands that cannot accommodate or do not require a large reactor, in remote locations as heat and power sources, as floating nuclear power plants, for providing flexibility in grids with large shares of variable renewable generators and so on) [25]. Demonstration projects are expected by the end of this decade to show whether these purported benefits truly enable overcoming of the diseconomies of scale from a smaller size.

Other than the initial construction and operating costs of the reactors during their useful life, the end-of-life decommissioning of the facility is also estimated to require between $ 600 and 1200/kW(e) in the developed economies, with the actual physical dismantling of the buildings and associated facility taking about 30 to 40% of the total decommissioning cost, while administrative expenditure and final waste disposal constitute the rest [35].

NUCLEAR POWER AND THE GREEN ECONOMY: EXAMINING THE NEXUS

The concept of a green economy is linked to those human activities and practices that create economic value but are not detrimental to the environment and human society. These activities preserve environmental quality for subsequent generations, are sustainable, regenerative and do not cause the bio-physical limits of the earth system to be breached. While there is no unique definition of a green economy, it broadly indicates the key role of economic decision making towards ensuring human welfare without detrimental impacts on the natural world. Söderholm discusses five dimensions of creating a green and sustainable economy: these include managing environmental risks, ensuring radical technology advances for managing these risks, promotion of green capitalism to facilitate these advances and adoption, role of policy makers in designing the appropriate policies and incentives and addressing the concerns around the impact of such transformations [36]. Climate change being a major environmental risk with systemic effects, technologies that address climate change are considered as green technologies and should be construed as enablers of green economy.

This idea has been examined by several researchers considering the case of nuclear power programs for facilitating the development of a green economy. For example, Bandyopadhyay and Rej find that

CO_2 emissions reduction of India is highly correlated to adoption and use of nuclear power, even when nuclear share is quite low in the final energy mix [37]. This establishes the need for greater nuclear adoption to further address CO_2 emissions and air pollution concerns. The Environment Kuznets Curve hypothesis for CO_2 emissions has been examined for the G7 countries (i.e., Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) in the context of nuclear and renewable energy adoption [38]. It is found that nuclear energy uptake causes statistically significant CO_2 abatement in all these countries, whereas the role of renewables in achieving this same outcome is only established for France and Canada and not the other nations. Teng *et al*. also used econometric methods to examine the relation between environmental load capacity and nuclear and renewable energy forms in nuclear equipped economies between 1990 and 2021 [39]. They find that an increase of 1% in renewable and nuclear power deployment improves environmental quality by 0.16% and 0.09% in the short run and by 0.12 and 0.21 in the long run. The long run positive impact of nuclear energy towards environmental quality preservation is thus established; this creates grounds for considering it part of growing the green economy. In a similar study focused only on the United States, it is again found that long term CO_2 emissions abatement is facilitated by nuclear energy use [40]. Pershukov *et al*. establish that a closed nuclear fuel cycle and recycling of fuel in fast breeder reactors facilitates the circular economy in the nuclear power programs and also prevents proliferation concerns [41]. Thus, this further enhances the sustainability characteristics of this energy form. They argue that this should be considered as justification for including them in the ambit of green technologies that support a green economy.

In brief, the nexus between the green economy and nuclear power adoption is well established through several quantitative studies based on data from different nations. It may therefore be said that the low carbon energy transition and carbon emissions abatement from energy use and industrial activities are an integral part of establishing the green economy. By ensuring mitigation of and adaptation to climate change, future economies are therefore safeguarded by this transition. Nuclear power programs are critical components of the energy transition process, given their clear role in enabling emissions reduction in many countries of the world. Therefore, this establishes its link with enabling and preserving the green economy.

EXAMINING THE MANY POTENTIAL ROLES OF BANKS IN FINANCING NUCLEAR POWER PROJECTS

A nuclear power program encompasses various phases and activities in each phase, from the initial decision making to embark on the program, to creating the necessary infrastructure to support the nuclear fuel cycle and reactor operation, to the mining of the ores, to fuel production, reactor construction, operation for at least 40 years and beyond, all the way up to final decommissioning, spent fuel management and disposal [42]. The overall commitment needed for such establishing and sustaining such a program is along the lines of a hundred years or so. The investment needs and the risk characteristics associated with each phase of the program are different and some are rather unique to nuclear power project [43]; this therefore creates the need for novel business models, different financing mechanisms and the potential involvement of different kinds of financial institutions as well, other than the traditionally significant role of sovereign de-risking of these projects.

