Design to Win Contextual Update

Completed April 2013

CEA California Environmental Associates

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ABOUT THIS REPORT

About this report

In 2007, several foundations sponsored Design to Win (DTW), a study on the role of philanthropy in the fight against climate change. DTW was instrumental in identifying the need for a coordinated global response to "win" in the battle against climate change, and helped spur philanthropic investment on the issue. The report defined a "win" of stabilizing global emissions at 450 ppm or 2° C, and identified the top priority policies, sectors, and geographies for avoiding dangerous climate change.

In the five years since DTW was released, the climate landscape–both technical and political–has changed with many lessons learned. This report focuses on how our understanding of some of the key *contextual* factors (the science, the emissions trajectories, the technology) that have changed since 2007, and identifies those issues that remain essentially unchanged since the original DTW report was published. This update is intended to be a quick "refresh" of the context of the DTW report, rather than a reexamination of the strategies and efforts that it spurred. Development of recommendations for future philanthropic intervention was outside of the scope of this study.

Sources and methodology

This report was compiled over a period of two months from February-March 2013, based on a synthesis of readily available data, supported by a small number of expect interviews.

In total, approximately thirty climate change experts were interviewed, selected in order to cover a range of key geographies(e.g., U.S., EU, China) and topics (e.g., science, policy, communications, industry, transport). The interviewees represent a wide variety of organizations, including NGOs, foundations, universities, multilaterals, think tanks, and consultants.

Although we have made our best efforts to compile a representative set of interviewees, It is important to note that given the wide breadth of geographies and sectors, the findings from the interviews, in some cases, reflect the thoughts of a small number of people. While we did not encounter any wide divergence of opinions, our impressions have been shaped by an by an insufficient number of interviews to draw certain conclusions. All interviewees were provided opportunity to review and comment on our findings; we have incorporated their comments to the extent practicable.

In order to maintain the confidentiality of those who participated in this process, we have neither attributed quotes nor included a list of interviewees.

SUMMARY

DTW contextual changes: overview

Emissions

- **High emissions:** In the last 7 years, global emissions have been tracking the most aggressive emissions projections from 2006. Along our current trajectory, we are on track to reach around 950 ppm by 2100, which is associated with a 4-6 degree Celsius temperature jump.
- **Abandoning 450:** 450 ppm is not a politically achievable target, even if it continues to be the correct framing. The International Energy Agency (IEA) estimates that infrastructure lock in for 450 ppm will occur in 4 years. 3 degrees may be a new, ambitious target.
- **Carbon budgets:** Conversation has shifted from emissions pathways to an overall carbon budget. The accepted carbon budget for 2 degrees is 1 trillion tons of carbon, of which half has already been emitted. The proven reserves of economically viable fossil fuels are now 40% larger than the remaining carbon budget, and total reserves are several times larger. A peak oil mentality no longer applies. "The climate change problem is a *stock* problem, not a *rate* problem. Because it's the *stock* of millennium-lived CO_2 that dominates the equation, which doesn't drain out of the biosphere at any meaningful rate—we can't dial back incrementally in *rate.*"

Science

- **Temperature rise has been flat, but other physical effects are in evidence:** Temperature rise is currently within the range of predictions of the Intergovernmental Panel on Climate Change (IPCC) , it has been flat in the past decade and observed changes may soon fall outside of the confidence intervals of the climate models. The reasons for this deviation are unclear, but there is still near consensus that background global warming is continuing. Nevertheless, IPCC Assessment Report 4 (AR4) projections were too optimistic[1] for several categories of impacts including Arctic sea ice, sea level rise, changes in hydrologic cycles, etc.
- **Effects on human and ecological systems will be worse than anticipated:** Our understanding of the severity of human impacts has also shifted: impacts from 2 degrees above preindustrial temperatures are expected to be worse than previously thought (e.g. impacts on crops, coastal infrastructure, ocean acidification, etc). While there is much greater uncertainty, impacts from 4-6 degrees will be more than double those from 2 degrees.
- **Continued uncertainty:** Climate model certainty around temperature has not increased despite advances in the science and computing power. Similarly, the error bars associated with some other types of impacts (e.g. extreme weather, glaciations) have actually widened, increasing concern over tail risks.

1. There was great uncertainty in the science for many of the predictions which prevented the committee from making clear assessments

DTW contextual changes: overview

Geopolitics

- **Failure of multilateralism:** The most obvious change in the geopolitical landscape since 2007 is the lack of success at Copenhagen. Interviewees suggested that the DTW hopes and expectations for an international deal were based on a widespread belief in the viability of international cooperation, which in hindsight proved to be unfounded. This has shifted the international agenda to smaller group discussions (e.g., G8, G20, Major Economies Forum (MEF), bilateral arrangements).
- **A major shift in the global economy:** Increasing growth in the developing world, particularly China, was faster than anticipated and offset the economic declines in the developed world. Since 2007, the global economy, economic growth, and carbon emissions are now much more tied to Asia than we thought they would be six years ago. In tandem, the notion that the West will lead by example and transfer technology solutions to the East is a less compelling model than it was.
- **Chinese ascendancy:** Chinese economic growth has reshaped the global emissions map for the worse, but Chinese internal leadership on energy and climate is one of the most significant bright spots in the overall picture since 2007. Rising awareness around air quality and energy security is helping to promote action in China. China is also playing an increasingly important role on the technology development front.
- **Recession in the US:** The economic situation in the U.S. has shifted the dynamic for both better and worse. The Recession has dampened the U.S. emissions trajectory and injected some money to mitigation through the American Recovery and Reinvestment Act (ARRA), but also shifted the discussion to deficits. The sputtering economy has also impacted the budgets of philanthropic organizations focused on climate change efforts.

DTW contextual changes: overview

Geopolitics

- **The politicization of climate in the US:** Politics and public opinion in the United States have soured dramatically since DTW. Climate is now a litmus test for the right wing, crushing any hopes of comprehensive climate legislation. Public opinion on climate has also taken a hit since the high water mark in 2007. The advocacy landscape in the US is now increasingly occupied fighting coal infrastructure, as well as with state-based fights on Renewable Portfolio Standards (RPS) and efficiency, and the challenge of crafting a strategy to build long-term political power.
- **Europe:** The European Union (EU) continues to lead on climate and is on track to meet its mitigation targets, but the strength of top-down leadership has flagged in the wake of the economic downturn, and efforts to increase the reduction targets from 20% to 30% have not gained traction.
- **India**: The conversation about climate in India is still tied up with international equity issues, but there has been some progress on national climate policy through the adoption of a development co-benefits lens.
- **Latin America**: Brazil and Mexico have adopted stronger leadership roles. In 2007, Brazil and Mexico were firmly ensconced in their position as non-Annex 1 countries, with Brazil strongly advocating that the global South lacked any climate obligations. In the lead up to Copenhagen, these countries substantially altered their position for the better, with both making emissions reduction commitments.

DTW contextual changes: overview

Sectors

The original DTW sectors and geographies appear to hold: "At some high level, nothing important has changed."

- **Power** – Growth in electricity demand has been even greater and more concentrated in the developing world than expected. Forecasts for renewables and natural gas have increased, but have yet to drastically shift the expected future generation mix. China is beginning to take a leadership position in renewables, but overall growth in electricity demand is outweighing this impressive progress and new coal generation is still being built at an alarming rate in China and the rest of the developing world. China accounts for 25% of total electricity capacity additions between now and 2035; India accounts for an additional 11%. China accounts for two-thirds of the anticipated increase in coal generation through 2035.
  - **Coal** – Forecasts for coal as a share of global electricity generation are only slightly lower than previous estimates despite progress in North America; coal is still expected to dominate generation in the future.
  - **Natural Gas** – In regions where fracking is taking off, natural gas is displacing coal as the most cost-effective generation source. This is mostly a US phenomenon, and in the short term, natural gas is not expected to radically shift the generation mix in China or other parts of the world. In the longer term, however, unconventional gas resources will have larger impacts on electricity generation in other parts of the world.
  - **Carbon Capture and Sequestration (CCS)** – Wider uptake of CCS has been disappointingly elusive, and has lost political and industry support without a carbon price. There is some progress in China on CCS combined with enhanced oil recovery (EOR), but wider adoption will require substantial policy support.
  - **Nuclear** – Despite Fukushima, forecasted nuclear development has not changed substantially. Nuclear's anticipated share of generation has declined, but forecasts for total megawatt hours (MWh) of production have remained steady. Some countries are scaling back nuclear (e.g., Germany), but growth in Asia appears to be resilient to the changing political climate for nuclear.
  - **Wind and Solar** – Deployment of wind has been much faster than expected, driven by policy and technological improvements. Similarly, strong policy support and technological improvements for photovoltaic (PV) solar have led to capacity outpacing forecasts and declining costs. China is emerging as a leader in renewable generation and as a developer and manufacturer of renewable technologies. However, the overall share of both wind and solar in global electricity production is forecasted to remain quite low.
  - **Efficiency –** Recognition of the potential of energy efficiency as a cost-effective means for meeting electricity demand has grown, especially in the U.S. Growth in rate-payer funded efficiency programs has been a bright spot.

DTW contextual changes: overview

Sectors (continued)

- **Industry:** There have been very few surprises in the industrial sector, which remains more or less on a business as usual (BAU) trajectory. Chemicals, iron and steel, and cement are the critical industries from an emissions perspective, and efficiency improvements have been incremental. Applying best available technologies across these industries would result in substantial emissions savings, but there are major barriers to retrofitting existing stock and current policies and incentives have not been sufficient to overcome them and rapidly increase adoption.
- **Transportation:** The transportation sector also continues on a business as usual trajectory. Important wins, such as fuel economy standards in the U.S. and Europe, and the recent downturn in vehicle miles travelled in member countries of the Organization for Economic Cooperation and Development (OECD), have been overshadowed by continued growth in the developing world, surprisingly high vehicle ownership in China, longer than expected vehicle turnover rates, and the shift toward emissions from more heavy-duty vehicles.
- **Buildings:** There have been substantial improvements in building codes in both the developed and developing world, but rapid progress on overall energy efficiency has remained elusive. While the U.S. has made surprising headway in modifying building codes, we have yet to take on the challenge of retrofitting existing building stock in a meaningful way. Even large-scale retrofit programs (e.g. ARRA) have not delivered change at the necessary scale. In terms of new buildings, the vast majority will be in the developing world: in the next two decades, China alone will build as much new building floorspace as there is in the entire U.S. While countries like China and India have made progress in changing their building standards as well, compliance with codes remains a persistent challenge. Appliance standards have been a bright spot in both the developed and developing world, and experts suggest that these standards could be pushed further.
- **Forestry and Agriculture:** Surprisingly good progress in Brazil, matched by continued disappointments in Indonesia and concern over the Congo. Expectations of carbon market funding have been partly replaced with public funds, and The United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) has continued to mature. In agriculture, continuing improvements in yield efficiency have been offset by the expansion of agriculture and increasing commodity prices globally.

DTW contextual changes: what did DTW not address?

Alternatives to the mitigation policy focus adopted by DTW[1]

- **The DTW country and sector mix was essentially right:** Interviewees felt that DTW's initial identification of key geographies and sectors was essentially correct. The analysis of where the tons are has not changed substantially. Similarly, interviewees did not take much issue with the particular wedges or policies that DTW focused on, though many of those policies (e.g., cap-and-trade or a global carbon market) have not come to fruition and some argue that DTW did not pay enough attention to soot and short term forcers. This omission was likely a conscious choice due to the large scientific uncertainty surrounding these short-term forcers and the need to limit the scope of the project. Most of the critiques we have heard so far have centered on the fact that DTW was largely a policy and technocratic analysis which centered on *what* was needed, and less on *how* to achieve it.
- **Behavioral change?** Given the huge challenge in stabilizing emissions, there is increasing discussion about the need to encourage mass behavioral change. DTW did not focus on the social/demand side of the equation (e.g., efforts to change diets, reduce consumption, change transportation preferences, virtualize travel, etc.), placing it into the "unknown" mitigation category. There are considerable challenges in realizing large-scale changes people's behavior.
- **Long-term technical solutions?** The potential receptivity to geoengineering has grown substantially since 2007. There is concern that it could be advanced unilaterally by rogue states, and a desire to make sure that "bad" geoengineering doesn't occur. Some "geoengineering" efforts are clear win-wins (e.g., white roofs or reforestation), while others are clear losers: either way, there is increasing receptivity to exploring geoengineering options. "I don't think all resistance in the US or overseas to climate policy is know-nothingism and corporate hackery (although a lot of it is). There is a correct perception by many of our opponents that the green and philanthropic climate agenda is largely tied to jamming in efficiency, existing intermittent renewables, killing coal in the US, and maybe a little bit of forest protection. Dealing with fossil CCS, nuclear, or energy innovation is generally not discussed in polite green company and geoengineering is completely taboo."

1. ClimateWorks sought to turn DTW into a political strategy, but DTW itself was not a complete assessment of how to do that.

DTW contextual changes: what did DTW not address?

Alternatives to the mitigation policy focus adopted by DTW[1] (continued)

- **Adaptation?** Adaptation was not a focus of the DTW scope or recommendations. While it is not clear that investing in adaptation will improve the political dynamics of mitigation work, there is increasing emphasis on talking about adaptation out of the necessity of minimizing climate impacts.
- **Long-term political capacity?** DTW has been criticized for focusing on the near term policy priorities (e.g., cap and trade in the US) at the expense of a longer term focus on building power to sustain a protracted fight. The "First, Don't Lose" framing in some ways precludes longer term investments in capacity building (e.g., building forestry capacity in the Congo) and in creating an "issue public" on climate issues (e.g. in the U.S.). Although main conclusions of the DTW report stated that philanthropy must be willing to make a long-term commitment to fighting climate change, and that there was a need to build national level capacity, the "First, Don't Lose" mantra seems to have had a lasting impression amongst interviewees. The report did not anticipate the political backlash against climate in the US and elsewhere, and thus did not recommend bolstering against it. Some have voiced concern that DTW's 450 ppm target and an agreement at Copenhagen were never achievable goals, and that effort should have been invested in other areas. Despite the lack of progress in establishing an overarching, international agreement, there have been many major victories in the last several years. In no small part due to the ClimateWorks model, "there is much greater strength now in the bottom-up, sectoral reform strategy."

1. ClimateWorks sought to turn DTW into a political strategy, but DTW itself was not a complete assessment of how to do that.

DTW contextual changes: the current reality

Overall, there is near-consensus among interviewees that the context is substantially worse than we thought it was in 2007:

- "Hope is important but the fact is that it all adds up to a bleak story for climate. It's important not to let hope color sobriety."
- "I think the situation is really grim. I have to say that I worry a lot more about my kids' future now than I did five years ago. The impacts seem to be getting worse faster and the progress seems to be getting slower."
- "I have never been part of the two degrees club. It is so rhetorical…We are living in some kind of fantasy land. That's why we are going to end up at five degrees rather than three."
- "The overall direction since Copenhagen has been backward. It really has been astounding how much failure of nerve there's been."
- "I think [450] is fantasy and I think has been fantasy for a long time. You can't get there with any real world assumptions. The analyst community has done a real disservice to the policy community. The door shut on 450 a decade ago. The door is basically shut on 550."
- "There are bright spots, but the bright spots in the context of the challenge are not that bright. That doesn't mean that we aren't making any progress."
- "People just assume that because it is an international problem that policy and international coordination will flow from the top. The last few years have shown that's not true. I happen to think that the original vision was always a fantasy."
- "In the last 2-3 years, there has been an enormous amount of soul searching in the environmental movement about how did the Tea Party become more popular than us?"
- "Where we are right now is I think we are saying 'It is too hard.' It's terrible."
- "The prospects for comprehensive climate legislation are essentially zero now."
- Q: What keeps you from wanting to slit your wrists? A: "If I weren't endowed with an optimistic personality, maybe I *would* want to slit my wrists."

DTW contextual changes: bright spots and redefining a path forward

Despite the lack of progress in establishing an overarching, international agreement, there have been many major victories in the last several years. In no small part due to the ClimateWorks model, "there is much greater strength now in the bottom-up, sectoral reform strategy." This progress is occurring in both the developing world and developed world, and in ways that were not fully anticipated in 2007.

The major bright spots raised by interviewees included:

- **China's** increasing commitments around climate and energy policy, including increasing receptivity to addressing air pollution and adopting carbon policies
- **India's** adoption of a National Action Plan on Climate Change and the incorporation of climate co-benefits into its development agenda
- **Brazil's** successes in dramatically reducing deforestation in the Amazon due to a combination of new policies, improved enforcement and a dip in commodity prices
- **Brazil and Mexico's** adoption of national greenhouse gas mitigation targets and associated policies
- The continued leadership of **European** member states in rolling out renewable energy and energy efficiency incentives
- The successful efforts in the **United States** at the state level to increase renewable portfolio standards and to fight new coal infrastructure
- The roll-out of new models for mass transportation infrastructure in **cities** such as Guangzhou and Chennai
- Fuel economy improvements in the **United States** and **China**

For better and worse, the wicked problem of brokering an international deal has been replaced with the broader challenge of making progress at national, regional, and local levels, and in each individual sector. While this piecemeal approach is far more complicated, it is encouraging that some of the biggest successes pointed to in the last five years have been in countries such as China, Brazil and India, and have occurred in the absence of a broader system of international compensation. Similarly, great progress has been made on bilateral and multilateral agreements, which may be just as important as a global accord.

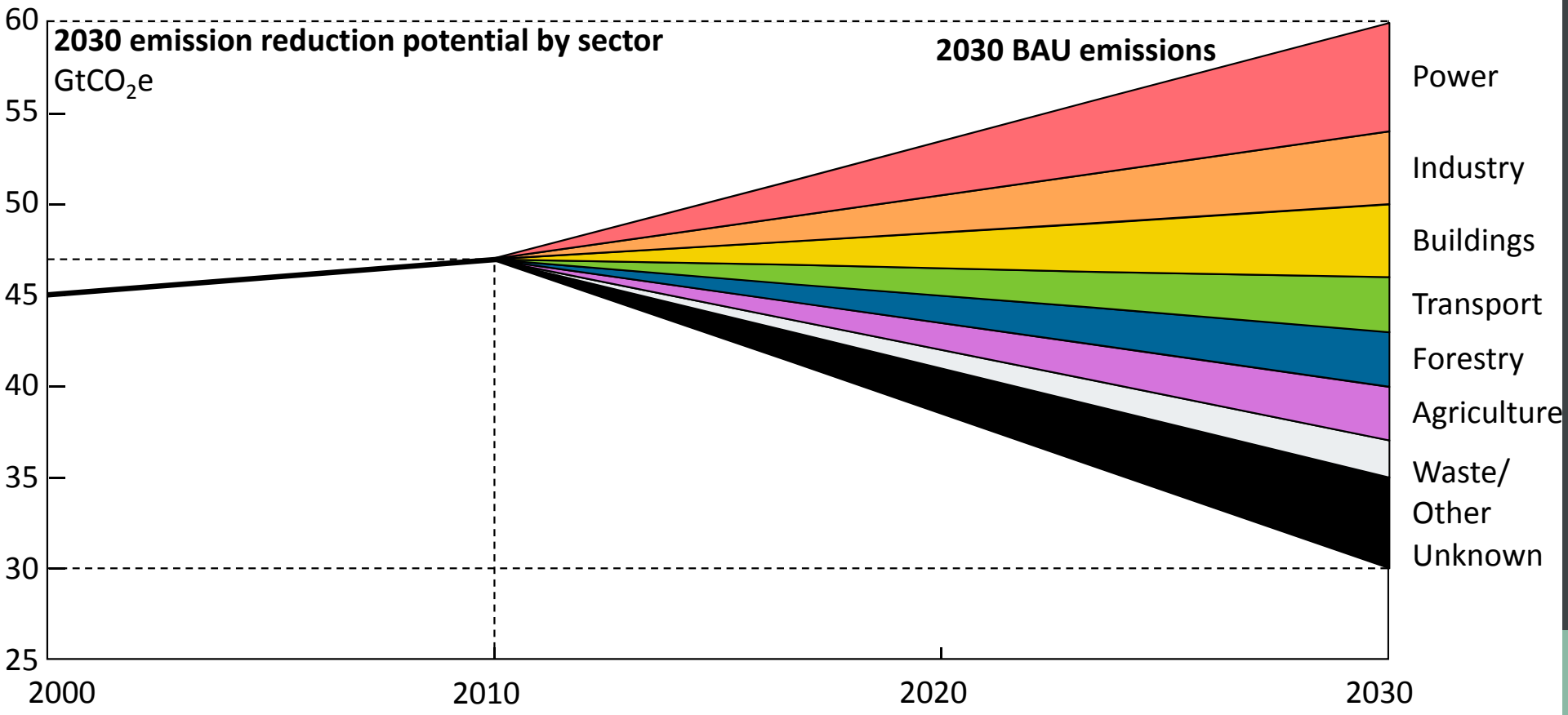
EMISSIONS TRAJECTORY

Emissions Trajectory: main themes

- **Overall emissions trajectory** – Current emissions trajectories are in line with the highest IPCC emissions scenarios. We are on track for 4-6 degrees of warming and the window has essentially closed on a 450 ppm future.
- **Carbon budget** – The conversation has shifted from emissions pathways to an overall carbon budget. The accepted carbon budget for 2 degrees is 1 trillion tons of carbon, of which half has already been emitted.
- **Regional trends** – Increasing growth in the developing world, particularly China, was faster than anticipated and offset declines in the developed world. The epicenter of the climate challenge is now even more definitively centered around the developing world.
- **Sectoral trends –** Overall, the sectors have not significantly deviated from expected BAU emissions. Forestry may be an exception due to progress on deforestation in Brazil, but the overall trajectory of emissions from land-use is not entirely clear.

Design to Win (DTW) projected that global GHG emissions would reach about 60 Gt CO_2e per year under a BAU scenario in 2030

This was based on projections of strong economic growth, and a largely fossil fuel based economy.



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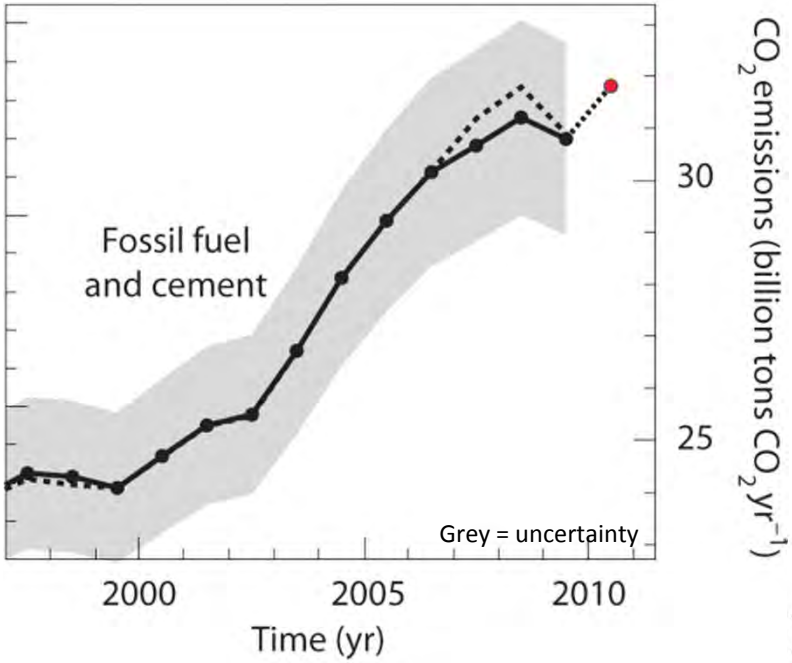
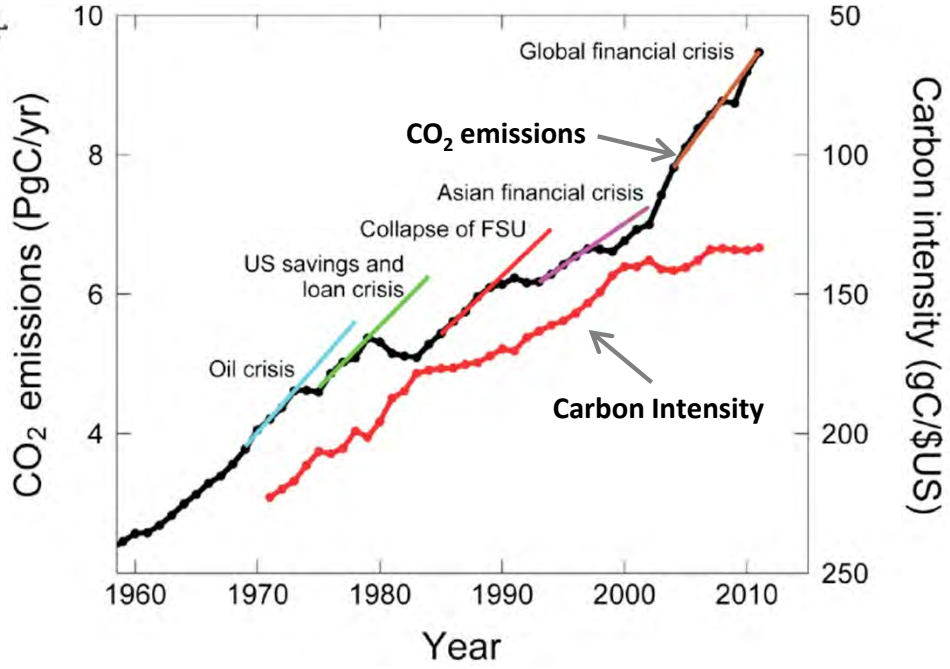
IPCC, 2006. "Fourth assessment report of the Intergovernmental Panel on Climate Change." Pachauri and Reisinger, eds.
US Environmental Protection Agency, 2006. "Global Mitigation of Non-CO2 Greenhouse Gases." EPA 430-R-06-005.

Over the past 5 years, global emissions dipped slightly in 2009 due to the financial crisis; but quickly returned to previous growth levels



- Global CO_2 emissions from fossil fuel burning decreased by 1.3% in 2009 owing to the global financial and economic crisis that started in 2008; this is half the decrease originally anticipated.

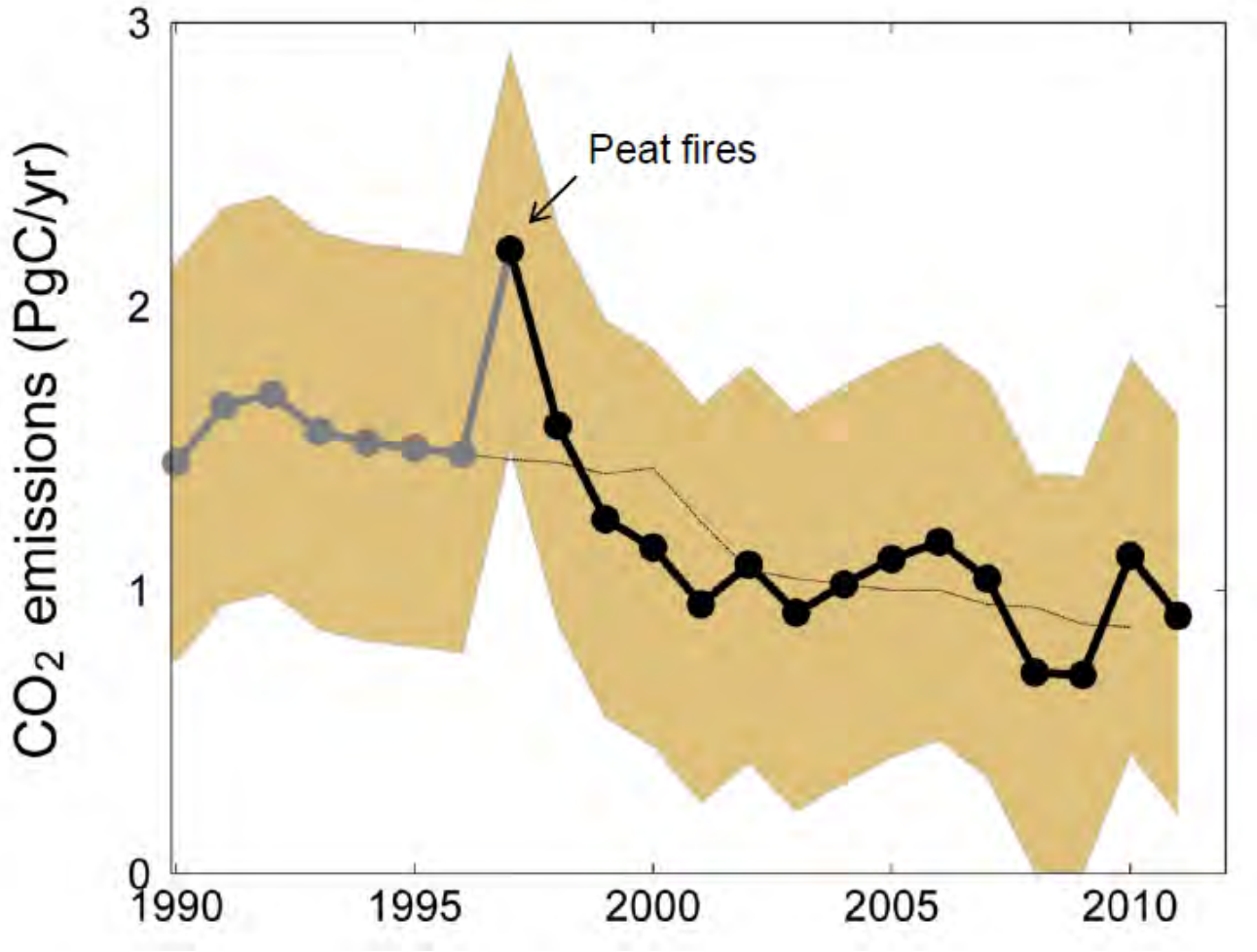
- The financial crisis had no lasting effect on emissions, and carbon intensity has not improved with increased economic activity since 2005



Friedlingstein et al., 2010. "Update on CO2 emissions." Nature Geoscience 3, 810-812 doi:10.1038/ngeo1022.

Global land use change and deforestation emissions have declined compared with the 1990s

This is primarily because of reduced rates of deforestation in the tropics and a smaller contribution from the rest of the world owing to afforestation

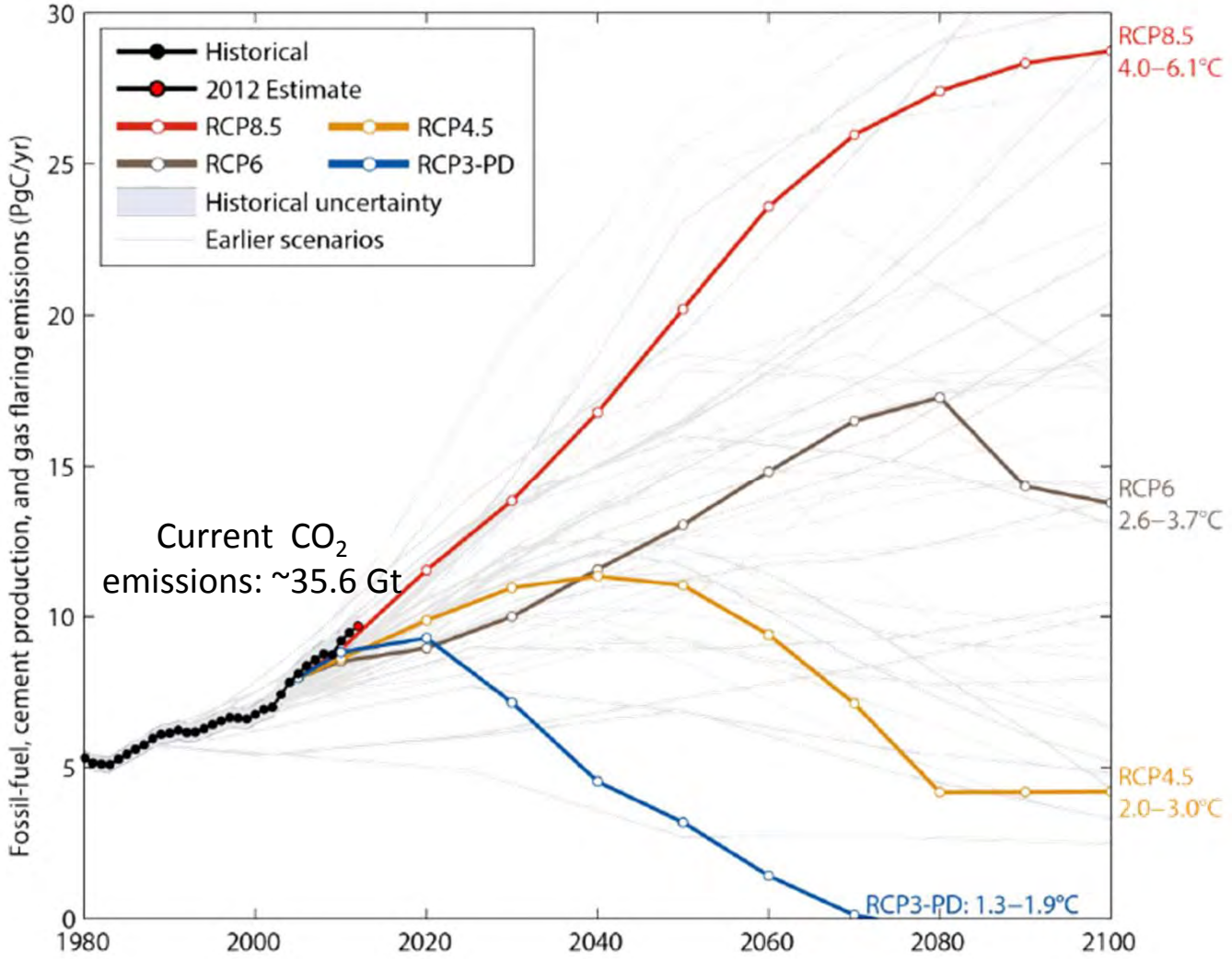


Black line: Includes management-climate interactions;

Thin line: Previous estimate

Global Carbon Project, 2012. "Global carbon budget 2012."

But overall, our current CO_2 emissions have been higher than expected, and are in line with the most aggressive emissions scenarios



Global CO_2 emissions

1 PgC = 3.67 GtCO2

From 1990-2010, the average year-on-year growth rate for CO_2 emissions was 2.0%,[1] higher than the 1.7% projected in IEA's 2006 reference scenario.[2]

Actual emissions and trend are now well above all IPCC mitigation scenarios, and match IPCC scenarios with aggressive growth projections.

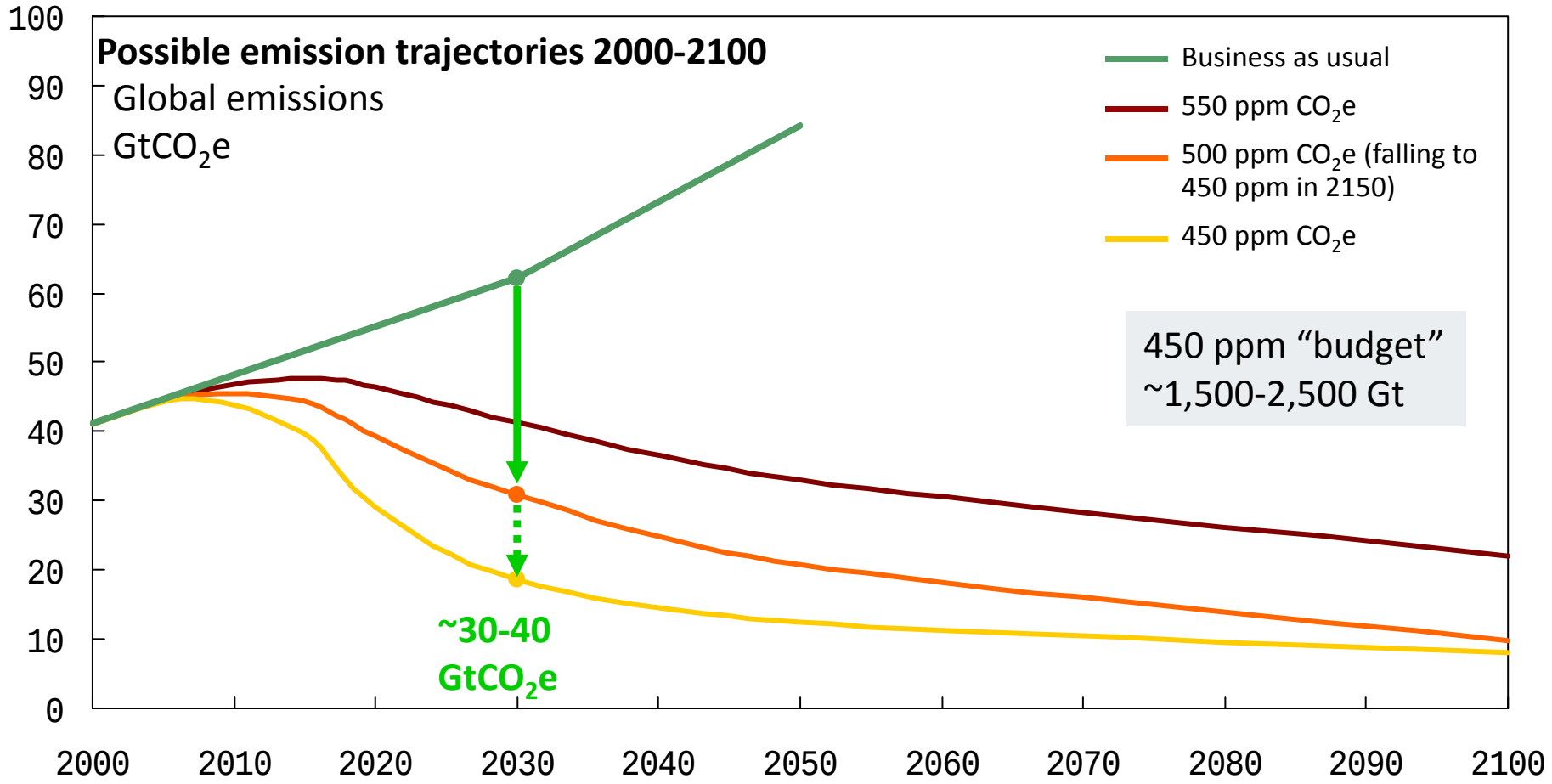
emissions trajectory

CEA California Environmental Associates

1. Peters et al., 2013. "The challenge to keep global warming below 2 degrees." Nature Climate Change 3:4-6 doi:10.1038/nclimate1783.
2. International Energy Agency, 2006. "World energy outlook."

DTW suggested that stabilization <450 ppm CO_2e implied a >30 $GtCO_2e$ annual emissions reduction by 2030 (50% reduction of BAU)

Based on early Socolow, Stern, and IPCC assessments, a 50% reduction in BAU greenhouse gas emissions by 2030 would be sufficient to stabilize climate at 450 ppm or 2 degrees above pre-industrial levels.



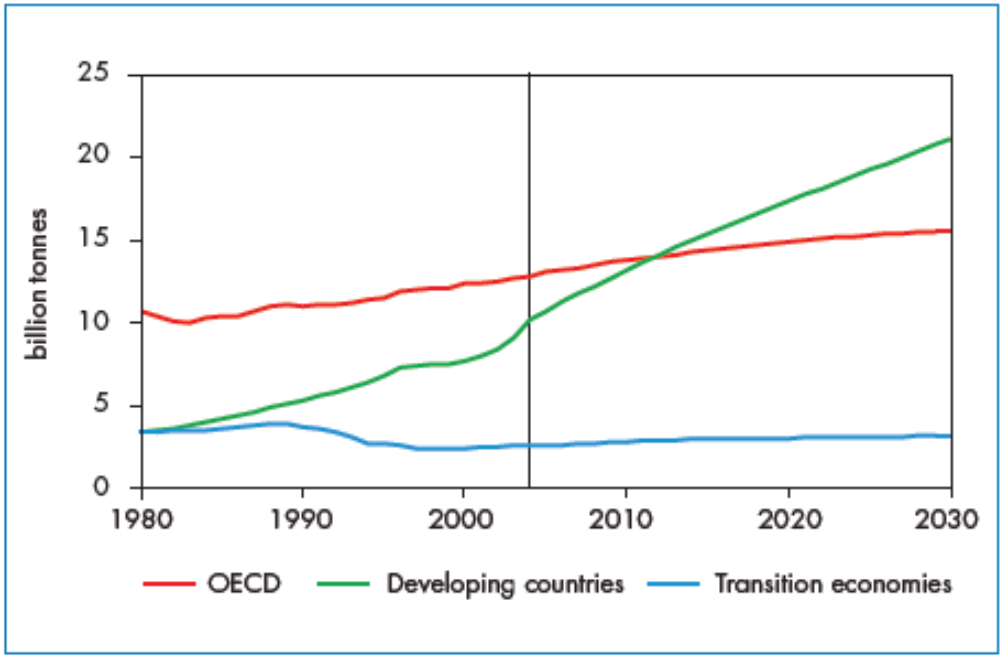
California Environmental Associates, 2007. "Design to Win: Philanthropy's Role in the Fight Against Climate Change"

But, early models were based on several flawed assumptions which provided an overly optimistic picture

- **Growth in emissions has been higher than modeled**
  - For example, the Stern review stabilization scenario assumed only 0.95% yr^{-1} growth in CO_2 emissions growth from 2000-2006; actual growth rate during that period was 2.4%[1]
- **The global peak in emissions is going to occur later than projected**
  - Many early 450 ppm stabilization scenarios modeled that global emissions would peak in 2010; the Stern Review assumed a global peak in 2015-2016 which is unlikely to be born out.[1] Current models predict an emissions peak between 2025 and 2030.[1]

- **Developing country emissions growth has been faster than anticipated**
  - Many early stabilization scenarios assumed that CO2 emissions from fossil fuel combustion of non-Annex 1 countries would exceed those from Annex 1 countries sometime between 2013-2025 (right); this actually occurred in 2006.[1]

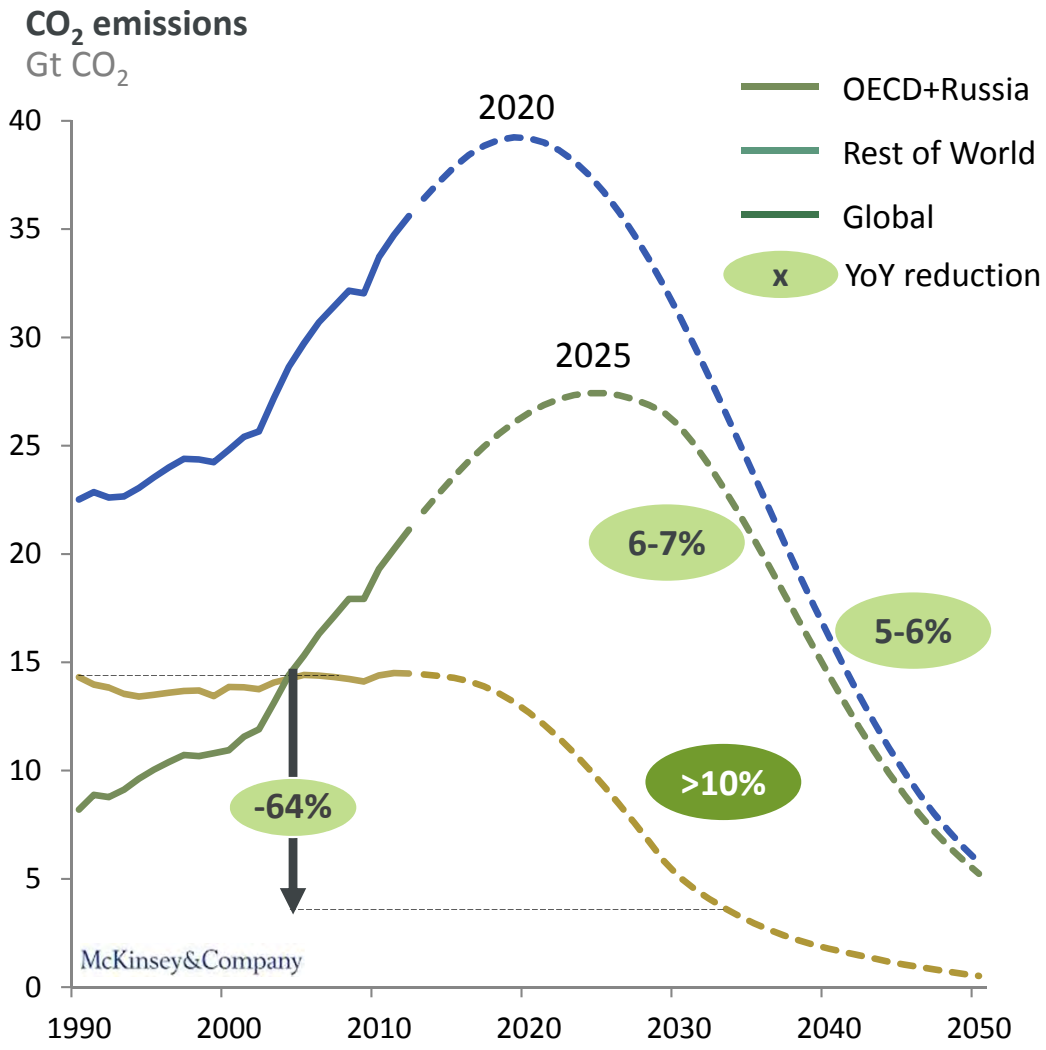
2006 projections of energy-related CO_2 emissions[2]



Note: Excludes emissions from international marine bunkers.

1. Anderson and Bows, 2008. "Reframing the climate change challenge in light of post-2000 emission trends." Phil Trans Royal Soc A 366 (1882): 3863-3882. doi: 10.1098/rsta.2008.0138.
2. International Energy Agency, 2006. "World energy outlook."

Limiting warming to 2° C will require more drastic (and unlikely) reductions than previously predicted



Post-peak rates of emissions reductions are significant and require even larger rates of GDP decarbonization

- Even 1% sustained annual emissions reductions have been historically rare and associated with economic recession or disruption
- Largest recent annual drop (5%) occurred when the economies of the former Soviet Union disintegrated
- Assuming average global GDP growth rate of 3.5% annually, 6-7% annual reduction in emissions **requires ~10% annual reduction in GDP emissions intensity** (and a higher rate in the developed world)

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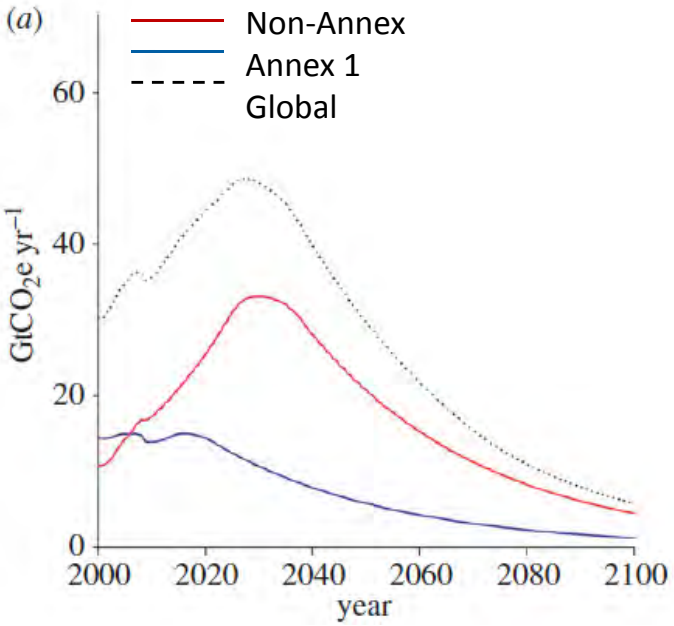
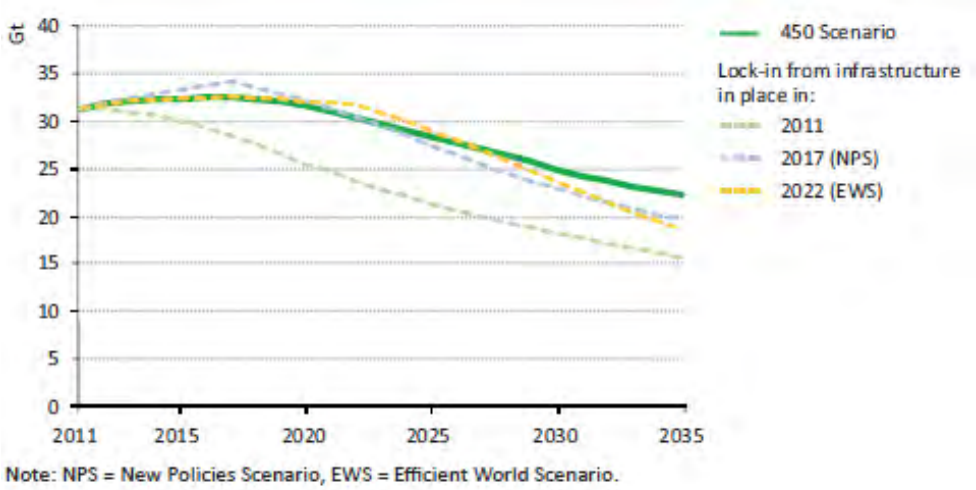
Analysis by McKinsey and Co.; based on Anderson and Bows, 2011. "Beyond 'dangerous' climate change: emission scenarios for a new world." Phil Trans R Soc A. 369. doi: 10.1098/rsta.2010.0290.

The window has essentially closed on 2° C; our current emissions trajectory has an 88-92% likelihood of exceeding 2° C of warming

Current emissions trends put us on track for an emissions peak around 2025-2030, emitting 2,741 $GtCO_2$ by 2100



The IEA estimates that infrastructure lock in for 450 ppm will occur in 4 years



Global energy-related CO_2 emissions from locked in infrastructure

- The emissions trend and forecast above represent an "orthodox" scenario based on recent emissions trajectories and a likely peak in global emissions 2028.
- Under this scenario, models show an 88%-92% chance of exceeding 2° C

Anderson and Bows, 2011. "Beyond 'dangerous' climate change: emission scenarios for a new world." Phil Trans R Soc A. 369. doi: 10.1098/rsta.2010.0290.
International Energy Agency, 2012. "World energy outlook."
IPCC, 2006. "Fourth assessment report of the Intergovernmental Panel on Climate Change." Pachauri and Reisinger, eds.

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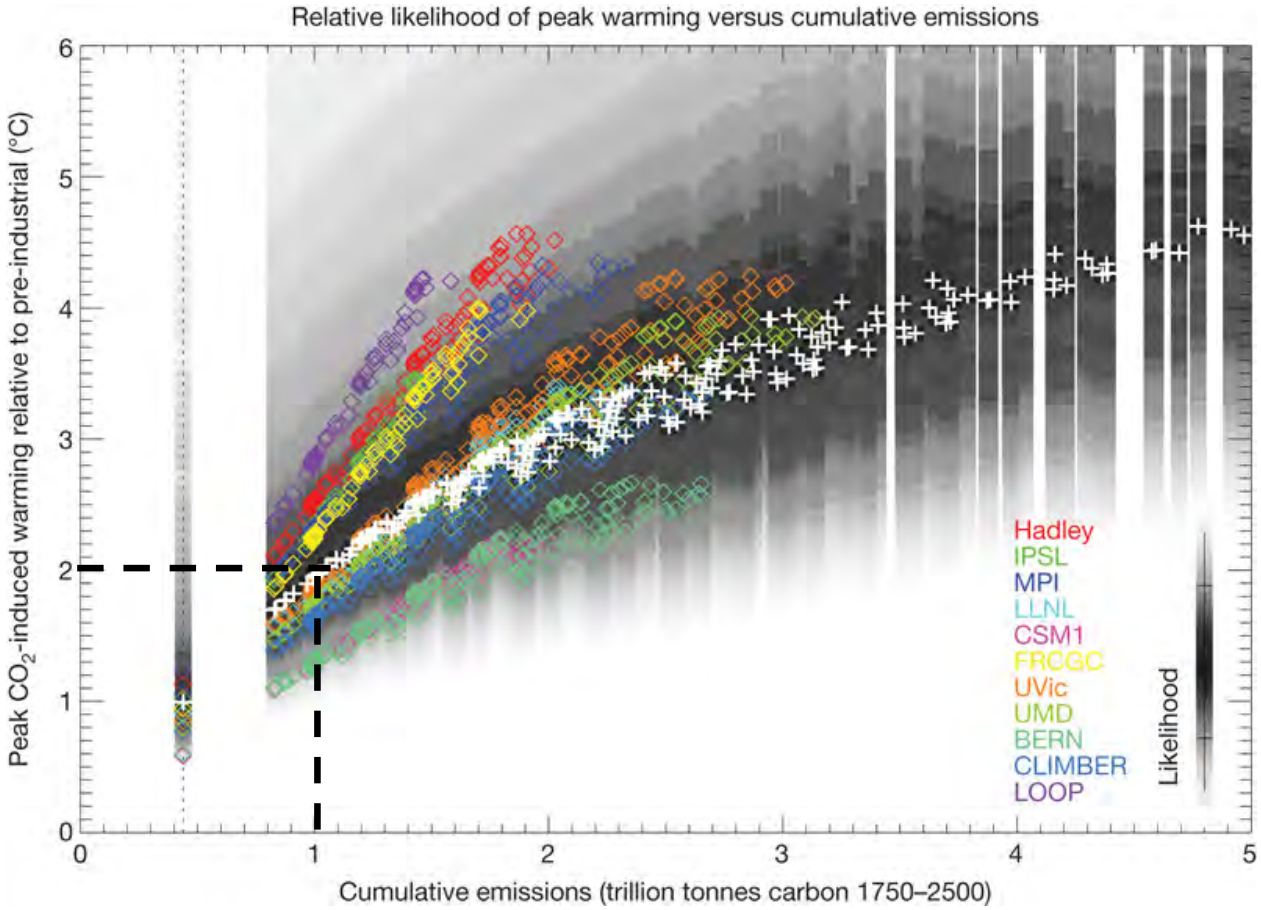
The concept of overall carbon budgets has become more prominent in the climate conversation

To keep warming under 2°C, the limit on cumulative anthropogenic carbon emissions is 1 trillion tons of carbon (3,662 Gt CO_2)



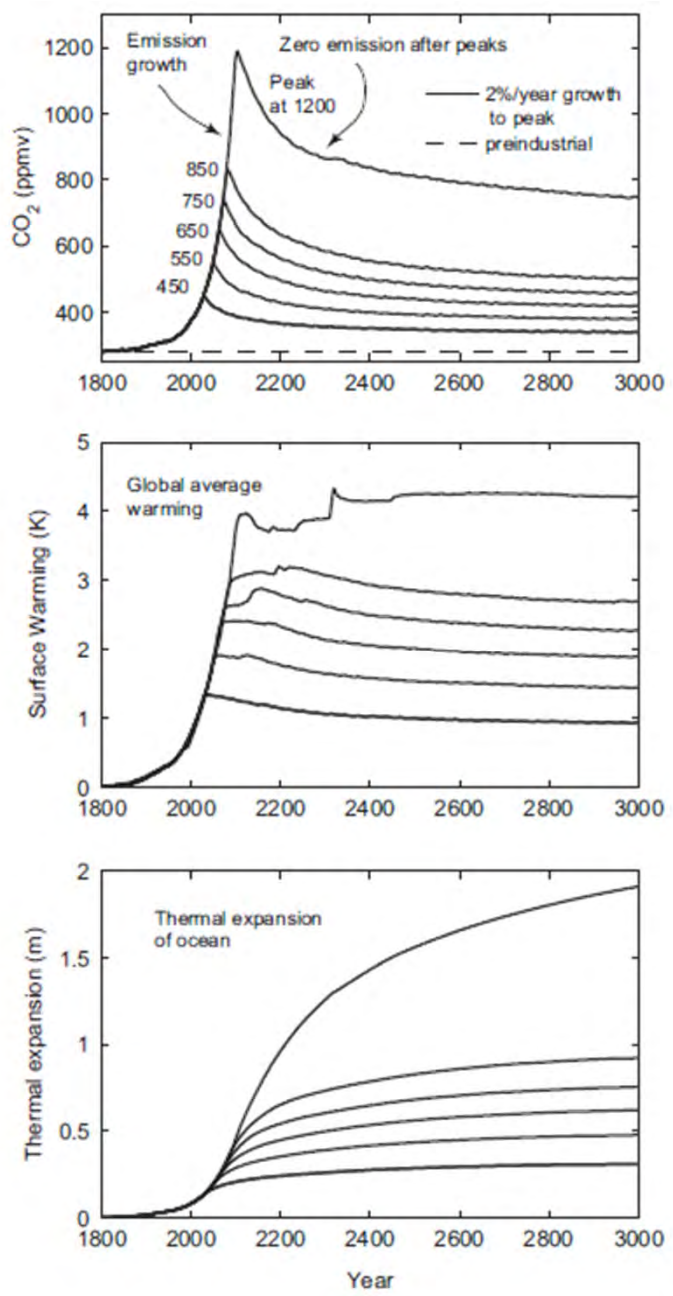
- Cumulative emissions allow for easier correlation to likely impacts because cumulative emissions map more closely to the rate of temperature increase than emissions pathways
- The overall target remains roughly the same: a 50% reduction from BAU emissions (~30 Gt CO2) is still a good indicator of probability of staying within 2° C of warming; scenarios where 2020 global emissions are > 50 Gt CO2 have an 80% chance of going over 2° C.

Allen et al., 2009. "Warming caused by cumulative carbon emissions towards the trillionth tonne." Nature 458, 1163-1166 doi:10.1038/nature08019.

A shifted focus on cumulative emissions highlights that stabilization requires ***zero emissions*** within a matter of decades…

While it not a change in our understanding, several papers in the past few years have reflected the change in framing from emissions trajectories to cumulative emissions; the latter focuses our attention on the long residence time of CO_2 in the atmosphere and associated permanence of impacts.

