

Technology Options to Address Climate Change Mitigation Needs

Keynote Speech

PECI Conference, Pabna Univ of Science & Technology, Bangladesh

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2023 IEEE President

17-18 June 2026



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Bangladesh

Technology Options to Address Climate Change Mitigation Needs

Keynote Speech, Pubna University of Science & Technology, Bangladesh

This lecture explains what carbonization is, addresses its causes and impacts. It then offers technological solutions to reduce CO₂ emissions from the electric power sector which is responsible over 30% of global Carbon emissions. In order to address the reduction of carbon emissions from the electric power sector, a collaborative approach between the industrialized nation states and emerging economies is necessary. This will involve a portfolio of solutions with low-carbon generation from wind, solar, hydro and nuclear, storage, cross-border power transfer and advanced technology focusing on energy efficiency. This talk also discusses the IEEE Climate Change program and related activities.

Saifur Rahman, PhD

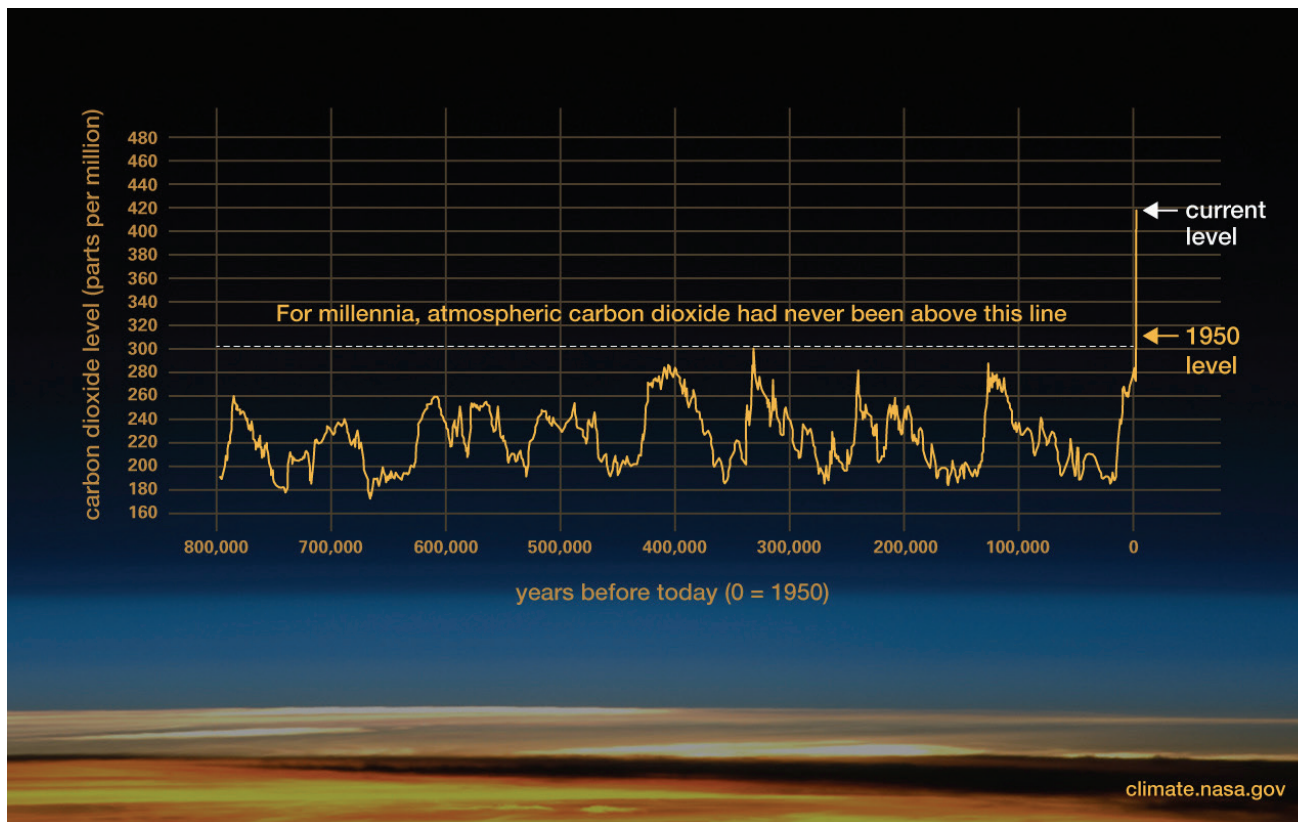
Joseph Loring Professor of Electrical Engineering and
Director, Virginia Tech Advanced Research Institute, USA
2023 IEEE President



