Global Environmental Policy

Global Environmental Policy 2015

Graduate School, University of Tokyo

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December 21, 2015：Group Discussion

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Recent Findings on Climate Change

IPCC Assessment Report

1st: 1990; 2nd: 1995; 3rd: 2001; 4th: 2007; 5th: 2014

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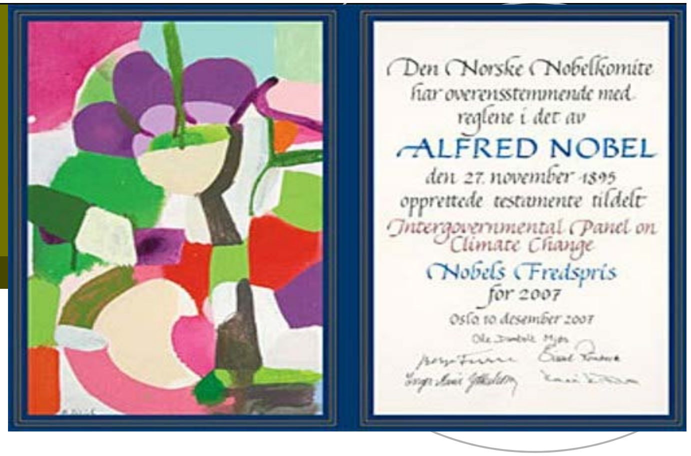
What is IPCC?

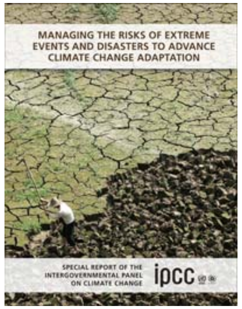


- **Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.**
- **The IPCC reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters.**
- **The work of the organization is therefore policy-relevant and yet policy-neutral, never policy-prescriptive.**
- **At the end of 2007 the IPCC was awarded the Nobel Peace Prize.**

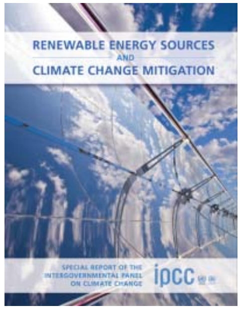
IPCC AR5

- **AR5 provides a clear and up to date view of the current state of scientific knowledge relevant to climate change and consists of three Working Group reports and a Synthesis Report (SYR).**
  - **The Synthesis Report distils and integrates the findings of the three working group contributions as well as the two Special Reports produced during this cycle.**
    - **The Working Group I contribution provides a comprehensive assessment of the physical science basis of climate change.**
    - **The Working Group II contribution considers the vulnerability and exposure of human and natural systems, the observed impacts and future risks of climate change, and the potential for and limits to adaptation.**
    - **The Working Group III contribution assesses the options for mitigating climate change and their underlying technological, economic and institutional requirements.**
    - **Renewable Energy Sources and Climate Change Mitigation (2011)**
    - **Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (2012)**

IPCC Fifth Assessment Report (AR5)

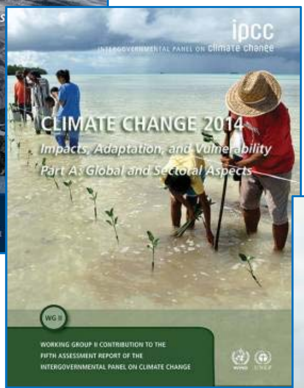


Special Report (2012)
Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation

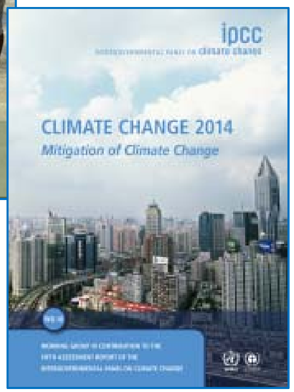


Special Report (2011)
Renewable Energy Sources and Climate Change Mitigation

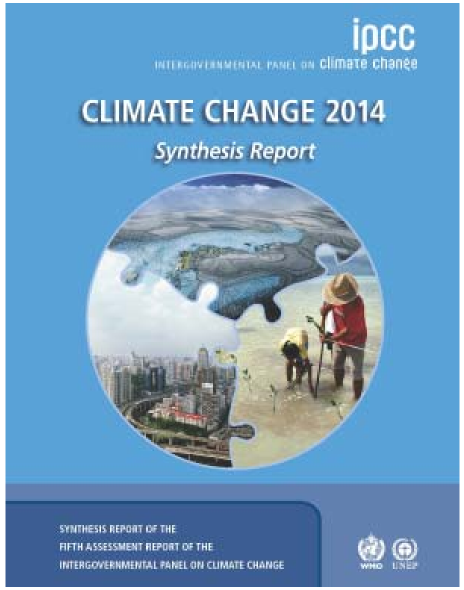
Climate Change 2013
The Physical Science Basis



Climate Change 2014
Impacts, Adaptation and Vulnerability



Climate Change 2014
Mitigation of Climate Change



Climate Change 2014
Synthesis Report

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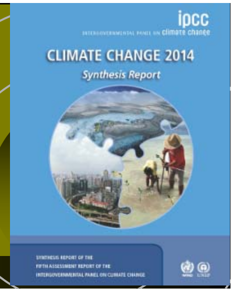
CLIMATE CHANGE 2014 - Synthesis Report
Contents



Summary for Policymakers

SPM 1. Observed Changes and their Causes

SPM 2. Future Climate Changes, Risks and Impacts

SPM 3. Future Pathways for Adaptation, Mitigation and Sustainable Development

SPM 4. Adaptation and Mitigation

Introduction

Topic 1: Observed Changes and their

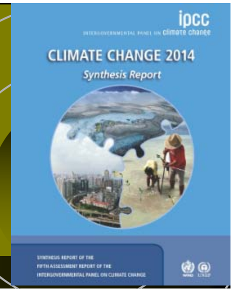
Topic 2: Future Climate Changes, Risks and Impacts

Topic 3: Future Pathways for Adaptation, Mitigation and Sustainable Development

Topic 4: Adaptation and Mitigation

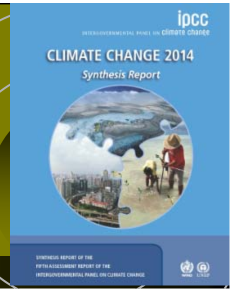
IPCC AR5 SYR SPM

Observed Changes and their Causes



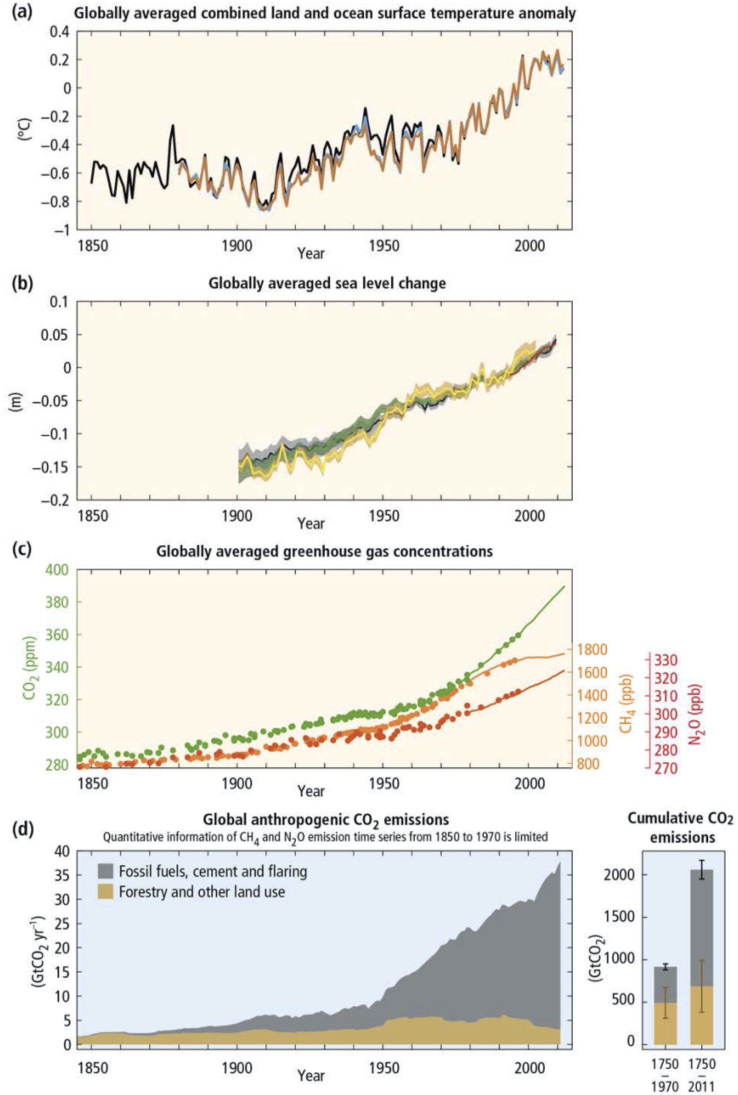
- **Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.**

IPCC AR5 SYR SPM
Observed Changes and their Causes



1. Observed changes in the climate system

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.



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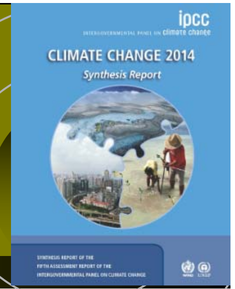
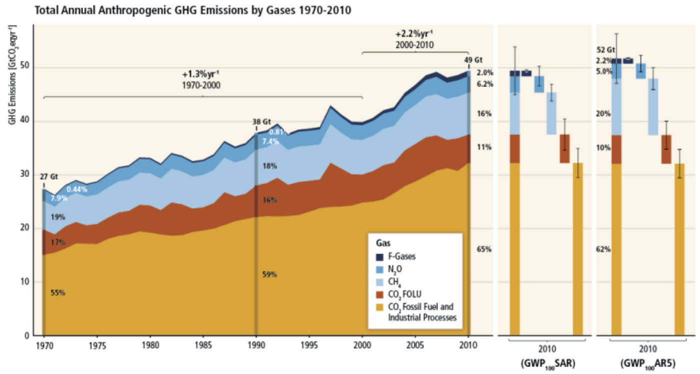
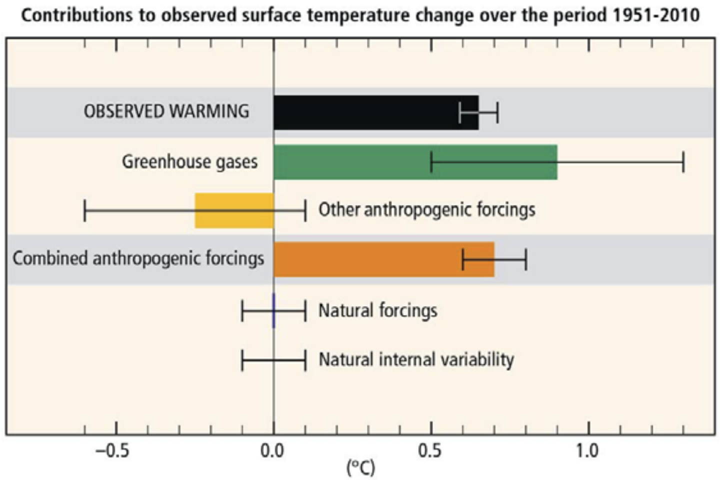
IPCC AR5 SYR SPM
Observed Changes and their Causes



2. Causes of climate change

Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are *extremely likely* to have been the dominant cause of the observed warming since the mid-20th century.





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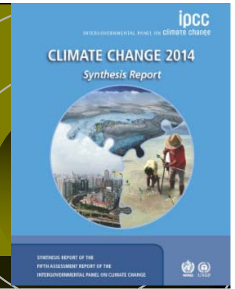
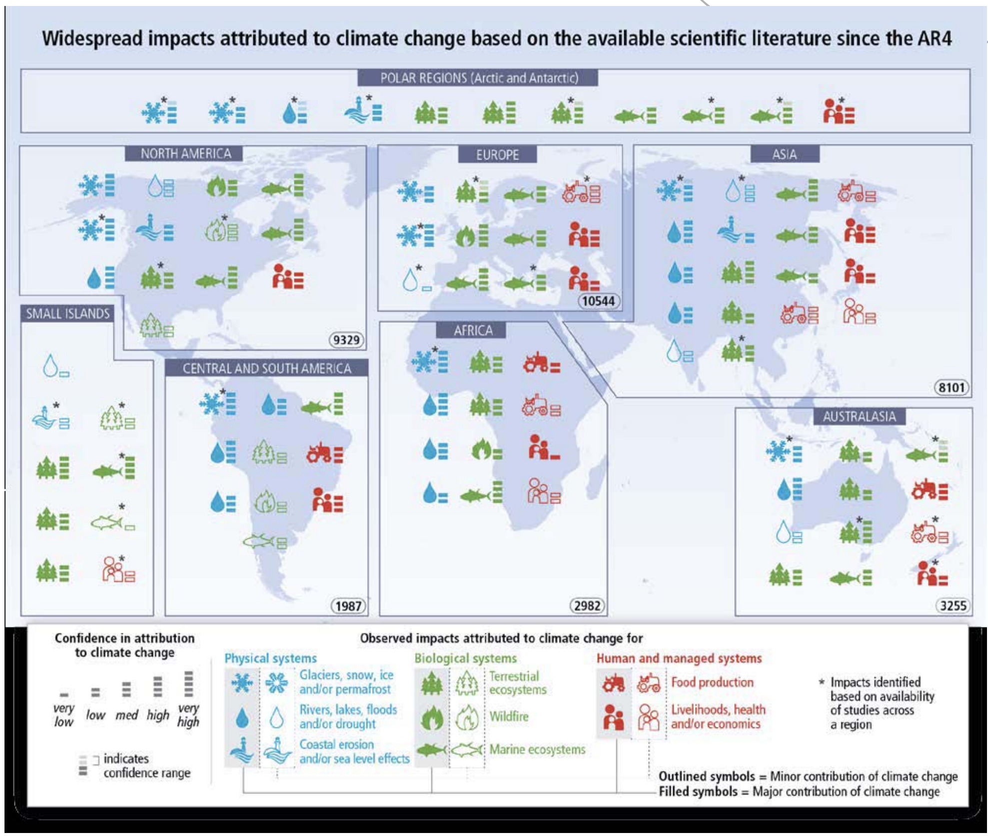
IPCC AR5 SYR SPM

Observed Changes and their Causes

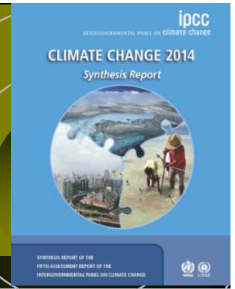


3. Impacts of climate change

In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. Impacts are due to observed climate change, irrespective of its cause, indicating the sensitivity of natural and human systems to changing climate.



IPCC AR5 SYR SPM
Observed Changes and their Causes



4. Extreme events

Changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions.

Ocean Acidification
Findings of WG1

AR4: Increasing atmospheric carbon dioxide concentrations lead to increasing acidification of the ocean. Projections based on SRES scenarios give reductions in average global surface ocean pH of between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times.

AR5: Climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO2 in the atmosphere (high confidence). Further uptake of carbon by the ocean will increase ocean acidification.

