Addressing Climate Change and Energy Transition

Prof. Saifur Rahman

2023 IEEE President & CEO

Director
Advanced Research Institute
Virginia Tech, USA

www.srahman.org

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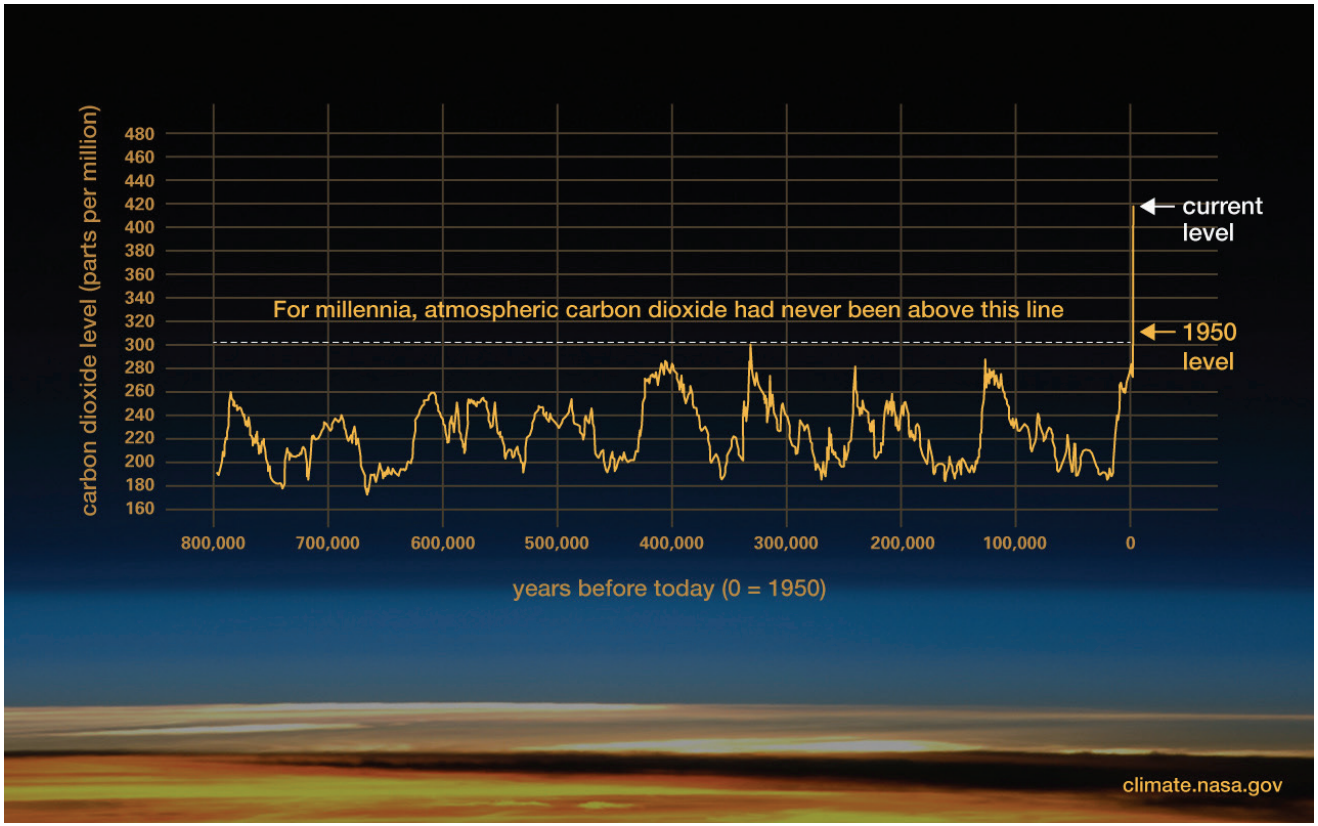
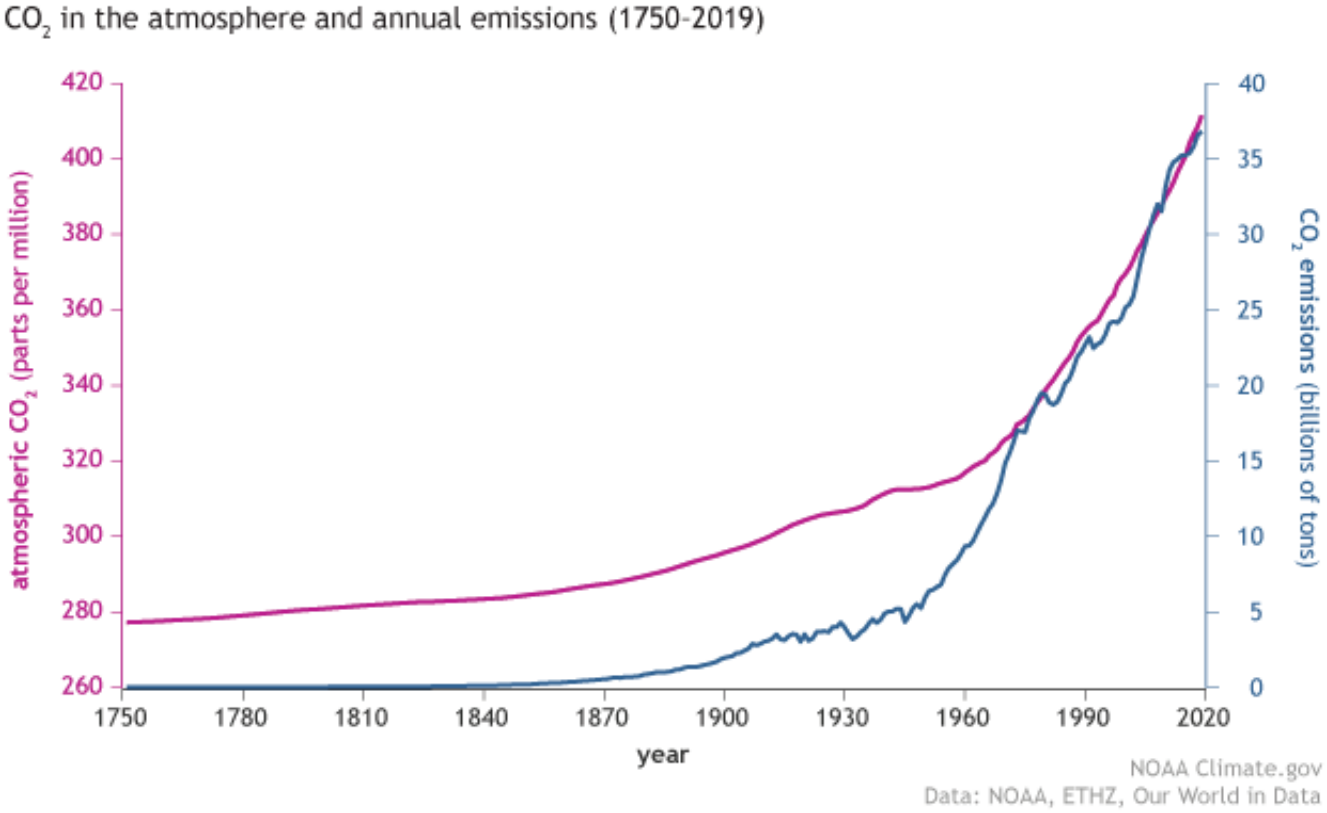
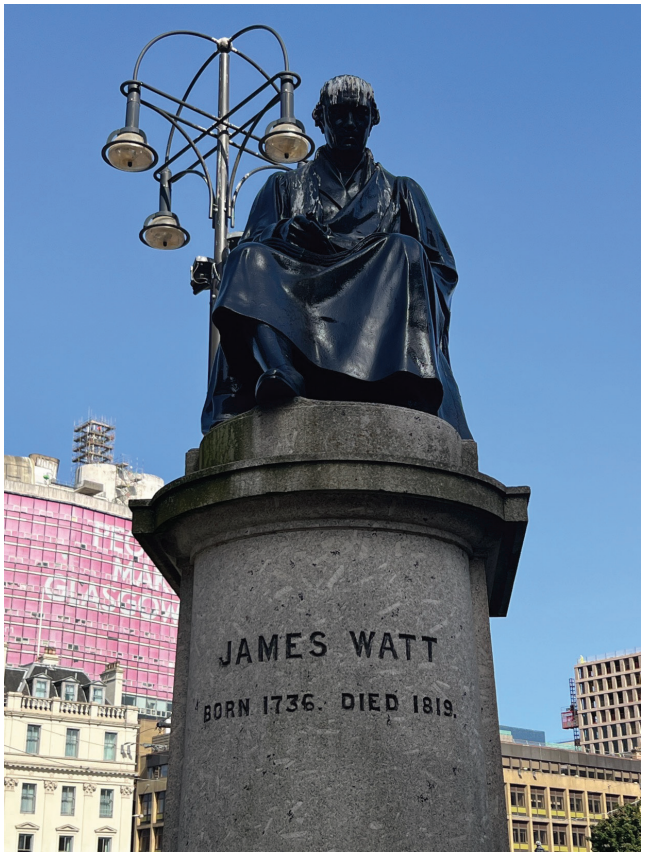
Carbonization is Challenging Climate Sustainability