Carbonization is Challenging Climate Sustainability



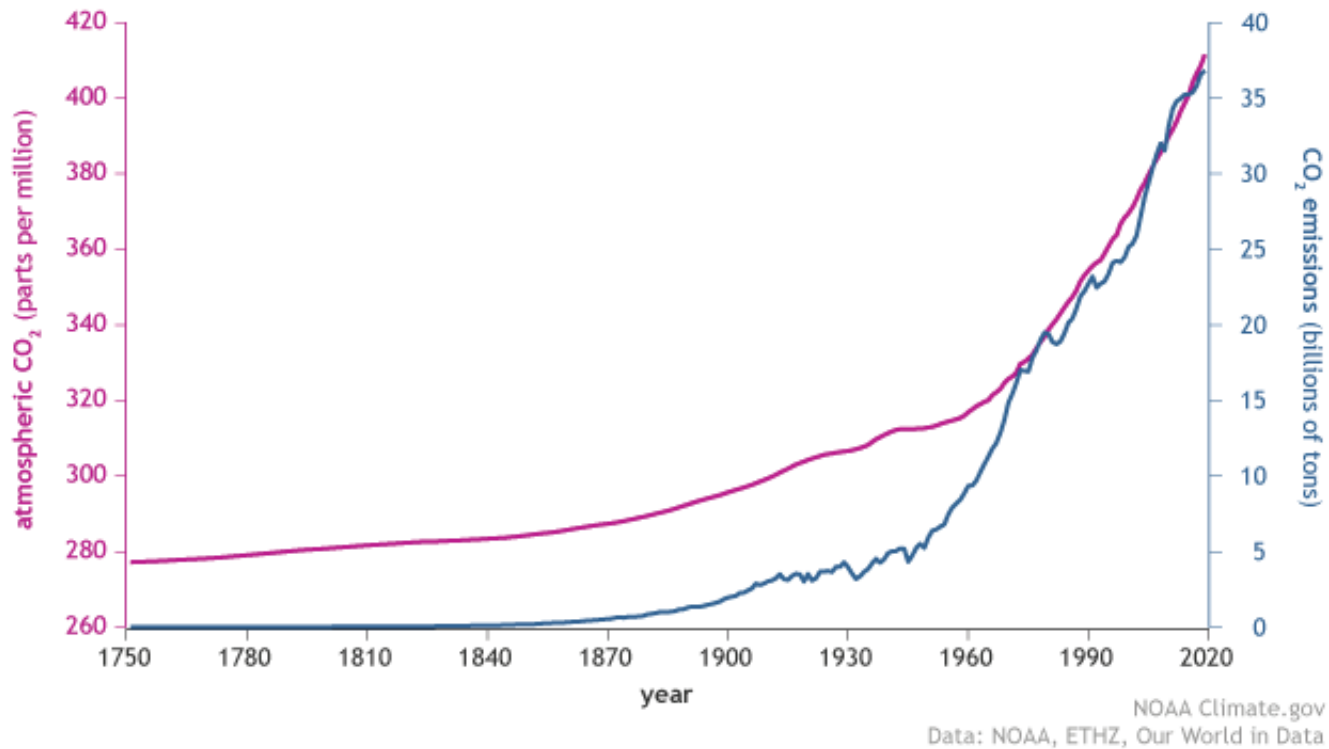
What is Carbonization?



Source: NASA

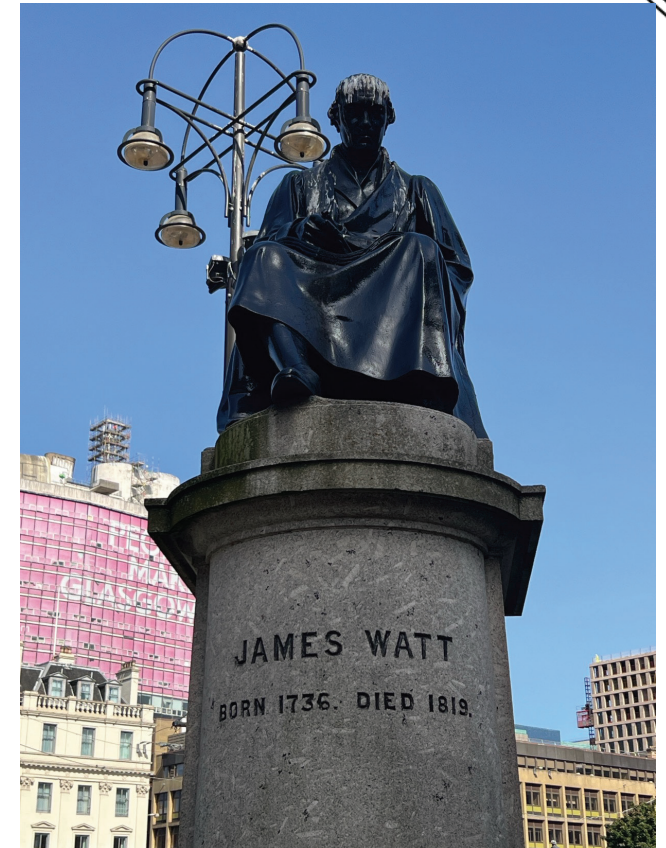
https://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/

