NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Energy and Global Climate Change: The Road From Paris to Denver

Rocky Mountain Association of Energy Engineers Forum

"Our Changing Energy Landscape"

Jeffrey Logan, NREL

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Today's Talk

- A word on NREL
- Snapshot: U.S. Power Sector Transformation
- A Brief History of Climate Negotiations
- The Paris Agreement: Why Different This Time?
- What's Required from Paris?
- What it Means for Us in Colorado

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NREL: A National Asset with a Global Mission

- Only national lab dedicated to EE and RE
- World-class facilities, renowned scientists
- Nearly 1,700 employees
- Campus is a model of sustainable energy
- National economic impact of $872M annually

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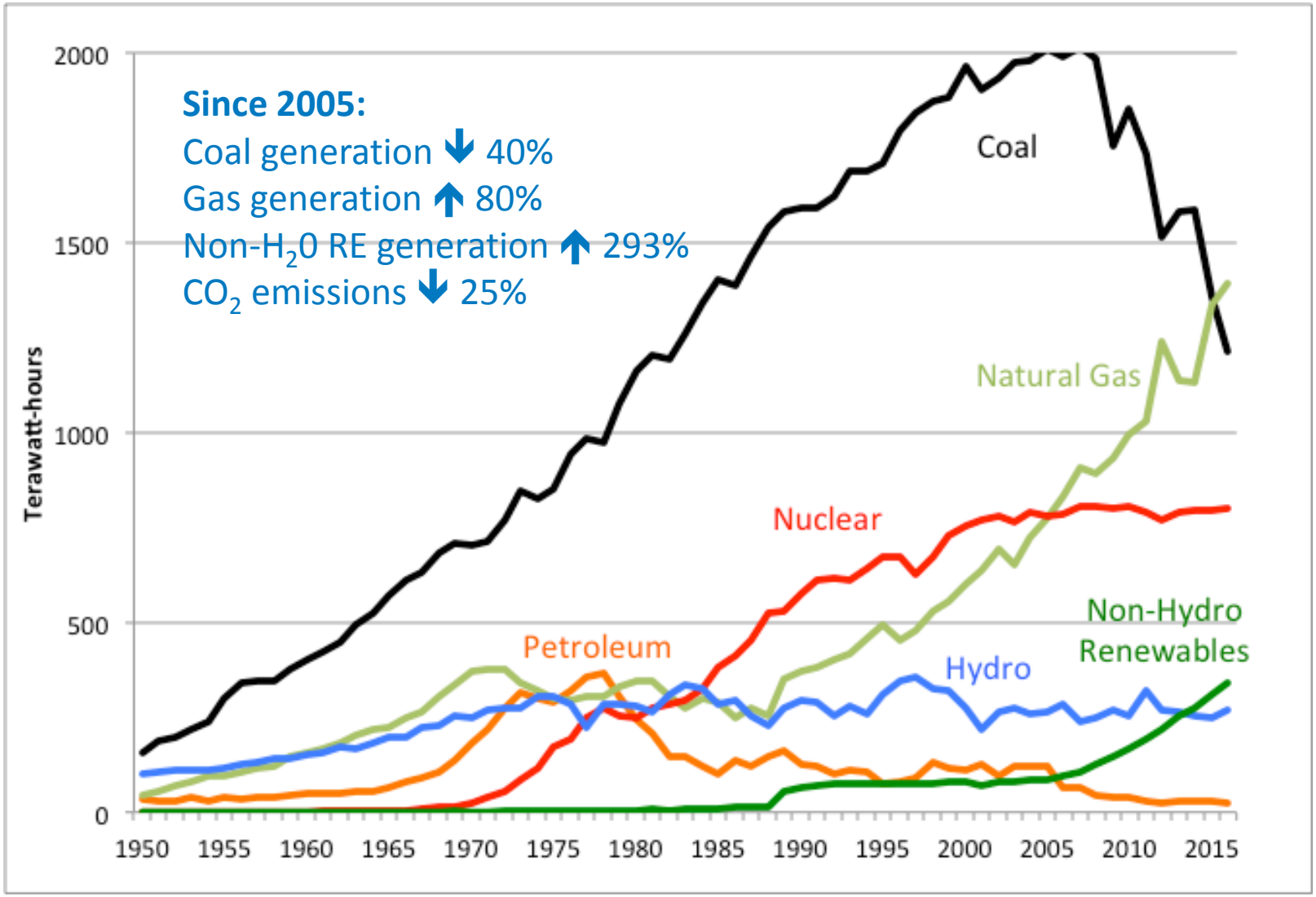
Changing U.S. Generation Mix



Source: EIA Electric Power Monthly. 2016 includes 12-month rolling average with data through July.

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A Brief History of Climate Change Negotiations

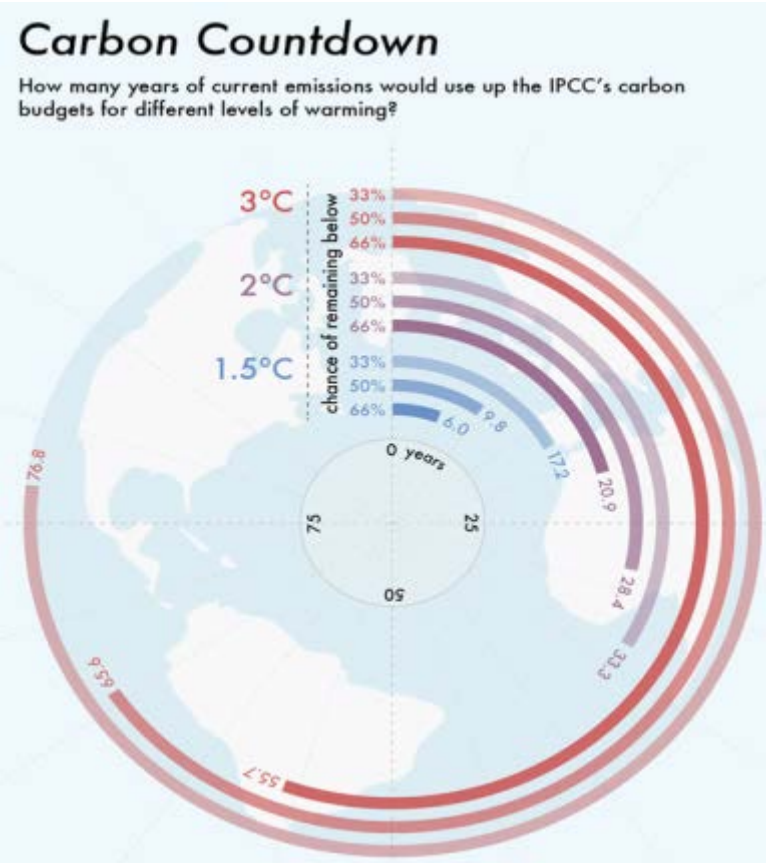
- Global Problem in Need of a Global Solution
- Earth Summit in Rio (1992): Established the UNFCCC.
  - Goal: Stabilize GHG concentrations at a level that would prevent "dangerous interference". Developed countries to reduce emissions to 1990 levels by 2000. Ratified by 191 countries including U.S.
- Kyoto Protocol (2005)
  - Set binding targets to reduce emissions by 5.2% below 1990 levels by 2012. Never ratified by U.S.
- Conference of Parties (COP) 15 in Copenhagen (2009)
  - Shifted to "pledged reduction" goals, including China, but never established treaty with binding commitments.
- COP 21 (2015) in Paris
  - Combines bottom-up "nationally determined contributions" and top down transparency and accountability measures. Limit warming to 2° C or less.

