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Southeast Asia looks to nuclear power to supercharge its energy transition

Most countries in fast-growing Southeast Asia are looking to develop nuclear energy in their quest for clean and reliable energy; nuclear energy is viewed by its proponents as a climate solution since reactors don't emit the plant-warming greenhouses gases released by burning fossil fuels

NEWS ANALYSIS

Associated Press
JAKARTA

Southeast Asia's only nuclear power plant, completed four decades ago in Bataan, about 40 miles from the Philippine capital Manila, was built in the 1970s but left idle due to safety concerns and corruption. It has never produced a single watt of energy.

Now the Philippines and other countries in fast-growing Southeast Asia are looking to develop nuclear energy in their quest for cleaner and more reliable energy. Nuclear energy is viewed by its proponents as a climate solution since reactors don't emit the planet-warming greenhouses gases released by burning coal, gas or oil. Advances in technology have helped reduce the risks from radiation, making nuclear plants safer, cheaper to build and smaller.

"We see multiple signs of a new era in nuclear power across the world," said Fatih Birol, executive director of the International Energy Agency, adding that it expects 2025 to be a historic high for nuclear-generated electricity because of new plants, national plans and interest in smaller nuclear reactors.

Nuclear energy has been used for decades in wealthier nations like the U.S., France and Japan. It produces about 10% of all electricity generated worldwide, with 413 gigawatts of capacity operating in 32 countries, according to the IEA. That is more than African's entire generating capacity. The IEA says construction of new nuclear power plants needs to "accelerate significantly" in this decade to meet global targets for ending emissions of greenhouse gases.

Tricky economics: Nuclear power plants are expensive and take a long time to become profitable. AP

Southeast Asia will account for a fourth of global energy demand growth between now and 2035, and fossil fuels account for most of the region's energy capacity

Southeast Asia will account for a fourth of global energy demand growth between now and 2035, and fossil fuels account for most of the region's energy capacity. Many countries in the region are showing interest in building nuclear power plants–which typically produce one gigawatt of power per plant–to help clear their smoggy skies and boost capacity.

Indonesia plans 20 nuclear power plants. A Korean company is assessing restarting the mothballed Philippine plant. Vietnam has revived nuclear plans, and Malaysia's future plans include nuclear energy. Singapore signed a nuclear cooperation agreement with the U.S. last year, and Thailand, Laos, Cambodia, and Myanmar have shown interest in nuclear power.

Expensive proposition

But nuclear power plants are expensive, take years to build and require a long time to become profitable. Vietnam suspended a nuclear project in 2016 after costs soared to $18 billion, but on Jan. 14, it signed a deal with Russia on atomic energy cooperation.

International financing for nuclear energy is becoming more available, said Henry Preston, a UK-based communications manager for the World Nuclear Association, noting that 14 major financial institutions endorsed a goal for tripling global nuclear energy capacity by 2050.

Financing sources are still limited, though. The World Bank does not fund any nuclear energy development projects.

"We hear the call from some stakeholders to explore nuclear power to decarbonize energy and improve energy supply reliability," a World Bank spokesperson said in a recent written response to questions from The Associated Press. "We continue to have conversations with our board, management, and external stakeholders to understand the facts."

Developing robust nuclear energy policies and regulations, now lacking in many countries, could catalyze more funding by reassuring investors, Mr. Preston said. And technological advances are making nuclear power more affordable, experts say.

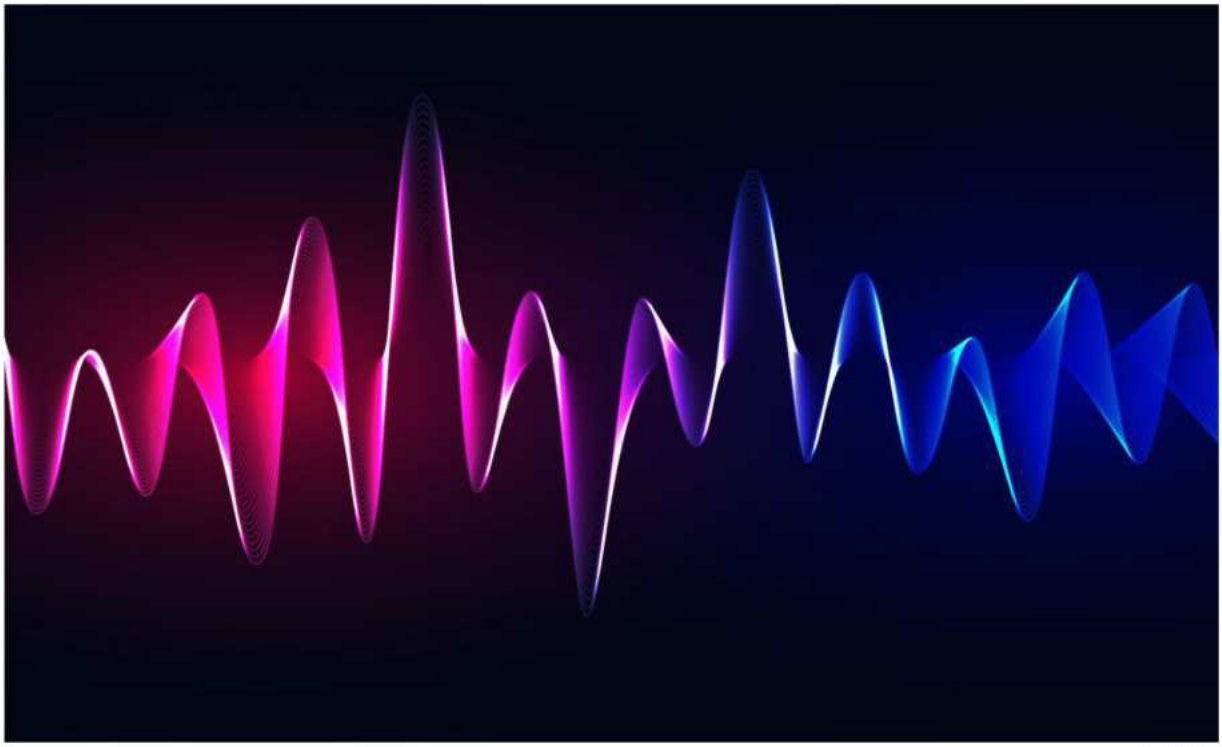
Small modular reactors, which advocates say can generate up to roughly one-third the amount of power of a traditional reactor, can be built faster and at lower costs than large power reactors, scaling to fit the needs of a particular location. Advocates say they are safer due to simpler designs, lower core power, and more coolant, giving operators more time to respond in case of accidents.

