Climate Change and Net-zero Transition
A Roadmap for Industrializing Countries

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Keynote Speech
IEEE Bangladesh Section Technical Expert Forum,
Institution of Engineers, Dhaka, 24 June 2023
Evolution of Global Electricity Generation Mix

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Generation (TWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>14,968</td>
</tr>
<tr>
<td>2021</td>
<td>27,783</td>
</tr>
</tbody>
</table>
Global Energy Use in 2019

Source: https://ourworldindata.org/electricity-mix
CO2 Emissions in Selected Emerging and Advanced Economies, 2000-2021
Who Has the Most Historical Responsibility for Climate Change

23 rich, developed countries are responsible for half of all historical CO₂ emissions.

More than 150 countries are responsible for the other half.
Who Has the Most Historical Responsibility for Climate Change

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.

• An unprecedented level of awareness of climate change and the role of decarbonization in enabling environmental sustainability moving forward

• In this talk the major focus is placed on the carbon produced through electricity generation, as it is responsible for roughly 30% of emissions globally
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 renewable energy adoption, the following six areas should be our priority.
Reduce Carbon Emissions from Electricity Production

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

Measured energy savings across deployments

- **20%** HVAC Energy Savings
- **25%** Lighting Energy Savings

**Occupant satisfaction:** spaces controlled by a building automation systems are more comfortable due to more consistent temperature profiles and healthier air quality through consistent monitoring of environmental factors (CO₂ levels, PM 2.5).
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

- Providing developing nations with lightbulbs that are more energy efficient can ensure that energy consumption and carbon emissions are being reduced requiring lesser investments in power generation, transmission & distribution
Highly Efficient Fossil-fuel Power Plants

- Combined Cycle Gas/Steam Power Plant
- Ultra-supercritical steam power plant
Eemshaven ultra-supercritical steam power plant, The Netherlands

Power Plant: Two units rated 800MW each
Efficiency: 46.2%
Temp: 609 deg C
Steam Turbine: Siemens SST5-6000
Built: 2014
Carbon Capture & Storage Systems (CCS)

• Can help ensure that emissions created during the energy generation phase will not be emitted into the atmosphere
• Direct Air Capture
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 renewable/nuclear energy solutions
- Ensure that electricity generated during off-peak hours does not go to waste
Changing Landscape for the Electric Utility
Roof-top Solar Photovoltaics in Virginia
Global Cumulative Installed PV Capacity Showing Top 10 Countries End of 2021 (942GW)

Source of Data: IEA, Snapshot of Global PV Markets: 2022
PV Annual and Cumulative Installed Capacity
Top 10 countries (2021)

<table>
<thead>
<tr>
<th></th>
<th>Country</th>
<th>Annual Capacity (GW)</th>
<th>Cumulative Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>54.9</td>
<td>308.5</td>
</tr>
<tr>
<td>2</td>
<td>USA</td>
<td>26.9</td>
<td>178.7</td>
</tr>
<tr>
<td>3</td>
<td>European Union*</td>
<td>26.8</td>
<td>123</td>
</tr>
<tr>
<td>4</td>
<td>India</td>
<td>13.5</td>
<td>78.2</td>
</tr>
<tr>
<td>5</td>
<td>Japan</td>
<td>6.5</td>
<td>60.4</td>
</tr>
<tr>
<td>6</td>
<td>Brazil</td>
<td>5.5</td>
<td>59.2</td>
</tr>
<tr>
<td>7</td>
<td>Germany</td>
<td>5.3</td>
<td>25.4</td>
</tr>
<tr>
<td>8</td>
<td>Spain</td>
<td>4.9</td>
<td>22.6</td>
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<tr>
<td>9</td>
<td>Australia</td>
<td>4.6</td>
<td>21.5</td>
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<tr>
<td>10</td>
<td>Korea</td>
<td>4.2</td>
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</tr>
<tr>
<td></td>
<td>Vietnam</td>
<td>3.3</td>
<td>17.4</td>
</tr>
</tbody>
</table>

