CENTRE INTERNATIONAL DE RECHERCHE SUR L'ENVIRONNEMENT ET LE DÉVELOPPEMENT

École des Ponts ParisTech

The energy of IPCC…
….or the IPCC of energy

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What is the IPCC?

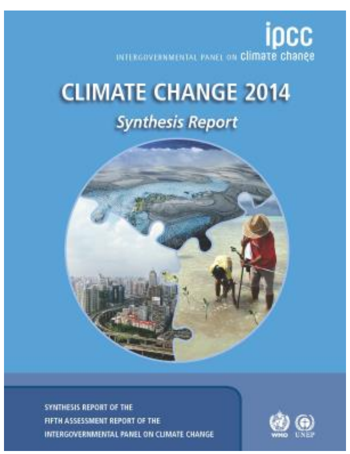
http://ipcc.ch/

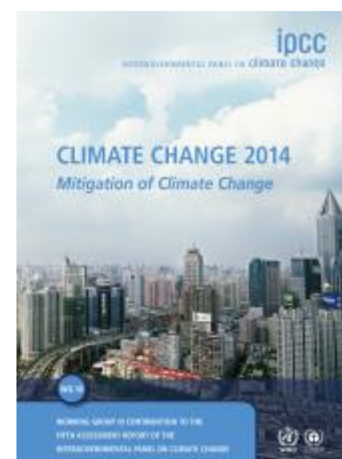
- The Intergovernmental Panel on Climate Change
- The United Nations body for assessing the science related to climate change
- Established by the United Nations Environment Programme and the World Meteorological Organization in 1988
- 195 member states
- 3 working groups:
    - WGI: the physical science basis of climate change;
    - WGII: impacts, adaptation and vulnerability;
    - WG III: mitigation of climate change.

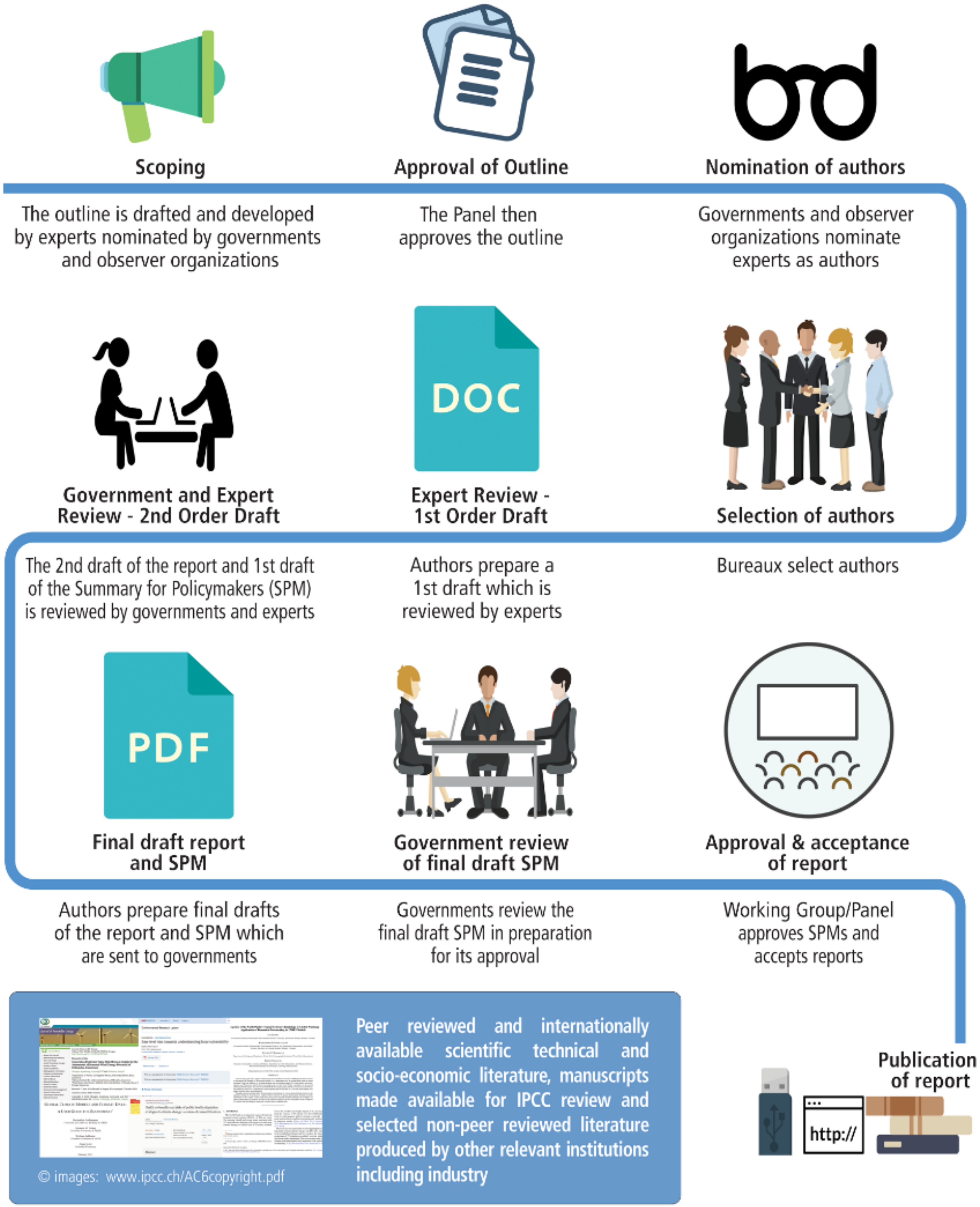
- “hybrid” scientific and intergovernmental nature
- “policy relevant, not policy prescriptive”