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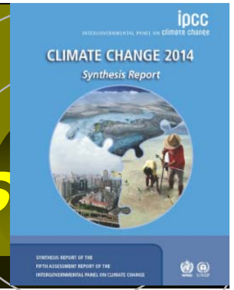
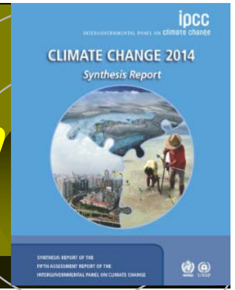
IPCC AR5 SYR SPM

Future Climate Changes, Risks and Impacts



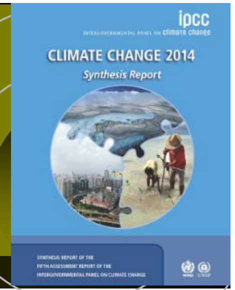
- **Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.**

IPCC AR5 SYR SPM
Future Pathways for Adaptation, Mitigation and Sustainable Development



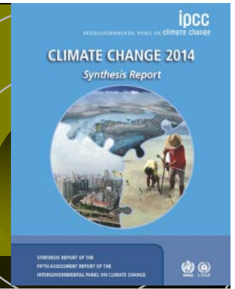
- **Adaptation and mitigation are complementary strategies for reducing and managing the risks of climate change. Substantial emissions reductions over the next few decades can reduce climate risks in the 21st century and beyond, increase prospects for effective adaptation, reduce the costs and challenges of mitigation in the longer term, and contribute to climate-resilient pathways for sustainable development.**

IPCC AR5 SYR SPM
Adaptation and Mitigation

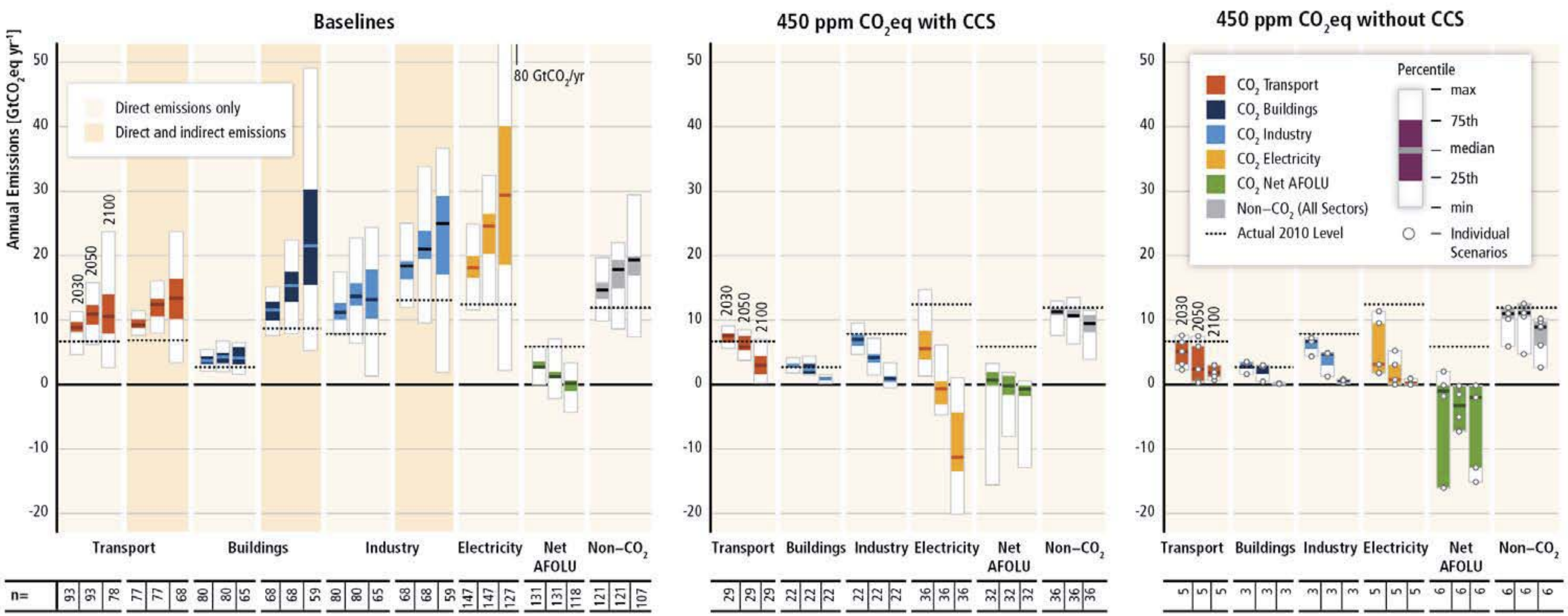


- **Many adaptation and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales, and can be enhanced through integrated responses that link adaptation and mitigation with other societal objectives.**

IPCC AR5 SYR
Response options for mitigation



Sectoral CO_2 and Non-CO_2 GHG Emissions in Baseline and Mitigation Scenarios with and without CCS



CO2 emissions by sector and total non-CO2 GHG emissions (Kyoto gases) across sectors in baseline (left panel) and mitigation scenarios that reach about 450 (430 – 480) ppm CO2-eq (*likely* to limit warming to 2˚C above pre-industrial levels) with CCS (middle panel) and without CCS (right panel).

The Road to Kyoto And Beyond

History of Global Warming (1/2)

1827	French mathematician Jean-Baptiste Fourier suggests the existence of an atmospheric mechanism keeping the Earth warmer than it would otherwise be. He likens it to a greenhouse.
1863	Irish scientist John Tyndall publishes a paper describing how atmospheric water vapor could contribute to this mechanism.
1890s	Swedish scientist Svante Arrhenius and American P.C. Chamberlain independently investigate the potential problems that could be caused by carbon dioxide (CO_2) building up in the atmosphere. They both suggest that burning fossil fuels could lead to global warming, but neither suspect the process might already have started.
1890s - 1940	Average surface air temperatures increase by about 0.25 C. Some scientists see the American Dust Bowl (a devastating, persistent drought in the 1930s) as a sign of the greenhouse effect at work.
1940 - 1970	Global temperatures cool by 0.2 C. Scientific interest in global warming declines. Some climatologists predict a new ice age.

History of Global Warming (2/2)

1957	U.S. oceanographer Roger Revelle warns that people are conducting a "large-scale geophysical experiment" on the planet by releasing greenhouse gases. Colleague David Keeling establishes the first continuous monitoring of atmospheric CO_2. He rapidly confirms a regular year-on-year rise.
1970s	A series of studies by the U.S. Department of Energy increases concerns about possible long-term effects of global warming.
1979	First World Climate Conference adopts climate change as major issue and calls on governments "to foresee and prevent potential man-made changes in climate".
1985	First major international conference on global warming in Villach (Austria) warns that average global temperatures in the first half of the 21^{st} century could rise significantly more than at any other time in human history. Warmest year on record. The 1980s is the warmest decade on record, with seven of the eight warmest years of the century.
1987	Global temperatures cool by 0.2 C. Scientific interest in global warming declines. Some climatologists predict a new ice age.

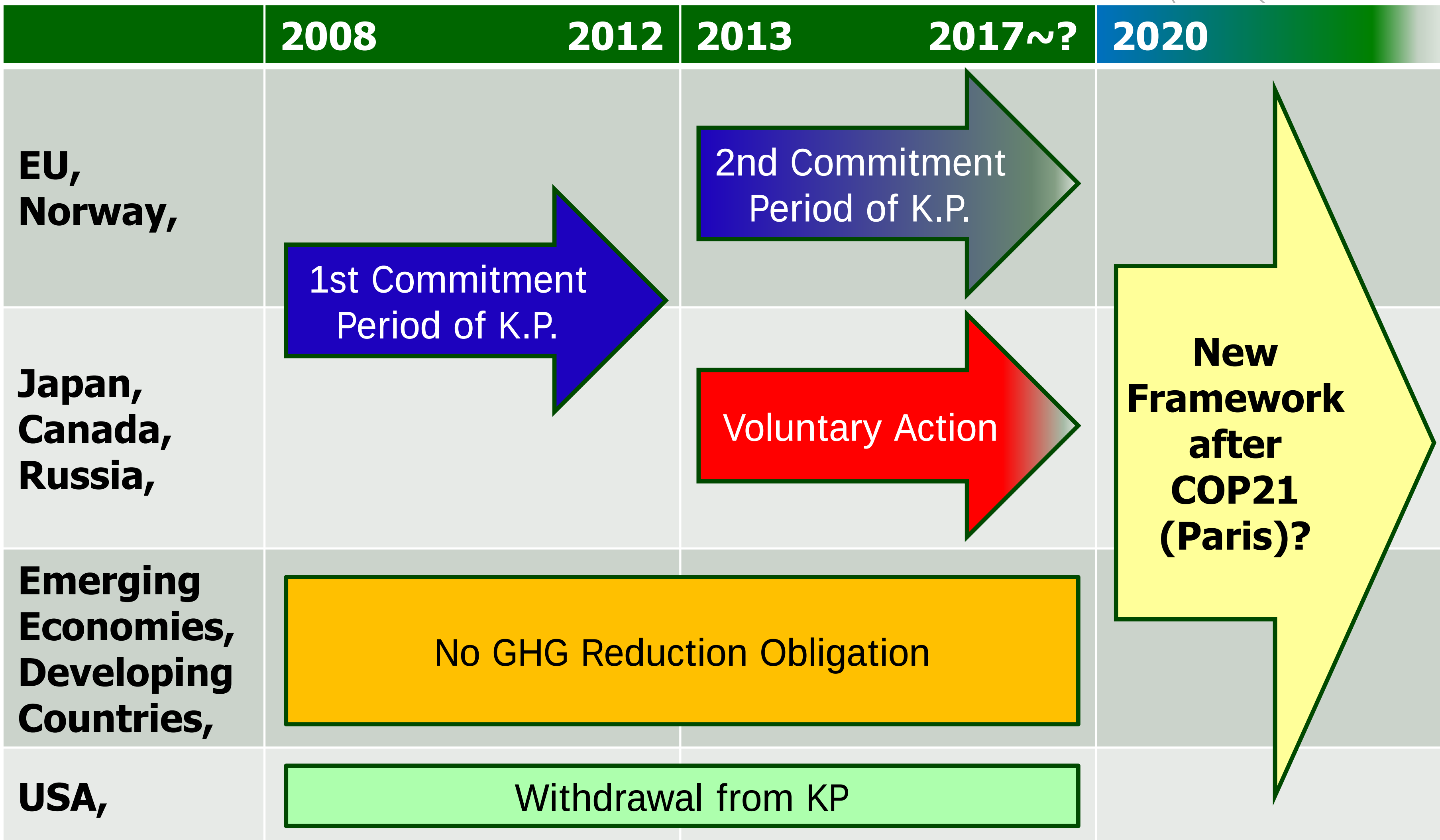
Road to Kyoto

1988	•Heat wave in U.S. granary •Testimony by Dr. Hansen •Toronto Conference •Establishment of IPCC
1990	•IPCC First Assessment Report
1992	•Earth Summit ⇒UNFCCC
1995	•COP-1 (Berlin) ⇒Berlin Mandate •IPCC Second Assessment Report
1996	•COP-2 (Geneva)
1997	•COP-3 (Kyoto) ⇒Kyoto Protocol

UNFCCC

- Sets an initial target for industrialized countries to reduce their GHG emission to 1990 levels by the year 2000.
- Demanded each industrialized nation to submit national communication on GHG emission inventory, and to provide financial and technical assistance to developing countries for the reporting.
- Came into force on 21 March 1994.

Current and Future Framework



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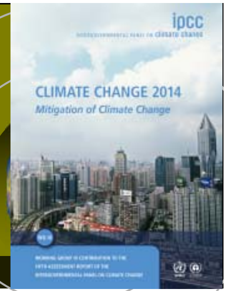
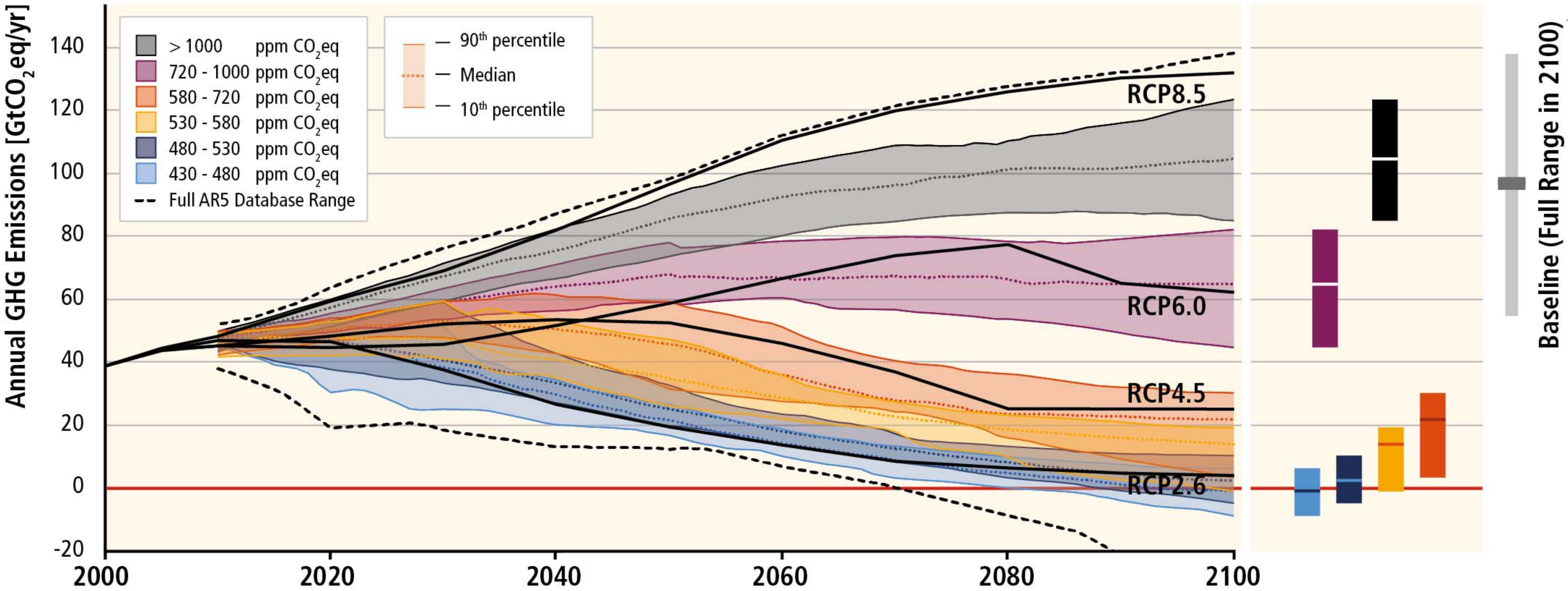
COP 21
30 November

- **One by one, the leaders of 150 nations stood up before the world at COP21's Leadership Event and positively committed in one way or another to addressing climate change.**
- **Several common themes emerged from many of the leaders' speeches on Day 1 of COP21, including:**
  - **belief in the science (with 97% of the world's climate scientists in agreement that exceeding 2 degrees C imposes dangerous levels of climate change); and**
  - **the need for solidarity and inclusiveness by developed and developing countries alike to undertake meaningful climate action.**

Towards a Deep Reduction of Greenhouse Gases

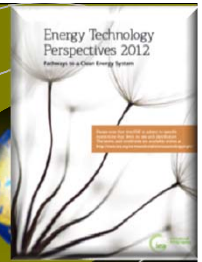
IPCC WG III - AR5
Mitigation of Climate Change