Select Highlights In International Climate Negotiations

Remaining Carbon Budget

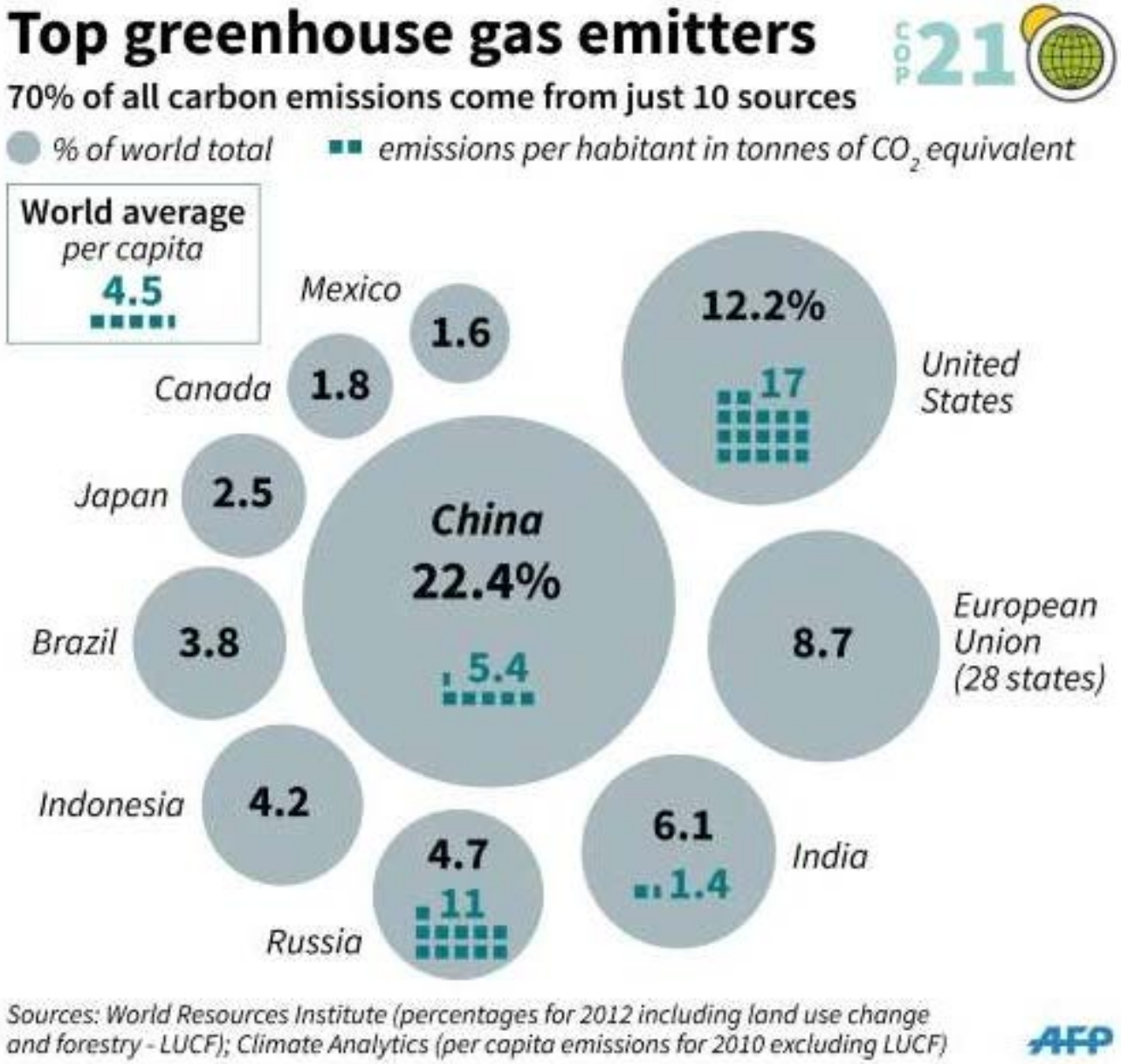
The remaining global carbon budget ranges from as little as 6 years of current emission levels to hold warming to 1.5°C at high confidence, to nearly 78 years of emissions at 3°C and low confidence.

These calculations are from Carbon Brief, and based on the Fifth Assessment Report of the UNFCCC.

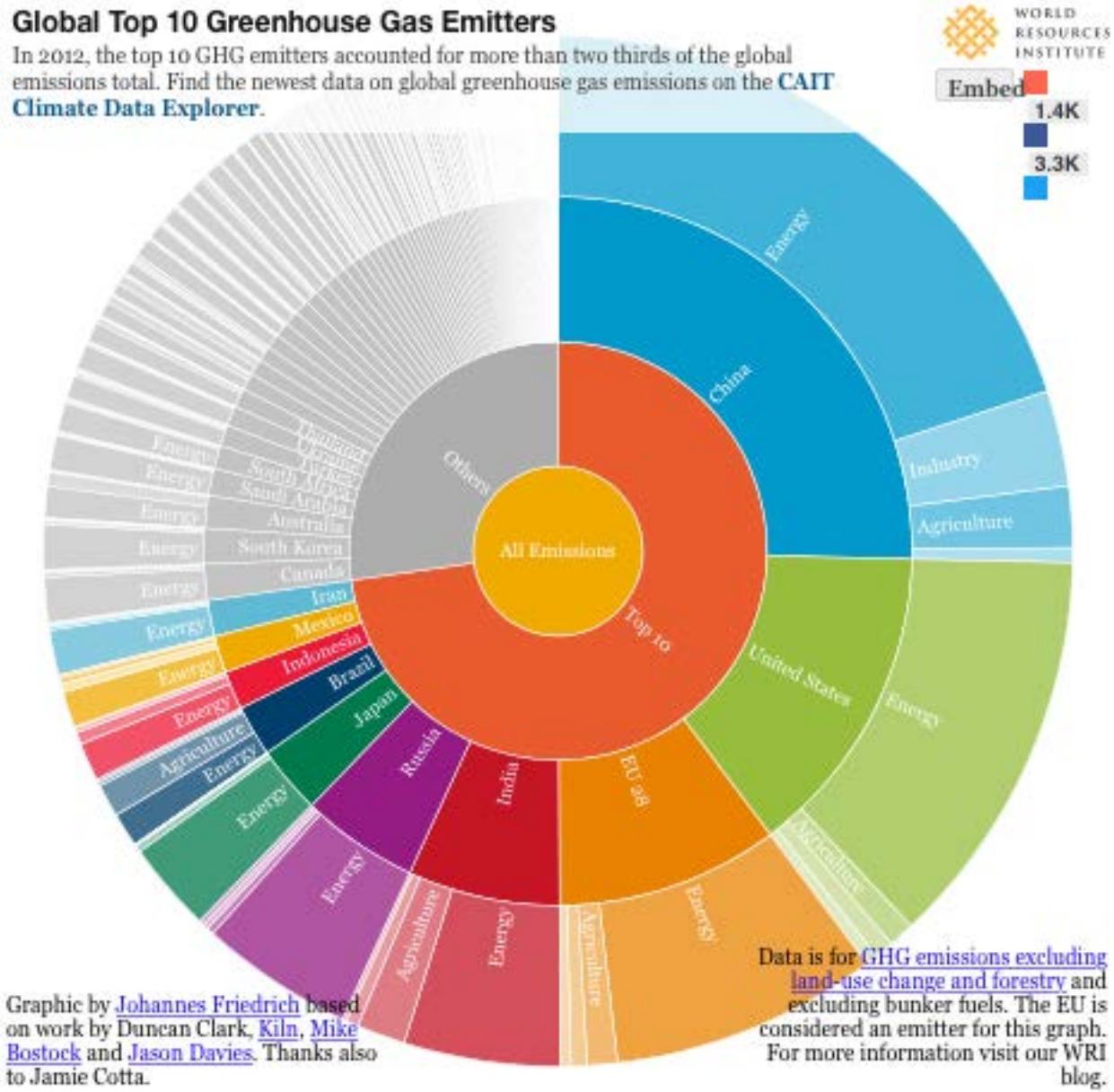


Source: Carbon Brief, 2014.

