Lenfest Center for Sustainable Energy
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AIChE ASME AIME IEEE ASCE
Carbon Management

NSF RCN-SEES: Multidisciplinary Approaches to Carbon Capture, Utilization and Storage (CCUS)

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Many different academic efforts

- US, Britain, Norway, Sweden, Canada, Australia, …
- Not just geological storage, not just flue gas scrubbing
- Not just engineering
  - Policy, law, economics, etc.
  - Sustainable development

Plentiful Sustainable Energy

Energy is central to human well-being

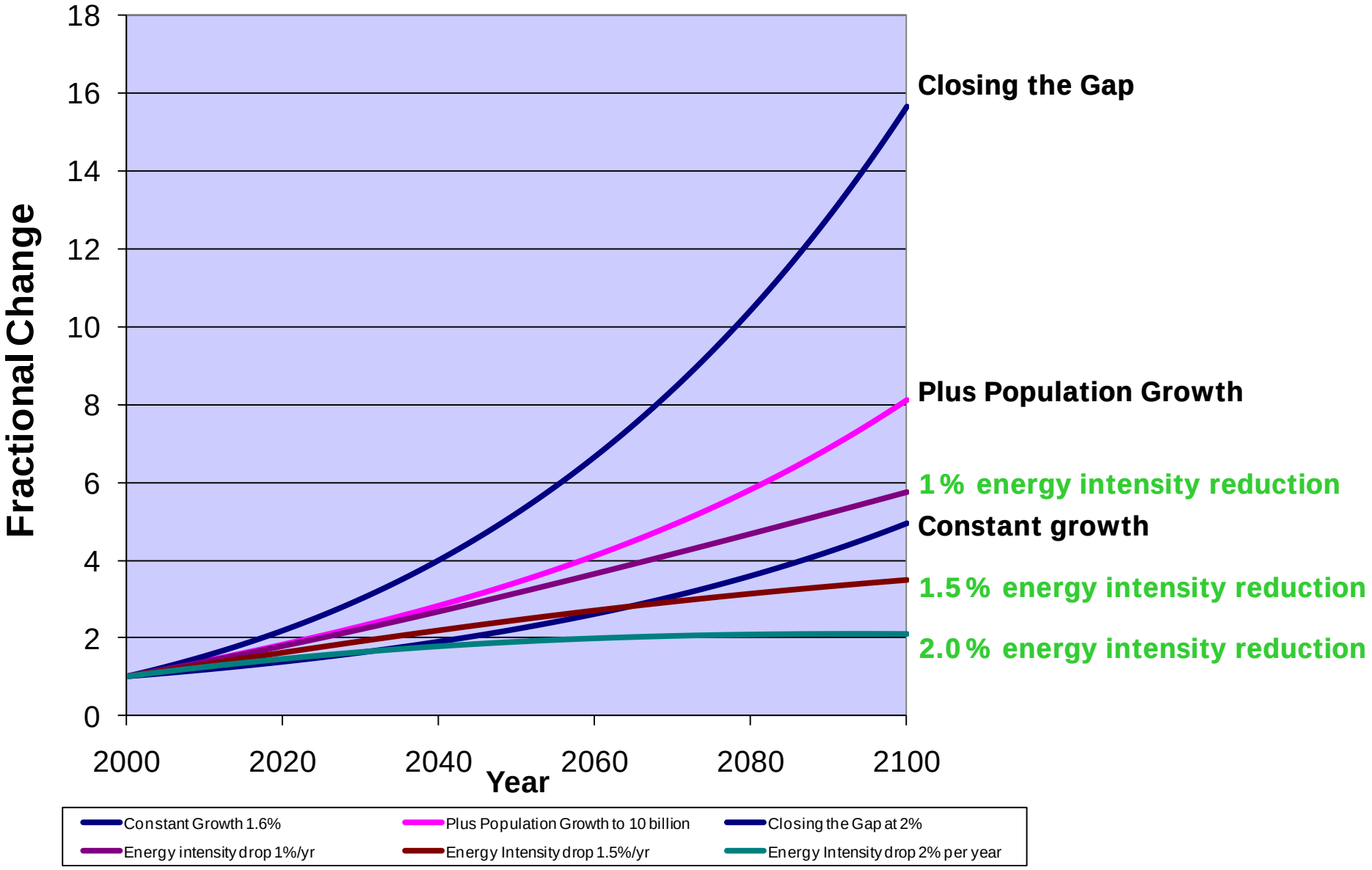
World needs affordable, plentiful and clean energy for all

