ENERGY POLICY

India-US Cooperation in the Energy Sector

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India's purchase of Russian crude oil emerged as a key point of friction in Indo-US relations in the second half of 2025. Paradoxically, the energy sector could potentially be an area of greater cooperation between the two countries. India is the fastest-growing major economy. According to the International Monetary Fund (IMF), the country's GDP is expected to grow by 7.3% in India's fiscal year (FY) 2025–26 (which runs April through March). This growth is projected to moderate to 6.4% in FY 2026–27.[1] This growth entails higher energy consumption, and India is an energy-importing country. The United States, meanwhile, has an energy surplus—it has emerged as the world's largest oil producer and is also the world's largest liquefied natural gas (LNG) exporter. These two factors taken together underscore complementarities.

The potential for Indo-US energy cooperation is not limited to oil and gas. The Indian government has announced a goal for the expansion of the country's nuclear power capacity from the current 8.8 gigawatts (GW) to 100 GW by 2047. The scale and pace of expansion could create opportunities for both domestic and foreign vendors. Through the 2008 India-United States Civil Nuclear Agreement, the United States had helped India obtain a Nuclear Suppliers Group (NSG) exemption. And with the December 2025 passage of the Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India (SHANTI) Act, India's regulatory regime has been changed to allow for participation of the private companies in the sector hitherto reserved for the public sector. The Act has also amended provisions of India's Civil Liability for Nuclear Damage Act of 2010 (CLND), which were seen by foreign companies as a major hurdle to entering the Indian market. With the SHANTI reforms, the nuclear power plant operator's Right of Recourse to claim damages from suppliers or vendors has been limited to contract terms, in line with international standards.

India's per capita electricity consumption is currently one-third of the global average. Its energy demands will grow with greater industrialization. India's digital economy will need more electricity. Google, for example, has recently announced an investment of $15 billion for setting up a major AI hub and data center in India.[2] This further increases electricity demand.

Commentaries on Energy as a Pillar of the US-India Relationship

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Ramping up Indo-US cooperation in an era of economic nationalism will not be easy. But the challenge can be met if we keep in mind the historical perspective. The two countries have come a long way since the days of the Cold War. In 1971, the Nixon administration sent the Seventh Fleet to the Bay of Bengal during the Indo-Pakistan war, a move widely interpreted inside India as a show of force in favor of Pakistan. There were other bumps along the way. In 1991, India was targeted under the Super 301 and Special 301 provisions of the US Trade Act of 1974, as amended, though sanctions were never implemented. After the Pokhran II nuclear test in 1998, US sanctions were imposed on India. This equation changed, however, in the new millennium after 9/11 and the shared global challenge of combating terrorism, along with the rise of China. These two developments brought about a convergence in the foreign policies of the United States and India, leading to significant joint achievements such as the 2008 Civil Nuclear Agreement.

Today, the bilateral trade balance has been reported as a new issue for the United States in its relations with India, as well as with many other major economies. India ran a surplus of $40.9 billion with the United States in FY 2024–25, and $26 billion in in the partial FY 2025–26 (April–December 2025).[3] But it ran a deficit of $116.1 billion with China in 2025.[4] This shows that India's problem is not trade with the US, though there has been considerable friction. India's problem is the huge and growing trade deficit with China. The United States, in turn, ran a deficit of $295.5 billion with China in 2024.[5] Though this shrank to $189.4 billion in 2025, it is still seven times the deficit with India. Even if it closes the trade gap with India, its larger problem will remain. Moreover, as this essay argues, the same Indian and US energy trends outlined above present a variety of options both to address our mutual trade balance and to build a foundation for greater cooperation.

INDIAN ENERGY GEOPOLITICS SINCE THE UKRAINE WAR

Public perceptions of Indo-US relations in both countries are influenced by friction over India's purchase of crude oil from Russia. The energy issue has been mired in tariff debate. But the damage from this debate goes beyond trade and economic relations. It could affect, and some think it has already affected, a strategic partnership that both Republican and Democratic administrations had nurtured over the last two decades. We need to examine the facts. Russia's share of India's crude oil basket was minuscule before the Ukraine crisis erupted. Though it went up substantially, India is not the largest buyer of Russian crude oil during the period from 2022 until now.

The spike in our imports of crude oil from Russia since the Ukraine war began is a function of US policy initiated by Janet Yellen, treasury secretary in the Biden administration. The "price cap" policy championed by the United States was a mechanism to reduce Russian oil revenues without affecting oil price stability in the global market (read: for the US consumer). The underlying strategy was to allow continued purchase of Russian crude, but at a discount.