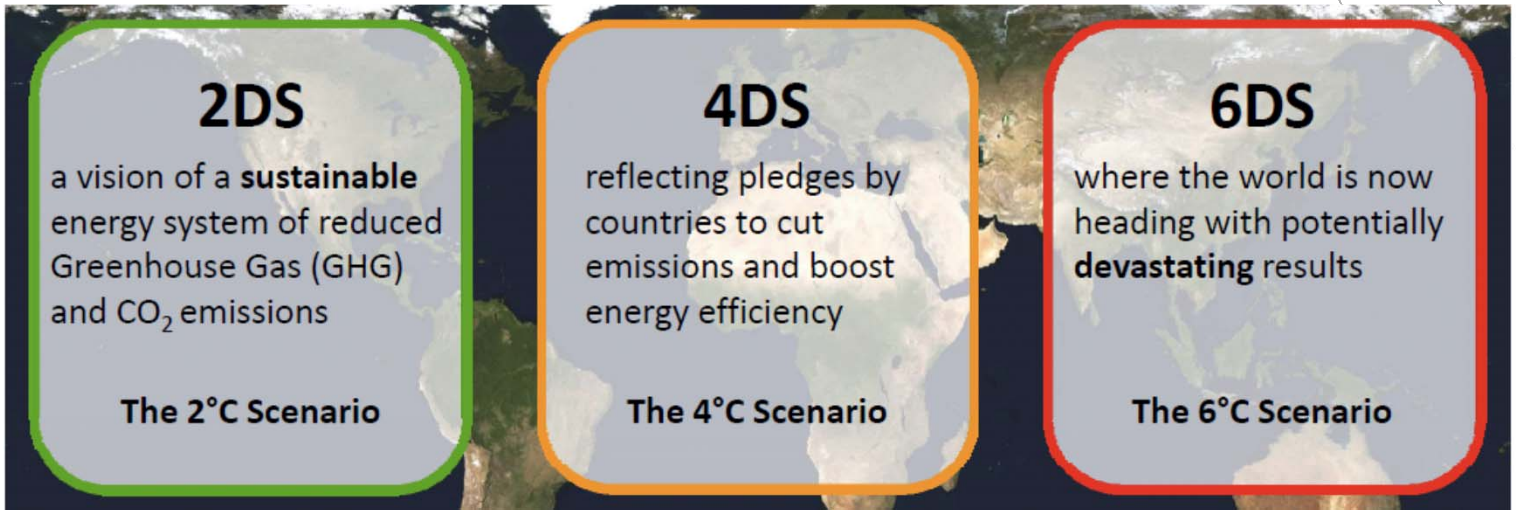


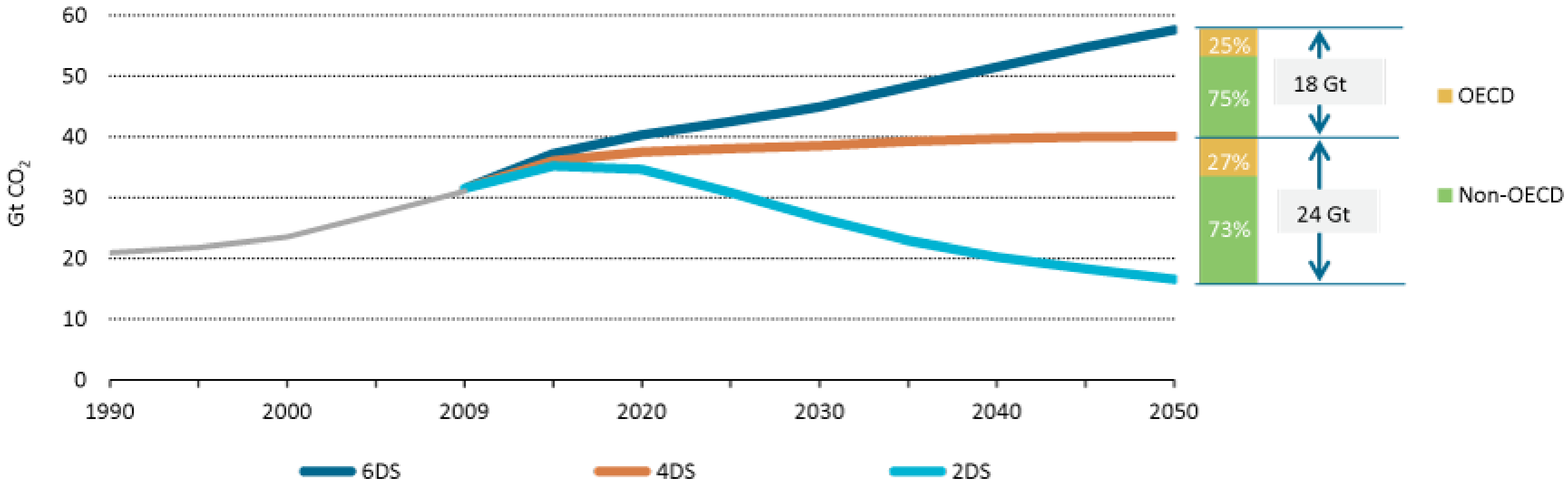


Pathways of global GHG emissions (GtCO2eq/yr) in baseline and mitigation scenarios for different long-term concentration levels.

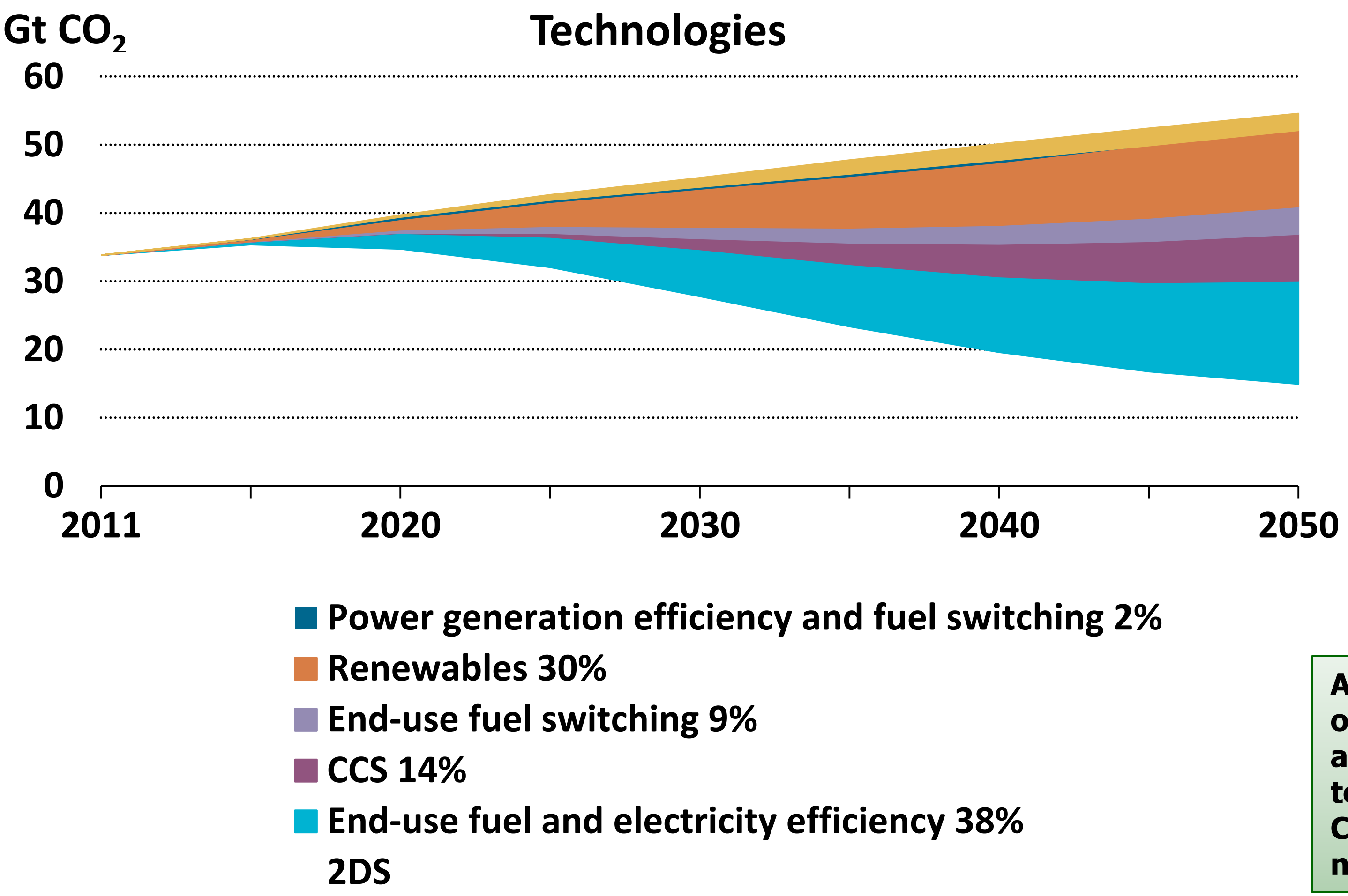
Energy Technology Perspectives 2014 (IEA)
3 Scenarios







Energy Technology Perspectives 2014 (IEA)
Contribution to Emission Reduction of Technologies



As part of a portfolio of actions, CCS accounts for 14% of total energy-related CO2 reductions needed by 2050.

Note: Percentage represent cumulative contributions to emissions reductions relative to 6DS scenario.

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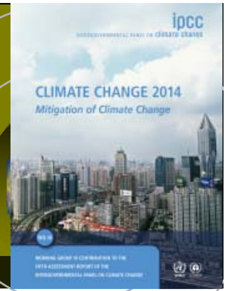
IPCC WG III - AR5
Mitigation of Climate Change



- **Decarbonizing (i.e. reducing the carbon intensity of) electricity generation is a key component of cost-effective mitigation strategies in achieving low-stabilization levels (430 – 530 ppm CO_2eq).**
- **Carbon dioxide capture and storage (CCS) technologies could reduce the lifecycle GHG emissions of fossil fuel power plants.**

CO_2 Capture and Storage

or

CO_2 Capture and Sequestration

(CCS)

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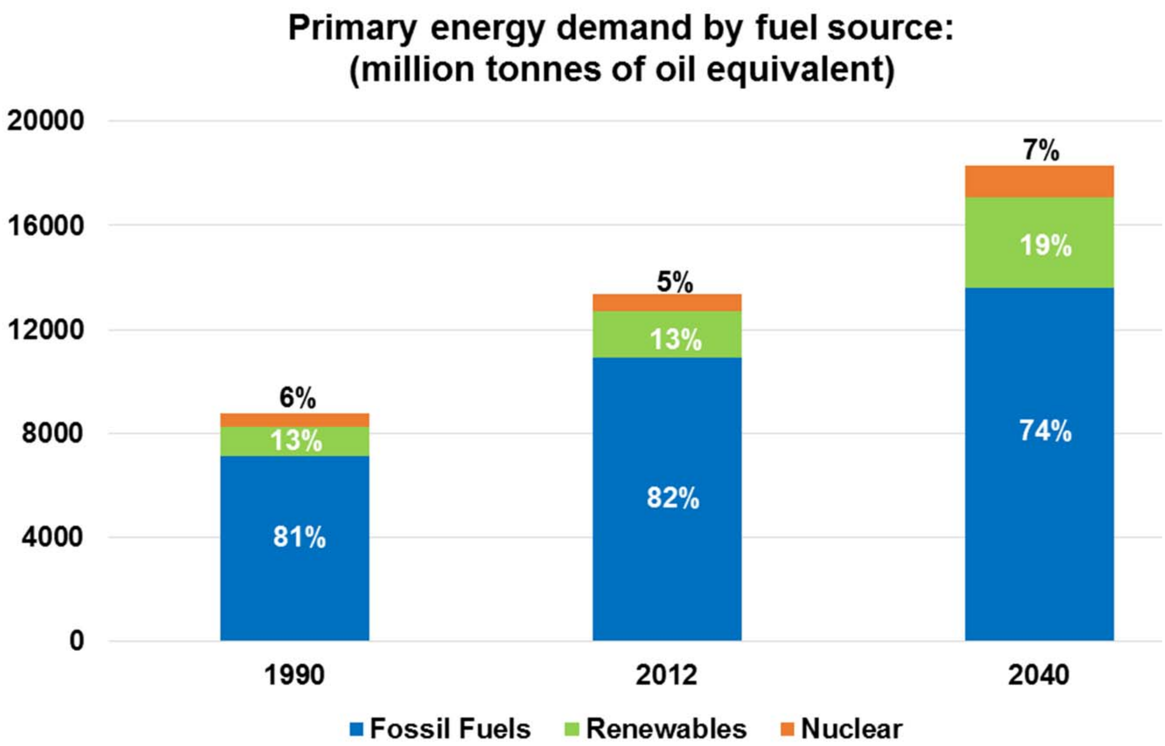
CCS as a Low Carbon Option

Fossil fuel demand growing and reserves robust



Source: *IEA World Energy Outlook,* 2014 (New policies scenario)

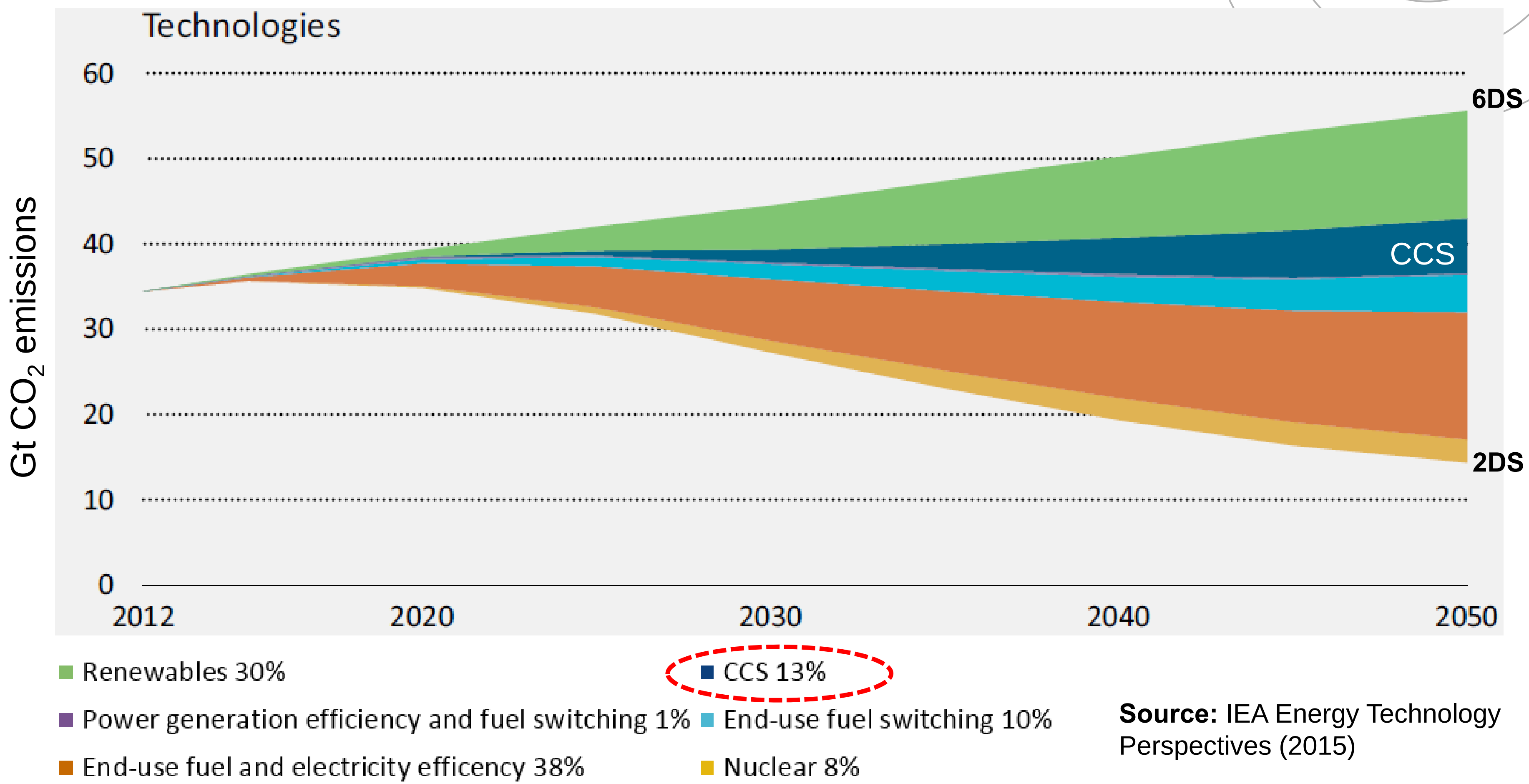
Fossil fuel proved reserves:

