

Inter-Academy Panel Statement On Ocean Acidification

1 June 2009

- **Signed by the National Academies of Science of 70 nations:**
 - Argentina, Australia, Bangladesh, Brazil, Canada, China, France, Denmark, Greece, India, Japan, Germany, Mexico, Pakistan, Spain, Taiwan, U.K., U.S.....
- **“The rapid increase in CO₂ emissions since the industrial revolution has increased the acidity of the world’s oceans with potentially profound consequences for marine plants and animals, especially those that require calcium carbonate to grow and survive, and other species that rely on these for food.”**
 - Change to date of pH decreasing by 0.1, a 30% increase in hydrogen ion activity.
- **“At current emission rates, models suggest that all coral reefs and polar ecosystems will be severely affected by 2050 or potentially even earlier.”**
 - At 450 ppm, only 8% of existing tropical and subtropical coral reefs in water favorable to growth; at 550 ppm, coral reefs may be dissolving globally.
- **“Marine food supplies are likely to be reduced with significant implications for food production and security in regions dependent on fish protein, and human health and well-being.”**
 - Many coral, shellfish, phytoplankton, zooplankton, & the food webs they support
- **“Ocean acidification is irreversible on timescales of at least tens of thousands of years.”**

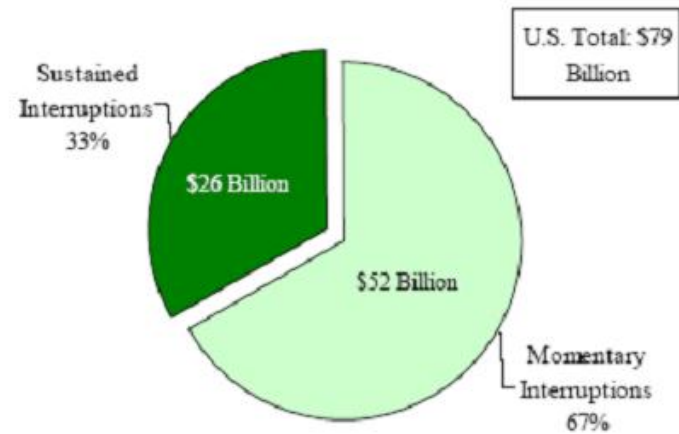
Power System Interruptions



**Northeast Blackout
New York City
August 2003**

**Hurricane Katrina
August 2005**

**Midwest & Mid-Atlantic
Derecho
June 2012**

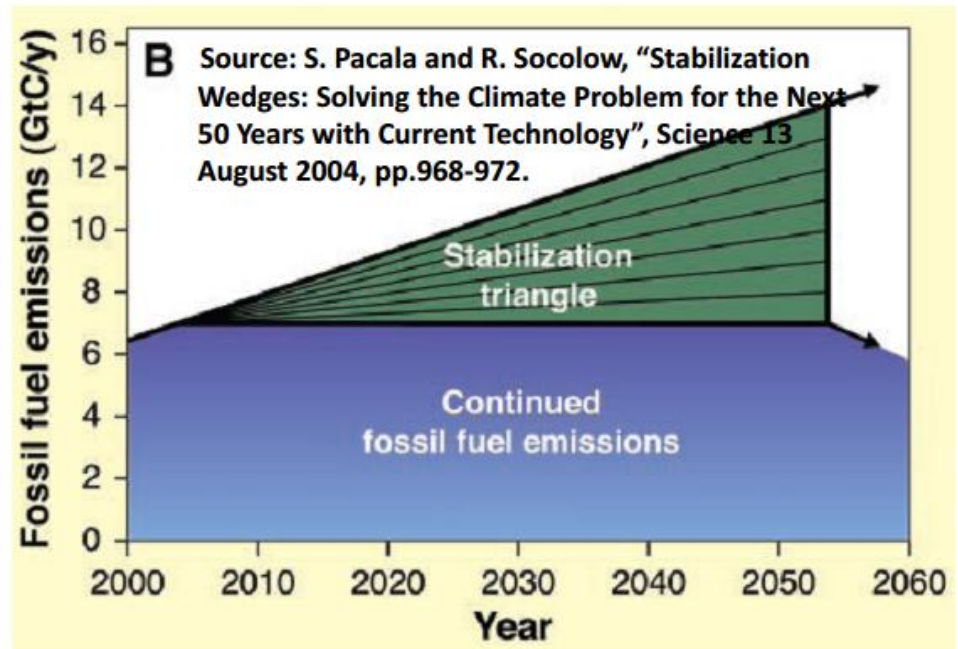


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Scale of the Challenge

- **Install 1 million 2-MW wind turbines.**
- **Install 3000 GW-peak of Solar power.**
- **Increase fuel economy of 2 billion cars from 30 to 60 mpg.**
- **Cut carbon emissions from buildings by additional one-fourth by 2050.**
- **Introduce Carbon Capture and Storage at 800 GW of coal-fired power.**
- **Install 700 GW of nuclear power.**

- **See also:** Steven J. Davis, Long Cao, Ken Caldeira, Martin I. Hoffert, "Rethinking Wedges", Environ. Res. Lett, 8 (2013)



Time Constants

- Political consensus building ~ 3-30+ years
- Technical R&D ~10+
- Production model ~ 4+
- Financial ~ 2++
- Market penetration ~10++
- Capital stock turnover
 - Cars ~ 15
 - Appliances ~ 10-20
 - Industrial Equipment ~ 10-30/40+
 - Power plants ~ 40+
 - Buildings ~ 80
 - Urban form ~100's
- Lifetime of Greenhouse Gases ~10's-1000's
- Reversal of Land Use Change ~100's
- Reversal of Extinctions Never

Can EE & RE Meet These Challenges?

- **Extending Current Options**
 - Fossil/CCS
 - Nuclear
- **Efficiency**
 - Buildings
 - Industry
 - Transportation
 - Smart End-Use Equipment (dispatched w/ PV)
 - Plug-In Hybrids/Smart Charging Stations
- **Renewable Energy & Energy Storage**
 - Biomass
 - Geothermal
 - Hydropower
 - Ocean Energy
 - Solar Photovoltaics / Smart Grid / Battery Storage
 - Solar Thermal / Thermal Storage / Natural Gas
 - Wind / Compressed Air Energy Storage / Natural Gas
- **Transmission Infrastructure**
 - Smart Grid

**HOW FAR?
HOW FAST?
HOW WELL?
AT WHAT COST?
BEST PATHWAYS?**

Evaluation

- **Guidance:**
 - OMB/OSTP directives: *“evaluations.....determine how to spend taxpayer dollars effectively and efficiently.”*
 - President: e.g., *Executive Order 13450: improving Government Program Performance*
 - Congress: *“The Committee directs the Department to quantify and track the progress”*

- **NAS/NRC Review: “Energy Research at DOE: Was It Worth It?”**
 - Economic; Environment; Security; Knowledge
 - Realized; Projected; Options

- **NAS/NRC Findings:**
 - **\$1.6 B of RD&D Investment reviewed**
 - Electronic Ballasts: \$ 15 B
 - Low-E Windows: \$ 8 B
 - Refrigerator Compressors: \$ 7 B
 - SubTotal **\$30 B** (1999\$)