If we look at the period from December 2022 until the end of August 2025, we can see that India was not the biggest importer of fossil fuels from Russia. For crude oil, China bought

47% of Russia's crude exports, followed by India (38%), the EU (6%), and Türkiye (6%). For coal, China again purchased 44% of all of Russia's coal exports, followed by India (20%), Türkiye (11%), South Korea (10%), and Taiwan (4%). As for oil products, Türkiye was the largest buyer, having purchased 26% of Russia's oil product exports, followed by China (13%), Brazil (12%), and Singapore (7%). The EU, meanwhile, was the largest buyer of Russian LNG, purchasing 51% of Russia's exports of this commodity, followed by China (21%) and Japan (18%). The EU was also the largest buyer of pipeline gas, purchasing 36% of Russia's exports, followed by China (30%) and Türkiye (27%).[6]

More recently, the EU has imposed sanctions and reduced the purchase of LNG and piped gas from Russia. However, the EU gave itself ample time to effect the change of policy after the Ukraine war erupted. The EU oil sanctions only went into effect in November 2022, nine months after the war started. It will cease importing LNG in December 2026 and stop importing pipeline gas only in 2027. In any case, this does not change the fact that the EU continued to make large-scale purchases of Russian gas and LNG for more than three and a half years after the Ukraine war erupted.

How has this energy trade been viewed by the United States? According to the US Department of Energy's Energy Information Administration (EIA), Russia accounted for 39% of India's oil and condensate imports in 2023. The combined share from the Middle East was 45%, with Iraq accounting for 19%, Saudi Arabia 16%, the UAE 5%, and Kuwait 4%. The US share of India's crude oil imports was just 4%.[7] However, this situation has been changing fast. The Indian purchase of Russian oil is expected to drop sharply in the wake of the February 6, 2026, announcement of the Indo-US tariff agreement. So far in early 2026, there has already been a sharp uptick in Indian crude oil purchases from the United States.

The United States imposed a broad 25% reciprocal tariff on India in effect from August 7, 2025, alongside tariffs on many other countries globally with which it had a trade deficit. But it imposed a further 25% penalty from August 27 on the grounds that Indian purchase of Russian crude oil was funding Russia's war machine in Ukraine. On October 22, the US Treasury Department announced sanctions targeting Rosneft and Lukoil, two of the largest Russian companies exporting crude oil. Since then, Indian companies have recalibrated their purchase of Russian crude. This has increased the scope for oil purchases from alternative sources—in particular, India's crude oil and LNG purchases from the United States went up sharply in 2025.

On an annual basis, there was a 66% jump in petroleum crude imports, valued at $8.2 billion, from the United States from April to December 2025, while imports of Russian crude fell by more than 17%, from around $40 billion from April to December 2024 to $33.1 billion from April to December 2025, according to Indian government data.[8] Tables 1 and 2 show five-year trends in both crude oil and natural gas purchases from the United States.

Following these developments, the United States has announced a lowering of reciprocal tariffs to 18%, with a February 2026 joint statement mentioning a framework for an "interim agreement"

TABLE 1 INCREASE IN INDIA'S CRUDE OIL PURCHASES FROM THE UNITED STATES IN 2025 (BY FISCAL YEAR)

	2020–21	2021–22	2022–23	2023–24	2024–25	2025–26
Crude Oil Import from USA (million metric tons, MMT)	14.37	17.45	7.73	7.03	11.20	18.17

Source: India Department of Commerce.

TABLE 2 INCREASE IN INDIA'S LNG PURCHASE FROM THE UNITED STATES IN 2025 (BY FISCAL YEAR)

	2020–21	2021–22	2022–23	2023–24	2024–25	2025–26
LNG Import from USA (MMT)	2.90	3.65	2.65	3.26	5.21	3.22

Source: India Department of Commerce.

based on reciprocal trade. That statement specified that India intends to purchase $500 billion of US energy products, aircraft and aircraft parts, precious metals, technology products, and coking coal over the next five years.[9] As of the spring of 2026, however, the issue remains in flux following the US Supreme Court's decision that the president lacked executive authority under the International Emergency Economic Powers Act (IEEPA) to enact broad-based tariffs.

INDO-US OPPORTUNITIES IN OIL

According to the US EIA's December 2025 Short-Term Energy Outlook (STEO), India emerged as the leading source of growth in global oil consumption in 2024 and 2025, overtaking China. Over 2024 and 2025, India accounted for 25% of total oil consumption growth globally.[10] According to S&P Global, India's oil demand looks set to reach 6.7 million barrels per day (mbd) by 2030, up from 5.4 mbd in 2023. India's expanding energy demand offers opportunities for US crude oil exports, even beyond the short-term uptick we have seen in recent months. This journey may have just begun.

One potential attraction for Indian buyers is price. For example, the US West Texas Intermediate (WTI) crude oil price averaged $60.26 per barrel in October 2025. As illustrated in table 3, this made it cheaper than Brent ($64.03 per barrel), Dubai ($63.17 per barrel), and the Indian crude

TABLE 3 COMPARATIVE OIL BASKET PRICES, OCTOBER 2025

Crude oil	Price ($/bbl)	Year % change
WTI	60.26	–15.3%
Brent	64.03	–14.7%
Dubai	63.17	–14.9%
Indian crude oil basket*	64.98	–13.9%

*Petroleum Planning and Analysis Cell (PPAC), India Ministry of Petroleum and Natural Gas

Source: World Bank Commodities Price Pink Sheet, November 2025.

oil basket ($64.98 per barrel). In fact, the WTI price has been consistently lower than the Indian crude oil basket price over the long-term horizon. During the past year, the price differential has ranged from $5.48 per barrel on February 11, 2025 (with the Indian crude oil basket at $78.80 per barrel as against WTI at $73.32 per barrel) to $3.01 per barrel on February 10, 2026 (Indian crude oil basket at $67.43 per barrel as against WTI at $64.42 per barrel).[11]