CO₂ in the atmosphere and annual emissions (1750-2019)



Source: State of the Planet

<https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/>



Impacts of Carbonization

Global mean temperature 2024 was the warmest year on record

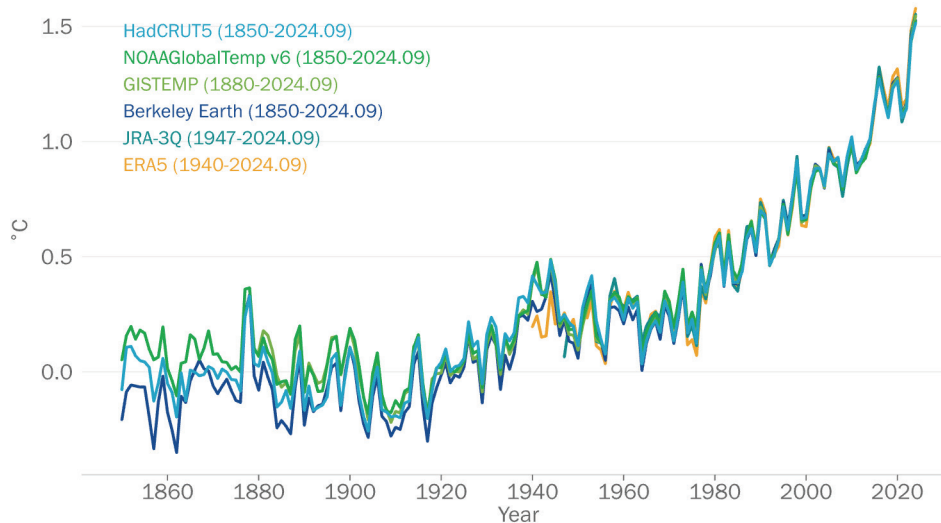
Global mean temperature
January-September 2024
 $1.54 \pm 0.13^\circ\text{C}$

Note that a single year above
 1.5°C does not mean that we
have passed the warming levels
in the Paris Agreement

On track to be the warmest year
in all six datasets

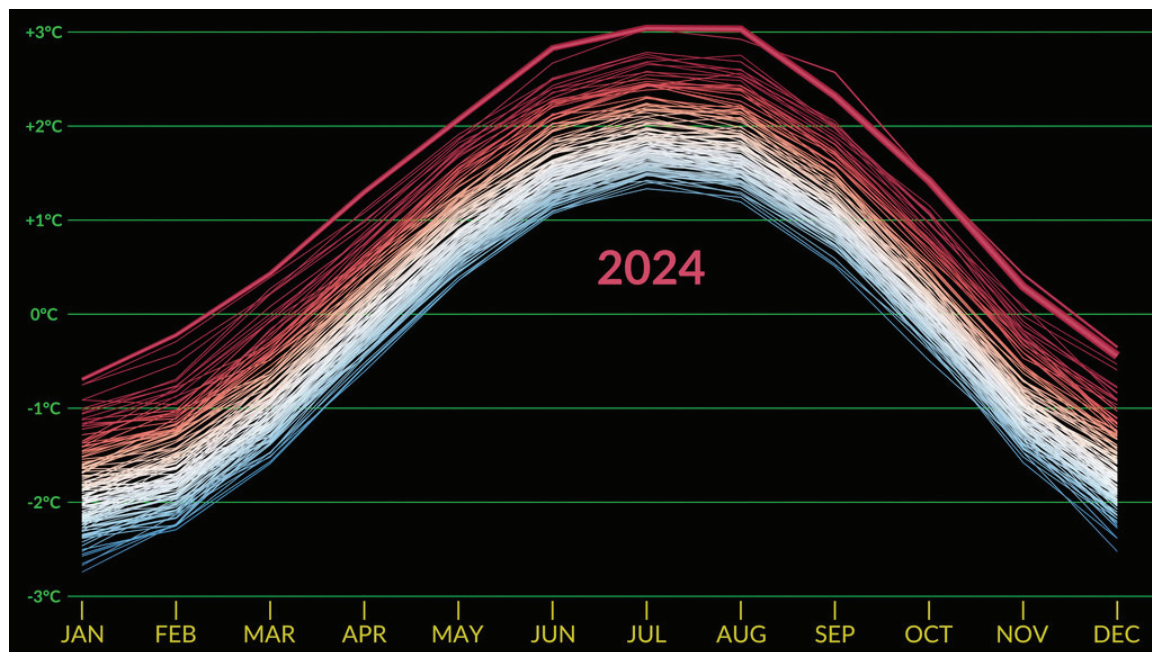
The past 10 years 2015-2024
are the 10 warmest years on
record