Clean energy can overcome other sustainability limits

Atmospheric CO_2 level must be stabilized

Fossil carbon is cheap and plentiful

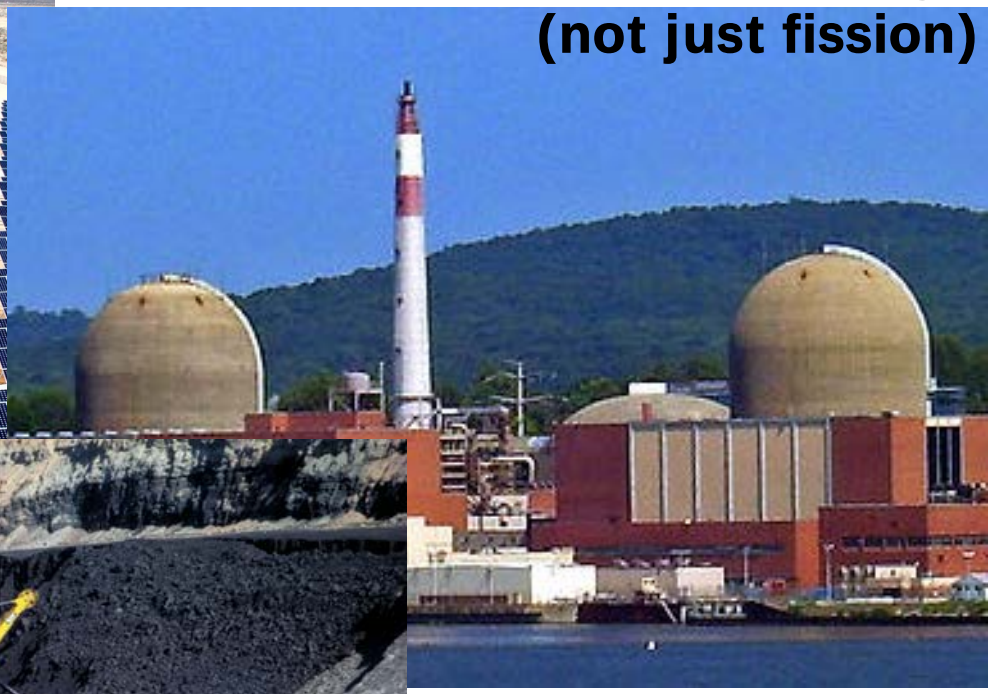
Room for 21st century growth



The three big energy options

Solar energy (not just PV)