Is the price differential sufficient to cover the higher freight cost due to increased distance as compared to the Persian Gulf, which is India's traditional supplier? US exporters will have to be price competitive and offset the higher freight cost. The import of WTI crude from the US also involves a longer voyage time, which entails costs; it is forty-five to fifty days, compared to seven to eight days from West Asia and thirty to forty-five days from Russia.[12]

Many Indian refineries are now complex refineries, which can handle a larger range of crude. However, the refiners would also have to examine the crude assay that suits them. WTI is a light crude that yields more gasoline. Indian refineries are structured to produce more diesel. Indeed, diesel accounts for up to 47% of India's refining capacity.

The advantage of diversification away from overdependence on Persian Gulf suppliers can offset the disadvantage of longer voyage time. But US suppliers will also need to be flexible to make an inroad into this large, growing market.

INDO-US OPPORTUNITIES IN NATURAL GAS AND LNG

Though the Indian government has set a target of increasing the share of natural gas in the energy basket from its previous 7% primary energy share to 15% by 2030, the actual share as of 2025 has gone down to 6%. India's domestic production of natural gas is falling, which increases the need for the import of LNG to meet India's energy requirements.

INDIA'S NATURAL GAS DEMAND OUTLOOK

India's natural gas demand is expected to climb substantially, reaching 203 billion cubic meters (bcm) annually by 2030 (equivalent to roughly 19.7 billion cubic feet per day, bcf/d), up from 65 bcm in 2023 (6.3 bcf/d), according to S&P Global Commodity Insights.[13] India's import requirement of gas is increasing, as domestic production is insufficient. The United States is well endowed with gas and is increasing its LNG exports. This creates scope for cooperation, provided that the delivered price of US LNG in India is price competitive with imports from other sources.

SECTORAL STRUCTURE OF GAS CONSUMPTION

There are major differences between the Indian and the US energy profiles, and this affects how we can think about the prospects for natural gas in India.

In power, for example, according to the International Energy Agency (IEA), natural gas accounts for 42% of electricity generation in the United States. Power is the largest use case for gas in the United States. In the case of India, however, 74% of electricity generation is based on coal. The power sector is only the third-largest consumer of gas, with consumption of about 25 million metric standard cubic meters per day (MMSCMD, equivalent to 0.88 bcf/d) in 2024, out of a total of 187 MMSCMD (6.6 bcf/d). In fact, there are 17 GW of gas-based power plants lying stranded in India today—the Indian power sector cannot afford to operate economically at prevailing LNG prices.

There are, nonetheless, niche areas that may absorb higher input fuel costs and increase gas-based power generation in the future, including these:

- AI-driven computing loads
- Data centers
- Peak-load balancing and grid flexibility requirements. As the share of renewables in India's generation mix goes up, the need for gas-based power plants to supply electricity when the sun is not shining and the wind is not blowing will increase.

Other sectors in India show different gas consumption trends. The fertilizer sector is actually the largest consumer of natural gas in India, accounting for approximately 58 MMSCMD (2.1 bcf/d) in 2024. Natural gas is used as feedstock for ammonia-based urea production, making gas supply to this sector politically and socially sensitive, given that agriculture supports nearly 60% of India's population. Despite its size, gas demand in the fertilizer sector has largely plateaued, as no significant new urea plants are currently planned. While India continues to import urea to bridge demand-supply gaps, incremental gas demand growth from this sector is expected to remain limited.[14] The city gas distribution sector (CGD) represents the most dynamic and structurally robust source of future gas demand growth. It includes compressed natural gas (CNG) for transport and piped natural gas (PNG) for direct use by residential, commercial, and industrial consumers. Current consumption in the CGD sector is around 46 MMSCMD (1.6 bcf/d).

India's Petroleum and Natural Gas Regulatory Board (PNGRB) projections indicate that CGD will account for 29% of total gas consumption by 2030, rising to 44% of total gas consumption by 2040. The rapid expansion of CGD is primarily supported by priority allocation of cheaper domestic gas under the Administered Price Mechanism (APM, see below), regulatory certainty, and fuel substitution benefits in urban transport.

GAS PRICING FRAMEWORK AND PRICE SENSITIVITY

India's gas consumption history demonstrates a strong correlation between demand growth and price moderation. Gas usage increased when the international price of LNG went down during the pandemic in 2020. In turn, the sharp escalation in international LNG prices after the Ukraine war erupted in 2022 brought down gas usage. Since then it has recovered, but questions remain about achieving the target of 15% of primary energy use by 2030.