Global mean temperature 1850-2024
Difference from 1850-1900 average



Source: World Meteorological Organization

<https://svs.gsfc.nasa.gov/14743/>



Global Temperature Graph 1880-Present:

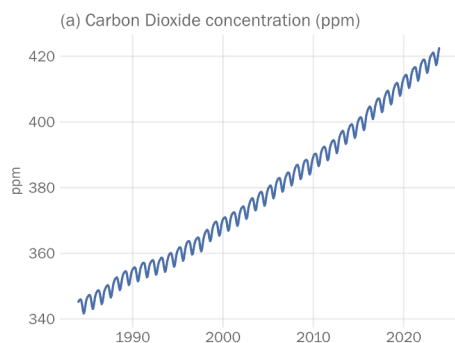
Earth's average surface temperature in 2024 was the warmest on record, according to an analysis led by NASA scientists. Global temperatures in 2024 were around 1.28 degrees Celsius above the agency's 20th century baseline (1951-1980). That is equal to a 2.30 degree Fahrenheit change and exceeds the record set in 2023. NASA scientists also estimate Earth in 2024 was about 1.47 degrees Celsius (2.65 degrees Fahrenheit) warmer than the mid-19th century average (1850-1900).

In 2024 the global average temperature was 1.47 deg C warmer than the average (1850-1900).

Paris Climate Conference target was a temperature increase of 1.5 deg C by 2100

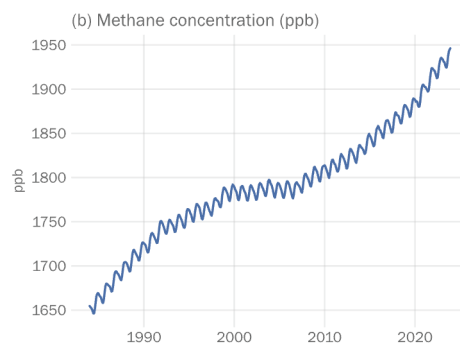
Greenhouse gas concentrations in the atmosphere reached record observed levels in 2023

Carbon Dioxide



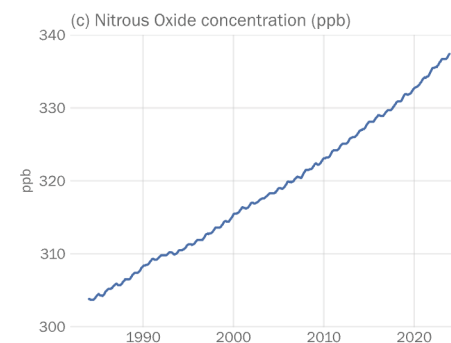
CO₂ in 2023
420.0 ± 0.1 ppm
151% of 1750

Methane



CH₄ in 2023
1934 ± 2 ppb
265% of 1750

Nitrous Oxide

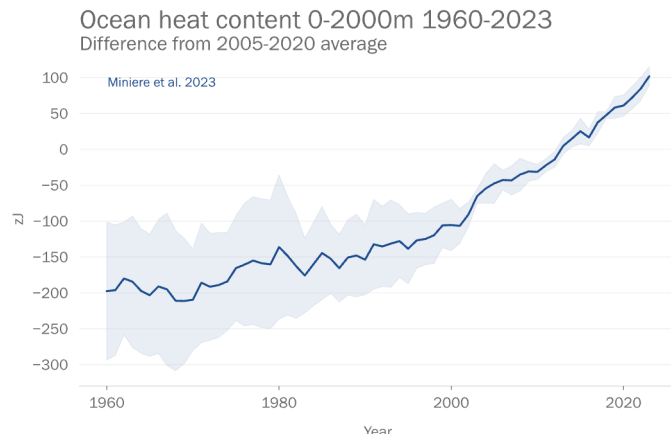


N₂O in 2023
336.9 ± 0.1 ppb
125% of 1750

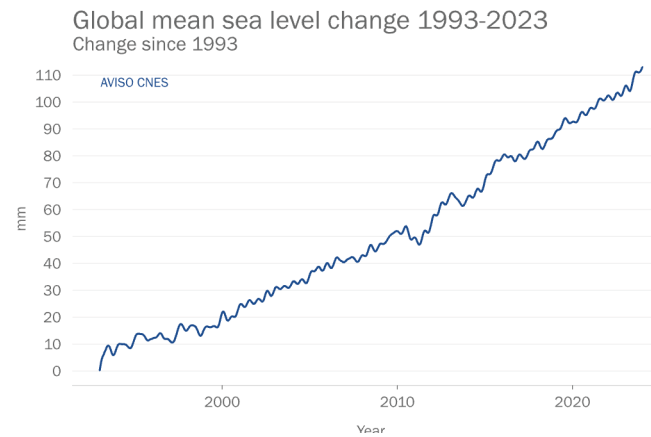
Data from World Data Centre for Greenhouse Gases

Ocean heat content 2023, highest on record

Sea level rise is accelerating



Ocean heat content in 2023 was the highest annual value on record, exceeding the 2022 value by 13 ± 9 ZJ.