6 trillion barrels of oil equivalent

Reserves to production ratio: *~75 years*

Source: *BP Statistical Review of World Energy* 2014

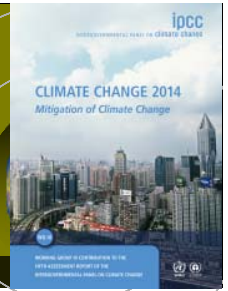
CCS is a vital element of a low-carbon energy future



Source: IEA Energy Technology Perspectives (2015)

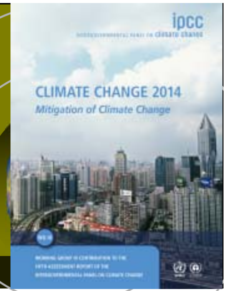
A transformation in how we generate and use energy is needed

IPCC WG III - AR5
Mitigation of Climate Change



- **Many models *could not* achieve atmospheric concentration levels of about 450 ppm CO_2eq by 2100 if additional mitigation is considerably delayed or under limited availability of key technologies, such as bioenergy, CCS, and their combination (BECCS).**
- **CCS is indispensable if we want a new deal for the climate - *Ottmar Edenhofer, co-chair of IPCC WG III.***

IPCC WG III – AR5
Mitigation cost increases in scenarios



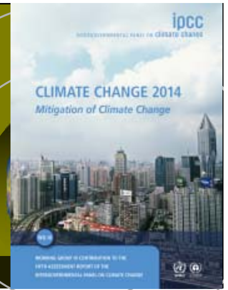
Percentage increase in total discounted mitigation costs (2015-2100) relative to default technology assumptions – median estimate

2100 concentrations (ppm CO_2eq)	no CCS	nuclear phase out	limited solar/wind	limited bioenergy
450	138% **4**/10	7% **8**/9	6% **8**/9	64% **8**/10

Symbol legend – fraction of models successful in producing scenarios (numbers indicate number of successful models)

All models successful	Between 80 and 100% of models successful	Between 50 and 80% of models successful	Less than 50% of models successful

IPCC WG III AR5, SPM
Global Mitigation Cost



"Under the absence or limited availability of technologies, mitigation costs can increase substantially … "

Increase in mitigation costs for 450 ppm scenario

- **No CCS: +138%**
- **Nuclear Phseout: +7%**
- **Limited Solar/Wind: +6%**
- **Limited Bio: +64**

	Increase in total discounted mitigation costs in scenarios with limited availability of technologies			
	[% increase in total discounted mitigation costs (2015–2100) relative to default technology assumptions]			
2100 Concentration (ppm CO_2eq)	No CCS	Nuclear phase out	Limited Solar / Wind	Limited Bio-energy
450 (430–480)	138 (29–297) [N: 4]	7 (4–18) [N: 8]	6 (2–29) [N: 8]	64 (44–78) [N: 8]
500 (480–530)				
550 (530–580)	39 (18–78) [N: 11]	13 (2–23) [N: 10]	8 (5–15) [N: 10]	18 (4–66) [N: 12]
580–650				

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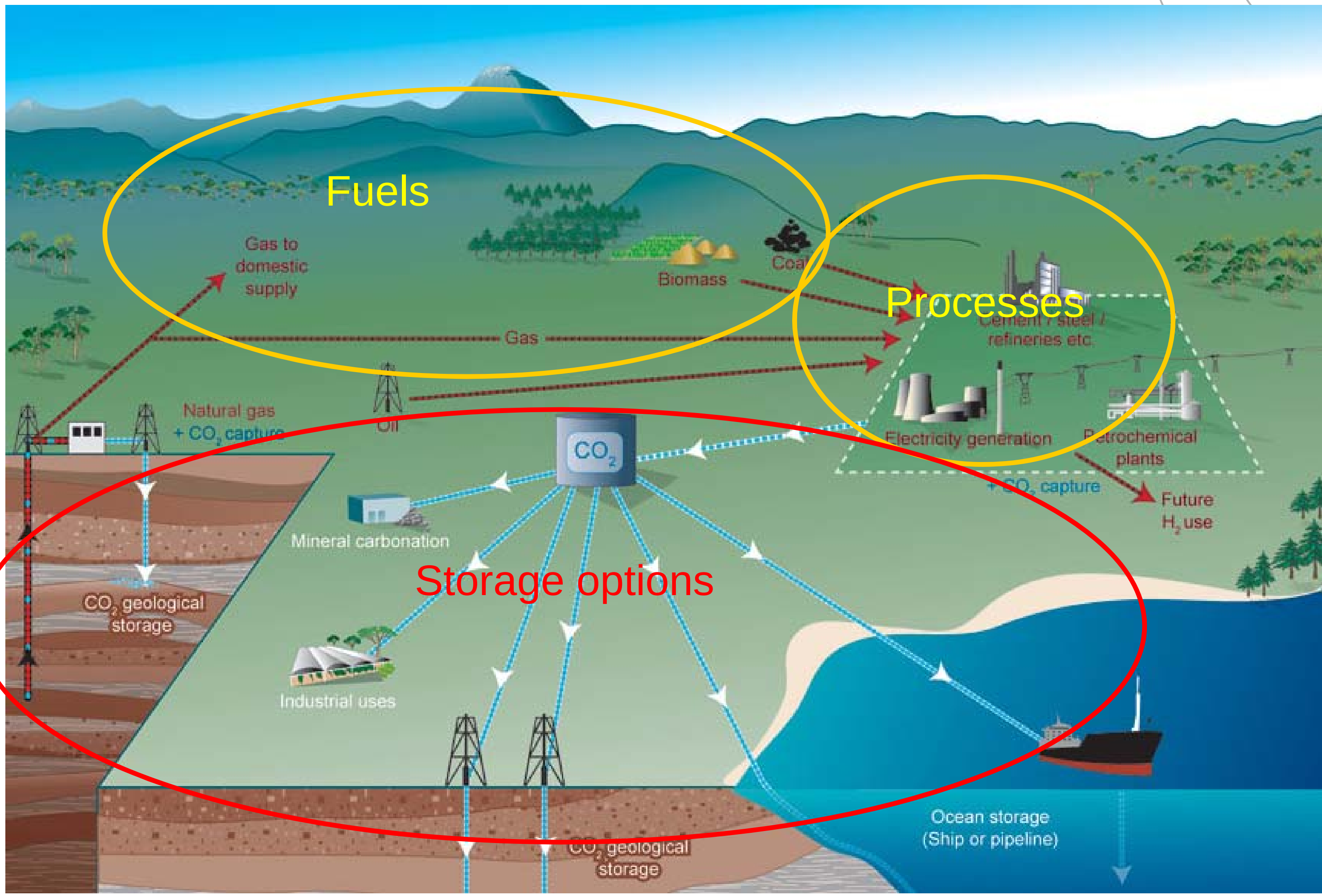
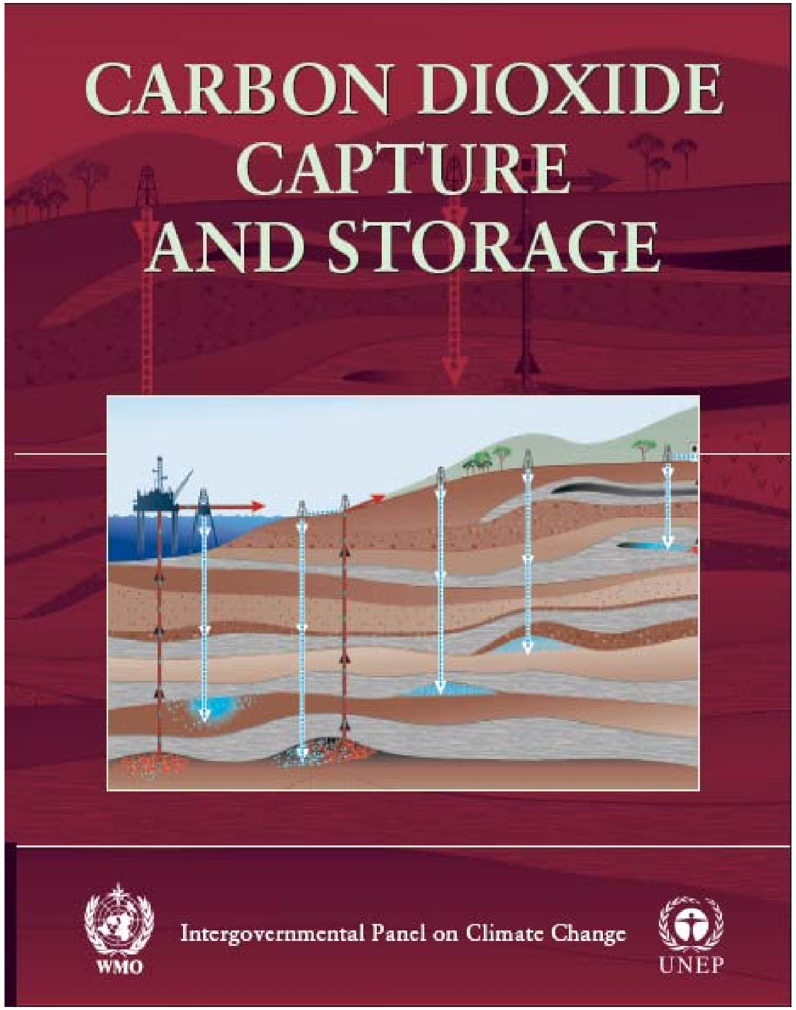
CO_2 Capture and Storage System



Source: IPCC SRCCS

The IPCC Special Report on Carbon Dioxide Capture and Storage



CCS in G8 Summit

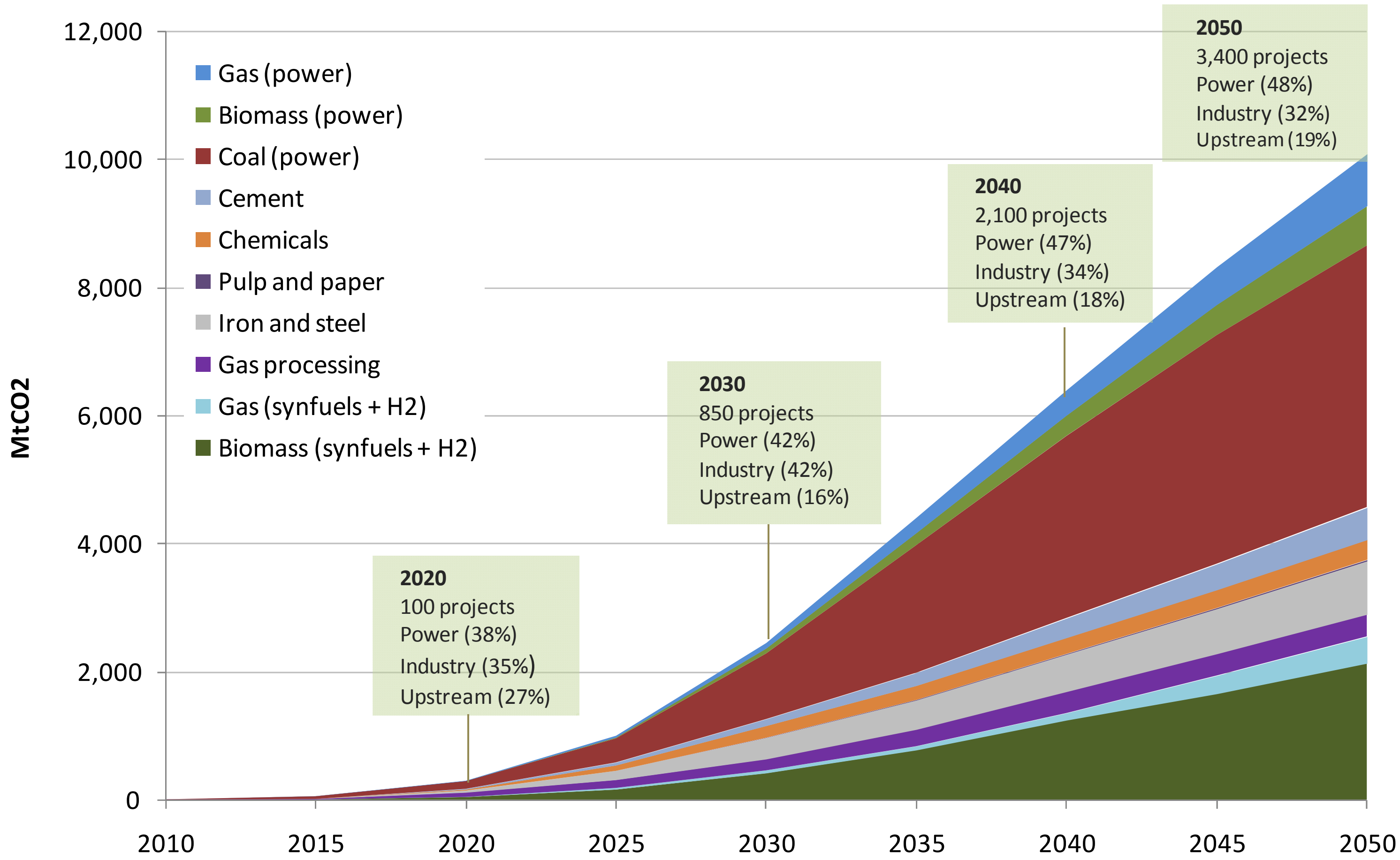
G8 Hokkaido Toyako Summit Leaders Declaration (8 July 200)

31. **We will establish an international initiative with the support of the IEA to develop roadmaps for innovative technologies and cooperate upon existing and new partnerships, including carbon capture and storage (CCS) and advanced energy technologies. Reaffirming our Heiligendamm commitment to urgently develop, deploy and foster clean energy technologies, we recognize and encourage a wide range of policy instruments such as transparent regulatory frameworks, economic and fiscal incentives, and public/private partnerships to foster private sector investments in new technologies. We strongly support the launching of 20 large-scale CCS demonstration projects globally by 2010, taking into account various national circumstances, with a view to beginning broad deployment of CCS by 2020.**