Importantly, the relative affordability of imported LNG differs from sector to sector in India and depends on both gas pricing policies within each sector and price comparisons with alternative fuels. The alternative fuels in the power sector are domestic coal, imported coal, and cheap but limited-quantity domestically produced gas. The competitive price for imported LNG to replace domestic coal in the power sector would be $5 to $6 per metric million British thermal units (MMBtu). Where imported coal is concerned, however, the competitive price of LNG could be higher—around $9 to $10 per MMBtu. Against domestic gas, the competitive price for LNG would have to be around $6 to $7 per MMBtu.[15]

ADMINISTERED PRICE MECHANISM

India follows an Administered Price Mechanism for so-called legacy natural gas, where the regulator (in this case, the Petroleum and Natural Gas Regulatory Board) sets a price band for conventional domestically produced gas, which in turn is allocated to government-designated priority sectors. As of early 2026, the current APM price ceiling is $6.75 per MMBtu, with an annual escalation of $0.25 per MMBtu each fiscal year. In the past, the fertilizer sector received the bulk of the APM gas allocation. But in recent years, the CGD sector has emerged as the primary beneficiary, significantly accelerating its growth.

In contrast, gas produced from more challenging domestic deepwater, ultra-deepwater, and high-pressure/high-temperature (HPHT) fields enjoys marketing and pricing freedom to encourage investment. For the period April to September 2025, the price ceiling for such gas was $10.04 per MMBtu.

For imported LNG, we can observe general demand sensitivity thresholds across different end-use sectors in India. Below $9.50 per MMBtu (Delivered Ex Ship [DES], which includes the cost of shipping the LNG to the buyer's port but not import duties or domestic delivery costs), we tend to see strong demand growth from the CGD sector, particularly in CNG for transport. Prices falling below $9.00 per MMBtu (DES) enables diesel substitution in long-haul trucking.

DOMESTIC PRODUCTION AND IMPORT DEPENDENCE

Over the longer term, India's domestic gas production has been declining at an average rate of ~2% per year since 2011–12, while LNG imports have increased by approximately 4% annually over the same period. Gas import dependence was 28% in 2011–12 and grew to 46% in 2023–24, when net domestic production totaled 35.7 bcm (3.45 bcf/d) and imports reached 31.8 bcm (3.08 bcf/d). In turn, India's LNG import bill grew from $6.83 billion in 2011–12 to $13.41 billion in 2023–24.[16]

LONG-TERM DEMAND PROJECTIONS

PNGRB projects India's gas demand under two scenarios:

- Good to Go (GtG): Moderate growth aligned with current policies
- Good to Best (GtB): Accelerated growth with favorable reforms and investments

Under the GtG scenario, gas consumption will increase from 187 MMSCMD (6.60 bcf/d) in 2024 to 297 MMSCMD (10.5 bcf/d) by 2030 and 495 MMSCMD (17.5 bcf/d) by 2040.

Under the GtB scenario, gas demand could reach 365 MMSCMD (12.9 bcf/d) by 2030 and 630 MMSCMD (22.3 bcf/d) by 2040, with CGD emerging as the dominant consumer.

TABLE 4 INDIAN LONG-TERM GAS DEMAND PROJECTIONS BY SECTOR

Sector	Consumption 2024 MMSCMD	2030 Good to Go	2030 Good to Best	2040 Good to Go	2040 Good to Best
CGD	36.9	87.1	126.1	216.4	270.8
Power	25.2	35.7	40.0	43.5	52.8
Refinery	22.0	43.4	50.9	52.4	57.8
Fertilizer	58.0	65.3	69.3	72.9	80.5
Steel	3.2	4.3	5.1	6.4	9.3
LNG Transport	0.0	3.9	6.6	26.3	65.7
Others (Tea Plantation, Industry, LPG Shrinkage)	42.0	57.3	66.6	76.9	93.3
Total	187.3	297.0	364.6	494.8	630.2

Source: *India's Natural Gas Demand Projection for 2030–2040*, Petroleum and Natural Gas Regulatory Board (PNGRB), May 19, 2025.

As table 4 illustrates, one can see that while fertilizer is currently the largest segment of demand, followed by CGD and then power, in every future scenario CGD emerges as the largest segment of demand.

INFRASTRUCTURE

There is sufficient infrastructure available in terms of pipeline and LNG import terminal regasification capacity to allow for increased gas usage in the case that imported gas price is competitive. According to PNGRB ex-board member A. Ramana Kumar, current pipeline capacity utilization is around 50%.[17] The PNGRB has authorized a total natural gas pipeline network of approximately 34,000 km. Out of this, 25,429 km were made operational as of June 2025, while 10,459 km of pipeline are in various stages of construction.[18] Meanwhile, India has 52.7 million metric tons per annum (MMTPA), equivalent to roughly 73 billion cubic meters per year (bcm/y), regasification capacity, with a 51% capacity utilization rate. According to a study prepared by Deloitte for PNGRB, this regasification capacity will go up to 70 MMTPA by 2030 and 100 MMTPA by 2040.[19]

PROSPECTS, CHALLENGES, AND GEOPOLITICAL CONSIDERATIONS FOR US LNG IN INDIA

The share of US LNG imports reached a record of 27 million metric tons (roughly 37 bcm), or 19% of India's total LNG imports in 2024, compared to just 11% in 2022.[20]

The recent war in the Middle East has upended the global LNG market from a surplus to a deficit. The attack on the Ras Laffan plant has destroyed 17% of Qatar's LNG capacity, which was 105 bcm/y. According to Qatar's estimate, the repairs will take three to five years to complete. Geopolitical uncertainties in the region and the possibility of Strait of Hormuz closure would create demand for additional, more predictable supplies from the United States and other sources in the short to medium term.