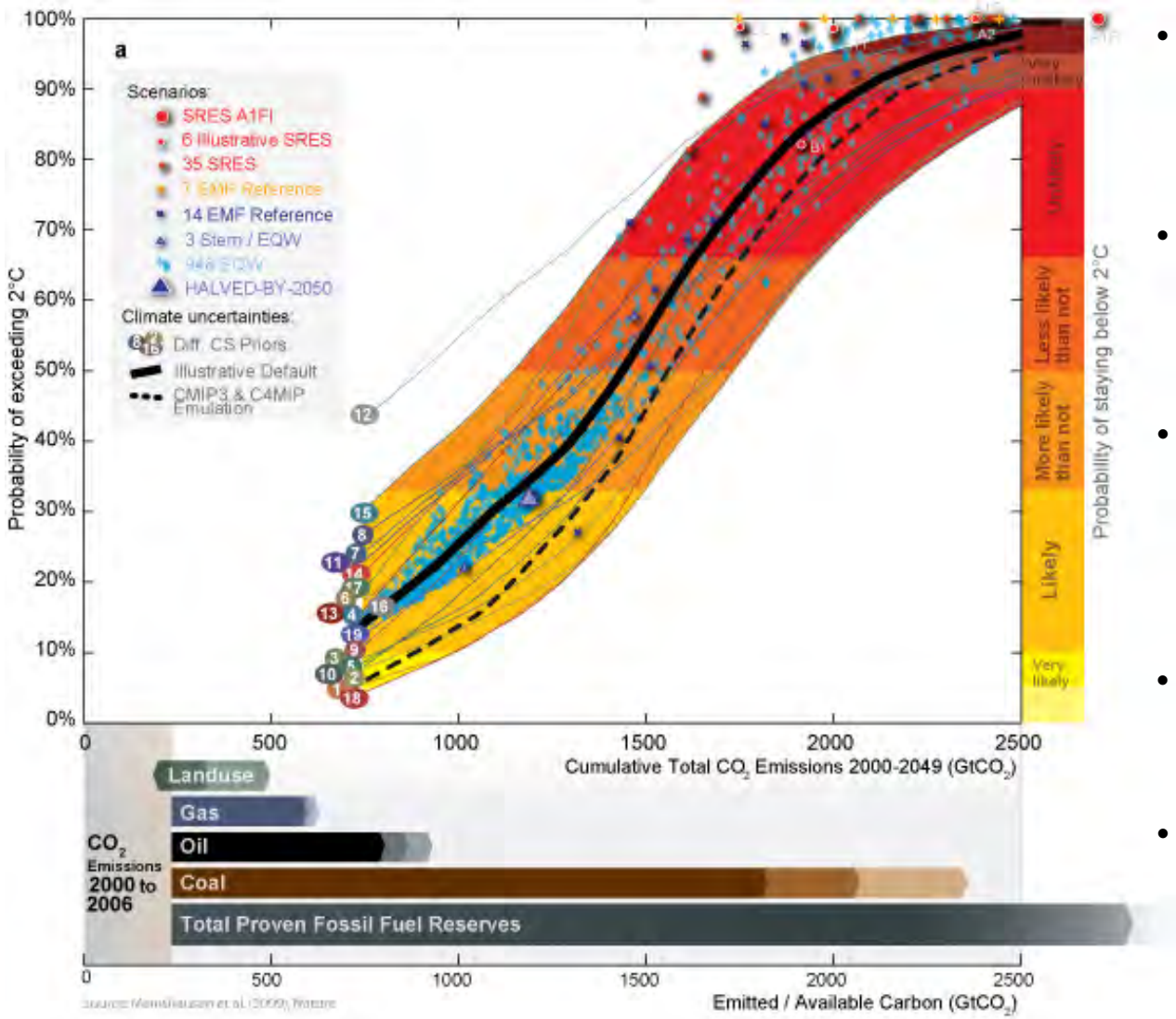
- For example, even zeroing out carbon at 2100 would lead to a millennium length "long tail" of high CO_2 concentrations at ~40% of peak levels through the end of the millennium (right)
- Temperature increases proportionally with emissions growth, but is projected to remain roughly constant post-peak (right)
- Sea level rise due only to thermal expansion (not counting contributions from melting glaciers and ice sheets) will result in irreversible global average sea level rise of at least 0.4–1.0 m at 600 ppmv and 0.6–1.9 m at ≈1,000 ppmv
- Peak CO_2 concentrations of 450–600 ppmv over the coming century will cause irreversible dry-season rainfall reductions in several regions comparable to those of the "dust bowl" era



Even zeroing out emissions after peak will lead to certain irreversible impacts

Solomon et al., 2009. "Irreversible climate change due to carbon dioxide emissions." PNAS 106(6):1704-1709. Doi:10.1073/pnas.0812721106.

…and leaving a large portion of fossil fuels in the ground. To stay within a 2° C carbon budget 40% of proven reserves need to stay in the ground (compared to 25% six years ago)

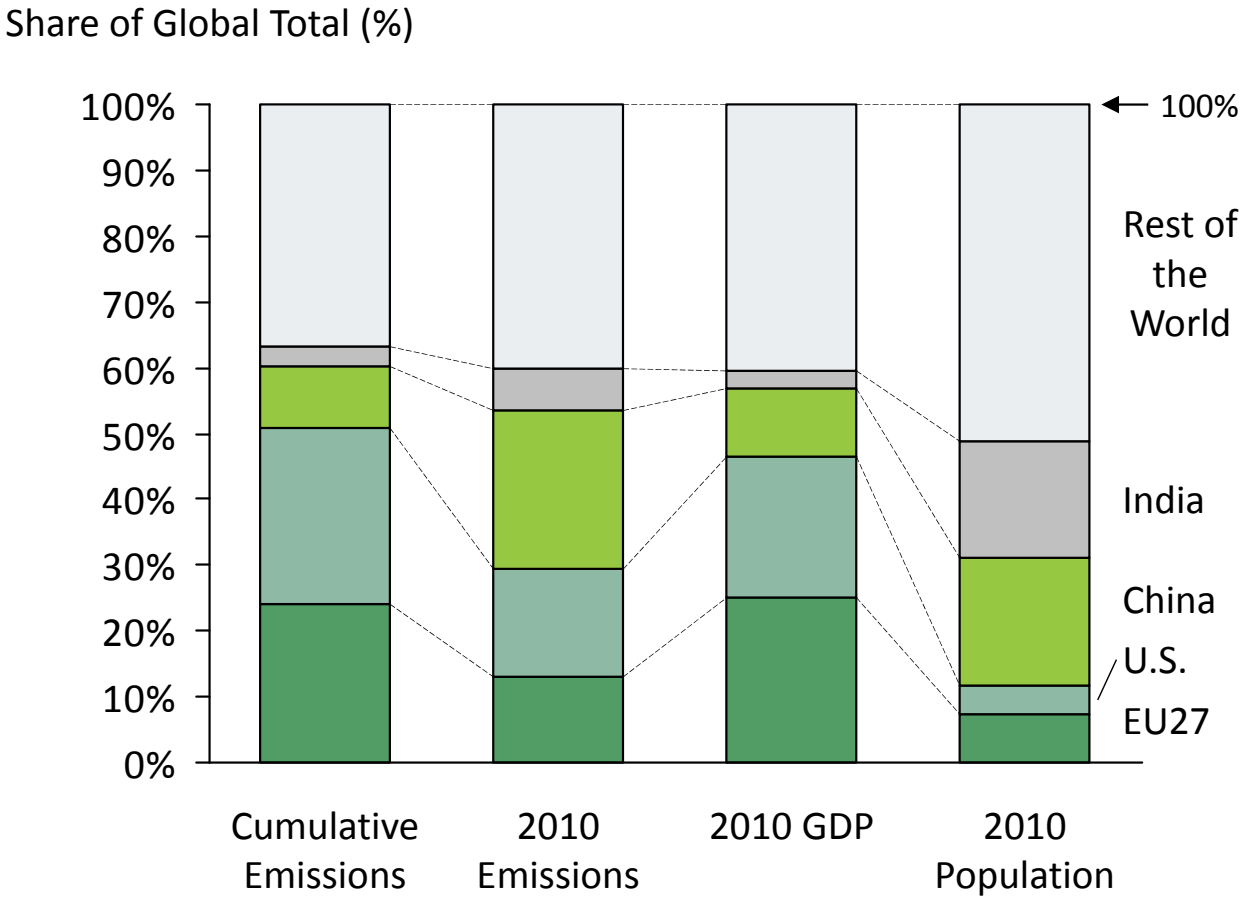


- Since 2006, proven reserves of oil, coal, and natural gas have increased by 21%, 2%, and 21% respectively
- As of 2006 we would have had to keep **25%** of proven fossil reserves to stay within a 2°C warming scenario
- As of 2011 we will have to keep almost **40%** of proven reserves in the ground (or be captured and stored) to stay within a 2°C warming scenario
- Using 2011 fossil fuel combustion rates, it will take ~50 years to use up the carbon budget.
- If emissions continue to grow at 3% per year, it will take ~30 years to use up the 2 degree carbon budget

Meinshausen et al., 2009. "Greenhouse-gas emission targets for limiting global warming to 2C." Nature 458(7242): 1158.
Carbon budget calculations based on 1 trillion tonne carbon budget (of which we have used 500)
Annual fossil consumption and proven reserves from BP, 2012. "BP statistical review of world energy June 2012."

Annex 1 countries have used a large share of the global carbon budget, making equity a continuing point of concern in climate change debates

The choice of whether to use a stock (i.e., carbon budget) or flow (i.e., annual emissions) lens leads to very different conclusions about the apportioning responsibility for GHG mitigation efforts



- The BASIC countries* have argued that they should have access to an equitable share of the remaining carbon budget.

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•Brazil, South Africa, India and China

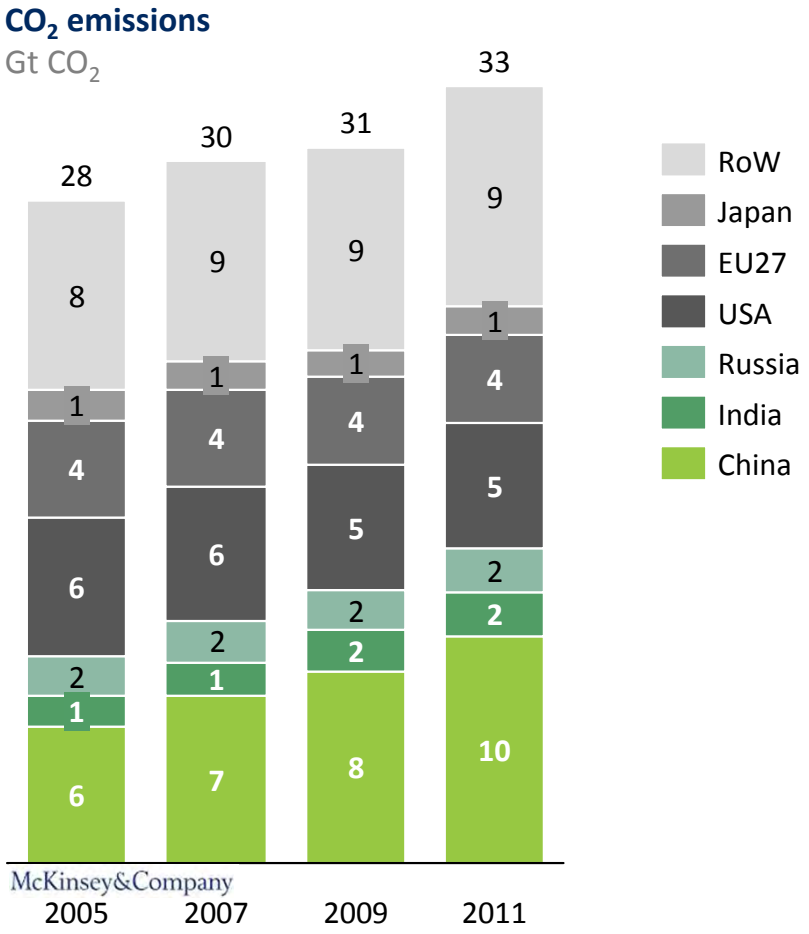
Carbon Dioxide Information Analysis Center database. Retrieved March, 2013. http://cdiac.ornl.gov/#

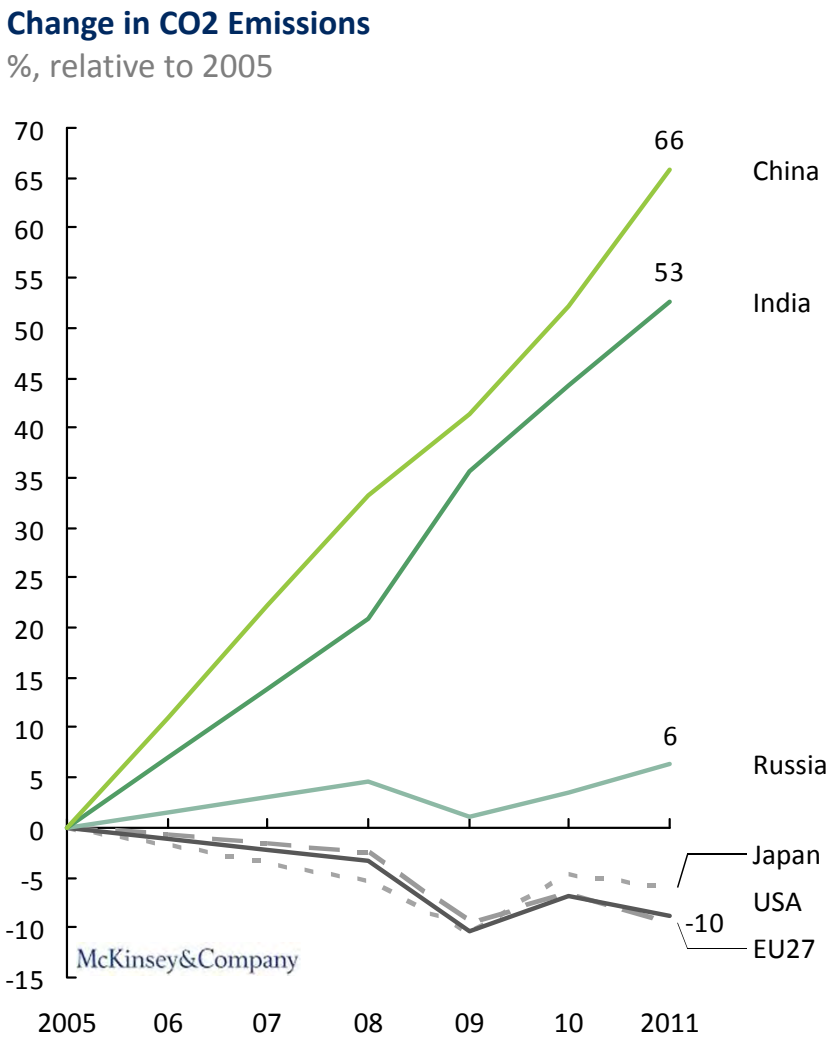
World Bank. Data: GDP (Current US$). Retrieved February, 2013. http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

Emissions Trajectory: main themes

- **Overall emissions trajectory** – Current emissions trajectories are in line with the highest IPCC emissions scenarios. We are on track for 4-6 degrees of warming and the window has essentially closed on a 450 ppm future.
- **Carbon budget** – The conversation has shifted from emissions pathways to an overall carbon budget. The accepted carbon budget for 2 degrees is 1 trillion tons of carbon, of which half has already been emitted.
- **Regional trends** – Increasing growth in the developing world, particularly China, was faster than anticipated and offset declines in the developed world. The epicenter of the climate challenge is now even more definitively centered around the developing world.
- **Sectoral trends –** Overall, the sectors have not significantly deviated from expected BAU emissions. Forestry may be an exception due to progress on deforestation in Brazil, but the overall trajectory of emissions from land-use is not entirely clear.

Emissions have been flat or declining in the developed world, while China and India have seen rapid growth

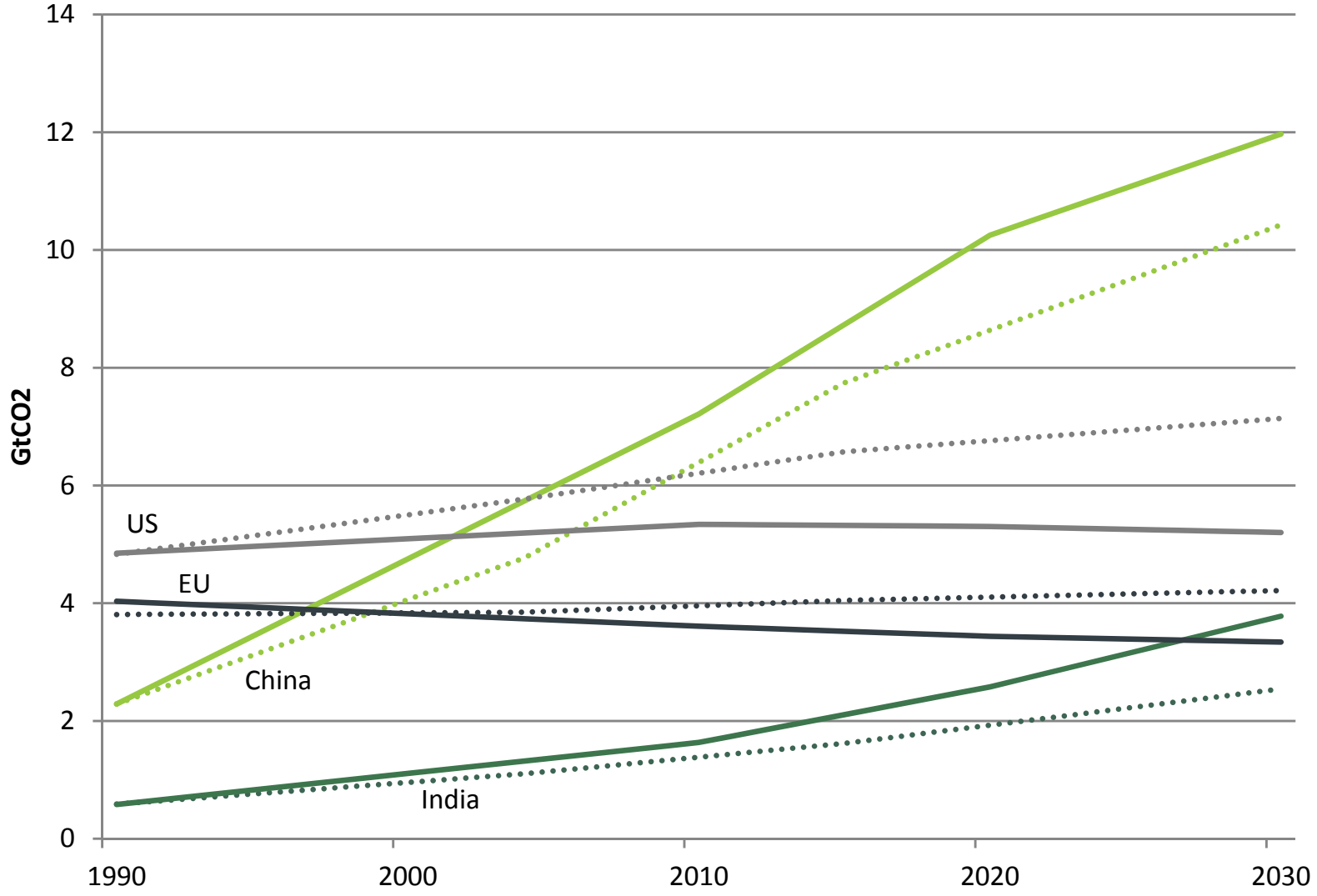




Analysis by McKinsey and Co., based on European Union, 2012. Emission Database for Global Atmospheric Research. Emissions Data. Retrieved November, 2012. http://edgar.jrc.ec.europa.eu/index.php

These trends have been even more dramatic than anticipated six years ago

Historic and Projected CO_2 emissions for 2012 (solid lines) and 2006 (dashed lines)



Adapted from International Energy Agency, 2006. "World energy outlook." Reference Scenario
Adapted from International Energy Agency, 2012. "World energy outlook." Current Policies Scenario

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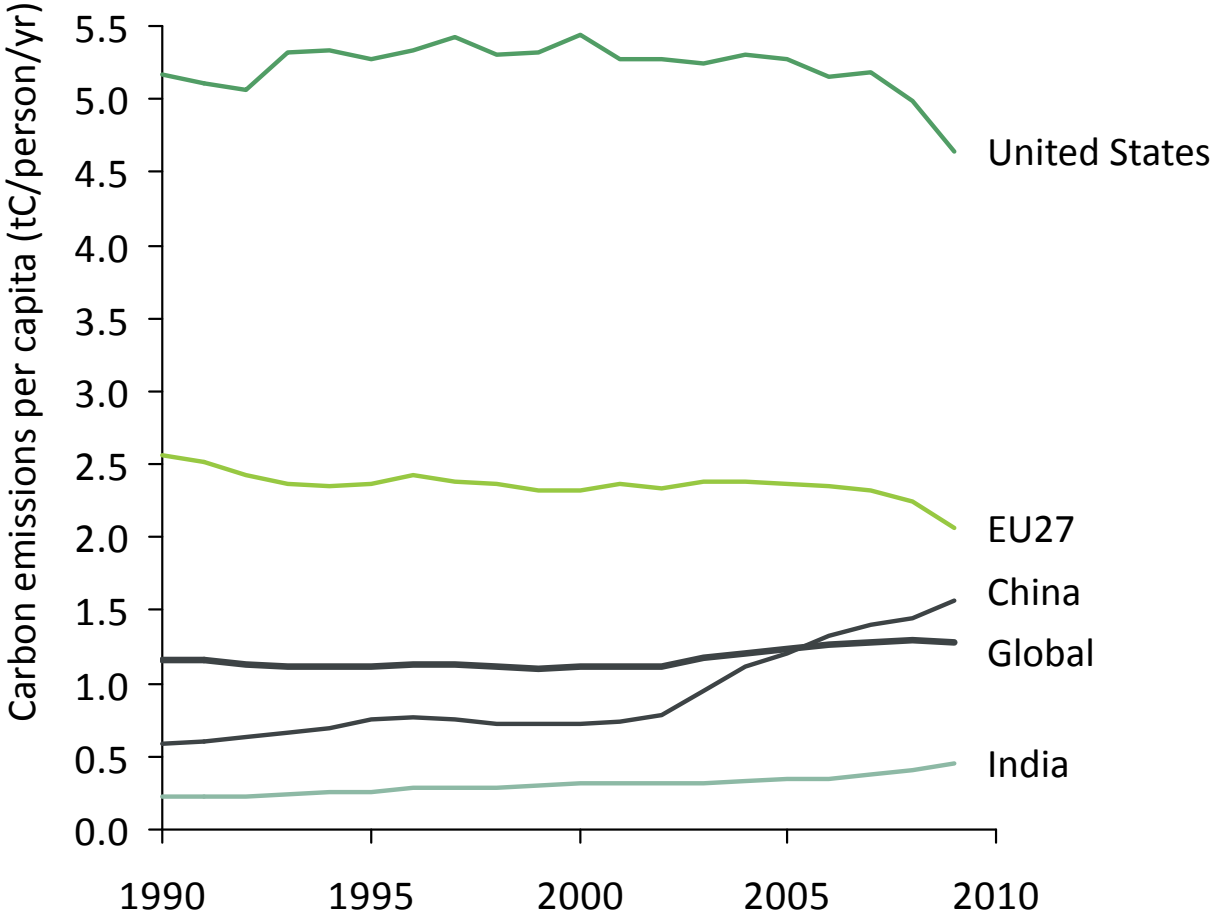
Although total emissions in China and India are growing rapidly, they are still well below the E.U. and U.S. on a per capita basis



Carbon Dioxide Information Analysis Center database. Retrieved March, 2013. http://cdiac.ornl.gov/#

European Union. European Environment Agency Greenhouse Gas Data Viewer. Retrieved March, 2013. http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

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Overall emissions projections have inched upwards in the last few years, but there have been no major changes in the distribution across sectors

Forecasted fossil fuel CO2 emissions in 2030 (GT CO_2)

emissions trajectory

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Adapted from Exxon Mobil, 2009. "The outlook for energy: a view to 2030"
Adapted from Exxon Mobil, 2012. "2012 the outlook for energy: a view to 2040."

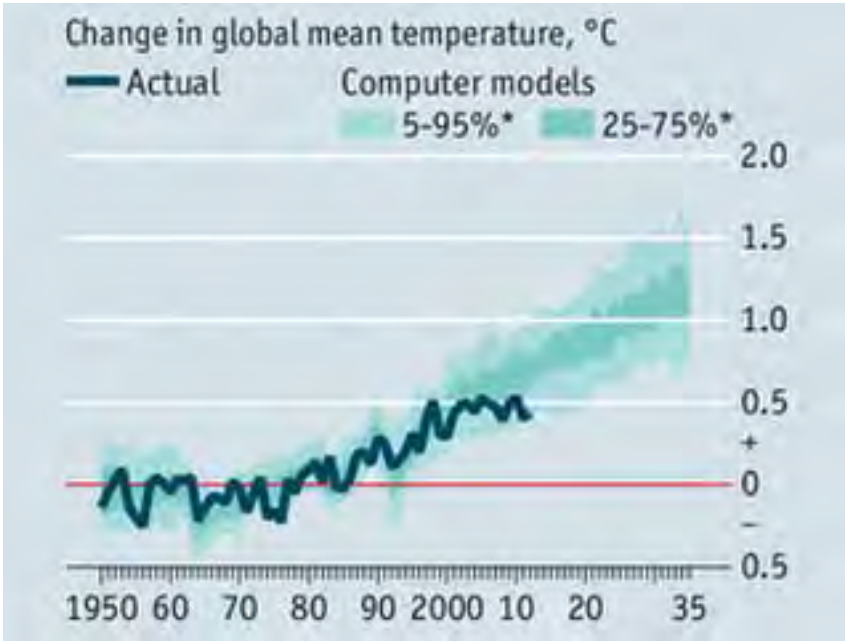
SCIENCE

Science: main themes

- **Temperature rise has been flat in the past decade and may soon fall outside of the confidence intervals of climate models. The reasons for this deviation are unclear, but there is still near consensus that background global warming is continuing.**
- But, 2007 models were too optimistic for several categories of impacts including Arctic sea ice, sea level rise, changes in hydrologic cycles, etc.
- Impacts from a 4 degree temperature increase, which has become more probable in the last five years, are thought to be at least double those from 2 degrees.

Despite higher than expected emissions, global temperatures have been flat in the last decade, and may soon fall out of range of climate model predictions

Global mean temperature anomaly and model predictions[1]



* Confidence intervals

- The five year global mean temperature has been essentially flat for the last decade. The reasons behind this are not clear, but several sources of uncertainty have been proposed, including:
  - Solar variability[2]
  - Impact of clouds[1]
  - The reduction in climate forcing from non-CO2 gases
  - Impact of aerosols[2]
  - General climate variability – various analyses indicate that even in the context of global warming it is likely that there will be decade(s) of flat or cooling temperatures[3]
  - Increased heat uptake in the deep ocean[4]
- Some recent assessments have predicted lower mean temperature increases and upper confidence intervals than IPCC estimates, but it is not clear whether a downward revision of temperature estimates is warranted at this time

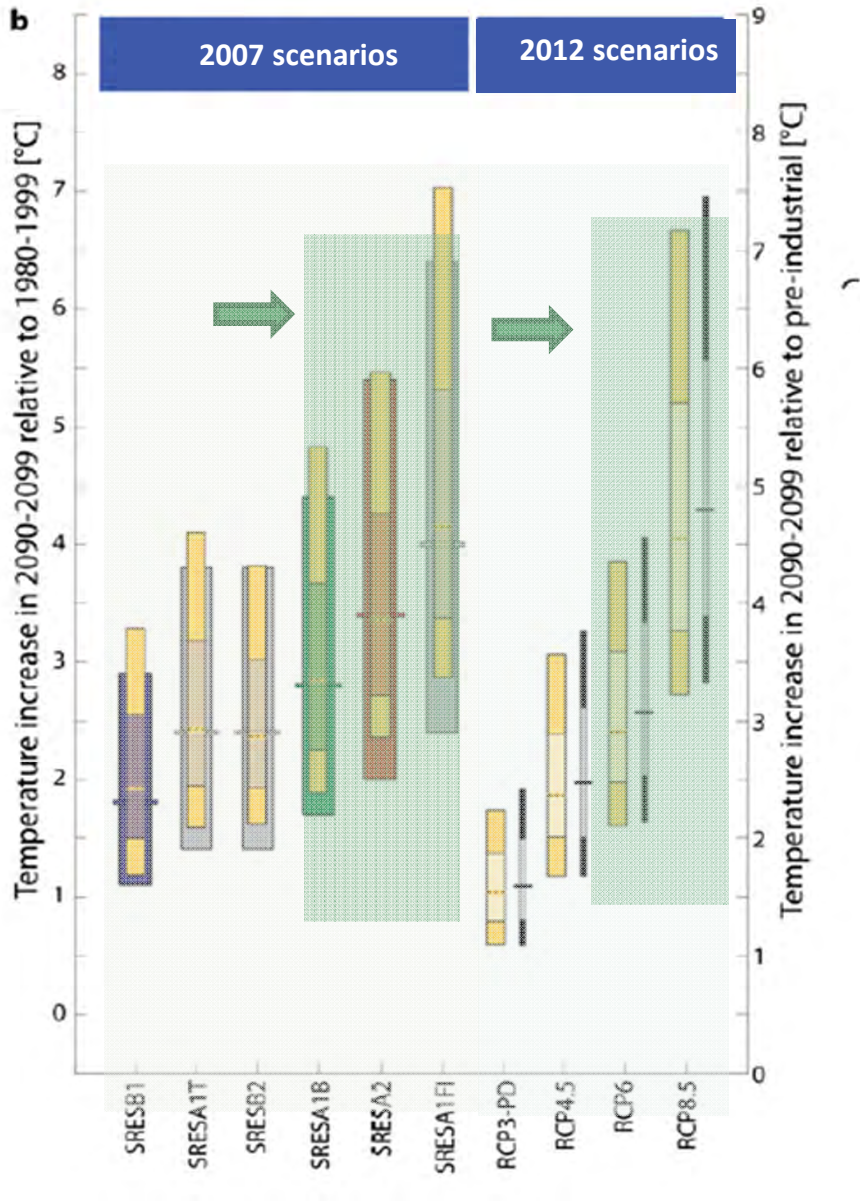
But, despite the recent flattening of global temperatures, climate scientists still believe that background global warming is continuing.[2]

1. Economist, 2013. "Climate science: a sensitive matter."
2. Hansen et al., 2013. "Global temperature update through 2012."
3. Easterling and Wehner, 2009. "Is the planet warming or cooling?"
4. Meehl et al., 2011. "Model-based evidence of deep-ocean heat uptake during surface-temperature hiatus periods." Nature Climate Change 1:360-364. DOI: 10.1038/NCLIMATE1229.

Despite these recent trends, new IPCC emissions scenarios project equivalent temperature rise to old scenarios

In both 2007 and 2012 scenarios, most scenarios show 2-4.5° C temperature increase relative to pre-industrial levels. However, recent trends makes highlighted *high emission scenarios* (shaded) such as SRESA1FI and RCP85 seem more probable.

Models from the IPCC 5th Assessment Report (2012) show much the same expected temperature increases as the IPCC 4th Assessment Report (2007) models



Rogelj et al., 2012. "Global warming under old and new scenarios using IPCC climate sensitivity range estimates." Nature Climate Change 2:248-253. DOI: 10.1038/NCLIMATE1385.

Science: main themes

- Temperature rise has been flat in the past decade and may soon fall outside of the confidence intervals of climate models. The reasons for this deviation are unclear, but there is still near consensus that background global warming is continuing.
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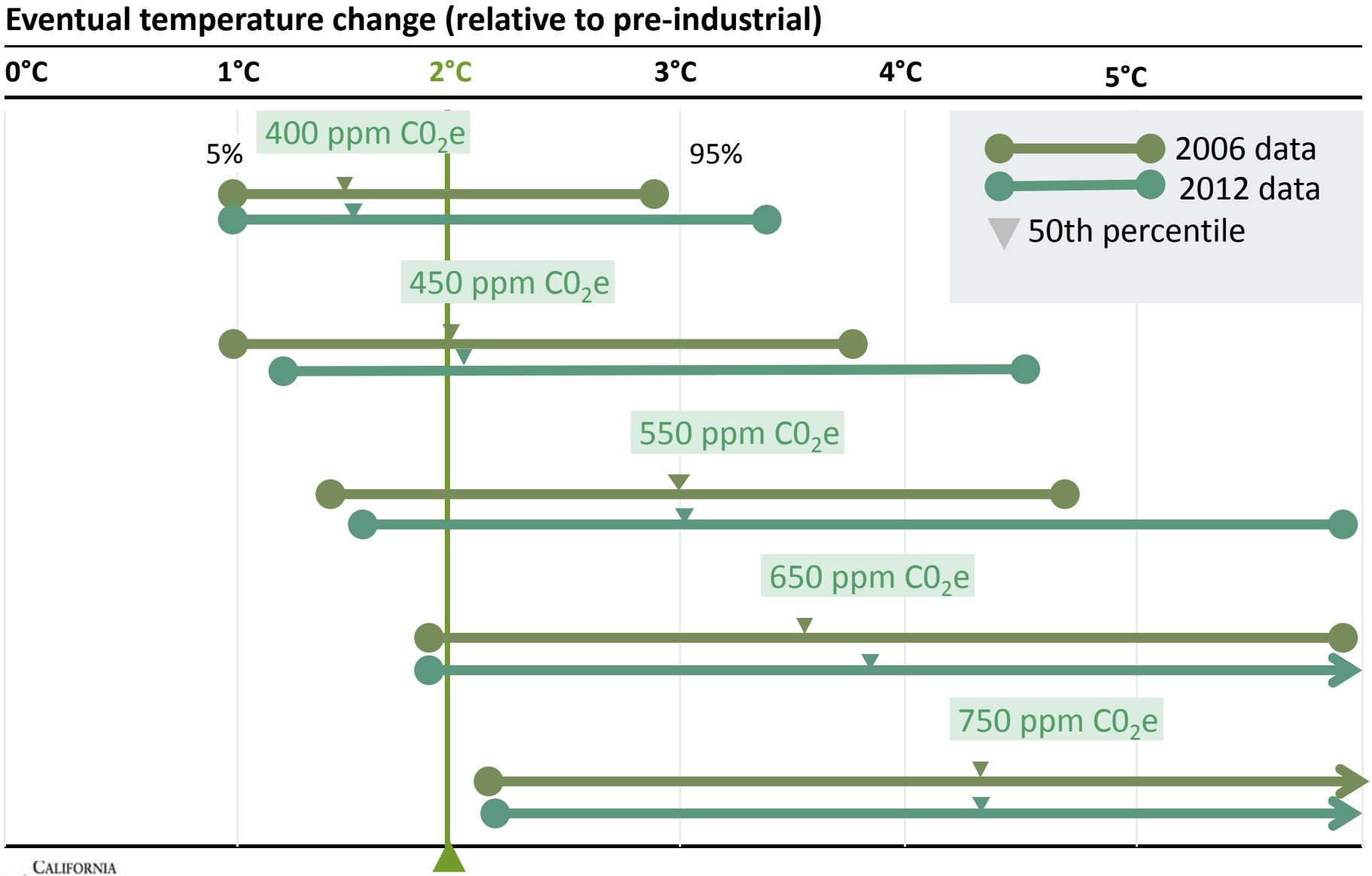
- Impacts from a 4 degree temperature increase, which has become more probable in the last five years, are thought to be at least double those from 2 degrees.

Previous models were too optimistic in some respects: an equivalent CO_2e concentration is now associated with greater warming, especially at the upper end of estimates

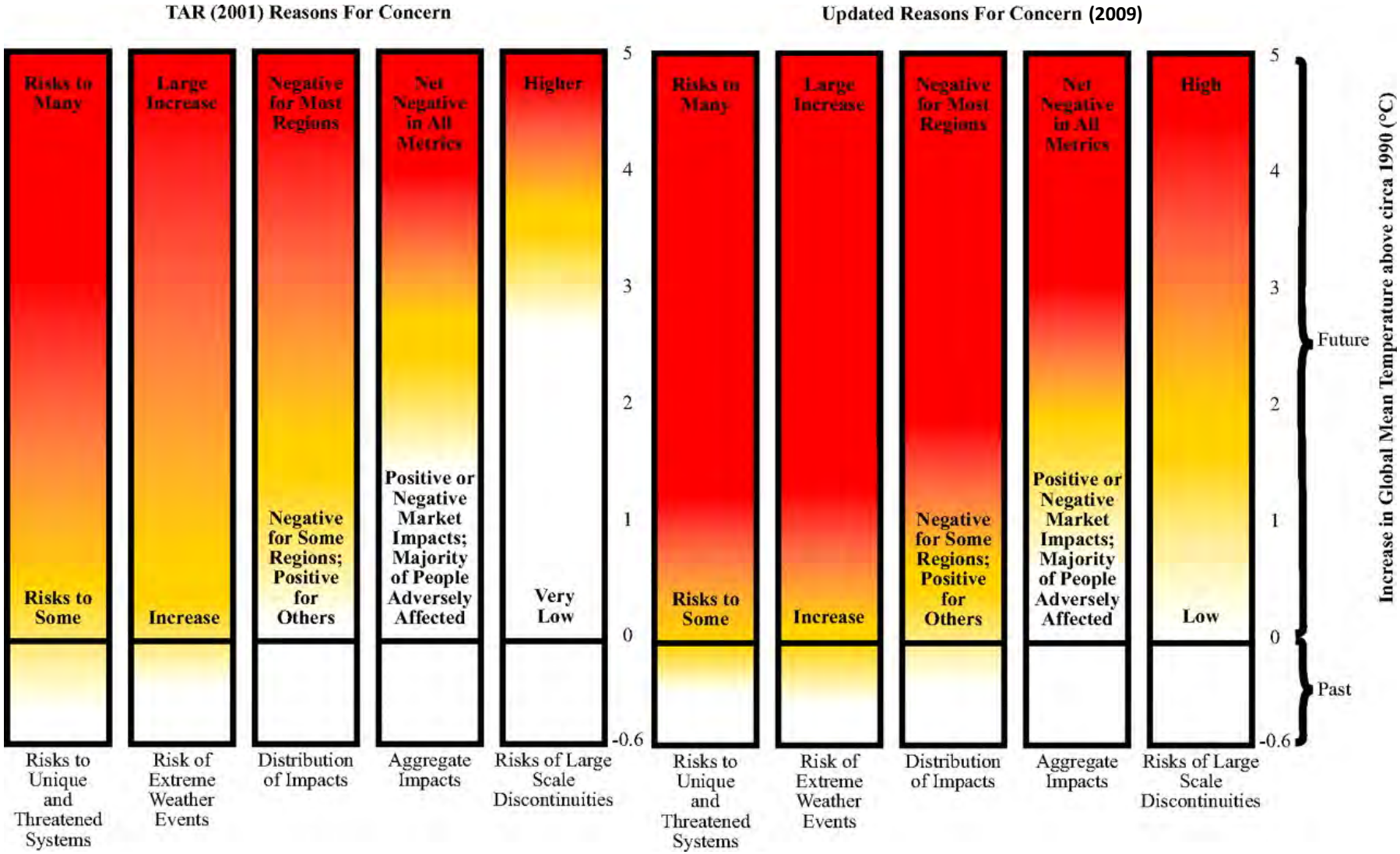


Stern Review, 2006. "The economics of climate change." United Kingdom Treasury.

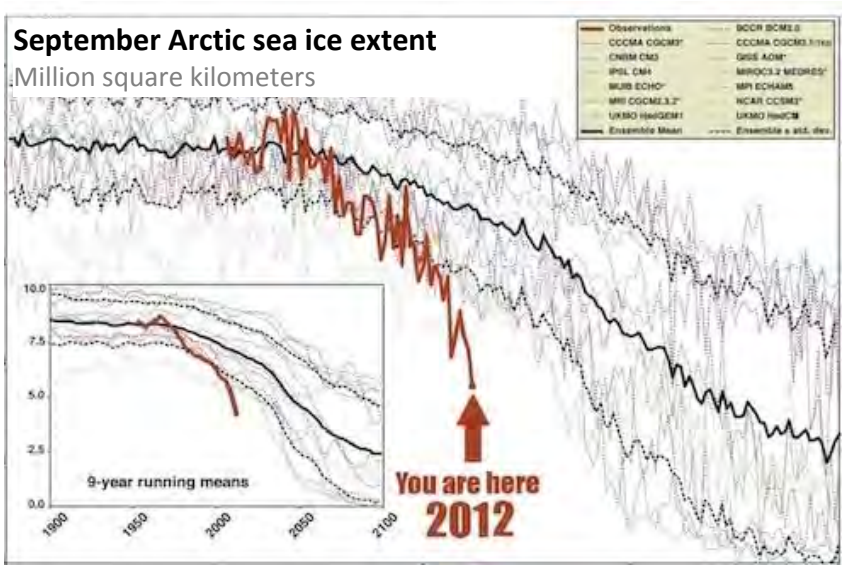
Rogelj et al., 2012. "Global warming under old and new scenarios using IPCC climate sensitivity range estimates." Nature Climate Change 2:248-253. DOI: 10.1038/NCLIMATE1385.

And based on current science and observations, 2° C is expected to cause more severe impacts than initially projected

Risks from climate change, based on what we knew in 2001 compared to 2009 (below)

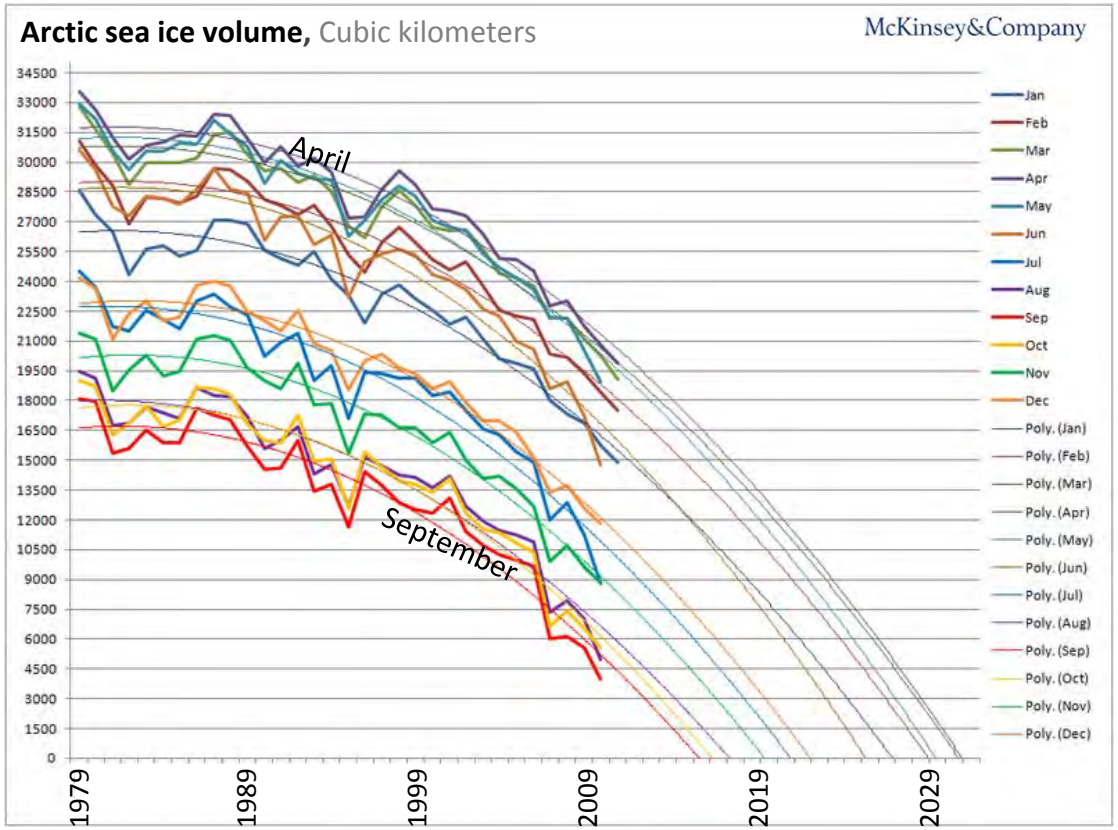


Smith et al., 2009. "Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) 'reasons for concern.'" PNAS 106:4133-4137



Current trends show that observed impacts, such as loss of sea ice, have been more severe than anticipated

Black lines: IPCC AR4 models. Note that models more accurately forecast winter and Antarctic sea ice extent, and that GHGs are estimated to be responsible for about half of sea ice loss



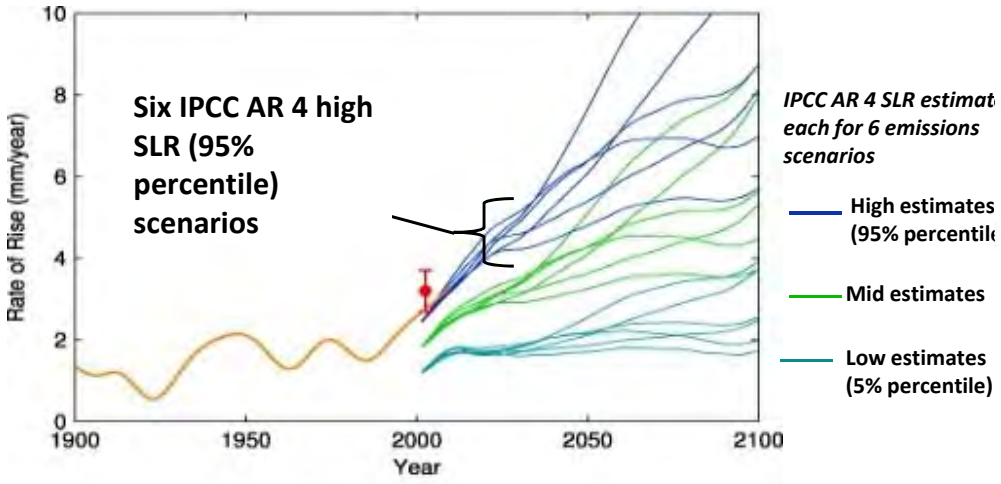
The decline in Arctic sea ice has occurred much faster than predicted (upper left)[1]; current trends point to an ice-free Artic summer in 3 years and an entirely ice-free Arctic by 2030 (left).[2]

Stroeve et al., 2007. "Arctic sea ice decline: faster than forecast. " Geophysical Research Letters 34 doi: 10.1029/2007GL029703.
Analysis by McKinsey and Co., based on data from University of Washington's Polar Science Center. PIOMAS Arctic Sea Ice Volume Data. Retrieved, November, 2013. http://psc.apl.washington.edu/wordpress/data/

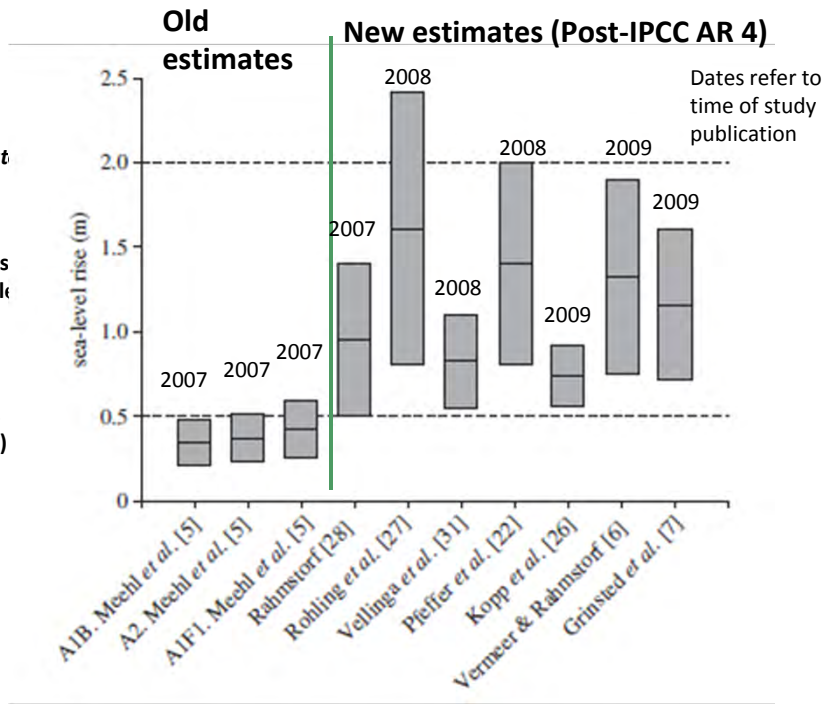
Actual sea level rise is tracking on the high end of previous forecasts, and new forecasts are predicting worse outcomes

Early models may not have accurately accounted for complicated ice sheet dynamics, which remain a large source of uncertainty. Research since IPCC AR 4 shows that irreversible decay of the Greenland ice sheet could occur at 1.5 ° C (rather than the predicted 1.9 - 4.6 ° C) and that West Antarctica Ice Sheet is losing ice faster than projected. New models, especially those that are based on the relationship between temperature and sea level rise in the past (semi-empirical), are more grim than previous ones.

Satellite altimeter (red) and tide gauge data (orange) suggest that we are on the upper end of projected IPCC AR 4 sea level rise (SLR) scenarios



Post-IPCC AR 4 projections and observations of sea level rise are more aggressive than IPCC scenarios (Shown: projected mean SLR by 2100)



Rahmstorf et al., 2012. "Comparing climate projections to observations up to 2012." Environmental Research Letters 7 doi:10.1088/1748-9326/7/4/044035.
Nicholls et al., 2011. "Sea-level rise and its possible impacts given a 'beyond 4°C world' in the twenty-first century." Phil Trans R Soc A 369:161-181 doi: 10.1098/rsta.2010.0291.
World Bank, 2012. "Turn down the heat: why a 4°C warmer world must be avoided."

Our certainty that the magnitude of extreme events will increase with climate change has grown incrementally

Previous projections of extreme events were characterized by likelihoods that phenomena would change in a certain direction in certain regions, rather than specific estimates of how much those phenomena would change. Although certainty has not increased significantly, there is a sense that the magnitude of change is greater than previously understood.

Phenomenon	Direction of	Likelihood	Change in certainty	Change in magnitude
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	↗	Virtually certain	→ IPCC SREX	↗ Rises as a product of higher projected global mean temperature
Warm spells/ heat waves. Frequency increases over most land areas	↗	Very likely	↗ Duffy and Debaldi 2012; Jones, Lister, and Li 2008; Hansen et al. 2012; Stott et al. 2011; Coumou, in review; Otto et al. 2012; Rupp et al 2012 → IPCC SREX	**Unknown**
Heavy precipitation events. Frequency increases over most areas.	↗	Very likely	↘ "It is *likely* that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe" (IPCC SREX)	↗ (see subsequent slide)
Area affected by drought increases.	↗	Likely	*Change in framing*: "There is medium confidence that droughts will intensify in the 21st century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration" (IPCC SREX)	↗ "The area of the Earth's land surface affected by drought has also likely increased substantially over the past 50 years, somewhat faster than projected by climate models." (World Bank 2012)
Intense tropical cyclone activity increases	↗	Likely	→ IPCC SREX	Current understanding: Storm intensity up 2-100% by 2100 Frequency up 6-34% 20% > precip w/in 100km storm center [Knutson 2010]
Increased incidence of extreme high sea level (excludes tsunamis)	↗	Likely	↗ "It is *very likely* that mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future." (IPCC SREX)	↗ See levels rising faster than expected (see previous slide)

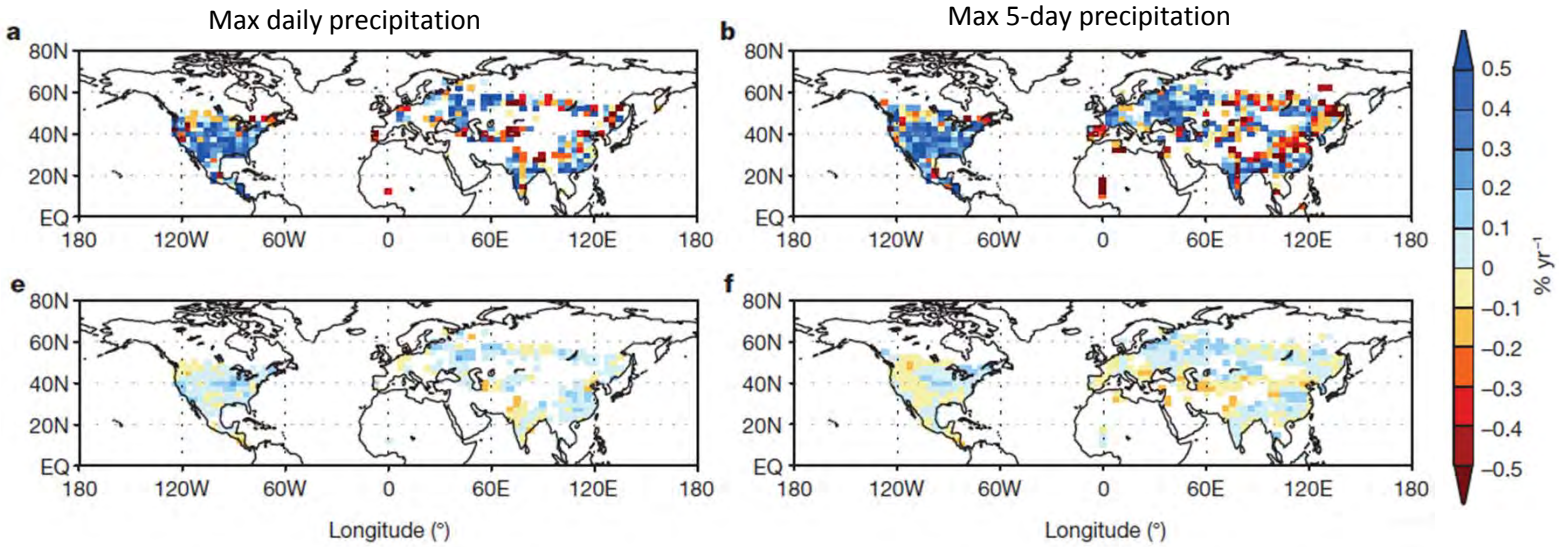
Assessment based on:

IPCC, 2006. "Fourth assessment report of the Intergovernmental Panel on Climate Change." Pachauri and Reisinger, eds.
IPCC, 2012. "Managing the risks of extreme events and disasters to advance climate change adaptation."
World Bank, 2012. "Turn down the heat: why a 4°C warmer world must be avoided."

Changes in hydrological cycles are, in many cases, occurring faster and with more intensity than models predicted

General changes in hydrological cycles are more or less occurring as expected: a warming atmosphere holds more water vapor, leading to more intense precipitation events, and wetter areas are getting wetter while dry areas become drier. However, over oceans, evaporation and precipitation has intensified twice as fast as predicted by current models. Models also underestimated changes in the intensity of precipitation over land (below).

Models underestimated observed geographical distribution of trends of extreme precipitation indices (PI) during 1951–99. GHGs were found to contribute to intensification of heavy precipitation events over 2/3 of the studied area.



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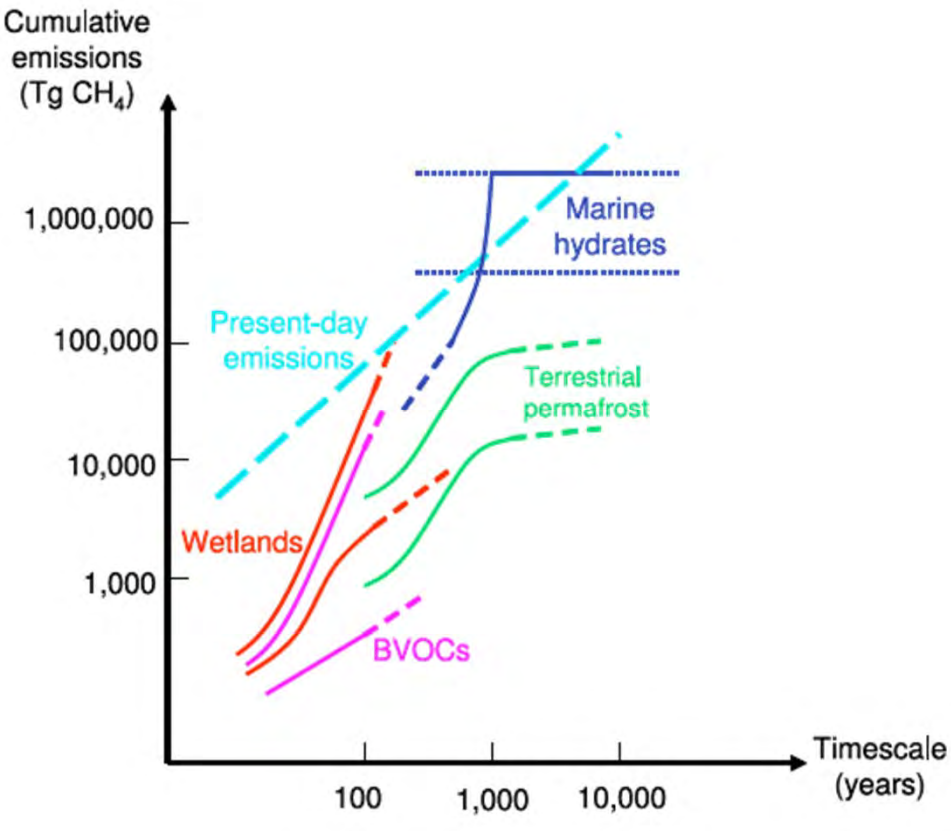
Min et al., 2011. "Human contribution to more-intense precipitation extremes." Nature 470 doi:10.1038/nature09763.