Source: IEA PVPS

Wind Energy

Off-shore Wind turbines, Blyth, U.K.
Wildorado Wind Ranch - Siemens

**LOCATION:** Wildorado, TX
25 miles west of Amarillo in Oldham, Potter and Randall Counties

**SIZE:** 161 MW

**COMMERCIAL OPERATIONS DATE:** April 2007

**UTILITY:** Xcel Energy
(Southwestern Public Service Company)

**TURBINE EQUIPMENT:**
70 Siemens 2.3 MW Mk II

Source: http://www.nikkiphotography.com/category/environmental-issues/
http://www.cielowind.com/projects/completed-developments/wildorado-wind-ranch
Nysted Wind Farm-Siemens

Nysted Wind Farm
Located in the Baltic Sea, it is one of the world’s largest wind farms.

**Owner:** DONG Energy, Denmark (80%) and E.ON Sweden (20%).

**Layout:** The wind farm is made up of 8 rows of 9 turbines, of which the nearest are placed some ten kilometers offshore.

**Turbine:** each can generate 2.3 MW. The combined effect is 165.6 MW.

**Commercially handed over:** Dec. 1st, 2004

Source: http://www.dongenergy.com/Nysted/EN/Pages/index.aspx
Global Installed Wind Capacity (GW) 2001-2021 (Cumulative)

Historic development of total installations (GW)

CAGR – compound annual growth rate of investment

Source: GWEC Global Wind Report, 2022
Total Onshore and Offshore Installed Wind Capacity
Top Ten Countries (2021)

Source: GWEC Global Wind Report, 2022
Future Wind Power New Capacity Growth (GW) 2022 - 2026

CAGR – compound annual growth rate

Source: GWEC Global Wind Report, 2019
Renewable Energy Integration

Inverter-based resources pose new challenges

- Focus on where energy is needed most, via three core components:
  - Energy generation
  - Transmission
  - Distribution
Advanced Nuclear Technologies

- 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

Source: NUScale Power
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
IEEE Climate Change Engagement Opportunities
IEEE’s Engagement in Addressing Climate Change

Mission-based Challenge

- Pragmatic and accessible technical solutions are urgently needed to address climate change
- We, as engineers and technologists, are well and uniquely placed to provide technical solutions and offer a neutral space for discussion and action

What IEEE Brings to the Challenge

- Commitment to the constant pursuit of innovation and excellence for the benefit of humanity
- The technical expertise of IEEE members and volunteers from across IEEE OUs
- The power of IEEE’s collaborative platforms to enable innovation with purpose
- Longer-term IEEE engagement in creating and promoting technical solutions and applications for addressing climate change
IEEE Climate Change Website

https://climate-change.ieee.org
As the world's largest organization of technical professionals, IEEE has both the opportunity and the responsibility to assist in organizing the response of engineers, scientists, and technical professionals across the world to address the causes, mitigate the impact, and adapt to climate change.

IEEE's scholarly publications, conference proceedings, technical standards, and other materials help foster the exchange of technical knowledge and information for the critical climate issues that our planet faces today.
Ecosystem for IEEE’s Climate Sustainability Work

IEEE Spectrum: Climate Change News Feed; Podcasts; Features; Archives; Journal Watch Posts (Xplore); The Institute (Engineers of Climate Change; Coverage of Conferences and Standards)

Xplore: Engineers to Follow; Journal Watch Articles (free); Climate Change Articles

Social Media

Sponsored Content From Industry

Jobs from IEEE Job Site

Conferences

Standards

Newsletters
2022 IEEE President and CEO Social Media Channels

Follow the President’s channels and stay abreast of climate change information

There are four social media channels for the IEEE President:
https://www.facebook.com/ieeepresident

https://www.instagram.com/ieeepresident/

https://www.linkedin.com/showcase/ieeepresident

https://twitter.com/ieeepresident
THANK YOU!

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