What does the IPCC do?

- provides policymakers with **regular scientific assessments** concerning climate change, its implications and risks, as well as adaptation and mitigation strategies.
- **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.
- identifies **where there is agreement** in the scientific community, **where there are differences of opinion**, and **where further research is needed**.
- mobilizes hundreds of scientists to produce its reports (but only a dozen permanent staff work in the IPCC's Secretariat).







The process from scoping to publication of the report takes roughly 5 years.

Factsheet from AR5 WGIII report

The Report

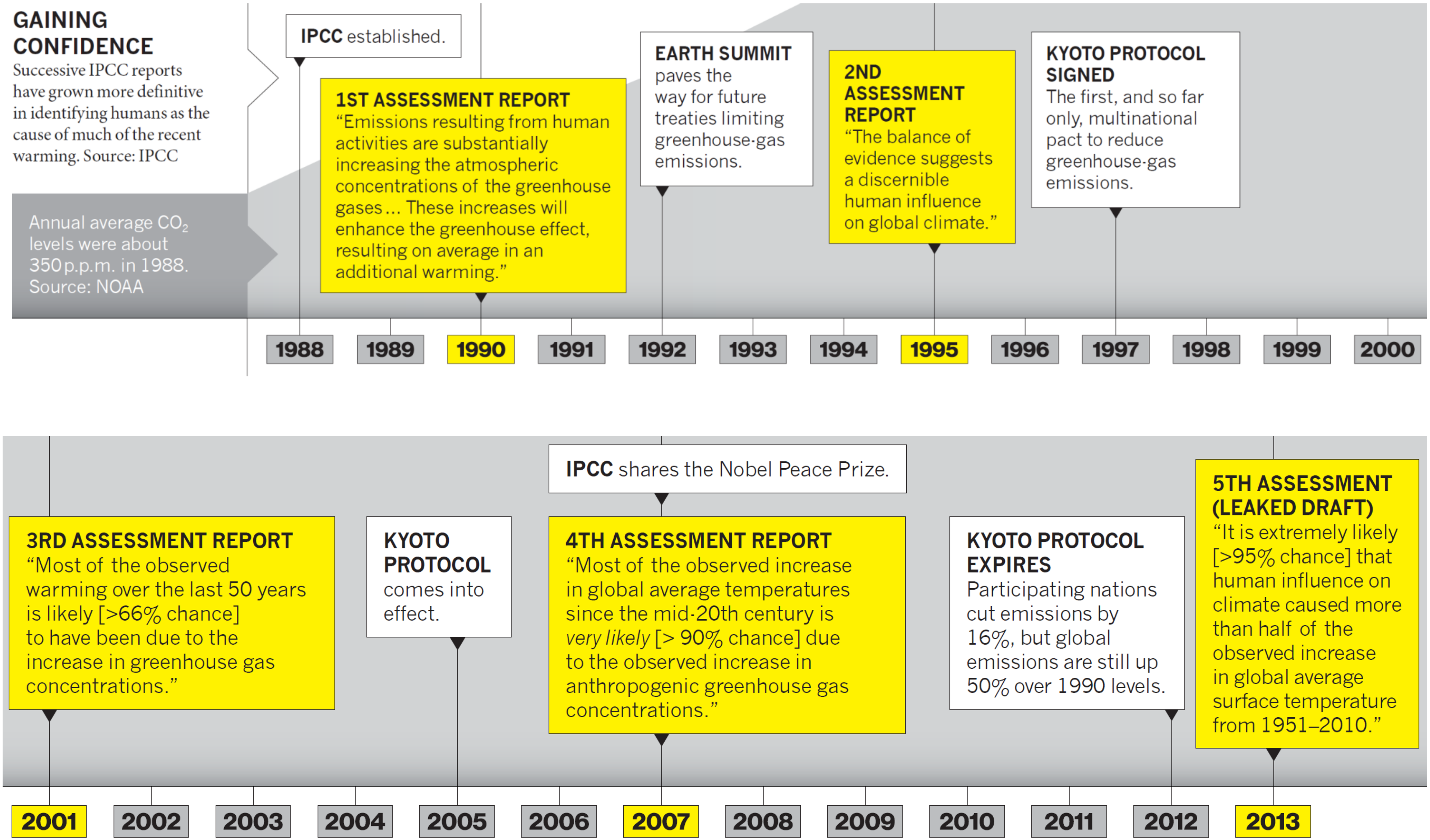
▪ **1** Scoping Meeting ▪ **1** Summary for Policymakers ▪ **16** Chapters ▪ More than **1400** nominations from **85** countries ▪ **235** Coordinating Lead Authors and Lead Authors and **38** Review Editors from **58** countries[1] ▪ **176** Contributing Authors from **35** countries[2] ▪ Close to **1200** scenarios of socioeconomic development analyzed ▪ Close to **10,000** references to literature