Sea level rise is accelerating. Rate increased from $2.13 \text{ mm}\cdot\text{yr}^{-1}$ between 1993 and 2002 to $4.77 \text{ mm}\cdot\text{yr}^{-1}$ between 2014 and 2023.

Source: World Meteorological Organization

ZJ \rightarrow Zeta Joule, 10^{21}

State of Global Water Resources

- ▶ 2023 marked the driest year for global rivers in over three decades.
- ▶ Highly elevated temperatures in 2023 and 2024 with widespread dry conditions contributed to prolonged droughts.
- ▶ Hydrological cycle has accelerated and become more erratic and unpredictable.
- ▶ 3.6 billion people face inadequate access to water at least a month per year and this is expected to increase to more than 5 billion.



Climate-change Impacts





The Palisades Fire tears through a neighborhood in Pacific Palisades, Los Angeles, driven by strong winds on Tuesday, Jan. 7, 2025.

Source: <https://apnews.com/article/los-angeles-wind-wildfires-climate-change-weather-42b55ae1e66b56a6375300e448f01946>

Fire in Los Angeles

January 2025



A beach house is engulfed in flames as the Palisades Fire burns along Pacific Coast Highway in Malibu, Calif., on Jan. 8, 2025.

Source: <https://abcnews.go.com/US/worst-fire-pacific-palisades-experts/story?id=117507457>
Agustin Paullier/AFP via Getty Images

Flooding in Bangladesh – August 2024



Heat Wave in Delhi – May 2024



Flooding in Spain in 2024



Source: National Public Radio, USA

Flooding in Greece in 2023



A vehicle crosses a flooded road in the city of Volos, central Greece (AFP via Getty Images) Sept 2023



Cars in a flooded road in the city of Volos, central Greece (AFP via Getty Images) Sept 2023

Droughts in 2022



<https://idsb.tmgrup.com.tr/ly/uploads/images/2022/07/08/217454.jpg>

Dry riverbed in **Italy** (Po River) due to worst drought in 70 years, June 2022



The Jialing Riverbed at the confluence with the Yangtze River is exposed due to drought on August 18, 2022 in Chongqing, **China**.

<https://image.cnbcfm.com/>

Wildfires in Europe - Summer of 2022



Southwestern France, July 17, 2022



Central Portugal, July 13, 2022



Brandenburg, Germany, August 2022



Greece, July 2022



Northern Spain, June 2022



Central Italy, July 2022

“The number of wildfires in 2022 in the EU have nearly quadrupled the 15-year average”

[Source: CNN according to Copernicus, EU Earth observation program](#)

Siberia: Wildfires in June 2020 and June 2021



The Greenpeace Russia team has documented forest fires in the Krasnoyarsk region.
JULIA PETRENKO / GREENPEACE



In this June 16, 2021 photo, firefighters work at the scene of forest fire near Andreyevsky village outside Tyumen, western Siberia, Russia. -
Copyright AP Photo/Maksim Slutsky, File

Reduce Carbon Emissions from Electricity Production



Reduce Carbon Emissions

1. Use less electricity, energy efficiency
2. Use low carbon fossil fuel power plants
3. Use H₂ & other storage technologies
4. Promote more renewables
5. Accept some nuclear
6. Promote cross-border power transfer

Customers Controlling Buildings Optimized for Savings

Energy savings from air conditioning control: 10-15%

Energy savings from lighting control: 15-20%



Energy Efficiency Applications

Consider light bulbs

- Provide more energy efficient applications and tools globally
- The amount of electricity required to run an LED light bulb is less than 15% of what is needed to run an incandescent light bulb producing the same amount of light