Historically, development finance institutions including development banks have stayed away from lending to nuclear power projects, mainly due to perceived risks around spent nuclear fuel management, final disposal of radwaste, nuclear proliferation issues and even due to a stated lack of in-house technical expertise in understanding and evaluating the nuclear power technologies as an asset class. However, recently the World Bank Group has been encouraged to shift its stance towards nuclear power by many of its member states and international organizations [44]. Given the increasing needs for this critical technology as one of the clean energy solutions for large scale and reliable system-wide decarbonization, the involvement of development finance institutions can make it feasible for smaller countries to access financing for their nuclear programs, especially those which are considering or are just embarking upon such an initiative.

Other than the multi-lateral development banks, the central and national banks can also assist with the sovereign financial backing that these projects often need. Some of the concrete steps that they can take are as follows:

1. *Debt instruments*: Involvement in the issuance of long-term debt instruments like bonds (or even labelled green bonds) dedicated for nuclear power projects, whose maturity times match the long asset life time in the nuclear sector.
2. *Concessional and blended finance*: Debt could also be provided as concessional finance to the nuclear project in the form of long-term, low-cost loans, as in the case of other infrastructure projects. The reduction of the cost of capital for a nuclear project is an especially significant step towards their cost reduction [45]. With the backing of sovereign banks, private sector investments could also be brought into the nuclear sector.
3. *Deposits*: Long term deposits managed by banks, such as pension funds and insurance products could be yet another source of long-term capital for nuclear power projects, again, in line with the long project lifetime and long payback periods (due to high initial capital intensity) that these projects typically exhibit.
4. *Project finance*: Should project finance be accepted as a method to finance nuclear power projects in certain jurisdictions, depending upon the legal framework for nuclear power, banks including syndicated commercial banks can also serve as the sponsor or lender to the special purpose vehicles created for the specific power reactor projects.
5. *Underwriting services*: Investment banks can serve as the underwriters for a nuclear power utility in case of raising equity capital for a project through initial public offerings (IPOs).
6. *Carbon finance*: Banks can also facilitate the creation and governance of carbon markets and direct the proceeds to fund a nuclear power project or related activities along the fuel cycle.
7. *Financial risk management*: Banks also have a critical role in issuing financial derivative instruments to hedge against the financial risks of these projects, for example, interest rate swaps to mitigate interest rate risk in debt financing of the projects or exchange rate swaps to manage currency exchange rate volatility when a nation is importing a reactor technology or the nuclear fuel materials needed to keep the reactor operational.
8. *Export credit services*: Export credit agencies (ECAs) of one country in connection with a domestic bank can also provide debt capital towards nuclear power projects in another country importing a reactor technology from the home country [24]. The domestic bank lends capital to the buying country's project developer and pays the technology supplier after the project has been delivered. This has served as a very useful financing mechanism for nuclear projects in several developing economies, where sovereign funds alone might have been inadequate for a nuclear power project.

Creating the Rationale for Banks to Finance Nuclear Power Projects

In identifying sustainable investment opportunities and ensuring greening of the portfolio of assets held by them, banks can make use of financial taxonomies that have been developed using science backed principles about the beneficial characteristics (e.g., the Environmental-Social-Governance or ESG attributes) of the technologies. It has been argued that nuclear power projects report vary favorably on the sustainability attributes and metrics that practically all the reporting frameworks require [46]; this should make it possible for them to be identified as an ESG-compliant, bankable investment asset classes and thus access bank-based financing on similar terms as other projects designated as environmentally friendly and socially benign, such as renewable energy projects. It is to be noted that nuclear power is already included in the financial taxonomies of countries like Russia and China (where substantial reactor new build projects are currently underway) and as a transitional activity in the EU green finance taxonomy as well [47]. Detailed assessments of the life cycle impacts of nuclear power projects have been performed by agencies like JRC of Europe, which establish their positive effects and the fact that they 'do no significant harm' (DNSH) to the environment [48].