What is Carbonization ?



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



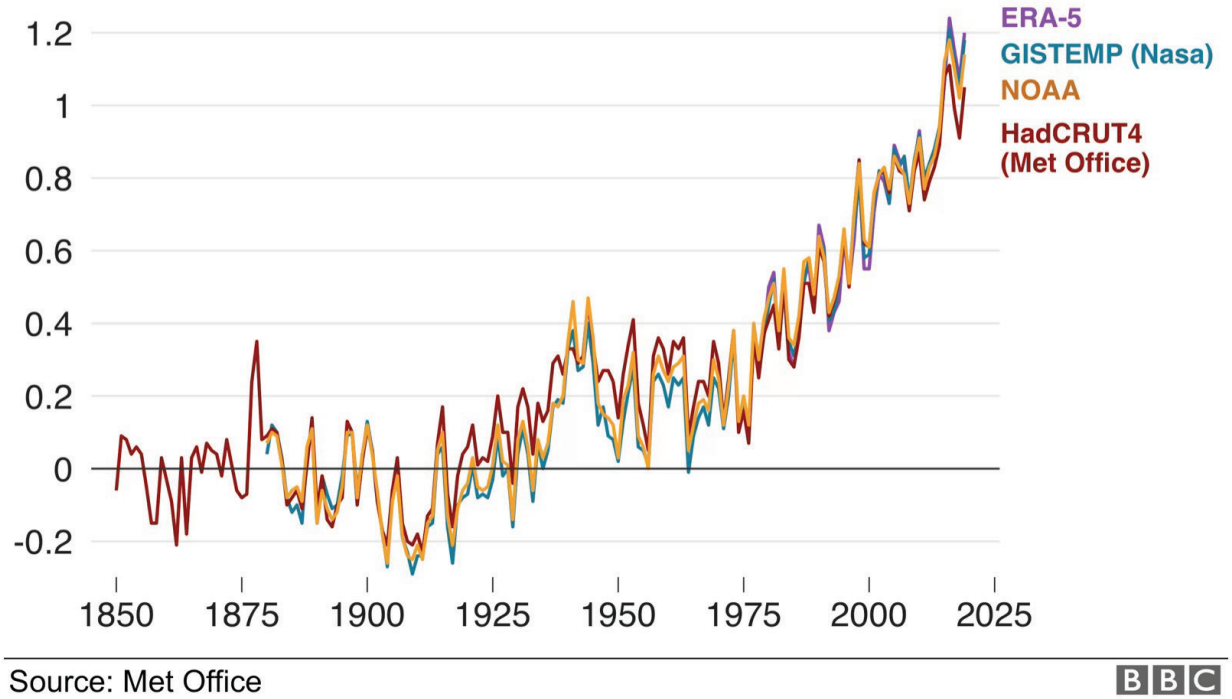


Source: State of the Planet
https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/

Impacts of Carbonization

Temperature rise since 1850

Global mean temperature change from pre-industrial levels, °C



Source: Met Office

BBC

Source: https://www.bbc.com/news/science-environment-51111176

Paris Climate Sustainability Goal: Limit to 1.5 dec C Rise

Temperature rise of 2.0 deg C ➡ Point of No Return

Climate-change Impacts

Fethi Belaid/Agence France-Presse — Getty Images

2023 January Flooding in New Zealand

Aljazeera News, The Waiohiki Bridge is washed away in Napier. [Kerry Marshall/Getty Images]

Flash flood caused by torrential rains in Auckland area in late January 2023
https://youtu.be/5r2AzhxEvxM

Superstorm Sandy
New York, New Jersey 2012

Beijing Flood (August 2023)

Beijing

Floods inundate a village in Baoding city, Hebei province, on 02 August 2023.