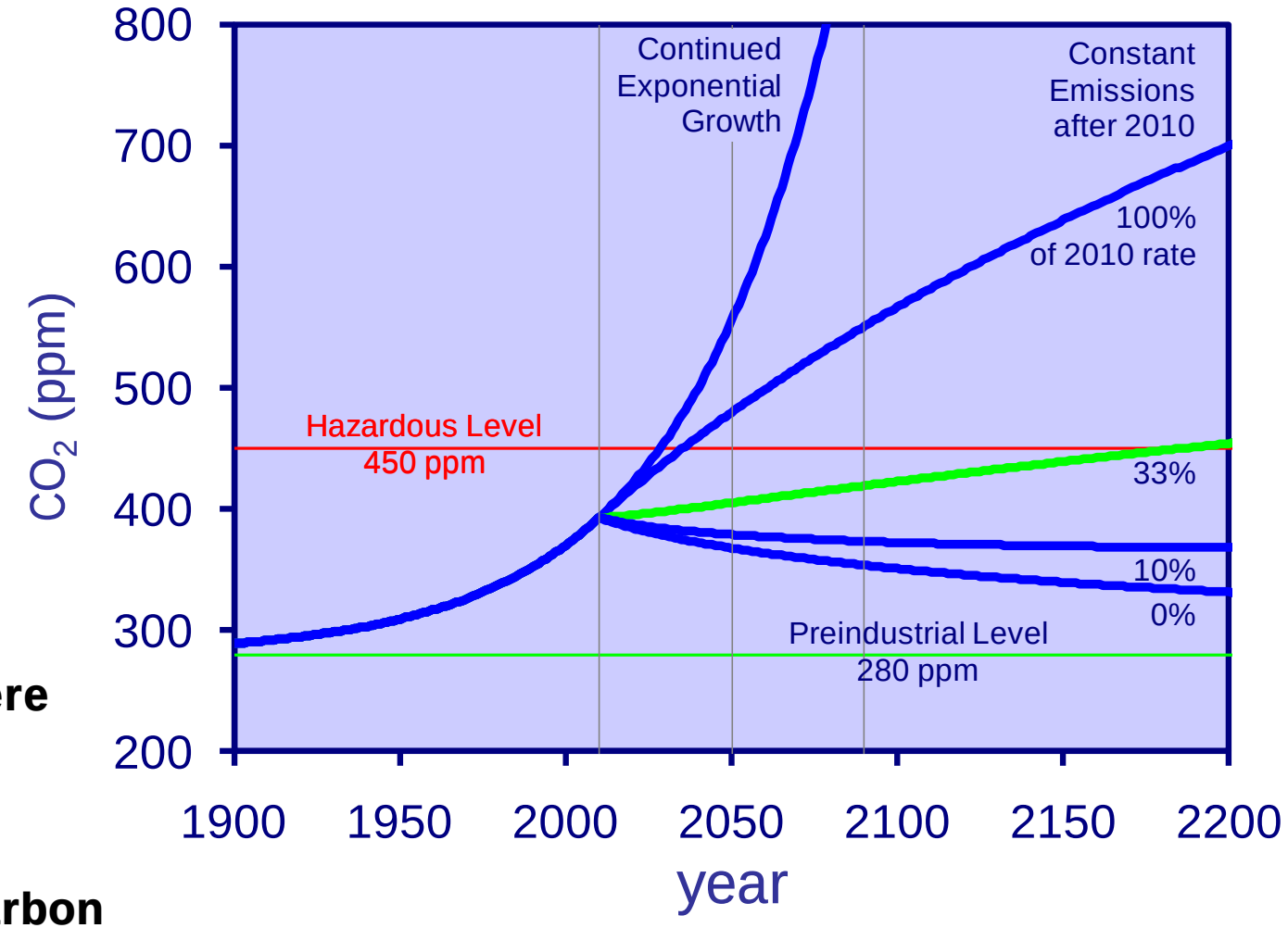
Nuclear energy
(not just fission)



Fossil energy
(not just coal)

Environmental Limits – Not Resource Limits

Stabilize CO_2 concentration – not CO_2 emissions



Ocean-atmosphere reservoir is not <u>big</u> enough or <u>fast</u> enough to handle excess carbon

Without Carbon Capture and Storage all fossil fuels will have to be phased out

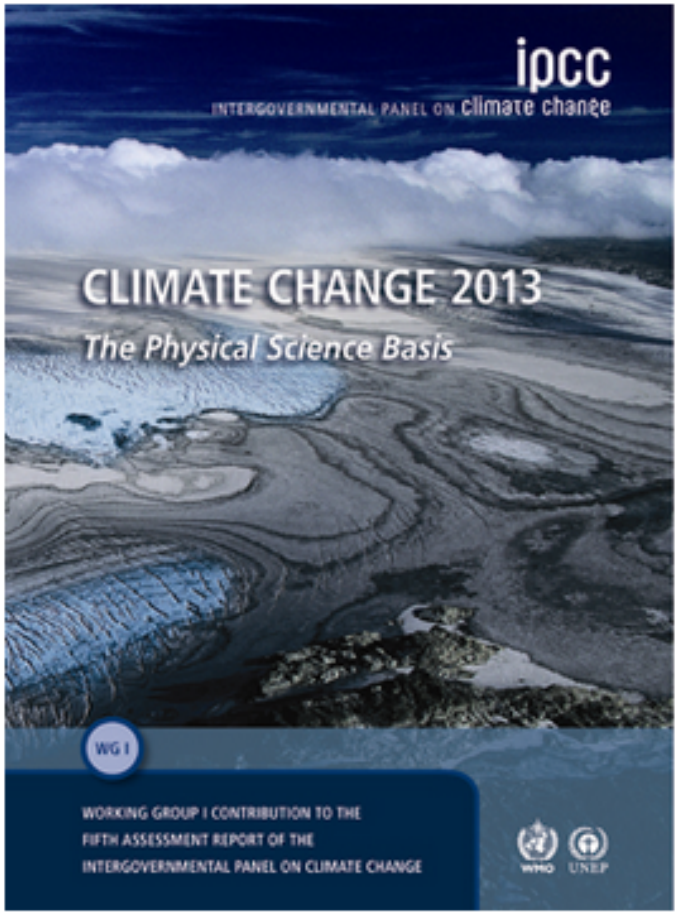
The allowable CO_2 concentration limits the effective resource size