Our understanding of the risk posed by non-linear feedback loops remains low, though it continues to be an area of concern

Over the medium term (50-100 years), feedback loops such as the release of methane from wetlands and biogenic volatile organic components remain a concern, with the possibility to cause more radiative forcing than human sources by 2100.

Illustrative summary of the relative size and time scale associated with methane feedbacks. Dotted lines indicate bound likely range of impacts. Wetlands and biogenic volatile organic compounds (BVOCs) are the most immediate sources of concern.

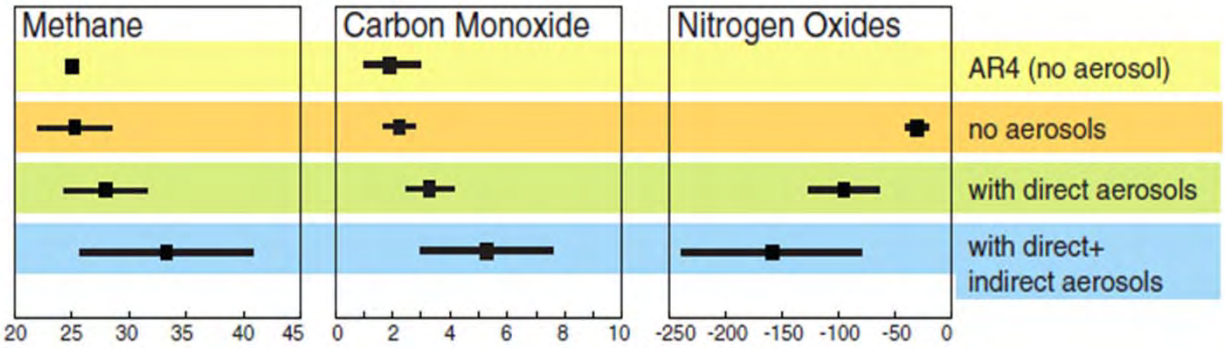


O'Connor et al., 2010. "Possible role of wetlands, permafrost, and methane hydrates in the methane cycle under future climate change: a review." Reviews of Geophysics.

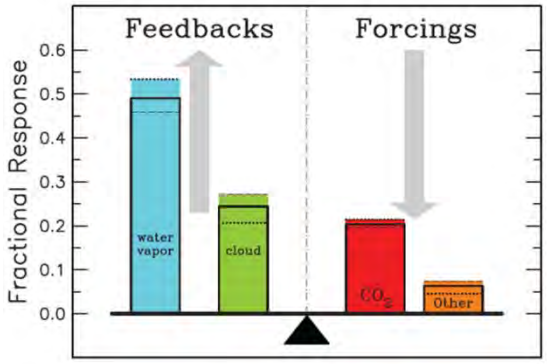
Our understanding around the impacts of non-CO_2 gases has shifted, showing increases in uncertainty and potentially in the severity of impacts

- Black carbon appears to cause more radiative forcing than acknowledged in IPCC AR 4
- Some interactions among greenhouse gases were not included in the 100 year global warming potential estimates included in the 4th IPCC Assessment Report (below)
- Overall, the impact of aerosols is still the subject of considerable debate
- Water vapor and cloud cover also remain research priorities because they have such a large effect on climate that even small changes could have enormous effects

100 year GWPs of some GHGs were not fully modeled in AR4 and cause significant increases in the uncertainty of impacts



Water vapor and clouds contribute more to the greenhouse effect than human sources, making them an important research priority



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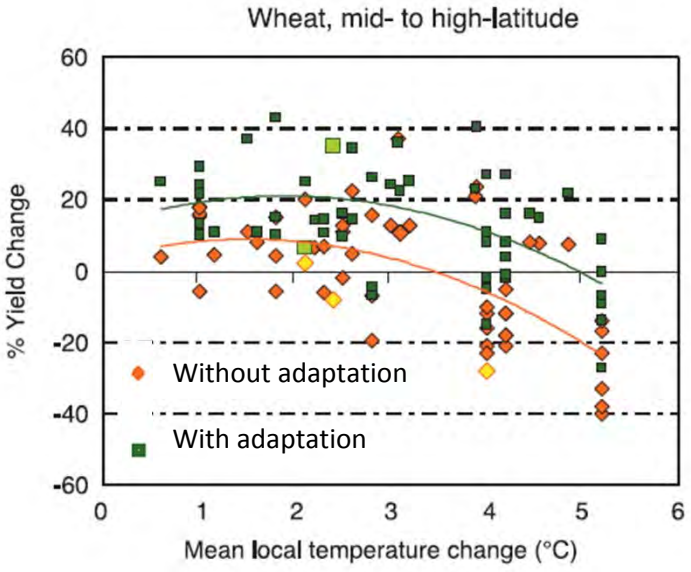
Bond et al., 2013. "Bounding the role of black carbon in the climate system: a scientific assessment." American Geophysical Union doi: 10.1002/jgrd.50171.
Lacis et al., 2010. "Atmospheric CO2: principal control knob governing Earth's temperature." Science 330, 356. DOI: 10.1126/science.1190653.

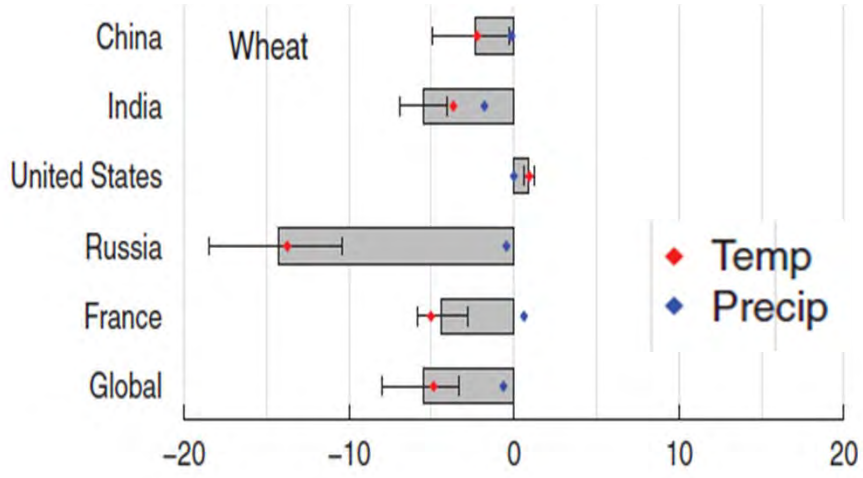
Our understanding of crop yield declines has improved, showing that previous assessments were too optimistic

Although earlier models suggested some increase of crop yields as a result of climate change and CO_2 fertilization, recent data suggests that temperature rise has already decreased yield for wheat and maize (yields for rice and soybeans may have increased slightly due to CO_2 fertilization). Generally, crops may be more be more sensitive to temperature increase than previously thought.

Wheat yields were expected to increase up to >3.5˚…



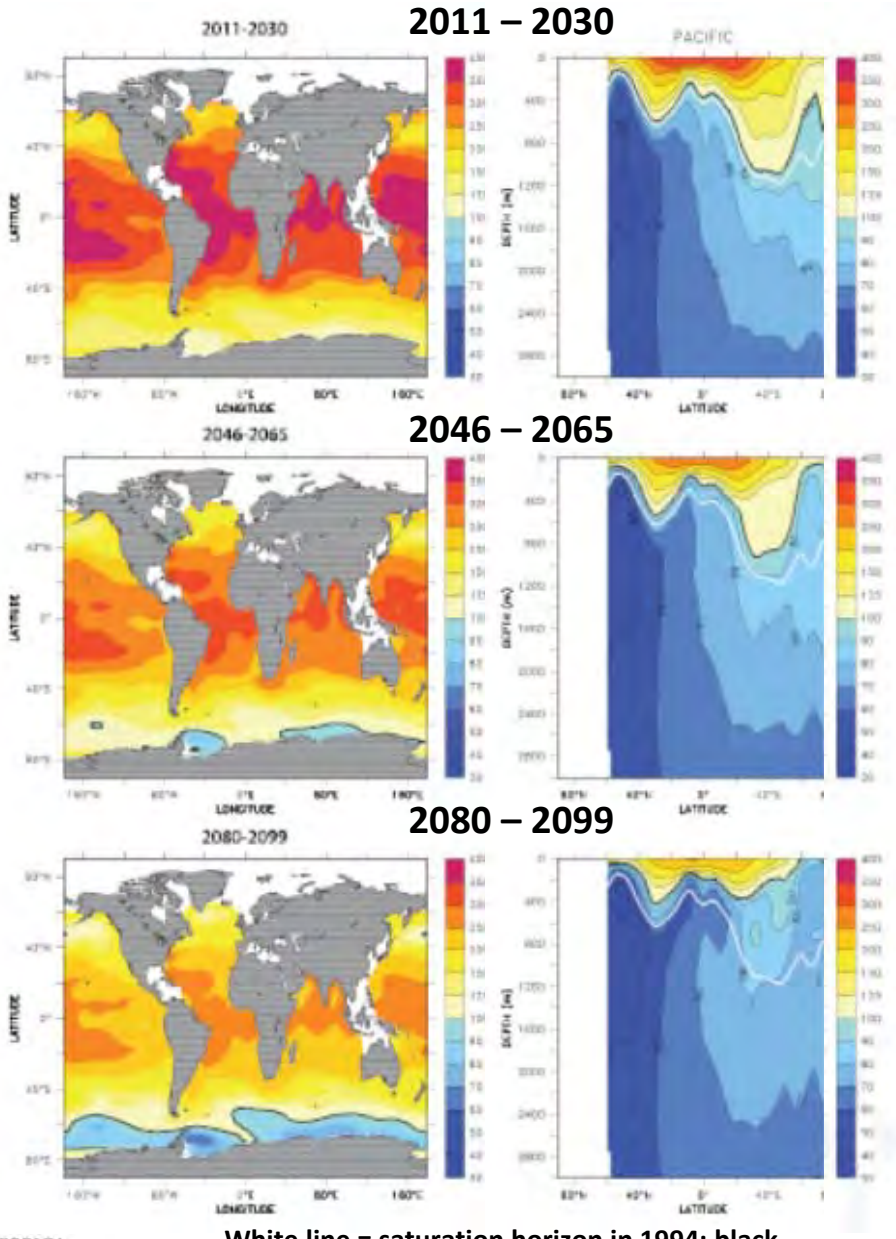
…but data from 1980-2008 suggests that yields have decreased already



Estimated net % yield impact of climate trends, 1980-2008

IPCC, 2006. "Fourth assessment report of the Intergovernmental Panel on Climate Change." Pachauri and Reisinger, eds.
Lobell et al, 2011. "Climate trends and global crop production since 1980." Science 333, 616. DOI: 10.1126/science.1204531.

Ocean impacts, such as increasing acidification and de-oxygenation, are gaining attention



White line = saturation horizon in 1994; black line = saturation horizon for modeled period

The formation and solubility of calcium carbonate ($CaCO_3$), the primary mineral in shells and skeletons of marine organisms is determined by the saturation state of aragonite and calcite ions, which are correlated with carbonate ion concentrations. Undersaturation of calcite and aragonite prevents shell and skeleton formation.

The calcite/aragonite saturated layer of the ocean is becoming shallower (30-200m since the preindustrial era), and increased upwelling brings up deeper, corrosive waters.

Projected shifts in aragonite saturation state
Over time, we see an increasingly shallow aragonite saturated layer (right panels), with lower saturation rates in nearshore waters, out of reach of corals and shellfish (left panels).

Models project lower aragonite saturation rates (i.e., conditions less favorable to shell and skeleton formation) in shallow waters as CO_2 levels rise.

Doney, et al., 2009. "Ocean acidification: the other CO2 problem." Annual Review of Marine Science 1: 169-192 DOI: 10.1146/annurev.marine.010908.163834.

Science: main themes

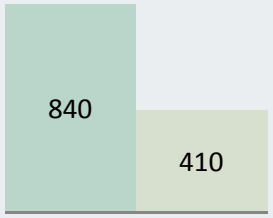
- Temperature rise has been flat in the past decade and may soon fall outside of the confidence intervals of climate models. The reasons for this deviation are unclear, but there is still near consensus that background global warming is continuing.
- But, 2007 models were too optimistic for several categories of impacts including Arctic sea ice, sea level rise, changes in hydrologic cycles, etc.
- **Impacts from a 4 degree temperature increase, which has become more probable in the last five years, are thought to be at least double those from 2 degrees.**

The impacts of 4° C of warming are likely more than double those associated with 2° C

4° C above pre-industrial examples:

- Estimated 840 million people (15% of global population) experience increased water stress globally

Millions of people experiencing increased water stress

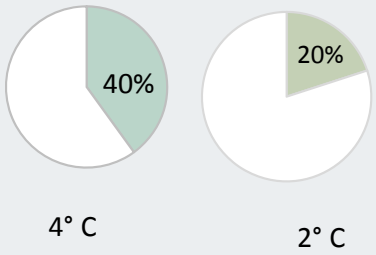


2° C above pre-industrial examples:

- Estimated 410 million people experience increased water stress globally

- Estimated 40% of studied species at risk of extinction
- Functional extinction of coral reefs
- Widespread loss of ecosystem services

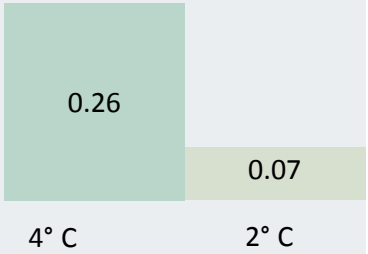
Studied species at risk of extinction



- Estimated 20% of studied species at risk of extinction
- All coral reefs bleached
- Some loss of ecosystem services

- Oceans drop additional 0.26 pH
- Risk of disruption of marine ecosystems

Additional drop in ocean pH



- Oceans drop additional 0.07 pH
- Some damage to marine ecosystems

In addition, many of the potential interactions between effects may become severe at 4 ° and are poorly understood.

Warren, 2011. "The role of interactions in a world implementing adaptation and mitigation solutions to climate change." Phil Trans R Soc A 369:217-241 doi: 10.1098/rsta.2010.0271.

POLITICAL ECONOMY

Interviewee reflections on the geopolitical economy

The fundamental shifts in geopolitical economy since 2007 that interviewees pointed to are as follows:

1. The failure at Copenhagen and reduced expectations for an international deal
2. A realignment in the global economy toward the developing world
3. The pairing of Chinese energy demand with positive political receptivity to climate change
4. The dramatic politicization of climate issues in the US
5. European progress, but flagging leadership in the face of the economic downturn
6. Increasing salience in India, tied to co-benefits

1. Interview reflections: the failure at Copenhagen and reduced expectations for an international deal

Expectations have moved away from the UNFCCC process. The most obvious change in the geopolitical landscape since 2007 was the failure to reach a global agreement at Copenhagen. Several interviewees have suggested that the original hopes and expectations for an international deal were based on a widely held belief in the viability of international cooperation that, in hindsight, was unfounded. COP 15 did help build momentum for different countries to figure out national climate change plans and policies (e.g., Mexico, Brazil). But, the failure to reach a global agreement has shifted the overall approach to smaller group fora.

- "People just assumed that because it is an international problem that policy and international coordination will flow from the top. The last few years have shown that's not true."
- "Copenhagen and the international negotiations produced literally nothing."
- "I happen to think that the original vision was always a fantasy… The international top down approach is not working and for the foreseeable future will not be a driver."
- "We need some realism about what is achievable – ambition and optimism are hard to temper. My own view is that we can't solve large, complex, costly problems by negotiating in very large groups."
- "7 years ago, the dominant thinking was that a top-down global strategy focused on global carbon abatement targets that would drive progress across all sectors. We have seen the faith in that model collapse…In many countries it is about long-term structural reform and the policy framework and less about a carbon price signal."

As a result, work has more recently shifted to other, smaller forums. "I have thought for a very long time that the solutions are going to come by negotiating in small groups." Small group deals can expand over time, which is basically what happened with trade, though trade is much easier because it is a reciprocal activity (tit-for-tat approaches work). We are seeing a shift in diplomacy to groups like the MEF, G8, G20, etc. We are experimenting with the idea of reviving the MEF, which is on ice. The G20 was useful after the subsidies work until the financial crisis sucked the air out of everything else. "But progress there is not going to be fast. It's going to be slow. And it's not going to get you 2 degrees."

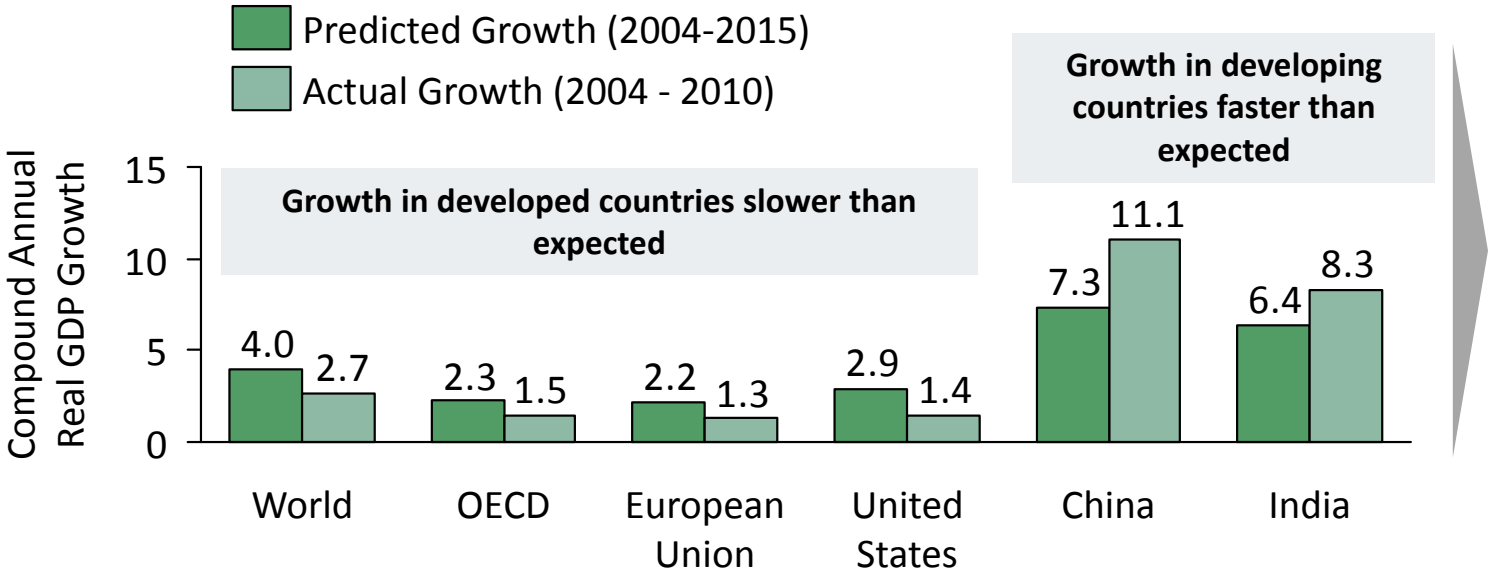
2. Interviewee reflections: a major shift in the global economy

Since 2007, the global economy, economic growth, and carbon emissions are now much more tied to Asia than we thought they would be six years ago. In tandem, the notion that the West will lead by example and transfer technology solutions to the East is a less compelling model than it was:

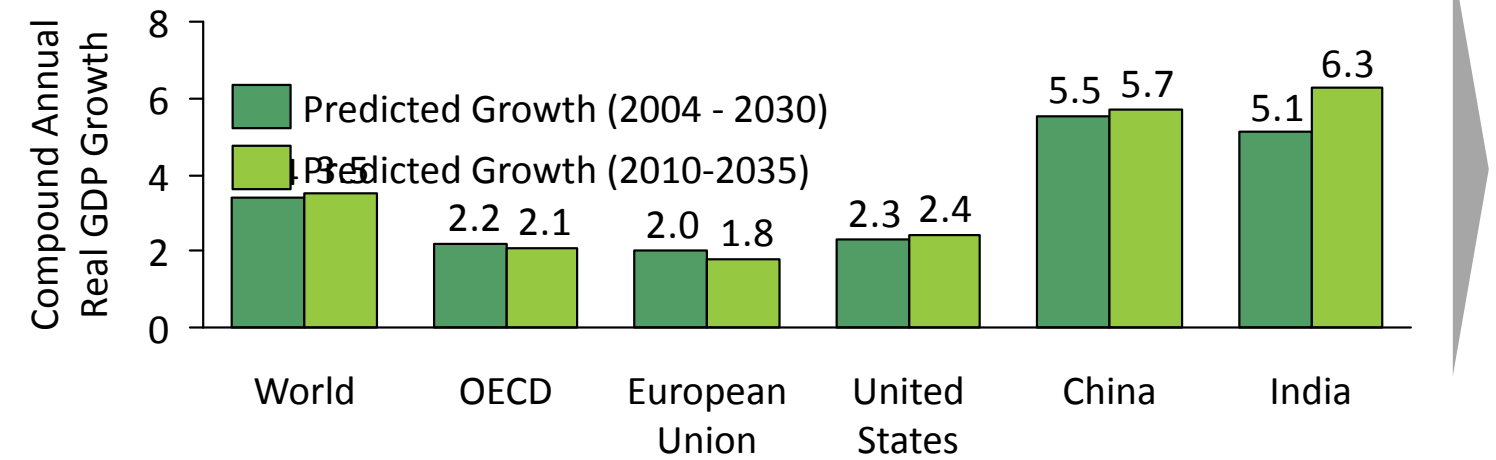
- The structure of the world economy is fundamentally different today. While it was obvious six years ago that the Asian economies were growing rapidly, we did not appreciate the full implications of that growth. The economic slowdown in OECD countries was much more pronounced than in China. "Back in 2006, we were still enjoying the notion that this was our Century in America. In the intervening years, we have seen an incredible shift of power away from the United States, and that is changing the fundamental nature not just of global geopolitics but climate."
- Six years ago was also the beginning of the recarbonization of the Chinese economy: carbon/ unit GDP went up because central planners had panicked and built a lot of coal-fired generation. The net effect is that the industrializing country economies have "decoupled" from those of OECD countries to a greater degree. "What it tells you is that the imperative to have some kind of strategy that engages the Chinese in particular is even more important now than it was 6 years ago."
- China is now the leader in both the production and installation of renewable technologies. "Go back 5 years ago, China didn't have a renewable industry at all – now they are the leading manufacturer of wind and solar." In addition, it is the region moving forward with installing nuclear power, experimenting with carbon, capture, use and storage (CCUS), and looking at advanced nuclear technologies. From an industrial perspective, "There is absolutely no doubt that there are some top performers; for example in iron and steel in China or cement factories in India. Some of the world's biggest oil refineries are in India." The notion that we will develop these technologies in the West and export them to the East is now not nearly as compelling than it was 6 years ago, though there remains a role for innovation in the West.
- In tandem, the global debate over climate has evolved such that "it is no longer just north and south. The whole identity of the south has undergone a major change."

2. Interviewee reflections: a major shift in the global economy

Developing economies have grown faster than expected, while OECD economies have grown slower than expected with the "global" recession



The industrializing economy has decoupled from the global economy to a larger degree than expected.

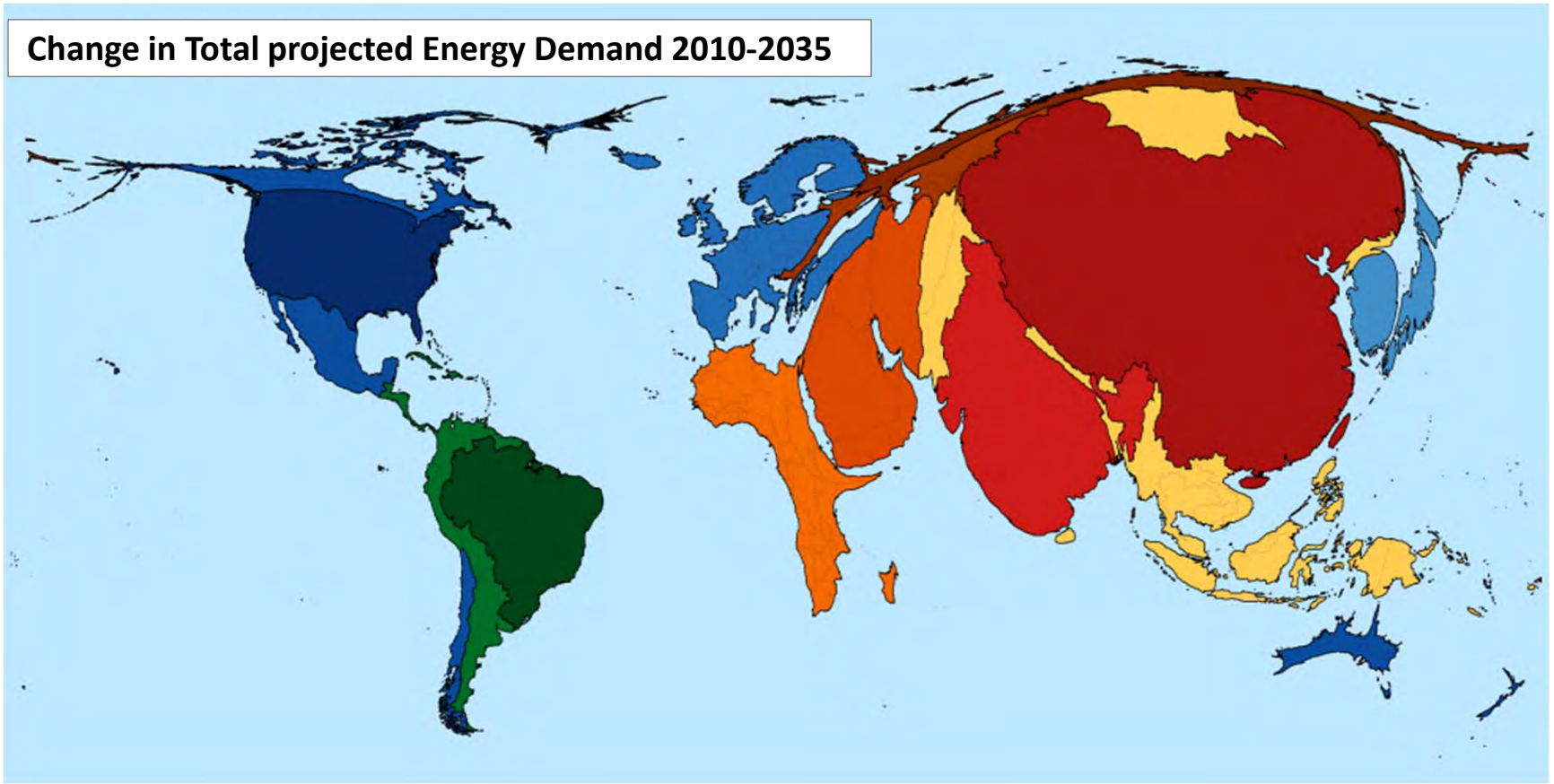


This trend is expected to continue making the imperative that climate strategies engage the industrializing world (esp. China and India) even more important than six years ago

International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook."
World Bank. Data: GDP (Current US$). Retrieved February, 2013. http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

2. Interviewee reflections: a major shift in the global economy

The epicenter of the climate challenge is now even more definitively centered around industrializing countries.



Clean Air Task Force based on data from U.S. Energy Information Administration, 2010. "International energy outlook 2010."

3. Interviewee reflections: the pairing of Chinese energy demand with positive political receptivity to climate change

Chinese economic growth has reshaped the global emissions map for the worse, but Chinese internal leadership on energy and climate is one of the few major bright spots in the overall picture since 2007.

- **"The China issue is driving the global trend."** There has obviously been a huge ramp up in emissions despite actions in China.
  - The overall emissions profile has emerged much faster in China than anticipated. The Chinese economy is growing so fast, which is driving overall energy growth. That growth is being fueled on the back coal. While there has been progress on renewables, nuclear, and efficiency, the vast majority of growth comes from massive investments in coal. "The coal issue is just staggering there."
  - While growth in energy efficiency and renewables has exceed expectations, the overall growth has been "completely marginal" to the expansion in coal and oil use. IEA projections anticipate that coal will remain the dominant force in the energy mix. Coal generation will increase by over 80% in non-OECD countries, outweighing reductions in OECD countries by several times. China continues to contribute the largest increase in coal-fired generation, accounting for two-thirds of the global increase through 2035.[1]
  - While on paper China has substantial shale gas resources (which may be overstated), its gas is in a much more difficult environment to access and the geologic conditions are different as well. Given that their gas infrastructure is poorly developed, we don't expect that gas will have the same moderating effect on coal use that we've seen in the United States.

1. International Energy Agency, 2012. "World energy outlook."

3. Interviewee reflections: the pairing of Chinese energy demand with positive political receptivity to climate change

Chinese economic growth has reshaped the global emissions map for the worse, but Chinese internal leadership on energy and climate is one of the few major bright spots in the overall picture since 2007.

- **We didn't anticipate this level of positive Chinese engagement:**
  - "*I don't think the Chinese behave how we thought they would*. We no longer think that the Chinese and Indians are going to prioritize economic growth at all costs. For example, there is a lot more work going on there now on climate impacts assessment." That change has the promise to shift the geopolitical dynamic hugely, as the biggest emitters may no longer see binding agreements as counter to their national interests.
  - On the positive side for China, there is growing momentum for action on climate. "The political wind is at our backs." "Pre-Copenhagen, China's attitude was that this is a developed world problem and that the developed world has to fix it. Now, there is a clear linkage between a domestic energy agenda and a climate agenda. Leadership at the highest level recognizes the importance of climate."
  - "The change in political awareness in China is a big shift." The Chinese government has been helped to see that, "It is time for China to internalize climate change." It is "no longer considered an issue that is for the West."
  - This has also happened in the *absence* of major US action: "There is a growing recognition in China on the US's inability to move quickly. It is very frustrating." "Copenhagen and the promise of international funding failed. Instead, China is funding its own national action plans."
- **As a result of this political receptivity to climate change, China has already taken some legitimate steps on energy and climate:**
  - For example, the growth in the solar and wind industries, vehicle fuel efficiency standards, investments in nuclear, national energy intensity, and carbon intensity targets, etc.. Efficiency has always been on China's energy agenda – there was a push on it in the last Five Year Plan. But leadership is increasingly cognizant of the fact that continued growth is imposing a very challenging energy security issue.
  - That said, "so far, they are doing things but you would not expect them to do really painful things – they are mostly doing things tied to jobs and investment."

3. Interviewee reflections: the pairing of Chinese energy demand with positive political receptivity to climate change

- **There is hope that China will do more, particularly tied to air quality and energy efficiency**
  - China may be a case of "enlightened despotism." The good thing about China is that "when it wants to, it can move faster than any other country in the world. Just look at the recent growth in renewables."
  - Air quality is going to be a driving issue. "The good news is that China is being forced to address the ground level criteria pollutants." They will need to clean up power plants, though the extent to which they'll deal with collateral carbon interests as they do that is certainly not assured. The government appears to be willing to let social media and public engagement occur around air quality, which is very encouraging. "The fact that state media and social media can editorialize on air quality suggests that the government is willing to move in this area."
  - The air quality work is also important in terms of cleaning up short term forcers. "The other thing that I think would make a lot of sense is to radically increase attention on pollutants (methane and soot)." A big effort on soot has the potential to improve climate forcing quickly, and comes with major health benefits. "China and India care about climate, but not that much; the soot politics are much easier."
  - In the longer term, there is also the possibility for climate change to become a relevant issue in China. According to polling data, Chinese citizens have heard of climate change as much as Americans and see it as a greater risk than Americans do. The Chinese government is already organizing a national "Low Carbon Day" for June and also announced that they are considering instituting a carbon tax.
- **The big question in China is how to create deeper engagement and drive change in the utilities and fossil fuel industry and in more senior ministries**
  - "In China, I would think that some of the market reform has been slower than we thought (for example, energy prices or incorporating a carbon price). We have seen a big boom and there is an incoming bust in renewable energy investment." This would be much less painful if the market pricing signals had been fixed. I would get inside the electric companies, coal companies, and utilities to see what makes them tick. Renewables are important, but these other companies are key. The utilities are being squeezed economically by fixed prices for electricity and fuel costs.
  - Philanthropy in China is a very immature field and giving goes to traditional philanthropic causes (e.g. poverty), not policy. "You don't mess with policy" in China.
  - Deeper engagement with industry and senior ministries is a key need, but as one interviewee commented, "the biggest challenge will always be implementation at the local level, not just in the senior ministries."

4. Interviewee reflections: the dramatic politicization of climate issues in the U.S.

The economic situation in the U.S. has shifted the dynamic for better and worse. Several interviewees commented on the double-edged sword of the Great Recession for the emissions picture in the United States.

- **The context in 2007 was a time of great hope and huge risks:**
  - Before DTW, we had Democrats in the ascendency, a hot economy, RGGI and AB32 making progress, 20 states with carbon plans, renewables and nuclear were both promising because of the high gas prices and strong RPS standards, there was the possibility of breaking transmission logjams with wind in the plains, presidential hopefuls were talking about climate, and Copenhagen beckoned.
  - However, at the same time, we also had a "disgusting" BAU trajectory with a heavy reliance on coal. With high natural gas prices, there was an expectation of locking in a huge new round of coal fired power plants. Consumers were concerned over rising gas and energy prices, as well as the loss of manufacturing due to high energy prices.

4. Interviewee reflections: the dramatic politicization of climate issues in the U.S.

- **In 2013, the situation is neither clearly better nor worse:**
  - **Political leadership:** Obama was elected and re-elected, but carbon policy has been "kicked down the priority list" and the partisan politics of climate change have soured dramatically with the rise of the Tea Party. Cap-and-trade died on the vine and there is no prospect for comprehensive carbon legislation in the near term. Public awareness and concern over climate also dropped substantially between 2007 and 2010.
  - **Economic constraints:** The Great Recession has shifted priorities substantially. "We're now in a situation where leaders think we can't afford to deal with climate protections." "The dominant framing now is that economic recovery is more important than climate protection." "The deficit is killing near term support for current low carbon technologies." On the other hand, the recession also tempered the demand trajectory, and ARRA put a substantial amount of money into energy efficiency. Cumulative emissions have actually dropped in the last 2 years, though they will rise again.
  - **Natural gas:** The development of fracking dramatically increased the supply of natural gas. In 2008-09, natural gas prices dropped to a point where they (along with the anti-coal campaign work and Clean Air Act) effectively killed the economics of new coal plants. In tandem with the recession, low natural gas prices have also created enormous economic pressure on renewables and nuclear, and as a result we have seen a chilling of the pipeline of new renewables. Since the US hasn't decarbonized, as the economy grows net emissions are expected to increase in the future, and the replacement of coal with natural gas may lock in fossil fuel infrastructure that will prevent us from meeting necessary carbon reduction goals.

4. Interviewee reflections: the dramatic politicization of climate issues in the U.S.

Politics and public opinion in the United states are far worse than they seemed in 2007, but they may be starting to rebound since 2010.

- **Climate is now a pawn of party politics:** Since 2007, the politics of climate change in the US has gone from bad to worse. While the two parties started moving in different directions in the 1990s, DTW did not anticipate how quickly climate was going to become politicized – between Fox News and the rise of the Tea Party, climate change became a litmus test for the GOP candidacy. "This issue itself has become a poster child for the polarization. It is a political litmus test." "A mistake that the field made was not recognizing how detrimental the client science attacks were going to be." That is true in both public opinion and elite opinion – the divergence in elite opinion is greater than the general public. The bipartisan, McCain-Leibermann approach no longer appears viable, and carbon legislation is not a near term option.
- **This has ended the potential for comprehensive federal legislation in the near term:** As a result, "the prospects for comprehensive climate legislation are essentially zero now." "I don't see another opportunity for cap and trade legislation for another three to four years. The next opening through Congress is likely to be 2016-17." A carbon tax coming out of the budget discussion is very long odds, but "a valuable bank shot." It's a "very low probability event."
- **Public awareness:** In tandem with the politics, public awareness of and interest in climate change has waned since 2007. "The overall context is pretty clear. We had a high water mark back in 2007, which was driven in large by media events and new precedents (*Inconvenient Truth*, the Academy Award, the Nobel Prize, the IPCC report, etc). Then we saw a substantial drop in a variety of indicators (belief, concern, engagement, etc.) which bottomed out in 2010 and has started to rebound. We aren't back to 2007 levels, but perhaps to 2008."

4. Interviewee reflections: the dramatic politicization of climate issues in the U.S.

Politics and public opinion in the United states are far worse than they seemed in 2007, but they may be starting to rebound since 2010. (continued)

- **The situation may be improving:** The "political landscape is tougher, much tougher, than it was in 2007, but it may be better now than 2010-2012." "I think 2012 election was the end of that period." The LCV helped knock out some of the worst offenders in Congress ("the Flat Earth Five"). Encouragingly, the rebound in public opinion has also happened in a very different context – most Americans think of climate change as a distant problem in time and space. "That has long been a real constraint. And that has started to gradually shift because of extreme weather events. Americans are connecting the dots themselves despite a complete absence of media drivers up until the last 9 months."

The advocacy landscape in the US is now increasingly framed around fighting coal infrastructure and building long term political power, rather than climate policy.

- **Focusing on killing off coal with Administrative Action:** With irrationally low natural gas prices, EPA standards on hazardous air pollutants, and new source standards, this is "a tremendous opportunity to get coal out." Tougher EPA standards are seen as the main opportunity in play over the coming years. "Given all the events in the US, this is *the* time to go after coal in a way that we couldn't have before." With existing authority, recent analysis suggests that Obama could reach the 17% reduction target without Congress acting. "Maybe there is a little bit of hope."
- **Focusing on states and regions:** As a result of the Federal logjam, "the politics have shifted back to the states, where deficits are a challenge." "The main area of movement is going to be states and regions. The politics is really shifting to states, regions, and regional power markets." Efforts on RPS standards are now actively being reversed by the right wing.

4. Interviewee reflections: the dramatic politicization of climate issues in the U.S.

The advocacy landscape in the US is now increasingly framed around fighting coal infrastructure and building long term political power, rather than climate policy.

- **Need for a longer political battle:** Underscoring every conversation about the US was a recognition that there is a need for a larger, longer political battle: “We need to build the politics. We have got to switch to creating the political landscape that allows us to set harder policies.” “DTW was an inside-the-Beltway kind of mentality.” “I have been jumping up and down for five years now. There is no serious effort to build an ‘issue public.’ That is a fundamental strategic mistake.” “Our side is brilliant on the policy work, but not very good on the basic work of people and politics. No elected officials feel like there are any consequences for where they stand on climate. We have no political swat.” The state work is actively taking on more political overtones by focusing on swing states and swing districts. The coal work may also have benefits in that killing coal may shift the allegiances of coal state votes. In the future, the best way to engage the “refusenik” Republican party on climate is unclear. Two basic options would be to either 1) push the GOP further to the right, making it less viable in national elections until there is recognition that climate change is an issue needed to appeal to independents (like David Cameron and the conservatives in the U.K.), or 2) to support and provide cover for moderate GOP members. “You have to change the political calculations for Republicans that are inclined to support climate policy, but are worried about the conservative base. It is about the primaries. Republican office holders are afraid of being challenged from their right flank.”

5. Interviewee reflections: European progress, but flagging momentum in the face of the economic downturn

Europe is on track to achieve its emission reduction goals, but is not seeing the same momentum it had several years ago.

The financial crisis has had an impact on how Europe is dealing with climate change

- While the downturn helped slow emissions, it has also had a chilling effect on Europe's international leadership.
- Similar to what has happened globally, leadership on climate has become much more regional, rather than top down, with progressive member states (e.g. Germany, Denmark, the UK) driving change rather than the European Commission.
- The option to increase the 20% reduction target to 30% has been effectively forestalled given the financial downturn and lack of an international agreement. The carbon market is suffering from the same effects. The recession substantially reduced the need for allowances to cover emissions, and the reduction target has not been ratcheted down in tandem.

Europe's power sector has not changed as substantially as the U.S.

- Unconventional gas has not followed the same aggressive development trajectory in Europe. Natural gas continues to be much more expensive in Europe than the US, and there has not been a broad switch to gas-fired power plants. As a result, coal is retaining an important role in the electricity generation mix.
- Growth in renewables has been impressive, thanks in part to policy support such as Germany's feed-in-tariff. However, nuclear appears poised to go through a pull back. In the wake of Fukushima, Germany has announced plans to phase out nuclear and other countries (e.g. Switzerland) have retrenched as well.
- "We are not paying proper attention to the grid." Further, investments in the grid infrastructure are needed to cope with higher levels of renewable energy.

Public interest in climate continues to build; Europe has not gone through the same politicization as climate in the US

- Europe has not had the same wave of climate denialism and conservative rancor as the United States. Public interest in climate has been fueled (rightly or wrongly) by extreme weather events, which provides "a sparkle of optimism."
- While civil society is frustrated by the slow pace of change, governments and NGOs are at least moving in the same general direction.

6. Interviewee reflections: increasing salience in India, tied to co-benefits

India has begun to incorporate mitigation into national planning efforts, but progress is slow.

- **The political narrative on climate has shifted in India to allow for more action on climate**
  - Climate change is a much more visible issue today than it was seven years ago, and media reporting is up, though the way that the issue is reported on has not changed much. The dominant narrative still revolves around sovereignty and North-South equity, or "the language of imperialism." As a result, comprehensive climate mitigation remains off the table.
  - However, the new consensus at the policy level is that India needs to *seem* to be caring about climate change for international reasons, and that India *should* care about it for domestic reasons. "It was dominantly a diplomatic problem 7 years ago. Now it is partly diplomatic and partly developmental."
  - As a result, India has adopted a national Plan of Action, due in part to G20 pressure. The plan has 8 missions: five on adaptation and three on mitigation. Those missions have become useful in driving a climate agenda. "It has actually had an effect, even though it was set up hastily, and almost as window dressing." In addition to the national work, around 22 states in India are preparing state action plans.
  - "I'm optimistic… The language of the policy is changing, the principles the public sector is adopting today are changing… Today we are seeing much more engagement… There may be a certain latent period before we will see the effects show up. But the direction of change is what is important."
- **The co-benefits rationale has opened doors, though in a different way than expected**
  - The national action plan talks about co-benefits as the way forward, though the primacy of benefits is reversed: In India, the emphasis is on development actions that bring mitigation gains as a co-benefit. This framing has been useful because it allows for action on mitigation without the worrying about raising the country's baseline or capping growth.
  - "If you go back to the DTW exercise, it was driven by tons: it was very CO_2 centric. In the developing world, the CO_2 issue had to be pegged to co-benefits. It has become much sharper now. Co-benefits make it much more relevant."

6. Interviewee reflections: increasing salience in India, tied to co-benefits

India has begun to incorporate mitigation into national planning efforts, but progress is slow

- **Energy security and air pollution are more pressing drivers for mitigation actions than climate**
  - Energy security is the predominant driver of action currently: "it has risen up the political agenda…The dominant obsession is the slow down in India's growth." Energy security could drive grid restructuring, energy efficiency, appliance standards, and renewables build-out. However, energy security is also a pressing rationale to increase the construction of coal-fired utilities (though political unrest in coal producing regions and forest protections will likely slow significant expansion).
  - Air pollution is an emerging issue in India: While there has been recent notable global focus on Beijing's air pollution, Delhi's air pollution is also high, and deaths from air pollution are increasing. Smog has yet to rise to the same level of prominence as in China ("it hasn't really emerged as a big issue"), but is on the rise. So far, local air pollution has not become a driver of change to the same extent as energy security.
- **However, the slow economy and governance implementation challenges have weakened progress**
  - The downturn has reduced the prospects for investment in renewables and also in enforcement. "In India what we have seen in the last few years, as far as the environmental action is concerned, is that government budgets are very weak on the environmental mandate." In tandem, the public perception of the risks associated with climate change "took a back seat to the economy… Concerns over the job loss implications of climate policy has meant that support has been weaker than hoped."
  - Despite national action, implementation at the state, regional, and local level has also been problematic; for example the implementation of transportation plans and building codes in cities is stymied by the lack of capacity on the ground. More generally, governance issues in energy continue to pose a challenge: the gaming of contracts in O&G, a recent coal allocation scam, political opposition to reducing fossil fuel subsidies, etc.

7. Interviewee reflections: Brazil and Mexico have adopted a stronger leadership role

- **Brazil and Mexico have shifted to a more proactive stance on climate change**
  - In 2007, Brazil and Mexico were firmly ensconced in their position as non-Annex 1 countries, with Brazil strongly advocating that the global South lacked any climate obligations. In the lead up to Copenhagen, these countries substantially altered their position for the better, perhaps seeing the negotiations as an opportunity to take a leadership role. Brazil made commitments to reduce its emissions by 40% by 2020, and Mexico 30% by 2020 against business as usual trajectories.
  - Following Copenhagen, both Brazil and Mexico have passed national framework climate change legislation. Brazil's legislation codifies their 40% target, while Mexico's lays the groundwork for carbon markets, creates an office of climate change, and implementing guidelines for ministries.
- **Implementation challenges in both countries loom on the horizon**
  - Climate work is now transitioning from the "chic" dialogues and commitments to the "hard slog of implementation." It is going to be a major test to write robust sectoral implementation plans, as the governments lack institutional capacity to craft strong climate policies. There is a tension emerging between the climate advocates and policy makers concerned about their constituents.
  - With the recent downturn in the economy, climate has taken less and less of a role in policy discussions. "The president of Brazil does not care about climate. She cares about jobs and development. Why would Brazil do anything that is going to hurt its competitiveness." Recent climate policy wins have been associated with economic development (e.g., tax incentives for efficient vehicle purchases) or clear co-benefits.
- **Forestry has been a major win in Brazil, and attention is turning to other sectors**
  - Through a combination of tools, Brazil completely altered deforestation trends in the Amazon. Now government and civil society are looking at the transportation and energy sectors, but it has been difficult to demonstrate sufficiently strong co-benefits there to date.

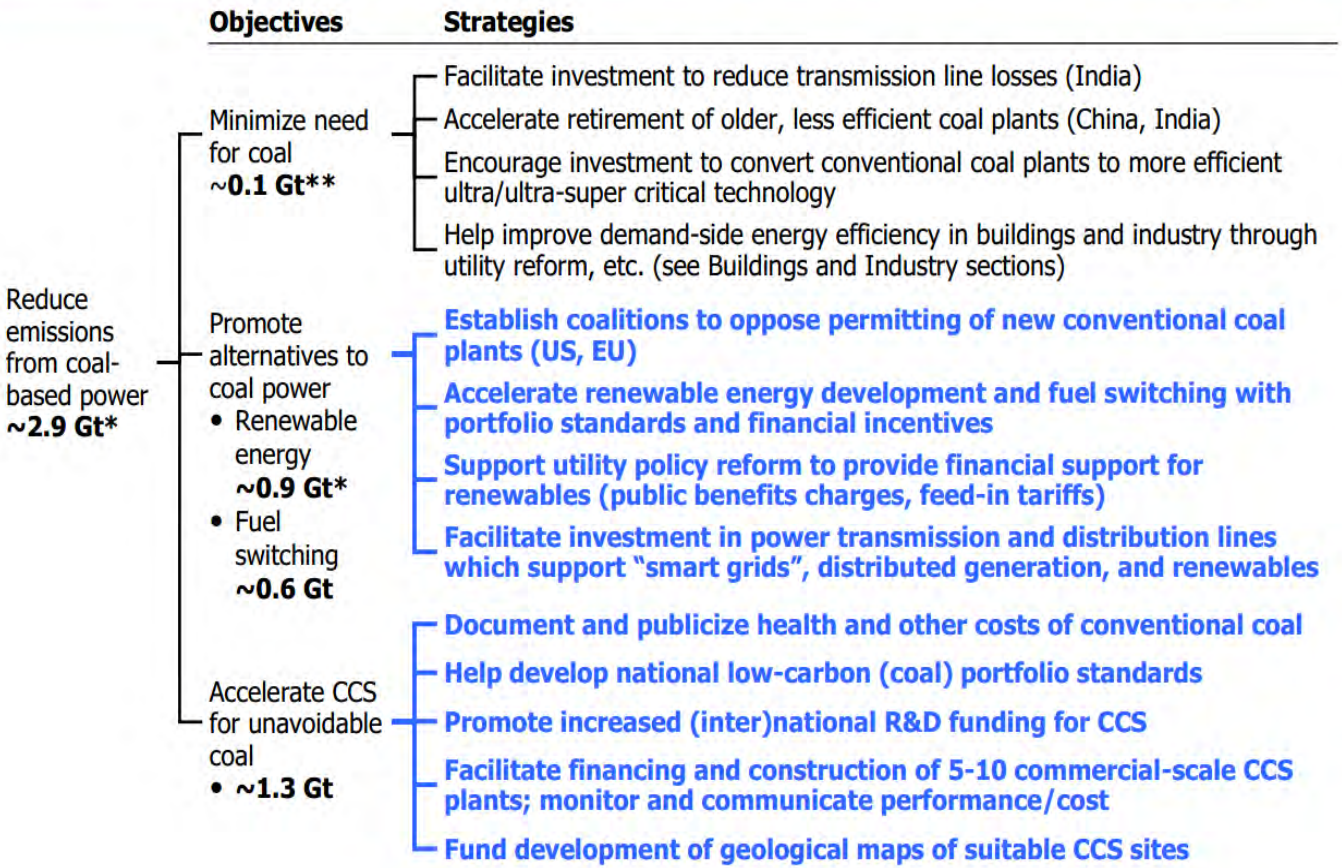
SECTORS

POWER

Interview reflections on the power sector – Original DTW framework

Power Sector - DTW identified the following interventions as the largest sources of mitigation potential: CCS (~3GT), Nuclear (~1.5 GT), Renewables (.75 GT), Efficiency and fuel switching (.75 GT). The mitigation potential was believed to be evenly distributed between OECD countries and Non-OECD countries.

FIGURE 12: Philanthropy Can Help Avoid Coal and Implement CCS (DTW Priorities Highlighted)



California Environmental Associates, 2007. "Design to Win: Philanthropy's Role in the Fight Against Climate Change"

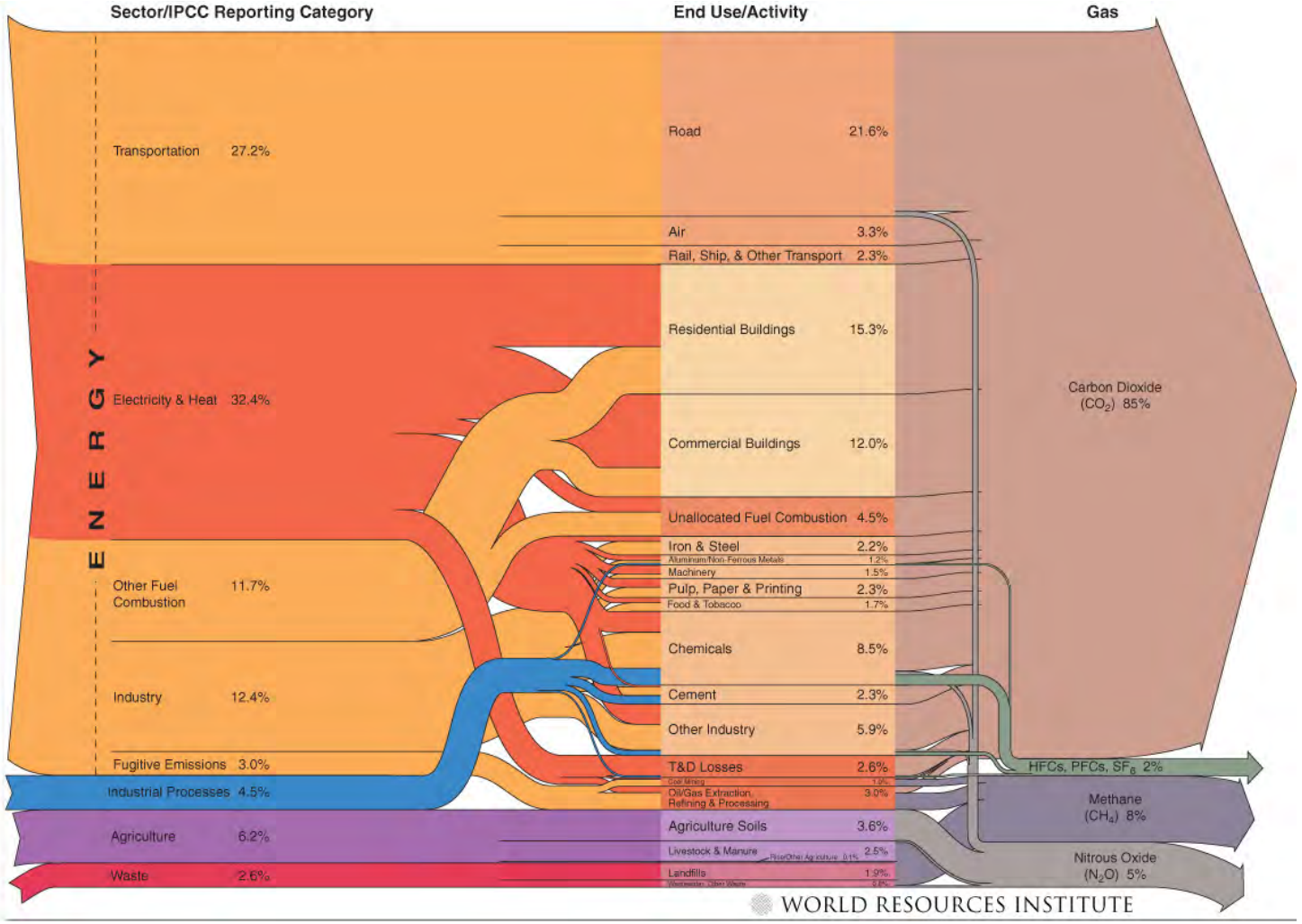
Power sector: main themes

- **Overarching trends** – Electricity demand outpacing forecasts and more concentrated in the developing world than expected. No major changes in the generation mix forecast.
- **Coal** – Forecasts for coal slightly lower as a percentage of generation, but coal is till expected to dominate generation in the future.
- **Natural Gas** – In regions where fracking is taking off, natural gas is displacing coal as the most cost-effective generation source.
- **Carbon Capture and Sequestration** – Wider uptake of CCS remains elusive, and will require substantial policy support
- **Nuclear** – Despite Fukushima, forecasted nuclear development has not changed substantially.
- **Wind** - Deployment of wind has been faster than expected driven by policy and technological improvements. Overall share still expected to be low.
- **Solar** – Strong policy support and technological improvements for PV solar have led to capacity outpacing forecasts. Overall share still expected to be low.
- **Energy Efficiency** – The recognition of energy efficiency as a cost-effective resource has grown in recent years, especially in the U.S.

Both supply and demand side work are important for reducing emissions in the power sector

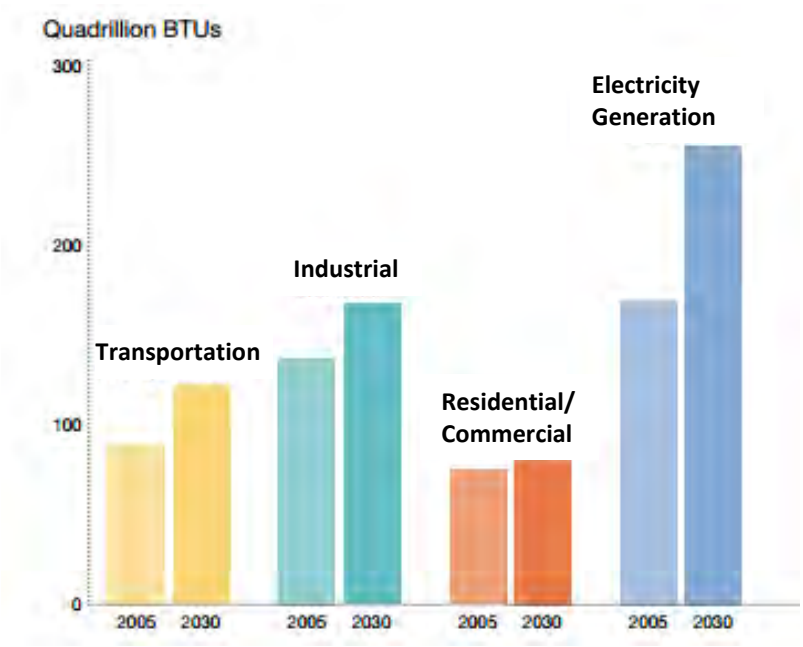
The following section focuses primarily on supply side efforts that can reduce emissions from power generation. Demand-side energy efficiency efforts in the buildings and industrial sectors are important strategies for reducing GHG emissions from the power sector and are discussed in those sections of the report.