IEA CCS Roadmap

Global Deployment of CCS 2010–50 by Sector

BLUE Map Scenario (~450 ppm)



Global Status of CCS

- Large Scale CCS Projects
- Notable CCS Projects
- New Development in Japan

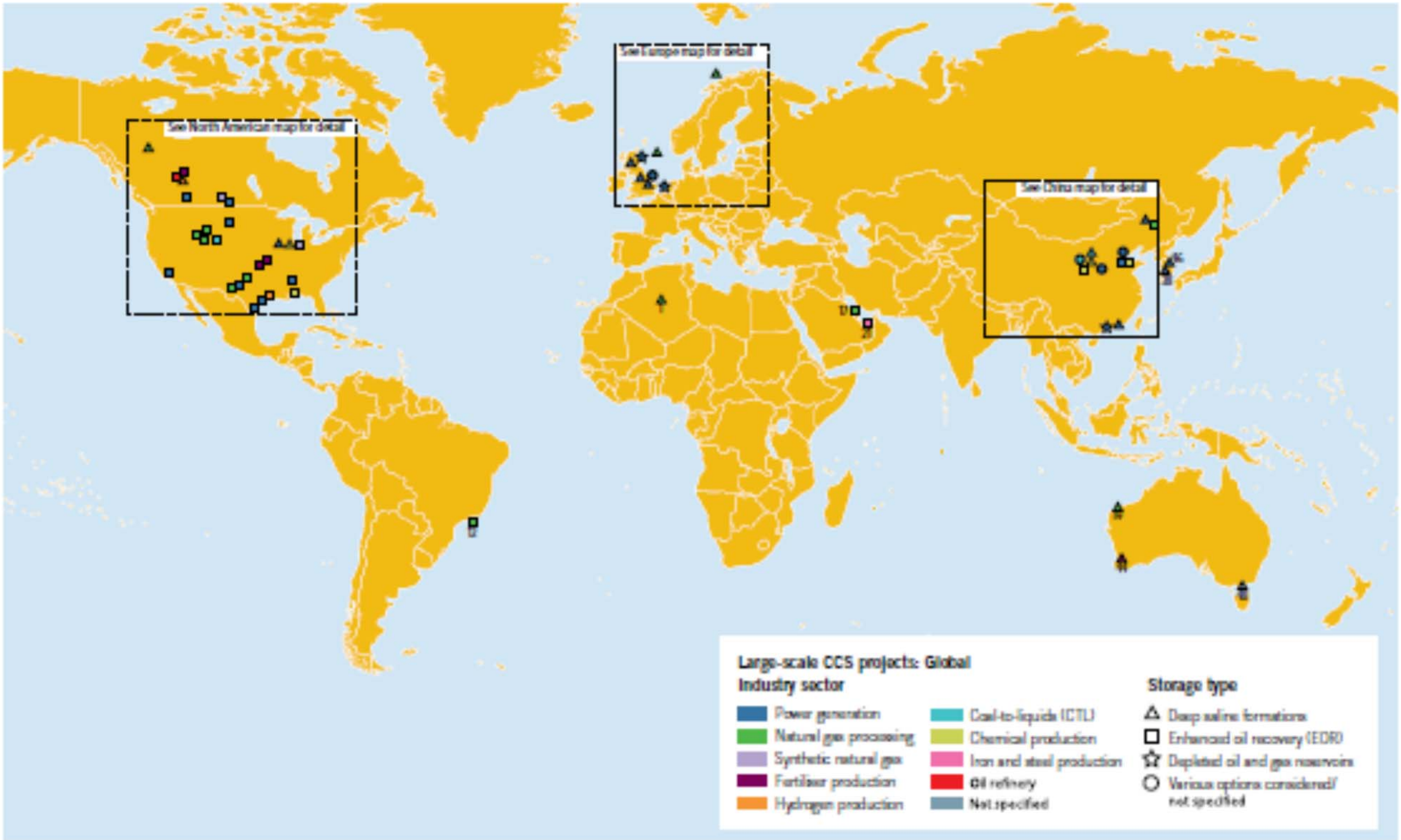
Large Scale CCS Projects

Definition of Large Scale Integrated Projects (LSIPs)

- **Large-scale integrated CCS projects (LSIPs) are defined as projects involving the capture, transport, and storage of CO_2 at a scale of:**
  - **at least 800,000 tonnes of CO_2 annually for a coal–based power plant, or**
  - **at least 400,000 tonnes of CO_2 annually for other emissions–intensive industrial facilities (including natural gas–based power generation).**

The thresholds listed above correspond to the minimum amounts of CO_2 typically emitted by commercial–scale power plants and other industrial facilities. Projects at this scale must inject anthropogenic CO_2 into either dedicated geological storage sites and/or enhanced oil recovery (CO_2-EOR) operations, to be categorized by the institute as LSIPs.

World Map of Large Scale CCS Projects



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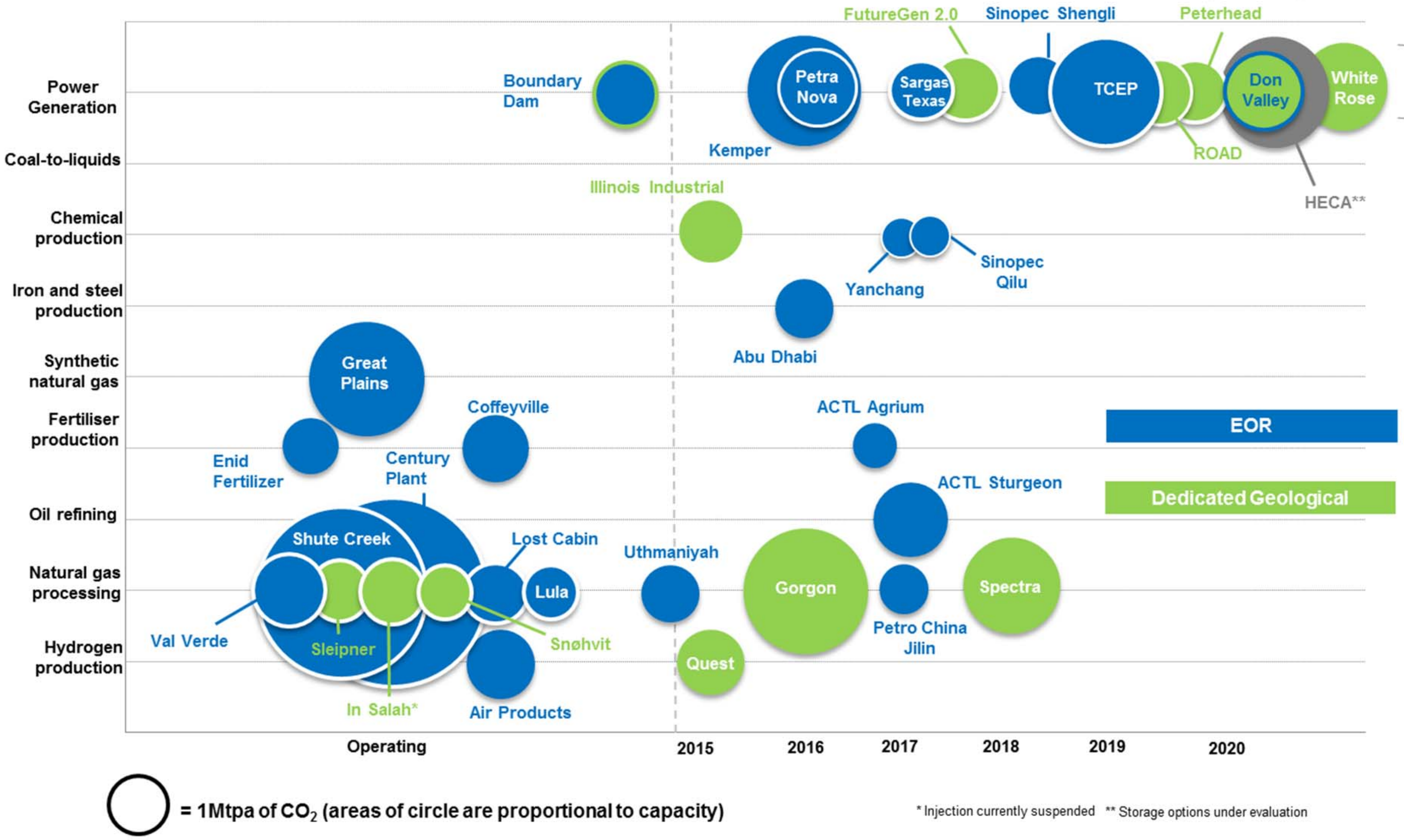
Large-scale CCS Projects by Region or Country

	Early planning	Advanced planning	Construction	Operation	Total
Americas	1	5	6	10	22
China	5	4	-	-	9
Europe	2	4	-	2	8
Gulf Cooperation Council	-	-	1	1	2
Rest of World	4	-	1	1	6
Total	12	13	8	14	47

North America (with 15 in the US and 6 in Canada), China (with 9) and UK (with 5) have the most projects

Actual and expected operation dates for projects in operation, construction and advanced planning



2015-2016 is a watershed period for CCS – it is a reality in the power sector and additional project approvals are anticipated

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Pathway to CCS deployment

New horizons	Realising the portfolio	Widespread deployment
Decisions made at start of decade are now bearing fruit	Ensure conditions are supportive for projects in advanced planning	Decisions and actions required now to lay policy, legal and infrastructure foundations for post-2020 project portfolio
2010 – 2015	**2016 – 2020**	**2020 →**

2015 and 2016 are watershed years for CCS

LSIPs in Operation (1/2)

Overall capture capacity of 13 projects: 27.4 Mtpa

Project Name	Location	Operation Date	Industry	Capture Capacity (Mtpa)	Primary Storage Type
Val Verde Natural Gas Plants	United States	1972	Natural Gas Processing	1.3	EOR
Shute Creek Gas Processing Facility	United States	1986	Natural Gas Processing	7	EOR
Sleipner CO2 Storage Project	Norway	1996	Natural Gas Processing	0.9	Dedicated Storage
Enid Fertilizer CO2-EOR Project	United States	1982	Fertiliser Production	0.7	EOR
Great Plains Synfuel Plant and Weyburn-Midale Project	Canada	2000	Synthetic Natural Gas	3	EOR
In Salah CO2 Storage	Algeria	2004	Natural Gas Processing	0(injection suspended)	Dedicated Storage
Snøhvit CO2 Storage Project	Norway	2008	Natural Gas Processing	0.7	Dedicated Storage

LSIPs in Operation(2/2)

Overall capture capacity of 13 projects: 27.4 Mtpa

Project Name	Location	Operation Date	Industry	Capture Capacity (Mtpa)	Primary Storage Type
Century Plant	United States	2010	Natural Gas Processing	8.4	EOR
Coffeyville Gasification Plant	United States	2013	Fertiliser Production	1	EOR
Lost Cabin Gas Plant	United States	2013	Natural Gas Processing	0.9	EOR
Petrobras Lula Oil Field CCS Project	Brazil	2013	Natural Gas Processing	0.7	EOR
Air Products Steam Methane Reformer EOR Project	United States	2013	Hydrogen Production	1	EOR
Boundary Dam Carbon Capture and Storage Project	Canada	2014	Power Generation	1	EOR
Uthmaniyah CO2 EOR Demonstration Project	Saudi Arabia	2015	Natural Gas Processing	0.8	EOR

LSIPs in Execute Stage (1/2)

Project is considered to have entered construction

Overall additional capture capacity of 8 projects: 12.2 – 13.3 Mtpa

Project Name	Location	Operation Date	Industry	Capture Capacity (Mtpa)	Primary Storage Type
Quest	Canada	2015	Hydrogen Production	1.1	Dedicated Storage
Abu Dhabi CCS Project (Phase 1 being Emirates Steel Industries (ESI) CCS Project)	United Arab Emirates	2016	Iron and Steel Production	0.8	EOR
Gorgon Carbon Dioxide Injection Project	Australia	2016	Natural Gas Processing	3.4 - 4.0	Dedicated Storage
Illinois Industrial Carbon Capture and Storage Project	United States	2016	Chemical Production	1	Dedicated Storage

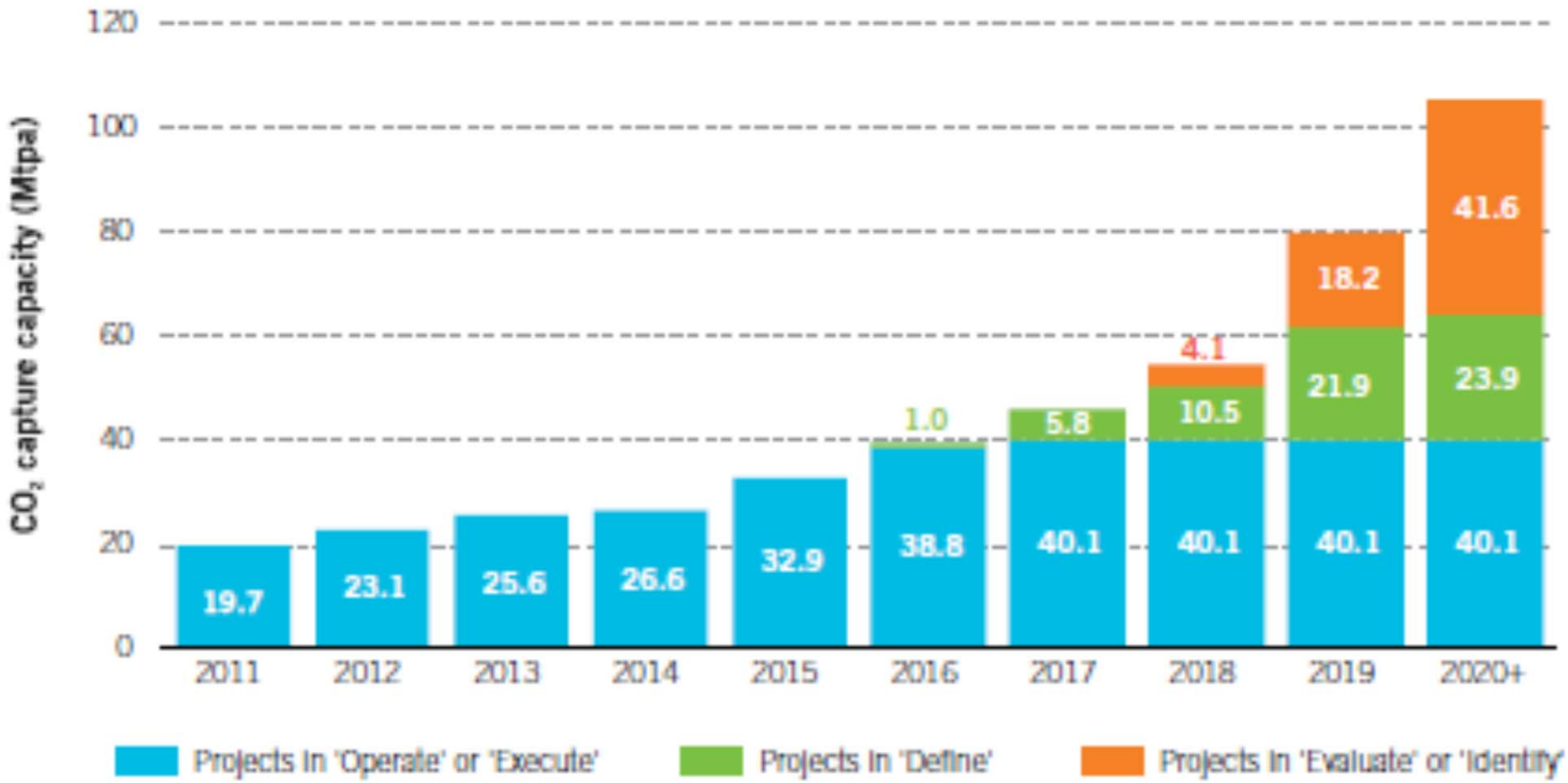
LSIPs in Execute Stage (2/2)

Project is considered to have entered construction

Overall additional capture capacity of 8 projects: 12.2 – 13.3 Mtpa

Project Name	Location	Operation Date	Industry	Capture Capacity (Mtpa)	Primary Storage Type
Kemper County Energy Facility (formerly Kemper County IGCC Project)	United States	2016	Power Generation	3	EOR
Petra Nova Carbon Capture Project (formerly NRG Energy Parish CCS Project)	United States	2016	Power Generation	1.4	EOR
Alberta Carbon Trunk Line ("ACTL") with Agrium CO2 Stream	Canada	2016-17	Fertiliser Production	0.3 - 0.6	EOR
Alberta Carbon Trunk Line ("ACTL") with North West Sturgeon Refinery CO2 Stream	Canada	2017	Oil Refining	1.2 - 1.4	EOR

CO_2 capture capacity of all identified large-scale CCS projects



CCS

Technical Issues

CO_2 capture – focus on cost

- First generation projects will deliver important lessons.
- Continued R&D activities – on materials, processes and equipment – will help drive down costs.
- Collaboration crucial to achieve cost and performance goals.
- Next-generation technologies ready for the 2020-2025 timeframe.