Total Reviews

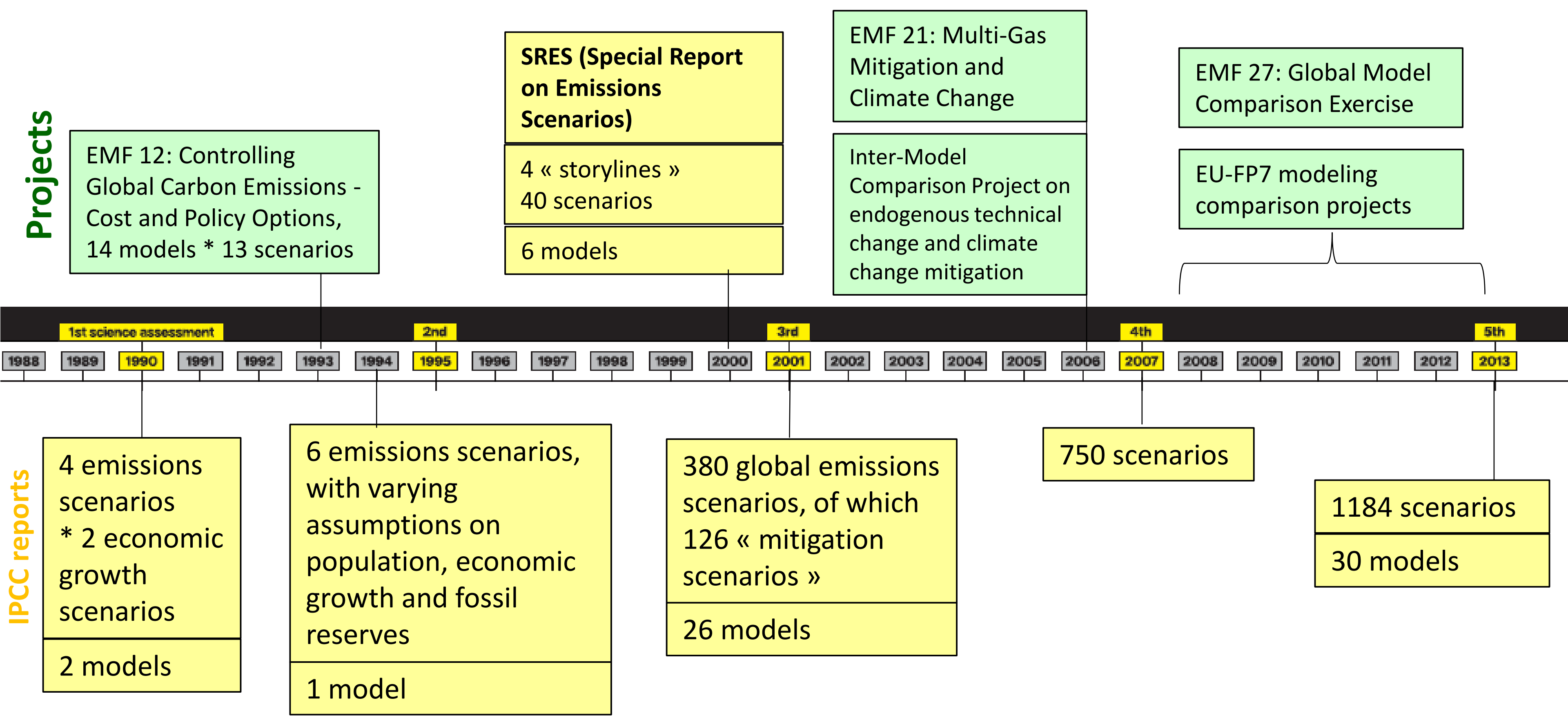
▪ **38,315** comments ▪ **836** Expert Reviewers from **66** countries ▪ **37** Governments