US GHG Emissions Flow Chart

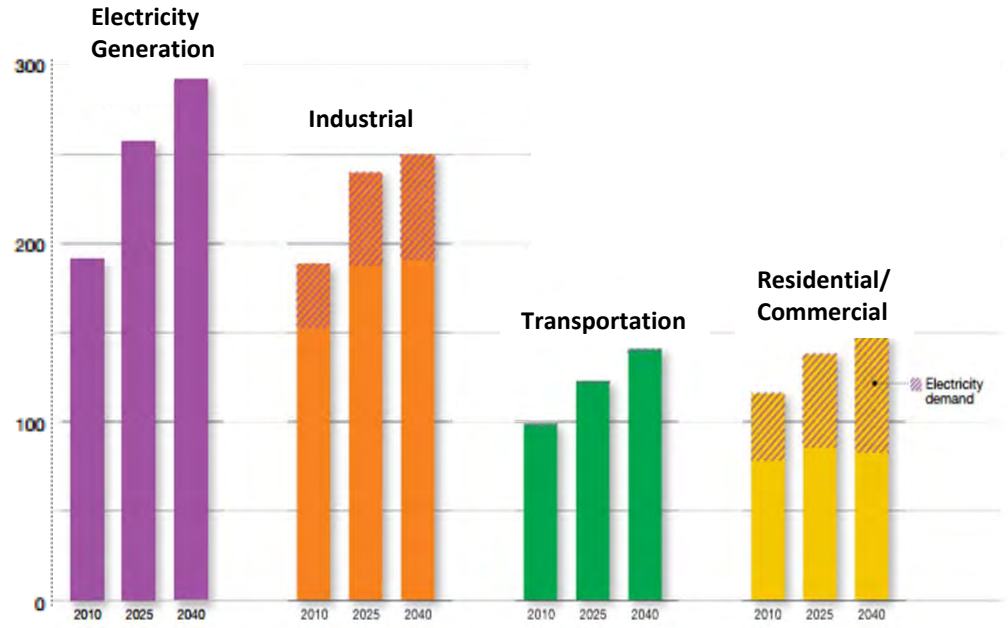


World Resources Institute, 2008. "U.S. Greenhouse Gas Emissions Flow Chart." Retrieved April, 2013. http://www.wri.org/chart/us-greenhouse-gas-emissions-flow-chart

The power sector is still expected to be the fastest growing energy-consuming sector



2009 WEO forecasts

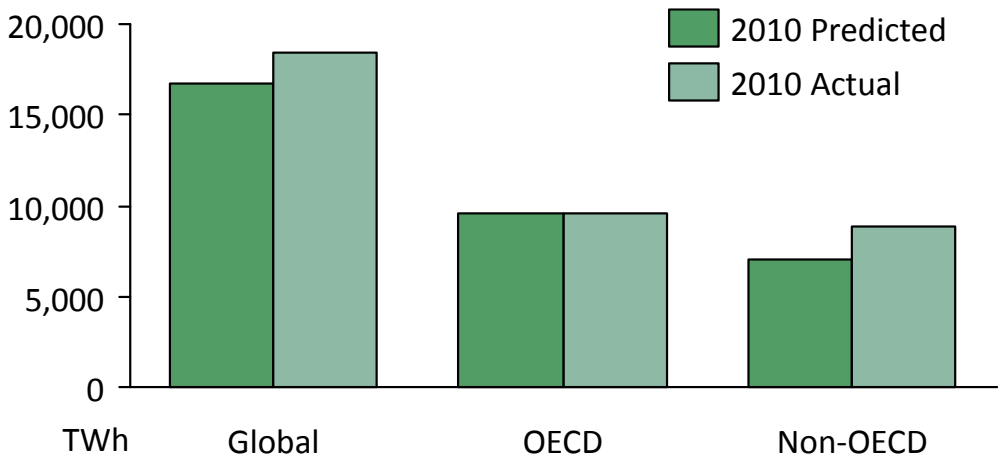


2013 WEO forecasts

Exxon Mobil, 2009. "The outlook for energy: a view to 2030"
Exxon Mobil, 2013. "The outlook for energy: a view to 2040."

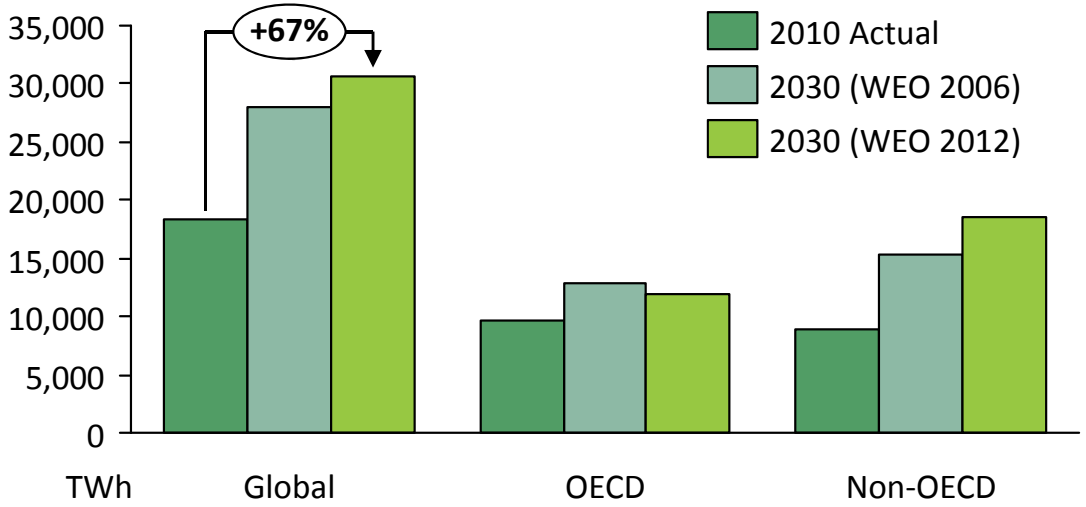
Mirroring economic growth forecasts, electricity demand is growing faster than expected in non-OECD countries

Predicted and actual annual electricity demand



Demand from non-OECD countries faster than expected
Growth in non-OECD countries has been faster than expected, driven by strong economic growth.

Forecasted annual electricity demand

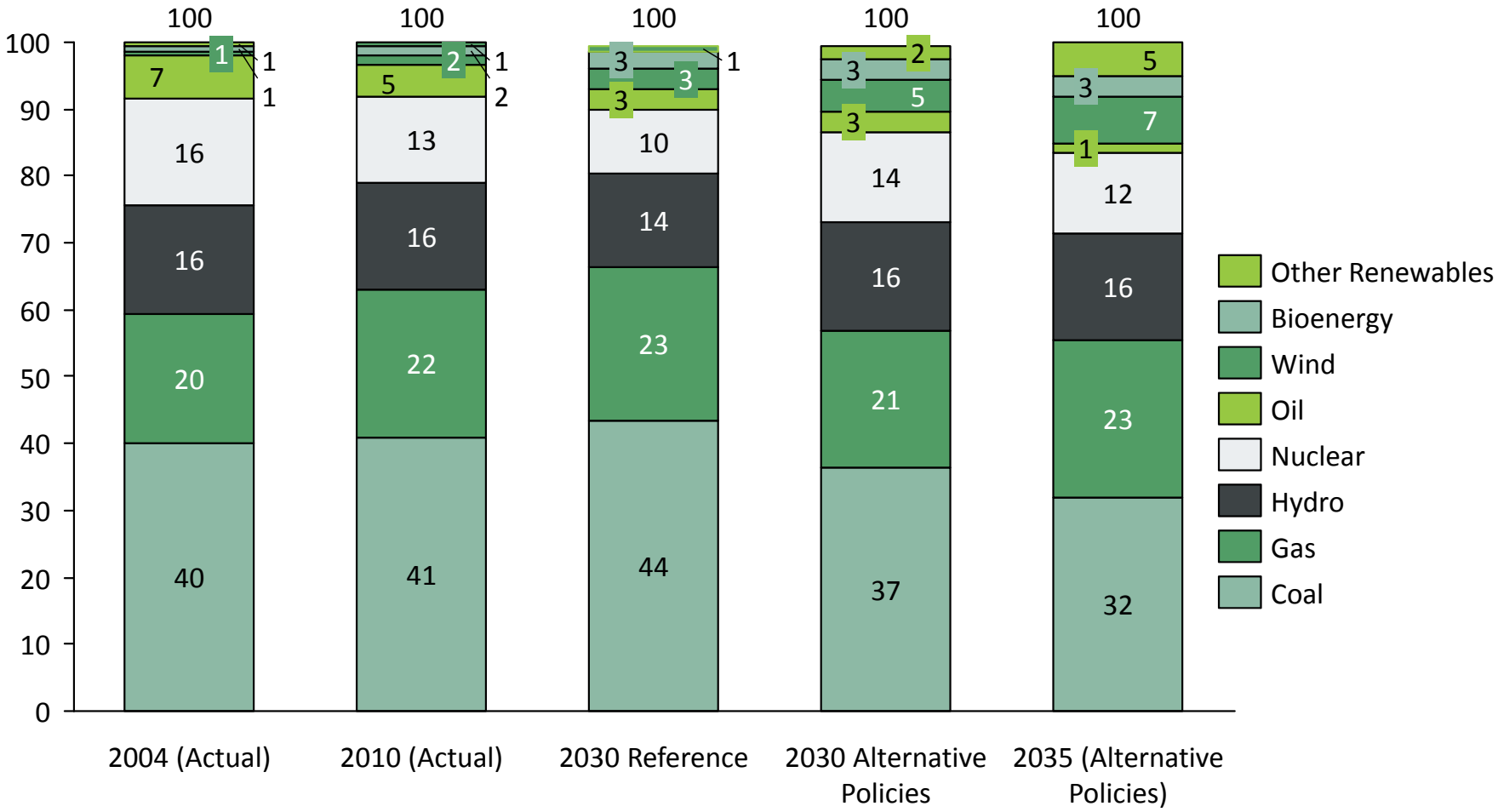


Non-OECD countries will continue to be the main drivers of demand growth
Global electricity demand is expected to grow by more than 70% by 2035, with more than 80% of the growth in non-OECD countries. Over half of the demand growth will come from China and India.

International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook."
2030 estimates from 2012 report calculated using compound annual growth rate between 2010 and 2035; 2010 estimates calculated by applying constant growth rate based on 2004 actual demand and 2030 estimates.

Predictions for the generation mix have changed slightly, with coal forecasted to have a lower share and renewables a higher share than forecasted in 2006.

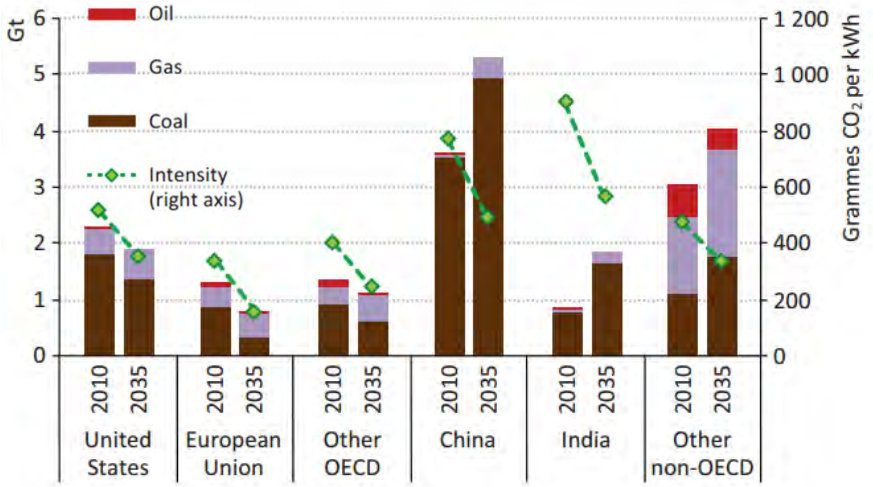
Share of Global Electricity Generation



International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook."

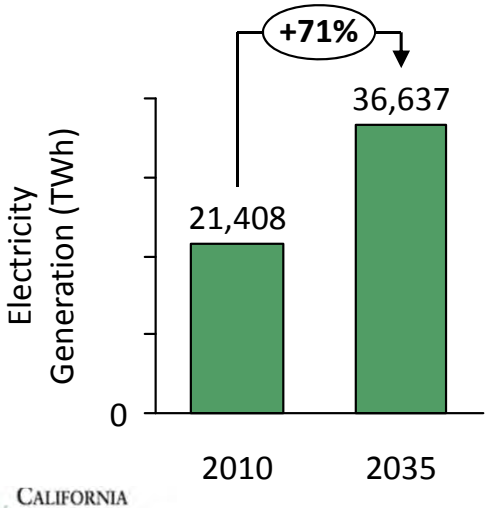
Changes in the generation mix are reducing emissions factors, but not enough to offset increased electricity demand. Power sector emissions forecasts are higher than 6 years ago.

Annual power sector emissions and emission factors

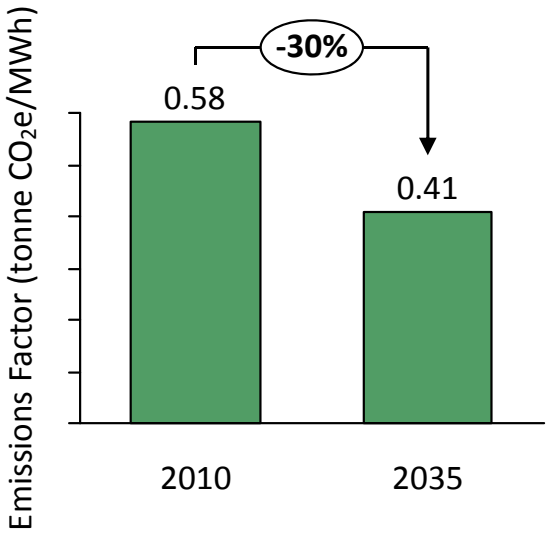


- Carbon intensities are expected to decline significantly in all regions of the world, but gains are more than offset by increased demand in developing countries.
- Without improvements in emissions factors, CO_2 emissions from the power sector could increase by 8 GT by 2035 instead of the 2.3GT currently forecasted.

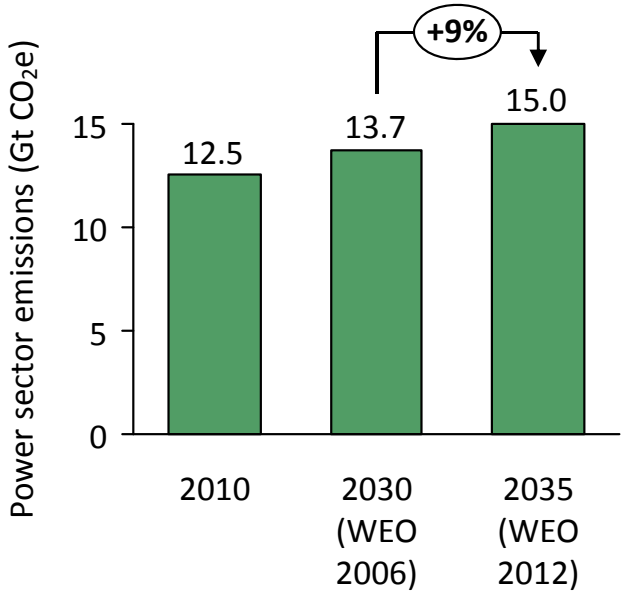
Electricity Generation



Emissions Factors



Annual Power Sector Emissions



International Energy Agency, 2006. "World energy outlook." alternative policy scenario
International Energy Agency, 2012. "World energy outlook." alternative policy scenario

CEA California Environmental Associates

Power sector: main themes

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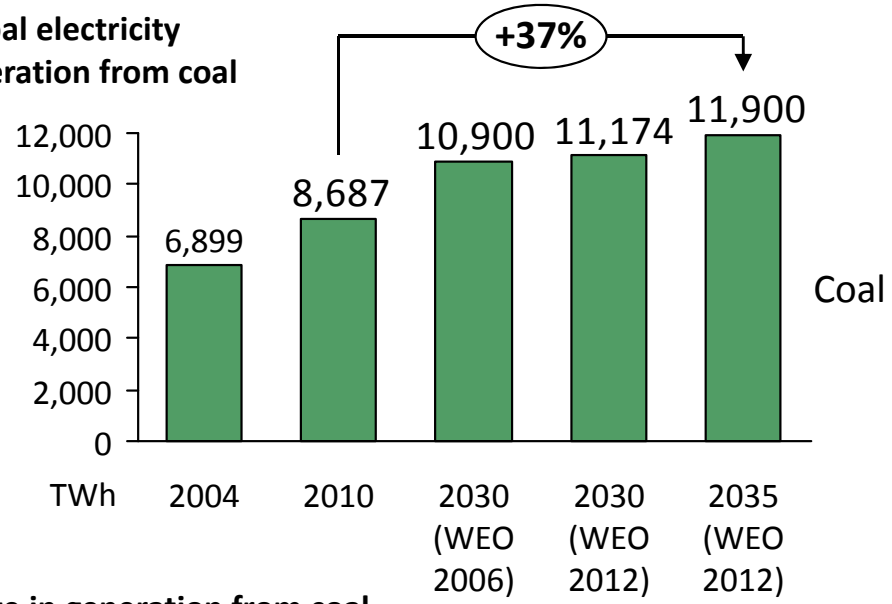
- **Energy Efficiency** – The recognition of energy efficiency as a cost-effective resource has grown in recent years, especially in the U.S.

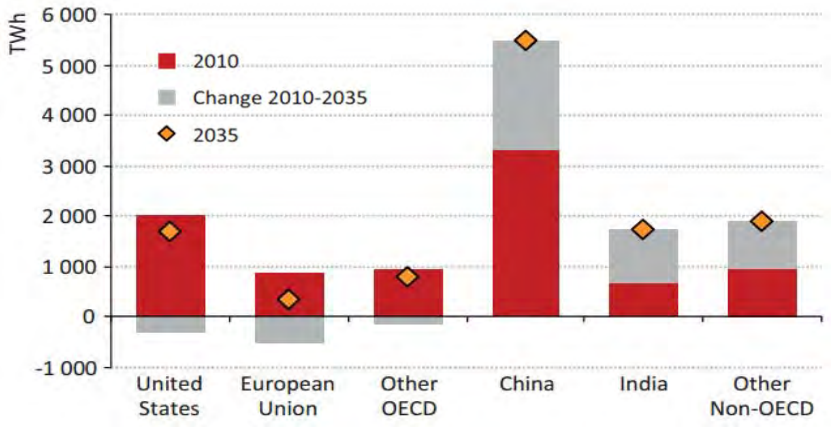
No significant changes expected in total generation from coal. Reductions in OECD countries will be overwhelmed by additional coal generation in developing countries.

Global electricity generation from coal



- Despite the progress against coal in OECD countries, coal generation is still expected to increase by 37% by 2035 under the alternative policies scenario.

Change in generation from coal 2010-2035 (Alternative Policies Scenario)



- Total coal generation in OECD countries is expected to decline, but this will be more than offset by incremental coal generation in the rest of the world.
- India and China are expected to account for more than 70% of incremental coal generation between now and 2035.

International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook."
2030 estimates from WEO 2012 estimated using a constant compound annual growth rate from 2010.

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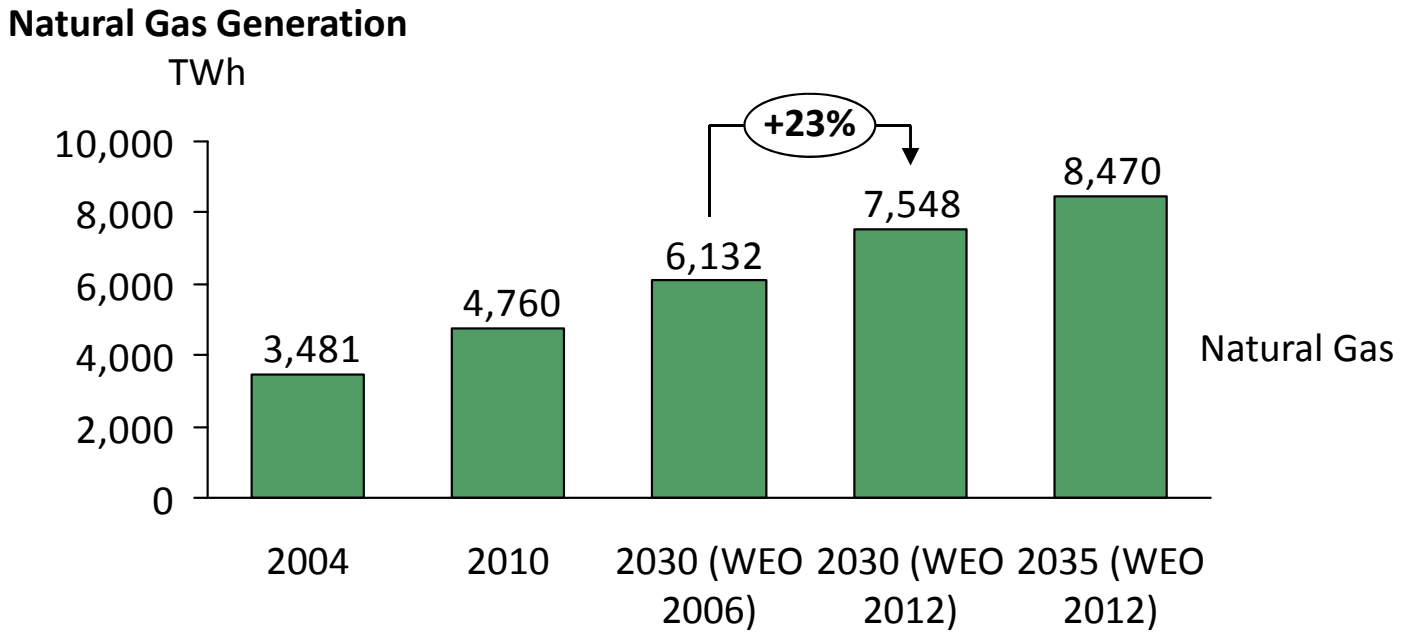
Forecasts for natural gas are greater than previously expected, driven by increases in electricity demand and cheap shale gas in the U.S.

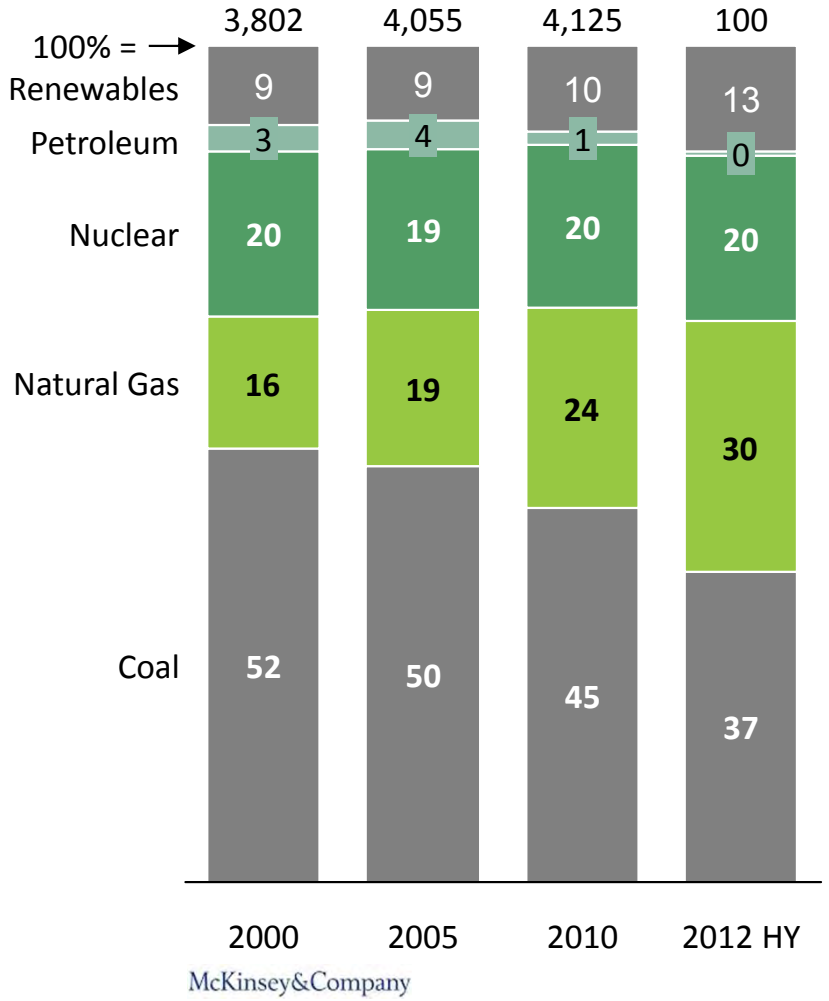


International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook."

Cheap shale gas has driven a substitution away from coal in the power sector in the U.S., contributing to an 11% decline in emissions from that sector

US power sector generation by fuel

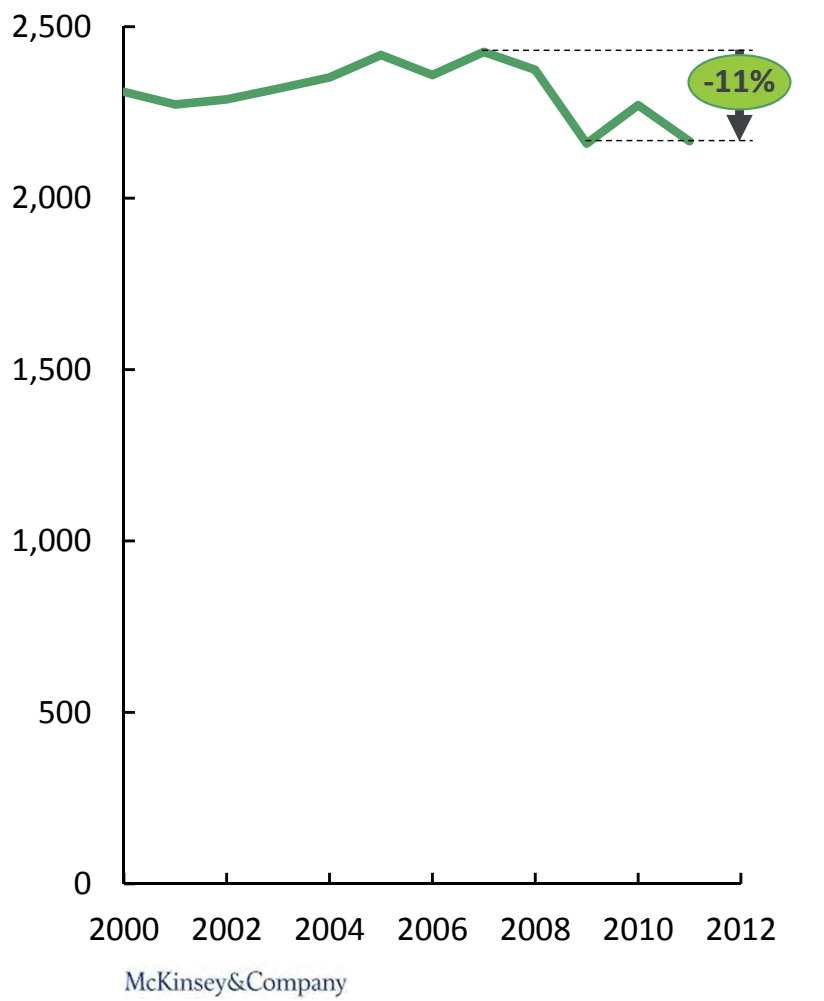
%; TWh



McKinsey&Company

US power sector CO2 emissions

MtCO2

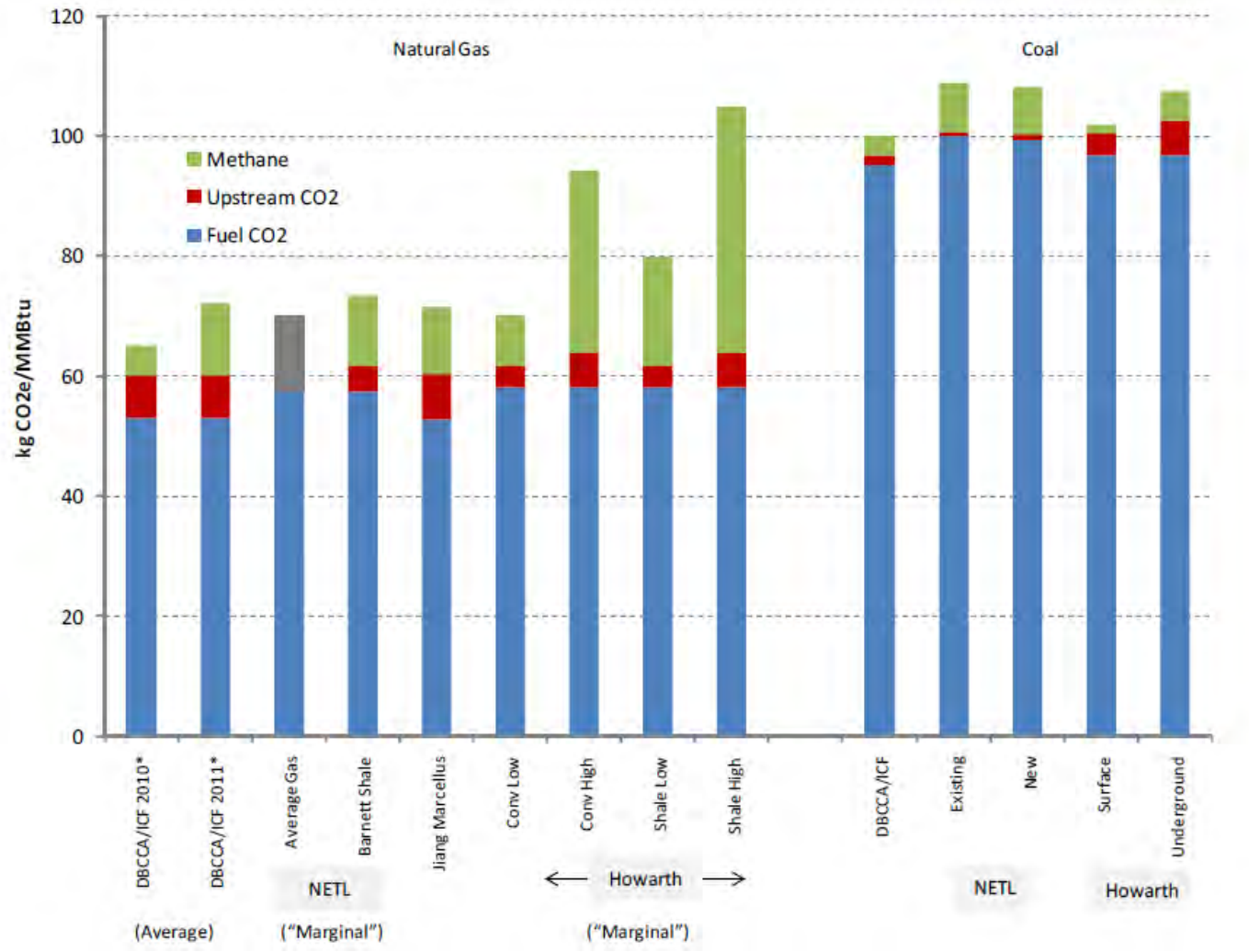


McKinsey&Company

McKinsey Analysis based on U.S. Energy Information Administration. Electricity Data. Retrieved November, 2013. http://www.eia.gov/electricity/data.cfm

Natural gas generation is replacing a portion of coal retirements, but there is uncertainty about the net emissions savings from natural gas.

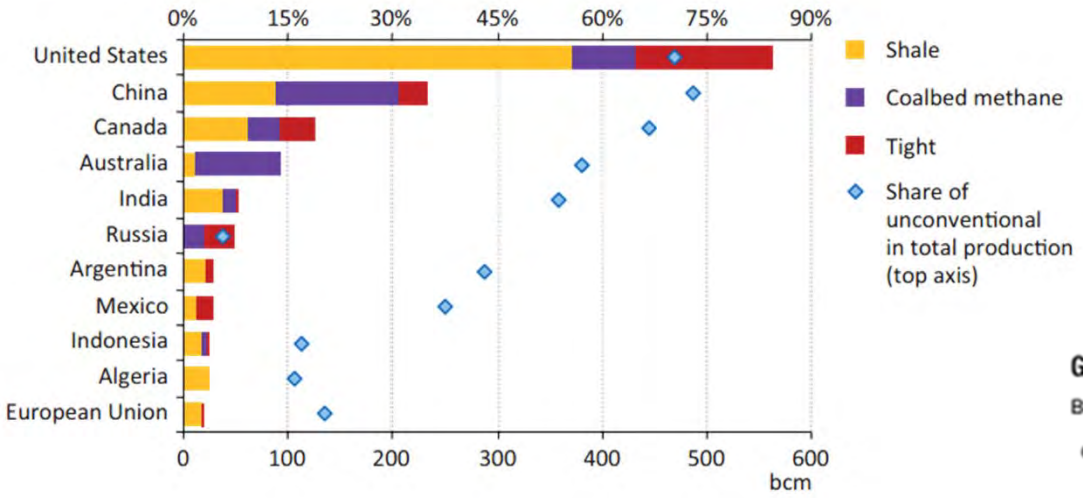
Comparison of recent bottom-up life-cycle assessments of coal and natural gas



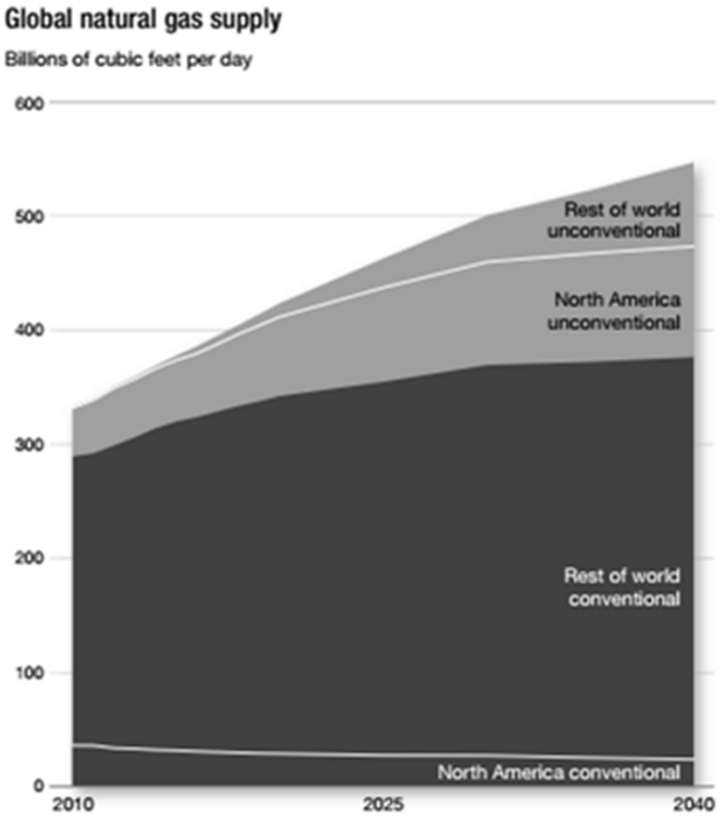
Fulton et al., 2011. "Comparing life-cycle greenhouse gas emissions from natural gas and coal." Deutsche Bank Group.

Shale gas is revolutionizing the U.S. market, but the global impact may not be as profound

Unconventional gas production in leading countries in 2035 (New Policies Scenario)



- North America is forecasted to be the dominant producer of unconventional natural gas for the foreseeable future

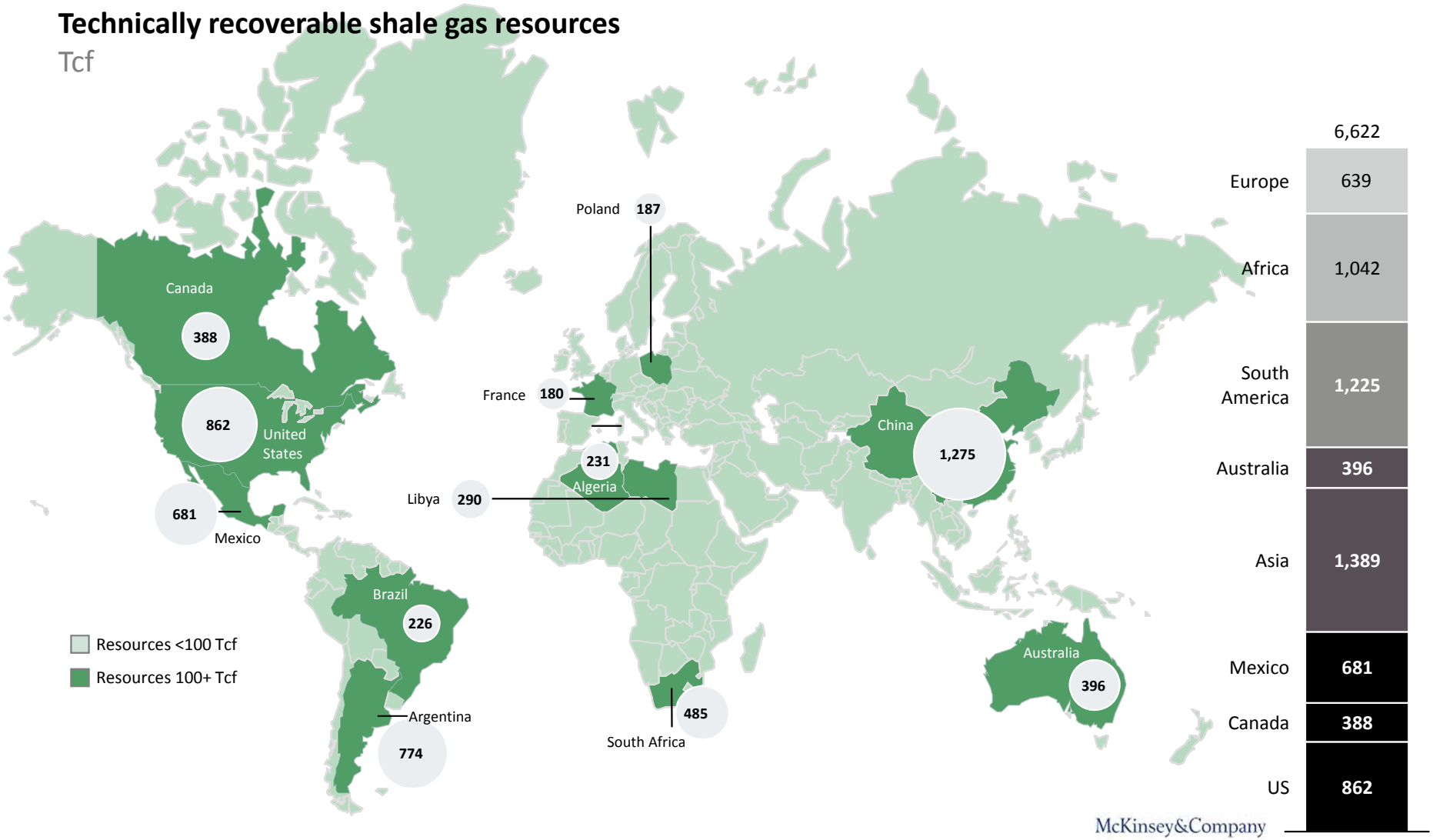


International Energy Agency, 2012. "World energy outlook."
Exxon Mobil, 2013. "The outlook for energy: a view to 2040."

Vast majority of unconventional gas resources are outside the US and Canada, but are not likely to be developed rapidly in the near future

Technically recoverable shale gas resources

Tcf



McKinsey&Company

McKinsey analysis based on U.S. Energy Information Administration, 2011. "World Shale Gas Resources: An Initial Assessment of 14 Regions."

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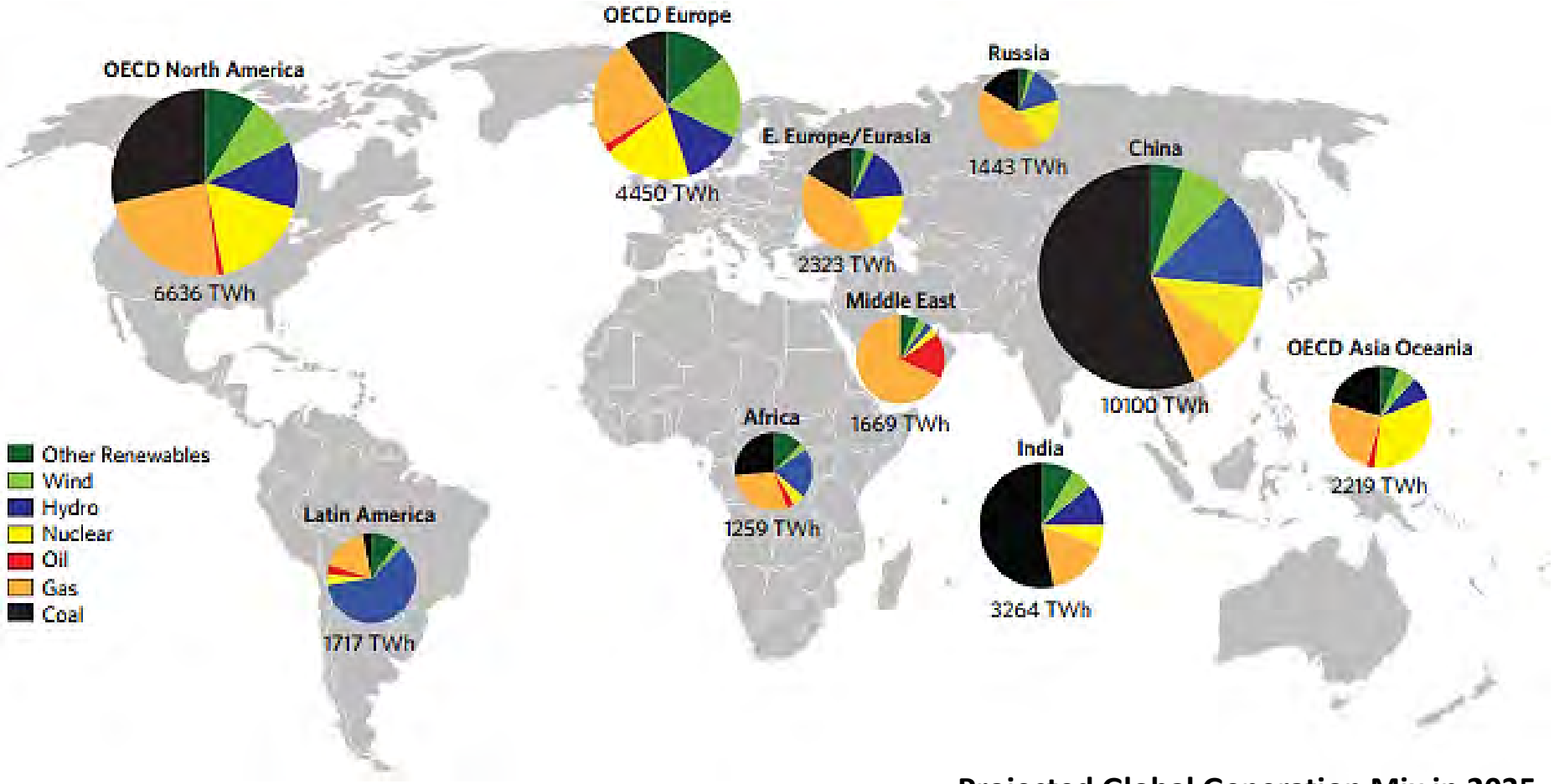
Forecasts for the generation mix are still calling for large shares of coal and natural gas, demanding a CCS solution if we are to meet deep CO_2 mitigation targets

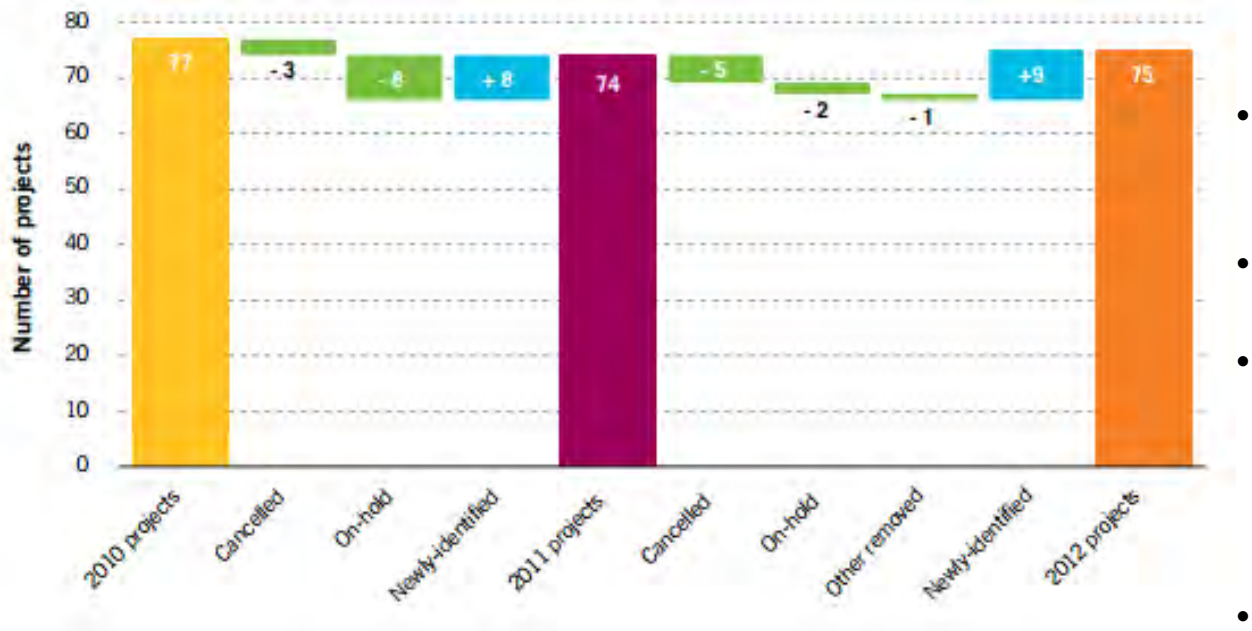


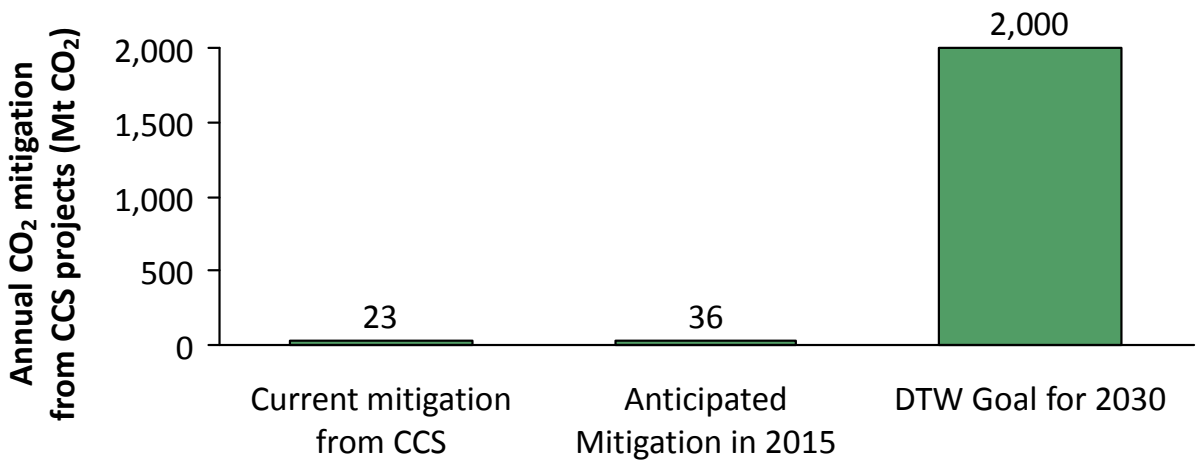
Projected Global Generation Mix in 2035, New Policies Scenario

International Energy Agency, 2011. "World energy outlook."

Design to Win flagged CCS as a priority for carbon mitigation, but progress has been limited

Changes in Large Scale Integrated Projects from 2010-2012





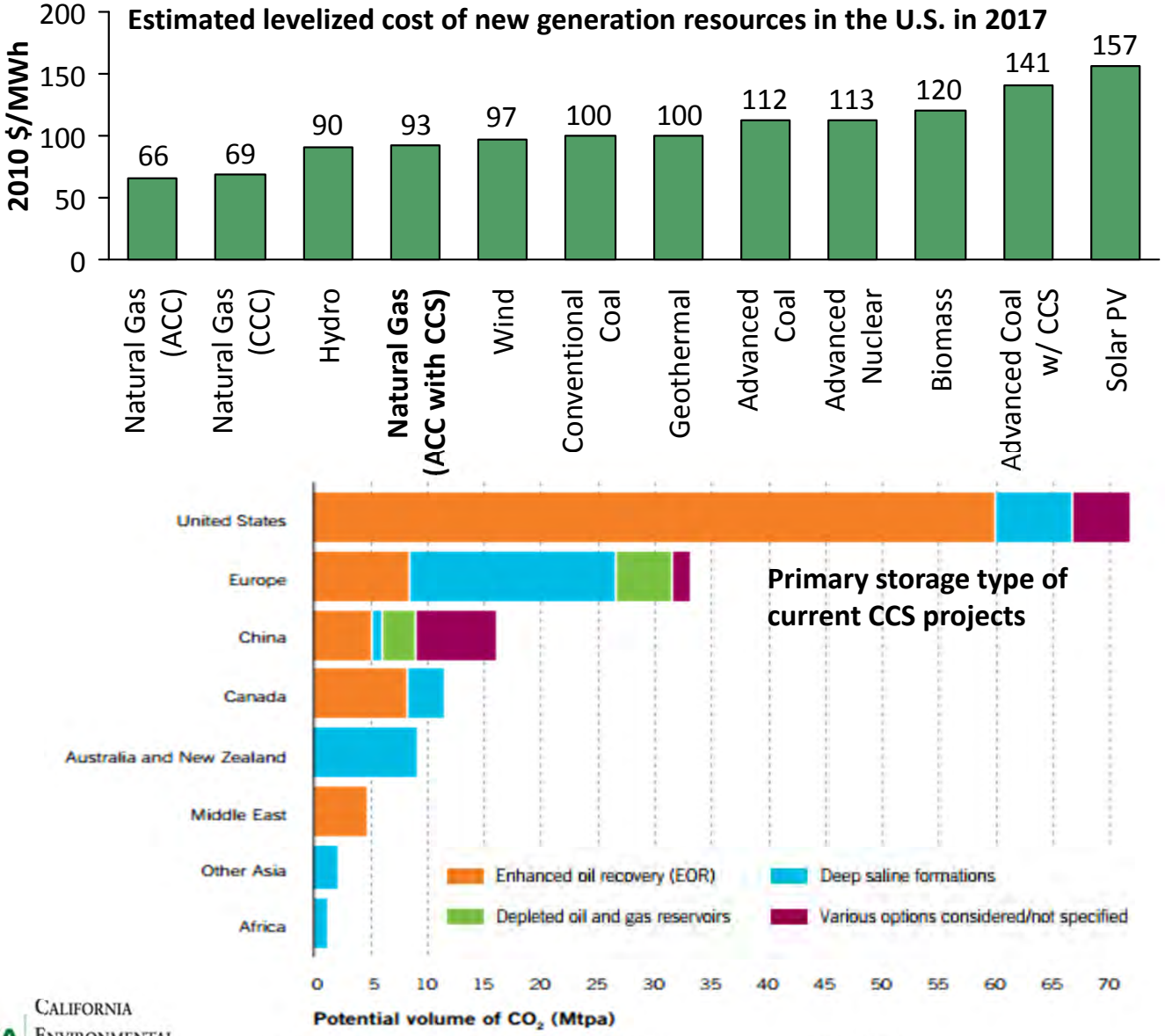
- Challenging economics are resulting in CCS cancellations and project delays.
- Only eight of the current projects are operational, with an additional eight under construction.
- Current projects are mitigating just 23 Mt CO2 per year
- CCS has not received comparable policy support to renewables, which partly explains its slow pace of deployment.

- The World Energy Outlook did not include CCS in its reference or alternative policy scenarios in 2006.
- Little has substantively changed with regards to CCS as it is still a technology play in need of economic support
- To meet aggressive targets, hundreds of large scale CCS projects need to be in operation in the 2020s

CEA California Environmental Associates

Global CCS Institute, 2012. "The global status of CCS 2012."
California Environmental Associates, 2007. "Design to Win: Philanthropy's Role in the Fight Against Climate Change"

Low natural gas prices and enhanced oil recovery have changed the landscape for CCS, but widespread adoption is still unlikely



- Natural gas CCS appears to be headed towards being cost competitive with other low-carbon options in the U.S., but will still require policy support for wider adoption

- Enhanced oil recovery (EOR) is the storage mechanism for the majority of CCS projects worldwide.
- But, at current U.S. CO_2 prices of 10-40 dollars per ton, CCS will still require policy support to be competitive with fossil generation without CO_2 capture.
- There is some evidence that CCS projects with EOR in China may be cost competitive.

U.S. Energy Information Administration, 2012. "Annual energy outlook 2012."
Global CCS Institute, 2012. "The global status of CCS 2012."

CEA California Environmental Associates

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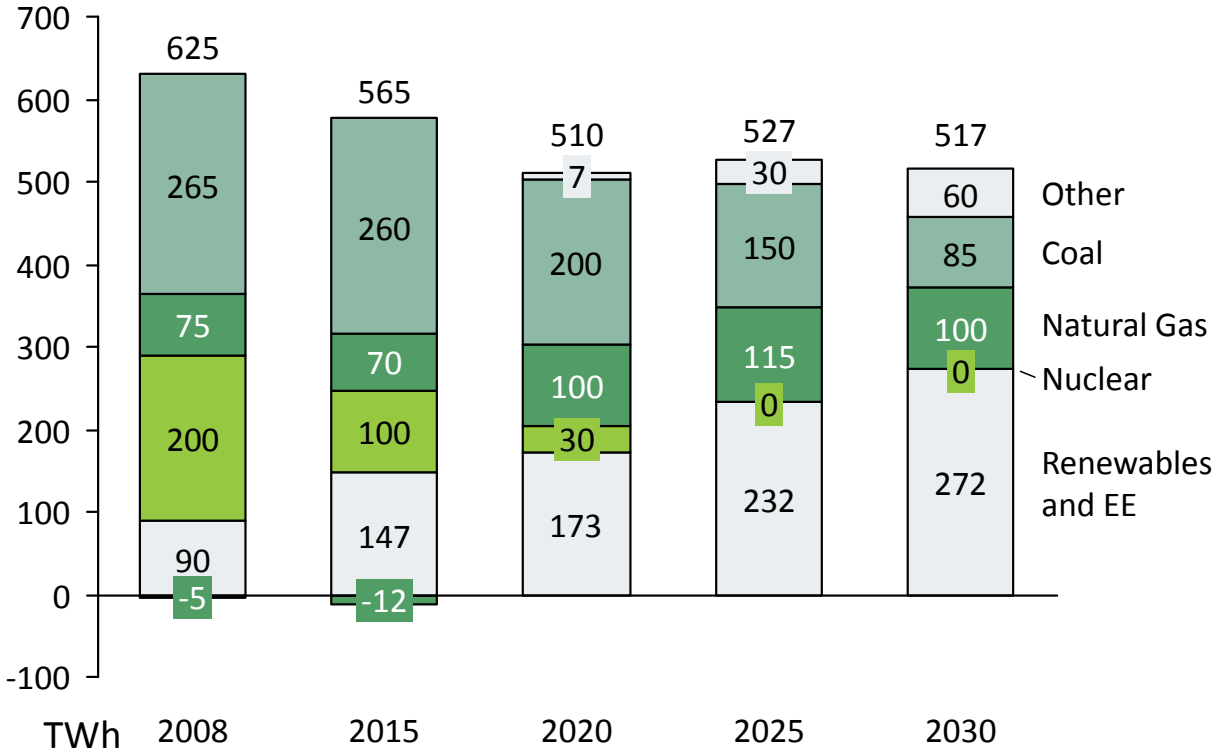
After Fukushima, some countries made pledges to phase out nuclear

- Germany pledged to eliminate nuclear power from its generation mix by 2025. Fukushima as well as lofty renewable goals may both have played a part in the decision.
- Switzerland has pledged to not build any more reactors
- In Japan all reactors were shut down following the disaster, and only two have been granted permission to restart
- In China there have been delays in issuing permits for new facilities

Germany's planned changes in generation mix

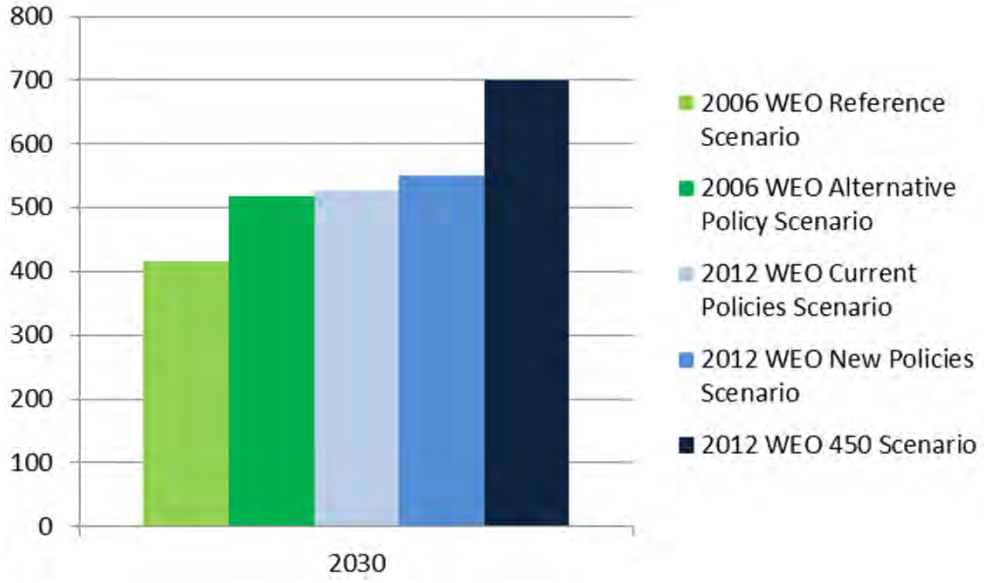


Prognos, EWI, and GWS, 2011. "Energieszenarien."