A Brief History on Climate Change Negotiations

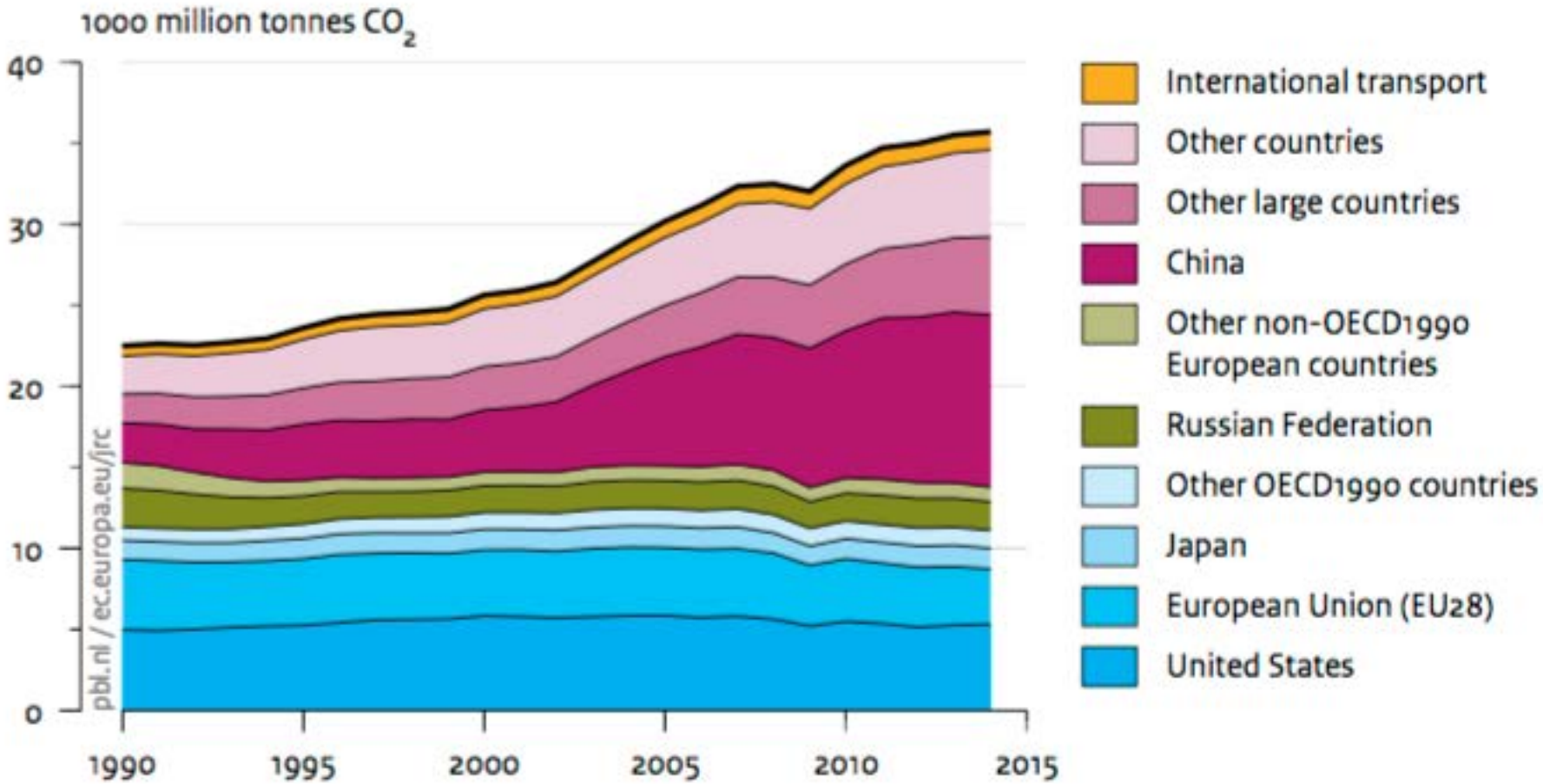


Top 10 Global Greenhouse Gas Emitters in 2012



Source: WRI

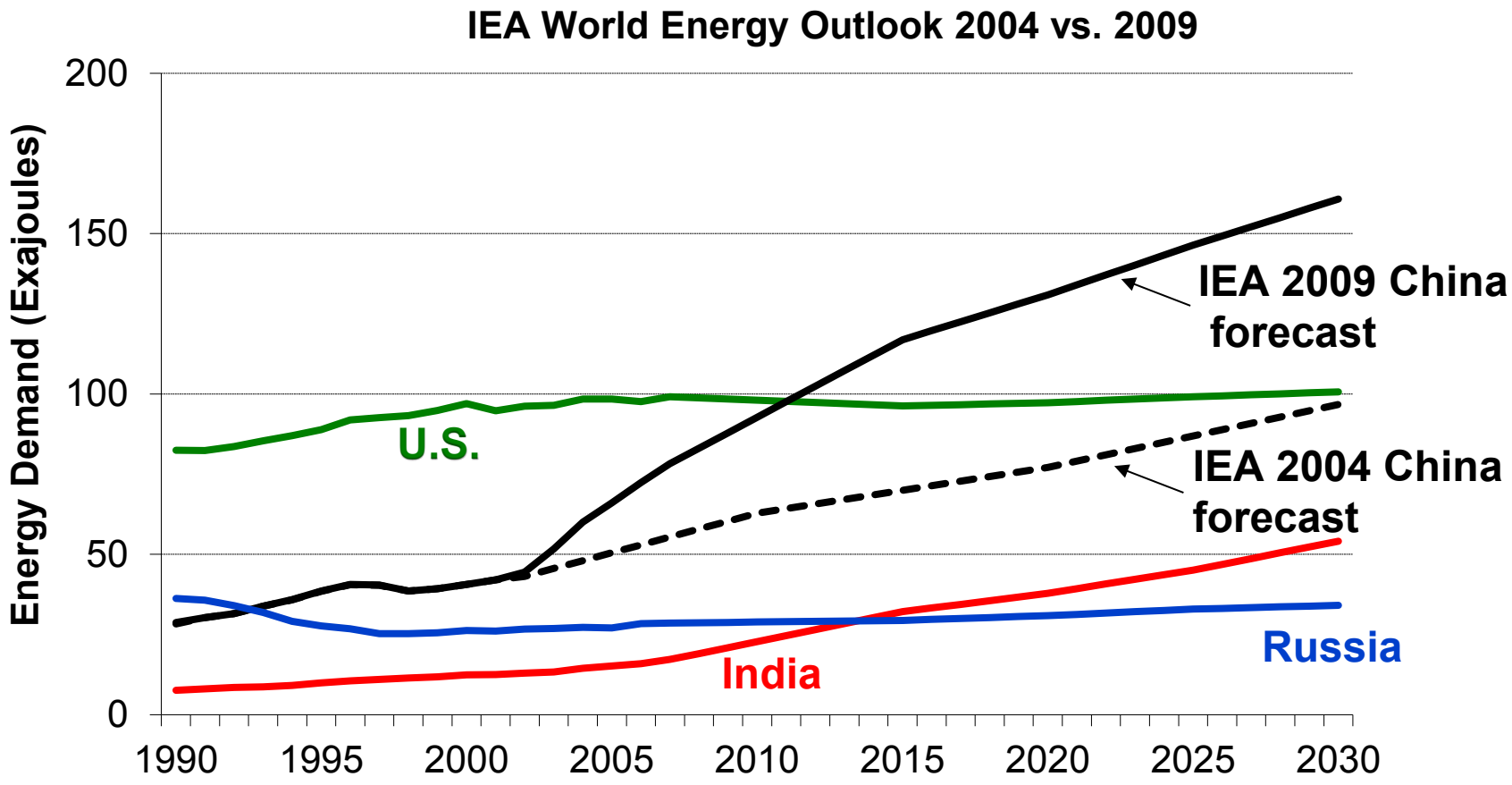
Global CO_2 Emissions



Chinese Emissions Grew Rapidly a Decade Ago, India Next?