Source: https://www.cnn.com/2023/08/04/china/china-northeast-hebei-beijing-flooding-recovery-intl-hnk/index.html

Zhuozhou, north China's Hebei Province, 02 August 2023

Source: https://english.aawsat.com/world/4466926-beijing-records-heaviest-rainfall-least-140-years-causing-severe-flooding-and-21

Beijing

Flooded street after heavy rains in Zhuozhou, in northern China's Hebei province August 2, 2023. (AFP)

Source: https://english.aawsat.com/features/4470081-what-caused-record-rainfall-beijing-and-northern-china

Residents are evacuated by rubber boats through flood waters in Zhuozhou in northern China's Hebei province, south of Beijing, Wednesday, Aug. 2, 2023. China's capital has recorded its heaviest rainfall in at least 140 years over the past few days. Among the hardest hit areas is Zhuozhou, a small city that borders Beijing's southwest. (Andy Wong/AP)

Source: https://www.stripes.com/theaters/asia_pacific/2023-08-02/beijing-china-rainfall-deaths-10925575.html/

Brazil

Aerial view of the area affected by an extratropical cyclone in Rio Grande do Sul State, Brazil (AGENCIA RBS/AFP via Getty Images) Sept 2023

Greece

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

Flooding in Pakistan – August 2022



Source: https://www.npr.org/sections/pictureshow/2022/08/30/1119979965/pakistan-floods-monsoon-climate

Source: https://www.nytimes.com/2022/09/07/briefing/climate-change-heat-waves-us-europe.html

Droughts in 2022

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

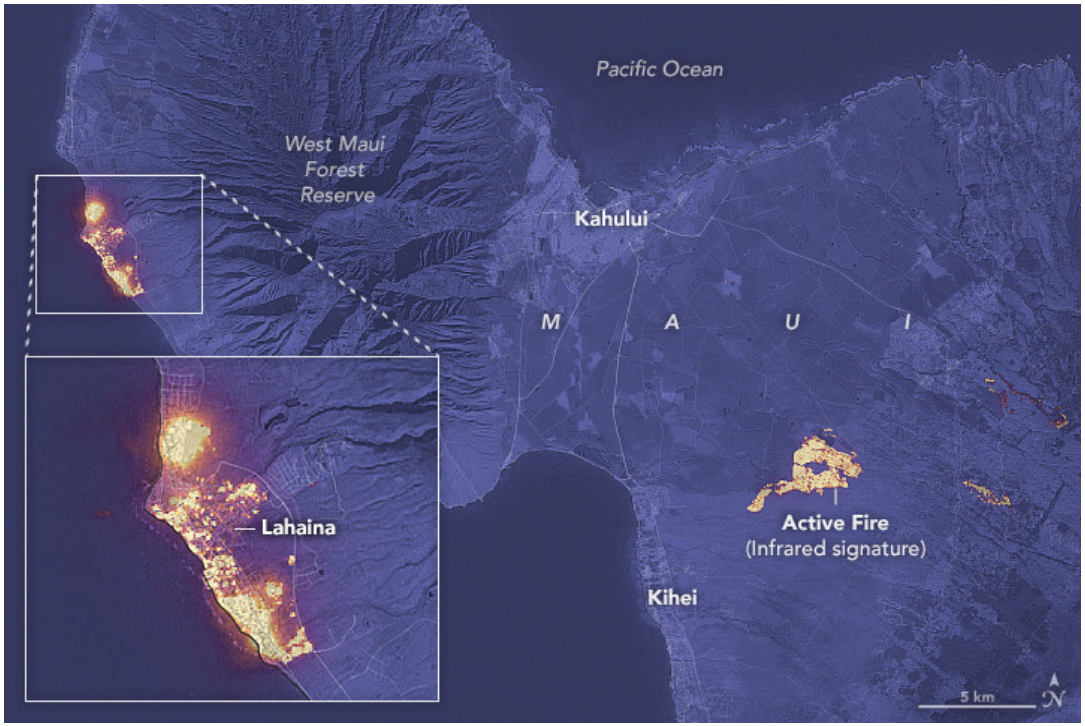
https://idsb.tmgrup.com.tr/ly/uploads/images/2022/07/08/217454.jpg

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

https://image.cnbcfm.com/

Hawaii Wildfire (August 2023)

Hawaii



NASA imagery showing the signature of the fire at 10:25 p.m. local time on August 8, 2023, as observed by the Operational Land Imager (OLI) on the Landsat 8 satellite.

Much of Lahaina, a town with a resident population of nearly 13,000 people, appeared to be on fire at the time of the image.