However, in the long run, Qatar remains a formidable challenger, with established footprints in India. Before the recent war in the Middle East erupted, QatarEnergy was planning to bring online 105 bcm/y LNG liquefaction capacity from Qatar and 17 bcm/y from Golden Pass, US, beginning in 2026. Out of this, a contract has been signed for 27 bcm/y with Asian and European end users and 15 bcm/y with aggregators such as Shell and ConocoPhillips, which will need to resell the LNG to final buyers. This will leave 78 bcm/y, or 75% of the total additional capacity, that will come on stream either not contracted or contracted with a buyer that needs to resell it. These plans will be delayed now. However, as and when it materializes, this will bring downward pressure on prices. This also means that US exporters trying to increase their market share in India will have to show more flexibility.

There are new entrants to the Indian market. Indian Oil Corporation (IOC) signed a deal with Abu Dhabi National Oil Company (ADNOC) in the United Arab Emirates (UAE) for the supply of 1 MMT (~1.35 bcm) of LNG per year from the Ruwais LNG facility. Its price is linked to crude oil, at around a 12.4% pricing slope. Earlier, IOC signed a fourteen-year deal with ADNOC in

TABLE 5 NATURAL GAS PRICES IN INDIA, 2025

APM	$6.6 per MMBtu
LNG Contracted DES	$9.8 per MMBtu
LNG Spot DES	$12.4 per MMBtu

Sources: Petroleum Planning & Analysis Cell (PPAC), India Ministry of Petroleum and Natural Gas; CRISIL, a company of S&P Global. Administered Price Mechanism (APM) gas prices are on GCV basis (effective from November 1, 2014) and are landfall price excluding taxes, Delivered Ex Ship. It does not include customs and other taxes.

July 2023 at a 12.6% slope to crude oil. The latest deal—a 12.4% slope to the Dated Brent crude oil price of $73.995 per MMBtu—would imply a price of $9.175 per MMBtu. The UAE, like Qatar, has the advantage of a shorter distance to Indian LNG import terminals compared to the United States. At the same time, it is subject to geopolitical risks of transit through the Strait of Hormuz, as demonstrated in the recent war.[21] Table 5 illustrates the average price of long-term contracted and spot LNG import prices landed in India in 2025 versus domestically produced gas.

Overall, however, while LNG freight costs from the United States are higher than those from Qatar, US LNG offers key strategic advantages. First is its geographical diversification, reducing reliance on supplies routed through the Strait of Hormuz. Second is its price index diversification: Whereas Qatar LNG is oil-indexed, US LNG is Henry Hub–indexed. Since oil and gas prices do not always move in tandem, Henry Hub–linked LNG provides a natural hedge during periods of oil price spikes. With the war erupting in the Persian Gulf in early 2026, both aspects of diversification have become extremely salient.

INDO-US OPPORTUNITIES IN NUCLEAR

Nuclear power will play a critical role in India's energy transition to net zero emissions by 2070. It is a source of emission-free, stable baseload power. It currently accounts for 2% of capacity and 3% of electricity generation in India, from an installed capacity of 8.18 GW. This is expected to go up to 22.48 GW by 2031–32. Finance Minister Nirmala Sitharaman announced in her budget speech in February 2025 that the government will target a nuclear power capacity of 100 GW by 2047. The recently enacted Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India Act of 2025, or SHANTI, has for the first time allowed entry of the private sector into civil nuclear investment and channeled the liability for any potential damages to the plant operator, in line with international conventions. These changes have opened the scope for a sharp ramp-up of nuclear power and Indian collaboration with international companies to supplement domestic efforts.

In fact, the United States already has footprints in the nuclear sector in India. India's first commercial nuclear power plants, boiling water reactors 1 & 2 at Tarapur Atomic Power Station, which reached criticality in 1969, were built by Bechtel with GE reactors. But for different reasons, US involvement in India's nuclear sector in years since has been minimal. Importantly, the SHANTI Act adopted in the December 2025 session of Parliament has amended the provision regarding the Operator's Right of Recourse to bring it in line with international conventions.

Though the goal of 100 GW of nuclear power capacity by 2047 may appear ambitious, it is actually a modest target. Achieving net zero emissions by 2070 would require replacing coal with clean energy sources. Coal currently accounts for 74% of India's electricity generation, with a total of 240 GW thermal power capacity.[22] This will have to be phased out gradually. The choice is essentially between renewables and nuclear. Renewables are an intermittent source of energy, and battery storage costs remain high. Renewables also have high transmission costs and a very large land footprint. Therefore, much of the burden for replacing India's coal capacity will have to be borne by nuclear. Hence, the nuclear power capacity required is likely to be substantially more than the target of 100 GW. Such dynamics are detailed in the VIF Task Force Report on India's Energy Transition in a Carbon-Constrained World, which is covered later in this paper.

The increase in generation capacity will have to be accompanied by the expansion of transmission capacity. India already has one of the largest operational synchronous grids in the world, with 476 GW of installed power-generation capacity as of May 2025. The grid size is expected to increase to 777 GW by 2030. This will include 500 GW of non–fossil fuel capacity, including nuclear.