Source: EDGAR (http://edgar.jrc.ec.europa.eu/news_docs/jrc-2015-trends-in-global-co2-emissions-2015-report-98184.pdf)

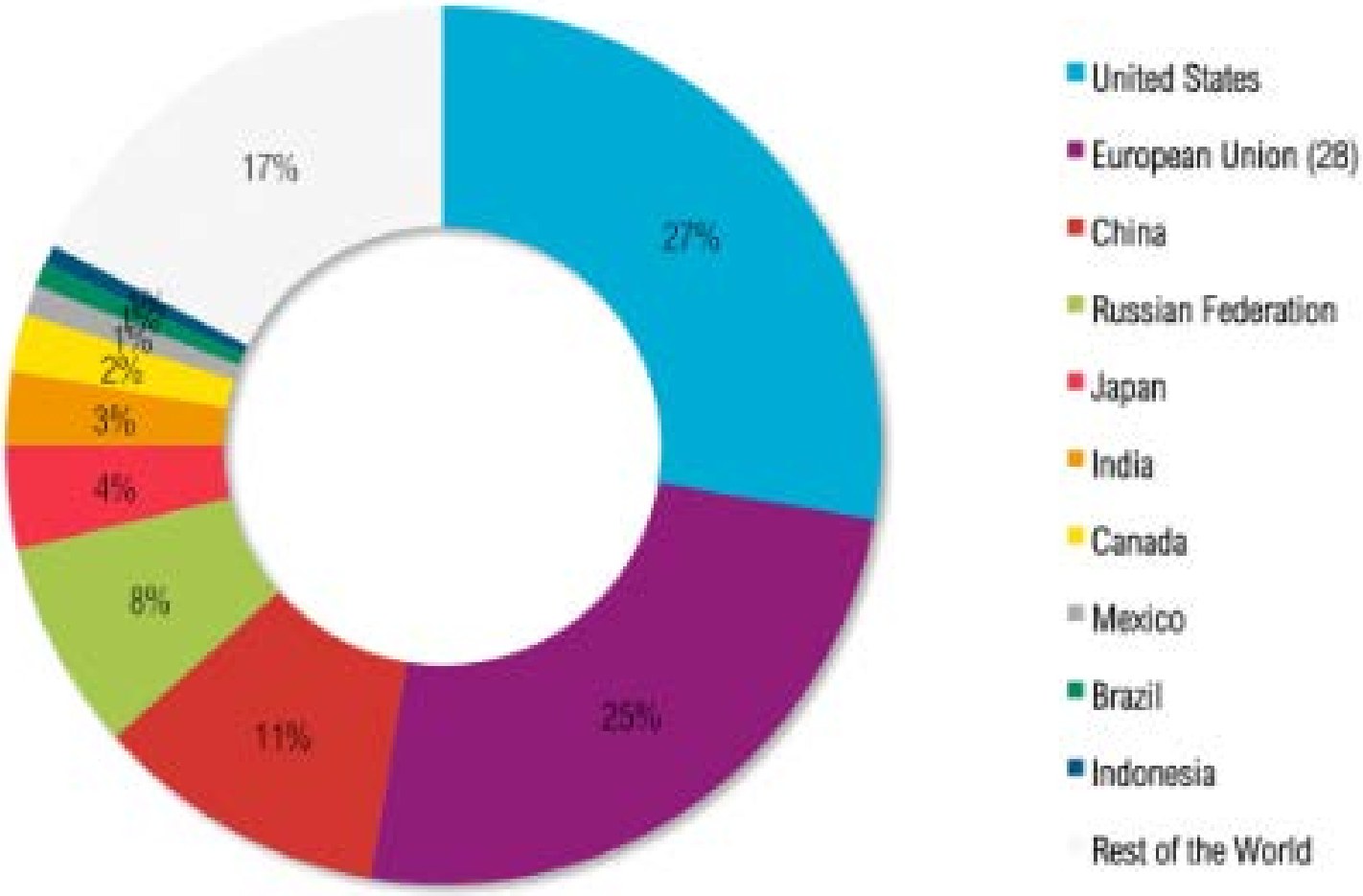
The Chinese Energy Surge: Highlight on Uncertainty



Chinese Energy Demand, and Emissions, Surged from 2002 to 2007

Source: IEA World Energy Outlook 2009 and 2004.