Toll as of Aug 15, 2023

- At least 110 dead
- More than 11,000 people evacuated
- Widescale power outages
- Cell phone disruptions

Source: https://earthobservatory.nasa.gov/images/151688/devastation-in-maui, NASA Earth Observatory

Hawaii

Reuters

Greece Wildfire (July 2023)

Greece

Before/After image of Fire Damage in Kiotari Rhodes, Greece
Source: Maxar Technologies via BBC. July 2023

Algeria/Tunisia Wildfire (July 2023)

Algeria/Tunisia

Burnt vehicles are pictured in the aftermath of a wildfire in Bejaia, Algeria July 25. REUTERS/Ramzi Boudina

Source: https://www.reuters.com/world/africa/deadly-fires-rage-along-algeria-coast-spread-tunisia-2023-07-25/

- Death toll at least 34 fatalities, including 10 firefighters in Algeria
- At least 26 others have been injured.
- Over 1,500 people evacuated in Bejaia, Bouira, and Jijel, Algeria
- Over 2500 evacuated from Maloula and Tabarka in Tunisia

Source: Crisi24
https://crisis24.garda.com/

Wednesday 26/07/2023

A man inspects the remains of a burnt vehicle in the aftermath of a forest fire near the town of Melloula in northwestern Tunisia close to the border with Algeria, July 26, 2023. (AFP)

Source: https://thearabweekly.com/tunisia-algeria-contain-wildfires-heatwave-sweeps-across-north-africa

Algeria/Tunisia

Fethi Belaid/Agence France-Presse — Getty Images

Forest fire in northwestern Tunisia, close to the border with Algeria, July 24, 2023

Aftermath of forest fire in northwestern Tunisia, close to the border with Algeria

Source: https://www.nytimes.com/article/wildfires-greece-italy-algeria.html

Siberia: Wildfires in June 2020 and June 2021

The Greenpeace Russia team has documented forest fires in the Krasnoyarsk region.

JULIA PETRENKO / GREENPEACE

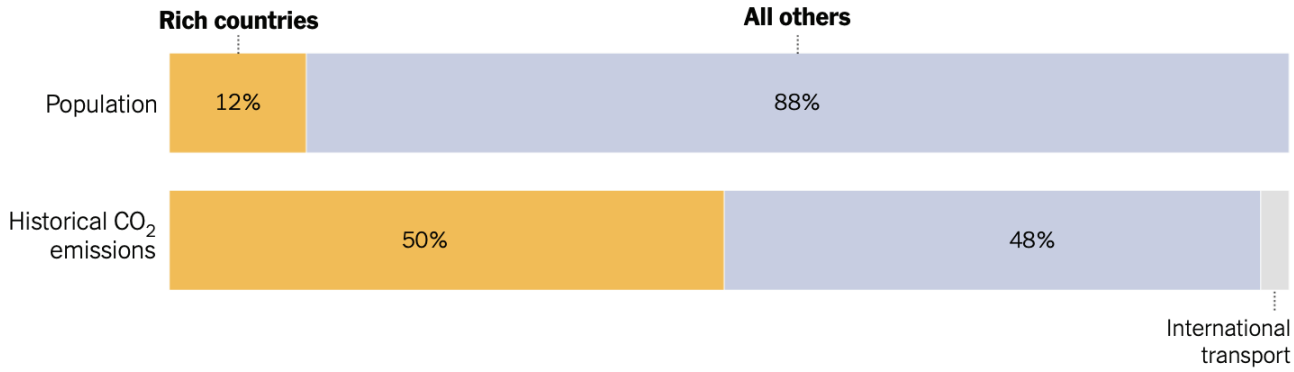
In this June 16, 2021 photo, firefighters work at the scene of forest fire near Andreyevsky village outside Tyumen, western Siberia, Russia. -

How Do We De-Carbonize?

The industrializing world needs sustainable, affordable and accessible energy sources

Who Has the Most Historical Responsibility for Climate Change (population based)

Rich countries, including the United States, Canada, Japan and much of western Europe, account for just 12 percent of the global population today but are responsible for 50 percent of all the planet-warming greenhouse gases released from fossil fuels and industry over the past 170 years.



Source: The New York Times article "Who Has The Most Historical Responsibility for Climate Change?" by By Nadja Popovich and Brad Plumer, Nov. 12, 2021 (https://www.nytimes.com/interactive/2021/11/12/climate/cop26-emissions-compensation.html)

Navigating the tension between industrialized nations and emerging economies for global decarbonization efforts requires a diverse portfolio of solutions for low-carbon generation, storage and demand side management with advanced technology focusing on energy efficiency.

To more efficiently facilitate the global shift towards lox-carbon electricity, the following six areas should be our priority.

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 H_2 & 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: 10-15%

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

Challenge?

Needs Changes in Behavior

Highly Efficient Fossil-fuel Power Plants

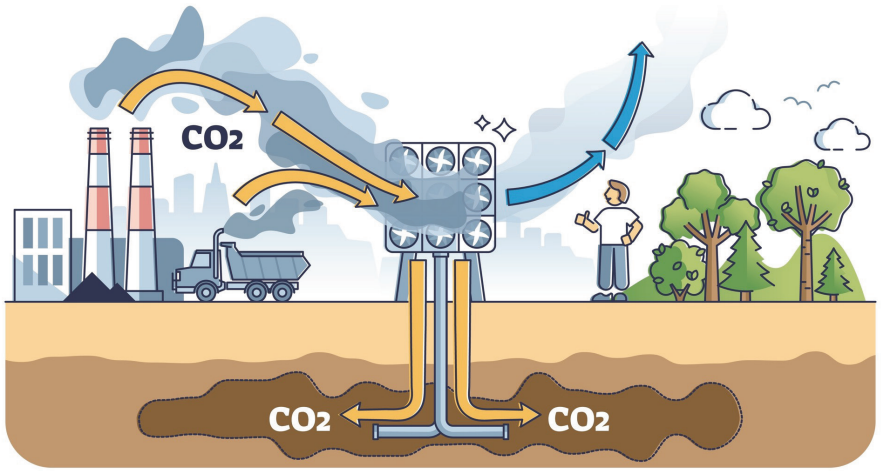
- Combined Cycle Gas/Steam Power Plant
- Ultra-supercritical steam power plant

Challenge?

Higher initial cost

Carbon Capture & Storage Systems (CCS)

- 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



Challenge?