Roughly: Emission of 4 Gt C raises atmospheric CO_2 by 1 ppm

For every ton of fossil carbon extracted from the ground another ton will have to be returned

Stocks not flows

http://www.ipcc.ch/report/ar5/wg1/#.Uk0OXVO8ySo



Summary for Policymakers | Full Report

Quick Links

- Fifth Assessment Report (AR5)
- More on Working Group I (WGI) report
- More on AR5

Report by Chapters

Technical Summary

- Introduction
- Observations: Atmosphere and Surface
- Observations: Ocean
- Observations: Cryosphere
- Information from Paleoclimate Archives
- Carbon and Other Biogeochemical Cycles
- Clouds and Aerosols
- Anthropogenic and Natural Radiative Forcing
- Evaluation of Climate Models
- Detection and Attribution of Climate Change: from Global to Regional
- Near-term Climate Change: Projections and Predictability
- Long-term Climate Change: Projections, Commitments and Irreversibility
- Sea Level Change
- Climate Phenomena and their Relevance for Future Regional Climate Change

Annex I: Atlas of Global and Regional Climate Projections
Annex II: Glossary
Annex III: Acronyms and Regional Abbreviations

Changes to the Underlying Scientific/Technical Assessment (IPCC-XXVI/Doc.4)

Complete Underlying Scientific/Technical Assessment (166MB)

E.8 Climate Stabilization, Climate Change Commitment and Irreversibility

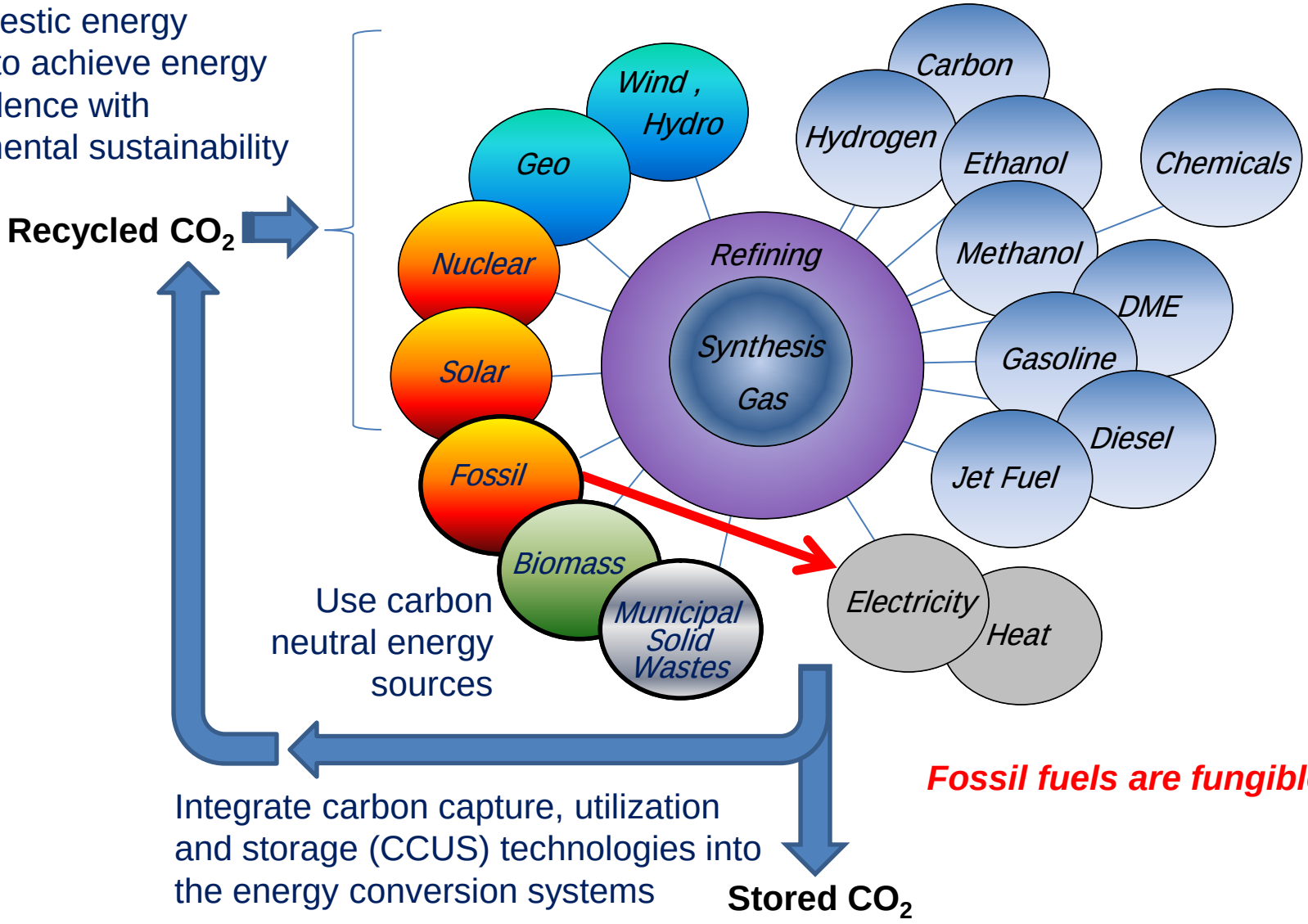
Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond (see Figure SPM.10). Most aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO_2. {12.5}