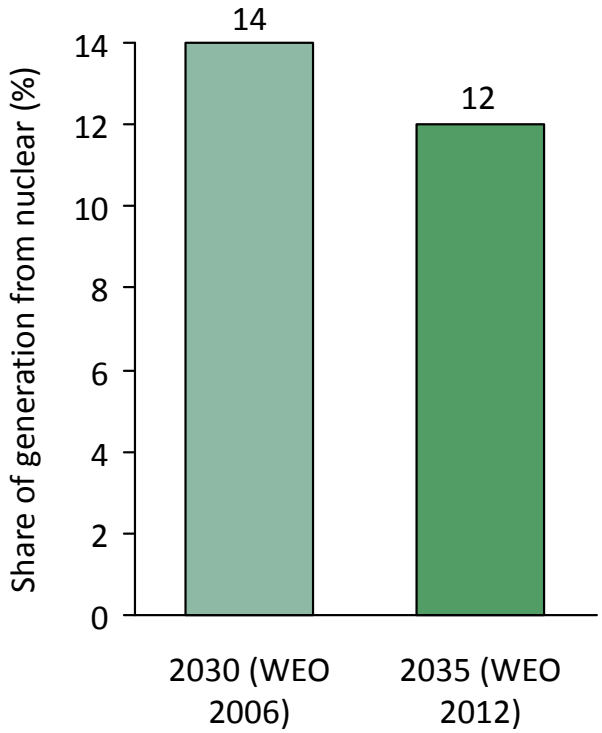
Nuclear power's global prospects have actually improved slightly since 2006 from a total generation perspective, but have declined as a share of total generation

- All 2012 WEO scenarios (which take into account the impacts of the Fukushima Daiichi accident) forecast installed capacity in 2030 to be above the high end of the 2006 range (526-629 GW, supplying between 10%-19% of global electricity).

Projected 2030 Installed Nuclear Capacity (GW) from 2006 and 2012 International Energy Agency (IEA) World Energy Outlook (WEO) Scenarios.



Share of generation from nuclear under the alternative policies scenarios

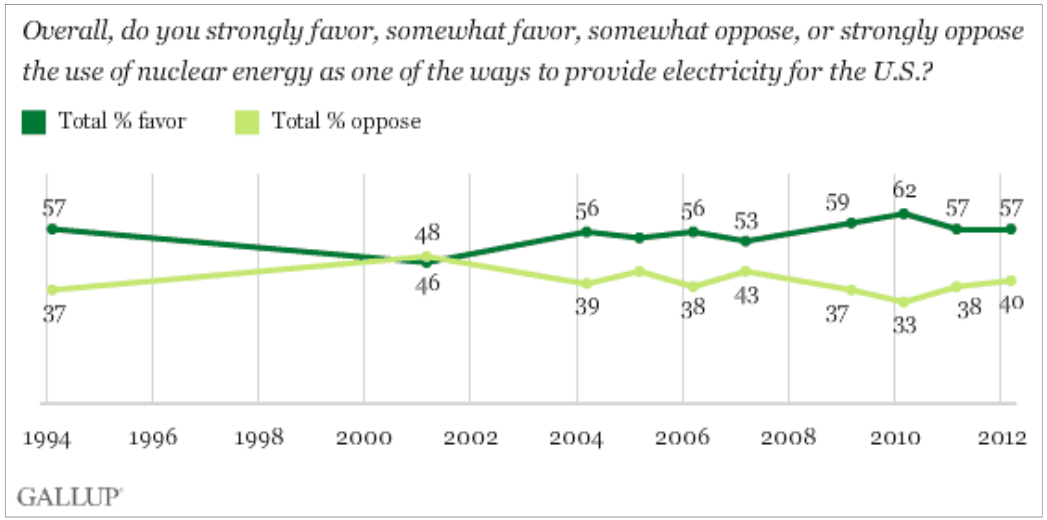


International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

Fukushima had little impact on the public perception of nuclear power

- **Nuclear Renaissance Derailed by Fukushima?** Fukushima does not appear to have fundamentally altered the underlying economic and policy dynamics affecting nuclear power growth in most countries & regions. While several countries have abandoned plans to build new nuclear reactors, and post-Fukushima forecasts are limited, most forecasts continue to call for installed nuclear capacity to grow in-line with global electricity demand, maintaining its current share of overall electricity production. Examples of national responses to Fukushima:
- **China.** Reduced pre-Fukushima 100 GW installed capacity target for 2020 by 10 GW post-Fukushima. However, many considered the goal unrealistic and the reduction may have reflected non-safety considerations.
- **Japan.** Commitment to phase out nuclear by 2040 unlikely to withstand political scrutiny from newly-elected government.
- **Germany.** Commitment to phase out nuclear by 2022.
- **United States.** No meaningful policy change beyond safety review of all nuclear plants. Other economic factors (e.g. low natural gas prices) at play in limiting nuclear power growth.

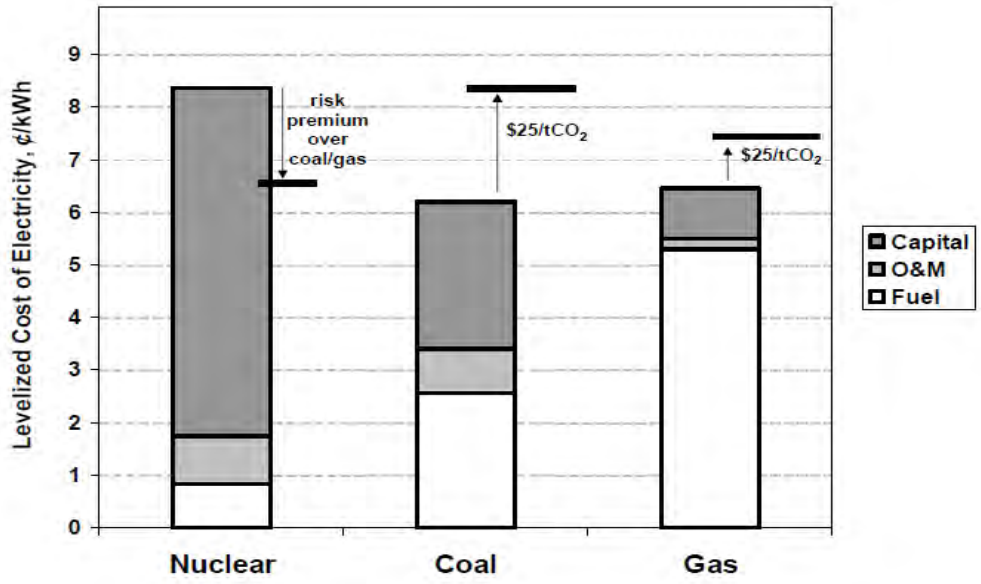
Survey of U.S. resident opinions on nuclear power (1994-2012). Fukushima impacts on long-term public sentiment trends appear to be minimal.



Joskow et al., 2012. "The future of nuclear power after Fukushima."
Newport, 2012. "Americans still favor nuclear power a year after Fukushima." Gallup.

Better economics help to drive nuclear power development in parts of Asia…

- Nuclear is expected to remain more expensive than coal or gas globally, but this price premium declined from 63% to 35% from 2003-2009.
- This price difference masks regional variability that makes nuclear more attractive in certain parts of the world. Price forecasts for China are almost 100% lower than the U.S. primarily due to lower permitting costs (and lower likelihood of regulatory delays) and lower capital costs (public financing). These price forecasts may be optimistic, as China may face challenges (e.g. insufficient supply of skilled labor, lack of opportunity for learning-by-doing gains) given its aggressive targets.



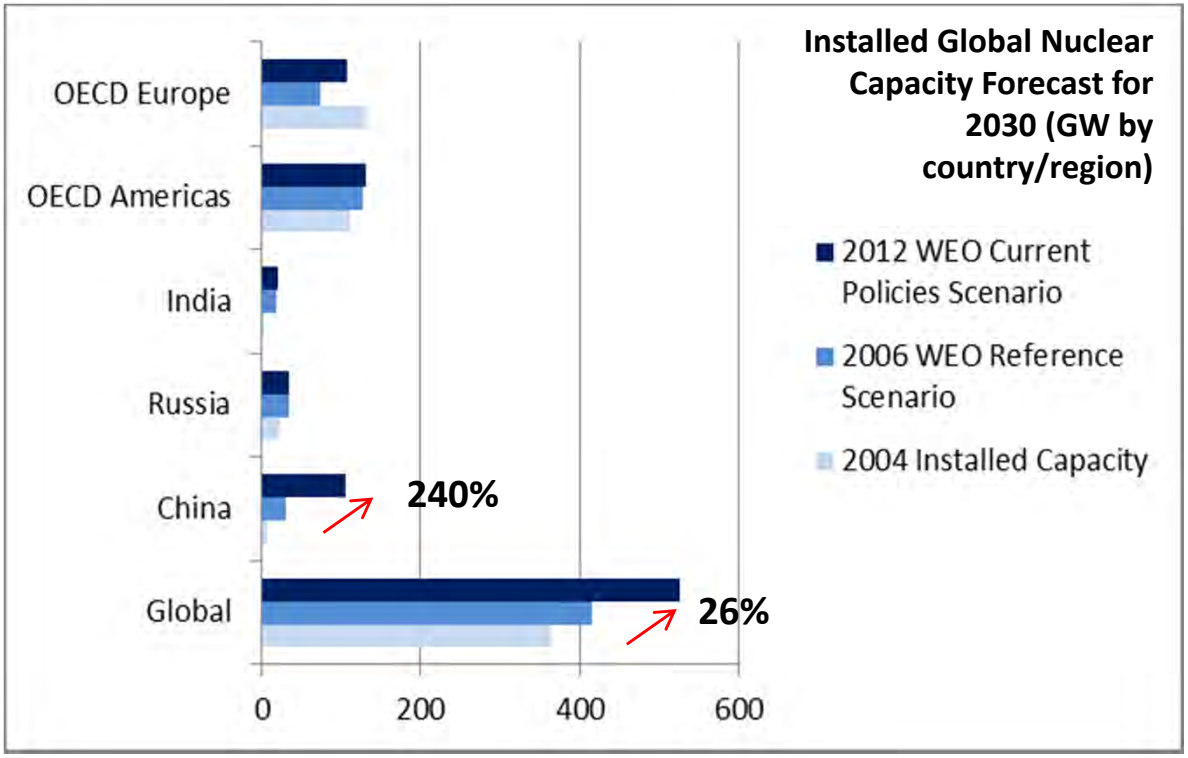
Long-Run Projected Global Average Levelized Cost of Nuclear Power Compared to Coal (top) and Regional Forecasts (bottom).

(cents $ 2013/kWh)	U.S.	EU	China	Japan
Nuclear	8.03-8.35	7.81-8.13	4.07-4.39	8.45-8.77
Coal	8.67-9.31	10.27-12.20	6.10-7.38	14.66-15.73
Gas	9.10-9.42	11.13-11.56	10.27-11.56	14.98-17.66

Deutch et al., 2009. "Update of the MIT 2003 future of nuclear power." MIT Energy Initiative.
Difiglio and Wannter, 2012. "Economics of Nuclear Power in Liberalized Power Markets." World Federation of Scientists.

Growth in installed capacity forecasts since 2006 are driven largely by China…

- The 2012 WEO global installed nuclear capacity forecast increased 2030 expectations by 26% from the 2006 forecast. This increase is driven primarily by China, where installed capacity projections increased from 31 GW to 105 GW.

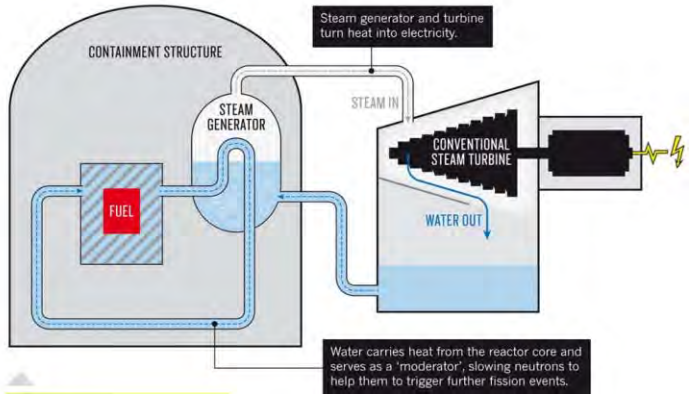


- These projections correspond to increasing forecasts for Chinese electricity demand—IEA's baseline 2030 Chinese electricity production forecast increased by 35% from 2006 to 2012. China dominates nuclear power expansion forecasts due to a range of factors including this energy demand growth, lower nuclear power costs than other countries, and China's energy security & environmental concerns about relying on fossil fuels for power.

International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

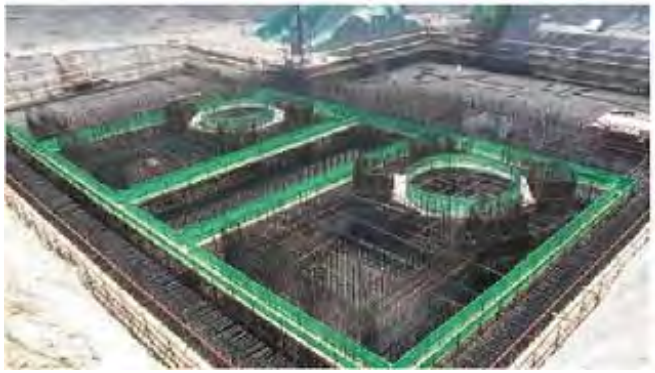
Interest in advanced nuclear generation technologies is reemerging, but its impact on power generation is uncertain

- There are many advantages of other reactor designs, and designs for other reactors have been available for decades.
- But, light-water reactors (LWR) were the first to market and have maintained their market dominance since; other designs have received limited interest from funders and researchers.



Schematic of a light water reactor

- Growing climate concerns and electricity demand, along with safety concerns around traditional LWRs, new reactor designs, such as high-temperature reactors, fast reactors, and molten salt reactors are beginning to gain increased attention.
- These designs offer several advantages over traditional LWR, but there are substantial barriers to wider adoption such as, public perception, safety, and waste management.
- China is pushing ahead with a commercialization program for thorium reactors, and has begun construction on the first gas-cooled pebble bed modular reactor.



The high-temperature gas cooled pebble bed modular reactor footprint before concrete pour

Waldrop, 2012. "Nuclear energy: radical reactors." Nature 492:26-29 doi:10.1038/492026a.
Image of high temperature reactor provided by Clean Air Task Force

Power sector: main themes

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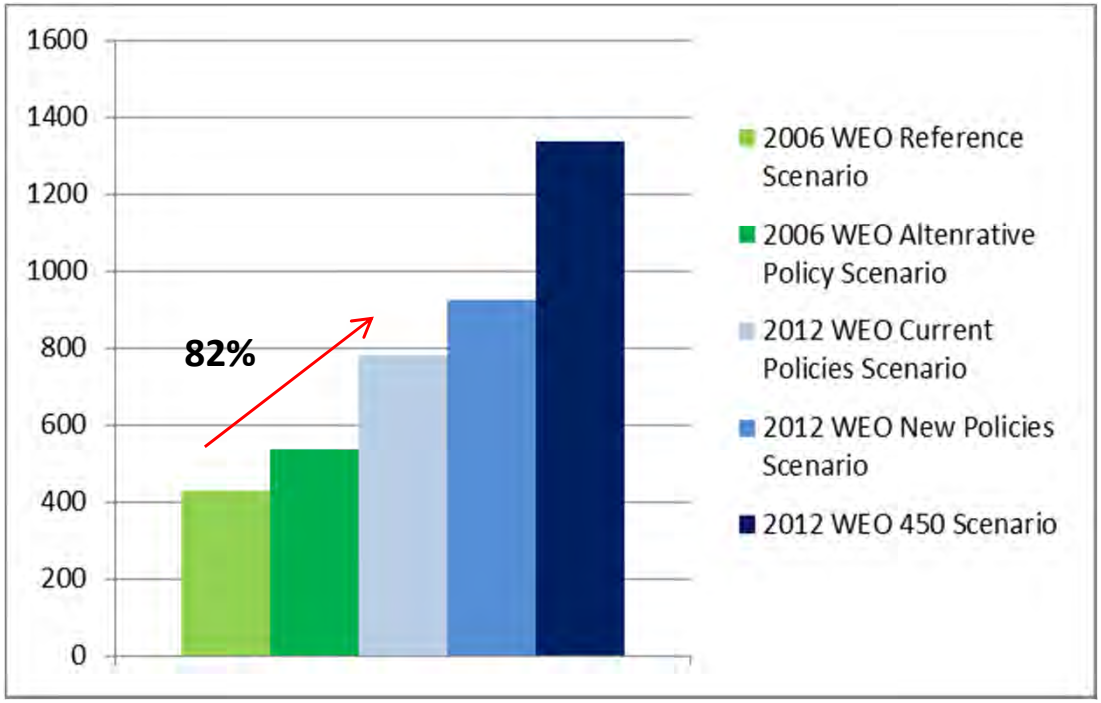
- **Coal** – Forecasts for coal slightly lower as a percentage of generation, but the fuel is still expected to dominate generation in the future.
- **Natural Gas** – In regions where fracking is taking off, natural gas is displacing coal as the most cost-effective generation source.
- **Carbon Capture and Sequestration** – Wider uptake of CCS remains elusive, and will require substantial policy support
- **Nuclear** – Despite Fukushima, forecasted nuclear development has not changed substantially.
- **Wind** - Deployment of wind has been faster than expected driven by policy and technological improvements. Overall share , though still expected to be low.
- **Solar** – Strong policy support and technological improvements for PV solar have led to capacity outpacing forecasts. Overall share, though still expected to be low.
- **Energy Efficiency** – The recognition of energy efficiency as a cost-effective resource has grown in recent years, especially in the U.S.

Wind's global prospects have improved dramatically since 2006…

- 2006 scenarios forecast that installed capacity would grow from 48 GW capacity in 2004 to between 430-538 GW in 2030. All 2012 scenarios forecast installed capacity in 2030 to be above the high end of the 2006 range (786-1,137 GW). The low end of the updated 2030 forecasts is 82% higher than the 2006 reference forecast.



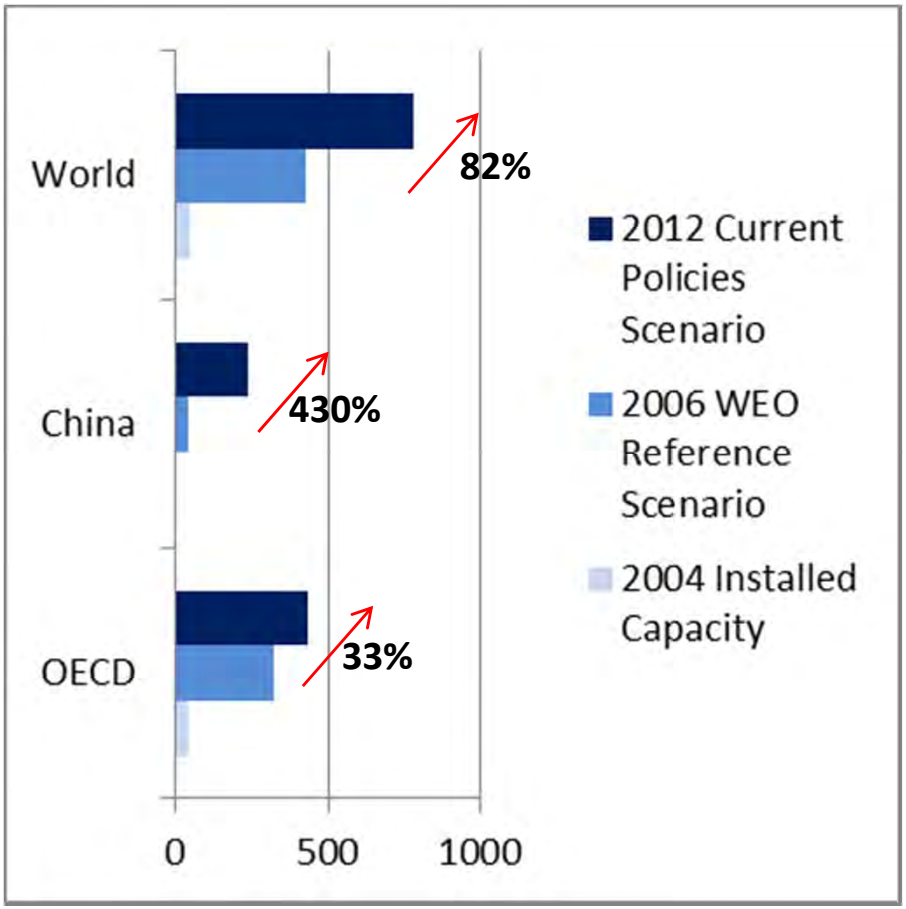
Projected 2030 installed wind capacity (GW) from 2006 and 2012 International Energy Agency (IEA) World Energy Outlook (WEO) scenarios.

International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

China & the OECD are the primary drivers of these wind forecast increases .

- 2012 forecasts call for China to have 50% of the world's installed capacity by 2030 (up from 10% forecast in the 2006 reference scenario), with the OECD accounting for 33% of global installed capacity in 2030 (down from 76% in the 2006 reference scenario).
- In 2010, China surpassed the WEO 2006 forecast for its installed capacity in 2030. In the 2012 forecast, forecasts for China's installed wind capacity increased over 400% from the 2006 forecast, accounting for 55% of the increase in expectations for 2030 installed capacity. Forecasts for the OECD also increased, accounting for 31% of the global forecast increase (the US is responsible for about half of this increase).

2004 Installed Wind Capacity and 2006 & 2012 WEO Forecasts for Installed Capacity in 2030 (GW).

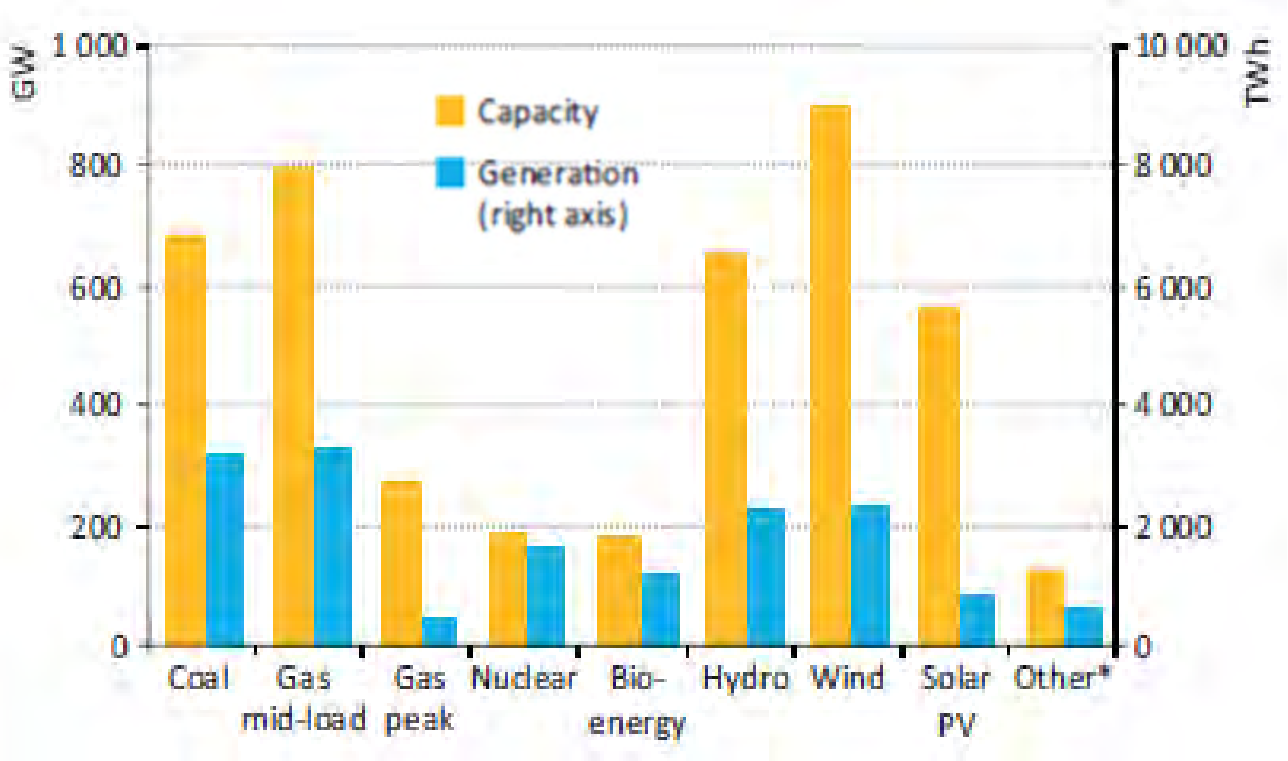


International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

Global net wind capacity additions are forecast to increase more than all other resources, but natural gas but this growth is less impressive from a total generation perspective

- Wind power net and gross capacity additions are expected to exceed those for all resources but natural gas through 2035. Wind power is expected to account for approximately 35% of renewables investment during this period.

World net incremental generation and capacity by type in the 2012 WEO New Policies Scenario, 2010-2035

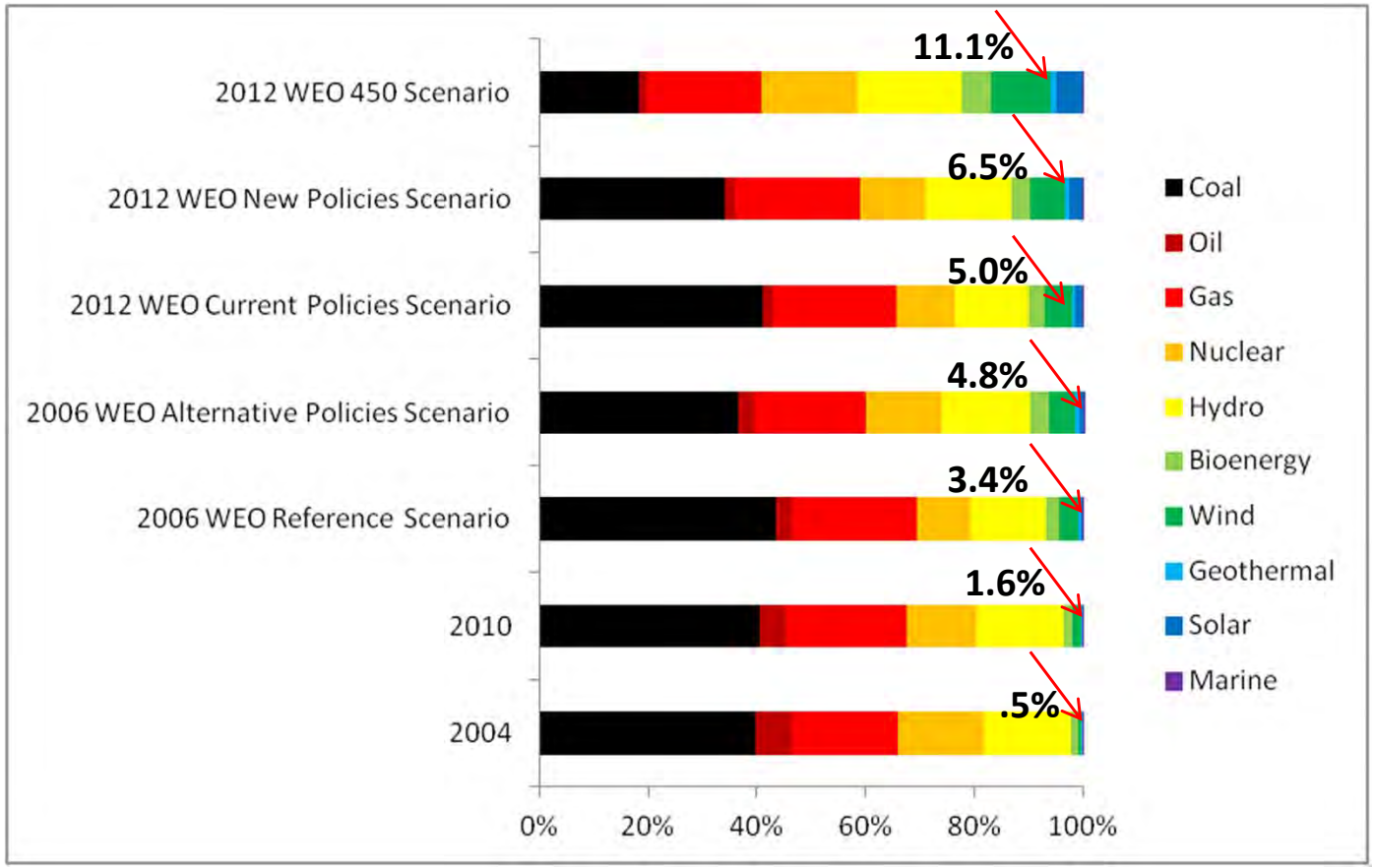


International Energy Agency, 2012. "World energy outlook."

While the wind outlook has improved, wind is forecast to remain a relatively small fraction of the global electricity mix

- From 2006 to 2012, IEA increased it's baseline forecast of wind's share of the overall global electricity production mix in 2030 from 3.4% to 5.0%. IEA's higher renewables penetration scenario increases from 4.8% wind power in the 2006 forecast to 6.5% in the 2012 model, short of the 11.1% wind production projected to be required to stay below 450 ppm.

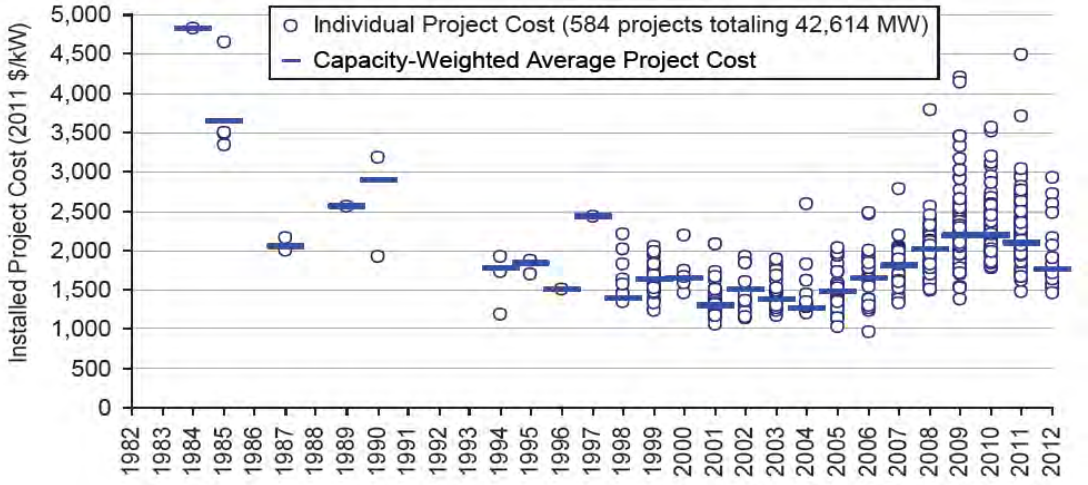
2004, 2010 and Forecasts for 2030 Global Electricity Generation Mix by Fuel (TWh) & % of Generation Delivered by Wind.



International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

Despite increases in deployment forecasts, installed wind project costs have underperformed expectations…

U.S. Installed Wind Project Costs 1982-2012 (2011 $/kW).



Estimated 2010 Installed Costs of Wind Power & Levelized Cost of Energy (by country or region).

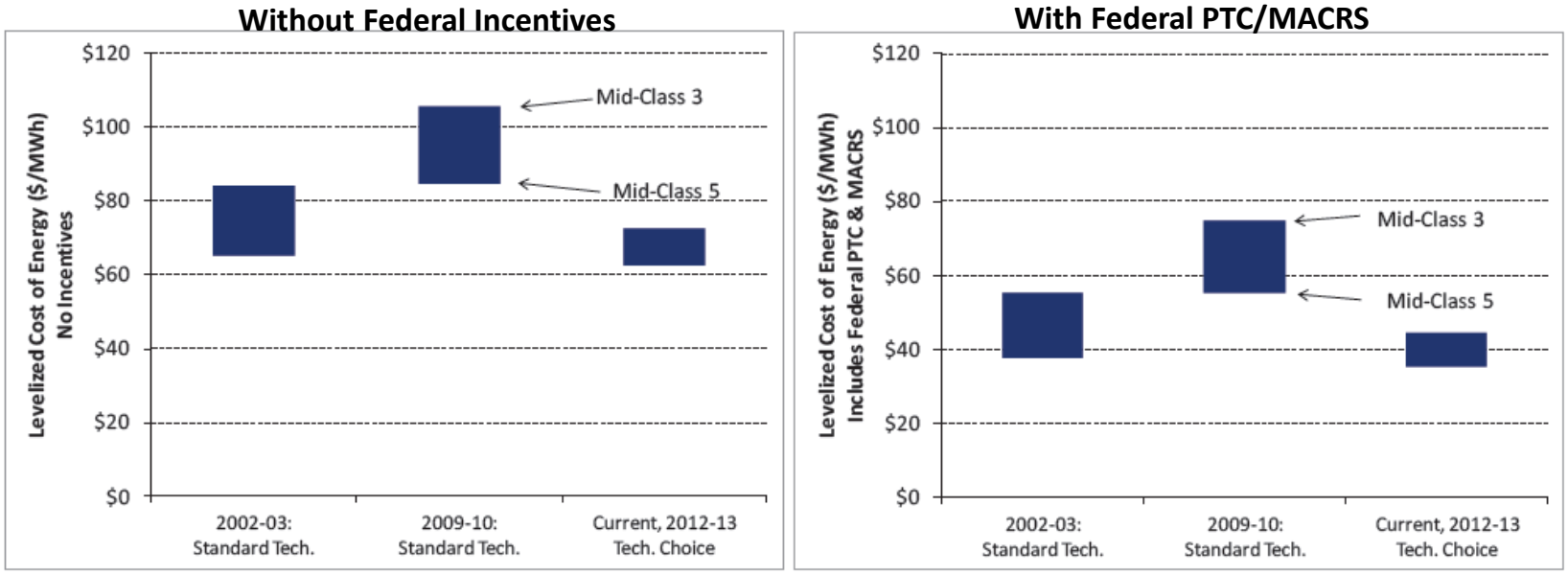
	Installed cost (2010 USD/kW)	Capacity factor (%)	Operations and maintenance (USD/kWh)	LCOE* (USD/kWh)
Onshore				
China/India	1 300 to 1 450	20 to 30	n.a.	0.06 to 0.11
Europe	1 850 to 2 100	25 to 35	0.013 to 0.025	0.08 to 0.14
North America	2 000 to 2 200	30 to 45	0.005 to 0.015	0.07 to 0.11

- Declining commodity prices and increasing turbine manufacturing & assembly capacity (and now overcapacity) have led to installed project cost reductions since 2010 (left).
- The 2012 WEO new policies scenario forecasts average wind prices of ~$1680/kW from 2012-2035. This estimate makes WEO 2006's estimate that installed wind costs would reach $1,060/kW (2013 $) in 2015 and ~$800-850/kW in 2030 look optimistic.
- These installed costs vary by country/region due to a range of factors including labor & capital costs, the presence of local low-cost manufacturers in some countries, the nature of a nation's power markets & supporting policies and site-specific factors. Grid connection costs(~10-15% of project cost), for example, are paid for by transmission system operators in some countries and wind farm owners in others.

Wiser et al., 2012. "2011 wind technologies market report." Lawrence Berkeley National Laboratory for U.S. Department of Energy.
International Renewable Energy Agency, 2012. "Renewable Energy Technologies: Cost Analysis Series: Wind Power."

But, installed costs tell an incomplete story. The levelized cost of wind energy is improving.

- While U.S. installed project costs remain higher than they were a decade ago, technological improvements have led to LCOE reductions of 24-39% since 2002-2003—with incentives, 2012-2013 wind LCOE is estimated at ~$.04/kWh. This cost is below IEA's 2006 WEO estimate that average wind costs would be ~$.06-$.09/kWh through 2030, although without Federal incentives, U.S. wind costs fall into WEO's forecast range. Despite the ~50% installed cost premium for US wind projects compared to China, higher capacity factors and higher quality wind resources lead to levelized costs of energy (LCOE) that are approximately equal.
- Studies suggest that wind LCOEs may decline by 20-30% from current levels by 2030.
- Integration costs for wind are significant, on the order of $0.04/kwh



U.S. Wind Prices with and without Federal Incentives (2002-2013).

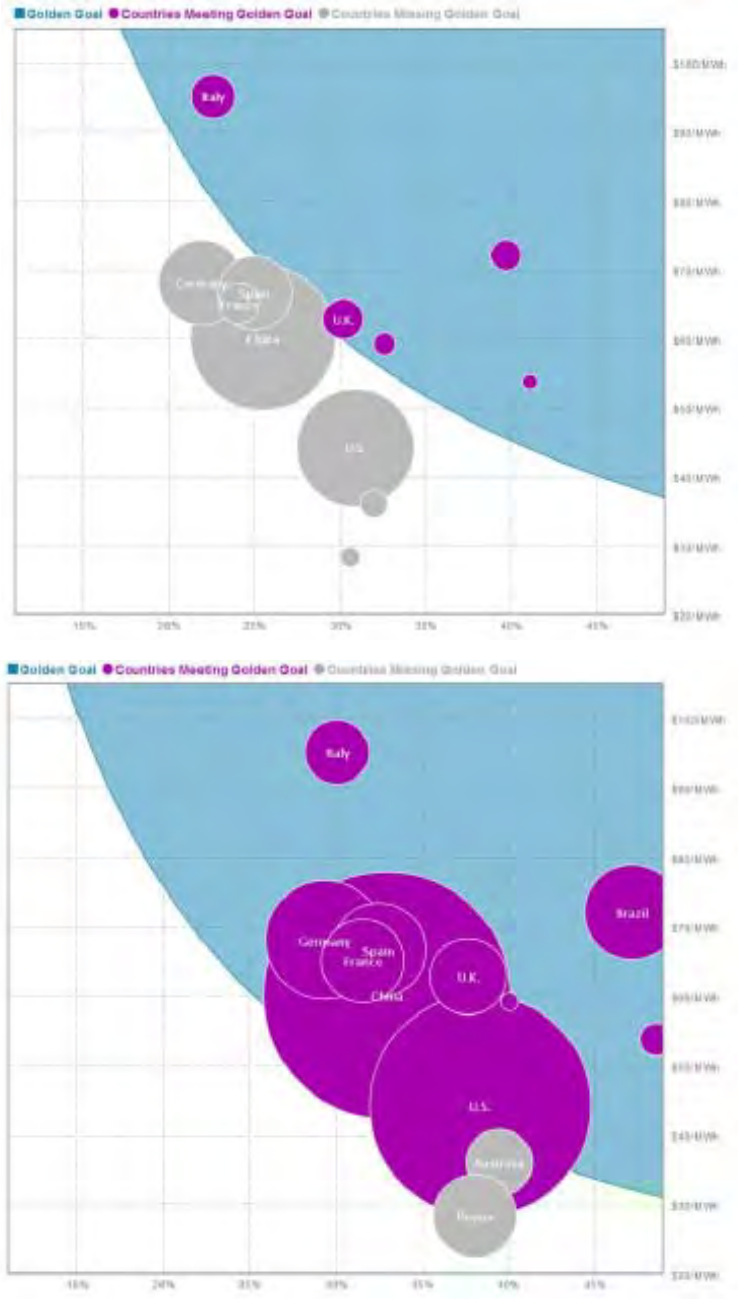
International Renewable Energy Agency, 2012. "Renewable Energy Technologies: Cost Analysis Series: Wind Power.

Wiser et al., 2012. "Recent developments in the levelized cost of energy from U.S. wind power projects." NREL and Lawrence Berkeley National Laboratory for the U.S. Department of Energy.

Idaho Power, 2013. "Wind integration study report."

In the short run, policy & natural gas prices are key wind drivers in most markets.

- WEO 2012 forecasts that the wholesale LCOE of wind will reach "grid parity" in the EU in 2020 and China in the early 2030's. WEO 2012 assumes that low long-term natural gas prices and the absence of a carbon price hampers wind's US cost competitiveness. Other estimates suggest that grid parity may come sooner in high-price, high quality resource markets and that the US (and many other nations) will reach grid parity by 2030 (see graphic below).
- Policy continues to drive wind in the intervening years:
  - China's 12th 5-year plan calls for 200GW of wind by 2020.
  - US renewable portfolio standards and tax incentives (e.g. PTC, MACRS) reduce wind LCOE by $.02-$.03. Uncertain policy support and transmission bottlenecks threaten the US growth trajectory.



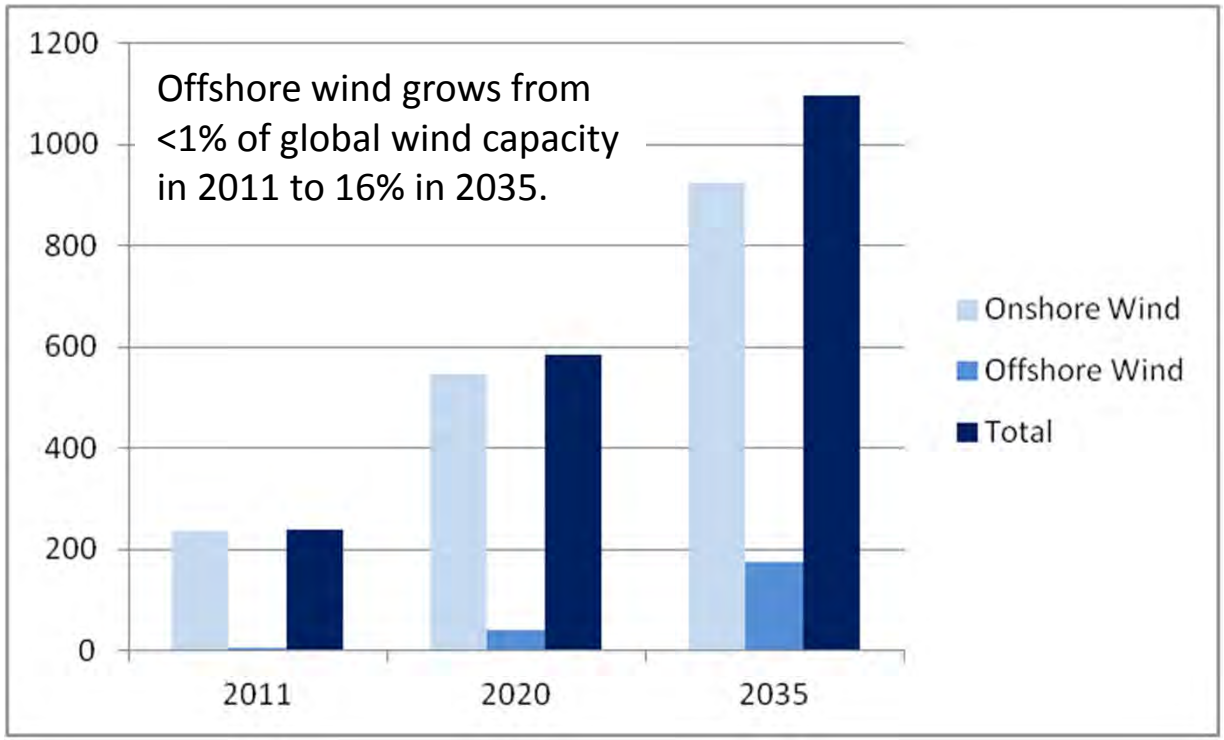
Countries Expected to Achieve Wind Grid Parity (purple) in 2012 (top) and 2030 (bottom). The blue shaded area represents grid parity or better. The x-axis represents capacity factor, the y-axis represents wind price ($/MWh).

Randall, 2012. "Wind innovations drive down costs, stock prices." Bloomberg New Energy Finance.
International Energy Agency, 2012. "World energy outlook."
Wiser et al., 2012. "Recent developments in the levelized cost of energy from U.S. wind power projects." NREL and Lawrence Berkeley National Laboratory for the U.S. Department of Energy.

Offshore wind becomes an increasingly important resource…

- Onshore wind is projected to account for 80% of the growth in wind installed capacity. While offshore wind is forecast to make up 16% of installed global wind capacity in 2035, it contributes 29% of wind-generated power by 2035 due to the higher quality offshore resource (i.e. steadier wind yields higher capacity factors).
- Europe and China are expected to be responsible for 2/3 of offshore wind production in 2035.
- Current offshore wind power costs are estimated at $.11-$.22/kWh and are forecast to decline to $.06-$.09/kWh in 2035. This suggests an ongoing cost premium for offshore wind relative to onshore, although onshore wind transmission constraints may make offshore wind more attractive in some markets.

IEA Onshore, Offshore & Total Wind Installed Capacity Projections for 2020 & 2035 (GW).



International Energy Agency, 2012. "World energy outlook."
Renewable Energy Policy Network for the 21st Century (REN21) and Institute for Sustainable Energy Policies (ISEP). "Renewables global futures report 2013."

Power sector: main themes

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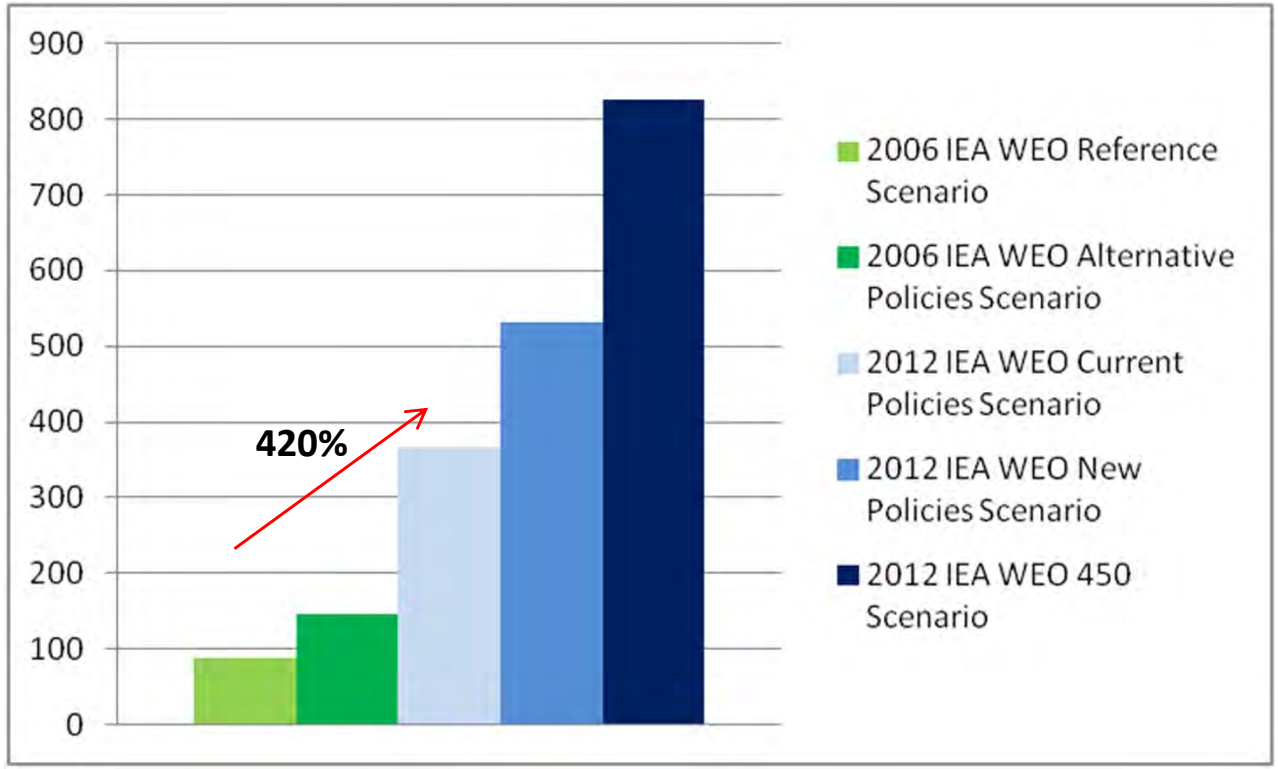
- **Energy Efficiency** – The recognition of energy efficiency as a cost-effective resource has grown in recent years, especially in the U.S.

Solar's global prospects have improved dramatically since 2006…

- 2006 scenarios forecast that installed capacity would grow from 4 GW capacity in 2004 to between 145-366 GW in 2030. All 2012 scenarios forecast installed capacity in 2030 to be above the high end of the 2006 range (531-827 GW). The 2012 current policies scenario is 420% higher than the 2006 reference forecast (the New Policies Scenario is 266% higher than the 2006 Alternative Policies Scenario).
- Grid-connected solar PV is forecast to be the dominant technology, accounting for between 87-92% of installed solar capacity in 2030.

Projected 2030 Installed Solar Capacity (GW) from 2006 and 2012 International Energy Agency (IEA) World Energy Outlook (WEO) scenarios.

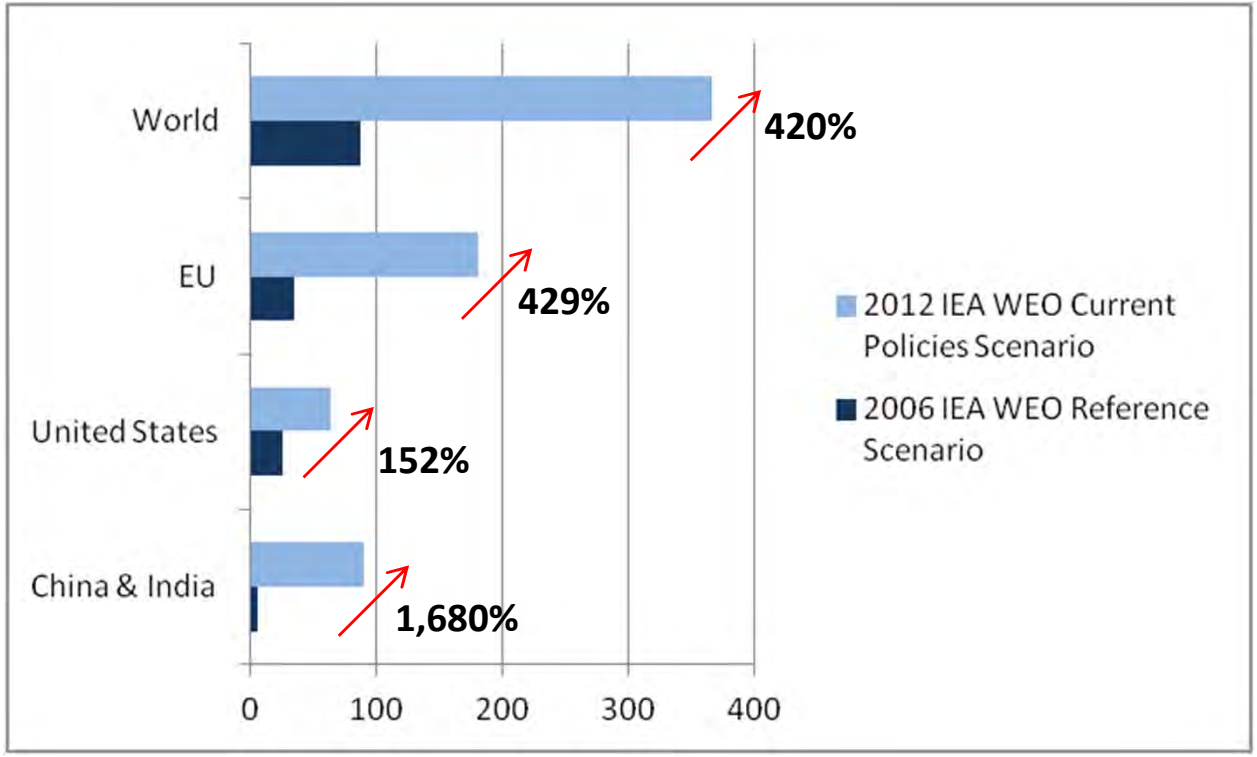


International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

The EU, US, China & India are the primary drivers of these solar forecast increases.

- The 2012 WEO current policies scenario calls for the EU to have 49% of the world's installed capacity by 2030 (up from 39% forecast in the 2006 reference scenario), with China & India accounting for 24% of global installed capacity in 2030 (up from 6% in the 2006 reference scenario) and the US accounting for 17% (down from 29%). In the 2012 New Policies Scenario, growth outside of the EU drives higher solar market penetration, and the EU falls to 28% of global installed capacity.
- The EU, US, China & India account for 96% of the increase in expectations for 2030 installed capacity from 2006 to 2012.

2006 & 2012 WEO Forecasts for Installed Capacity in 2030 (GW).



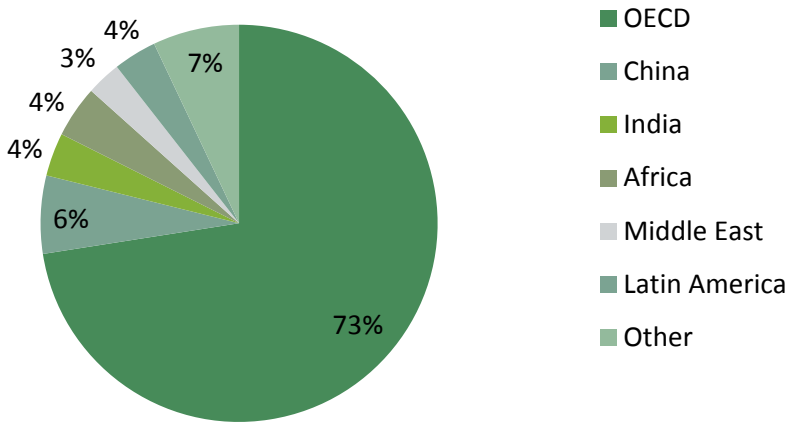
International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

The OECD continues to dominate solar electricity generation, but China & India are expected to be increasingly important players.

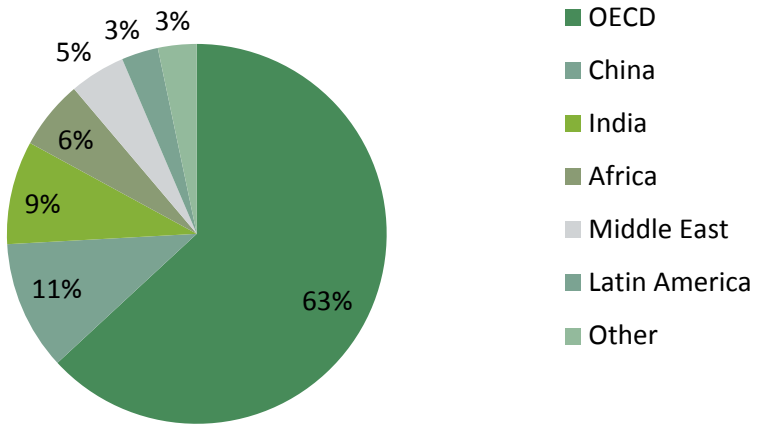
- In the 2012 reference scenario, expectations for the OECD's share of 2030 solar electricity production decline from 73% in the 2006 scenario to 63%, with China & India responsible for an increasing share of global production.
- In the more aggressive 2012 scenarios, OECD solar generation falls to ~50%, with China & India taking on larger shares of global generation. While IEA scenarios suggest ongoing robust growth in Europe, recent subsidy declines in Germany & Italy (the largest & third largest solar PV markets in 2012) suggest that US installations will have to grow aggressively to offset these declines and maintain OECD's market share.

Distribution of global solar electricity production in 2030 from IEA WEO 2006 and 2012 forecasts (by country/region in TWh).

2006 WEO Reference Scenario



2012 WEO Current Policies Scenario

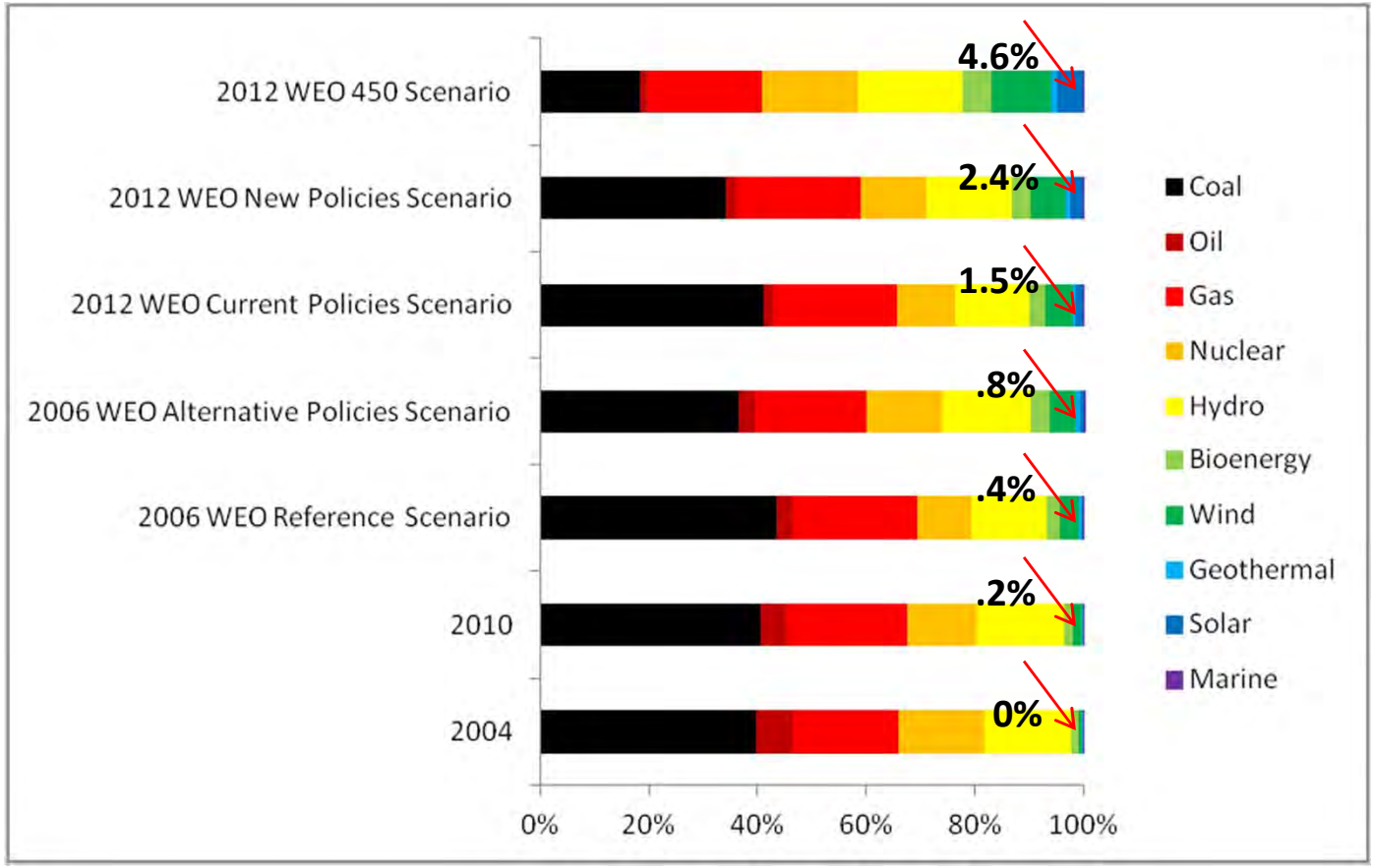


International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

While the solar outlook has improved, solar is forecast to remain a small fraction of the global electricity mix.