Unproven Technology in Scale

Cost

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

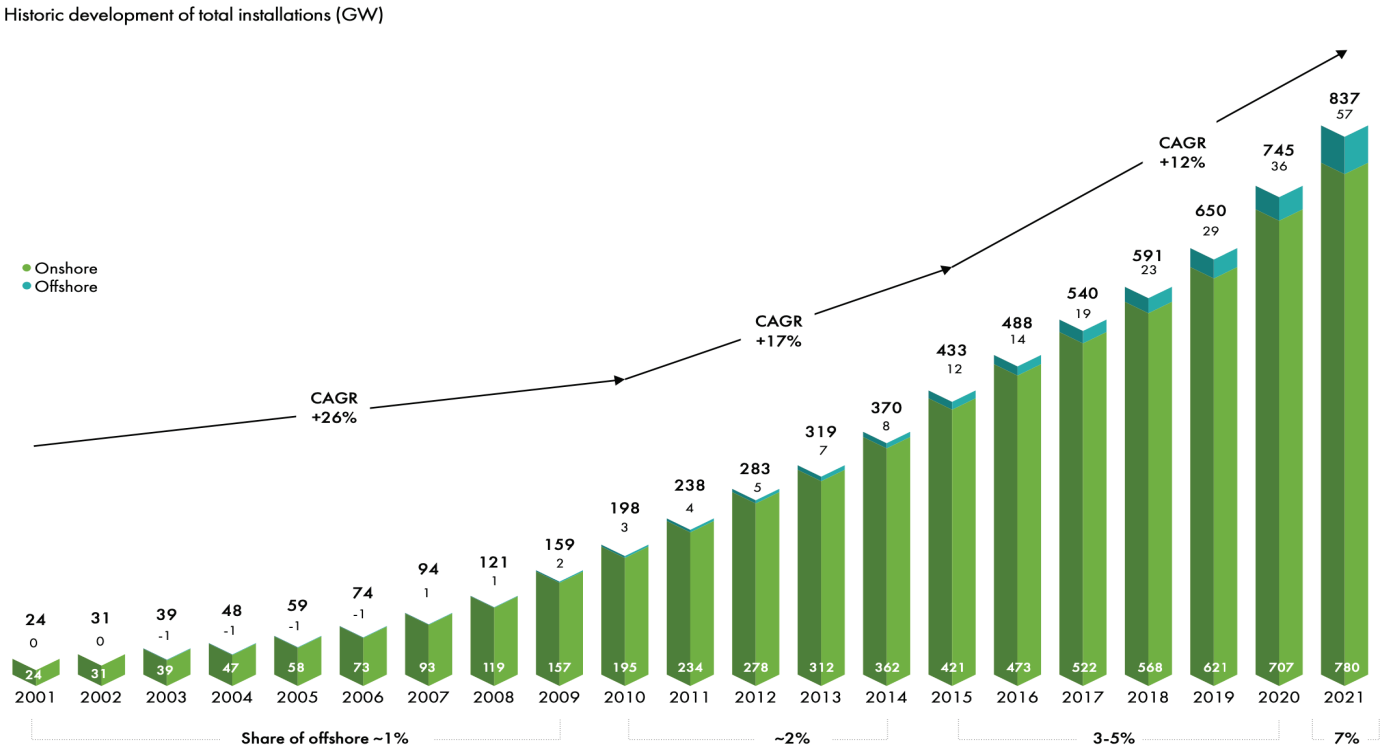
Challenge?

Safety
Flexibility
Cost

On-shore Wind Farm

Whitelee Windfarm, Glasgow, Scotland

Global Installed Wind Capacity (GW)
2001-2021 (Cumulative)

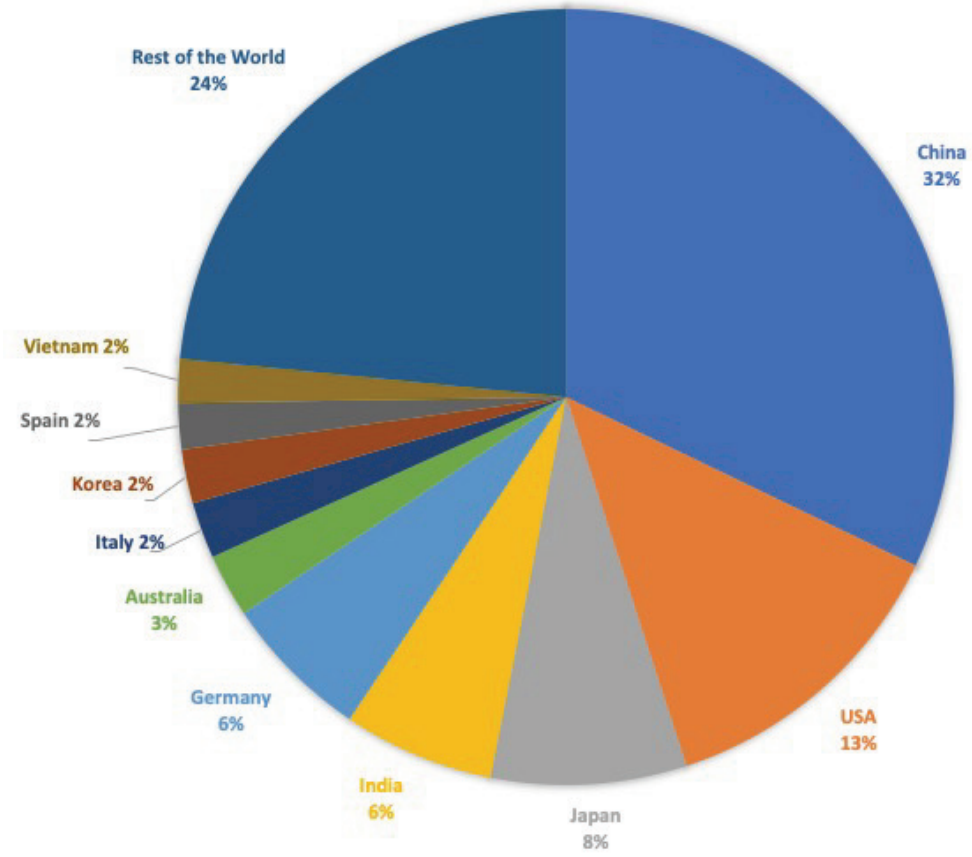


CAGR – compound annual growth rate of investment

Ground and Roof-mounted Solar Projects

Roof-mounted Solar in a School in Morocco

Global Cumulative Installed PV Capacity Showing Top 10 Countries End of 2021(942GW)