Additionally, nuclear power plants exhibit very small land footprints and high resource-use efficiency arising from an extremely energy-dense fuel; far less forest clearance is needed and land use conflicts

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are minimized by adoption of nuclear power compared to dilute energy harvesting systems such as renewables. Thus, these attributes of nuclear power also have a very positive contribution towards preserving the ecosystem and biodiversity [49]. These studies should serve as science-backed guides to banks to create their in-house rationale and framework for investing in nuclear power programs (or a part thereof). The ultimate objective would be to recognize nuclear programs as a part of their own transition plans (whether voluntary or compliance based).

Banks and nuclear energy projects: Initiatives already in place

In this context, it is important to mention the role of banks as already seen in support of nuclear power projects in certain nations. For example, the EXIM bank of USA has already supported exports of reactor technologies from USA based developer companies and vendors to other importing countries, by providing lower cost credit to the buying country [50]. Similar instances can be cited for Russia as well, yet another nation actively involved in reactor exports. In another positive development, very recently, 14 international private banks have also expressed their support towards civil nuclear power project development, as part of enabling the realization of the COP 28 pledge to triple the nuclear installed capacity [51]. This may be viewed as a significant and critical step forward for de-risking nuclear finance and drawing in other banks as capital providers as well.

One example of the diversity of funding opportunities for banks in the nuclear sector is provided by the initiatives of the European Bank for Reconstruction and Development (EBRD), which manages seven funds to facilitate activities like ensuring nuclear safety, remediation and decommissioning in Europe, particularly in Russia and Eastern European countries, including the Chernobyl site [52].

One recent, ongoing initiative is the proposed creation of the International Bank for Nuclear Infrastructure-Implementation Organization (IBNI-IO), which is intended to serve as a specialized, multilateral finance organization along the lines of a global infrastructure finance institution, based on financial contributions from member states and organizations and dedicated exclusively to nuclear projects. It targets issues like project demand aggregation, supply chain streamlining, channeling financial opportunities and mechanisms to the projects, including insurance requirement, in developed and developing countries [53].

Other than the large capacity nuclear power plants (~1000 MW(e) rated power or so), there are other advanced technologies being developed actively including smaller, modular nuclear reactors (with capacities ranging from a few MW(e) up to 300 MW(e)). These reactors will require much less upfront capital investment and are also expected to have shorter overall construction phases. Due to these factors, these projects have potentially lower financial risk; therefore, this is emerging as another category of investment opportunity for banks.

CONCLUSION

Nuclear power projects have traditionally been viewed by capital providers as risky investment ventures due to their huge upfront capital investment needs. But the need to expand nuclear power deployment at the global level to facilitate an economical and reliable clean energy transition is now very clear. Therefore, the investment needs for these projects should be viewed as excellent, new sustainable investment opportunities by financial institutions like banks instead of harboring a blanket rule about not getting involved at all. A technology-neutral approach to supporting the clean energy transition and greening of their own asset base and portfolios to mitigate climate related financial risks is needed. These projects also have the potential to become important elements of the banks' low carbon transition plans as well. The various long term financial products and funding mechanisms available from banks are very compatible with the long asset lifetime and payback period of new build nuclear power projects. Access to lower cost financing facilitated by banks can have a very positive impact on making nuclear power economical by reducing the cost of the debt component and on favorably shaping the attitudes of other financial institutions and capital providers towards these projects, including investors of the private sector. Other than reactor construction, there are other opportunities for bank-based financing in the entire nuclear power program and fuel cycle projects; based on the risk appetite of different banks, they can participate in any of those activities as well. To facilitate this, the following recommendations to banking authorities may be provided as an outcome from the analysis in this study:

a. Banks must begin by reviewing already existing studies (such as economic and econometric studies) and evidence of nuclear power reactors in emissions abatement and support towards creation and maintenance of the green economy.
b. They must then build the necessary technical capacity to evaluate the various facets of the nuclear fuel cycle, associated technologies and their scientific, micro and macroeconomic, social and financial characteristics together, instead of just the investment requirements for such programs.
c. They must establish close cooperation and collaboration with the various nuclear agencies and science and technology bodies for this capacity building initiative.
d. Risk-reward characteristics for the various investment opportunities along the entire program should be assessed and accordingly involvement and investment decisions should be made by the banks.

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