URANIUM CONSTRAINTS AND INDIA'S THREE-STAGE NUCLEAR POWER PROGRAM

India's three-stage nuclear program was originally envisioned to harness the power of abundant thorium (Th) reserves that the country is blessed with to overcome the constraint of limited availability of uranium. The math of fuel that is theoretically available from India's domestic mineral endowments illustrates the long-standing appeal of such a strategy.

India has a total of about 78,000 metric tons of uranium metal, versus about 518,000 tons of thorium metal, available to be extracted. If the country's entire uranium resources were to be used in a uranium-fueled, pressurized heavy-water reactor (PHWR), the type most commonly deployed today in India's domestic nuclear reactor technology stack, it is estimated that about 420 GW electric-years of electricity could be produced.

If depleted uranium fuel and separated plutonium from these PHWRs are used in fast breeder reactors (FBR), an additional 54,000 GW electric-years of electricity could be generated. In such FBRs, production of uranium-233 (U-233) could also be achieved by loading thorium assemblies in their blanket and low-power zones.

Eventually, by transitioning to generations of Th-U-233-fueled breeder reactors, India should be able to produce an additional 358,000 GW electric-years of electricity. Thus, even at a substantial installed nuclear power capacity of 500–600 gigawatt electrical (GWe) (five to six times the current nuclear power capacity in the United States), the country's nuclear resources would be able to sustain its electricity generation needs far beyond the extent of its coal deposits.[23]

India's three-stage nuclear program would depend upon reprocessing spent fuel in the first stage to produce plutonium. This plutonium can be used with thorium to breed more fuel in the second stage. The program has progressed to the second stage so far. In a landmark development, the Prototype Fast Breeder Reactor (PFBR) has recently gone critical. The project is undertaken by the government-owned, special-purpose enterprise Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVINI). India has the right to reprocess spent fuel derived from imported uranium, subject to international safeguards.

2025 NUCLEAR ENERGY MISSION

In addition to these existing efforts around a three-stage nuclear fuel cycle, Finance Minister Nirmala Sitharaman, in her FY 2025–26 budget speech, further announced the launch of a "Nuclear Energy Mission." This initiative is in line with the government's commitment to achieving 100 GW of nuclear energy capacity by 2047, which in turn is expected to reduce carbon emissions while meeting India's future energy demands. A sum of Rs 20,000 crore (approximately $3 billion) has been allocated for developing five domestically designed and operated small modular reactors (SMRs) by 2032. The government has also announced that Indian private sector companies can invest in the construction of a specific class of 220 MW PHWRs designed by government-owned operator Nuclear Power Corporation of India Limited (NPCIL), called the Bharat Small Reactor (BSR). This is a proven design and is considered to be cost-effective in the Indian context.

REGULATORY FRAMEWORK: SHANTI ACT

The Atomic Energy Act of 1962 provided the basic regulatory framework for India's nuclear sector. It limited the production and development of atomic energy to the government or a government company. But this has been changed under the recently enacted SHANTI Act to allow entry of the private sector. Further provisions of the Act and related policies are intended to substantially improve the investment attractiveness of this sector.[24]

The new Act has also amended the provisions of the Civil Liability for Nuclear Damage Act of 2010 regarding the Operator's Right of Recourse and Section 46. It has channeled the liability to the plant operator for any potential damage, in line with international conventions. With these changes, India's nuclear power sector has emerged as an attractive investment destination and has removed the key apprehension of foreign vendors about supplying equipment to the Indian market. It has conferred statutory status to the Atomic Energy Regulatory Board as an independent nuclear regulator. The finance minister has recommended an extension of the customs duty exemption on import of goods required for nuclear power projects until 2035, expanding it for all nuclear power plants irrespective of their capacity. The budget also proposes to provide a basic customs duty exemption to the import of capital goods required for the processing of critical minerals in India.

Critically, under Article 3 of the SHANTI Act, the private sector is for the first time allowed to "build, own, operate or decommission a nuclear power plant or reactor" subject to a license. The license can be given to "any Government company," "any other company," or "a joint venture among any of the aforesaid."

The Act has also limited liability for nuclear incidents. Article 13 states, "The maximum amount of liability in respect of each nuclear incident shall be rupee equivalent of three hundred million Special Drawing Rights or such higher amount as the Central Government may, by notification, specify."

Under the 2010 CLND, a nuclear plant operator had the liability for nuclear incidents, but it could, in turn, exercise a Right of Recourse under Article 17 to pass the liability to reactor vendors. This included, under Article 17b, damages for "latent defects." This provision has been eliminated under the new law. Under Article 16 of the SHANTI Act, the Operator's Right of Recourse has been limited to contract conditions or acts that result from "commission or omission of an individual with an intention to cause nuclear damage."

Under the previous dispensation, a claim for damage arising from a nuclear incident could be raised under any existing law. This created the risk of litigation under laws other than the CLND. So, the SHANTI Act has both channeled liability to the operator and closed these other windows for bringing forward a legal claim. Article 54 states, "Whoever suffers nuclear damage shall be entitled to claim compensation in accordance with *this* Act" (emphasis added). Civil courts have been barred from exercising jurisdiction on claims for compensation.