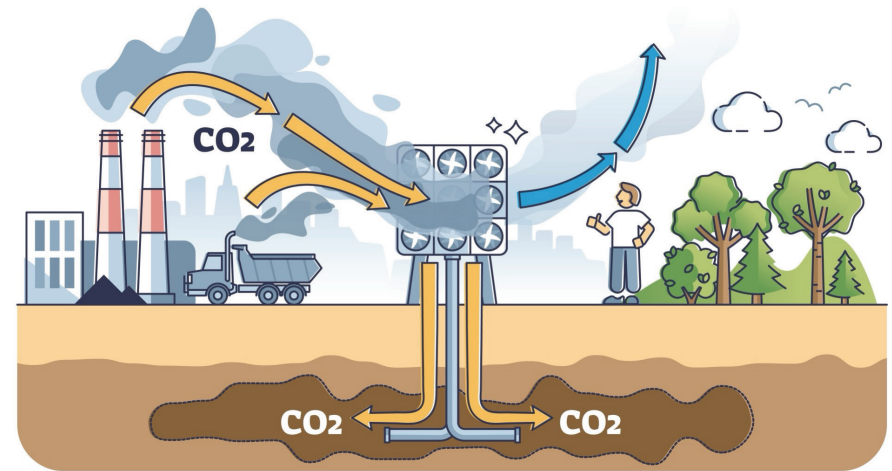
Highly Efficient Fossil-fuel Power Plants



- Combined Cycle Gas/Steam Power Plant
- Ultra-supercritical steam power plant

Carbon Capture & Storage Systems (CCS)

- Direct Air Capture (DAC) can help ensure that emissions created during the energy generation phase will not be emitted into the atmosphere
- These technologies have the potential to significantly reduce carbon emissions in energy systems across the board



Hydrogen and Storage Solutions

Optimize renewable energy solutions being integrated into energy grids



- Low-carbon hydrogen will help emerging economies to meet climate goals in and of itself
 - Provide for diverse energy portfolios
 - Improving resilience
 - Lowering costs
- Storage solutions serve as optimizers for other renewable energy solutions
 - Ensure that electricity generated during off-peak hours does not go to waste

Renewable Energy Integration

Whitelee Windfarm, Glasgow, Scotland



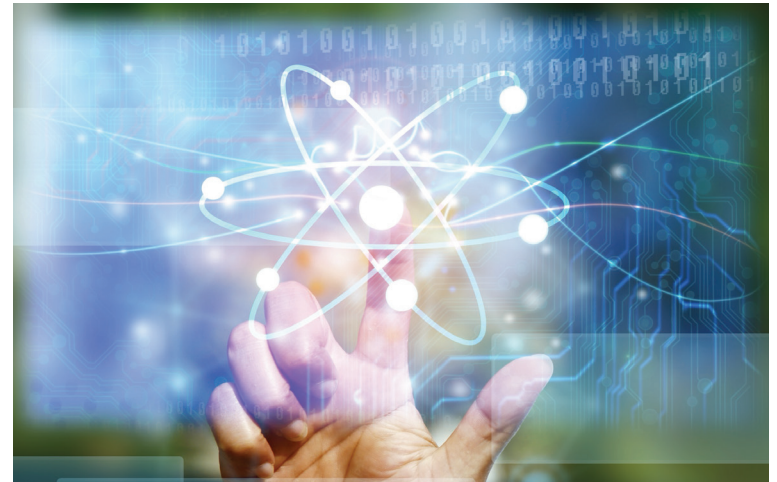
Kenya School of Monetary Studies, Nairobi