- From 2006 to 2012, IEA increased it's baseline forecast of solar's share of the overall global electricity production mix in 2030 from .4% to 1.5%. IEA's higher renewables penetration scenarios increase from .8% in its 2006 forecast to 2.4% in its 2012 model, just over half of the level necessary to stay below 450 ppm in IEA's model.

2004, 2010 and Forecasts for 2030 Global Electricity Generation Mix by Fuel (TWh) & % of Generation Delivered by Solar.

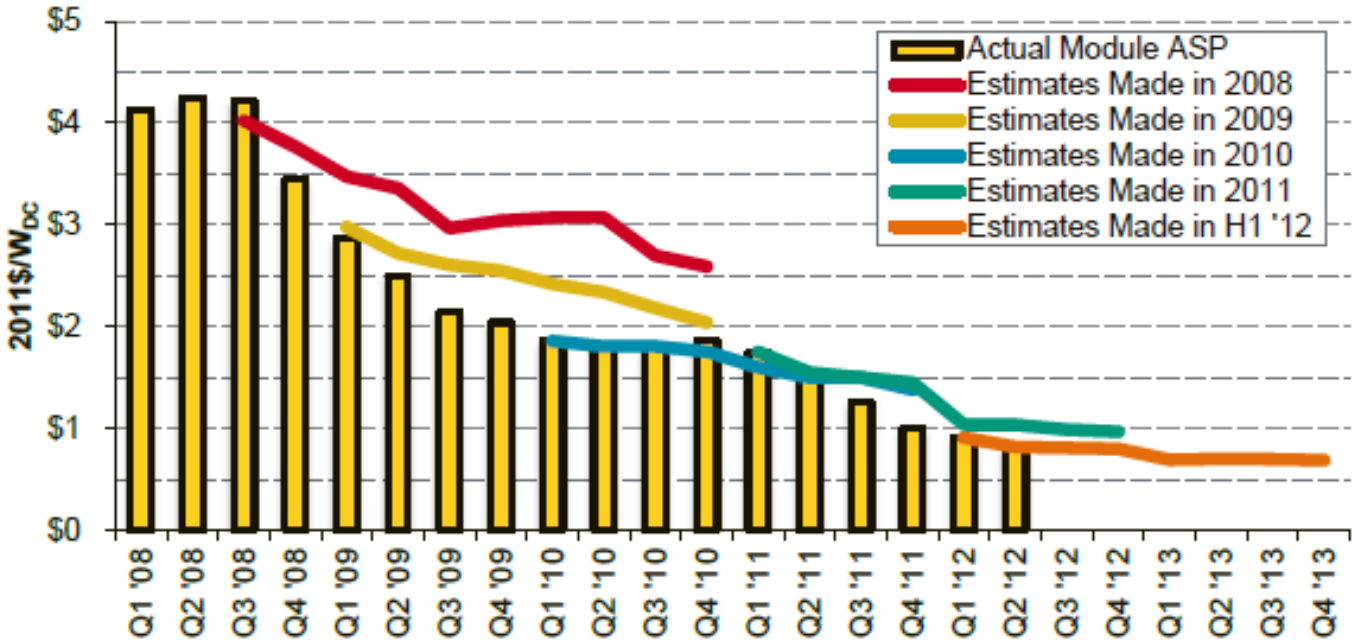


International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook.".

Solar PV prices have outperformed expectations.

- In 2006, IEA estimated that solar PV module costs would be ~$1.70/W (2013$) in 2030. 2013 module costs (~$.65/W) are already well below IEA's 2030 expectations. IEA also estimated that installed costs would be ~$3/W (2013 $) in 2030. By 2011, the capacity-weighted average installed cost of US utility-scale solar PV had already declined to ~$3.50/W (2013 $) from a cost of ~$6.25/W from 2004-2008.
- IEA's WEO 2012 projected that installed solar PV costs will continue to fall in coming years, averaging ~1.70/W from 2026-2030.
- However, integration costs may still be significant.
- Future PV price reductions are likely to come primarily from balance of systems costs (including non-hardware soft costs), which now make up the majority of installed system costs and account for regional solar pv installed priced differences.

Solar PV Module Average Selling Price Compared to Analyst Estimates (2011$/W).



Feldman, 2012. "Photovoltaic (PV) pricing trends: historical, recent and near-term projections."

While pricing has become more competitive, policy remains the primary growth driver….

United States—The 2006 WEO Alternative Policies Scenario anticipated that State-based Renewable Portfolio Standards (RPS) would be met & strengthened from 2006-2012, but it did not include the implementation of the Federal ITC & Recovery Act cash grant support that has helped to drive US markets in recent years. Today, RPS policies are under attack in several states, and their future is uncertain. Federal tax benefits (ITC & Depreciation) have declined in value from ~52% of project costs to ~35% of project costs. These benefits are scheduled to expire in 2017. MLPs & REITs may offer a vehicle for maintaining some tax benefits post-2017 (or complementing existing incentives if extended). U.S. PV policy support—and market growth potential—remains uncertain and volatile.

Europe—European nations have predominantly used Feed-in Tariffs (FiTs) to drive solar PV demand over the past decade. While WEO 2006 likely included these existing policies, in several countries (e.g. Germany, Italy), FiT reductions lagged installed solar PV cost declines in recent years. High incentive levels helped to drive installations well-above expectations. In Germany, Italy & Spain, these incentive levels have dropped and market penetration is slowing. In 2010, the EU set targets that each member state would use 20% renewables by 2020.

China—In 2005, China implemented a 1.8 GW solar PV capacity target for 2020. Since WEO 2006 was released, China has rapidly increased this target. In 2011, China released its 12th 5 year plan for 2011-2015, which included a solar PV installed capacity target of 5 GW—this target has since been revised upwards to 40 GW. This 40 GW 2015 target is double the WEO 2012 new policy scenarios forecast, suggesting that the report is underestimating Chinese solar PV growth. Targets have been raised to take advantage of low PV prices, support domestic PV manufacturers and address the nation's increasing smog problems. A range of incentives are used to drive installation volume,

India—In 2008, India set a target of 20 GW installed solar capacity by 2022 (1 GW by 2013, 4 GW by 2017) as pat of its National Solar Mission. It reached the 1 GW target in 2012, and its draft second phase National Solar Mission now targets 9 GW by 2017 and the 20 GW 2022 target remains. A range of incentives are used to drive installation volume.

CEA California Environmental Associates

Current market conditions may be untenable and necessitate rapid demand growth to avoid losses in manufacturing capacity.

- Aggressive manufacturing capacity build up in 2010 and 2011 combined with curtailed subsidies in major markets resulted in significant overcapacity and inventory build up.
- There has been significant consolidation and liquidation, particularly in high cost-regions, like the U.S. and Western Europe. These regions accounted for 32% of PV manufacturing capacity in 2009, but are expected to account for just 9% of global capacity by 2015.
- In many cases, manufacturers are adding production capacity so that they can be ready to meet demand when it comes. In the case of PV, it is not build it and they will come, but build it for when they come.
- This has led to high module and BOS inventories and declining gross profit margins for PV module suppliers (>30 percent in late 2010 to low single digits in mid-2012). Producer balance sheets are under severe stress, and overcapacity is likely to persist through much of 2013.
- PV manufacturers cannot hold out indefinitely. Recent US/China PV "dumping" actions highlight tension. US market and developing country markets need to demonstrate they are viable in order to avoid significant production capacity declines and price increases.
- If predicted global growth (particularly in China, a source of tremendous uncertainty) does not materialize, losses in manufacturing capacity would likely result which may both raise the price trajectory of solar PV and reduce the market's ability to scale rapidly should market/policy dynamics shift.
- The Middle East & South America are "wild cards" that could significantly increase solar's trajectory, particularly the Middle East—for example, in February 2013, Saudi Arabia proposed 54 GW of renewable energy installations by 2032 (of which ~35-40 GW will be solar PV & CSP).

Mints, 2012. "Solar going forward." Presented March 21, 2012 at EPIA 7th Market Workshop.
Shah, 2013. "Clean technology 2013 outlook." Deutsche Bank Markets Research.

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- **Overarching trends** – Electricity demand outpacing forecasts and more concentrated in the developing world than expected. No major changes in the generation mix forecast.
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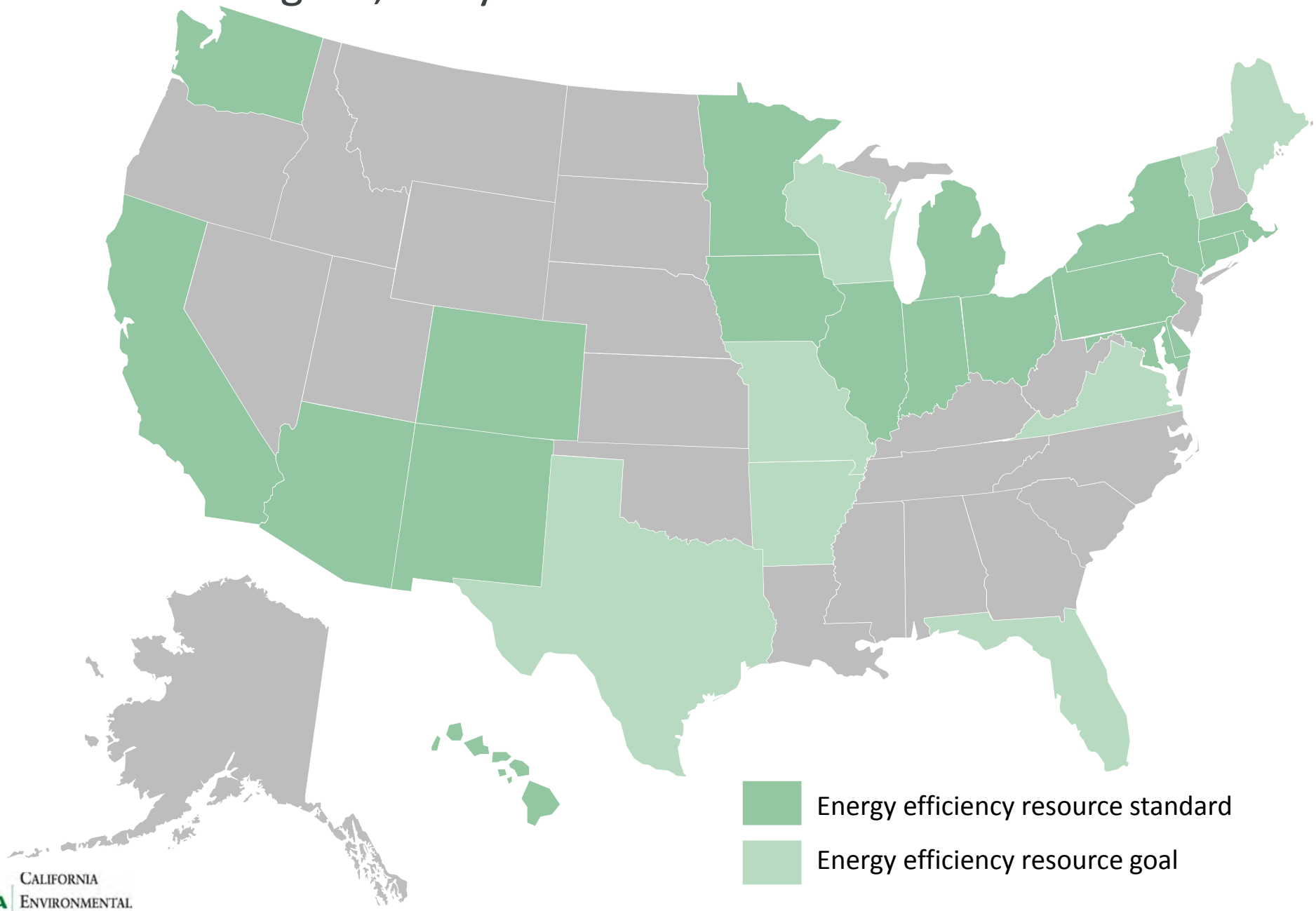
- **Energy Efficiency –** The recognition of energy efficiency as a cost-effective resource has grown in recent years, especially in the U.S.

Twenty-seven states have implemented energy efficiency resource standards or goals, many since 2007

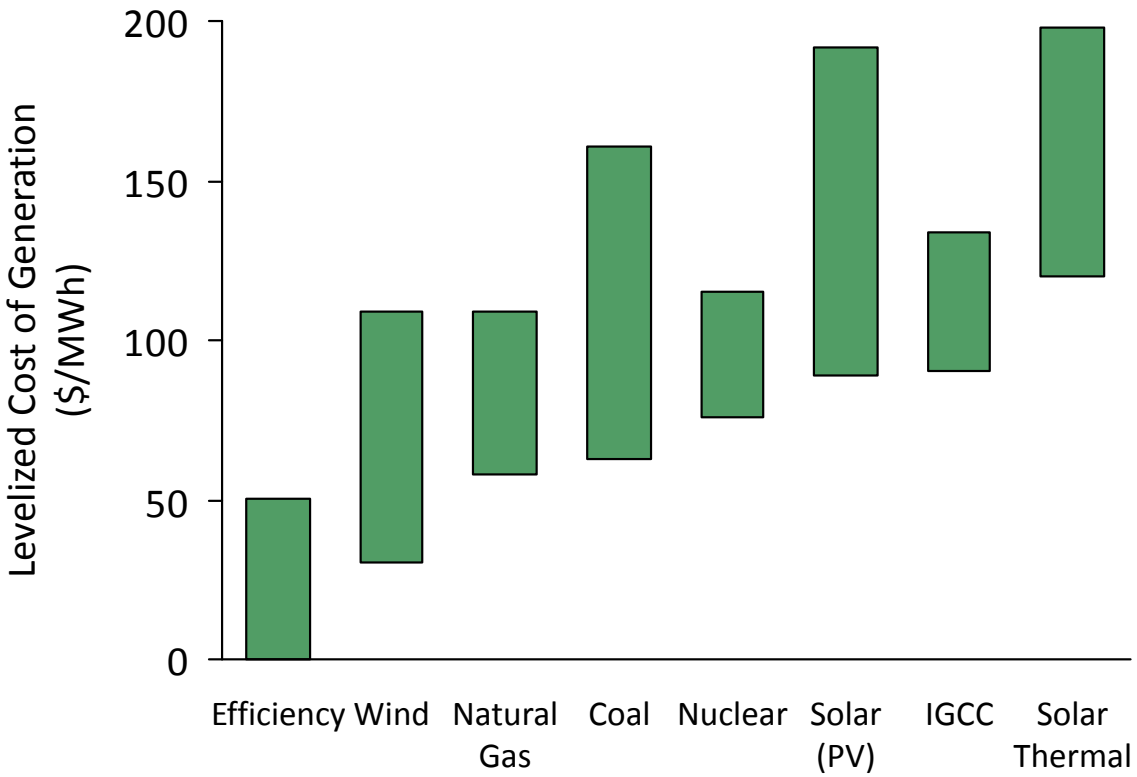


Database of State Incentives for Renewables and Efficiency (DSIRE). Retrieved March, 2013. http://www.dsireusa.org/

CEA California Environmental Associates

Energy efficiency is often the lowest cost means of meeting electricity demand

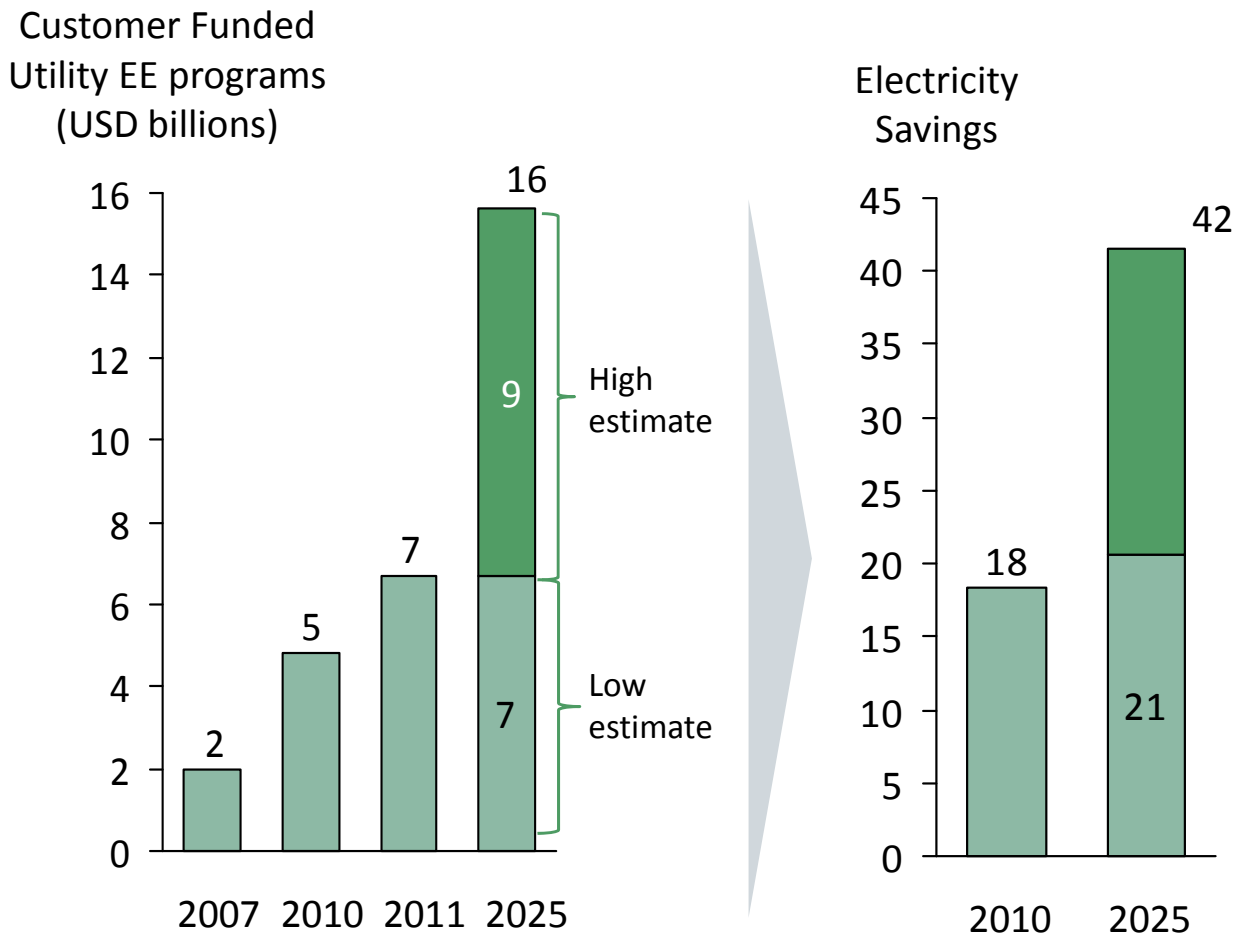
Levelized cost of generation for various resources[1]



- Given the low cost of efficiency, some of the most ambitious states (e.g., Massachusetts) have implemented mandates that require "the acquisition of all available energy efficiency and demand reduction resources that are cost effective or less expensive than supply"[2]

1. Lazard, 2011. "Levelized cost of energy analysis – version 5.0."
2. American Council for an Energy-Efficient Economy. State Policy Database. Retrieved April, 2013. http://aceee.org/sector/state-policy/

Utility funded efficiency programs in the U.S. are a bright spot, and have more than tripled efficiency spending since 2007.



- High scenarios for rate-payer funded efficiency could offset 120% of EIA's reference case electricity load growth, slightly reducing overall electricity consumption.
- Although this has been a bright spot, it is concentrated in just a few states; the top 10 states account for 70% of the electricity efficiency spending, and 80% of natural gas efficiency spending.
- These programs have generally failed to incorporate the industrial sector.
- Some EE programs are now under attack due to low natural gas prices.

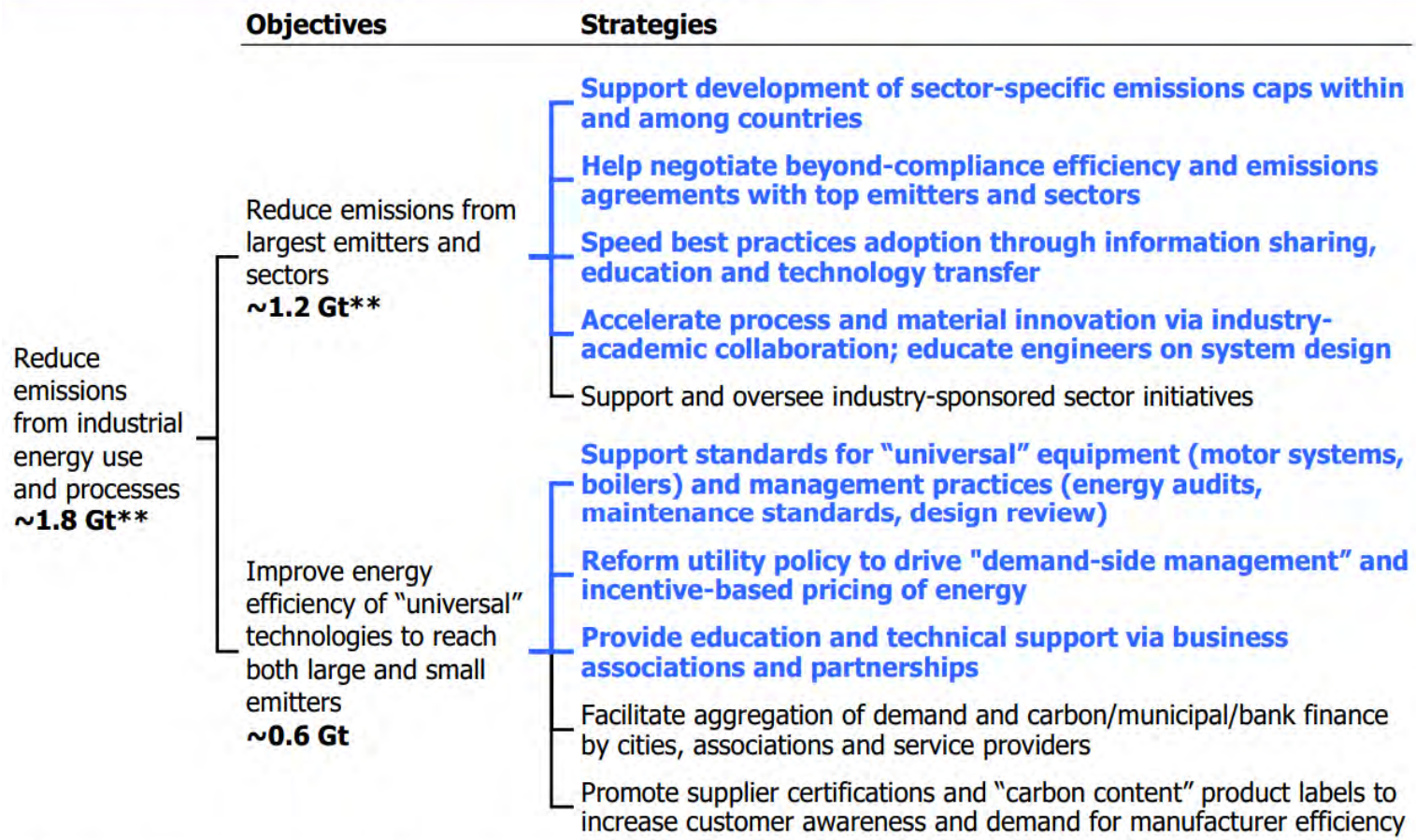
Barbose et al., 2013. "The future of utility customer funded energy efficiency programs in the United States: projected spending and savings to 2025." Lawrence Berkeley Laboratories.

INDUSTRY

Interviewee reflections on industry

DTW identified the following priorities for mitigation in the industrial sector: Large Emitters (e.g., cement and steel) (2GT), motor systems (1GT), Non-CO2 emissions (e.g. HFCs) (0.5GT), and CCS (0.5GT). About two-thirds of the potential was in non-OECD countries.

FIGURE 14: Philanthropy's Role in Industry (DTW Priorities Highlighted)



* Estimates likely conservative due to underestimation of gains from "clean-sheet" total system design
** Does not include CCS or non-CO_2 mitigation options
Source: Mitigation potential adapted from IPCC, USEPA, Vattenfall

California Environmental Associates, 2007. "Design to Win: Philanthropy's Role in the Fight Against Climate Change"

Interviewee reflections on industry – BAU trajectory

1. **The industrial trajectory is probably BAU, though experts don't have ready data to point to**
   - "I think my reaction is that emissions are probably tracking what might have been projected then as BAU… Maybe there is a small downward shift, but not dramatic enough. It hasn't probably moved beyond what might have been BAU."
   - "I'm really tempted to say BAU."
2. **DTW selection of sectors and geographies was essentially correct, but hasn't clearly bent the arc**
   - The DTW analysis was "spot on and I think is still really valid today." Cement, iron, steel, chemicals, and petroleum are the most important sectors. That is absolutely the case even now. They still cover 70-80% of all emissions from industry.
   - DTW suggested that China, India, and the US as the three major geographic areas of focus. These remain the most relevant countries of interest, as China comprises 70% of global industry. "Even though there has been a lot of discussion about Mexico, Russia, Brazil, etc. I think if this model can be made to work in China, India, and the US, it can be franchised in other regions." "If I could add one more country it would be Mexico."
   - The change we've seen has been in incremental advancements by sector, and has not been transformative. "You look at all the work that has been done…my gut feeling is that it really hasn't penetrated to top management yet." "I don't think there is anything terribly unusual in terms of technological developments."
     - **Cement:** Our major conclusion was to get rid of the vertical shaft kiln, which is not a major technological breakthrough.
     - **Pulp and paper** are focused on increasing recycling rates, not technology.
     - **Iron and steel:** Key recommendations were around replacing blast furnaces with electric arc furnaces. The US has had a major transformation and has become one of the most efficient iron and steel producer in the world thanks to the use of recycled materials. The Chinese use primary materials, so this is an area of interest in places outside of the US.
     - **Chemicals:** "Energy system optimization" has gained some interest: Instead of just looking at a single unit, manufacturers are looking at a wider boundary of equipment together to find energy reductions.
   - "In the U.S., the fact that consumer funded efficiency programs did not associate with the industrial sector is also a "miss" in my book. Yes, industrial customers are motivated by competitiveness to be efficient, but their horizon for cost-effectiveness is more limited than society's, and standards don't make up the difference."

Interviewee reflections on industry – surprising developments

3. **There were only a few obvious bright spots in the industrial sector**
   - **Recession:** The global recession was positive in that reduced overall emissions
     - It also exposed excess capacity in industry overall, which led China and others to shut down smaller, less efficient units. For example, China shut down 400 cement factories in the last 5 years and a similar number for steel.
     - For a variety of reasons, including energy prices, we are also seeing the return of some manufacturing to the US, which is positive in terms of global emissions (even if it is negative in terms of US emissions).
   - **Alternative material use** in the cement industry is a potential *future* bright spot. The development of alternatives to clinker is progressing in the research and trialing phase (including at Lafarge), and there is an increasing appetite for this substitution. "I think there is a lot of progress in this area." Industrial adoption will need to be matched with an effort to ensure that the regulatory regime allows for it.

4. **On the other hand, the sector's trajectory has not been worse than expected either – we just haven't made the progress that we hoped for**
   - DTW's focus on sector-specific emissions caps and the integration of beyond-compliance sectors didn't materialize, which has left the community without much of a stick. While there has been progress in sharing best practices, there isn't a major driver for the implementation of the costly technologies that would shift BAU (e.g., CCS). Similarly, it has been difficult to point to the net impact of the focus on investment, particularly those associated with carbon credits or multilateral programs, because of the additionality question. "This focus on investment. I just wonder, does that focus really get us away from BAU?...I have a feeling that an awful lot of these investments would have been bought anyway."

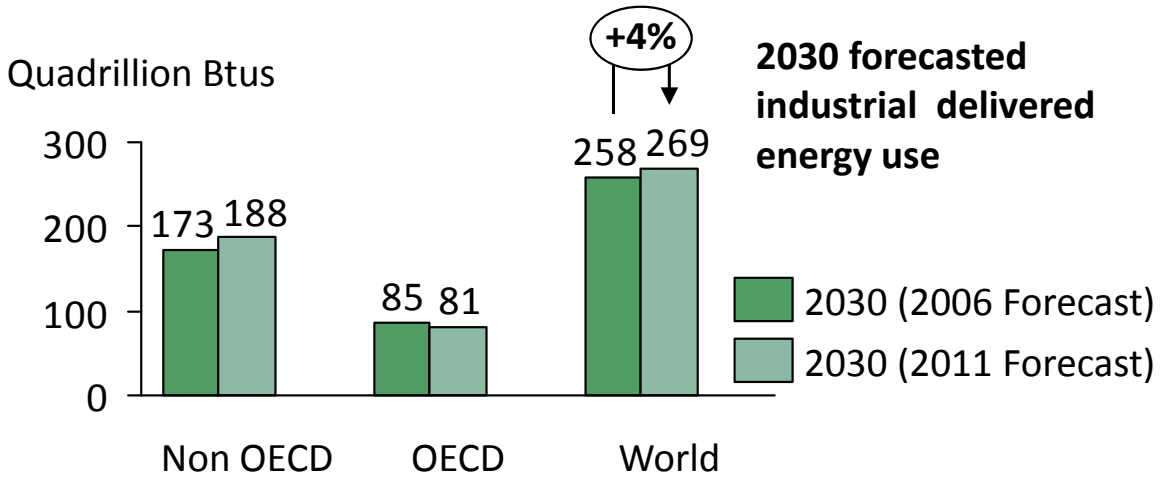
Interviewee reflections on industry – benefits of hindsight?

5. Reflection on would you have done differently in retrospect?

- **Less of a policy focus and more of an implementation focus** The overall DTW document emphasized policies. In industry, the policy regime is important but execution and implementation of policy is more important, particularly in places like India and China. Policies are put in place but there aren't drivers that turn the policies into reality. Industry has often gamed or resisted policy, or been absent entirely. The engagement of industry is crucial. There has been too much focus on policy to the detriment of implementation. That said, it is unclear how we more effectively could engage industry on the implementation front.

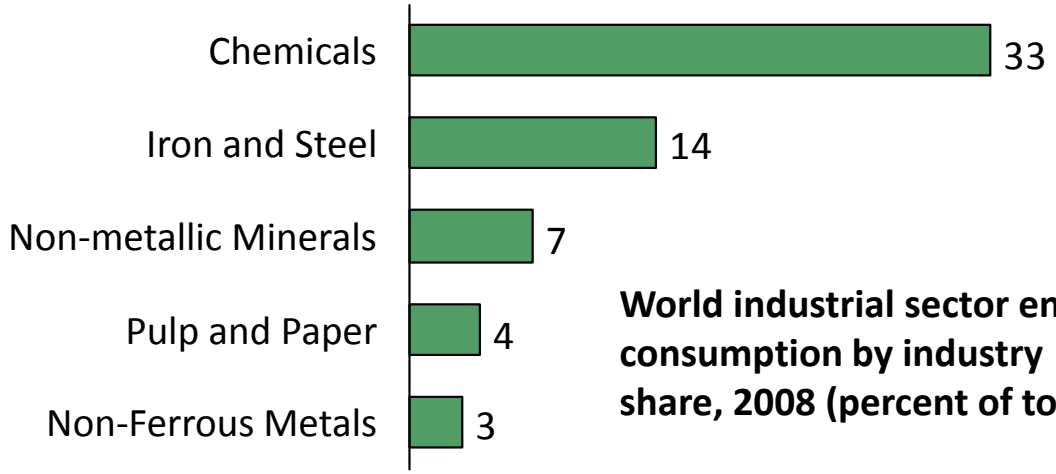
- **Add Information and Computing Technology (ICT) to the discussion**. "It is time also to start talking about ICT."
  - ICT is important both in terms of its own emissions and its potential role to help reduce emissions. ICT has obvious role to play in reducing transportation emissions (telecommuting policies, telemedicine, teleconferencing, real time congestion charging, toll roads, etc.). ICT also plays a critical role in efficiency (e.g., ensuring buildings are optimized, demand response, smart grids, etc.).
  - "I have considerable interest in the potential future role of ICT-enabling activities in energy efficiency and GHG emissions mitigation… An updated version of the paper could… add new material on lifestyle change through ICT. It will happen anyway but needs to be steered to make a net positive impact on energy use and emissions. I think this would be a suitable role for philanthropy to take the lead on."

Forecasts for industrial energy consumption have increased slightly since 2006, driven by non-OECD countries. Chemicals, steel, and cement are still the most important industries.



2030 forecasted industrial delivered energy use

- OECD countries are continuing-their transition to service based economies and growth in industrial energy use is expected to be slow (~0.5% yr^{-1}).
- Industrial energy use in non-OECD countries is expected to grow at 2.1% yr^{-1} through 2030.

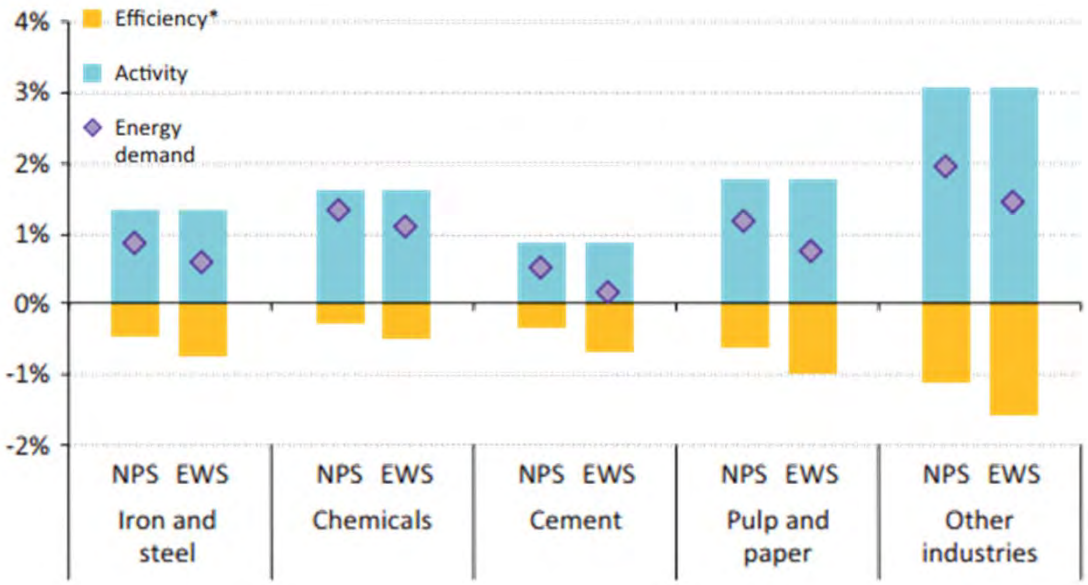


World industrial sector energy consumption by industry share, 2008 (percent of total)

- "Cement, iron, steel, chemicals, and petroleum are the most important sectors. That is absolutely the case even now."

U.S. Energy Information Administration, 2006. "International energy outlook: 2006." Reference Case
U.S. Energy Information Administration, 2011. "International energy outlook 2011." Reference Case

Even under IEA's 2012 "efficient world" scenario, emissions in the industrial sector are expected to be higher than 2010 levels in 2035



Average annual change in energy demand by industrial sector 2010-2035 (New Policy Scenario and Efficient World Scenario)

* Negative values for efficiency represent improvements.

Note: NPS= New Policies Scenario; EWS = Efficient World Scenario.

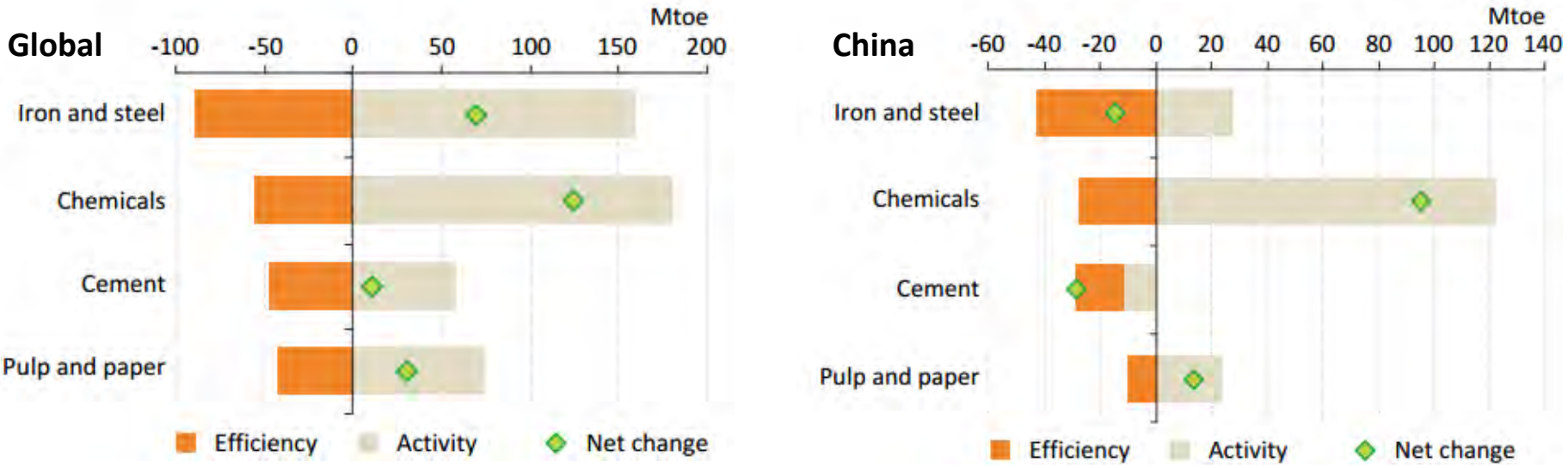
Global industry energy demand by fuel and CO2 emissions 2010-2035 (Efficient World Scenario)

Fuel	2010	2020	2035
Total (Mtoe)	2421	2901	3171
Coal	676	769	748
Oil	321	343	330
Gas	463	577	688
Electricity	638	838	999
Heat	126	133	121
Bioenergy	197	242	285
CO2 emissions (Gt)	9.8	10.9	10.5

International Energy Agency, 2012. "World energy outlook."

Under IEA's efficient world scenarios, the chemicals industry is expected to have the largest increase in energy demand in the industrial sector. China accounts for most of this increase.

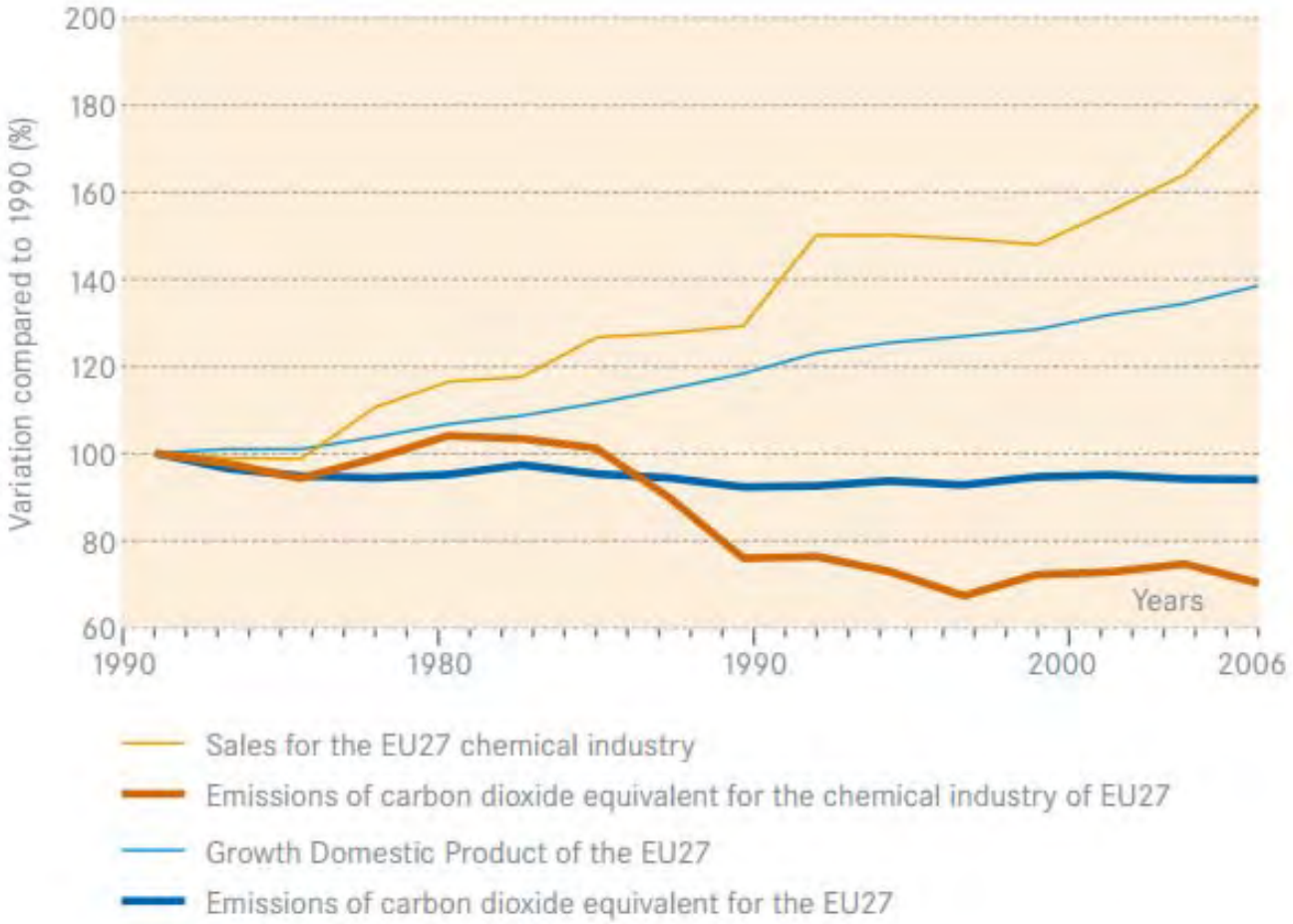
Global change in energy consumption in energy-intensive industries in the "Efficient World" Scenario. 2010-2035



International Energy Agency, 2012. "World energy outlook."

The chemicals industry has made steady improvements in energy efficiency, but has yet to deviate substantially from BAU trajectories

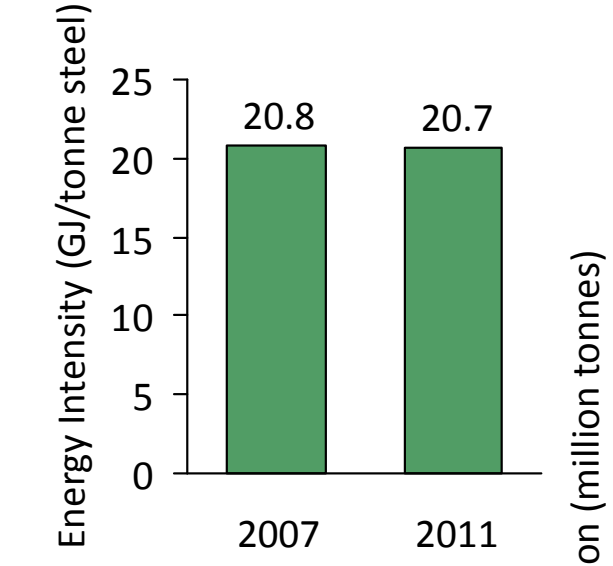
Comparison of the evolution of economic growth and carbon dioxide emissions

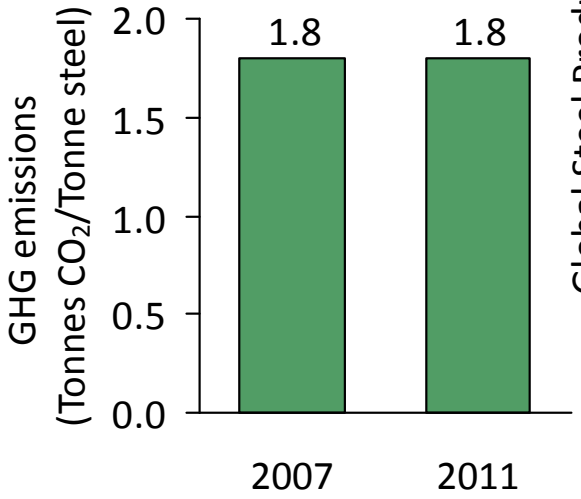


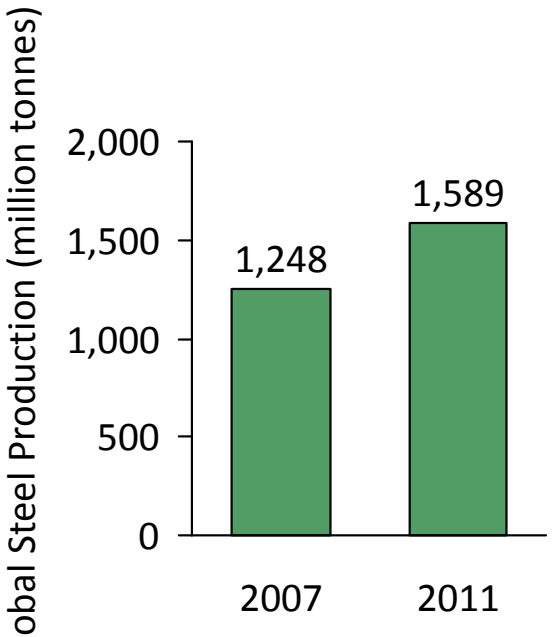
The chemical industry has continued to make incremental improvements in energy efficiency, but sharp deviation from BAU trajectories is a challenge due to the relatively diffuse nature of the industry (i.e., many different chemicals, production techniques, and facilities)

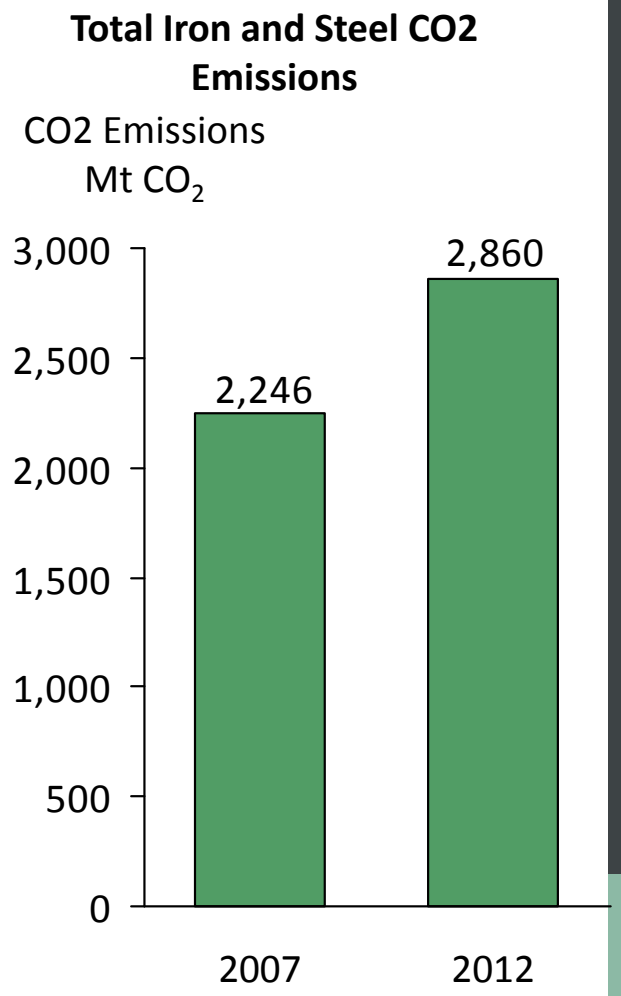
International Council of Chemical Associations, 2009. "Turning the tide on climate change: the climate change challenge and the chemical industry."

The steel industry has seen almost no improvements in production efficiency since 2007. This coupled with increased production has led to increased emissions since 2007.





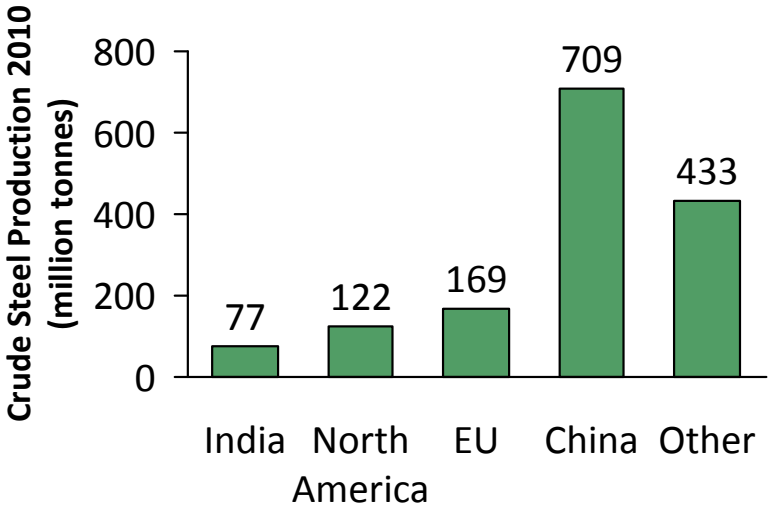




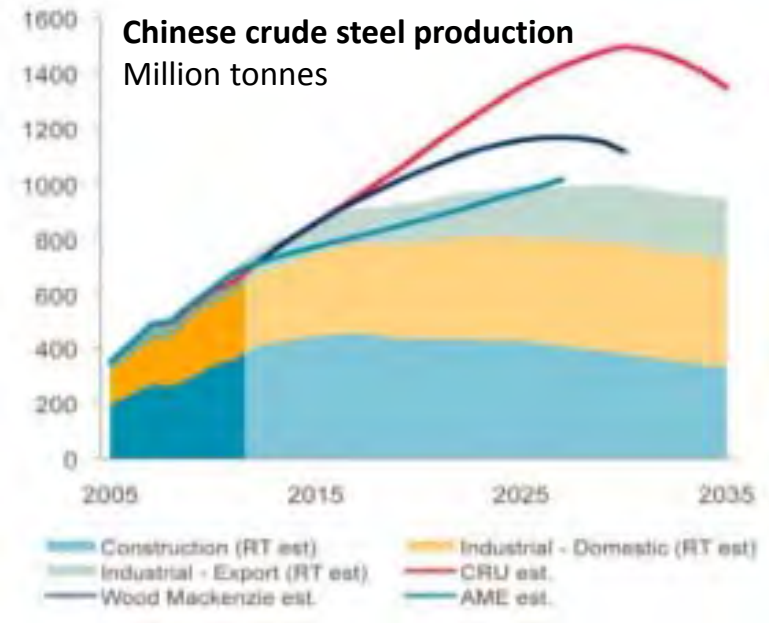
CEA California Environmental Associates

World Steel Association, 2012. "Sustainable steel: policy and indicators 2012."
Total CO2 emissions based on emissions factor and global production from World Steel: Statistics Archive. Retrieved March, 2013. http://www.worldsteel.org/statistics/statistics-archive.html

China accounted for almost 50% of global steel production in 2012, but has been a laggard in implementing efficiency measures.



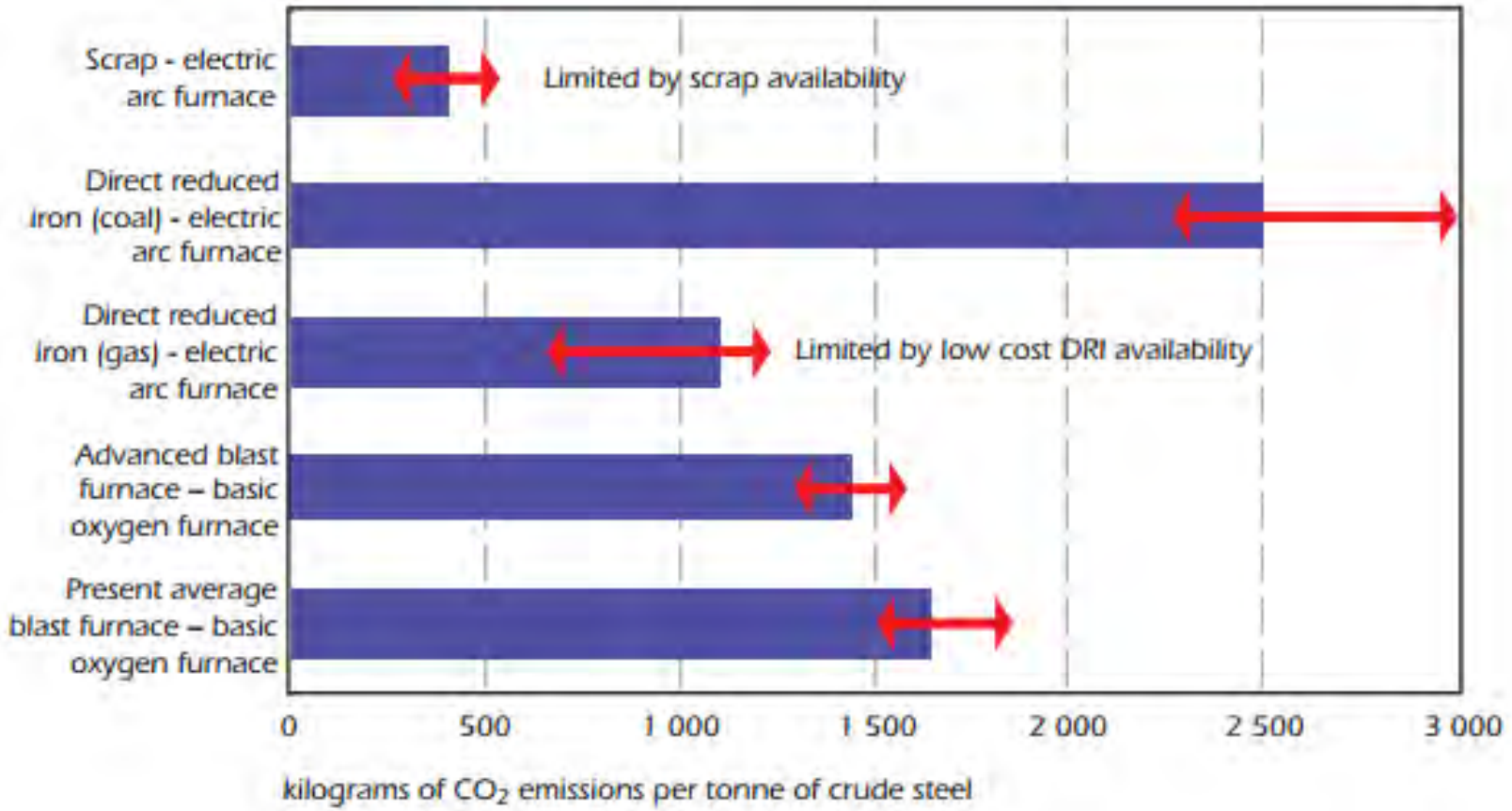
- "The US has had a major transformation and has become one of the most efficient iron and steel producer thanks to the use of recycled materials. The Chinese use primary materials, so this is an area of interest outside of the US."
- Growing demand for steel in China will limit the potential of using recycled materials to reduce emissions.



- Chinese production of steel is expected to grow through 2030.
- Chinese per capita steel demand from 1990-2010 was still much lower than peak demand seen in OECD countries. China is unlikely to reach levels seen in these countries, but probably has substantial room to grow.