The WGIII Approval Session

▪ 7-11 April 2014, Berlin, Germany ▪ The Summary for Policymakers was approved line-by-line and accepted by the Panel, which has **195** member Governments



From Jones (2013). 25 years of IPCC. *Nature* 501.


Projects
EMF 12: Controlling Global Carbon Emissions - Cost and Policy Options, 14 models * 13 scenarios
SRES (Special Report on Emissions Scenarios)
4 « storylines » 40 scenarios
6 models
EMF 21: Multi-Gas Mitigation and Climate Change
Inter-Model Comparison Project on endogenous technical change and climate change mitigation
EMF 27: Global Model Comparison Exercise
EU-FP7 modeling comparison projects
1st science assessment
2nd
3rd
4th
5th
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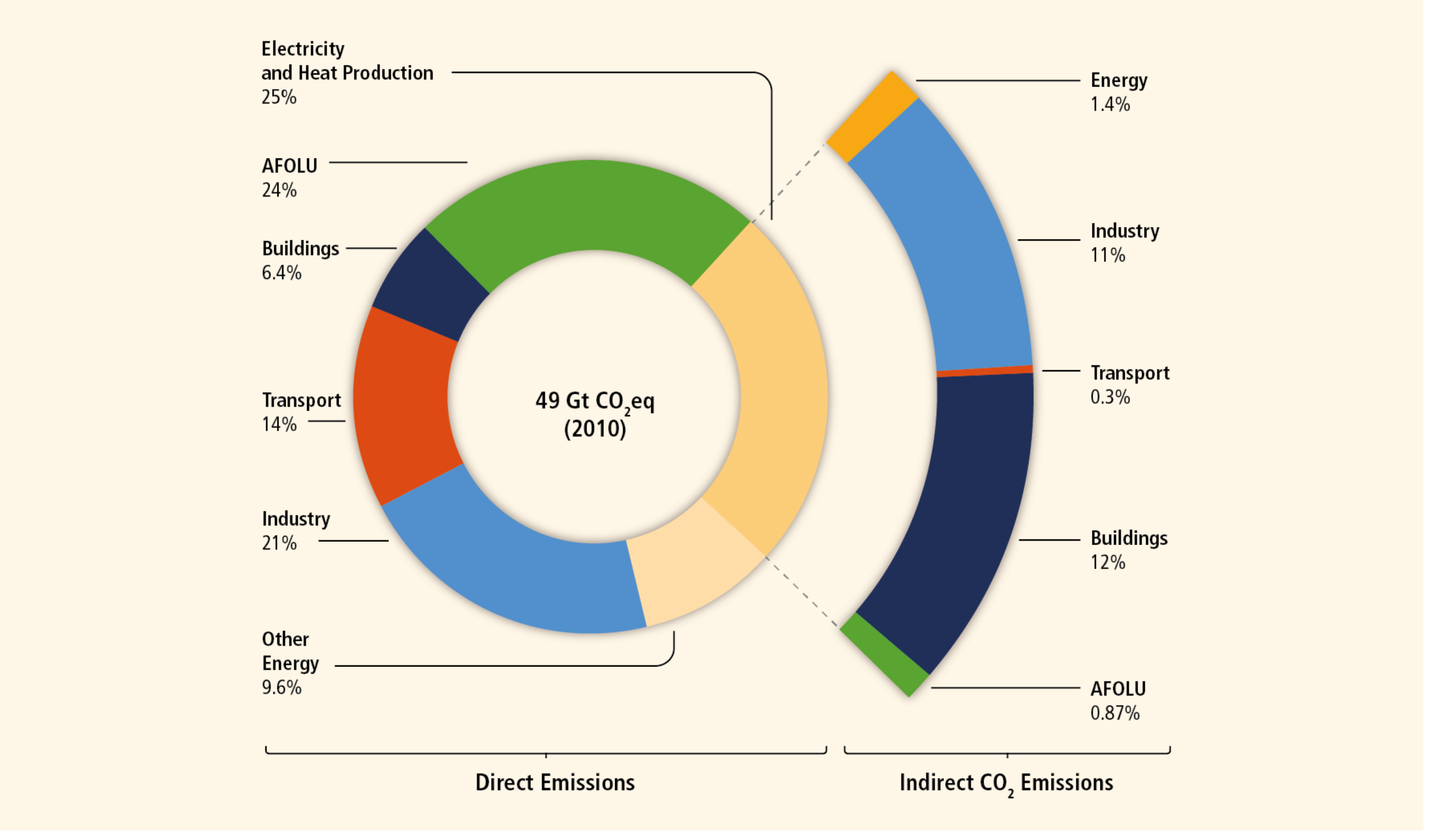
IPCC reports
4 emissions scenarios * 2 economic growth scenarios
2 models
6 emissions scenarios, with varying assumptions on population, economic growth and fossil reserves
1 model
380 global emissions scenarios, of which 126 « mitigation scenarios »
26 models
750 scenarios
1184 scenarios
30 models