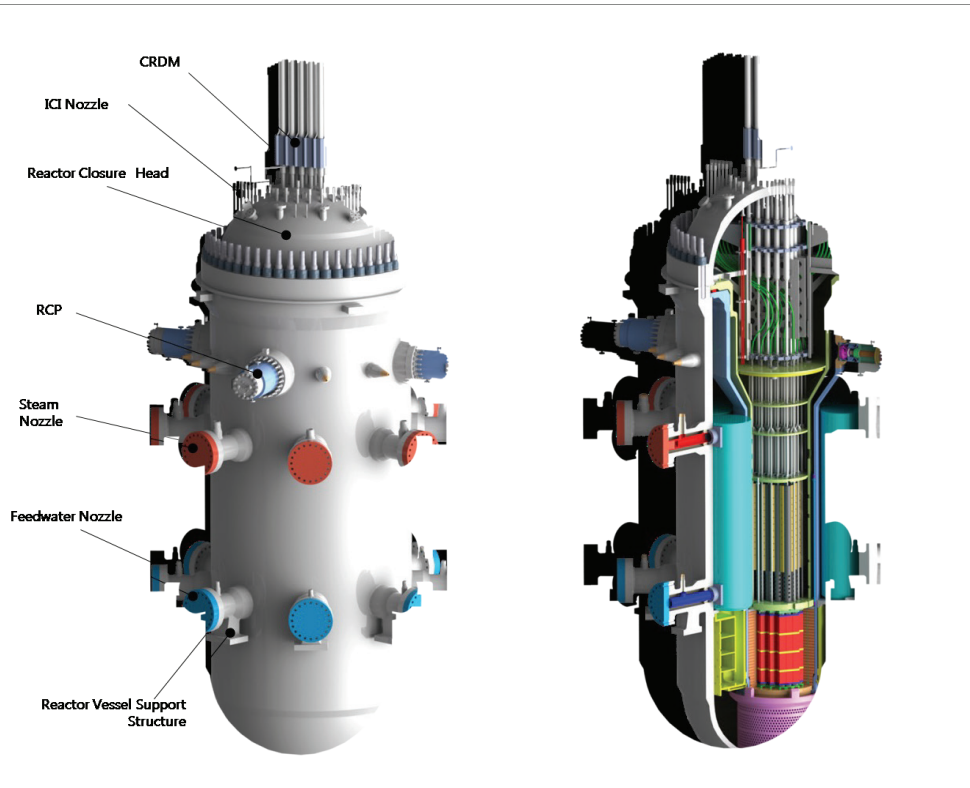
Advanced Nuclear Technologies

Diverse solutions to address climate change

- ▶ Advanced nuclear technologies, such as small modular reactors (SMRs), can play a role
 - Smaller and can be built more quickly than more traditional nuclear reactors
- ▶ Ramping up the development of SMRs can help to produce energy when and where needed
- ▶ This energy could be integrated into existing power grids
 - helping to provide improved resiliency while simultaneously reducing emissions

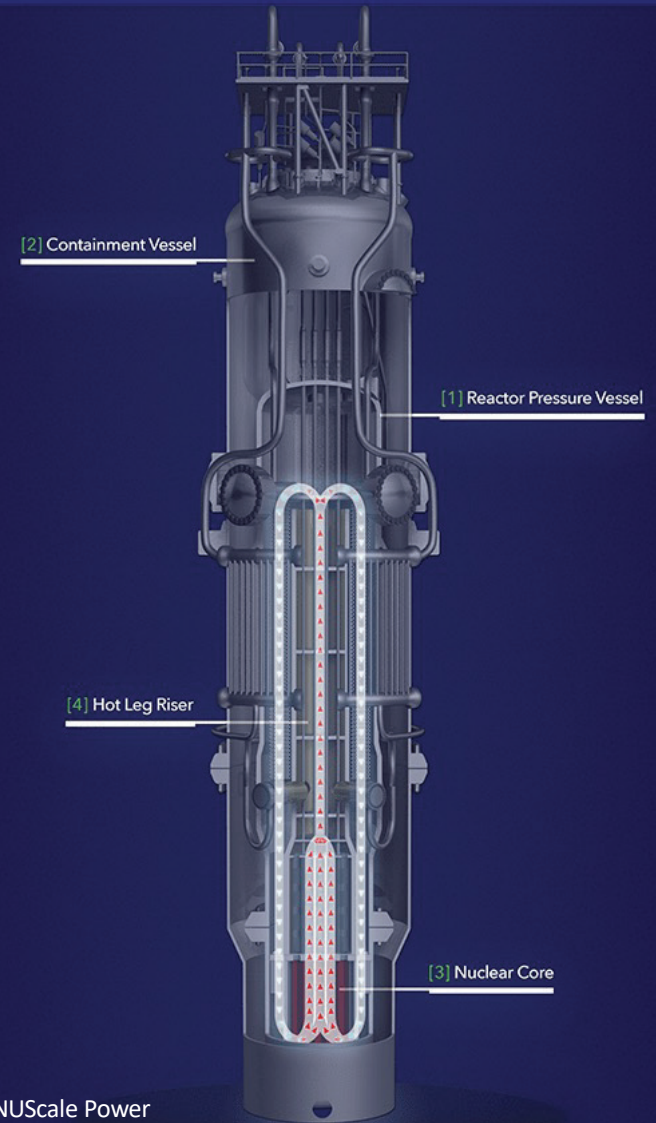


Small Modular Reactors (SMR)