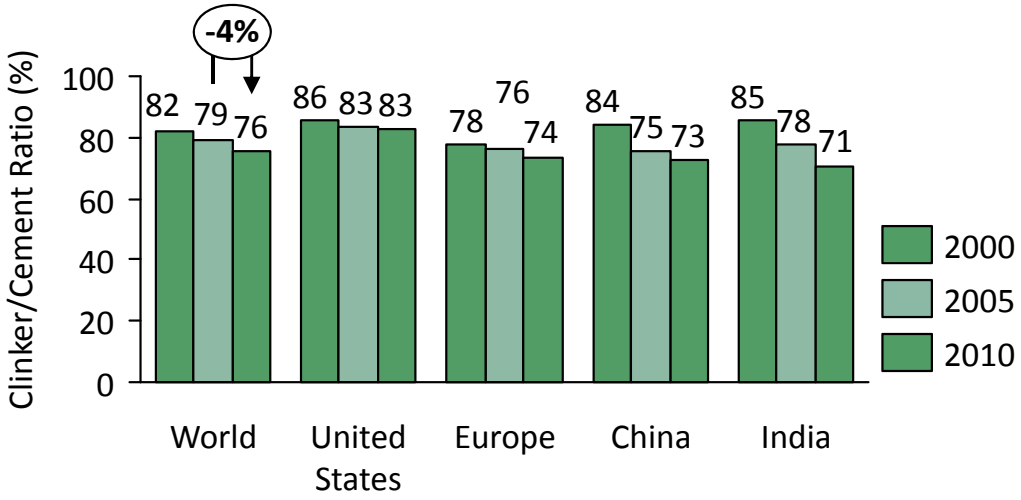
World Steel: Statistics Archive. Retrieved March, 2013. http://www.worldsteel.org/statistics/statistics-archive.html
Rio Tinto, 2013. "Chartbook." http://www.riotinto.com/documents/investors_databook/Chartbook.pdf

Crude steel production using scrap has much lower emissions, but is limited by material availability

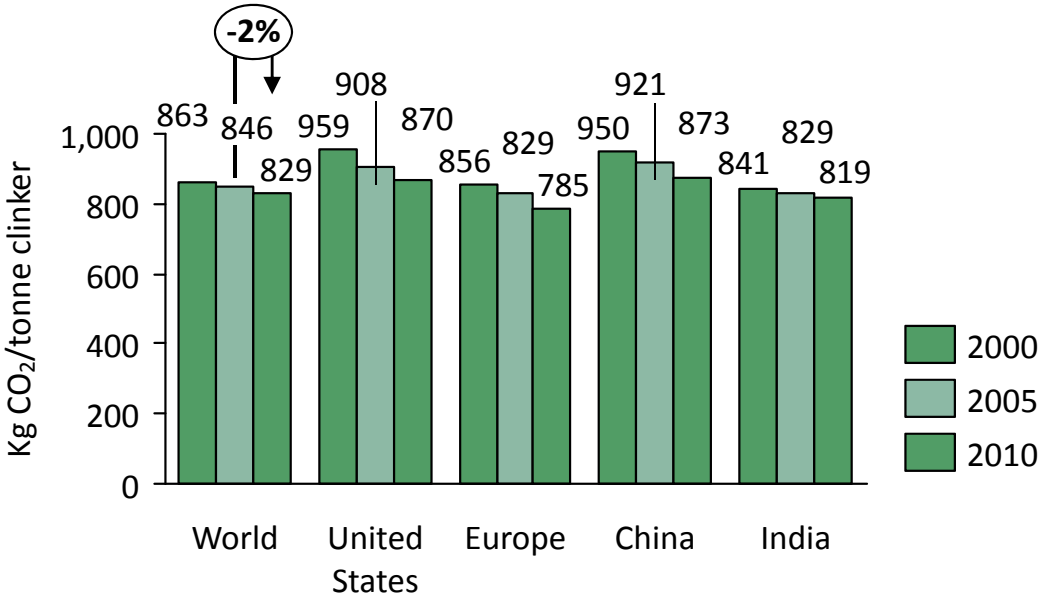


International Energy Agency, 2007. "Tracking industrial efficiency and CO2 emissions."

The cement industry has seen incremental improvements, but is not deviating from BAU trajectories



- Improvements in the ratio of carbon intensive clinker to cement are being realized across all regions, but at a slow pace.
- Both the availability of suitable substitutes (e.g., fly ash, slag, etc.), and determining and standardizing performance of alternative cement blends have limited the rate of progress.
- The difference between the U.S. and E.U. (the latter substitutes more) shows substantial room for improvements in clinker ratios.



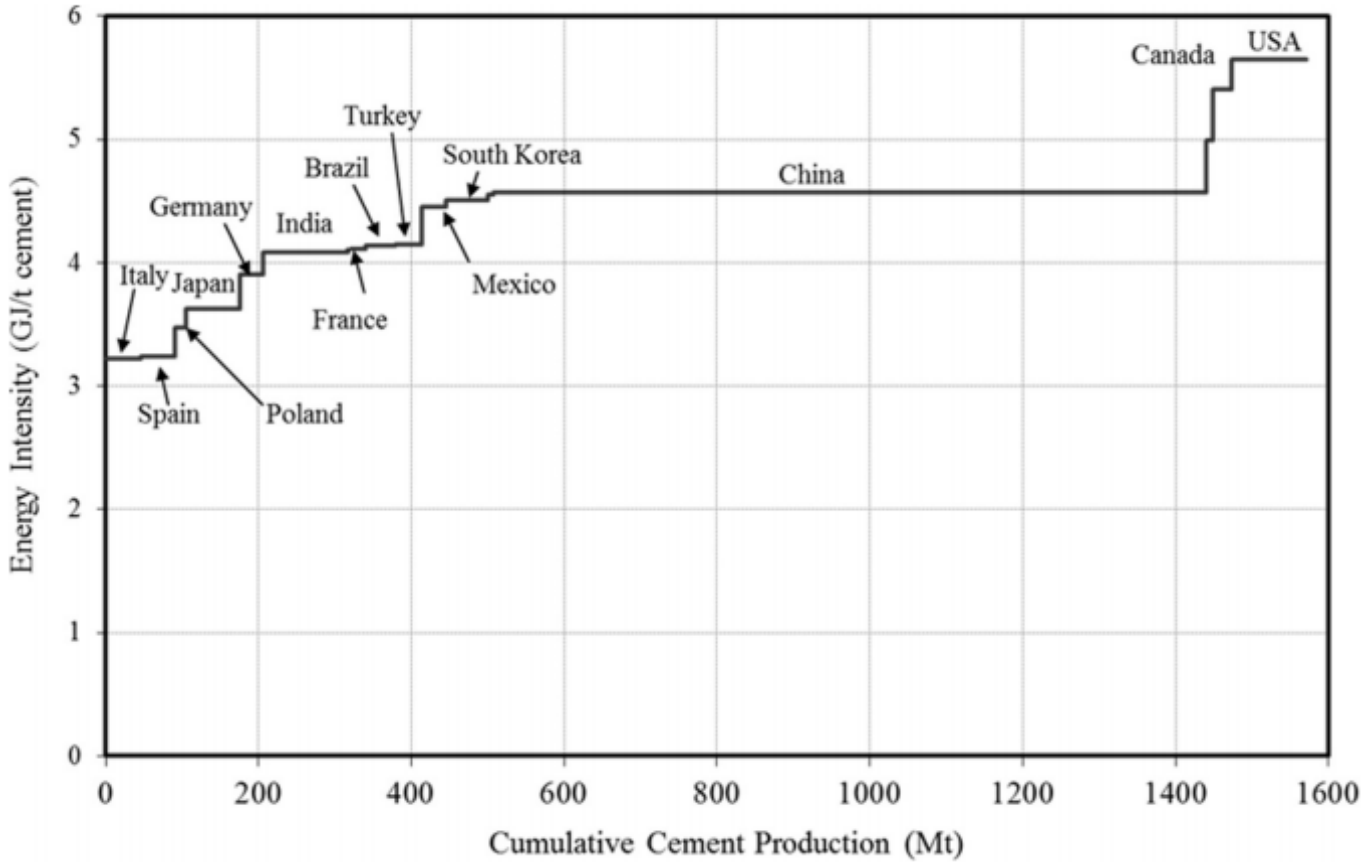
- Deployment of more fuel efficient technologies is improving the efficiency of cement production, but these changes are incremental.
- Potential interventions include phasing out of wet kilns, deployment of more efficient grinders, use of alternative fuels, etc.

World Business Council for Sustainable Development: Cement Sustainability Initiative – Global Cement Database on CO2 and Energy Information. Retrieved March, 2013. http://www.wbcsdcement.org/index.php/key-issues/climate-protection/gnr-database

Note this data covers reporting facilities that account for 25% of global production.

Slow stock turnover limits the pace of deployment of more efficient technologies

In some cases, developing countries have some of the most efficient facilities due to growing industries



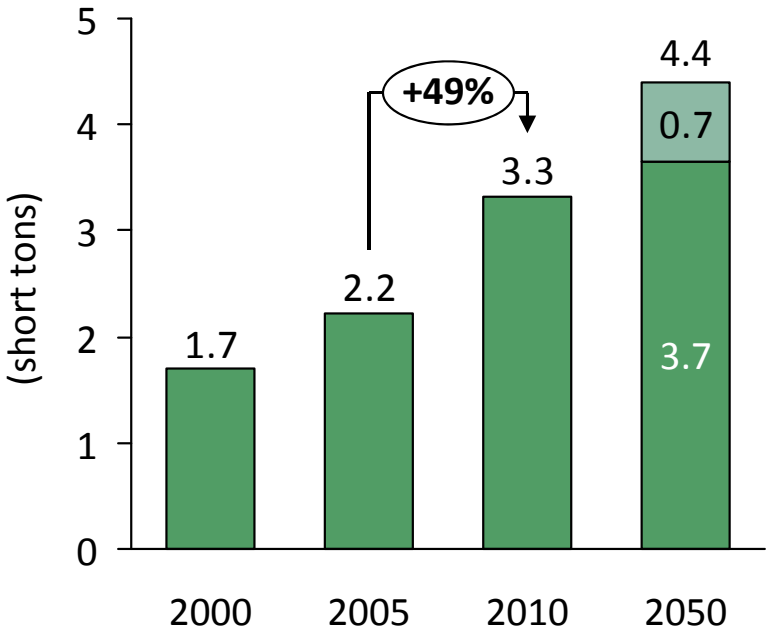
Energy intensity of cement production in selected key cement-producing countries, expressed as primary energy (Gj/t)

- "Some of the most energy efficient cement plants are India, because they are new. Same for aluminum."
- India also does not subsidize fuel costs for industrial users, and has poor domestic coal resources. The relatively high cost of fuel has pushed industry to reduce its energy consumption, and the country is one of the lowest cost producers of steel, aluminum, and cement.

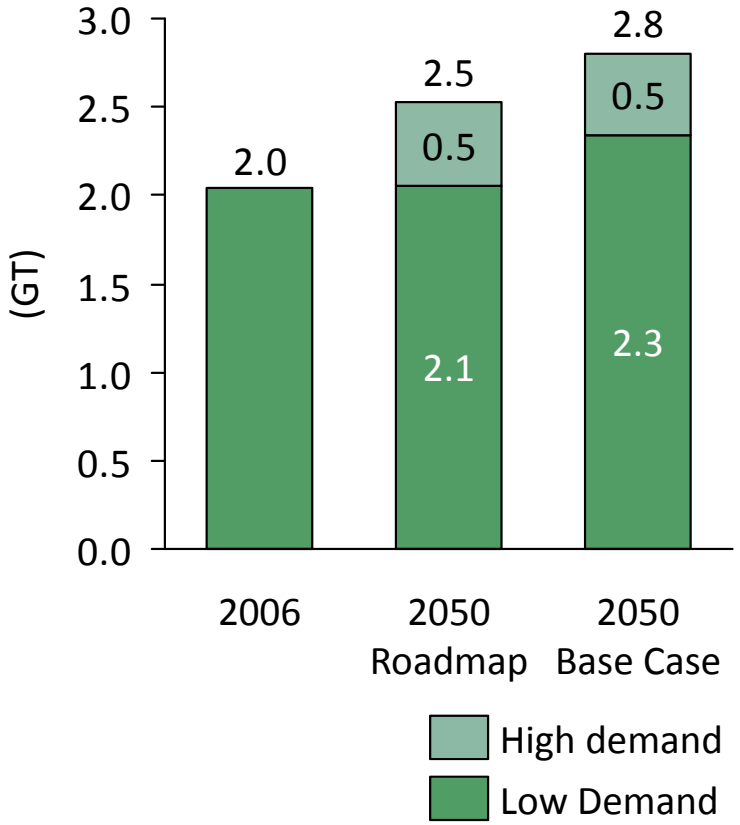
International Institute for Applied Systems Analysis, 2012. "Global energy assessment."

The incremental improvements in production efficiency are not sufficient to bring down total emissions from the cement industry

Global Cement Production

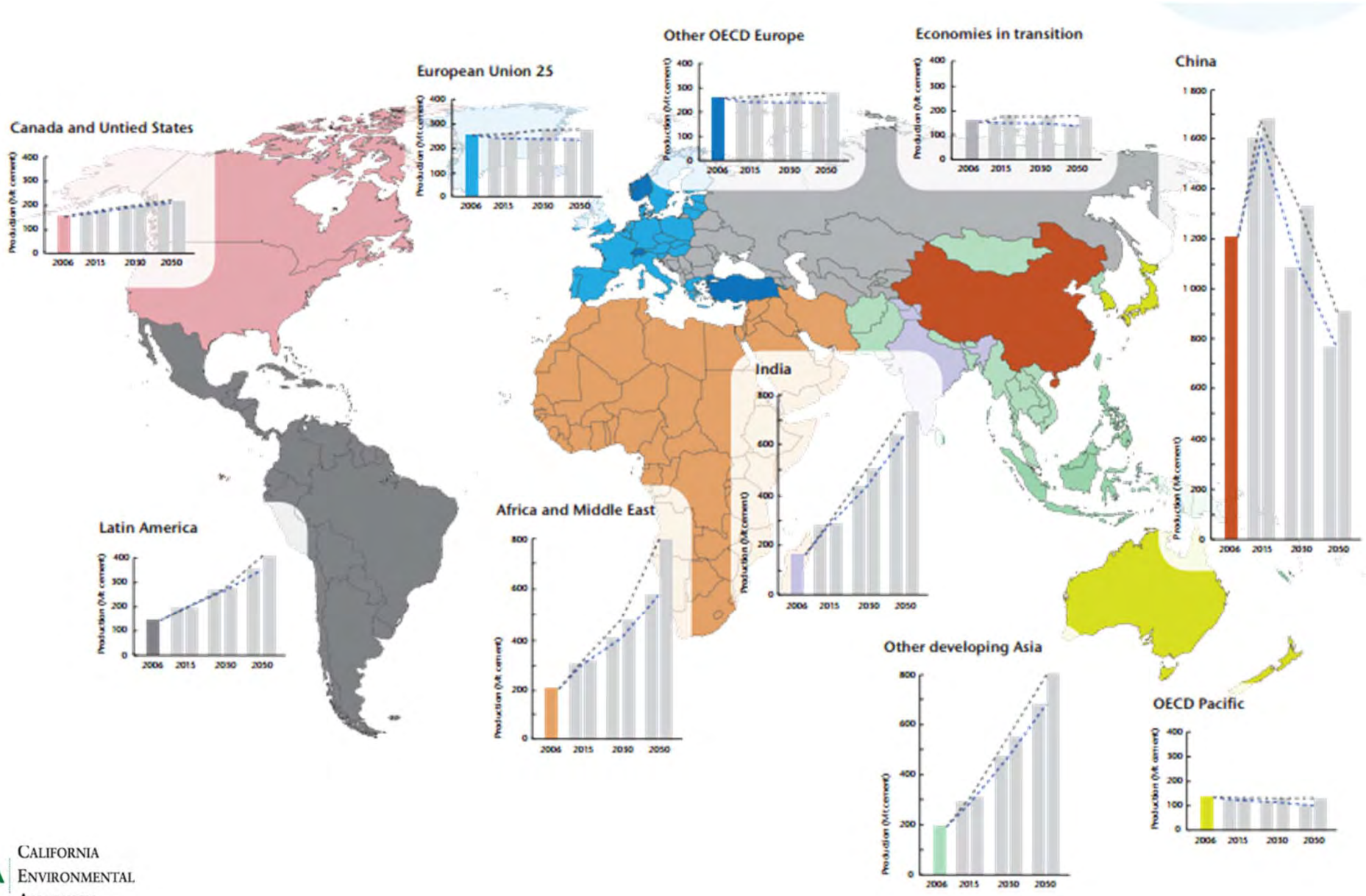


Global CO2 emissions from cement production



United States Geological Survey, 2013. Minerals Information: Cement. Retrieved March, 2013. http://minerals.usgs.gov/minerals/pubs/commodity/cement/
International Energy Agency, 2009. "Cement roadmap."

Cement production in China is expected to peak between 2015 and 2030, at which time other emerging economies will drive cement production.



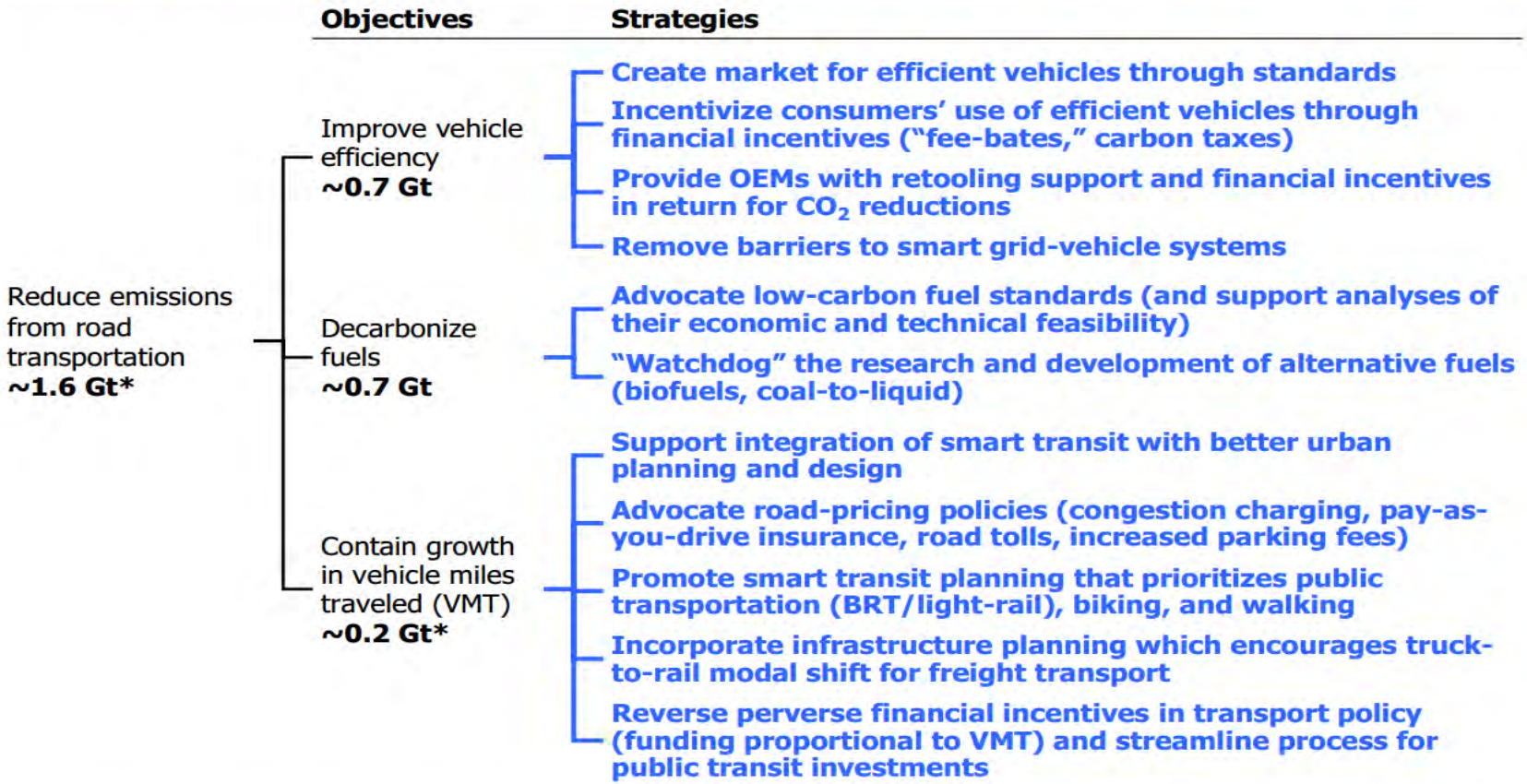
International Energy Agency, 2009. "Cement roadmap."

TRANSPORTATION

Interview reflections on transportation

DTW identified the following priorities for the transportation sector: Road Vehicle Efficiency (~1.5 GT), Fuel Decarbonization (~1.3 GT), VMT (0.2 GT), Air/Train/Ship (~0.1 GT); with an equal split between OECD and non-OECD countries.

FIGURE 18: Philanthropy's Role in Transportation (DTW Priorities Highlighted)



*Estimates likely conservative due to underestimation of gains from "clean-sheet" total system design
Source: Mitigation potential adapted from IPCC, USEPA, Vattenfall

California Environmental Associates, 2007. "Design to Win: Philanthropy's Role in the Fight Against Climate Change"

Interviewee reflections on transportation – BAU trajectory

1. **Little movement globally on projects:** The transportation landscape has not shifted dramatically in recent years
   - "Nothing surprising has happened in the last 6 years." And, "there has not been any global consensus on projections of BAU. That is one of the key challenges for the next several years… My gut sense is that the transport sector has continued to grow faster than other sectors."
2. **An emissions pivot toward the developing world.** Asia (and to a lesser extent Latin America and Africa) is increasingly where transportation infrastructure and emissions growth is occurring.
   - **United States**: Transportation emissions in the U.S. have largely stabilized and are falling (mainly due to light vehicles). The new fuel economy standards were an important victory. In tandem, vehicle miles traveled (VMTs) per capita peaked in the late 1990s and have been flat or declining since 1997. Total VMTs hit an all time high around 2005-06, and started to fall before the recession. Now VMTs are down 10% or so and stable. In the US, we are seeing a long term tide change caused in part by changing social attitudes, demographics, gasoline prices, etc. The rate of drivers licenses and car ownership for people under 35 has dropped by 20-25% over the last decade.
   - **Europe, Japan:** Emissions growth has been flat. Population growth and sprawl have largely stopped, and the cost of owning a car and improved fleet efficiency will drive reductions in emissions from passenger vehicles. In the EU, these declines may be offset by growth in emissions from heavy vehicles, air, and shipping.
   - **China** is the epicenter of growth in transportation emissions, with major increases in both passenger vehicles and the commercial fleet. Car ownership in China has exceeded expectations.
   - **India** is much further down the motorization and urbanization curves than China, with car ownership rates at approximately 10 per 1,000 people. However, overall emissions are growing; motor bike use, mass transit options, rail, and car ownership for the top income decile are all important issues.

Interview reflections on Transportation – unexpected challenges

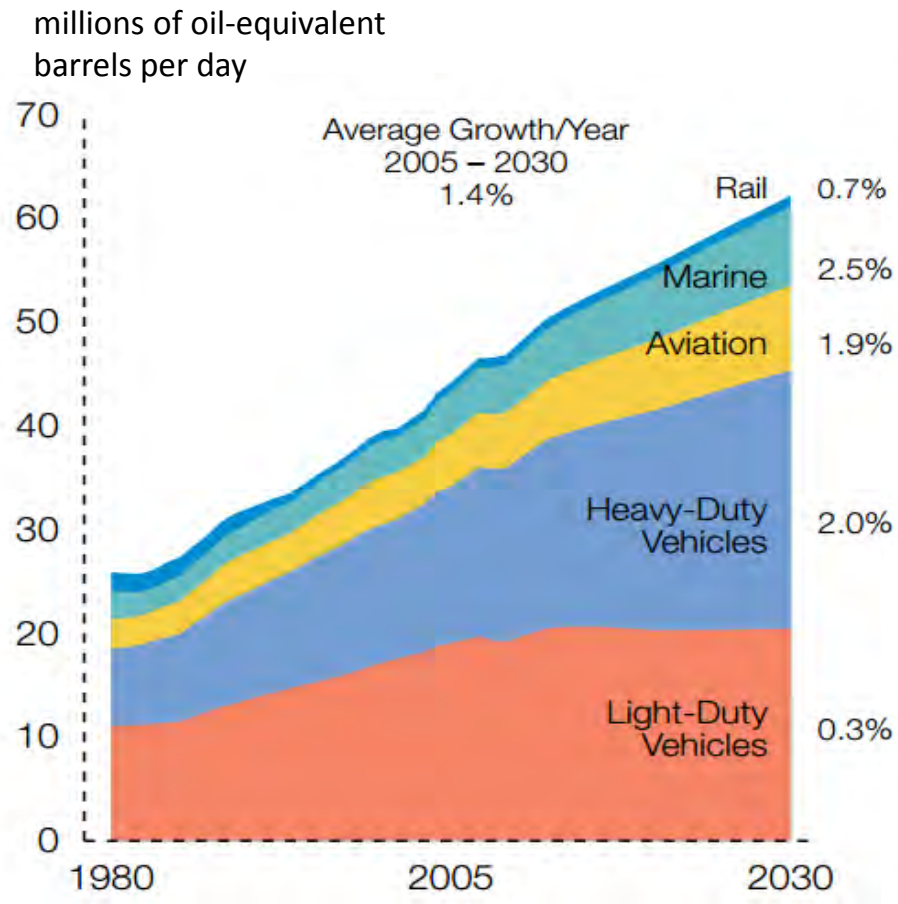
1. **Vehicle fleet turnover rates** appear to be slower than anticipated ("We thought it was eight years and it looks more like twelve"). Because the pace of motor vehicle turnover "may have been overstated," the penetration of new fuel-efficient technologies has also been slower than expected. Not only is the average age of motor vehicles in places like the US at an all time high, but because older vehicles are then exported to lower-income countries, the lifecycle of vehicles globally is even longer than it is in the more affluent countries.
2. **Chinese vehicle ownership has grown much faster than anticipated.** There are several places where the growth in car ownership is surprising, but China is clearly the most salient case of "reality outstripping expectations." This increase is due not only to general economic growth, but also growing income stratification. The rate of motor vehicle ownership in Chinese cities is approaching 300 cars per 1,000 people (approximately that of less affluent cities in Europe) about 8 years ahead of schedule. Beijing has about 450 cars per 1,000 (exceeds Tokyo), and is growing at 20% per year.
3. **Congestion pricing** was expected to take off more than it has, given the early progress that was made in Scandinavia and Europe; that progress stalled substantially after the NYC failure.
4. **Slow growth in electrification and alternate fuels**. "We still haven't had the fundamental breakthrough on battery technologies needed for rapid, massive commercialization of electric vehicles." "Progress on fuels has been kind of limp."

Interviewee reflections on transportation –modest wins

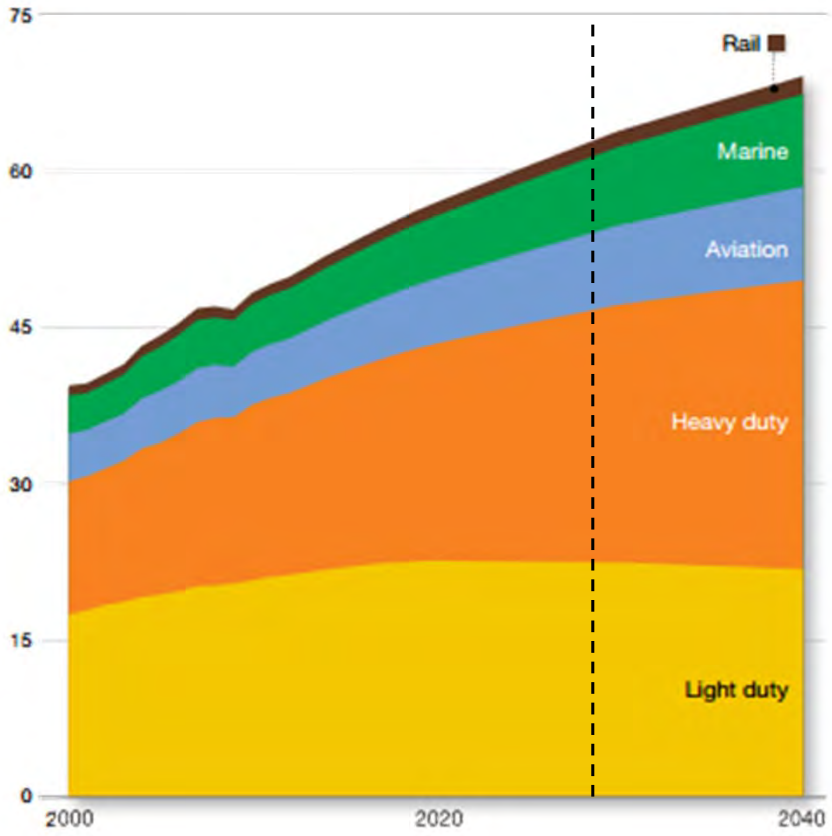
1. **Fuel economy standards and VMT in the OECD:** Passage of the new CAFE standards were an important, though not unexpected, win in the United States. The decline of VMTs in the United States has also been a bit of a surprise, but is now expected to continue into the future Similarly, the adoption of fuel economy standards in Europe and in China have substantially reduced emissions relative to the reference scenarios.
2. **Building momentum in non-OECD countries:** Interviews pointed to a few bright spots emerging in the developing world as well:
    1. Bus rapid transit (BRT) and infrastructure planning successes in key cities in India (Chennai) and in China (Guangzhou). Interest in transportation is being driven from more of a green growth agenda then from an environmental/climate lens. Concerns over air pollution and lost economic productivity due to congestion are a primary driver.
    2. Technology has not been revolutionary, but there have been some unexpected successes in applying new information sharing approaches or modifying existing technology: Public bikes ("these things are spreading like wildfire across China"), parking management, car sharing, and electric bicycles ("there has been an explosion of electric bicycles! There is now 130 million in China alone.").
    3. Multilateral engagement: "We are seeing movement at the G20 to remove fossil fuel subsidies by 2020. Countries like China and Nigeria are making moves to remove those subsides as well. These perverse subsidies are on the order of $400-600 billion per year." "There has been unprecedented cooperation from multilaterals which have pledged money to more sustainable transport."

There hasn't been any significant change in forecasted energy consumption in the transportation sector

2008 Forecasts for Global Transportation

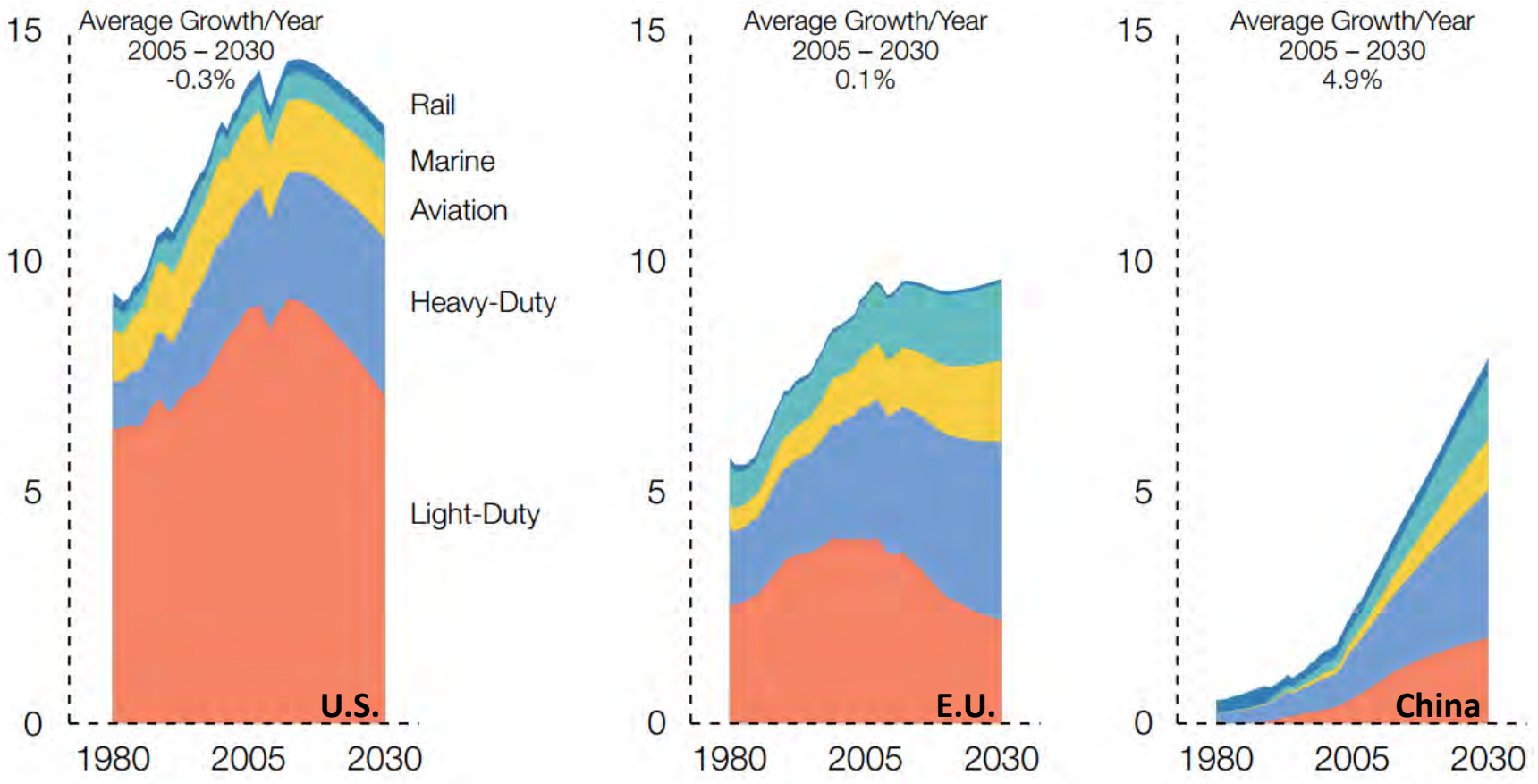


2013 Forecasts



Exxon Mobil, 2008. "The outlook for energy: a view to 2030"
Exxon Mobil, 2013. "The outlook for energy: a view to 2040."

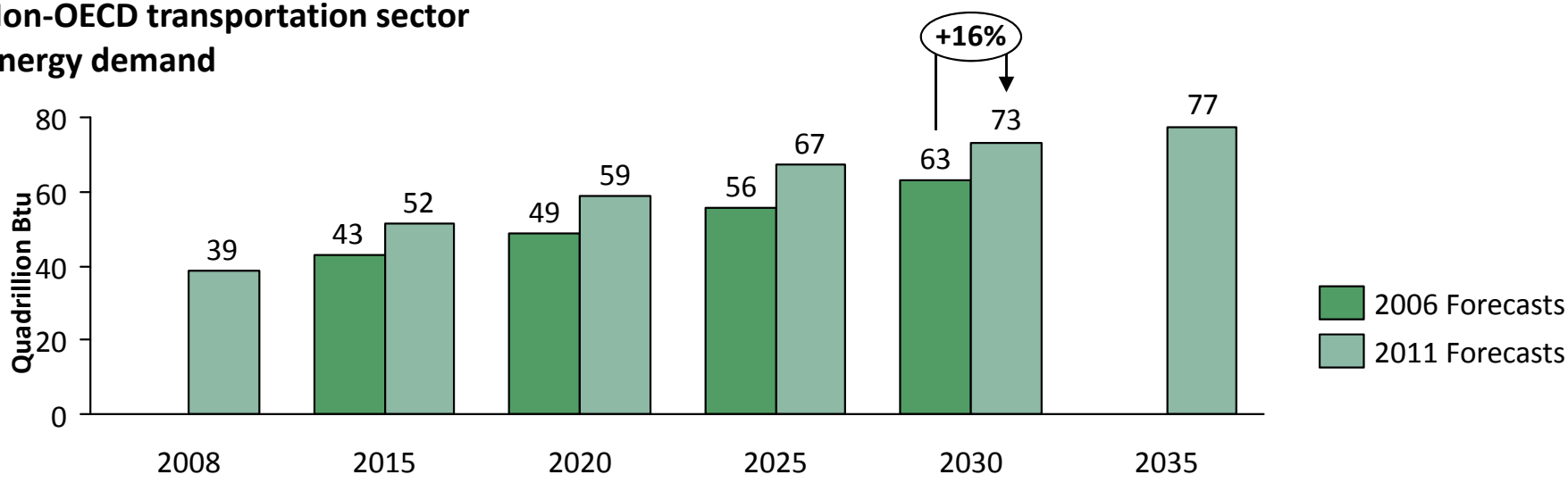
Mirroring other sectors, transportation energy consumption will likely be flat or slightly declining in OECD countries with rapid growth in China and the rest of the developing world



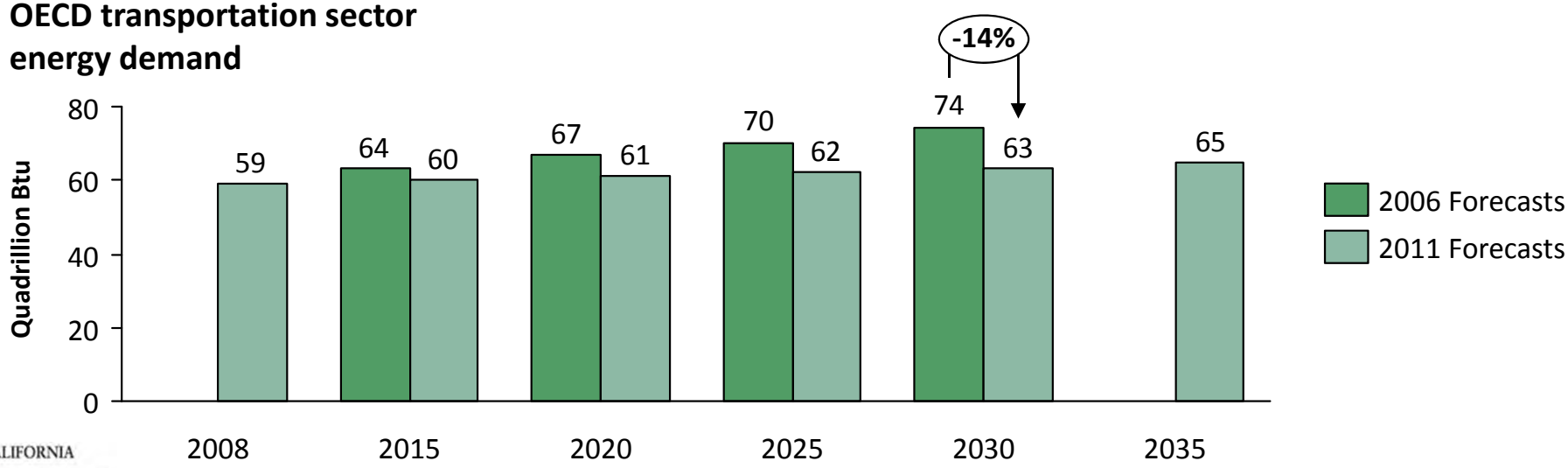
millions of oil-equivalent barrels per day

Forecasted energy consumption in the transportation sector has not changed since 2006 but distribution has. Forecasts are lower for OECD countries and higher for the developing world

Non-OECD transportation sector energy demand



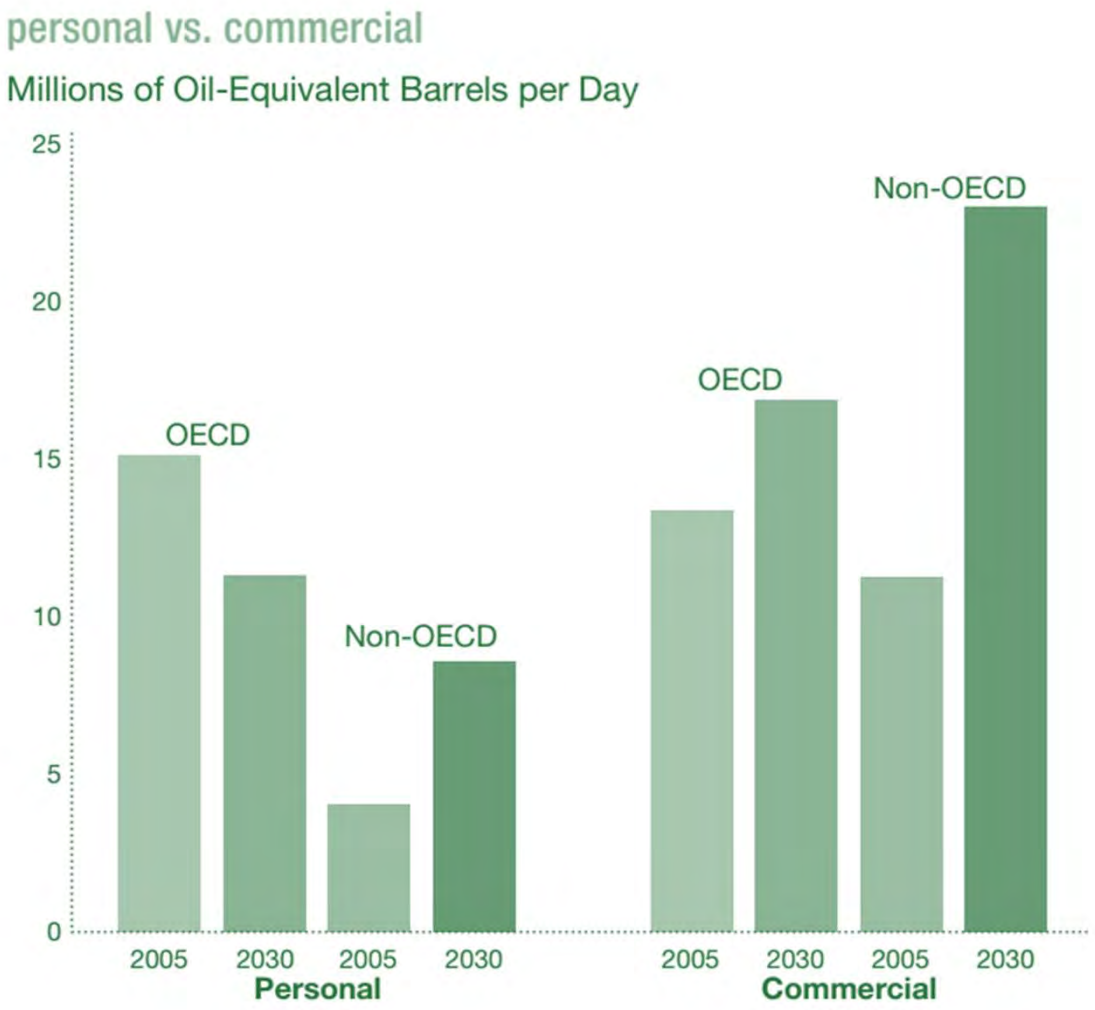
OECD transportation sector energy demand



U.S. Energy Information Administration, 2006. "International energy outlook: 2006."
U.S. Energy Information Administration, 2012. "Annual energy outlook 2012."

CEA California Environmental Associates

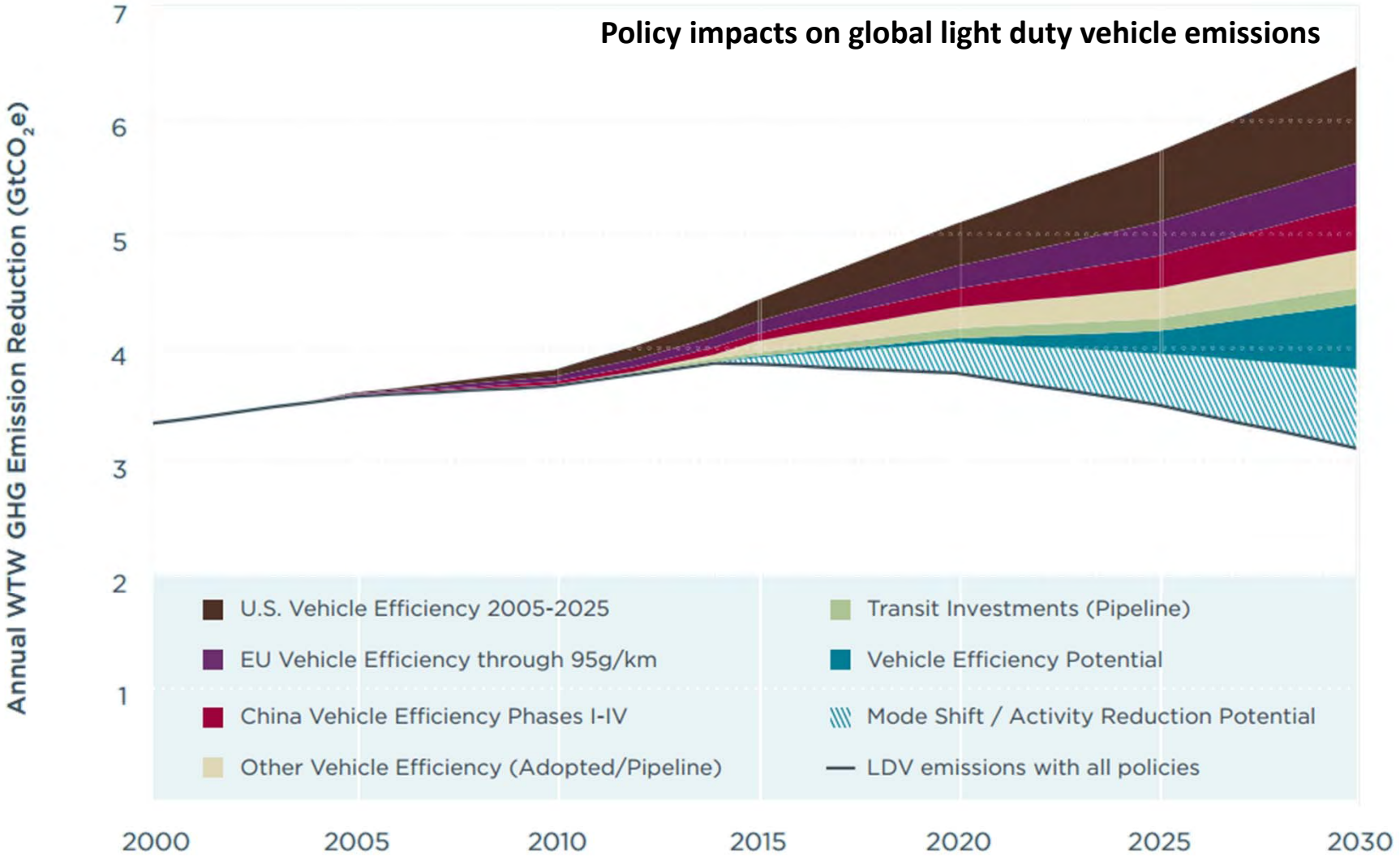
OECD countries will still lead personal vehicle fuel consumption, but the developing world will become the primary consumer of fuel for commercial transport.



CEA California Environmental Associates

Exxon Mobil, 2009. "The outlook for energy: a view to 2030"

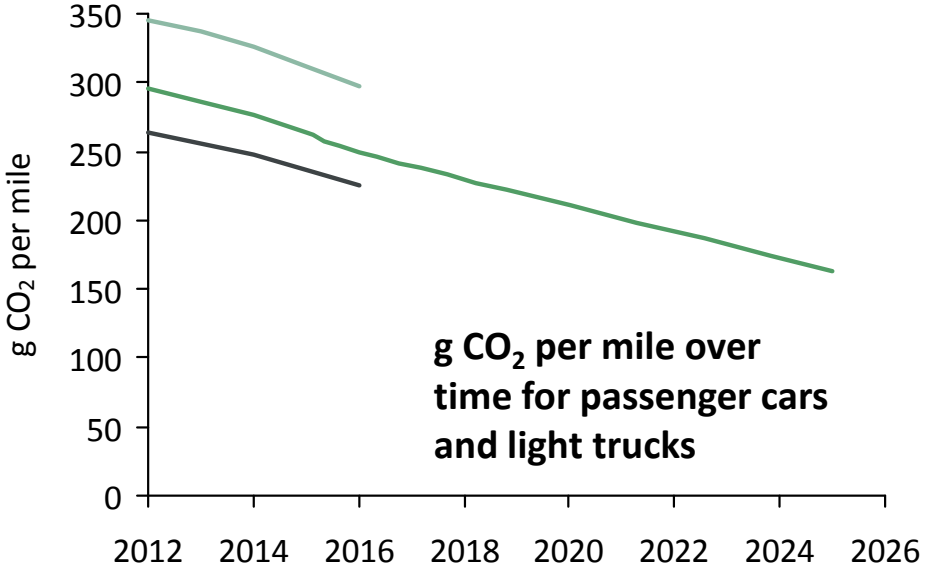
A suite of interventions is still needed to stabilize or reduce light duty vehicle emissions



International Council for Clean Transportation, 2012. "Global transportation energy and climate roadmap."

CAFÉ standards in the U.S. have been a bright spot; proposed federal standards for vehicle efficiency over the next decade are expected to nearly double the fuel efficiency of the fleet.

- Standards for model years 2012 to 2016 were set in 2010. They are projected to reduce U.S. greenhouse gas emissions by 960 Mt CO_2e over the lifetime of the vehicles made in those years. [1]
- In 2011, EPA and DOT proposed standards for model years 2017 – 2025 for light-duty vehicles. Over the lifetime of the vehicles made in those years, the standards are expected to reduce ghg emissions by ~ 2Gt CO_2e. [1]
- If the proposed standards are passed (as expected), the light-duty fleet would have an average fuel economy of 49.6 miles per gallon by 2025.[2]



250 g per mile is the required standard for model year 2016, corresponding to 35.5 miles per gallon.

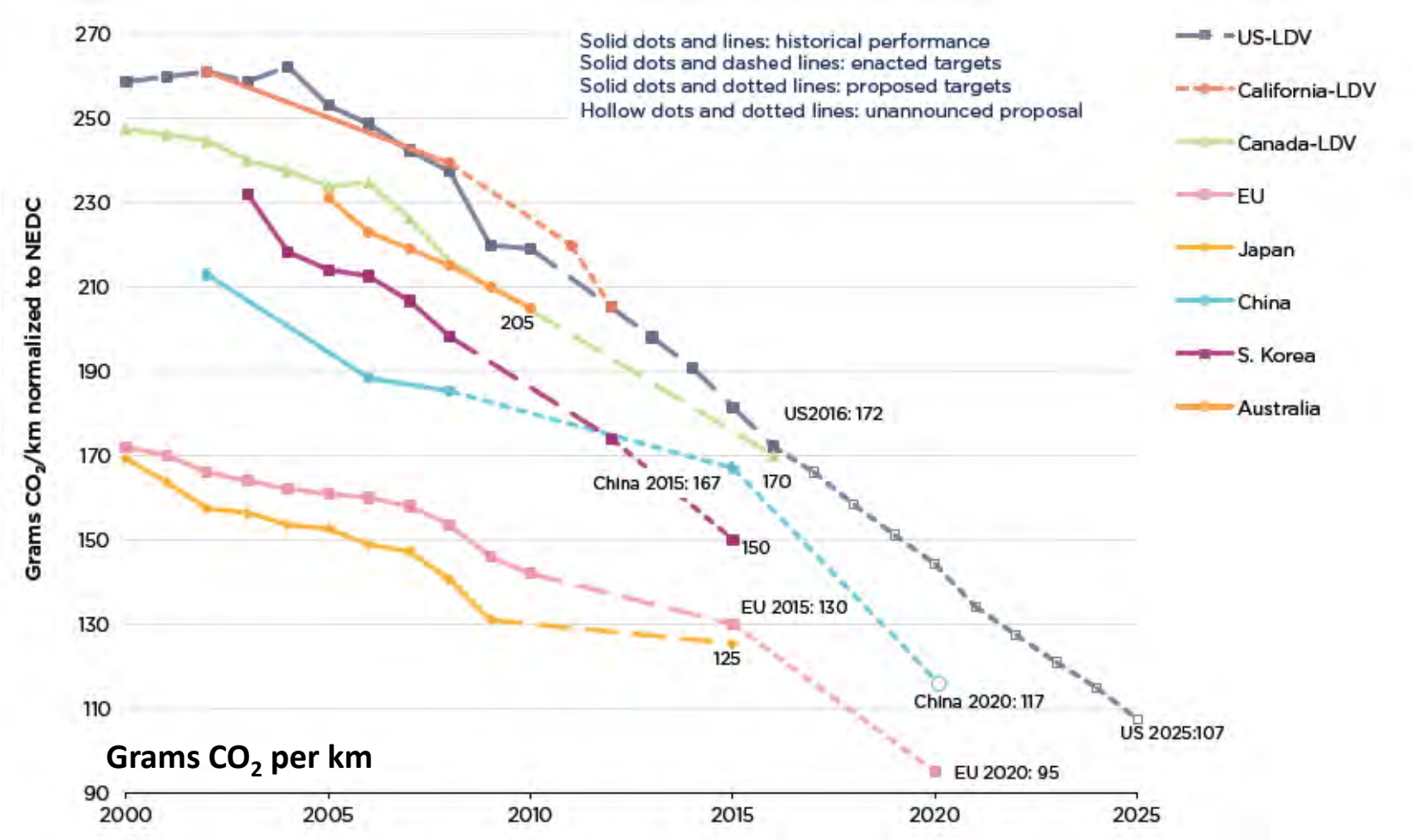
163 g per mile is the required standard for model year 2025, corresponding to 54.5 miles per gallon. **A 35% reduction over 2016.**

- Passenger cars (2012 - 2016 standard)
- Light trucks (2012 - 2016 standard)
- Combined Cars & Trucks (proposed 2017 - 2025 standard)

1. U.S. Environmental Protection Agency, 2010. "EPA and NHTSA finalize historic national program to reduce greenhouse gases and improve fuel economy for cars and trucks."
2. Manufacturers are allowed to trade fuel economy with low-GWP air conditioning refrigerants, which is why total the average fuel economy is expected to be 49.6, instead of 54.5 mpg (the rate that corresponds to the greenhouse gas standard of 163 g/mile). ICCT, "Policy Update #13: EPA/DOT SNOI for 2017-2025 Light-Duty Vehicle Standards", 2011.

Proposed continuous increase to vehicle efficiency standards in the US bring the US fleet closer to parity with Europe by 2025

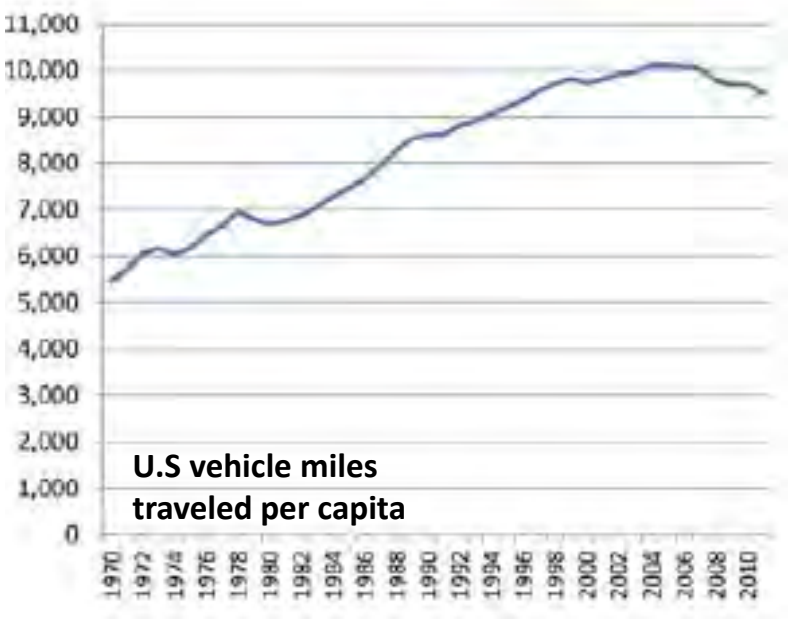
If regulation continues on its expected trajectory, gains will be very significant. The key will be ensuring that the standard does not get modified in the interim review (set for 2017), and ensuring that manufacturers do not earn too many ways to trade out of the standard through off-cycle credits (these trade-offs will be set in the next few months).

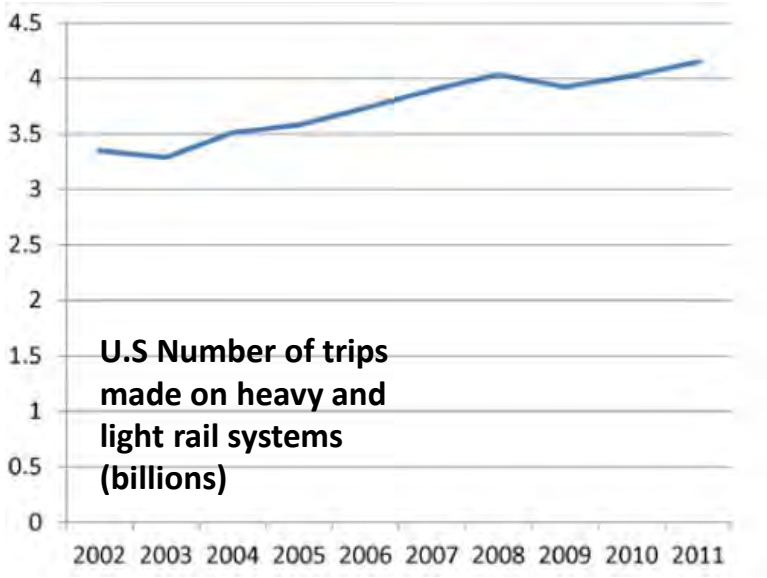


International Council for Clean Transportation, 2011. "Policy update #13: EPA/DOT SNOI for 2017-2025 light-duty vehicle standards."

VMT reductions now appear feasible -- VMT per capita across the US dropped by 6% between 2004 – 2011. In parallel trends, the number of passenger rail trips have increased since 2000

VMTs peaked in 2004, and have been dropping in the last few years. Although the recession and rising gasoline prices have played a large role in reducing the miles driven by Americans, demographic changes may be a factor as well. Specifically, younger people seem to be leading the trend away from driving.