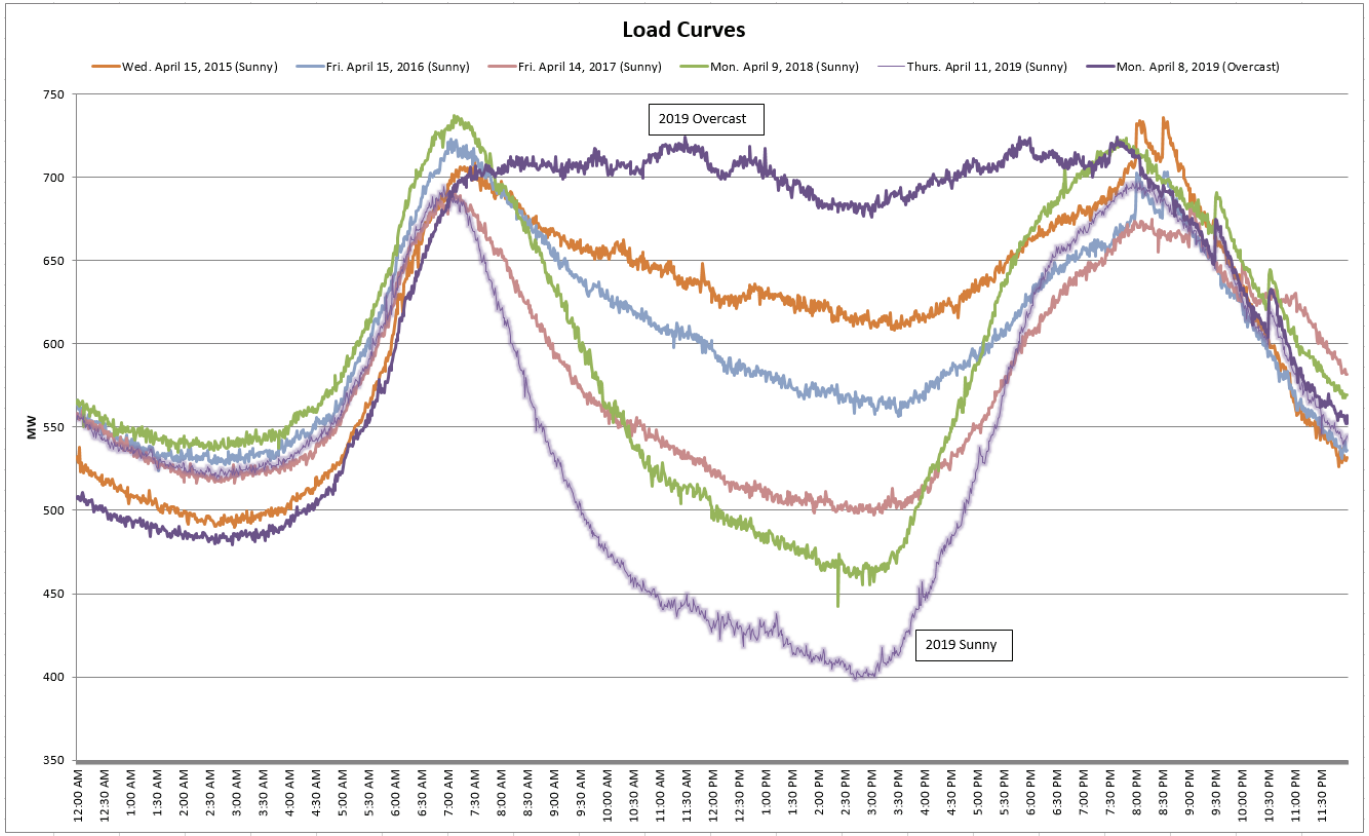


Source of Data: IEA, Snapshot of Global PV Markets: 2022

Challenges?