- Methods that aim to deliberately alter the climate system to counter climate change, termed geoengineering, have been proposed. Limited evidence precludes a comprehensive quantitative assessment of both Solar Radiation Management (SRM) and Carbon Dioxide Removal (CDR) and their impact on the climate system. CDR methods have biogeochemical and technological limitations to their potential on a global scale. There is insufficient knowledge to quantify how much CO_2 emissions could be partially offset by CDR on a century timescale. Modelling indicates that SRM methods, if realizable, have the potential to substantially offset a global temperature rise, but they would also modify the global water cycle, and would not reduce ocean acidification. If SRM were terminated for any reason, there is *high confidence* that global surface temperatures would rise very rapidly to values consistent with the greenhouse gas forcing. CDR and SRM methods carry side effects and long-term consequences on a global scale. {6.5, 7.7}

http://www.scientificamerican.com/article.cfm?id=latest-ipcc-climate-report-puts-geoengineering-in-the-spotlight

Sustainable Energy and Environmental Research
Lenfest Center for Sustainable Energy at Columbia University

Use domestic energy sources to achieve energy independence with environmental sustainability



Fossil fuels are fungible…

Goal of NSF RCN program

The goal of the RCN program is to advance a field or create new directions in research or education by supporting groups of investigators to **communicate** and **coordinate** their research, **training** and **educational activities** **across disciplinary, organizational, geographic and international boundaries**. RCN provides opportunities to foster new collaborations, including international partnerships, and address interdisciplinary topics. Innovative ideas for implementing novel networking strategies, collaborative technologies, and development of **community standards for data and meta-data** are especially encouraged.

Mission Statement of RCN-CCUS

Our mission is to build a trans-disciplinary Research Coordination Network (RCN) on Carbon Capture, Utilization and Storage (CCUS) that will facilitate research collaborations and training that cross the boundaries of the natural sciences, engineering, and the social and economic sciences to develop new understanding, theories, models and technologies as well as assessment tools for the developed technologies and their implementation plans for global communities.

Proposed Outcomes of RCN-CCUS

Potential Audiences:

- **Primary: Academia – lead researchers, graduate students,**
- **Existing graduate students involved in CCUS research**
- **Undergraduate students wanting to learn about CCUS**
- **Industry/professional audiences**
- Government agencies and policy makers
- K-12
- General public