THE SCALE OF FUTURE DEMAND

The announcement of an ambitious target of 100 GW nuclear power capacity by 2047—equal to the approximate installed capacity of nuclear power in the United States today—has raised eyebrows. But a report by the Vivekananda International Foundation (VIF) Task Force on India's Energy Transition in a Carbon-Constrained World has actually put the scale of demand and the capacity required to meet it much higher if the country is to achieve the goal of net zero emissions by 2047. The multidisciplinary group was headed by Anil Kakodkar, former chairman of India's Atomic Energy Commission.[25]

As India moves toward a low-carbon economy, fossil fuels will have to be progressively replaced by clean energy sources (e.g., nuclear and renewables) as well as by coal with carbon capture and storage (CCS). This is a mammoth task. Not only will coal have to be replaced with nuclear, but the overall demand for electricity will also substantially increase. How high will the demand for electricity have to be to achieve the goal of net zero emissions by 2047? Which is the cheapest form of energy to reach this goal? The VIF Task Force asked the Indian Institute of Technology (IIT) Bombay to address these twin questions based on mathematical modeling.

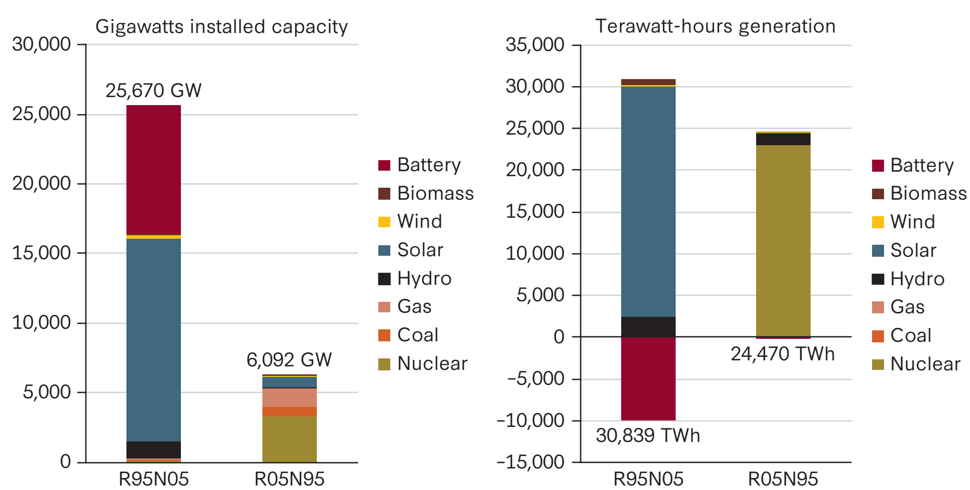
The modeling included, apart from business as usual, different scenarios with varying energy mix—referred to as R95N05, R60N10CCS30, R50N20CCS30, R40N35CCS25, and R05N95 (where R stands for renewable, N for nuclear, and CCS for carbon capture and storage). R95N05 was therefore a high-renewable scenario, with 95% of power generated by renewables and 5% by nuclear. At the other end of the spectrum was the high-nuclear scenario, R05N95, with a 5% renewable and 95% nuclear mix. The model was based on converting 75% of the overall energy demand into electricity. Across all five scenarios, IIT Bombay was asked to examine 10% of electricity delivered as hydrogen.

As illustrated in figure 1, the report brought out that India's electricity demand will have to reach between ~24,500 and 30,800 terawatt (TW)-hours per year if it is to reach its goal of net zero emissions by 2070. The high-nuclear scenario (R05N95) could achieve this demand with a smaller capacity—6,092 GW of total electric generation capacity, as against 25,670 GW needed in the high-renewables case (R95N05). In the first scenario, half of India's electricity would be contributed by nuclear power, while the rest would be provided by renewables. Such a magnitude of electricity demand would open up a much larger market for nuclear power in India than the current goal as announced by the government.

Taking into account system costs, the high-nuclear scenario was also the cheapest option in the VIF study, estimated to cost $11.2 trillion, as against $12.1 trillion for business as usual and $15.5 trillion for the high-renewable scenario, in order to reach a net zero emissions target in 2070.

The demand for electricity projected by the VIF report—between ~24,500 and 30,800 TW-hours by 2070, and a higher slope in the years before then—is substantially higher than the longest-term demand projection of just 3,433 TW-hours by 2040 as currently made by the IEA.

FIGURE 1 **VIF study 2070 net zero scenario installed capacity and generation mix, high-nuclear and high-renewable scenarios**



Source: *India's Energy Transition in a Carbon-Constrained World: Final Report*, Vivekananda International Foundation, 2022.

Which is correct? Considering India's population in 2040 to be about 1.6 billion, the IEA's electricity demand projection would amount to per capita electricity consumption of 2,146 kilowatt (kW)-hours by 2040. According to the VIF projection, India's per capita electricity consumption in 2040 would be approximately 4,705 kW-hours. For context, the IEA's 2040 projection for India would also be roughly one-third below the world average per capita electricity consumption of 3,257 kW-hours in 2020.[26] If we compare it with India's per capita electricity consumption of about 1,400 kW-hours in 2024, the IEA's projection represents a growth rate of only about 2.7% over sixteen years, which is less than half of what is expected to achieve the net zero level of electricity demand. Thus, IEA's projection not only does not take into account India's growth aspirations, but also makes it difficult to achieve the target of net zero emissions by 2070.