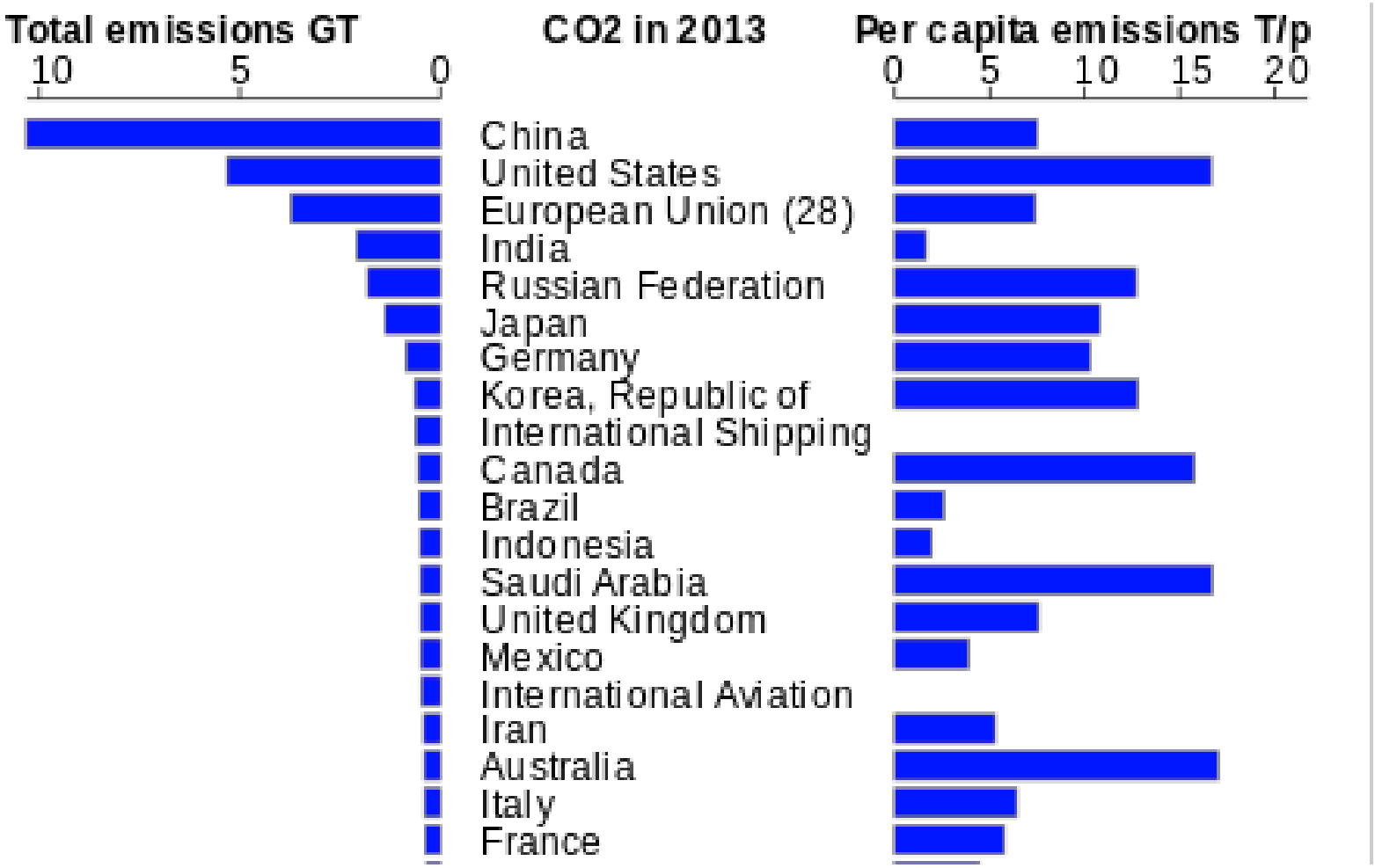
Cumulative GHG Emissions, 1850-2011



The U.S. and EU Still Dominate Cumulative, Historic Emissions

Source: WRI (http://www.wri.org/blog/2014/11/6-graphs-explain-world's-top-10-emitters)

Top 20 CO_2 Emitters in 2013, Total and Per Capita



Source: EDGAR (http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts_pc1990-2013)

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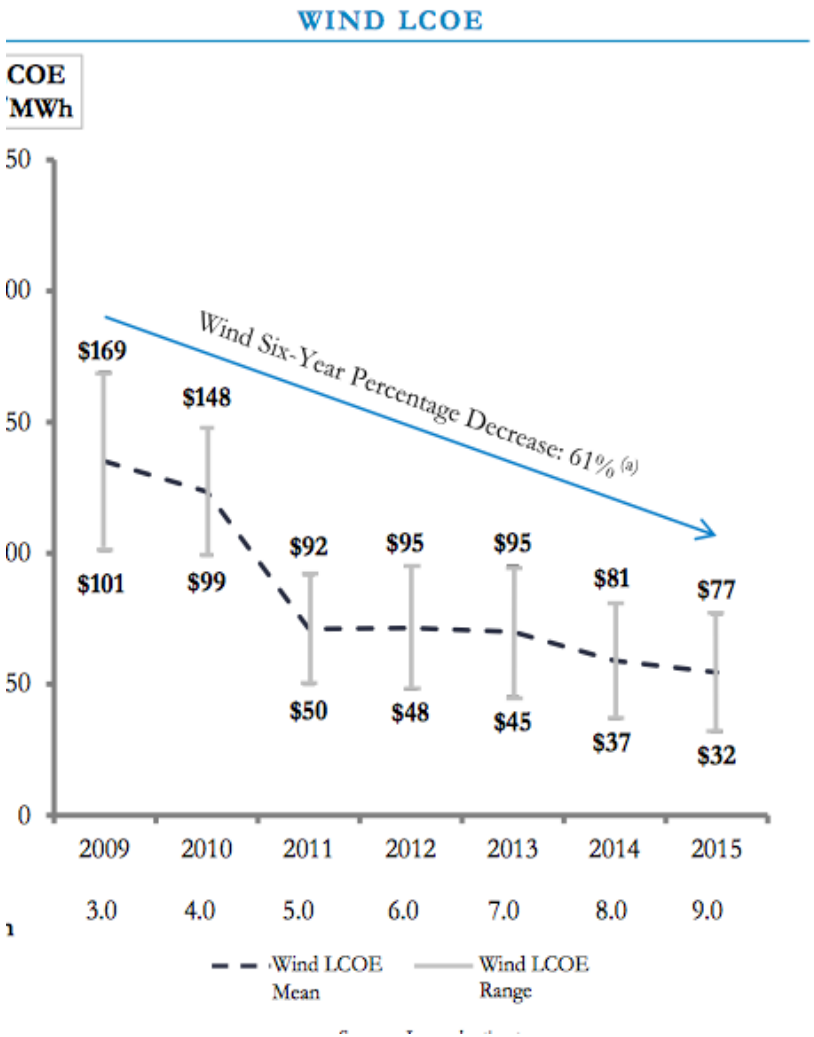
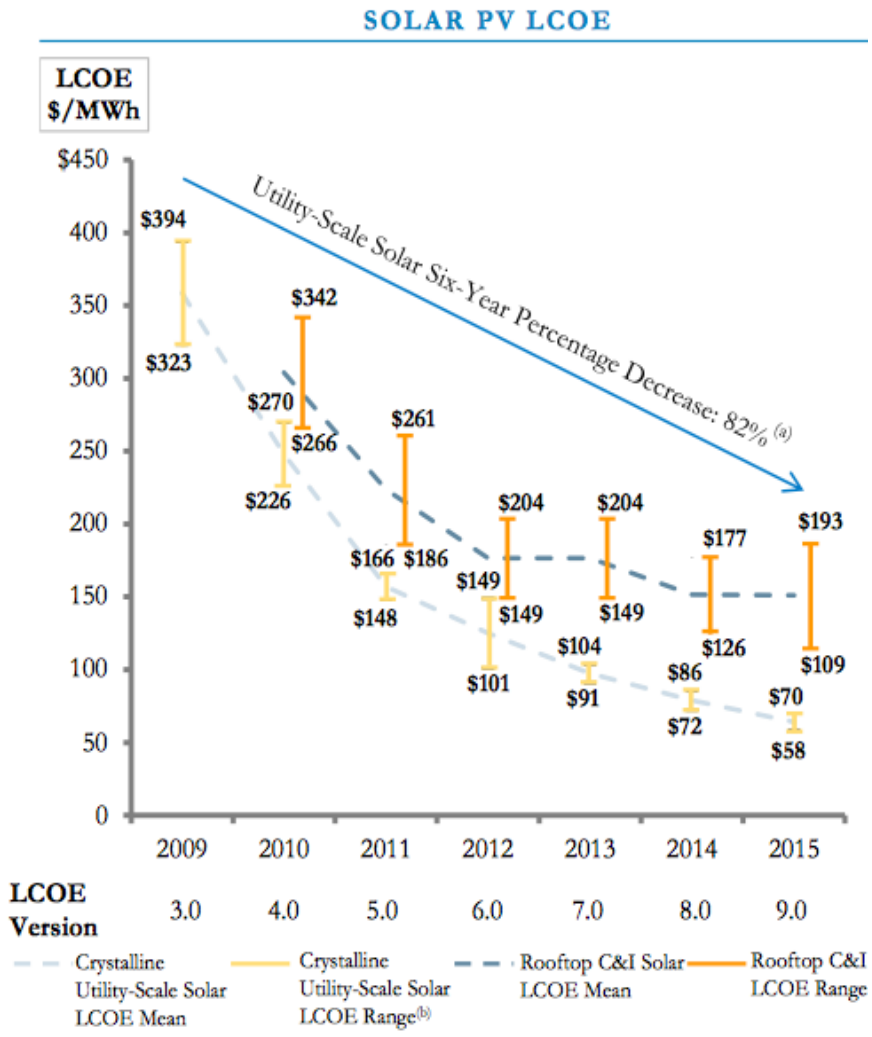
How Did The Paris Agreement "Succeed"?