Small Electric Utilitiy with Large PV penetration

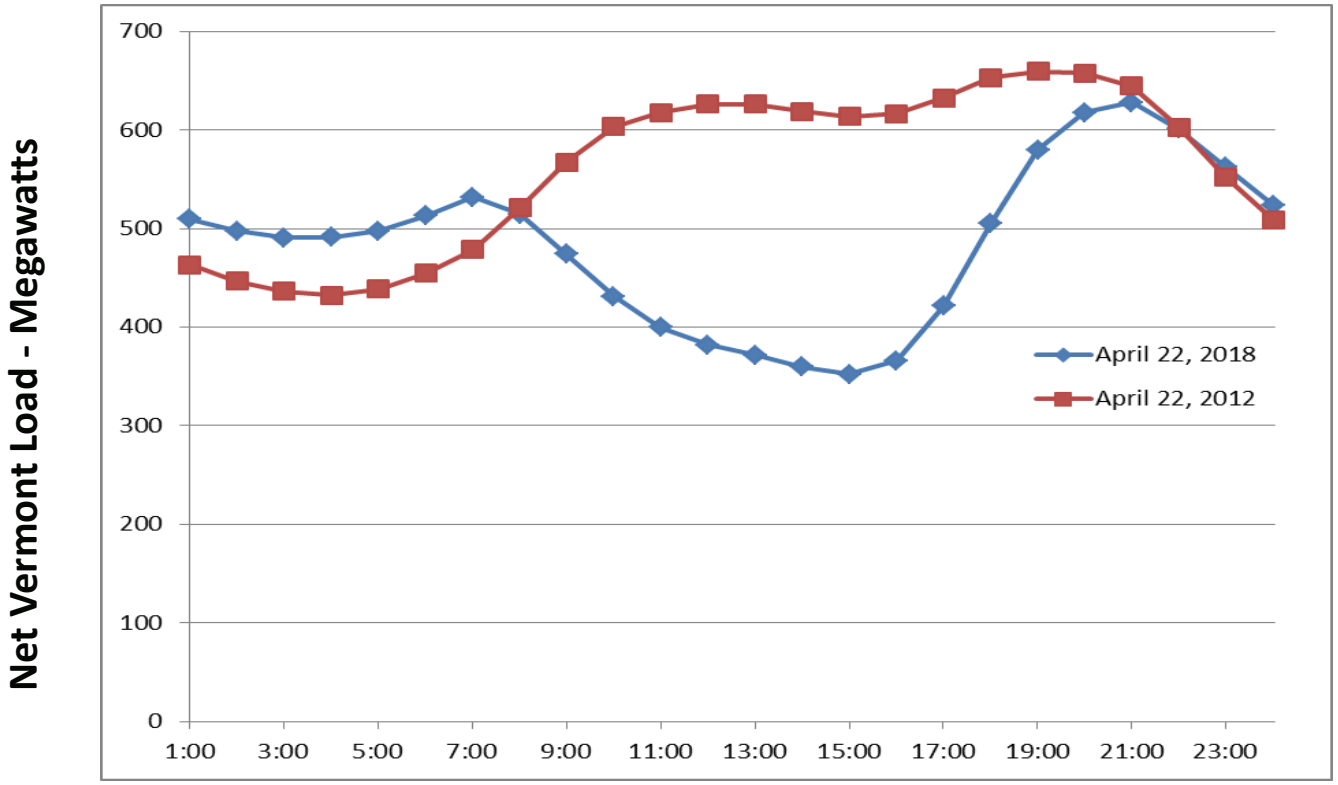
April Load Comparison



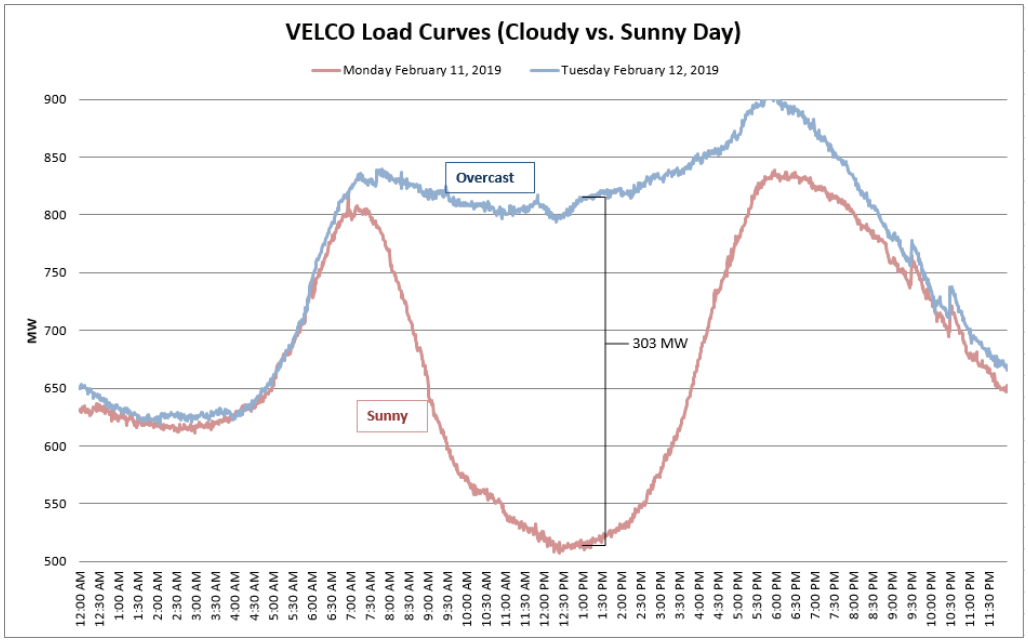
Source: VELCO

Impact of PV on Vermont Electric Company

A Tale of Two Sundays



Load Comparison



1. Weather Dependent
   - Cloudy, snow, calm winds
     - Low capacity factors
     - Intermittent generation
2. Inverter Based Generators
   - Large amounts not monitored
     - Behind meter
     - On distribution system
     - Not visible to transmission operators
   - Most connected to internet
     - No cyber regulations on smaller plants
   - IEEE 1547 adoption still occurring
   - Reduction in fault current (safety)

Renewable Integration Issues (continued)

3. Voltage Control
   - Voltage on distribution circuits
     - Impacted by distributed generation
     - Changes at night
   - Impact to transmission system
     - High voltage issues
   - Conventional utility voltage control methods too slow
   - New system improvements will be required to improve performance
4. Large Scale Renewables – not close to loads
   - Potential for new transmission
   - Duck curve in New England

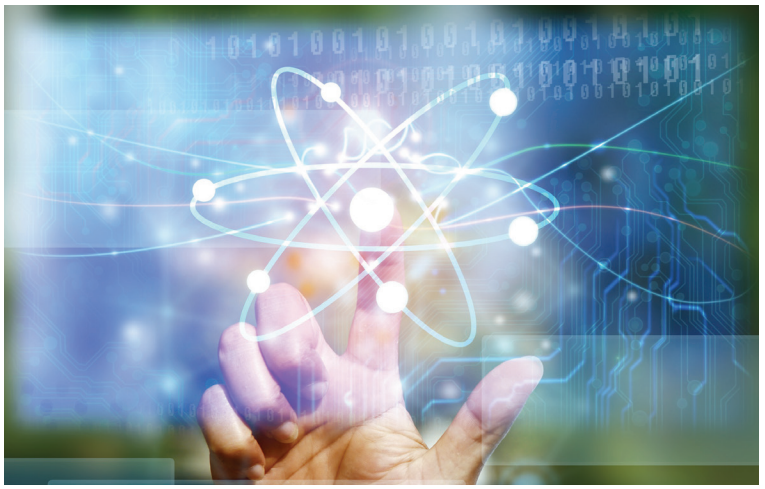
How About Hydro?