Critics question how inexpensive the technology might be since smaller reactors have not been widely commercially deployed, said Putra Adhiguna of the Jakarta-based Energy Shift Institute.

The small modular reactors already operating are run by state-owned entities that aren't transparent about performance or costs. The cost of the first such reactor that was to be commercially deployed in the U.S. inflated by about half before it was cancelled, he said.

Nuclear disasters dimmed earlier enthusiasm for nuclear power in Southeast Asia. Ukraine's 1986 Chernobyl disaster was a factor behind the decision to shelve the project in the Philippines. Meltdowns in 2011 at the Daiichi nuclear power plant in Fukushima, Japan, following a catastrophic earthquake and tsunami also raised worries, leading Thailand to halt its nuclear power plans.

Some other challenges remain. Markets for nuclear technologies remain concentrated in a few countries–Russia controls roughly 40% of the world's supply of enriched uranium–and this is a "risk factor for the future," said an IEA report. It added that safely disposing of spent fuel and other radioactive waste is essential to gain public acceptance of nuclear power.



GETTY IMAGES

On amplifiers: how do they work and what are the different kinds?

Amplifiers have transformed entertainment, astronomy, search and rescue, medical diagnostics, and every human endeavour where some physical change can be converted to an electric signal. Power amplifiers come in multiple classes, each for specific applications

Vasudevan Mukunth

The amplifier remains a transformative invention for being able to receive the human voice and boost it so thousands of people can hear it at once. Without the microphone, politics itself may have evolved differently; the device has been ubiquitous in everything from public protests to political rallies. Amplifiers have also transformed entertainment, astronomy, search and rescue, medical diagnostics, and every human endeavour where some physical change can be converted to an electric signal. For simplicity's sake, let's focus here on audio signals.

What is a microphone?

A microphone is a type of transducer – a device that converts energy in one form to another, in this case from sound to electrical. There are different microphones for use in specific contexts, varying in terms of how they collect sound energy and how they convert it to electric signals.

Microphones in telephones and voice recorders are also called condenser microphones because they use capacitors to transduce audio signals ('condenser' is an old name for capacitors). A simple capacitor consists of two plates facing each other, separated in between by an air gap – or any suitable dielectric material – but connected on either side to a common circuit, including a power source. As the current enters one plate and builds up, it becomes depleted from the other. The difference creates an electric field between the plates that stores energy within the dielectric medium.

The ability of a capacitor to store energy is called its capacitance. A condenser microphone replaces one of the plates with a vibrating diaphragm. When a person speaks into the microphone, the diaphragm vibrates, altering the capacitance, which is converted to audio signals.

How is the sound amplified?

Once an audio signal is available, it is transported to a preamplifier (or preamp). Say there is an audio signal in the form of a varying voltage.

The preamp will acquire the voltage and supply it with more energy from an external power source while minimising noise. The ratio of the output of this process to the input is called the preamp's gain.

The key to minimising noise is a step called impedance-matching. Impedance is a measure of how much a given circuit resists, or impedes, the flow of electric current (in a direct-current circuit, the impedance is equal to the resistance.)

During impedance-matching, the impedance of the preamp's circuit is matched to that of the circuit that emitted the audio signal. If there is a mismatch, the signal will become noisy, reducing the preamp's gain.

The amplification itself is performed by an active component like a transistor.

How is voltage amplified?

A bipolar junction NPN transistor consists of a base, a collector, and an emitter.

First, the small incoming voltage is applied between the base and the emitter – that is, the transistor is forward-biased – such that electrons flow out of the emitter.

The base is configured so that most of the electrons diffuse into the collector, leading to a large collector current. In a typical transistor, the collector current is at least 50-times higher than the base current.

Next, the collector is supplied with a high voltage from an external source, like a battery, through a resistor. When the collector current flows across this resistor, it creates a strong voltage. This voltage when measured at the collector is the output voltage, that is, the amplified version of the input signal.

A signal can be drawn as a sinusoidal wave; an amplified signal will have the same shape but bigger, in this case meaning the voltage swing will be higher.

Before the preamplified signal goes to a loudspeaker, it also passes through the driver and power stages. The driver stage uses transistors to keep the voltage constant while increasing the current while the power stage further increases both the voltage and the current.

Power amplifiers come in multiple classes, each for specific applications. Class A and B amplifiers are used in basic sound systems and small studios. Home theatres and more intensive use cases prefer Class AB amplifiers. Antennae emitting radio-frequency signals at a single carrier frequency use Class C amplifiers whereas public announcement systems use Class D amplifiers.

Some of these groups have sub-classes that, while sharing many of the same features, deviate in particular ones like being able to handle very high power or enabling high-frequency signals.

How is loud sound produced?

The loudness of the sound produced at the loudspeaker is a function of the power of the input signal.

The loudspeaker has three basic components: voice coil, external magnet, and diaphragm. The voice coil is a coil of wire placed within the magnet. When the input voltage is applied across the wire, a large current is produced, which in turn produces a strong magnetic field around the coil. This field interacts with that of the external magnet, causing the coil to move as the input voltage varies.

The coil is connected to the diaphragm and the coil's motion vibrates the diaphragm's membrane, producing sound. The higher the power of the input signal, the louder the sound produced by the diaphragm.

To further enhance this process, the external magnetic field is made stronger, the diaphragm larger, and the input signal more powerful. Loudspeakers can also be built with smaller diaphragms with faster-moving membranes to facilitate high frequency sounds and larger diaphragms to facilitate low frequency ones.

How will the govt. produce the required fuel ethanol?

Does India's ethanol distillery industry have the capacity to produce nearly 1,100 crore litres of fuel ethanol? Why have maize imports increased substantially in the past year?

M. Kalyanaraman

The story so far:

Union Minister Nitin Gadkari said that India will achieve its target of 20% ethanol blending of petrol in the next two months, at least a year ahead of what was originally planned. This would entail the production of nearly 1,100 crore litres of fuel ethanol in one year.

Where will this come from?