Where is energy in IPCC reports?...

… everywhere!

Greenhouse Gas Emissions by Economic Sectors



FAR (1990) – Response Strategies working group report

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Key messages from AR5 ch7 on energy systems (1/3)

- **The energy supply sector is the largest contributor to global greenhouse gas emissions** (robust evidence, high agreement).
- **In the baseline scenarios assessed in AR5, direct CO_2 emissions of the energy supply sector increase from 14.4 $GtCO_2$ / yr in 2010 to 24 – 33 $GtCO_2$ / yr in 2050 (25 – 75th percentile; full range 15 – 42 $GtCO_2$ / yr), with most of the baseline scenarios assessed in AR5 showing a significant increase** (medium evidence, medium agreement).
- **Multiple options exist to reduce energy supply sector GHG emissions** (robust evidence, high agreement). These include energy efficiency improvements and fugitive emission reductions in fuel extraction as well as in energy conversion, transmission, and distribution systems; fossil fuel switching; and low-GHG energy supply technologies such as renewable energy (RE), nuclear power, and carbon dioxide capture and storage (CCS).
- **The stabilization of GHG concentrations at low levels requires a fundamental transformation of the energy supply system, including the long-term substitution of unabated fossil fuel conversion technologies by low-GHG alternatives** (robust evidence, high agreement).
- **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); in most integrated modelling scenarios, decarbonization happens more rapidly in electricity generation than in the industry, buildings and transport sectors** (medium evidence, high agreement).

- **Energy is the main issue.**
- **It is also the main solution.**
- **The reduction of the carbon intensity of electricity production is a key solution, together with electrification of uses.**

Key messages from AR5 ch7 on energy systems (2/3)