Very site-specific
Already fully developed
in industrialized countries

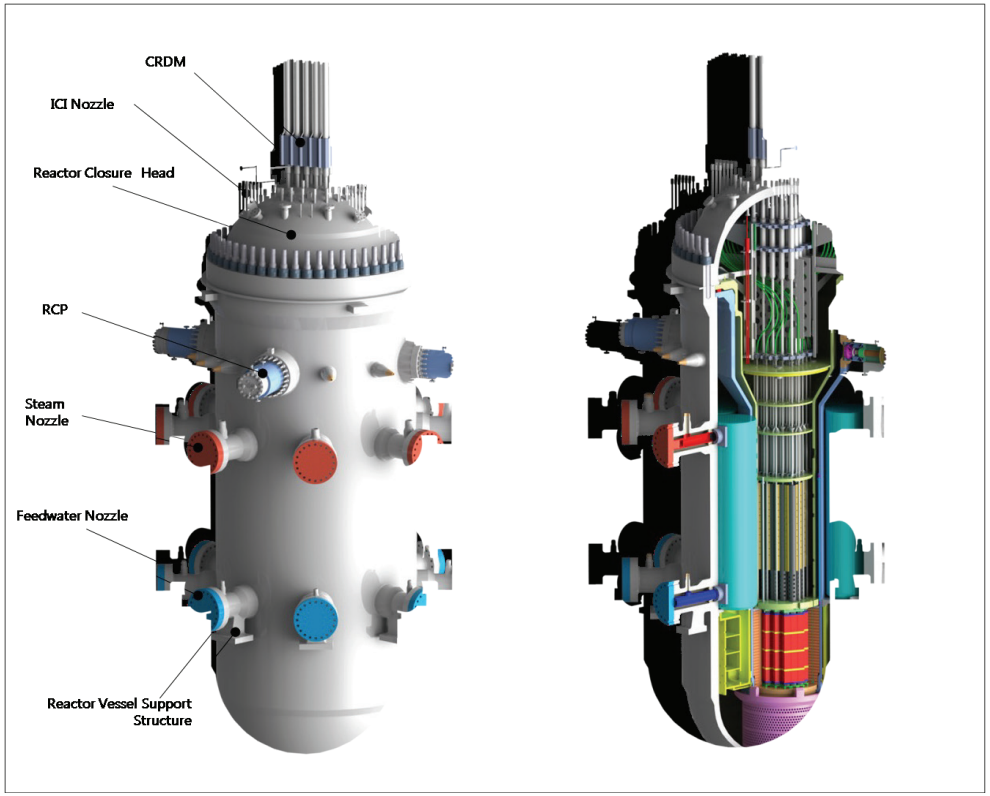
Advanced Nuclear Technologies

Diverse solutions to address climate change

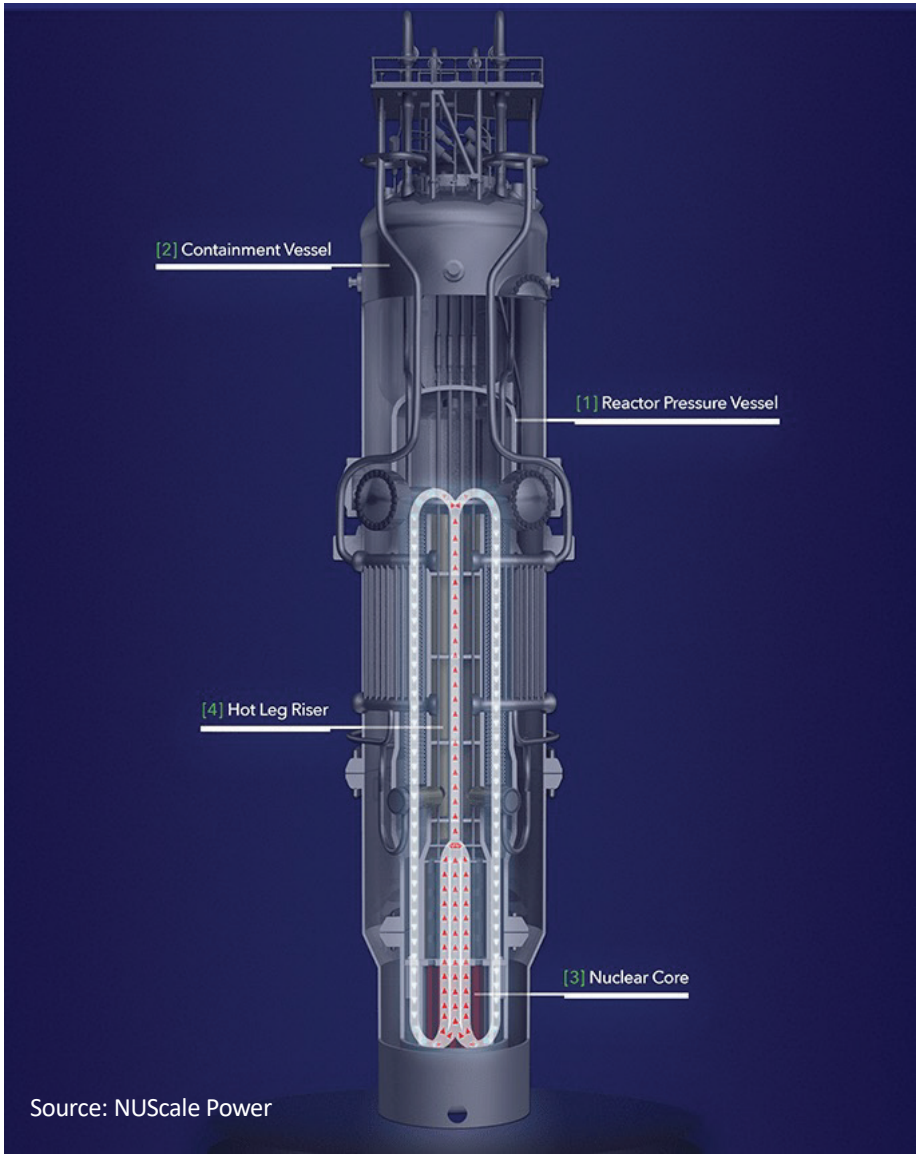
- Advanced nuclear technologies, such as small modular reactors (SMRs), can play a role
  - Smaller and can be built more quickly than more traditional nuclear reactors
- Ramping up the development of SMRs can help to produce energy when and where needed
- This energy could be integrated into existing 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



Cross-Border Energy Transfer

We all are impacted by climate change

- 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

Challenges?

International agreements needed to protect the security concerns of receiving countries

Thank you

web: www.srahman.org