The 1,100 crore litres of fuel ethanol will come from sugar and high grade molasses, Food Corporation of India (FCI) rice, broken rice, and maize. India's ethanol distillery capacity has ramped up to 1,600 crore litres, driven by a range of government incentives and the promise of a stable, lucrative market.

Sugar is expected to provide some 400 crore litres this ethanol year, according to Deepak Ballani, director general of Indian Sugar and Bio-energy Manufacturers Association. India had closing sugar stocks of around 80 lakh tonnes in October 2024. The projected sugar production for next year is around 315 lakh tonnes out of which 40 lakh tonnes will go to fuel ethanol. Mr. Ballani said that ethanol for non-fuel uses will come from low grade molasses called C Heavy that don't go into sugar production.

The government recently decided to reduce the price of FCI rice to distilleries from ₹28 to ₹22.5 per kg. The government handout states that some 110 crore litres of ethanol will be produced from FCI rice this ethanol year. This means almost 400 crore litres of fuel ethanol should come from maize. For context, India was producing little or no ethanol from maize until 2020. Besides pure-play grain-based distilleries coming up, some sugar distilleries have modified to dual-feed so in the off-season they can use other feedstock (maize) to produce ethanol.

How is maize playing a role?

India's maize production is just about enough for traditional needs such as for the poultry sector, livestock feed, starch production and some 10% for human consumption. As the government had imposed curbs on allowing sugar and high quality molasses for ethanol production, maize imports started ramping up in April 2024. From April to June, approx. ₹100 crore worth of maize was imported while, for 2023-24, maize imports were approx. $33 million. Ministry of Commerce figures show that a total of $188 million worth of maize was imported from April to November 2024.

The promise of a steady, lucrative ethanol market has meanwhile goaded many farmers to take to maize cultivation across India. The major maize producing States are Karnataka, Madhya Pradesh, Maharashtra, Andhra Pradesh, Rajasthan, Bihar, and Uttar Pradesh. For the 2024-25 ethanol year, maize output would be some 42 million tonnes out of which nine million can go towards producing the 350 to 400 crore litres of ethanol, H. S. Jat, director ICAR Indian Institute of Maize Research, Ludhiana, said. Citing good prospects for kharif this year, he said importing maize will not be necessary.

Since 2020-21. when ethanol production was almost all sugar-based, maize production had increased by nearly six million tonnes in three years, for potential ethanol use.

As things stand now, maize is cultivated in 10% more area at a higher yield, says Mr. Jat who also expects some diversion from traditional maize uses since supplying to ethanol is more lucrative for farmers. On whether that won't disrupt the market, Mr. Jat says DDGS (Distiller's Dried Grains with Solubles), a byproduct of ethanol, can be used for poultry. The long-term sustainability of fuel ethanol would depend on whether the switch to ethanol and stress on maize has a negative impact on production of other foodgrains. Mr. Jat estimates that 100 crore litres of fuel ethanol translates to ₹6,000 crore savings on oil imports and the money going into the internal economy including to farmers. For context, India's yearly oil import bill is some ₹10.5 lakh crore.

THE GIST

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- Sugar is expected to provide some 400 crore litres this ethanol year, according to Deepak Ballani, director general of Indian Sugar and Bio-energy Manufacturers Association.
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Delhi's gender budget: its decline and impact

While freebies and cash transfers, just before the election, can bring in immediate relief to families, what the women voters of Delhi really need are concrete steps that can enable systematic growth in the economic and social empowerment of women

ECONOMIC NOTES

Shabana Mitra
Cledwyn Fernandez
Anjhana Ramesh

There are 71 lakh women voters in Delhi, which is nearly half of the total electorate. Further, women have a high turnout rate as well. So, it is no surprise that all contesting parties provide incentives tailored towards women. These incentives then come to light through the budget. Over the last decade, the overall budget for Delhi has increased from ₹271 billion to ₹760 billion. But, how much of this budget is reserved for women?

Investing in women

Overall, the gender budget of Delhi has witnessed a seven-fold increase from ₹10 billion in 2011-12 to ₹71 billion in 2024-25 (Figure 1). While providing financial assistance to women and child development is essential to reduce the gender gap, it is equally important to invest in other components like, education and health. Investments in education have multiplier effects and lead to long term benefits by generating a highly literate and skilled workforce for the country. Education of women, particularly, can bridge the gender gap in employment and achieve wage parity. What is needed is not freebies but concrete steps that can enable systematic growth in the economic and social empowerment of women.

The neglect towards the education of women by Delhi is concerning. The spending on women's education in the gender budget stood at ₹2 billion in 2011-12, which increased to ₹18 billion in 2024-25. This budget reached its peak in 2017-18 touching ₹24 billion. Since then, the budget allocated for women's education has steadily declined. For the last five years, the education budget has reported a negative growth, with exceptions for 2019-20 and 2023-24

Need to focus on education

The neglect towards the education of women by Delhi is concerning. The spending on women's education in the gender budget stood at ₹2 billion in 2011-12, which increased to ₹18 billion in 2024-25. This budget reached its peak in 2017-18. Since then, the budget allocated for women's education has steadily declined.

KUMAR SS

Chart 1: Total gender budget and its share of education

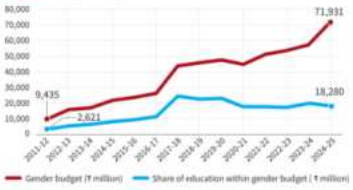


Chart 2: % change in the share of education in the gender budget

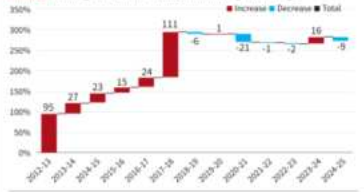
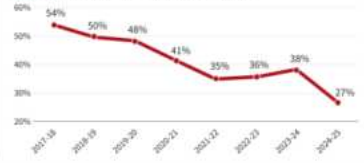


Chart 3: Proportion of education in the gender budget



(Figure 2). Another surprising fact is that the education budget made up 54% of the gender budget in 2017-18, but steadily declined to a mere 27% in 2024-25 (Figure 3). Concerningly, there was a massive decline of 9% in the education budget in just the past one year. The decrease is not just in the share, but also in the amount allocated to education (see figure 1), indicating that cash transfers and freebies have become the focus of gender budgets.