- **Since the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4), many RE technologies have demonstrated substantial performance improvements and cost reductions, and a growing number of RE technologies have achieved a level of maturity to enable deployment at significant scale** (robust evidence, high agreement).
- **There are often co-benefits from the use of RE, such as a reduction of air pollution, local employment opportunities, few severe accidents compared to some other forms of energy supply, as well as improved energy access and security** (medium evidence, medium agreement). At the same time, however, some RE technologies can have technology- and location-specific adverse side effects.
- **Infrastructure and integration challenges vary by RE technology and the characteristics of the existing background energy system** (medium evidence, medium agreement). Operating experience and studies of medium to high penetrations of RE indicate that these issues can be managed with various technical and institutional tools. As RE penetrations increase, such issues are more challenging, must be carefully considered in energy supply planning and operations to ensure reliable energy supply, and may result in higher costs.
- **Nuclear energy is a mature low-GHG emission source of baseload power, but its share of global electricity generation has been declining (since 1993). Nuclear energy could make an increasing contribution to low-carbon energy supply, but a variety of barriers and risks exist** (robust evidence, high agreement).
- **Barriers to and risks associated with an increasing use of nuclear energy include operational risks and the associated safety concerns, uranium mining risks, financial and regulatory risks, unresolved waste management issues, nuclear weapon proliferation concerns, and adverse public opinion** (robust evidence, high agreement).
- **Carbon dioxide capture and storage technologies could reduce the lifecycle GHG emissions of fossil fuel power plants** (medium evidence, medium agreement). While all components of integrated CCS systems exist and are in use today by the fossil fuel extraction and refining industry, CCS has not yet been applied at scale to a large, commercial fossil fuel power plant. A variety of pilot and demonstrations projects have led to critical advances in the knowledge of CCS systems and related engineering, technical, economic and policy issues.
- **Barriers to large-scale deployment of CCS technologies include concerns about the operational safety and long-term integrity of CO2 storage as well as transport risks** (limited evidence, medium agreement).
- **GHG emissions from energy supply can be reduced significantly by replacing current world average coal-fired power plants with modern, highly efficient natural gas combined-cycle (NGCC) power plants or combined heat and power (CHP) plants, provided that natural gas is available and the fugitive emissions associated with its extraction and supply are low or mitigated** (robust evidence, high agreement).

- **Renewable energy technologies are part of the solution… but come with some challenges.**
- **Nuclear energy could also be part of the solution… but comes with some challenges.**
- **Carbon capture and storage could become part of the solution… but is still very uncertain.**
- **Replacing coal with gas in power generation can reduce emissions (if…).**

Key messages from AR5 ch7 on energy systems (3/3)

- **Greenhouse** gas emission trading and GHG taxes have been enacted to address **the market exte**rnalities associated with GHG emissions (high evidence, high agreement).
- **The success** of energy policies depends on capacity building, the removal of f**inancial barriers, th**e development of a solid legal framework, and sufficient regulator**y stability** (robust evidence, high agreement).
- **The energy** infrastructure in developing countries, especially in Least Develop**ed Countries** (LDCs), is still undeveloped and not diversified (robust evidence, high agreement).

- **Some policies have been implemented with some successes.**
- **More policies are needed.**
- **Governance and finance are key.**
- **Development needs should not be forgotten.**

What is missing?

- How are the key words from the program of this week treated?

macroeconomy/ macroeconomic	materials	history of energy transitions	decentralization
stock-flow	grid stability		governance
finance	energy storage		commons
			inequalities

macroeconomy/ macroeconomic	1 occurrence of « macroeconomy » in the whole 1494 pages!/macroeconomic appears often [mainly « macroeconomic costs » or « macroeconomic context »]
stock-flow	0 occurrence [but a number of the models used are in fact stock-flow consistent],
finance	treated in short (3/4 page) section « **7.10.2 Financial and investment barriers and Opportunities »** [but also a dedicated chapter 16]

materials	a short section in Chapter 7
grid stability	0 occurrence [but treated under section « 7.6.1.1 System balancing — flexible generation and loads », with 42 references cited]
energy storage	2 paragraphs

Materials

- Competition for land and other resources among different **RE sources** may impact aggregate technical potentials, as might concerns about the carbon footprint and sustainability of the resource (e. g., biomass) as well as materials demands (cf. Annex Bioenergy in Chapter 11; de Vries et al., 2007; Kleijn and van der Voet, 2010; Graedel, 2011).
- Wind, ocean, and CSP need more iron and cement than fossil fuel fired power plants, while photovoltaic power relies on a range of scarce materials (Burkhardt et al., 2011; Graedel, 2011; Kleijn et al., 2011; Arvesen and Hertwich, 2011). Furthermore, mining and material processing is associated with environmental impacts (Norgate et al., 2007), which make a substantial contribution to the total life-cycle impacts of renewable power systems. There has been a significant concern about the availability of critical metals and the environmental impacts associated with their production. Silver, tellurium, indium, and gallium have been identified as metals potentially constraining the choice of PV technology, but not presenting a fundamental obstacle to PV deployment (Graedel, 2011; Zuser and Rechberger, 2011; Fthenakis and Anctil, 2013; Ravikumar and Malghan, 2013). Silver is also a concern for CSP (Pihl et al., 2012). The limited availability of rare earth elements used to construct powerful permanent magnets, especially dysprosium and neodymium, may limit the application of efficient direct-drive wind turbines (Hoenderdaal et al., 2013). Recycling is necessary to ensure the long-term supply of critical metals and may also reduce environmental impacts compared to virgin materials (Anctil and Fthenakis, 2013; Binnemans et al., 2013). With improvements in the performance of renewable energy systems in recent years, their specific material demand and environmental impacts have also declined (Arvesen and Hertwich, 2011; Caduff et al., 2012).
- [15 references]