NEED FOR LARGE-SCALE FLEET REACTORS

The sheer scale of Indian demand makes its market well suited to large-scale, fleet-built reactors of a proven design, such as the Westinghouse AP1000 with a capacity of just over 1.1 GW per unit. Their successful deployment and performance is demonstrated with four operating units and another twelve in the pipeline in China. In the United States, while initial first-of-a-kind construction costs were very high with Vogtle 3 and 4 in Georgia, substantial cost improvements were evident from the first to the second new reactor units built, and both have given excellent performance since operations began. The US government has subsequently announced plans for supporting a multiple-order-book fleet of such reactors, with Japanese investment.

While the mainstay of the Indian nuclear power program will likely continue to be PHWRs based on domestic nuclear technology, imported light-water reactors (LWRs), including those of US design, will be a useful addition given the scale of ramp-up and compressed time frame. To bring down the capital cost and ensure that the resulting electricity tariff is competitive, there is a need to localize production as much as possible.

HALEU FUEL

The development of high-assay low-enriched uranium (HALEU) fuel and imports from the United States could be another area of Indo-US energy cooperation. HALEU fuel, as being developed for use in the next generation of US "GenIV" SMRs, has a higher uranium enrichment level of approximately 19.5% and novel fuel forms. In India, HALEU could help utilize abundant domestic thorium resources, as the country has a very limited amount of uranium. As discussed previously, conversion of fissile uranium at scale through irradiation of thorium has been envisaged in India through the use of fast breeder reactors (FBRs)—the second stage of India's three-stage program. While the Prototype Fast Breeder Reactor has gone critical, thus attaining an important milestone, its full-scale deployment to irradiate thorium to produce U-233 needed to generate nuclear power at scale in the third stage of the program is considerably delayed.

As India did not have much uranium, irradiating thorium in PHWRs was not a feasible option. Hence, the second stage was conceived where thorium was to be irradiated in fast breeder reactors to produce more fissile material (U-233) for use in the third stage. Now that a large fleet of new, domestically designed PHWRs is expected to be developed using imported uranium fuel, it is possible to move to the third stage faster without waiting for the development of FBRs. According to Anil Kakodkar, "Having imported HALEU instead and irradiating it in PHWRs along with thorium would enable regaining the lost ground and switch on the thorium-uranium-233 stage much earlier."[27] HALEU fuel is also proliferation-resistant.

CONCLUSION

In sum, while it is not without additional challenges, the opportunity for future Indo-US cooperation in the energy sector goes far beyond the current short-term geopolitical concerns around oil trade.

OIL

US WTI crude oil is $3 to $4 per barrel cheaper than the Indian crude oil basket. However, it will have to compete on a landed-cost basis with crude oil imported from other sources. The crisis in West Asia has underlined the need to reduce dependence upon Persian Gulf oil by diversifying to other sources.

LNG

Meanwhile, for gas, India's high GDP growth rate, import dependency, and push for a cleaner environment create a market for US LNG.

Imported LNG from the United States will have to be competitive in terms of price with LNG imports from alternative sources, such as Qatar. It will also have to be competitive with alternative fuels.

The CGD sector will emerge as the principal demand driver, while fertilizer demand will plateau; power sector revival will depend upon niche markets. There is sufficient infrastructure in place, with India's existing LNG terminal import capacity at only about 51% capacity utilization, and pipeline capacity utilization at around 50%. As with oil, diversification of LNG sourcing will help India reduce geopolitical risks of excessive dependence on LNG imports from Qatar and the UAE, which are inside the Strait of Hormuz and subject to geopolitical risks.

NUCLEAR

Finally, ramping up nuclear power capacity from 8.2 GW currently to 100 GW by 2047, as announced by the Indian government, opens up the scope for new Indo-US collaboration. The current energy supply infrastructure and maritime disruptions in the Middle East will increase the demand for electrification and the need to ramp up nuclear power generation.

The SHANTI Act has brought Indian liability law in line with international conventions. US companies can now participate in supplying equipment for nuclear power plants or forming joint ventures to set up nuclear reactors on a large scale. Local production will be essential to keep the cost down so that relevant electricity tariffs from nuclear are competitive.

The scale of India's demand can only be met by a fleet of large-size reactors, and the Westinghouse AP1000 has a proven design. SMR technology will take more time before it becomes commercially feasible.

US companies can also establish a presence in the entire supply chain and supply of HALEU fuel. This could be a win-win situation for both the US and India. Import of HALEU fuel could provide a welcome boost to India's three-stage nuclear program, which is key to making use of India's abundant thorium resources.

If carefully managed, these areas could become a mutually beneficial and substantive element of the long-term commercial and diplomatic relationship between the two countries.

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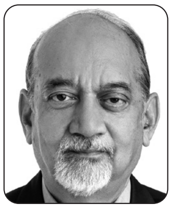

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