Priority for women's education

Education and technical training are major pillars for sustainable long-term growth. A lack of investment in the education sector can have negative spillovers into the labour market. According to the Periodic Labour Force Survey (PLFS, 2023-24), compared to the national average of 45.2%, Delhi's female labour force participation stands at 21%, the lowest in India. While most people in Delhi hold regular salaried jobs according to PLFS (2023-24), most women are working as house helps or cleaners, and men as shopkeepers or salespeople. Clearly, women are working in the lowest end of the skill spectrum. These jobs offer poor pay and low standard of living. Thus, low investments in female education lead to a relatively smaller female workforce, lower skill levels and low paying jobs. Secondly, the lack of a skilled women workforce can also lead to high gender inequalities in the labour force. As of 2023-24, the gender gap in labour force participation for Delhi stands at 51.6 percentage points. Moreover, the gender gap in top roles – legislators, senior managers, and CEOs – is stark, with 94% of these positions being held by men. Women are also under-represented in high skilled jobs, such as technicians and associate professionals. Only 3.8% of the female labour force are in these jobs compared to 10.34% of the male labour force. This points to the fact that investments in education are needed to bridge the gap in the high skilled workforce.

Third, the lack of technical and professional education of women has led to the concentration of women in certain fields. Most women professionals are in the teaching and health sector. It is crucial, therefore, to promote technical education training and professional courses among women to close the gender gaps in various sectors.

Cash transfers are necessary for relief but for empowerment of women, education and training are of utmost importance. Improving the budget for women's education would greatly reduce the gap in the long run.

The writers are with ICRIER, an economic think tank based in Delhi. The views expressed are personal.

THE GIST

- While providing financial assistance to women and child development is essential to reduce the gender gap, it is equally important to invest in other components like, education and health.
- The budget allocated for women's education in Delhi has steadily declined. For the last five years, the education budget has reported a negative growth, with the exceptions for 2019-20 and 2023-24.
- The lack of technical and professional education of women has led to the concentration of women in certain fields. Most women professionals are in the teaching and health sector.

The cause and effects of the U.S.'s withdrawal from WHO

Survey results indicate a growing negative sentiment among Americans towards the global public health body

DATA POINT

Sambavi Parthasarathy

Signing his first batch of executive orders following his return to the White House on January 20, 2025, Donald Trump announced the United States' withdrawal from the World Health Organization (WHO). Mr. Trump accused WHO of being biased towards China and mishandling the COVID-19 pandemic.

This is not the first time Mr. Trump has chosen to withdraw from the WHO. He took steps to leave the organisation in 2020 for the same reason. However, the Joe Biden administration decided to continue the partnership.

Close to 45% of Americans agreed with Mr. Trump's assessment back in 2020, according to the Global Attitudes Survey conducted by the Pew Research Center. The share of people with a similar opinion in the U.K. was 10 points lower at 34% and even lower at 31% and 30% in Canada and Germany, respectively **(Chart 1)**.

In a 2024 survey by Pew, close to 40% of U.S. citizens said the country was benefiting "not at all" or "not too much" from being a member of the WHO compared to the 34% who said so in 2021. **Chart 2** shows the respondents' views on whether the U.S. gains from WHO membership. These trends indicate a growing negative sentiment among Americans towards WHO.

Republicans were only half as likely as Democrats to say that the U.S. benefits from the WHO. While close to 80% of Democrats or Democratic-leaning people said in 2024 that the U.S. benefits from the WHO, only 38% of Republicans and Republican-leaning respondents said so **(Chart 3)**. The figure declined even further if only conservative Republicans were considered. Such opinions could have potentially influenced Mr. Trump's decision.

As per the latest executive order, the U.S. will pause the future transfer of any funds, support, or resources to WHO. This is a massive blow to WHO as the U.S. is its largest contributor. The U.S. has consistently contributed close to 15% of WHO's total funding since at least 2016-17. Its share dipped to 8.9% during 2020-21, when COVID-19 was at its peak, but went back again to the usual levels in the post-pandemic years. It contributed a record $1.2 billion in the biennium period for 2022-23 **(Chart 4)**.

WHO's other major contributors in the latest year (2024-25) include the Bill and Melinda Gates Foundation (12.9%), the GAVI Alliance (9.91%), the European Commission (8.06%) and the World Bank (5.34%). The share of contributions from China accounted for 3%.

Will some other country step up to fill the financial vacuum left by the U.S.? Those are big shoes to fill as no country's contribution has exceeded 5% of the total funding received by WHO. Among countries, Germany and the U.K. are in a distant second and third place, respectively, as per latest data.

Chart 5 shows how the funds from the U.S. are being utilised by WHO. In 2024-25, close to 26% of the funds were used to improve access to quality health services globally, 21% to respond rapidly to acute health emergencies, 20% for polio eradication, and close to 10% for prevention of epidemics and pandemics. Mr. Trump's decision to halt funding will have a cascading effect on these initiatives.

The President's order also calls for the recall and reassignment of U.S. personnel working in any capacity with the global public health body. This could potentially impact the staff in WHO collaboration centres in the U.S. These centres implement WHO's objectives and engage in collaborative research with the institutions it is a part of. The U.S. has the most number of WHO collaborating centres (79), followed by India and China, as shown in **Chart 6**.

Withdrawal symptoms

The data for the charts were sourced from the Pew Research Center's surveys and the World Health Organization

Chart 1: WHO's handling of the pandemic was...

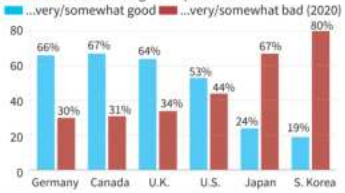


Chart 2: % of Americans who said the U.S. benefits _____ from being a member of WHO

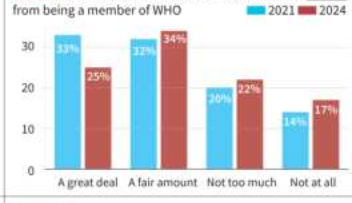


Chart 3: The views of Republicans( ) and Democrats ( ) on whether the U.S. gains from WHO

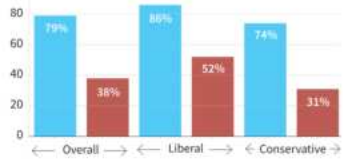


Chart 4: The chart shows the share of the U.S.'s contributions to WHO's total funding