- Growing concern about dangers of climate change: stakeholders (mayors, governors, NGOs) came out in force
- China, India and other large emitters pledged real action
- U.S. came to the table with significant mitigation INDC pledge and track record of success
- RE technologies seen as a viable answer this time

Wind and Solar Costs Have Declined Sharply Over the Past 5 Years



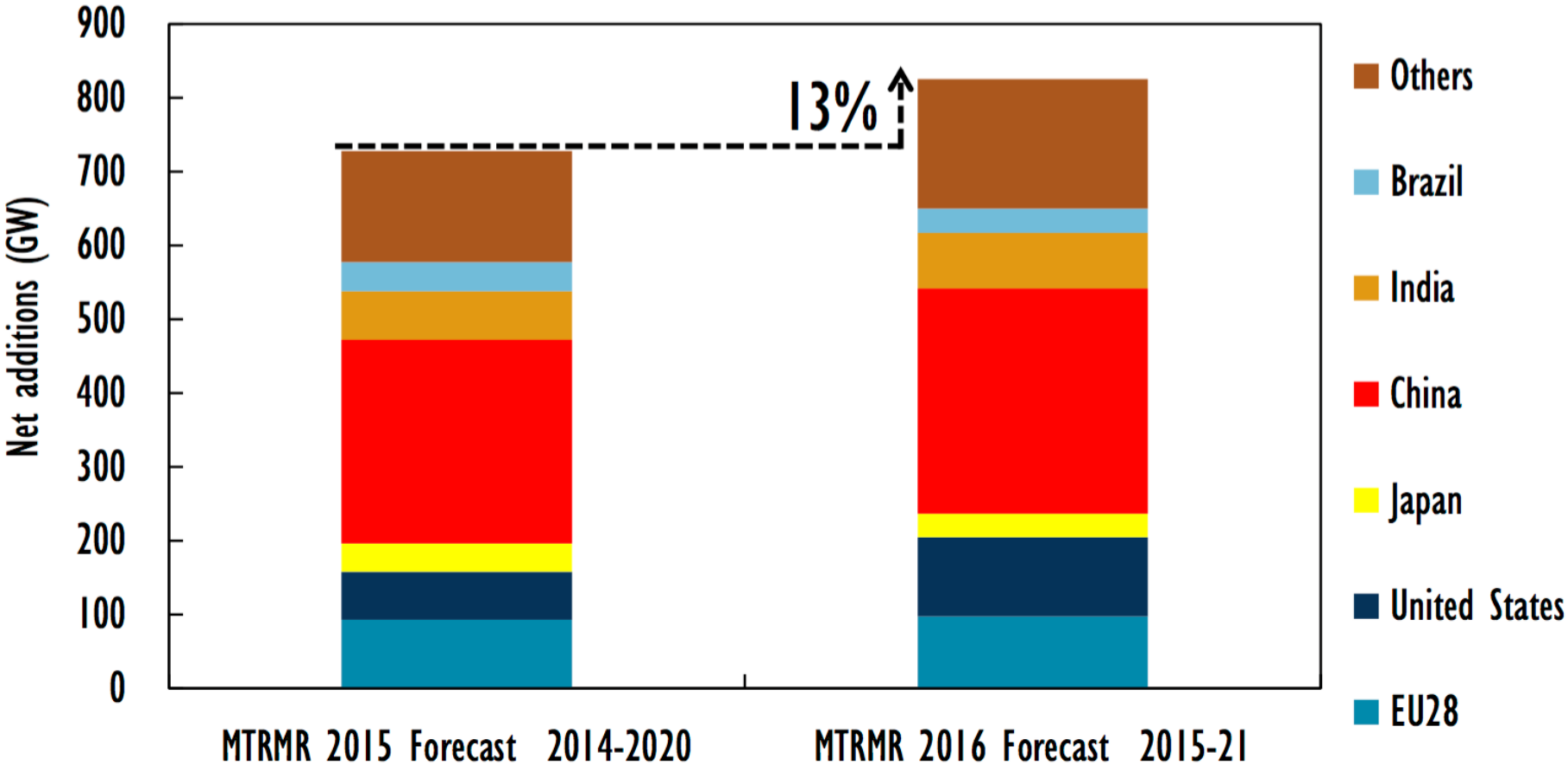


Wind LCOE Down 61%, Solar PV Down 82% Between 2009 and 2015

Source: Lazard 2015 LCOE v.9

Recent IEA Forecast for Renewable Growth is Bullish

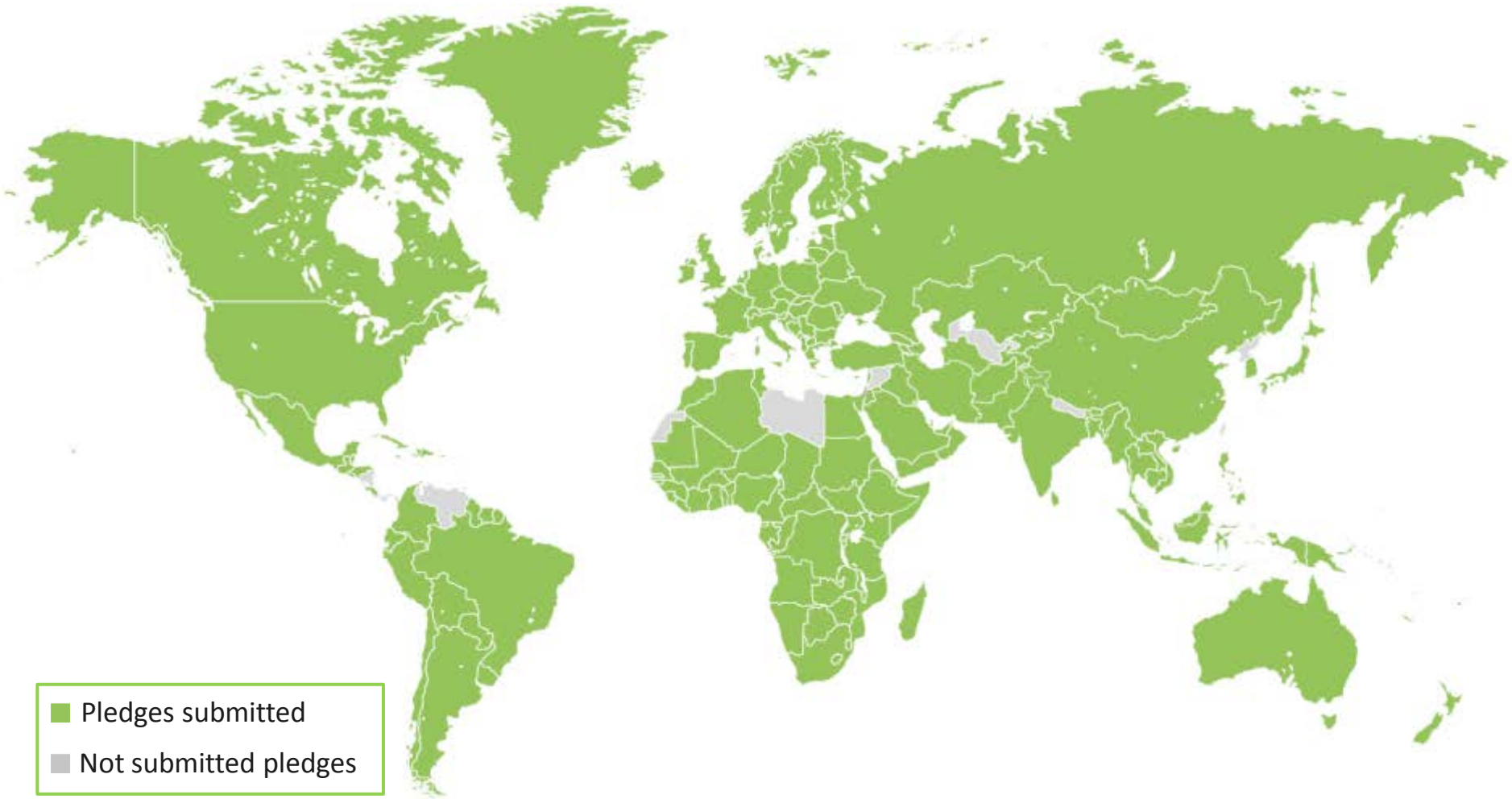
New Additions of Renewable Generating Capacity in Main Scenario



China to Remain Largest Market for New Renewable Capacity; US to Exceed EU for First Time