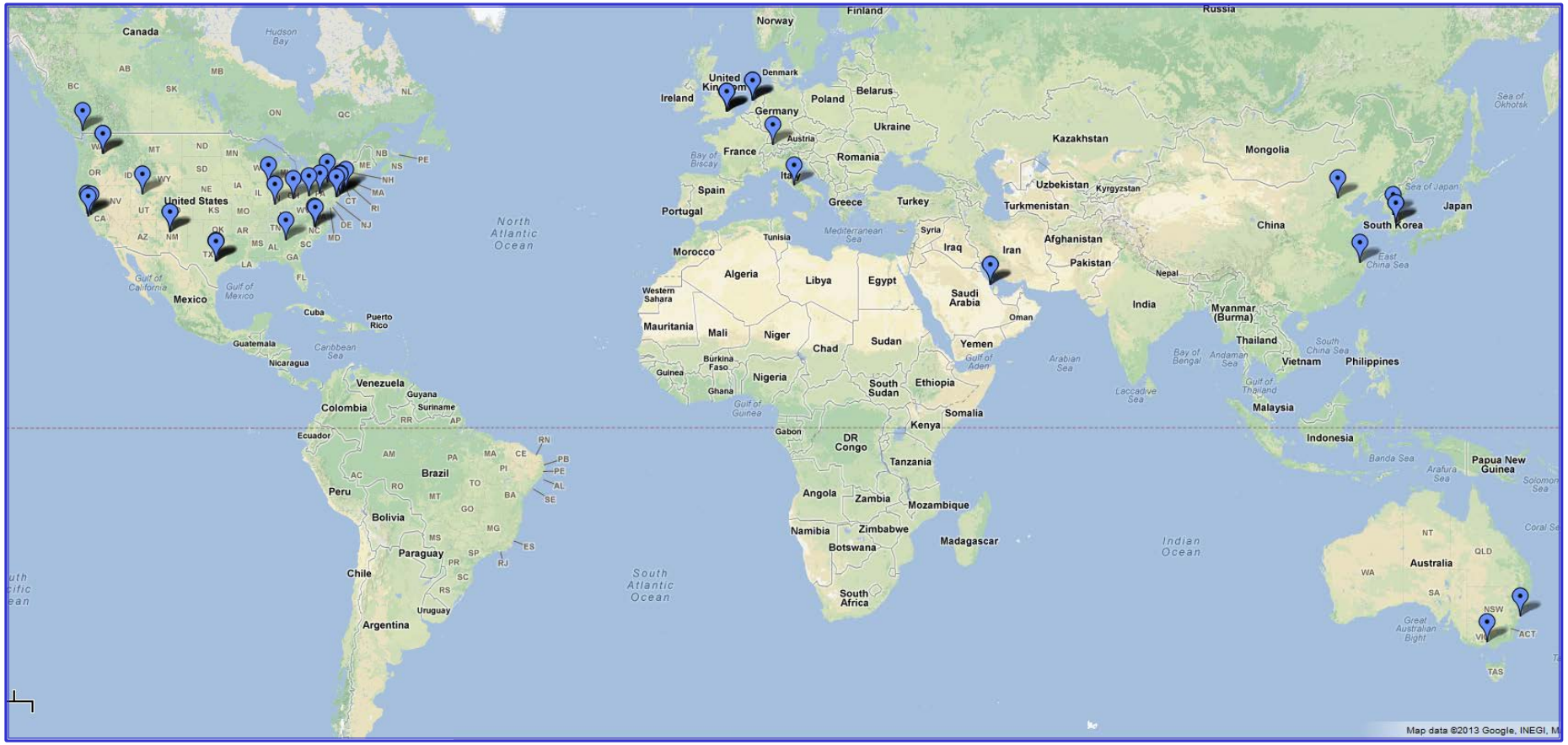
Proposed Outcomes of RCN-CCUS

- **Promote Innovative collaborations** on the basics of CCUS technologies: new ideas/synergies among researchers from different fields
- **Establish Success Matrix:** Cost analysis of CCS focusing on new technologies that are not yet commercial
- **Public outreach:** Engage social sciences during technology development and improve communication with the public.

Via:

- **Workshops on specific themes** → white papers or collaborative research proposals
- **Lecture/Seminar series** → webinars that are globally broadcasted, coordinate lecture series by linking them with on-going seminar series, coordinate travel of key speakers
- **Graduate students led workshops and network events** (e.g., summer school programs)
- **Linkages to existing conferences**
- Utilize social media to reach out to the younger generation
- Develop and share educational contents for graduate and professional certificate programs

RCN-CCUS participants (as of 02/12/2013)



- 10 countries
- ~60 Academic participants
- ~26 Non-academic participants
- Student participants are not counted yet.