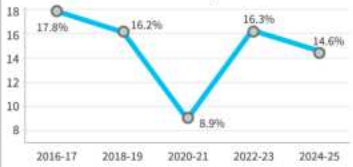


Chart 5: The chart shows how the funds from the U.S. are being utilised by WHO

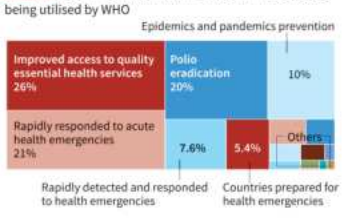
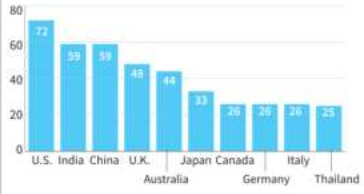


Chart 6: The chart shows the top 10 countries with the most number of WHO collaboration centres



The kind of jobs needed for the 'Viksit Bharat' goal

The Union Budget has been presented, and this is the right time to outline the three kinds of jobs this writer believes India must create. Beyond reviving private consumption in urban areas, we must continue to strengthen long-term job creation and real wage growth across India.

The 2024 Budget had introduced Employment Linked Incentives (ELI) under the Prime Minister's five-scheme initiative, designed to create over four crore jobs over five years with a central outlay of ₹2 lakh crore. The Prime Minister's internship scheme saw significant traction in 2024, with 6.21 lakh applications for 1.27 lakh opportunities. The outcomes on the rest four – beyond a draft Cabinet note on ELI and meetings by DPIIT with the Ministry of Labour and CII, remain to be seen. But there must be more deliberation on the kind of jobs we wish to create for a Viksit Bharat.

Impact of climate change

First, climate-resilience. India was the seventh most-affected country by climate change in 2019, having suffered an income loss of $159 billion in 2021, and according to the Reserve Bank of India, will face adaptation costs of nearly $1 trillion by 2030. The impact on agricultural and labour productivity and also livelihoods requires exponentially higher levels of funding for building rural and urban adaptation capabilities and the rejuvenation of local ecosystems to boost job creation.

To meet the net-zero targets by 2070, the Government must create and incentivise jobs which are "climate-resilient" by maximising all "co-benefits" (IPCC). This could mean providing three to four state-subsidised e-rickshaws in about 6,00,000 villages to create about two million jobs (focused on women drivers), also improving last-mile mobility. Or, there can be new ways to enable private investment in compressed biogas plants to bridge the gap of 82 plants set-up versus the target of 5,000 set (for FY23-24) in 2018. Or, even accelerating achieving the 500GW non-fossil energy capacity target to create over one million jobs, with stronger support for decentralised and rooftop solar which can be seven times more labour-intensive (CEEW).

Saubhagya Raizada

is an independent policy researcher based in Delhi and has a Masters in Public Policy from the Blavatnik School of Government, University of Oxford

Long-term structural reforms must result in climate-resilient, AI-resilient and aspiration-centric jobs

On AI resilience

Second, Artificial Intelligence (AI)-resilience. With the rise of generative AI, numerous jobs now have 50-plus% automation potential. Scenarios by McKinsey Global Institute show that 50% automation adoption in India can happen in the next 10 years. India's IT and business services, which comprised 70-plus% of services exports (Economic Survey 2021), hope to create millions skilled talent exports. But their employment potential can be limited in the gen AI-era as labour gets costlier relative to capital. With the launch of metaGPT simulating software companies, AI writing 25% of Google's code, and layoffs due to chatbots even in India, new jobs will also need to prioritise physical engagement and utilise our human 'creativity', which this writer terms as AI-resilience. This can take the form of larger education and health budgets to plug the deficit of millions of health-care professionals and teachers across states or dedicated financing for the National Rural Livelihood Mission to facilitate global and urban market linkages of local products, crafts, and knowledge of farmers and artisans in rural India.

Being aspiration-centric

Third, being aspiration centric. Despite their growing engagement with the startup culture, rural youth continue to have low confidence due to deeper insecurities from poor foundational education (this includes English) and resource-deprived upbringing. This can reinforce dependency on government jobs and 'coaching' to 'crack' entrance exams. As their aspirations are shaped by their socio-economic backgrounds, digital media, and interaction of the '*Samaaj*, *Sarkaar*, and *Bazaar*', the slow growth of non-farm jobs warrants off-farm job-creation which responds to these dynamic aspirations.

This can take the form of rapid infrastructure development such as building around 70,000 integrated pack-houses, plugging the 95-plus% infrastructure gap, to create over two million jobs. Or, boosting productivity and value-addition for high import/export-share items and tech-enabled local manufacturing of agri-inputs.

Greater use of tech, social media, and rebranding the 'rural' can also help make off-farm jobs aspirational for India's youth. One clear avenue is accelerating the 'National Mission on Edible Oils - Oilseeds' to reduce India's 57% import-dependence of edible-oil back to the pre-WTO levels with the revitalised rural processing of native oilseeds like soybean, sunflower (about 40% of edible-oil imports), and boosting retail of in-vogue cold-pressed oils. Enabling creation of many such large-scale businesses with private-public partnerships and investments, can address economic aspirations of our disheartened youth protesting examination leaks and low recruitment vacancies.

While tax relief may temporarily boost urban consumer demand, amidst growing household indebtedness and suboptimal private investment trends, the Centre can demonstrate greater commitment for long-term structural reforms which create these climate-resilient, AI-resilient and aspiration-centric jobs. Many opportunities exist as we embark towards our shared vision of a Viksit Bharat.

Green and clean

India must formulate a critical minerals framework that is just and equitable

India has come a long way in its attempt to transition to cleaner forms of power in the past decade. This is partly reflected in the budgetary allocation to the Ministry of New and Renewable Energy between fiscal years 2015 (BE ₹1,535 crore) and 2025 (BE ₹32,626 crore). But these allocations, other than in 2015 and 2023, have been underutilised, leading to lower revised estimates (REs). However, this does not fully reflect the clean energy journey. India attempted a major leap with the PM-KUSUM scheme in 2019, a year ahead of the COVID-19 disruptions, with an outlay of ₹34,422 crore. The scheme envisaged having off-grid solar irrigation pumps and grid-connected solar plants on fallow farmlands. While PM-KUSUM has received a tepid response, with less than half a gigawatt of installed capacity, the realisation that energy transition is both a desirable outcome and a requirement occurred during the COVID-19 years, when there were major supply chain disruptions to coal, oil and gas. This led to India pledging to produce half its energy requirements from renewables in about five years from now, at COP26 in 2021.