Source: Medium Term Renewable Energy Report 2016, IEA.

Nearly All Countries Submitted Climate Pledges for COP 21



Climate pledges for COP21 are consistent with a temperature rise of 2.7 °C, with investment needs of $13.5 trillion in low-carbon technologies & efficiency to 2030

Source: IEA WEO 2015.

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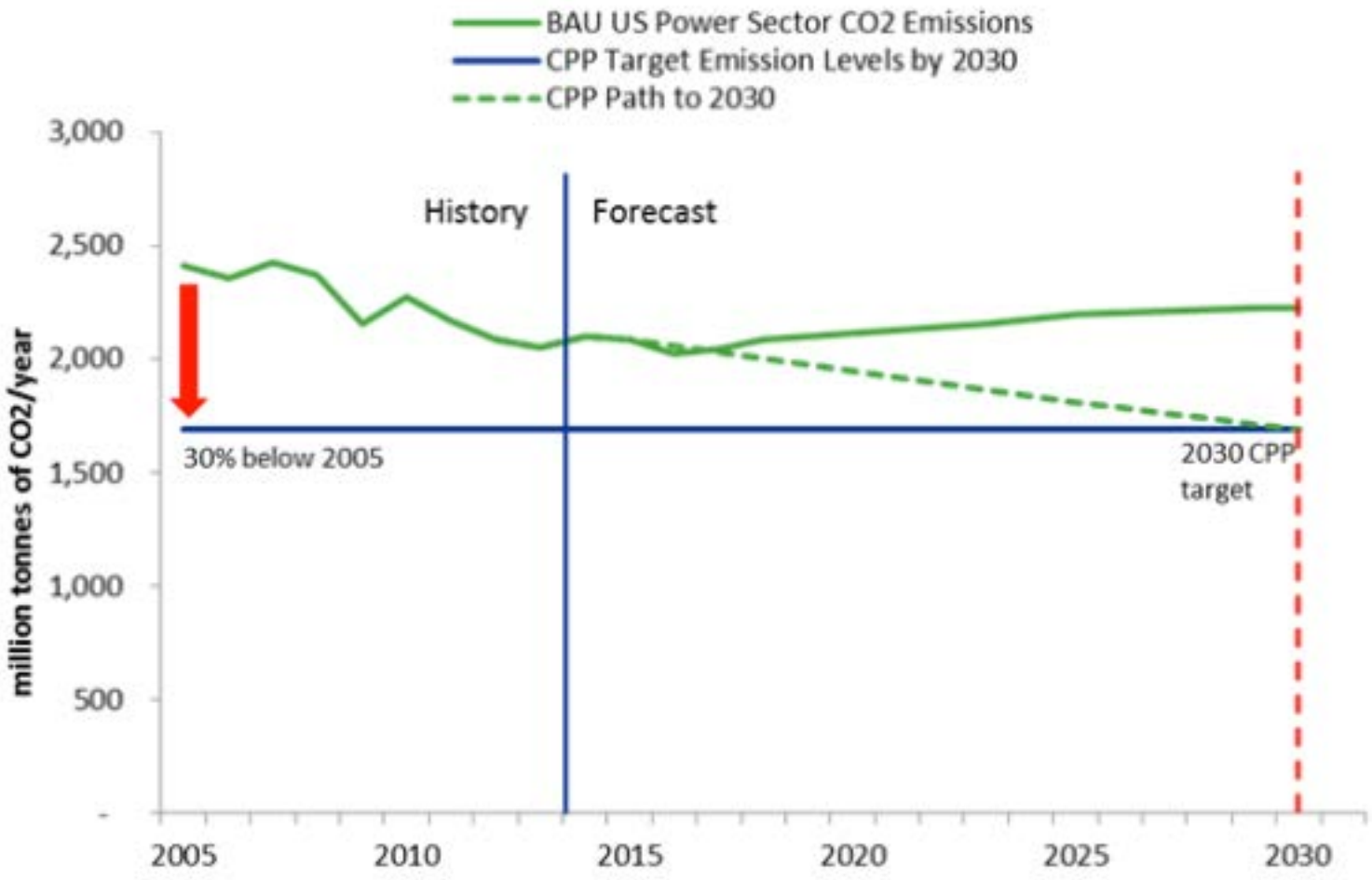
What's Required?

- Paris Agreement to Enter into Force on November 4, 2016.
- Reduce U.S. economy-wide GHG emissions by 26-28% by 2025 from 2005 levels.
- Executive action, not Treaty (no Senate ratification needed). "Shall vs. Should".
- Current Administration has in place laws and regulations that it believes can be adjusted to meet more ambitious targets over time.