CO_2 storage – focus on timing

- EOR providing support to current wave of CCS projects.
- Global deployment will require significant geological storage.
- 2℃ scenario requires over 2Gt annual storage by 2030, over 7Gt by 2050.
- Greenfields sites can take up to 10 years to assess to FID standard.
- Currently, industry has no incentive to undertake storage exploration.

CCS

Policy, Legal

and

Public Engagement

Global Legal & Regulatory Developments (1/2)

- **Several early-mover jurisdictions have reported that their legal and regulatory models for CCS are complete**
  - **Recent focus in some of these jurisdictions is on reviewing their models**
  - **There is a challenge in the absence of project-specific experience, it remains difficult to assess the success or otherwise of legislation.**
- **There is some progress globally on deploying more CCS legislation, as further jurisdictions seek to introduce models**
  - **These jurisdictions are focusing on the essential elements for domestic legal and regulatory frameworks;**
  - **Significant interest in the experiences of regulators in the early-mover jurisdictions.**

Global Legal & Regulatory Developments (2/2)

- **Institute conducts annual survey on legal and regulatory developments**
- **LSIPs have different views around the world as to whether the current legal and regulatory model in their jurisdiction supports a final investment decision:**
  - **Pre-existing legal and regulatory frameworks for EOR activities provide some experience, but not complete certainty**
  - **Other jurisdictions lack complete regulatory models**
- **The survey once again reveals projects view a number of continuing issues as 'unaddressed' in their domestic legal and regulatory models. Unaddressed issues include:**
  - **Standards to account for the transboundary movement of CO2;**
  - **Issues associated with long-term liability and financial security.**

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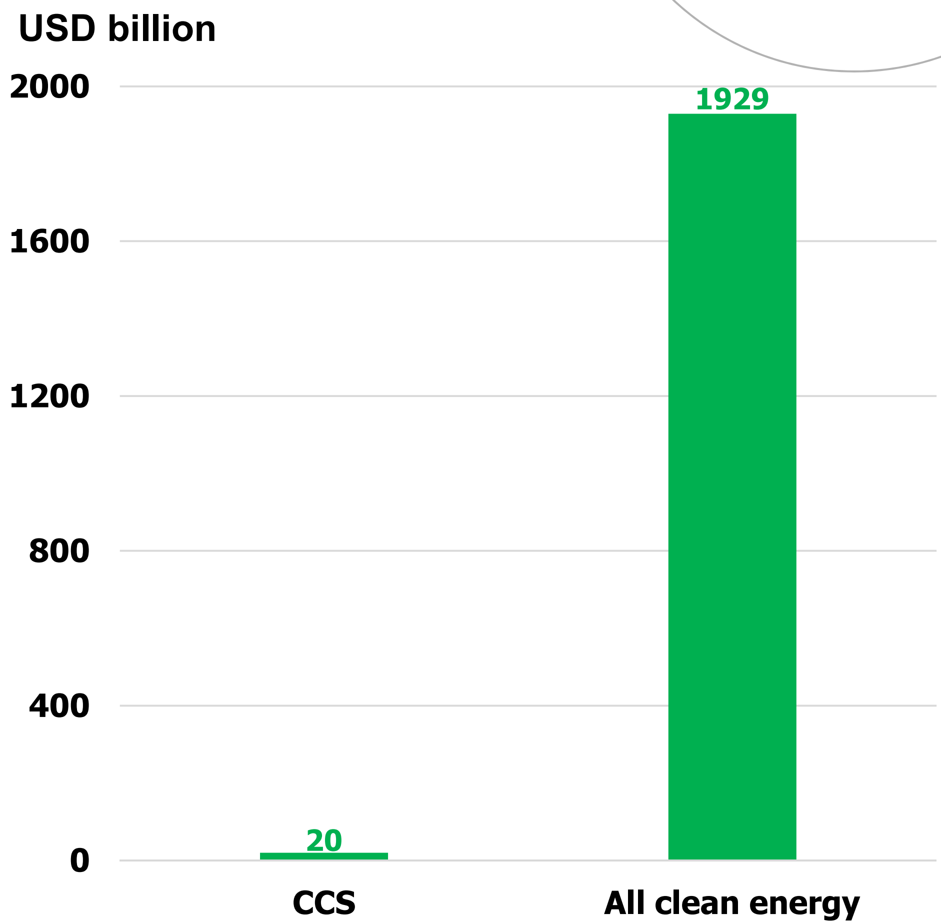
Policy developments

- **Supportive policies are gaining momentum**
  - **USA: emissions standards for generators, substantial government funding programs**
  - **UK: CCS £1billion competition, Contract for Difference; emissions standards for coal generators**
  - **Europe: reviewing ETS/ carbon pricing, including extension of NER300 funding for low emissions projects**
  - **China: peak emissions before 2030; joint CCS project with US; national emissions trading to commence from 2016**
  - **UN: pledges to Green Climate Fund surpass $10 billion**
- **Expect announcements from other countries, e.g. revised national mitigation targets, in the lead up to Paris COP21**

Strong policy drives investment

- **Scale of renewables investment is instructive**
- **CCS has not enjoyed commensurate policy support**
- **EOR has provided impetus in North America**
- **Policy parity is essential**
- **How do we get CCS onto a similar curve?**

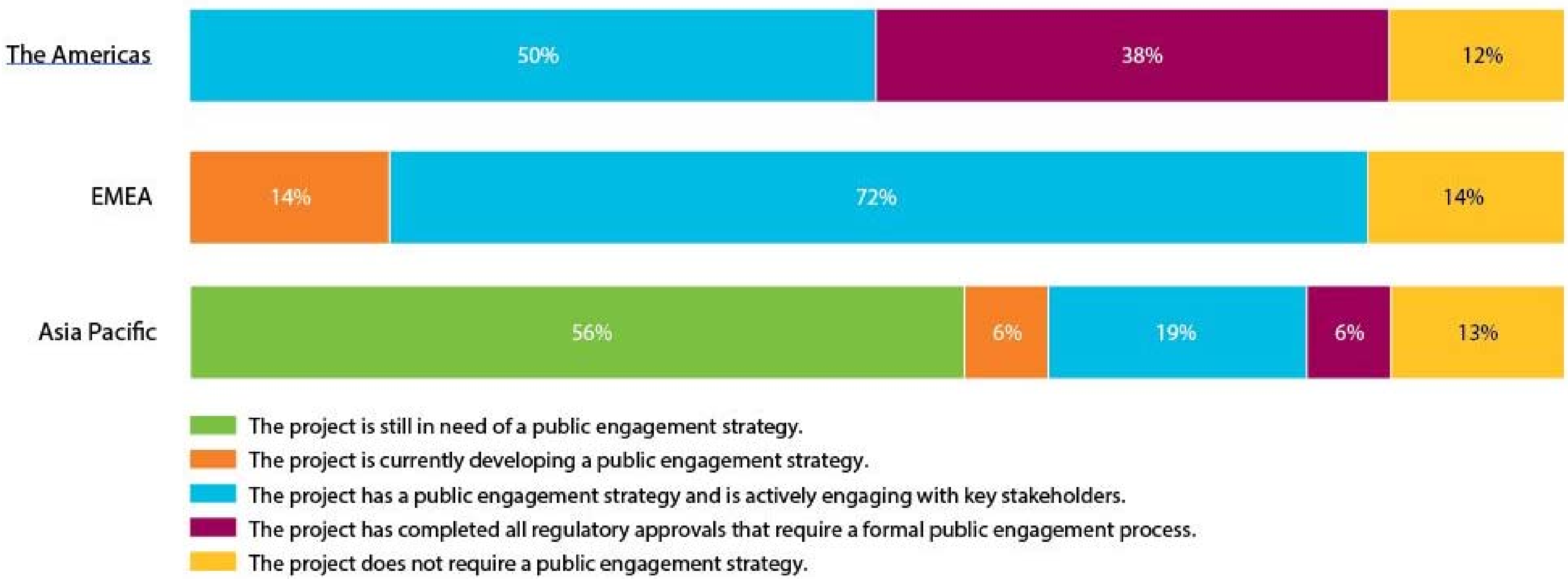
Clean energy investment between 2004-2013



Data source: Bloomberg New Energy Finance as shown in IEA presentation "*Carbon Capture and Storage: Perspectives from the International Energy Agency*", presented at National CCS week in Australia, September 2014.

Status of public awareness

Status of public engagement strategy development by region



"Communication is critical to any CCS project. Even where CCS awareness is high, many CCS projects - successful and failed - have received negative attention. Strategic outreach and engagement is necessary for ensuring CCS projects have support."

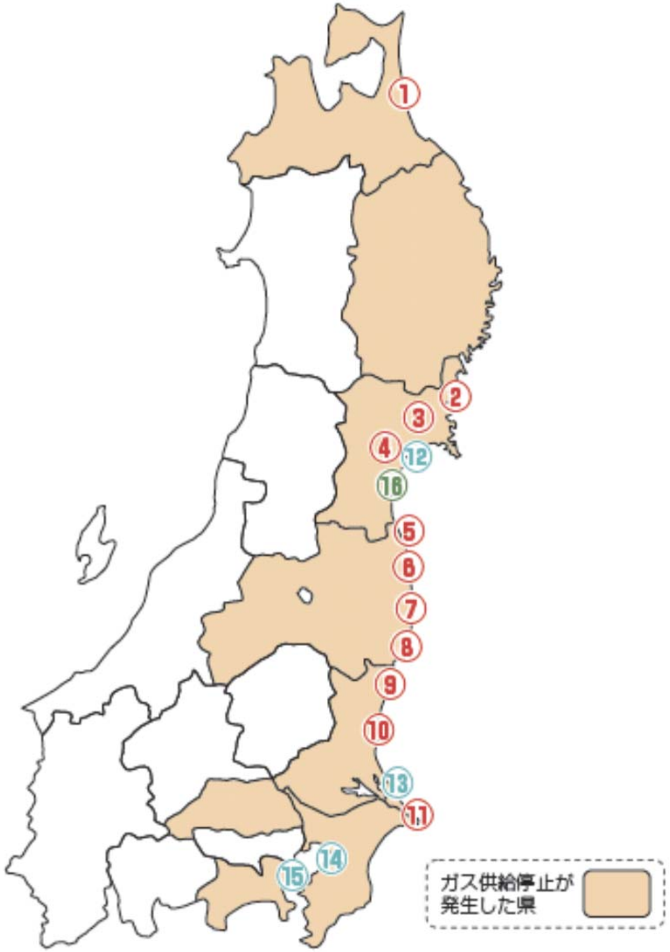
Petroleum Technology Research Centre (PTRC), 2014. *Aquistore - CO2 Storage at the World's First Integrated CCS Project,* Pg. 113.

Policy and regulatory support is vital

- **Achieving climate goals without CCS would incur substantial additional costs - or not be possible.**
- **Current large-scale CCS project activity is supported by public funding programs established towards the end of the last decade.**
- **Looking forward, a strong policy, legal and regulatory environment will incentivise and provide predictability for investors in CCS projects.**
- **Action is needed now if we are to deliver projects in the next decade**
- **The new international climate agreement under development will be an important foundation stone.**
- **Regional and national policy settings should be technology neutral to ensure that CCS is not disadvantaged relative to other technological solutions.**

What Happened after Fukushima Nuclear Accidents

What Happened to the Energy Supply by the Catastrophic Earthquake and Tsunami?
(11 March 2011)



Major installations affected by the earthquake and tsunami

Damaged Plants

- **Power Stations**
  - **Tohoku Grid**
    - **Fossil**

      Hachinohe (250MW), Sendai (446MW), Shin-Sendai (350MW), Haramachi (2000MW), Shinchi (2000MW)
  - **Tokyo Grid**
    - **Fossil**

      Hirono (3800MW), Hitachi-naka (1000MW), Nakoto (1625MW), Kashima (4400MW), Kahima (1400MW)
    - **Nuclear**

      Fukushima-1 (4700MW)
- **3 Refineries**
- **1 LNG terminal**

Most of the plants have been retrieved !