It was the 2021 Budget that heralded the clean energy shift, with ₹18,100 crore for a PLI scheme for advanced chemistry cell manufacturing to augment India's grid-scale battery storage capacity. A ₹4,500 crore PLI scheme for solar photovoltaic modules went up to ₹19,500 crore in 2022. But the government also decided to levy a 40% basic customs duty (BCD) on solar modules and 25% on solar cells to reduce the overwhelming import dependence on China. However, this slowed solar power installations nationwide with prices rising. And even while renewables constitute 46% of India's total installed capacity (October 2024), 70% of its power output is from coal. Experts have pointed to the need for grid-scale battery storage technology to augment India's renewables output, as intermittent RE production leads to the continued reliance on fossil-fuel based power. With the realisation that steep BCDs could be inflationary and counterproductive to localising production, particularly in the capital-intensive lithium-ion battery technology sector, the government has announced that it will exempt 12 critical minerals and 35 capital goods from BCDs. But reducing dependence on China for energy transition resources and technology would also require India showing leadership in formulating a critical minerals framework, that is socially and environmentally just during extraction, and equitable in its distribution. With the U.S. withdrawing its leadership position in these areas, India must aim to play a bigger role.

Plastic items collected and arranged on a beach in Hamilton, Canada. JAS MIN/UNSPLASH

The promises and problems of using bacteria against plastic

Plastic waste has driven biologists to look for sustainable solutions. Some of them study bacteria that can chew up plastics; others work directly with enzymes that can clean up the waste. Multiple scientists have turned into entrepreneurs, starting companies to use their solutions on a larger scale

Rohini Subrahmanyam

During her time in a drug discovery lab, structural biologist Kavyashree Manjunath first started thinking about how much plastic her group used, even for a single experiment. From the smallest of tips used to draw solutions to pipettes, bottles, and more – the plastic waste from her lab alone was enough to shock the average environment-friendly scientist. If they stopped to think about it the way she had.

One slightly comforting thought is that the plastic is recycled. But Manjunath found that that's not always the case. "Over a period of 65 years, since the large-scale production of plastic started, almost 8.3 billion tonnes of plastic has been produced," she said, quoting a 2017 *Science Advances* study. "Out of this, less than 10% alone is recycled. Almost 4.9 billion tonnes are there in the environment, in some form or other."

In their own fields

The immense amounts of plastics lying around choking our planet has driven multiple biologists to look for sustainable solutions in their own fields. Some of them are working on bacteria that can chew up plastics; others work directly with enzymes that can clean up the waste. Multiple scientists, including Manjunath, have turned into entrepreneurs, starting companies to use their solutions on a larger scale.

But the field is still very nascent, with most labs and companies still in the early discovery process. Biodegrading the tonnes of plastic we have generated – and will generate in the years to come – is the goal. But like most things in science, the path to success is long and arduous. How long the methods take to degrade plastic and the kinds of plastic they can act on remain some of the major bottlenecks to get across.

Delving into past work, Manjunath discovered there are natural enzymes that can break down the highly abundant polyethylene terephthalate (PET), a polyester found in many kinds of plastic items. Since Kohei Oda and his team at the Kyoto Institute of Technology first discovered the bacterium *Ideonella sakaiensis*, which breaks PET down using two enzymes, multiple groups have worked on isolating and improving those enzymes to try and degrade plastic efficiently.

But most of these natural enzymes take several months to years to work. "I thought, 'can these enzymes be engineered to break down PET much faster so that it can be used at a large scale in industry?'" Manjunath said.

To develop these enzymes, she founded Aprratima Biosolutions, a start-up incubated at the Centre for Cellular and Molecular Platforms (CCAMP), Bengaluru. One enzyme they developed can break down 90% of PET waste in 17 hours, into products like terephthalic acid and ethylene glycol, which can be purified and used again.

She and her team are now working on making the enzymes even faster and cheaper. Once the technology is ready, her plan is to partner with the PET recycling industry to help scale it up. "The main thing is the speed, because if it takes some 10 days or something, it's not feasible, right?"

'Really fascinated'

Degrading PET waste as quickly as possible is one part of the problem; there are many other kinds of problematic plastics out there. Some scientists are using microbes to directly degrade the plastic. These methods are slower but, depending on the versatility of the microbes involved, can offer some advantages.

Sukanya Punthambaker and Vaskar Gnyawali, former researchers at the Wyss Institute at Harvard University and co-founders and CEO and Chief Scientific Officer of Breaking Inc., developed such an approach. They discovered a bacterium called X-32 that degrades PET as well as polyolefins, found in some packaging materials and polyamides like nylon.

"Polyolefins have one of the toughest carbon-carbon bonds to break, so we were really fascinated that this one microbe can do all three major plastic types," Punthambaker said.

As of now, it takes the microbe 22 months to reduce these forms of plastic to carbon dioxide, water, and biomass. They are currently working on figuring out the enzymes involved so they can isolate them and edit their genes in a way to improve their speed and efficiency.

They also plan to test whether their microbe can be scaled up for use at an industrial level.

The biological approach

Apart from companies, academic researchers are also finding biological solutions to get rid of plastic. University of California San Diego nanoengineering professor Jon Pokorski is one of them. He is studying ways to make biodegradable plastic from scratch. He recently reported a method to make thermoplastic polyurethane (TPU), a commercial plastic found in memory foam, footwear, and foot mats, but infused with heat-resistant bacterial spores.

Pokorski and his team first evolved heat-resistant spores, made of *Bacillus subtilis* bacteria, in the lab. Then they incorporated the spores into the plastic; the spores can survive the high temperatures of plastic production and remain dormant in normal conditions. But as soon as the plastic is in a compost, the spores become active and start eating. Based on their findings, the bacteria took about five months to degrade 90% of the strips of TPU when they were in a moist, nutrient-rich compost environment ideal for their activation.

> Over a period of 65 years, since the large-scale production of plastic started, almost 8.3 billion tonnes of plastic has been produced. Out of this, less than 10% has been recycled. Almost 4.9 billion tonnes are present in the environment, in some form or other

The longer time may be a trade-off but Pokorski believes using the live-bacteria approach to degrade plastic is more amenable to scaling up than using pure enzymes.