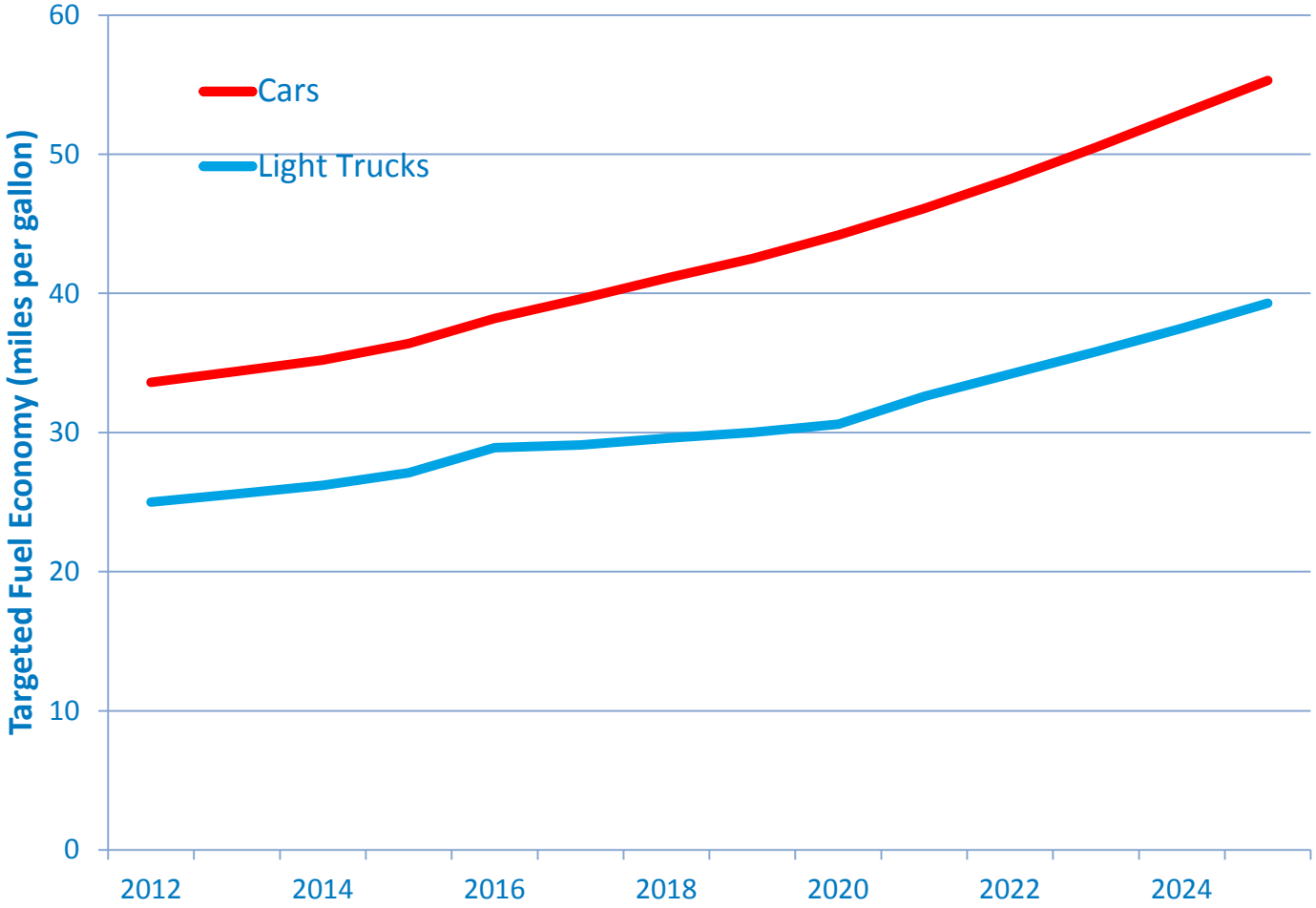
Illustrative U.S. Clean Power Plan Target



CPP, if enacted, would require each state to meet target emission's level in power sector

Source: DNV GL http://blogs.dnvgl.com/energy/us-clean-power-plan-building-blocks

Vehicle CAFÉ Standards



Source: NHTSA (http://www.nhtsa.gov/Laws-&-Regulations/CAFE-–-Fuel-Economy)

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Impacts in Colorado

- Clean Power Plan important to U.S. Paris pledge from an "enforcement" perspective, but still achievable without it
- CO mitigation target is significant, although prior coal-to-gas and RPS legislation, and wind power investments have taken the state much of the way there
- Governor Hickenlooper has executive plan to cut state's power sector emissions 35% by 2030 compared to 2012 levels
- Paris Agreement calls for continuous "ambition raising" in mitigation targets; EPA likely to increase target stringency
- CO seen as a progressive leader in many energy issues

Colorado Emissions Gap: How Much More is Needed?

- New RE assumed to offset existing coal generation
- Retired coal-capacity assumed to be offset by additional NGCC generation

Source: Steinberg, NREL, 2016

NREL International Work: Clean Energy Solutions Center

CleanEnergySolutions.org

The Clean Energy Ministerial (CEM) launched the Clean Energy Solutions Center in 2011.

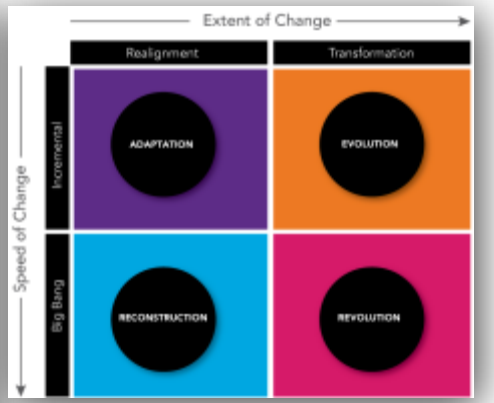
The Solutions Center:

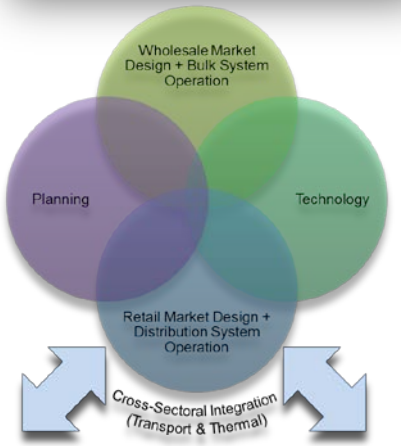
- Is one of several CEM Initiatives, which include:
  - International Smart Grid Action Network
  - 21st Century Power Partnership
  - Global Lighting and Energy Access Partnership
- Helps governments design and adopt policies and programs that support the deployment of clean energy technologies
- Has more than 35 partners, including IRENA, IEA, IPEEC, Sustainable Energy for All, Bloomberg New Energy Finance and Leonardo Energy
- Is co-chaired by the U.S. Department of Energy and the Australian Department of Industry, Innovation & Science

NREL International Work: 21st Century Power Partnership

21stcenturypower.org

- The 21st Century Power Partnership (21CPP) serves as an open, collaborative platform for sharing policy, regulatory and utility best practices in the service of **power system transformation (PST)**.
- **Applied academic engagements** studying trends and best practices in global PST, informed by:
  - Cutting edge research
  - Global network of practitioners
- **Multilateral technical assistance programs** targeting with policymakers, regulators, system/market operators, utilities in:
  - Mexico, South Africa, India, China*





* China may join 21CPP in FY2017

Synthesis

- Massive transformation underway in U.S. power sector
- Paris Agreement a “first of its kind” outcome for climate, but not a final “solution” to climate challenge
- Rising ambitions needed to meet 2° C (or less) temperature increase
- Colorado is one of the crucibles of policy and deployment experiments