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Shortage of Power Supply

- **March to summer 2011 (affected areas)**
  - Rotating blackout (March 2011)
  - Forced restriction of electricity use to large customers (-15% in Summer 2011).
  - Voluntary power saving in households.
- **2012 (before Summer)**
  - One out of 54 nuclear power stations is running, but would be stopped for scheduled maintenance within a month.
    ⇨ZERO Nuclear
  - In Kansai area, where about a half of the electricity had been supplied by nuclear, power shortage up to 20% was anticipated in the summer of 2012.
    ⇨Two nuclear power stations were re-started through the controversial decision by the Prime Minister

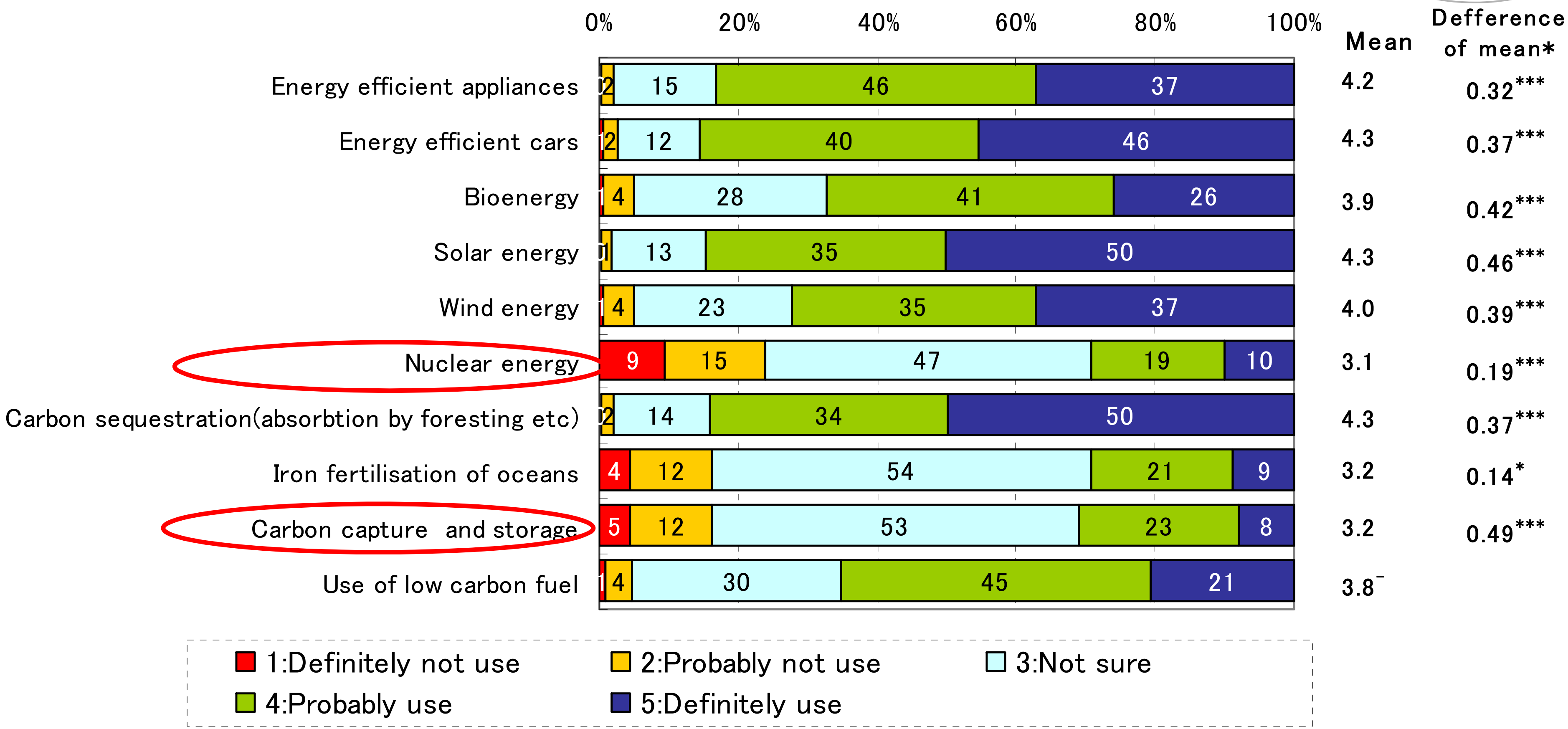
Short- to Mid-term Impacts
(1 year to 20 years)

- **Possibilities:**
  - Forced restriction of electricity use
  - Rotating blackout
  - Unmanageable black-out
- **Replacing nuclear electricity (1100MW) by fossil will impose about $1B/y of additional fuel cost.**
- **CO_2 emission from power sector in 2020 will be 50 to 250 Mton higher compared with BAU if CCS and Nuclear will not be employed.**
  - Based on a scenario analysis

Public Perception

Nuclear and CCS:
Similarity in Perception (AIST Study)

- **If you are responsible for climate policy in your country, do you use .....? (2007 survey)**



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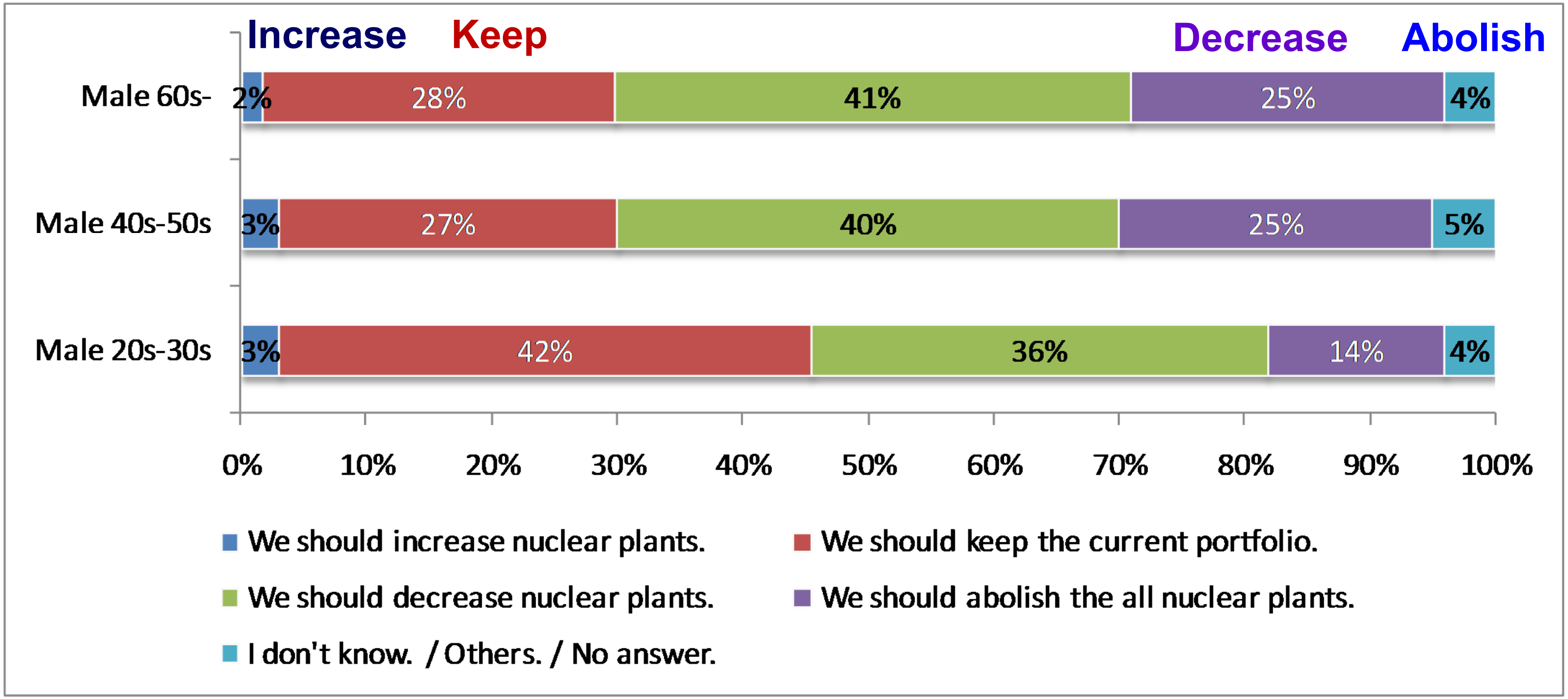
Public Opinion on Nuclear
After Fukushima Accident - Media Survey

- **What should we do about nuclear plants in Japan? (October 2011, each sex)**



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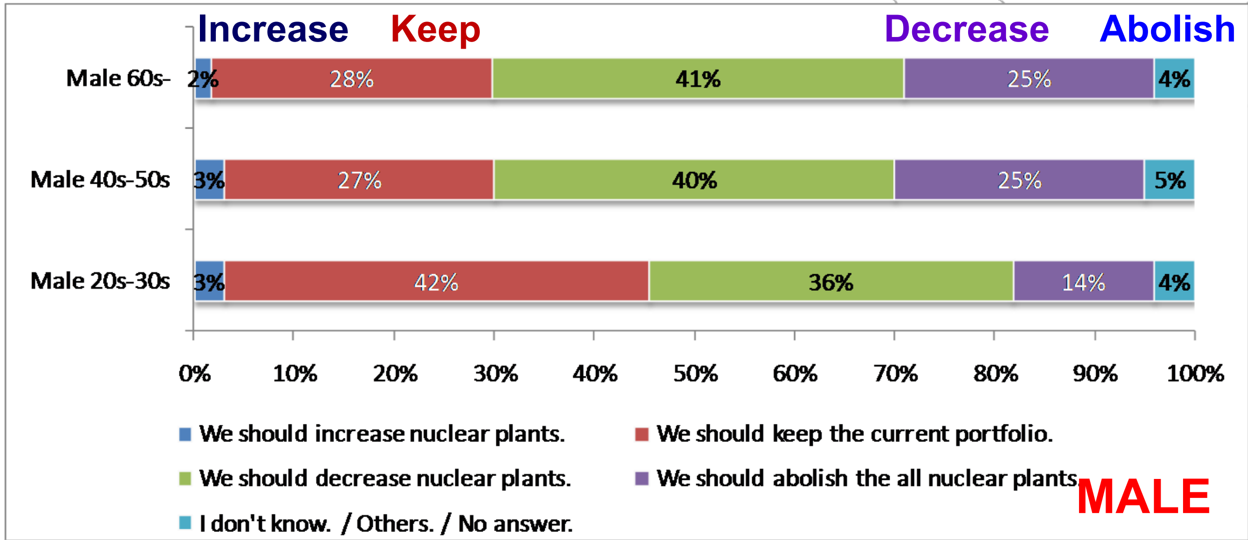
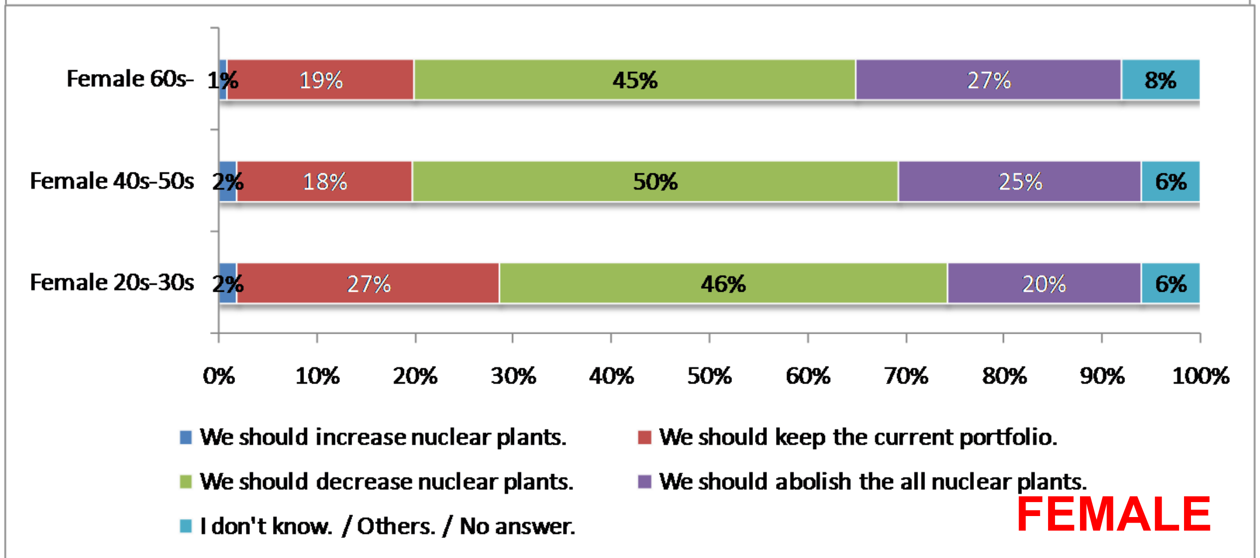
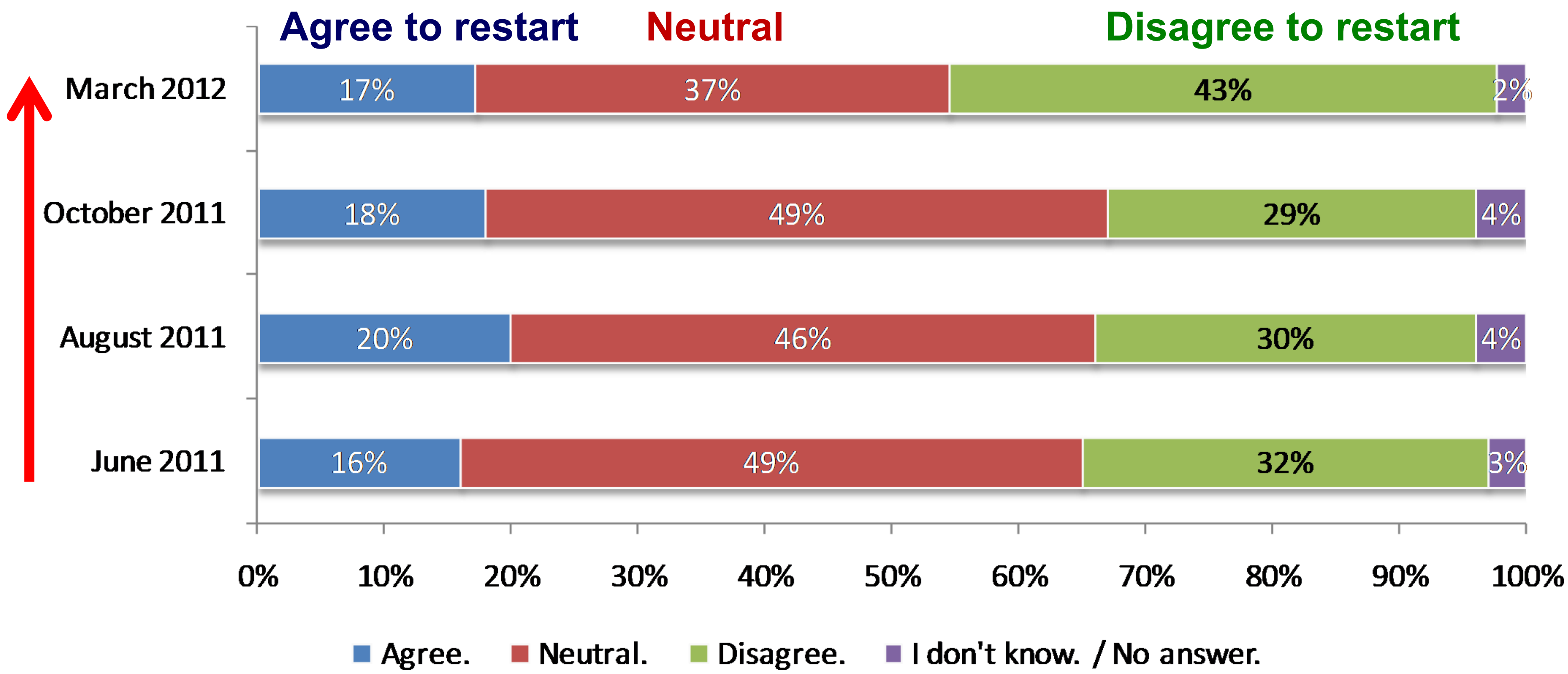




Public Opinion on Restarting Nuclear

- **Are you agree or disagree about restarting operation of nuclear plants that have shut for periodic inspections or earthquakes?**