"Purifying an enzyme is quite a challenge, especially purifying enough of it to satisfy the problem of millions of tonnes of plastic every year," Pokorski said. "I would argue that our solution is a much more viable solution for scaling. Because you're not relying on a single enzyme to perform its function; you're relying on something that's going to replicate."

Currently, at the academic lab scale they have tested, they needed very small amounts of spores for about a kilogram of plastic, and adding the spores improved the mechanical properties of the plastic as well.

"Like rebar reinforces concrete, the spores serve as a reinforcing additive to the polymer," Pokorski explained. "Ideally the plastic will either last longer or you could use less plastic because it's a better product."

However, he thinks consumer acceptance could be a challenge. "I don't know how regulatory agencies would feel about bacteria in plastics," he said. "The bacteria that are used are pretty harmless, but you never know, right?"

The rate-limiting step

Another advantage of using bacteria to break down plastic, according to biomolecular engineer Nathan Crook, is one can then evolve them to become more efficient. At North Carolina State University, Crook discovered a way to attach the two previously discovered PET-degrading enzymes onto the surface of a very fast-growing bacteria called *Vibrio natriegens* and use it to eat up plastic as it would eat any other carbon source. They are now working on evolving it in the lab in a way that it can break plastics down faster.

"The enzymes that break down the plastic are the rate-limiting step," Crook said. "If you have an organism where the only way it can survive is to break down plastic, it's going to find a way to mutate its enzyme so that they're really good at breaking down plastic."

But Manjunath, who works with enzymes, thinks scaling them up is not an issue. "There are a lot of fermentation industries which can produce the enzyme in large quantities," she said. The challenges she anticipates instead are whether the enzyme can be reused and the amount of PET waste loading they will need to optimise.

"For example, if you have a 10-litre reactor, how much PET waste can you load into it?" she asked. "Because the less you load, the more expensive it becomes, so you have to make sure the technology is able to handle large quantities of PET waste at a given time."

Another major challenge is to make sure the enzymes can degrade different kinds of PET waste – even the highly crystalline variety. Most enzymes in use now target PET used in packaging materials, but not the ones found in the pesky plastic bottles.

'See the plastic gone'

Despite its challenges, some leading scientists and companies still prefer the enzyme approach. Greg Beckhamm, a senior researcher at the National Renewable Energy Laboratory in the US and his team worked on improving one of the PET-degrading enzymes, such that it could also degrade the crystalline PET in water bottles.

Carbios, a French company that's one of the giants in the plastic-degrading business, has also engineered a highly efficient and heat-stable PET-degrading enzyme. Heating the plastic makes it easier to degrade, so the company worked on making the enzymes heat-stable to increase its speed of action.

According to a 2020 *Nature* paper, their enzyme takes 10 hours to degrade 90% of PET waste. The broken-down components can also be used as raw materials for fresh bottles, leading to a circular PET economy. They are now planning on building a large PET recycling plant to degrade plastic at a much larger scale but have now postponed it due to a delay in funding.

"It takes time because this is a very new technology in this particular domain, right?" said Manjunath. "But I think these kinds of solutions are very essential."

According to Crook, it need not only be a company that does the job of clearing up the plastic polluting the environment. "Maybe there's a non-profit that takes on this thing and tries to clean things up, or a governmental organisation that does this at a loss, because it's so expensive to clean up all the plastic," he said.

"I want to see the plastic gone in some way. Maybe it's our [bacterial] strain or somebody else's. At the moment, we're open to a variety of things."

(Rohini Subrahmanyam is a freelance journalist in Bengaluru. roh.subb@gmail.com)

In Trump 2.0, it is better for India to be seen as independent than as U.S. ally: geopolitics expert

Suhasini Haidar
MUMBAI

Given the kind of shifts in U.S. policy expected in Trump 2.0, it is better for India to remain independent than to be a U.S. ally, says Kishore Mahbubani, a Singaporean expert in geopolitics.

In an interview on the sidelines of an event by the Asia Society for his latest book *Living the Asian Century*, he called India "wise" to "keep its options open at this time", as a member of both the Quad grouping with the U.S., Australia, and Japan and the BRICS emerging economies grouping that includes Russia and China.

In particular, Mr. Mahbubani, who was Singapore's Ambassador to the United Nations and then Founding Dean of the Lee Kuan Yew School of Public Policy, said that U.S. President Donald Trump's second term in office would be considerably different from the first, and that he would be "completely unrestrained" about his demands from other countries on tariffs, geopolitics, and other issues.

"Since the end of World War 2, [the U.S.] has behaved more or less as a responsible stakeholder to the global order. And here comes along, Mr. Trump, and he completely tramples on all the principles of international order that the U.S. was committed to," Mr. Mahbubani said.

"[At this time], it is better for India to be seen as an independent pole in a multipolar world with far more options than, let's say, Japan, which is a completely dependent pole on the U.S.," he said, referring to the Quad grouping.

External Affairs Minister S. Jaishankar took part in the Quad Foreign Ministers meeting in Washington last month, convened by the new U.S. Secretary of State, Marco Rubio, and India will host the Quad Summit later this year, when Mr. Trump is expected to visit.


Kishore Mahbubani

China ties

Mr. Mahbubani, who has been criticised at times for advocating more engagement with China, said that while he foresaw a more "assertive" China and the U.S. jockeying for global power, he did not think a war over Taiwan was imminent.

"The paradox about Donald Trump is that he also says that he is not a warmonger, and it's true that in his first term, Trump was the first American president in a long time who hadn't started a war," Mr. Mahbubani said.

He added that he felt Mr. Trump was better placed to "make a deal with China, because he is not seen to be in any way soft on China" like his predecessors in office.

Mr. Trump had invited Chinese President Xi Jinping to his inauguration, although the latter declined, and his administration has taken a softer line on Taiwan, with Mr. Rubio telling Chinese Foreign Minister Wang Yi, according to the Chinese readout not denied by the U.S. so far, that the U.S. "does not support Taiwan independence".

Trade agreements

Asked about trading arrangements in Asia like the 15-nation Regional Comprehensive Economic Partnership that India walked out of in 2019 and the virtually defunct South Asia Free Trade Agreement, the Singaporean diplomat and academic said that economic studies showed that India would benefit from a bigger market.