Energy storage

- Energy storage might play an increasing role in the field of system balancing (Zafirakis et al., 2013). Today pumped hydro storage is the only widely deployed storage technology (Kanakasabapathy, 2013). Other storage technologies including compressed air energy storage (CAES) and batteries may be deployed at greater scale within centralized power systems in the future (Pickard et al., 2009a; b; Roberts and Sandberg, 2011), and the latter can be decentralized. These short-term storage resources can be used to compensate the day-night cycle of solar and short-term fluctuation of wind power (Denholm and Sioshansi, 2009; Chen et al., 2009; Loisel et al., 2010; Beaudin et al., 2010). With the exception of pumped hydro storage, full (levelized) storage costs are still high, but storage costs are expected to decline with technology development (IEA, 2009b; Deane et al., 2010; Dunn et al., 2011; EIA, 2012). 'Power to heat' and 'power to gas' (H2 or methane) technologies might allow for translating surplus renewable electricity into other useful final energy forms (see Sections 7.6.2 and 7.6.3).
- The addition of significant plants with low capacity credit can lead to the need for a higher planning-reserve margin (defined as the ratio of the sum of the nameplate capacity of all generation to peak demand) to ensure the same degree of system reliability. If specifically tied to RE generation, energy storage can increase the capacity credit of that source; for example, the capacity credit of CSP with thermal storage is greater than without thermal storage (Madaeni et al., 2011).
- [13 references]

history of energy transitions	0 occurrence [history twice, once about the history of EU-ETS, once about the history of energy security concepts]

decentralization	10 times in chapter 7, but also in chapters « Human settlements, infrastructure and spatial planning » and « National and sub-national policies and institutions » (with limited treatment)
governance	5 occurrences in chapter 7, but many occurrences in chapters 12-13-14-15-16
commons	0 occurrences in chapter 7, but some occurrences in chapters 3, 4, 13 and 15 [but only in the phrase « global commons », nothing on local commons] - note: in SPM, « negociations » at General Assembly have relegated the commons concept to a simple footnote
inequalities	0 occurrences in chapter 7, but many in chapters 3 and 4 [but very few in the « policy » chapters]

Remark: also an issue that the treatment of commons and inequalities is separated (in chapters 3 and 4) from that of governance (in chapters 12 to 16).

What is missing?

- How are the key words from the program of this week treated?
- Gaps in knowledge identified in chapter 7

- The diversity of energy statistic and GHG emission accounting methodologies as well as several years delay in the availability of energy statistics data limit reliable descriptions of current and historic energy use and emission data.

- Although fundamental problems in identifying fossil fuel and nuclear resource deposits, the extent of potential carbon storage sites and technical potentials of RE are acknowledged, the development of unified and consistent reporting schemes, the collection of additional field data, and further geological modelling activities could reduce the currently existing uncertainties.

- There is a gap in our knowledge concerning fugitive CH4 emissions as well as adverse environmental side effects associated with the increasing exploitation of unconventional fossil fuels. Operational and supply chain risks of nuclear power plants, the safety of CCS storage sites and adverse side effects of some RE, especially biomass and hydropower, are often highly dependent on the selected technologies and the locational and regulatory context in which they are applied. [illegible] research could, in part, reduce the associated knowledge gaps.

- There is limited research on the integration issues associated with high levels of low-carbon technology utilization.

- Knowledge gaps pertain to the regional and local impacts of climate change on the technical potential for renewable energy and appropriate adaptation, design, and operational strategies to minimize the impact of climate change on energy infrastructure.

- The current literature provides a limited number of comprehensive studies on the economic, environmental, social, and cultural implications that are associated with low-carbon emission paths. Especially, there is a lack of consistent and comprehensive global surveys concerning the current cost of sourcing and using unconventional fossil fuels, RE, nuclear power, and the expected ones for CCS and BECCS. In addition, there is a lack of globally comprehensive assessments of the external cost of energy supply and GHG related mitigation options.

- Integrated decision making requires further development of energy market models as well as integrated assessment modelling frameworks, accounting for the range of possible cobenefits and tradeoff between different policies in the energy sector that tackle energy access, energy security, and / or environmental concerns.