20m tall, 2.7m dia. 590 tons LWR
4.95% enrichment. 50 – 60 MWe

© Saifur Rahman



Source: NUScale Power

Cross-Border Energy Transfer

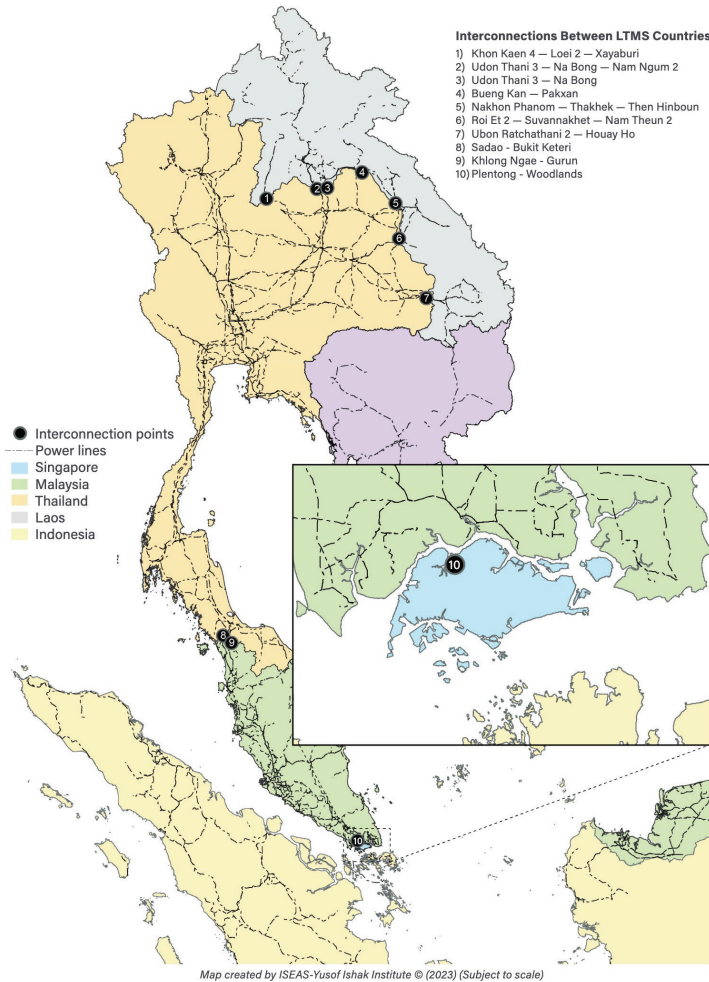
No Transition without Transmission

- ▶ As we are in this fight together, our solutions should be collaborative to secure better outcomes for all countries, regardless of location
- ▶ The International Energy Agency (IEA) has identified three main modes of cross-border energy integration:
 - Bilateral
 - Multilateral
 - Unified



Some Case-specific Examples

Figure 4. The Lao PDR-Thailand-Malaysia-Singapore Power Integration Project



Laos-Thailand-Malaysia-Singapore LTMS Interconnection

ACCELERATING THE ASEAN POWER GRID 2.0

Lessons from the
Lao PDR-Thailand-Malaysia-Singapore
Power Integration Project (LTMS-PIP)

Policy Report

Vietnam has opted to boost hydroelectricity imports from Laos

The limited electricity transmission capacity from the south to the north poses a major challenge.

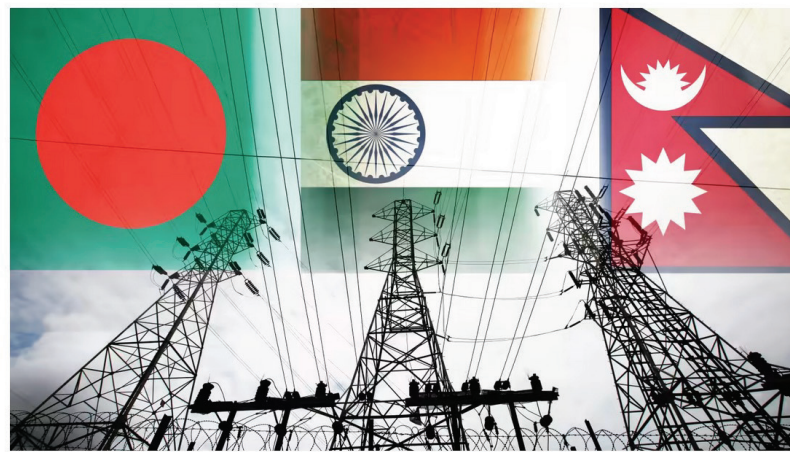
It is easier and more cost-effective to import hydro-electricity from Laos to shore up power supply for the North, given the shorter transmission distance.

Gulf Coordination Council Interconnection



Major Benefit: Reduction of Reserve Requirements
Also Helpful in Dealing with Intermittent Sources (PV)

Nepal needs to attract investment by developing a market outside



Bangladesh, India and Nepal are expected to soon finalize an agreement that would allow power sharing across Indian transmission lines. (Source photos by AP and Reuters)

In Nepal electricity demand is less in summer than in winter
It is opposite in India and Bangladesh due to high air conditioning load



*Advancing Technology
for Humanity*

What Can you Do to Serve Humanity?

Clean-Tech Solutions for Climate Sustainability

Climate
Change

IEEE: Enabling Innovation and Technology Solutions

38



IEEE's Climate Change Program

Climate Change

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<https://sustainable-climate.ieee.org>



*IEEE at UN Conference on Climate Change
Belem, Brazil, November 2025, COP30*

<https://cop30.br>



Strengthening Capacity Building for Energy Transition, COP30, Brazil

IEEE-ITU Symposium on Achieving a Resilience Climate

Geneva, 15-16 December 2025



<https://isasc.ieee.org>

IEEE-ITU Symposium Opening Speech

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Thank You

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