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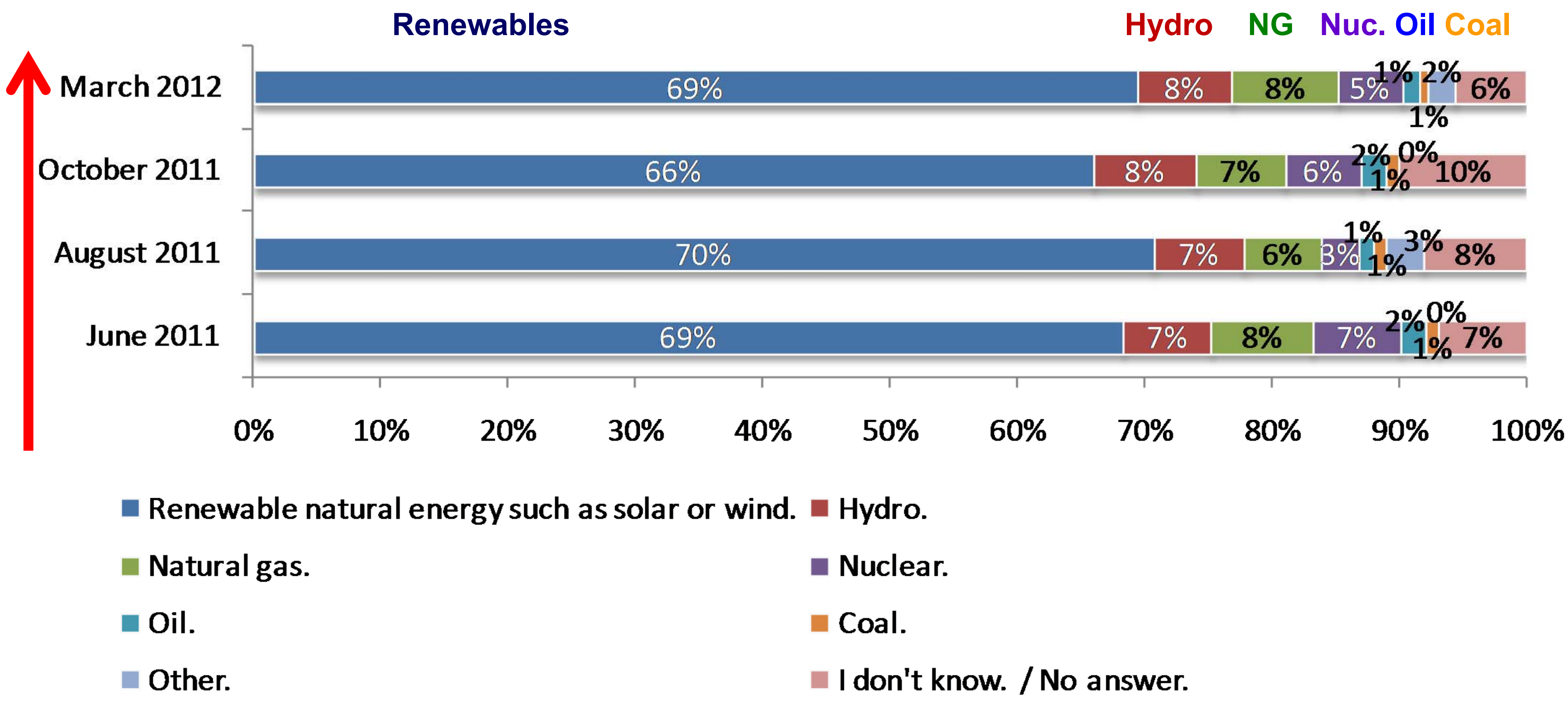
Public Opinion
Future Energy Portfolio

- **What kinds of energy sources should we expand more in the future?**



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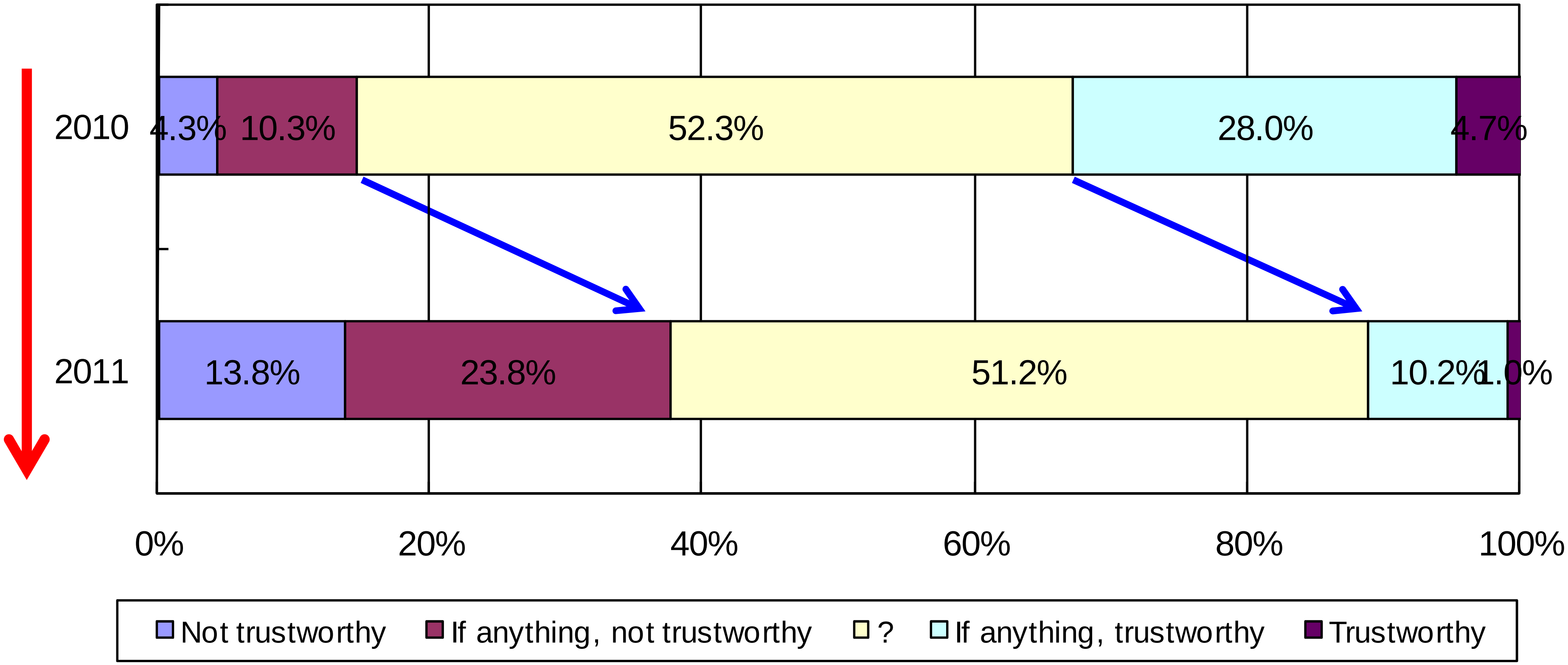
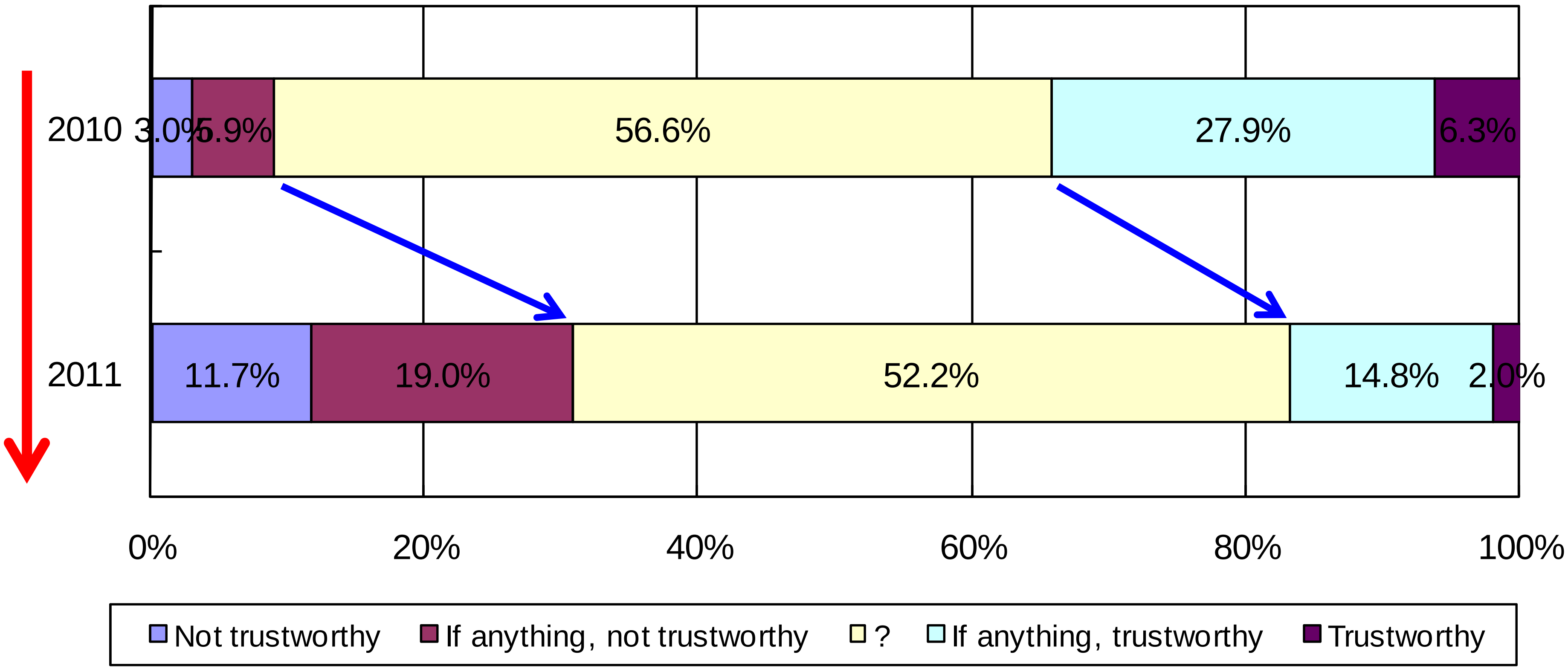
Public opinion - Losing Trusts
Governments

- **Trust in local governments and national government (nuclear safety regulators)**



Public opinion - Losing Trusts
Experts

- **Trust in nuclear experts and involved parties**



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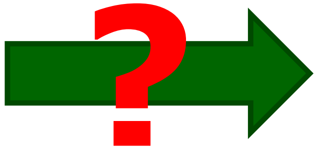
Rumor, Rumor, Rumor ...

Piece of pine trees suffered in an area far from Fukushima



The Gozan no Okuribi Festival (16 August in Kyoto)

- **A proposal was made to send pieces of pine trees suffered by the tsunami to Kyoto to be burned as a part of a famous farewell bonfire to mourn the victims.**

BUT

- **Many of the Kyoto citizens said NO because of unreasonable fear for radiation.**

Rumor, Rumor, Rumor …

- **Request to local authorities other than Tohoku area to accept non-radiative debris arisen from the earthquake and tsunami to help the incineration disposal.**
- **Some of the mayors, etc. said YES**

BUT

- **Only a little amount of debris has been accepted because of strong/hysteric oppositions of local citizens and non-local public.**

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What to Do in Japanese Society?
Observations

- **Poor knowledge of politicians on energy issues**
- **Emotional discussion on energy portfolio**
  - Nuclear vs. Renewables
  - Promoters of renewables or antinuclear activists try to revenge themselves on electric utilities, policy makers, etc. for long-term indignity by making best use of Fukushima accident.
  - Old fashioned skepticism on renewables of electric utilities, etc. to protect against challenge by promoters.
- **Harmful argument by non-expert "intellectuals"**
  - General public would be influenced by the opinion of so called "intellectuals" regardless of their expertise
- **Emerging new myth**
  - Absolute dangerousness of Nuclear Power Plants

What to Do in Japanese Society?
Impossible Dream?

- Improving energy literacy
  - General public, policy makers, politicians, etc.
- Restoration of the public's confidence on scientists, experts, policymakers, etc.
  - Elimination of pseudointellectuals
- Daily life considering RISK
  - Adverse reaction on the term "Risk"
    - Paraphrasing "risk assessment" as "safety assessment" even by the government.
- Education of media
  - Importance of improving media literacy of recipient

Political Will and R&D Challenge

- **Political Will as a key driver**
  - **To set desirable target for the future**
  - **To develop roadmaps**
  - **To promote R&D activities**

    ≈ Implementation of Roadmaps
  - **To design and promote socio-economic system to challenge policy goals such as energy security, climate change, etc.**
- **Available science and technologies, coupled with proper assessments, to drive Policies**

Need for Portfolio Approach

Scale of mitigation and cost for abatement

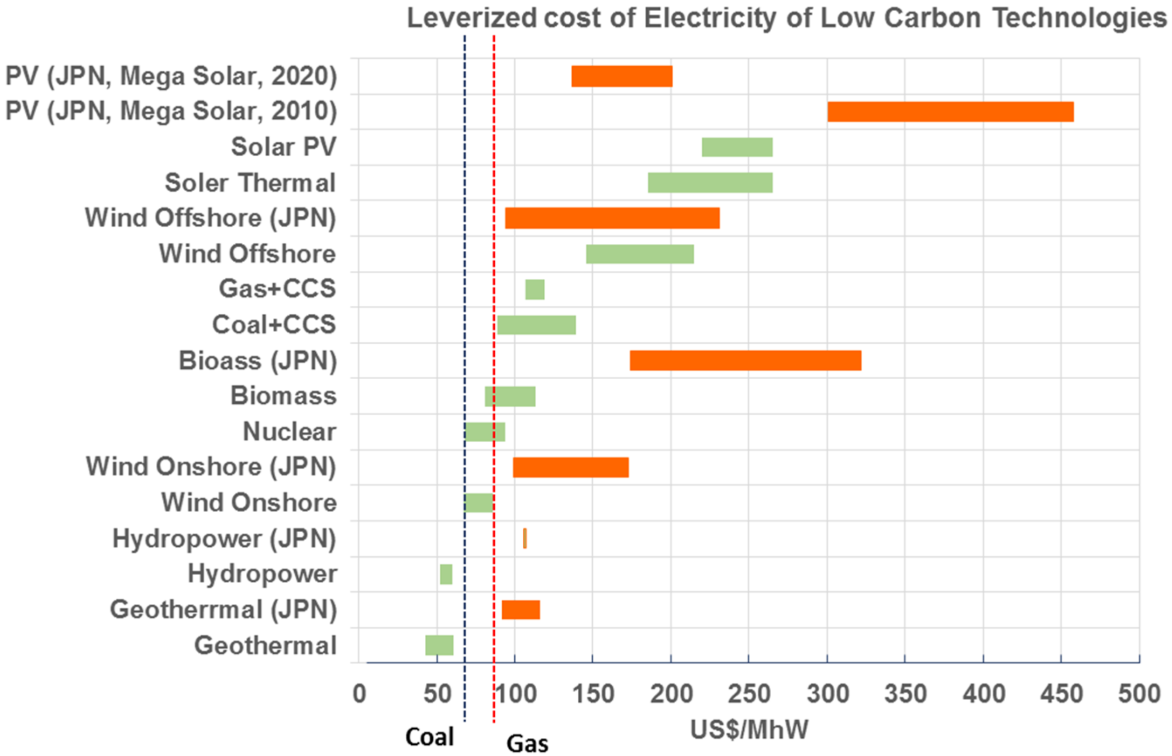
Scale of Mitigation:

- Rooftop PV: a few tons of CO2 pa.
- Concentrated PV: a few hundred tons of CO2 pa.
- CCS: several million tons of CO2 pa.

Abatement cost:

- Energy efficiency: minus to moderate
- PV: > ¥30,000/t-CO_2
- CCS: ~10,000/t-CO_2

Leverized cost of electricity



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Thank you!

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