- Research on the effectiveness and cost-efficiency of climate related energy policies and especially concerning their interaction with other policies in the energy sector is limited.

- **Data (energy, emissions statistics)**
- **Uncertainties in carbon storage sites potential**
- **Uncertainties in fugitive CH4 emissions**
- **Some risks associated with [nuclear/CCS/biomass/hydropower] hard to quantify**
- **Integration of high-levels of renewable energy**
- **Impacts of climate change on renewable energy potentials**
- **Globally comprehensive assessment of external cost of energy supply options**
- **Co-benefits and trade-offs, effectiveness and cost-efficiency of energy policies**
- **Interactions with other policies**

What is missing?

- How are the key words from the program of this week treated?
- Gaps in knowledge identified in chapter 7
- Other Gaps:
  - Life-cycle assessment and material flow analysis?
  - Cross-sectoral issues, systemic issues?
  - Energy-growth-development nexus?
  - Social sciences relevant to energy-demand behaviors and policies?

Will AR6 be better?

The Sixth Assessment cycle*

Special Reports	**October 2018**	Global warming of 1.5° C An IPCC special report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty
	August 2019	Climate Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems
	September 2019	Special Report on the Ocean and Cryosphere in a Changing Climate
Methodology Report	**May 2019**	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Sixth Assessment Report	**April 2021**	Working Group I contribution The physical science basis
	July 2021	Working Group III contribution Mitigation of climate change
	October 2021	Working Group II contribution Impacts, adaptation and vulnerability
	April 2022	Synthesis Report

Chapter outline of the Working Group III contribution to the IPCC Sixth Assessment Report (AR6)

1. Introduction and Framing

2. Emissions trends and drivers

3. Mitigation pathways compatible with long-term goals

4. Mitigation and development pathways in the near- to mid-term

5. Demand, services and social aspects of mitigation

6. Energy systems

7. Agriculture, Forestry, and Other Land Uses (AFOLU)

8. Urban systems and other settlements

9. Buildings

10. Transport

11. Industry

12. Cross sectoral perspectives

13. National and sub-national policies and institutions

14. International cooperation

15. Investment and finance

16. Innovation, technology development and transfer

17. Accelerating the transition in the context of sustainable development

Chapter 6: Energy systems

- Energy services, energy systems and energy sector, integrations with other systems (including food supply system, buildings, transportation, industrial systems)
- Energy resources (fossil and non-fossil) and their regional distribution
- Global and regional new trends and drivers
- Policies and measures and other regulatory frameworks; and supply and demand systems
- Fugitive emissions and non-CO2 emissions
- Global and regional new trends for electricity and low carbon energy supply systems, including deployment and cost aspects.
- Smart energy systems, decentralized systems and the integration of the supply and demand
- Energy efficiency technologies and measures
- Mitigation options (including CCS), practices and behavioral aspects (including public perception and social acceptance)
- Interconnection, storage, infrastructure and lock-in
- The role of energy systems in long-term mitigation pathways
- Bridging long-term targets with short and mid-term policies
- Sectoral policies and goals (including feed-in tariffs, renewables obligations and others)
- Mainstreaming climate into energy policy

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5. Demand, services and social aspects of mitigation

- Sharing economy, collaborative consumption, community energy

6. Energy systems

7. Agriculture, Forestry, and Other Land Uses (AFOLU)

- Provision of food, feed, fibre, wood, biomass for energy, and other ecosystem services and resources from land, including interactions in the context of mitigation strategies and pathways

8. Urban systems and other settlements

9. Buildings

- Access to sector specific services (e.g. affordability, energy poverty)

10. Transport

- Systemic interactions (e.g. energy sector, urban) and insights from life cycle assessment and material flow analysis

11. Industry

12. Cross sectoral perspectives

13. National and sub-national policies and institutions

14. International cooperation

15. Investment and finance

16. Innovation, technology development and transfer

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Concluding remarks: Some remaining gaps?

- Beyond FAQ for communication?
  - FAQ 7.1 How much does the energy supply sector contribute to the GHG emissions?
  - FAQ 7.2 What are the main mitigation options in the energy supply sector?
  - FAQ 7.3 What barriers need to be overcome in the energy supply sector to enable a transformation to low-GHG emissions?
- Limits of SPM for communication (all the more as some elements do not make it to the SPM – eg. regional disagregation of emissions trends, policy evaluations)?
- …

Thank you for your attention!
… and your questions?

The energy of IPCC…
….or the IPCC of energy

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