NSF RCN-SEES: Multidisciplinary Approaches to Carbon Capture, Utilization and Storage (CCUS)

PI: Ah-Hyung Alissa Park

(09/2012 – 08/2016, NSF Program Director: Bruce Hamilton)

Project Management
LCSE - Columbia University
PI: **A.-H. Alissa Park**
CU PMs: **Taylor** and **Gadikota** & AIChE team: **Schuster**

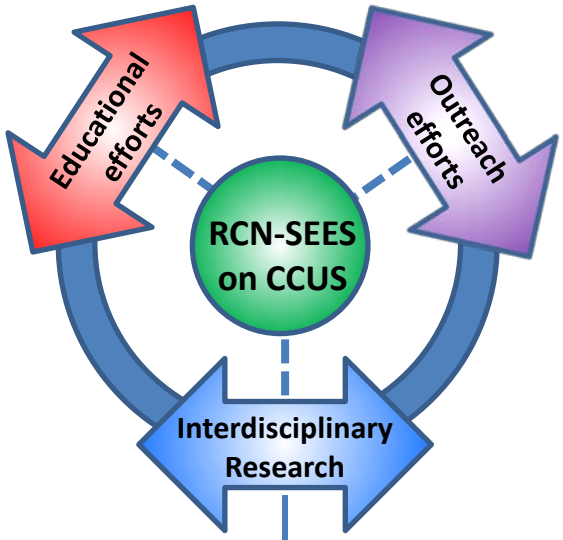
Steering Committee Thrust POC: **Park**
Members: Park, Lackner, Schlosser, Kelemen & Matter (Columbia), Aines (LLNL), Fan (OSU), Fitts & Socolow (Princeton), Jones (Georgia Tech), Keairns (AIChE), Mazzotti (ETH-Zurich), Rubin (CMU), Sageman (Northwestern), Smit (Berkeley), Snurr (Northwestern) and Song (Penn State)

Educational Thrust

Thrust POC: **Schuster & Pfirman**

- K-12: K-12 teachers (Buck and Miller)
- Young Professional (TBA)
- MCM at Columbia (Lackner)
- Research Experience in C Science (Tomski)
- Women in Science and Engineering (Gadikota)
- Council of Environmental Deans and Directors (CEDD, TBA)

*** Columbia participants unless noted**
*** International participants are in blue**



PE Society Thrust

Thrust POC: **Keairns & Schuster** (AIChE)

AIChE (TBA), AIME (TBA), ASCE (TBA), ASME (TBA), IEEE (TBA), Fox (IMECHE)

Industrial Thrust

Thrust POC: **Gupta (RTI) & Schuster** (AIChE)

B&W (Vargas), GE (Perry), RTI (Gupta), SK Energy (Park), ARAMCO (Katikaneni), ORICA Ltd. (Brent), POSCO (Jung), etc

Academic

CO_2 Capture & Conversion Thrust

Thrust leader: **Petit & West**

Aines (LLNL), Panagiotopoulos & Bocarsly (Princeton), Chen, Coppens (UCL), Lee (SKU), Farrauto, Liu & Heldebrant (PNNL), Li (NCSU), Wang (Zhejiang), Park, Reimer (Berkeley), Snurr (Northwestern), Song (PSU), Wilcox (Stanford), Yegulalp, Zhang & Zhang (CAS-IPE), etc

CO_2 Transportation, Storage & EOR Thrust

Thrust leader: **Matter (USH) & Brady (SNL)**

Baciocchi (UR-TV), Bonneville (PNNL), Blunt (Imperial), Bryant (UT Austin), Dipple (UBC), Dlugogorski (UNewcastle), Goldberg, Lee (KAIST), Park, Peters & Fritt (Princeton), Sageman & Husson (Northwestern), Wang (Yale), Zhu (Indiana), etc

CO_2 MVA & Risk Analysis Thrust

Thrust leader: **Stute & Venkat**

Bonneville (PNNL), Goldberg, Lackner, Meinrenken, Park, Peters (Princeton), Romanak (BEG Texas), Zhu (Indiana), etc

Policy, Business & Law Thrust

Thrust leader: **Barrett & Gerrard**

Coppens (UCL), Fox (IMECHE), Lackner, Marcotullio, Shindell, Urpelainen, van Ryzin, Weber, Welton, van der Zwaan (ECN), etc

RCN-CCUS: Year 1 summary

I. Research Coordination

- Formulation of Project Management Team & Identification of RCN participants
- Kick-Off Symposium at Columbia University (Feb. 14th, 2013)
- Steering Committee meeting at Columbia University (Oct. 4th, 2013)
- Seminars via Web-conferencing