"I think India should definitely revisit the RCEP question, especially as India wants to become a manufacturing economy," Mr. Mahbubani said.

"The way for China and India to grow their economies rapidly is to remain peaceful with all their neighbours. I'm not saying that India and Pakistan should sign a free trade agreement or give concessions to each other... they should just have normal trade," he added, citing booming trade between China and Vietnam, despite China's historic occupation of Vietnamese territory as an example.

(The full interview is at bit.ly/mahbubani)

Do not reduce forest land for linear projects, says SC

If any area is used for projects, the same amount of land must be given for compensatory afforestation; court was hearing pleas challenging amendments made in 2023 to the Forest Act

Krishnadas Rajagopal
NEW DELHI

The Supreme Court made it clear to the Union government and States on Monday that no steps will be taken by them to reduce forest land unless compensatory land is provided by them for afforestation.

"We will not allow you to reduce the forest area... You cannot use any forest land for linear projects. If you are using any area for these projects, the same amount of land must be given for compensatory afforestation," a Bench of Justices B.R. Gavai and K. Vinod Chandran addressed Additional Solicitor-General Aishwarya Bhati, appearing for the Centre.

The court was hearing a clutch of petitions challenging amendments made in 2023 to the Forest (Conservation) Act, 1980. The 1980 statute was enacted to check further deforestation leading to ecological imbalance.

In February last year, the top court significantly declared in an order that the expression 'forest' would continue to have a "broad and all-encompassing" meaning and include 1.97 lakh square km of undeclared forest lands.

Green cover: The top court had said that the term 'forest' would include 1.97 lakh square km of undeclared forest land.

The petitions had argued that Section 1A introduced through the amended Act had "circumscribed or substantially diluted" the definition of forest to two categories – declared forests and lands recorded as forests in 'government records' after 1980. The Centre, however, had denied using the amendments to reduce the forest cover. It pointed to the 'explanation' to Section 1A, which expanded the term 'government records' contained in the provision to include lands recognised as forest by any State or Union Territory authority, local body, council or recognised communities.

Meaning of 'forest'

However, the court had directed the government, for clarity's sake, to revert to the "dictionary meaning" of 'forest' as upheld in a 1996 Supreme Court decision in the *TN Godavarman Thirumulpad* case. The term 'forest' had been given a broad meaning by the court then to preserve these green expanses, irrespective of their nature, classification or ownership.

"The adoption of this dictionary meaning to forests was made to align with the intent of the Forest Conservation Act, 1980. It is clarified that the expression 'forest' will cover but not be confined to lands recorded as forests in the government records," the court had noted last year.

The Bench had clarified that the "all-encompassing" dictionary meaning upheld by the Supreme Court in the *Godavarman Thirumulpad* case over 25 years ago would continue to hold field till the States and Union territories prepare a "consolidated record" of all the lands recorded as "forest" in government records, including forest-like areas, unclassed and community forest lands.

The court said the exercise to prepare such a consolidated record was part of Rule 16 of a notification issued by the Environment Ministry on November 29, 2023, and would take a year.

Amid global meltdown, rupee breaches 87 against the dollar

Indian rupee slumps 49 paise on first day of trading after Trump imposes tariffs on Canada, Mexico, and China; Finance Ministry official hints Centre is unfazed by the currency's trajectory, terms it a global uncertainty that has to be dealt with

Vikas Dhoot
NEW DELHI

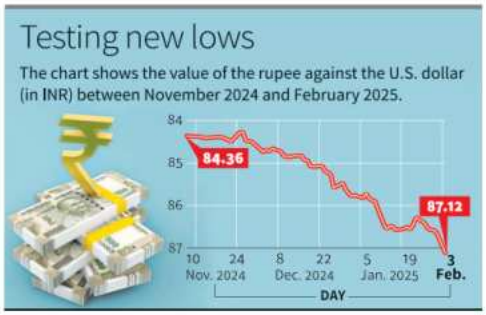
The Indian rupee slumped almost 0.6% or 49 paise to breach the 87 mark against the U.S. dollar on Monday, amid a meltdown for most emerging market currencies and stock markets across Asia and Europe on the first day of trading after President Donald Trump imposed higher tariffs on Canada, Mexico and China. The rupee, which had crossed the 86 mark vis-à-vis the dollar on January 10, closed at 87.11 after slipping close to 87.3 during the day.

A top Finance Ministry official signalled the government was unfazed by the currency's trajectory, terming it a global uncertainty that has to be dealt with and stressing that India does not believe in using "exchange rate policy" to push trade and the key is to manage volatility, not to attain a specified level for the currency.

'Dollar Index is high'

"What is happening over the last couple of months is that the dollar is appreciating. The Dollar Index is pretty high, and against all currencies... it is not just the emerging markets, but even with the developed countries. Today, the Dollar Index has picked up again and is above 109," Economic Affairs Secretary Ajay Seth told *The Hindu*. The index had risen over 1% through the day, to 109.7.

"As per our policy that we know the Reserve Bank of India follows, is to take care of the volatility at any level of dollar. At any level, if the dollar is appreciating, that means our imports become a little costlier, but our exports become competitive," he noted. "However, India has never used exchange rate policies to promote exports. That is not our policy. That's not a sustainable way to keep growing so we believe in strengthening our export competitiveness through better quality," Mr. Seth emphasised, adding that India can only envisage ways to handle the uncertainty that any move by the U.S. to raise tariffs will trigger.



"Each country takes a decision which it assesses to be in their best interest as a sovereign entity, just as we decide what we feel is the best interest of India and Indian people. In sovereign decision-making, there is nothing wrong, because this is the assessment of that particular country. The only things in our hand is – how do we deal with that uncertainty?" the Secretary said.

"What happens in the rest of the world whether the global growth rate is X or Y – that is given to us, we have to deal with it that and in spite of that factor, we have to do what we have to do. If there's this headwind, it means we must have a more powerful engine to move forward. That is what we try to do," Mr. Seth explained.

The government's focus, he said, is on making India more self-reliant by developing competitive advantages where it doesn't have them. "This is a nuanced approach and we should be clear about it. Second, we should not create cost disadvantages through the tariff policy or through our regulations, and clean up those areas. So this Budget again tries to clean up those areas," he pointed out.

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