II. Educational Development and Programming

- Curriculum Development (Masters of Carbon Management at Columbia University)
- Research Experience in Carbon Sequestration, 2013 in Birmingham, AL

III. Outreach Activities

- International Outreach (student exchange program)
- K-12 outreach (Hands-on workshops at international and national conferences)
- RCN-CCUS Website (www.ccusnetwork.org)
- Gordon Conference on CCUS (the first meeting will be in 2015)

1st Annual Meeting in New York City

Date: **April 14th – 16th, 2014**

Combine three events into a coherent conference: State of the Planet: Energy, RCN Annual Meeting, and LCSE-DTU workshop.

- Will create a diversity of topics and bring together experts from around the world contributing to discussions around energy and the carbon management.
- Will broaden exposure to the RCN, attracting speakers, and maximizing our impact.
- Participants may choose to attend all three events, thereby contributing to the diversity of exchange between the CCUS and carbon recycling communities.

	13-Apr Sunday	14-Apr Monday	15-Apr Tuesday	16-Apr Wednesday
Morning		LCSE/DTU	SOP	RCN
Afternoon	Bi- National Research Collaboration Meeting		RCN	

Carbon Capture Utilization & Storage

An NSF Research Coordination Network (RCN)

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Mission Statement

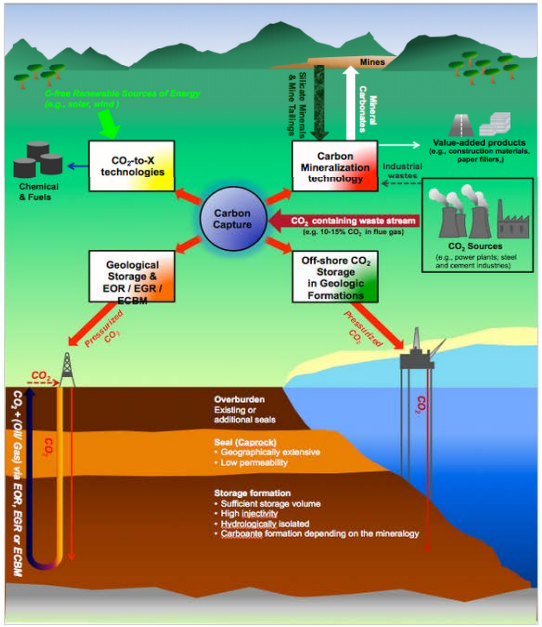
Overall Schemes of Carbon Capture, Utilization and Storage

Carbon Capture, Utilization and Storage (CCUS) is one of the greatest challenges faced by humanity that cannot be solved by simply employing traditional scientific or engineering approaches. The development of CCUS technologies as well as their implementation requires more than ever cross-cutting collaborations among natural science, engineering and social science disciplines.

Furthermore, the development of national and international policies and economic framework are also important for the significant reduction in the anthropogenic carbon emissions. The G8 recently stated the goal of achieving at least a 50% reduction in worldwide greenhouse gas emissions by 2050. To achieve this ambitious goal, we need to work together and encourage the effective rapid transfer of knowledge between participating members of the global communities.

In light of this, the RCN-SEES is formulated to provide transformative research collaborations in CCUS and facilitate research collaborations that effectively cross the boundaries of the natural sciences, engineering, and the social and economic sciences. If successful, this effort would lead to new understandings, theories, models and technologies as well as assessment tools for CCUS and their implementation plans for global communities.

The proposed activities of the RCN-SEES also include extensive educational and outreach activities, which will allow the creation of the workforce that has the holistic understanding of CCUS related issues with strong scientific and engineering skills.



Who We Are

Participating Institutions

Learn about the participation of Columbia University and AIChE teams as well as the CCUS Network teams.

Go to Participating Institutions →

Participating Members

Learn more about participating members from institutions througout the world.

Go to Participating Members →

Participating Institutions

Columbia University

AIChE ASME AIME IEEE ASCE Carbon Management

Lenfest Center for Sustainable Energy
Earth Institute | Columbia University

RCN-CCUS
Carbon Capture, Utilization, and Storage
Funded by the National Science Foundation

Learn More →

Participating Members.

See participating CCUS Network members from Columbia University and institutions worldwide.

Learn More

Columbia University
In the City of New York

For more information:

RCN-CCUS Website (www.ccusnetwork.org)