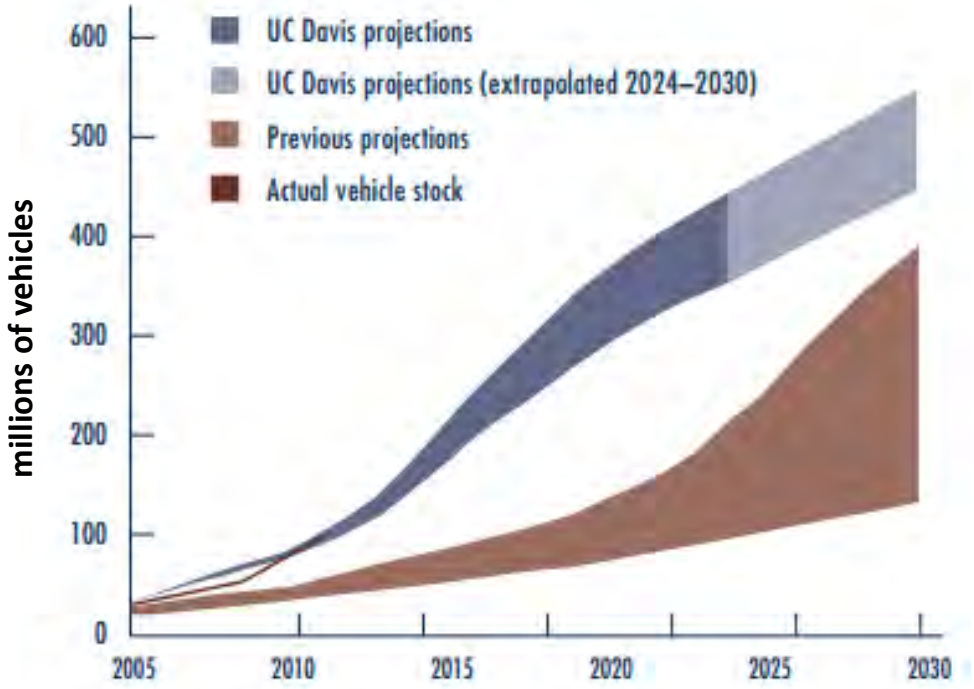
- From 2001 to 2009, the annual number of vehicle miles traveled by young people (16 to 34-year-olds) decreased from 10,300 miles to 7,900 miles per capita—a drop of 23%.

- From 2001 to 2009, the number of passenger-miles traveled by 16 to 34-year-olds on public transit increased by 40%.

Frontier Group & USPIRG, 2012. "Transportation and the new generation."

Vehicle ownership in China has grown faster than expectations

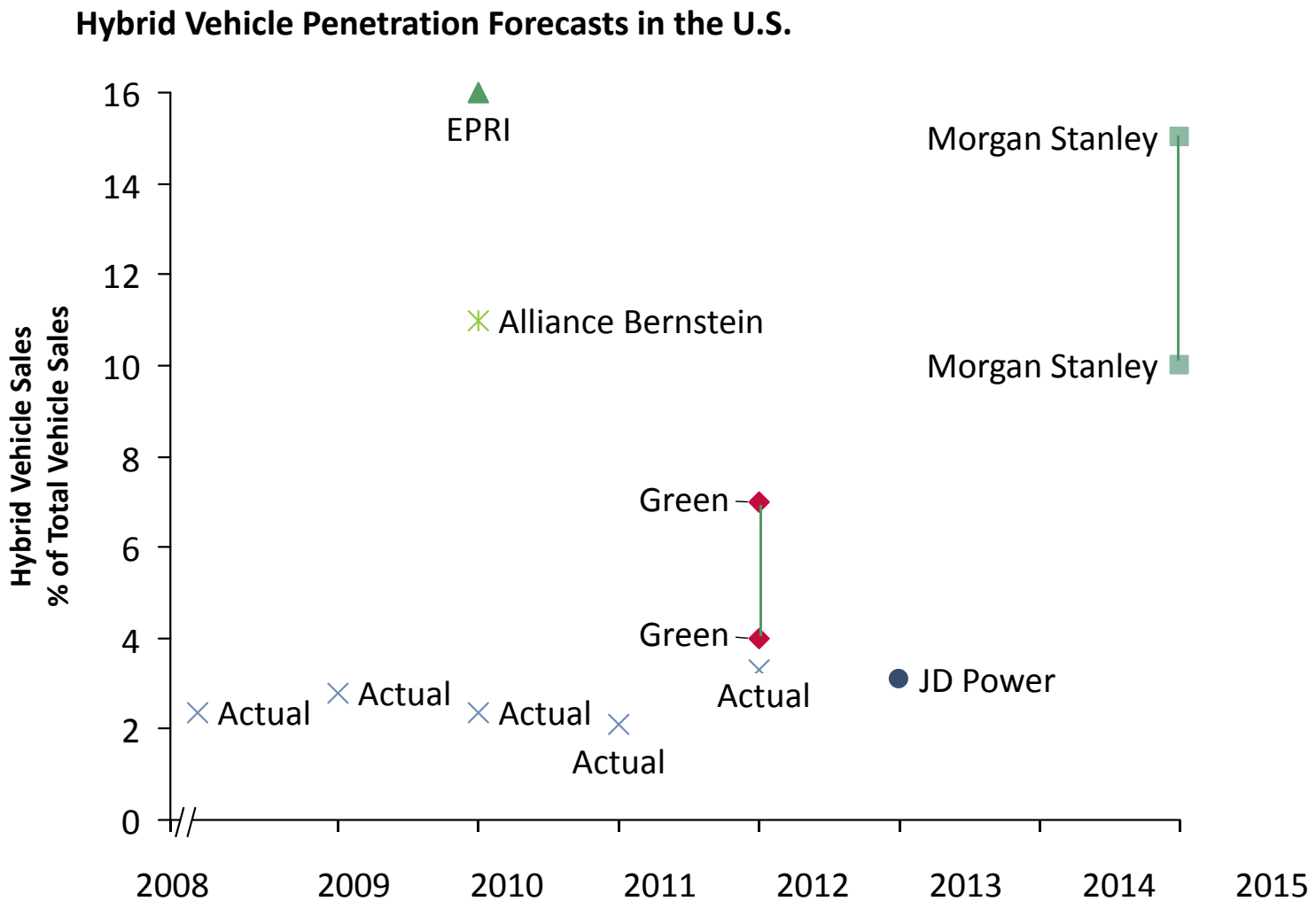
Projections of personal vehicle ownership in China



- Personal vehicle fleet size in China is far outpacing previous expectations.
- Vehicle ownership in China is already more than double EIA's stock projection for 2015 in its 2008 World Energy Outlook.
- Previous forecasts for vehicle fleet size in China in the chart on the left are bounded by Dargay 2007 (top) and EIA's International Energy Outlook in 2008 (bottom).

Wang et al., 2012. "Will China's vehicle population grow even faster than forecasted?" Energy Policy.

Penetration of new technologies has been slower than expected. Hybrid vehicle sales have been at the low end of forecasts



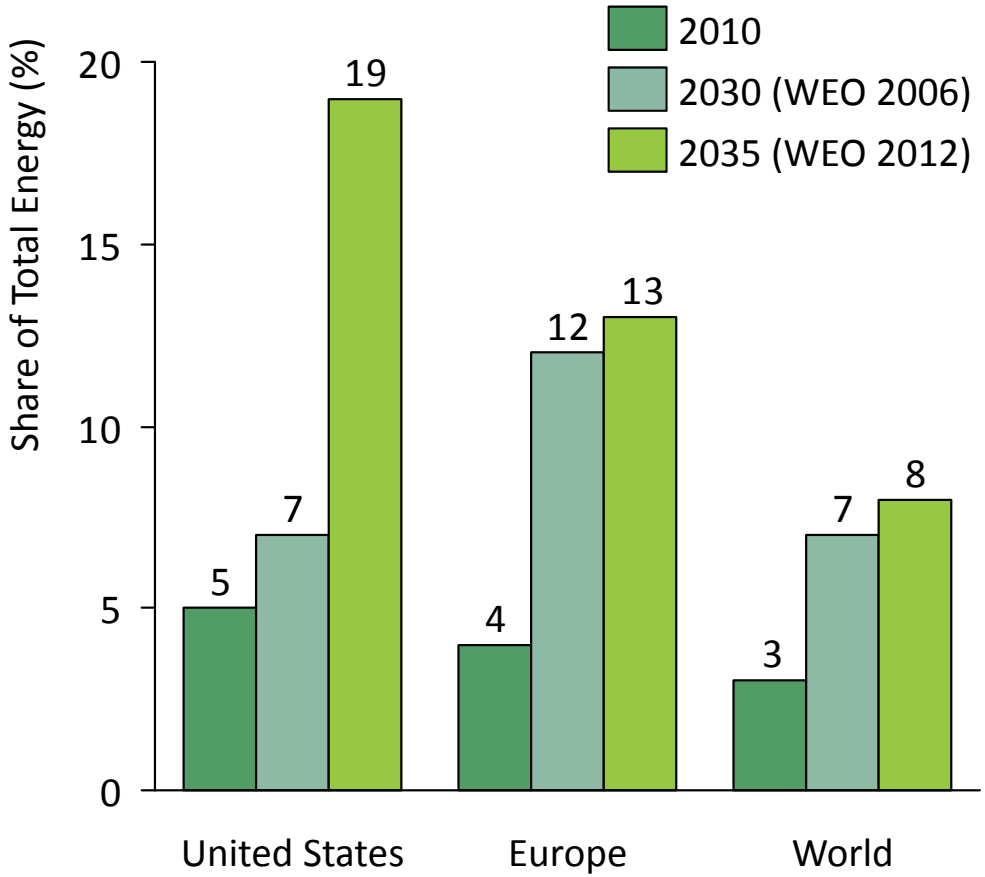
CEA California Environmental Associates

U.S. Department of Energy, 2008. "Plug-in hybrid electric vehicle market penetration scenarios."
U.S. Department of Energy, Alternative Fuels and Advanced Vehicle Data Center. Alternative Fuels Data Center. Retrieved March, 2013. http://www.afdc.energy.gov/data/tab/fuels-infrastructure/data_set/10301

The prospects for biofuels in transportation have improved slightly driven by increased ethanol consumption. Unfortunately, growth in lower carbon biofuels (e.g., cellulosic ethanol) has been slow.

The United States is the only country with a clear target for advanced biofuels. By 2035, only 18% of global transportation biofuel consumption will be advanced biofuels (e.g., switchgrass/cellulosic ethanol).

Share of Biofuels in Road Transport Fuel Consumption



Carbon intensities of selected fuels in California (g CO_2e/MJ)

Fuel	Carbon Intensity
CA Gasoline	95.86
Midwest Corn Ethanol	99.40
CA Corn Ethanol	80.70
Sugarcane Ethanol	73.40
CA Electricity	41.37
CH4 based H2	61.83

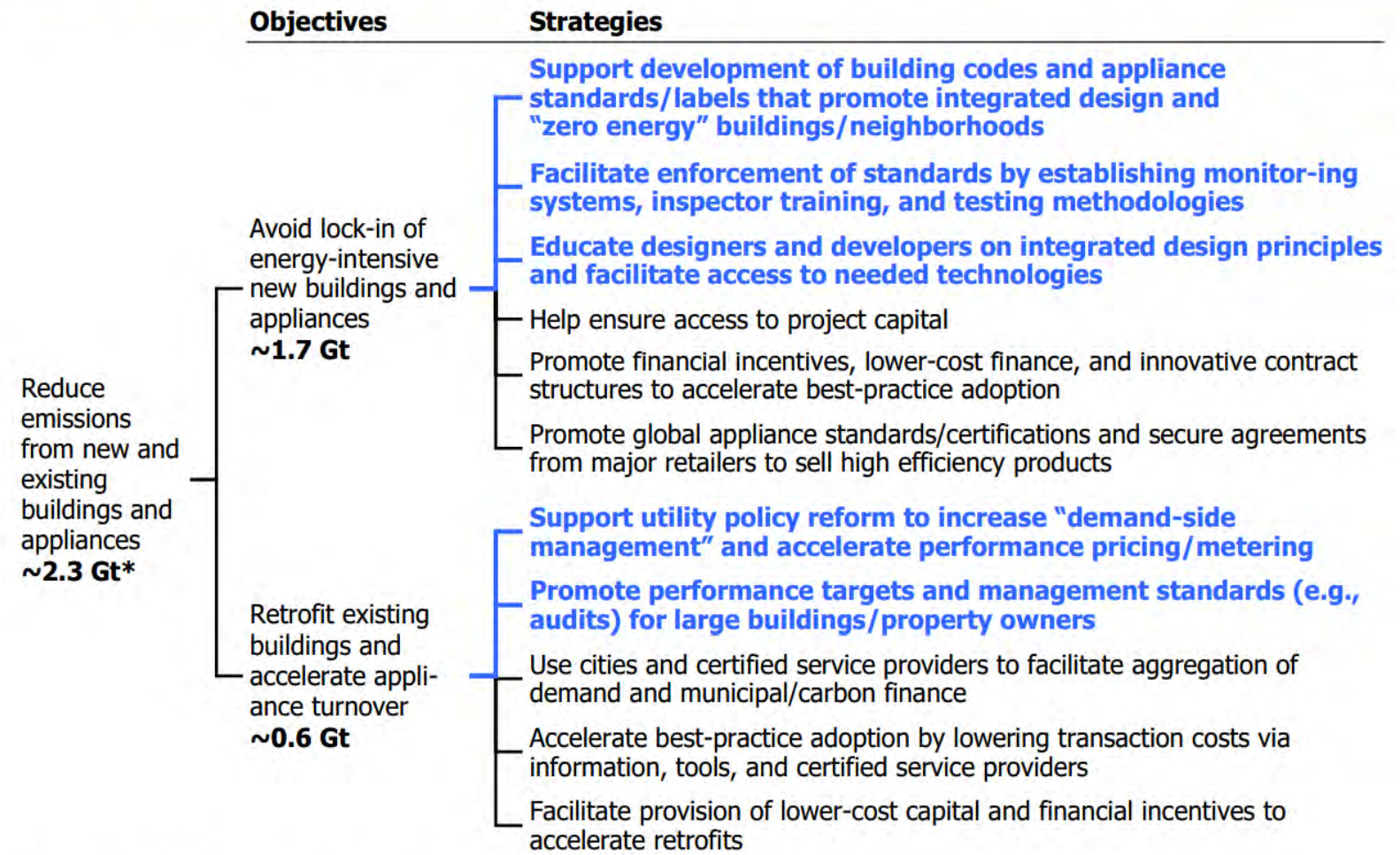
International Energy Agency, 2006. "World energy outlook."
International Energy Agency, 2012. "World energy outlook."
Argonne National Laboratory, 2009. "Well-to-wheels analysis of biofuels and plug-in hybrids."

BUILDINGS

Buildings

Buildings – DTW identified the following priorities for the building sector: New appliances (2GT), building retrofits (1GT), and new buildings (1GT), with an even split between OECD and non-OECD countries.

FIGURE 16: Philanthropy's Role in Buildings (DTW Priorities Highlighted)



* Estimates likely conservative due to underestimation of gains from "clean-sheet" total system design

Source: Mitigation potential adapted from IPCC, USEPA, Vattenfall

California Environmental Associates, 2007. "Design to Win: Philanthropy's Role in the Fight Against Climate Change"

Interviewee reflections on buildings

1. **The buildings sector is probably trending slightly better than BAU, though experts don't have ready data to point to**
   - "In the building sector, I've just been amazed at the progress that has been made in the last five years ago… The bad news is that it is just not enough… I'm much more pessimistic"
   - "I think we are going a little bit better than business as usual globally. I am not convinced that the U.S. is doing better than BAU."
   - "I don't think that the buildings sector has lived up to efficiency improvements that were highlighted. I have seen improved political willingness, but no implementation."
   - "Unfortunately nobody is tracking things very closely in the buildings sector."
   - "The data is notoriously bad, and it is really shocking.
2. **Reflections on Design to Win**
   - "The assumptions were incomplete and based on technical potential. The expectations were that if it is a cost saving measure, it will happen. The transaction and information barriers are bigger than we expected."
   - The U.S., E.U, China, and India are still the right geographic priorities
     - 70% of the houses that will exist in India in 2020 have yet to be built.
     - Most new construction in India has air conditioning, but there is no standard or policy for reducing cooling demand.
     - Over the next twenty years, China will build more building floorspace than currently exists in the entire United States

Interviewee reflections on buildings

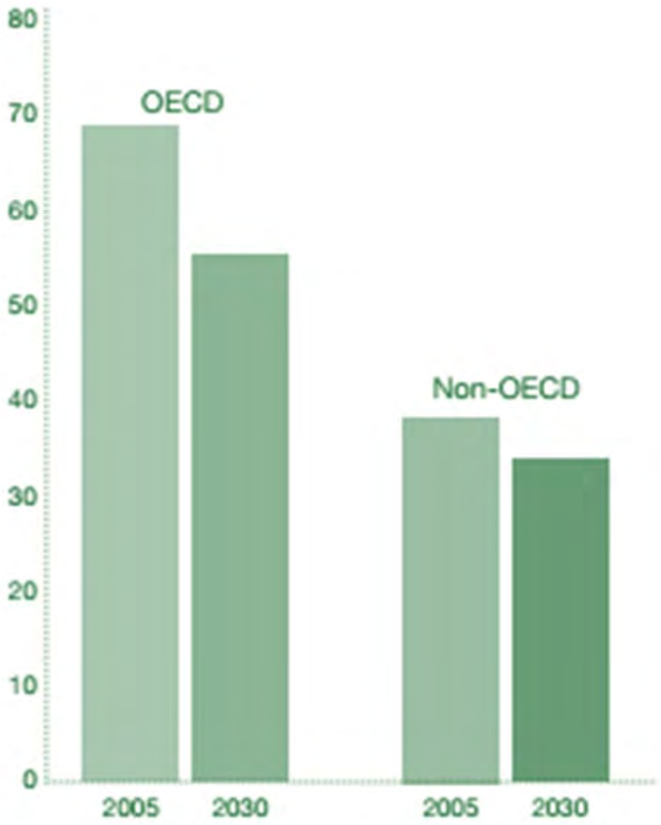
3. **Good progress has been made on building codes, but compliance remains an ongoing challenge**
   - "There has been fairly significant building code adoption and implementation in the developed economies. Anywhere from 20-50% energy savings over the last 5 to 10 years."
   - "On building energy codes in China there has been a lot of improvement made, but some people are skeptical of how real those numbers are. To the Chinese governments credit, there was no enforcement 8 or 10 years ago, and they have made it a priority, but there is a mentality that they will find a way around the rules in China."
   - "Enforcement is typically weak, even in the U.S. and Europe."
   - "I have seen states and cities adopt codes which I never would have thought would adopt a code"
4. **No strategies have emerged to unlock a large share of the mitigation potential in existing buildings**
   - There is a lot more discussion about getting at the existing building stock in Europe, but there are no good strategies yet.
   - "The Recovery Act retrofit programs spent a billion dollars in 18 months, but we really proved that doing broad-based, deep retrofits is not going to happen. Unfortunately, retrofits is where 99% of the benefits have to come from. "
   - "We are seeing 5-10% savings in existing buildings, not 20-40% savings. And only doing 50,000 versus 8 million year." (In the U.S.)

Interviewee reflections on buildings

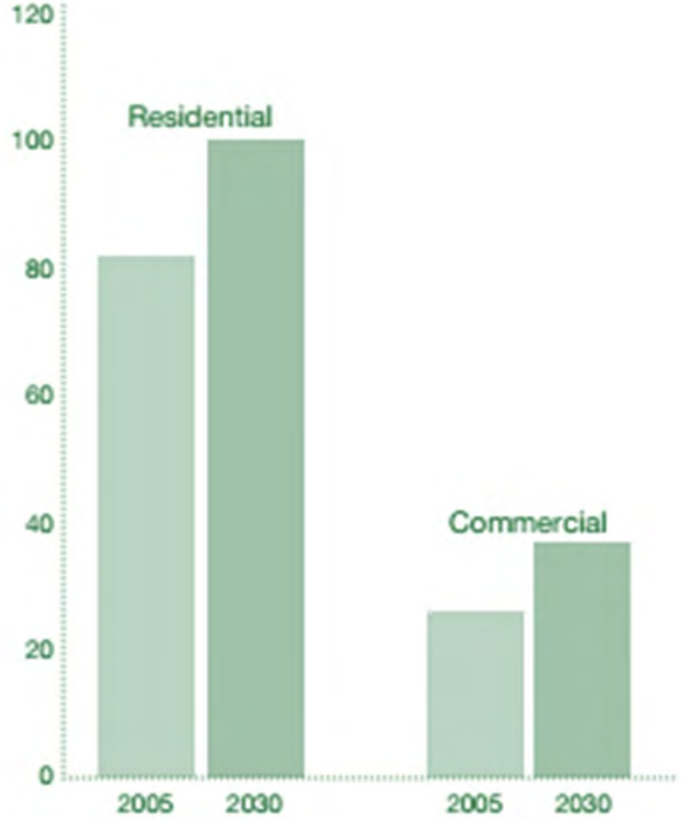
5. **Appliance standards appear to be a bright spot in the buildings sector, but better coverage and more rigorous standards are needed**
   - "You can move the lever on new buildings and appliances… If I had another $500k, I'd spend it on appliance standards."
   - "My sense is that things are actually going quite well. In the U.S. the pace of standards picked up a bit with the Obama administration. There has been a good deal of standards activity in China and some of that is putting pressure on the U.S. and EU to move faster."
   - "There is increasing coverage of appliance standards – Europe is leading the way and China is making some small steps. The U.S. got stuck in things that they know (e.g., refrigerators vs. electronics)."
   - "A lot more is possible in the commercial and industrial equipment standards, but this hasn't moved."
   - "Chinese appliance standards are not very ambitious."
6. **Building labeling and disclosure is an emerging area of interest**
   - The work on benchmarking, rating, and disclosure within cities is interesting. New York had remarkable findings – there was a 5-fold difference between the least efficient and most efficient quartile.
   - I think there is a potential there…but it depends on the structure of the market and how well the program is implemented. The experience is mixed in Europe.

Efficiency improvements are expected in both developed and developing world buildings, but will be subsumed by the overall growth in households.

Residential energy use
millions of BTUs per household



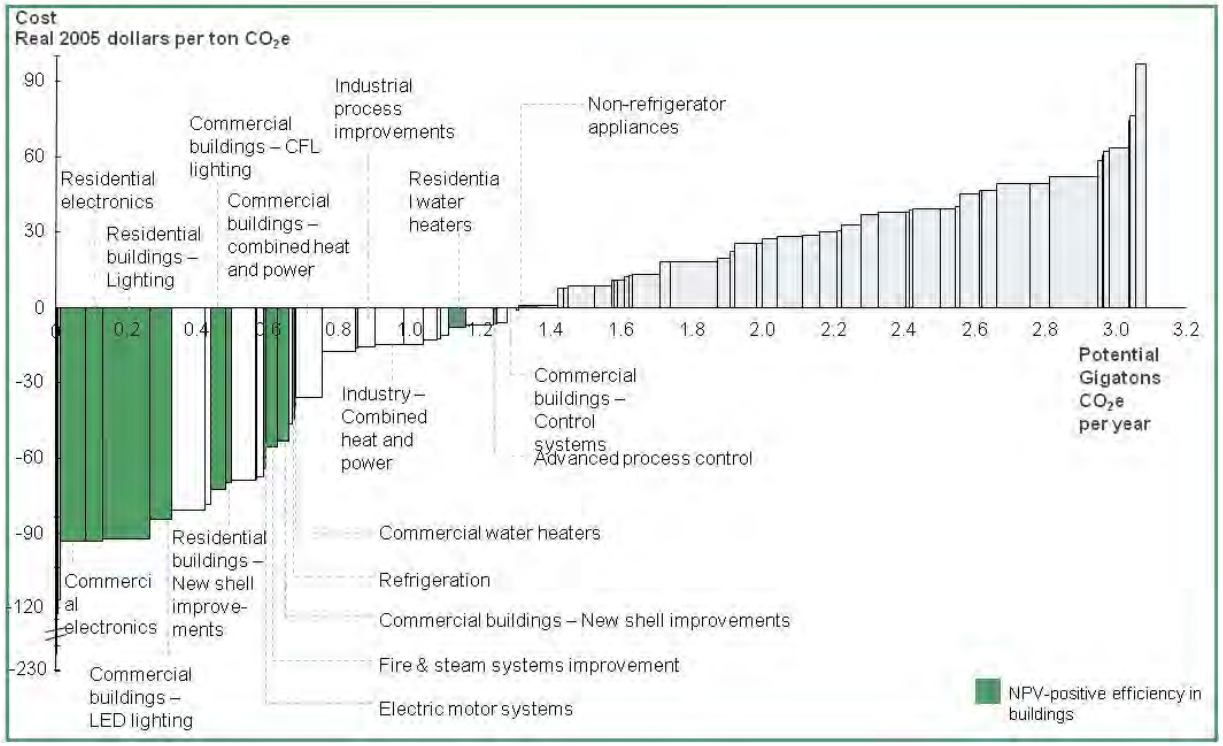
By Sector
quadrillion BTUs



Exxon Mobil, 2009. "The outlook for energy: a view to 2030"

Building efficiency remains the most cost-effective means for carbon mitigation, but accessing that potential has been difficult

Energy efficiency is still the most cost-effective means of carbon mitigation.



- *"The assumptions <of DTW> were incomplete and based on technical potential. The expectations were that if it is cost saving it will happen. The transaction and information barriers are bigger than we expected."*
- *"I still don't think we have a good idea of potential versus achievable emissions reductions."*

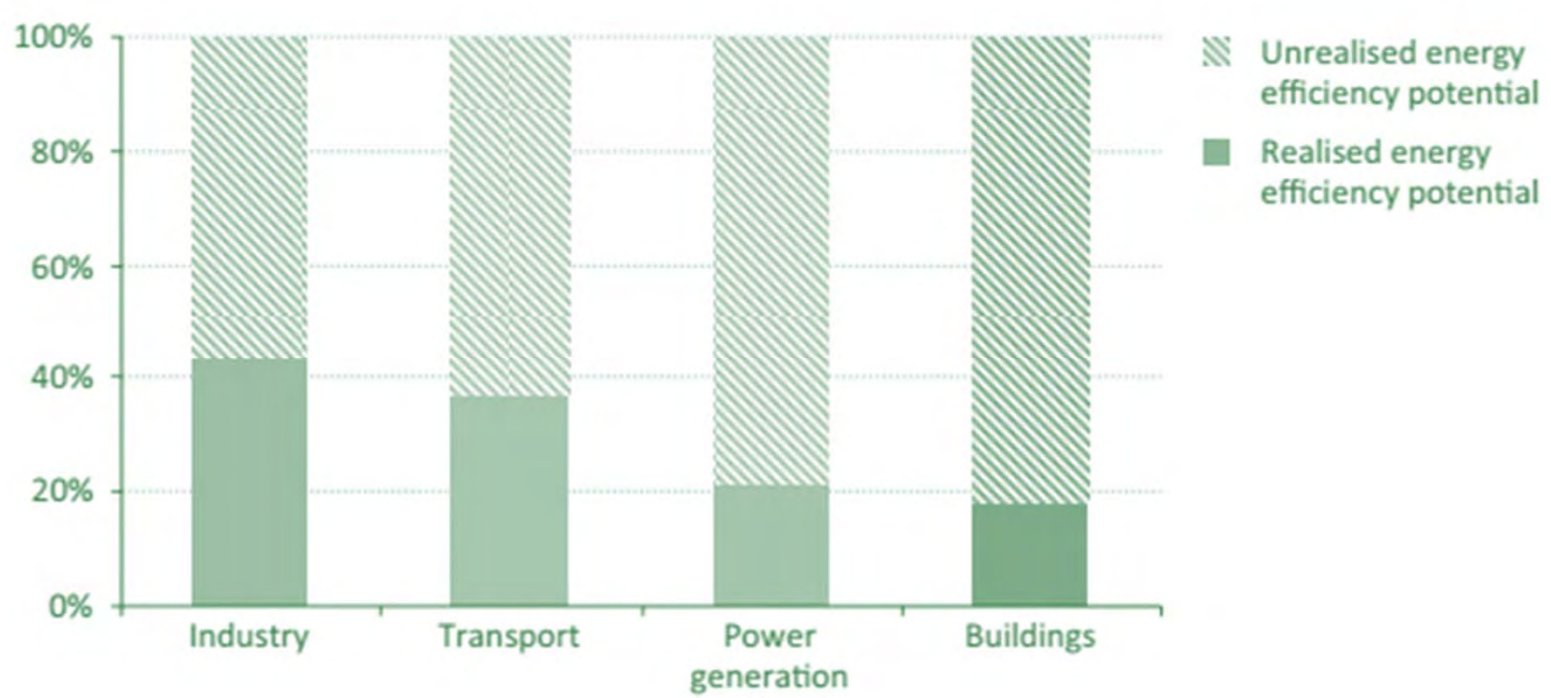
But barriers to energy efficiency still limit adoption:

- **Fragmented demand, lacking specific incentives, and drivers of consolidation** (e.g., high hurdle rate, complexity of interventions, low mind share, insufficient returns)
- **Weak supply –** Undifferentiated, lacking distinctive value proposition and business models because of some unresolved issues around EE
- **Non-conducive regulation** (e.g., low transparency/awareness of incentives, weak targets, and forcing mechanisms)

McKinsey Global Energy and Materials, 2009. "Unlocking energy efficiency in the U.S. Economy"
Confidential interview.

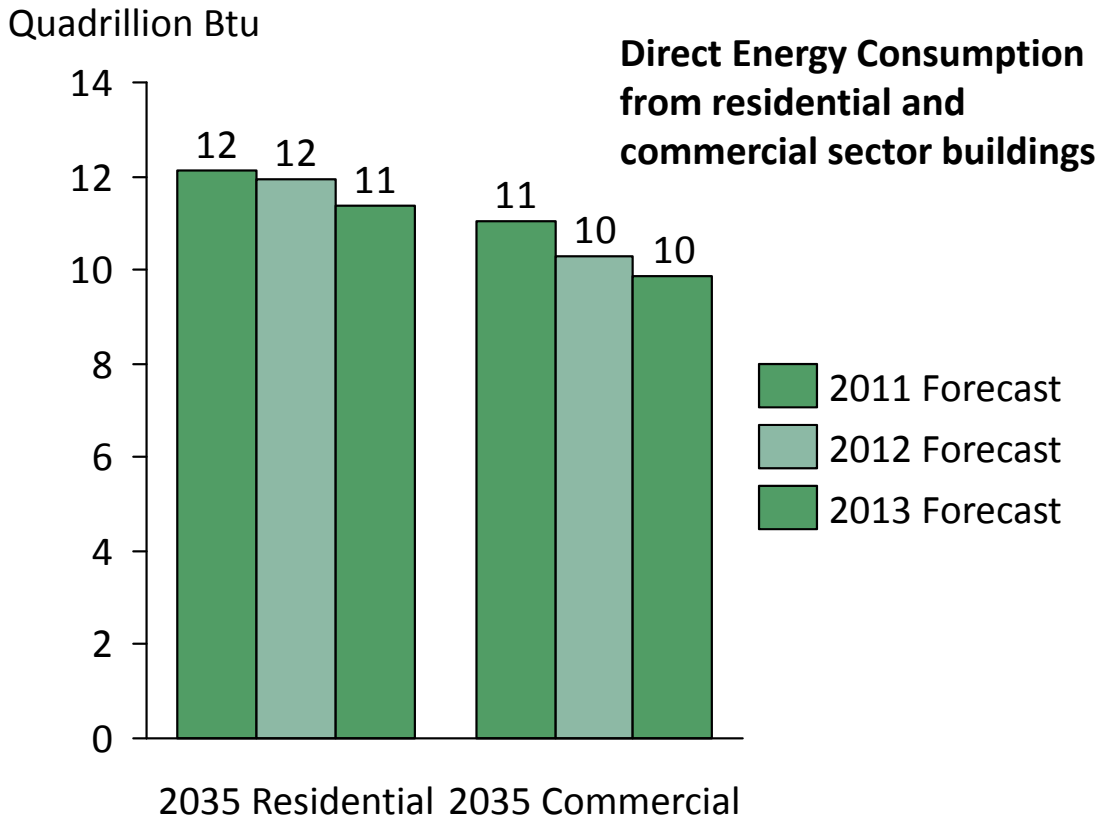
IEA forecasts expect that accessing EE potential in buildings will be an ongoing challenge

Utilized long-term energy efficiency economic potential in the New policies Scenario 2011-2035 by sector.



International Energy Agency, 2012. "World energy outlook."

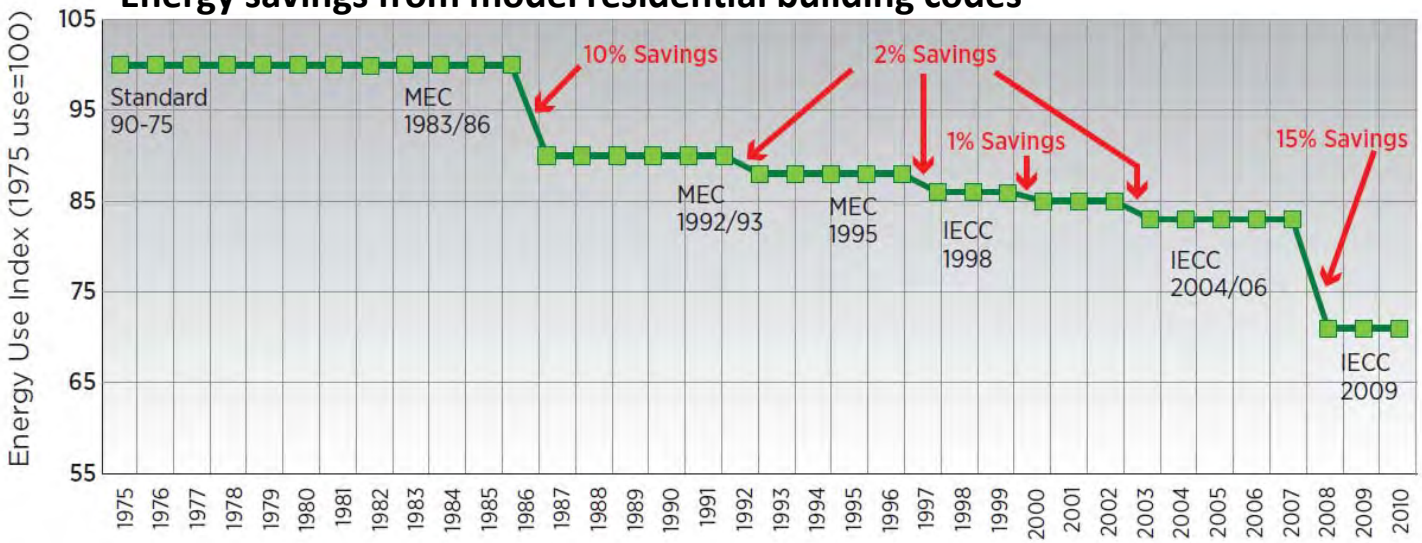
Forecasts for building energy use continue to trend downward in the United States



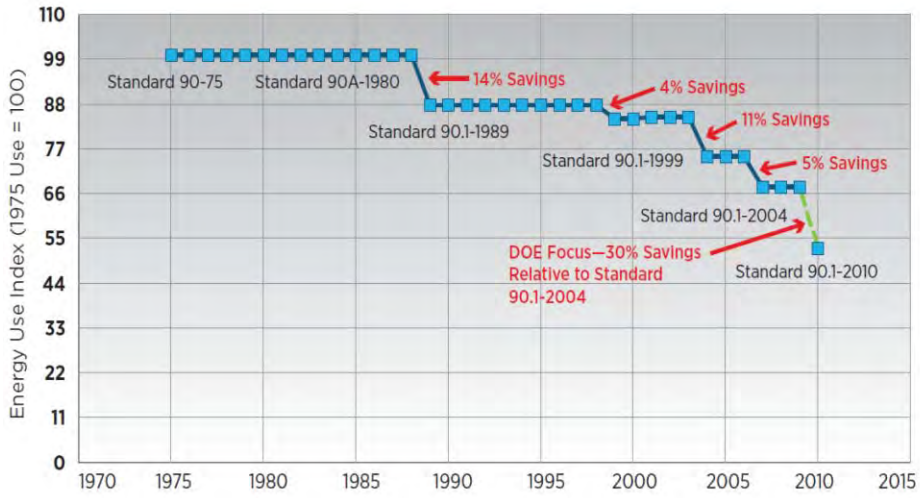
U.S. Energy Information Administration, 2011. "Annual energy outlook 2011." reference case
U.S. Energy Information Administration, 2012. "Annual energy outlook 2012." reference case
U.S. Energy Information Administration, 2013. "Annual energy outlook 2013 early release." reference cases

New model codes for residential and commercial buildings are believed to improve energy efficiency by 15%, but compliance is an ongoing problem

Energy savings from model residential building codes



Energy savings from model commercial building codes



- A study of residential code compliance in New York State in 2007 found that
  - 73% of all code requirements were met
  - 0% of buildings had >90% compliance
- *"[Inspectors] check the easy stuff, but not the things that are difficult to check."*

U.S. Department of Energy, 2010. "Energy efficiency trends in residential and commercial buildings."
American Council for an Energy-Efficient Economy, 2012. "Improved code enforcement: a powerful policy tool- lessons learned from New York State."

Retrofits remain an elusive opportunity, but building energy labeling and disclosure policies are being implemented and are gaining some traction since DTW

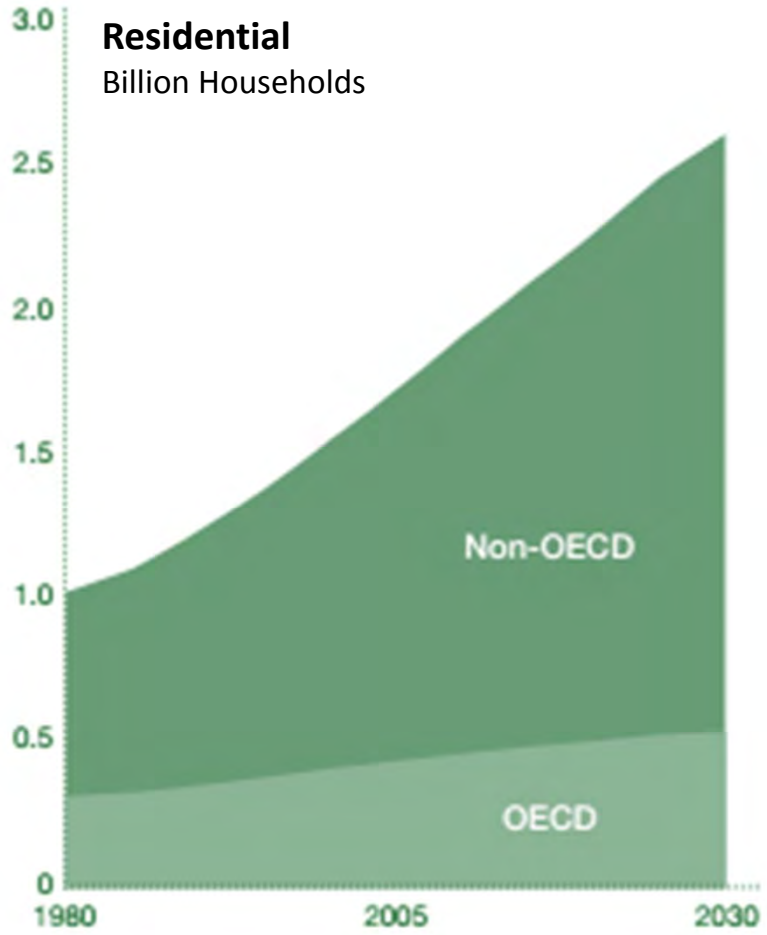
Building Retrofits

- "In the U.S., we are seeing 5-10% savings in existing buildings, not 20-40% savings, and we are only doing 50,000 a year versus the 8 million a year that is needed."
- "There is a bit of a divide between the deep vs. shallow retrofit camp."

Building Labeling and Disclosure

- The *Directive of the Energy Performance of Buildings* in Europe, passed in 2006, requires buildings to publicly display their energy performance certificates
- These programs have since migrated to the United States in cities such as, New York, Portland, and Washington, Seattle, San Francisco, and Austin
  - "This is the only thing that we have for retrofits."
  - "New York had remarkable findings – there was a 5-fold difference between the least efficient and most efficient quartile."

Approximately 900 million new households will be constructed by 2030, almost 90% of which will be in non-OECD countries



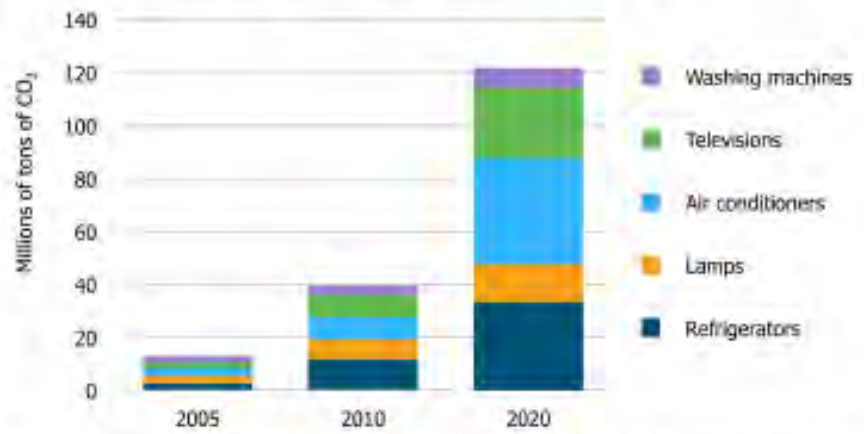
Interview reflections

- "The volume of construction and building energy consumption has been growing incredibly quickly in China. In India it is always on the verge of taking off, but never seems to."
- Indonesia may be a country to watch in the coming years. Air conditioners and other appliances are at a very low level of penetration, but if this country were to tip it would have huge energy and emissions impacts.

Exxon Mobil, 2009. "The outlook for energy: a view to 2030"

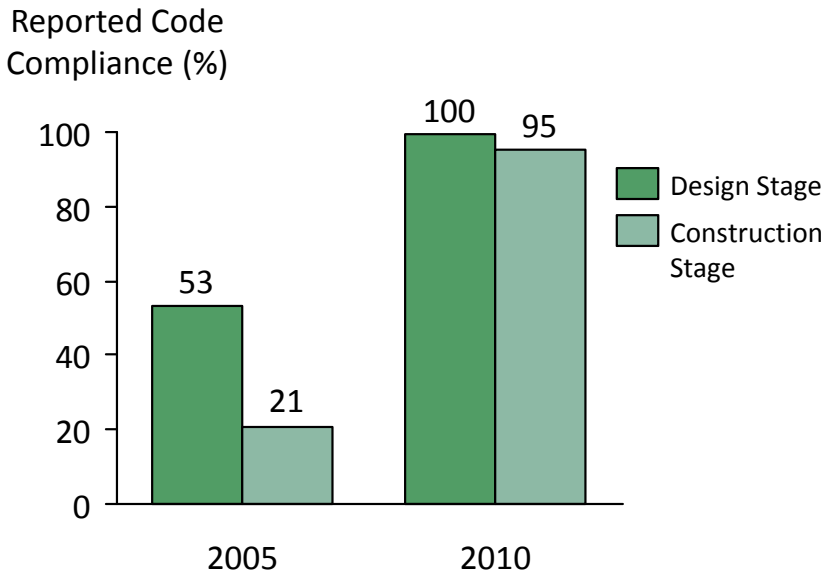
China has been implementing building codes and appliance standards, but efforts are not aggressive enough

Figure 5: Emissions savings from Chinese appliance standards



Source: Lawrence Berkeley National Laboratory, China Sustainable Energy Program

- "Chinese appliance standards are not that ambitious."
- "The rigor on appliance standards in China has not been too strong. But, they are making small steps."



- China is on track to build as much building floorspace in the next 20 years as exist in the entire United States. Current building codes require that new buildings 50% less energy than buildings constructed in 1980.
- "China has very ambitious program for new construction which seems to be doing good things, but compliance is a challenge."
- "China has a major enforcement problem. They have some pilots to try and address this, but they seem to be designed to generate positive results."

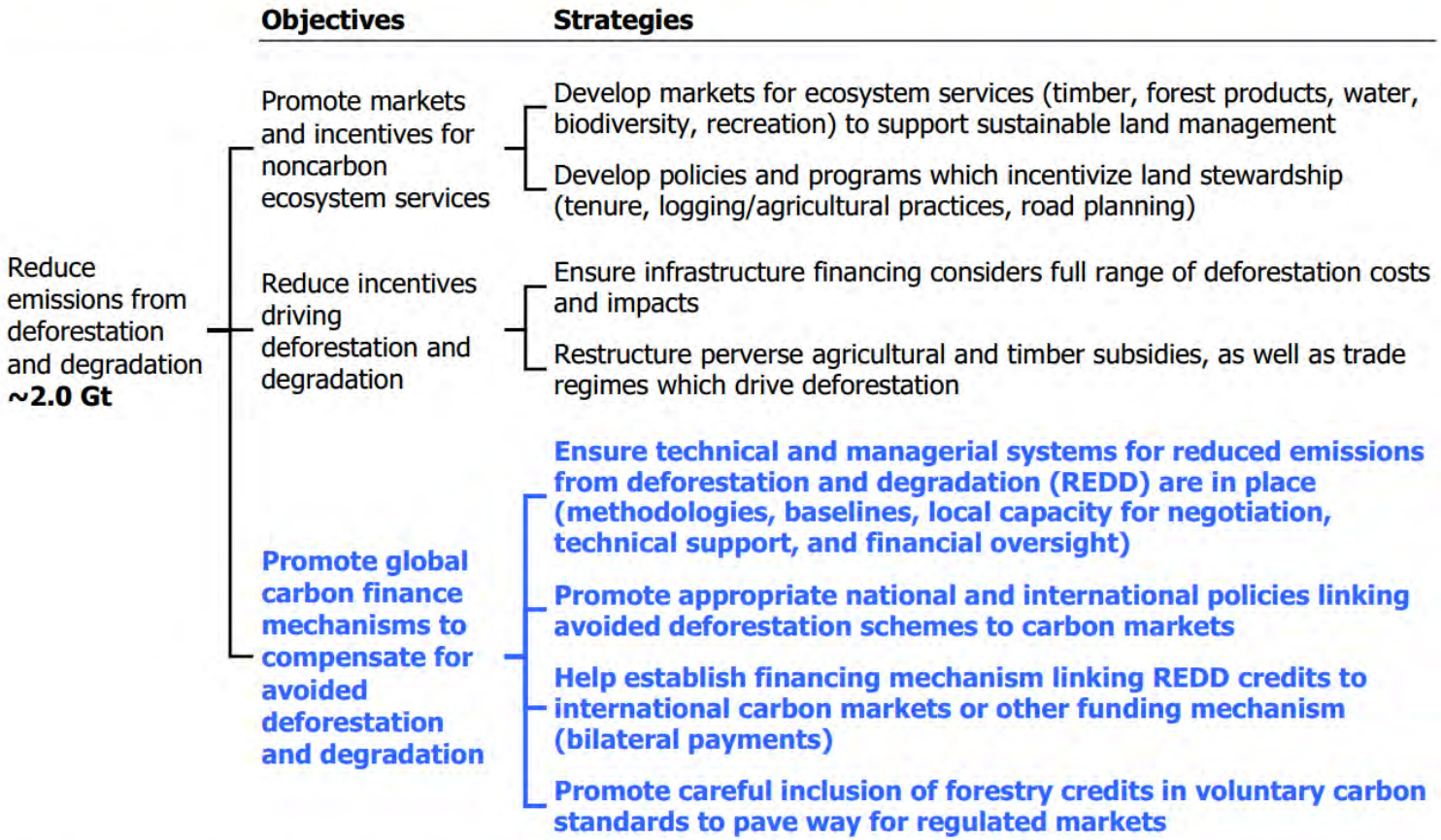
Harvey, 2011. "Energy policies in India and China."
American Council for an Energy-Efficient Economy, 2012. "Third parties in the implementation of building energy codes in China."
Confidential Interviews.

FORESTRY

Interviewee reflections on forestry

DTW identified a roughly equal split in potential between re/aforestation and avoided deforestation (~2GT each) with an equal split between OECD and non-OECD countries.

FIGURE 20: Philanthropy's Role in Avoiding Deforestation (DTW Priorities Highlighted)



Source: Mitigation potential adapted from IPCC, USEPA, Vattenfall

California Environmental Associates, 2007. "Design to Win: Philanthropy's Role in the Fight Against Climate Change"

Interviewee reflections on forestry

1. **The forestry trajectory is probably BAU, though experts don't have ready data to point to**
    1. No conclusive answer on the emissions profile within the sector - "Globally it is more or less as anticipated." "I couldn't point to any overarching analysis that would tell you whether we are better or worse."
2. **There has been a huge shift in the REDD trajectory from carbon markets to public finance**
    1. **Carbon market collapsed:** In 2007, there were huge hopes for REDD+. "It was only in 2007 at the Bali COP that what we now know as REDD became an accepted international concept." The following heady years when cap-and-trade in the US and Copenhagen seemed possible stimulated huge interest in carbon markets and forestry offsets, which was the basis of the DTW recommendations. The collapse of an overarching international deal "definitely slowed things down" and the absence of a carbon market "has been disappointing, to say the least."
    2. **Public funding filled the vacuum:** When the bubble was punctured, it obviously weakened the interest in carbon markets. However, the interest in REDD as a mechanism with public funding continued:
        1. **Success in attracting public funds.** The agreements on REDD at Copenhagen, and the $4.5B in public funding, were one of the few major successes of Copenhagen. UN, World Bank, and multilateral engagement has followed. "In the short term, REDD funding is not the problem. Finding good things to spend money on is the problem."
        2. **Success in high-level forest country engagement: "**We could not have anticipated how successful REDD was going to be in capturing the interest of high-level decision makers." This has been true in Indonesia, Brazil, and elsewhere. "It was beyond our wildest dreams, even if it ends up not being enough."
        3. **The architecture of REDD has advanced as a result.** In Brazil and other countries, a tremendous amount of work has been accomplished on the architecture of REDD. Great strides have been made in measuring reporting, and verification (MRV).

Interviewee reflections on forestry – positive developments

1. **Brazilian deforestation** has gone down faster than anyone believed possible, though it was already underway (the high point of deforestation was 2004). "The decreases in the deforestation rate are incredibly significant and real" and have been due to a combination of policy effort (e.g., enforcement) and REDD. Brazil has inspired confidence that deforestation can be slowed effectively. Outside of Brazil, we believe that there has been very significant re-forestation in a few regions (e.g., China and Vietnam). Both interviewees also pointed to Mexico and Central America more broadly as places where we believe that the rate of deforestation is lower, and have seen progress on community management approaches that hold promise.
2. **Demand side campaigns and market engagement:** In the absence of a carbon market carrot, demand-side work has been a surprisingly effective mechanism to increase the salience of policy efforts. "The demand side work is a second best alternative if you've given up on the supply side." A big change since 2007 has been the proactive engagement of some of the private sector companies/brands: "that has been really quite surprising to me." From soy and beef in Brazil, to palm oil in Indonesia, to the Carbon Disclosure Project and the Consumer Goods Forum, activists have been able to use brands to create issue awareness and the space for political change. Demand side strategies remain "a very fluid space." It will be interesting to see how they play out.
3. **Jurisdictional level REDD.** Beyond local or national level efforts, there have been sub-national efforts on REDD which were not anticipated. The Governor's Climate Change Task Force (between California and Brazil) and the focus on sub-national jurisdictions has allowed us to pilot REDD in the carbon market. These efforts are promising given that land use planning actually takes place at the sub-national level.

Interview reflections on forestry – negative developments

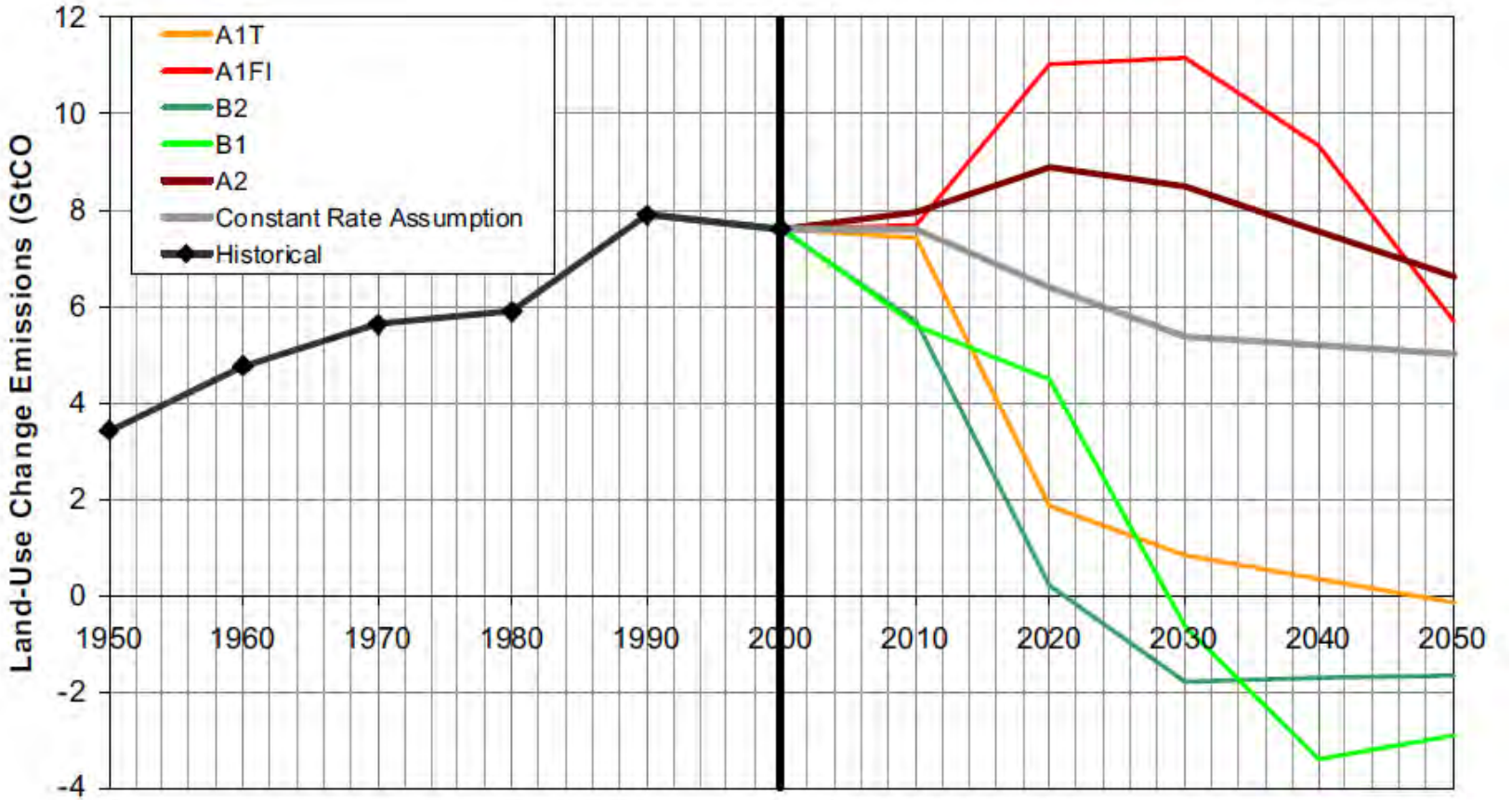
1. **Indonesia**: Despite high level political engagement, slowing the deforestation trend in Indonesia has been very difficult. “The situation in Indonesia is at least as bad as anyone anticipated, if not worse.” “Indonesia keeps me awake at night.”
    1. It is frustrating not to even have accurate information in the country. The overall emissions rate Indonesia is still under contention. There is a factor of three divergence between Indonesian and independent analyst estimates.
    2. While REDD has attracted presidential-level attention and broader awareness, to date the political establishment has “not been willing to lift a finger against these big conglomerates.” For example, the Letter of Intent with the Norwegians on REDD established a moratorium on new forest licenses, but was delayed and circumscribed with carve outs. “The fact that a billion dollar commitment couldn’t make more of a dent is pretty disappointing.”
2. **The Congo Basin**: Things appear to be worsening in Central Africa, with land grabs and increasing pressure for timber and clearing for agriculture.
    1. There is the continued recognition that “Central Africa is very difficult for philanthropy, to be honest. Civil society capacity is just so weak. If it is difficult in Indonesia, large parts of Central Africa make Indonesia look easy.” “There is a thin and fragile infrastructure to build on.” The other problem in Africa is that it is such a focus of government aid agencies – aid is the dominant agenda setting discussion.
    2. However, there is a mounting desire to “start laying the groundwork…. If you don’t start, that horizon is going to keep receding.” This requires a more long-term time horizon that the DTW “First, Don’t Lose” mantra didn’t really permit. “The philanthropic community has done a disservice by giving up on long term grantmaking”

Interview reflections on Forestry – negative developments

3. **Commodity prices:** The spike in commodity prices in 2009 led food deficit countries to panic and created a land grab mentality, and is driving conversion. Forest land remains the lowest hanging fruit in terms of convertible acres. For example, high prices of palm oil continue to drive the conversion of peat lands in Indonesia.
4. "**Aid-ification**" **of REDD** is seen as an increasing problem. While there has been success in attracting public funding, the money isn't sufficiently "pay for performance." Without the hard benchmarks of a carbon market, there is concern that the public funding will be swallowed up by governments without much gain. Similarly, while we have been successful at getting organizations from the global to local involved in the REDD space, they do not always work synergistically (for example, the World Bank and UN have multiple programs).
5. **Agricultural mitigation:** Very little progress has been made on agricultural mitigation opportunities. "It turns out, surprise, surprise, that agriculture is a very contentious topic." Attempts to include agriculture have been tied up in a range of issues (food security, trade, national interest, culture, development), which has slowed progress and made multilateral discussions more difficult than anticipated. Similarly, considerations of indirect land use change have further complicated discussions of agricultural mitigation opportunities.
6. **Anti-REDD campaigning:** REDD has attracted a lot of opposition, including from an army of NGOs who have previously exhausted themselves campaigning against the World Bank. Civil society is disproportionately opposed to REDD or focused on safeguards, rather than the potential good of protecting forests from development.

DTW assumed annual land use change emissions declining slowly to a rate of about 5 $GtCO_2$ yr^{-1} in 2030

CO_2 emissions from land-use changes between 1950 and 2000, and projections of future emissions

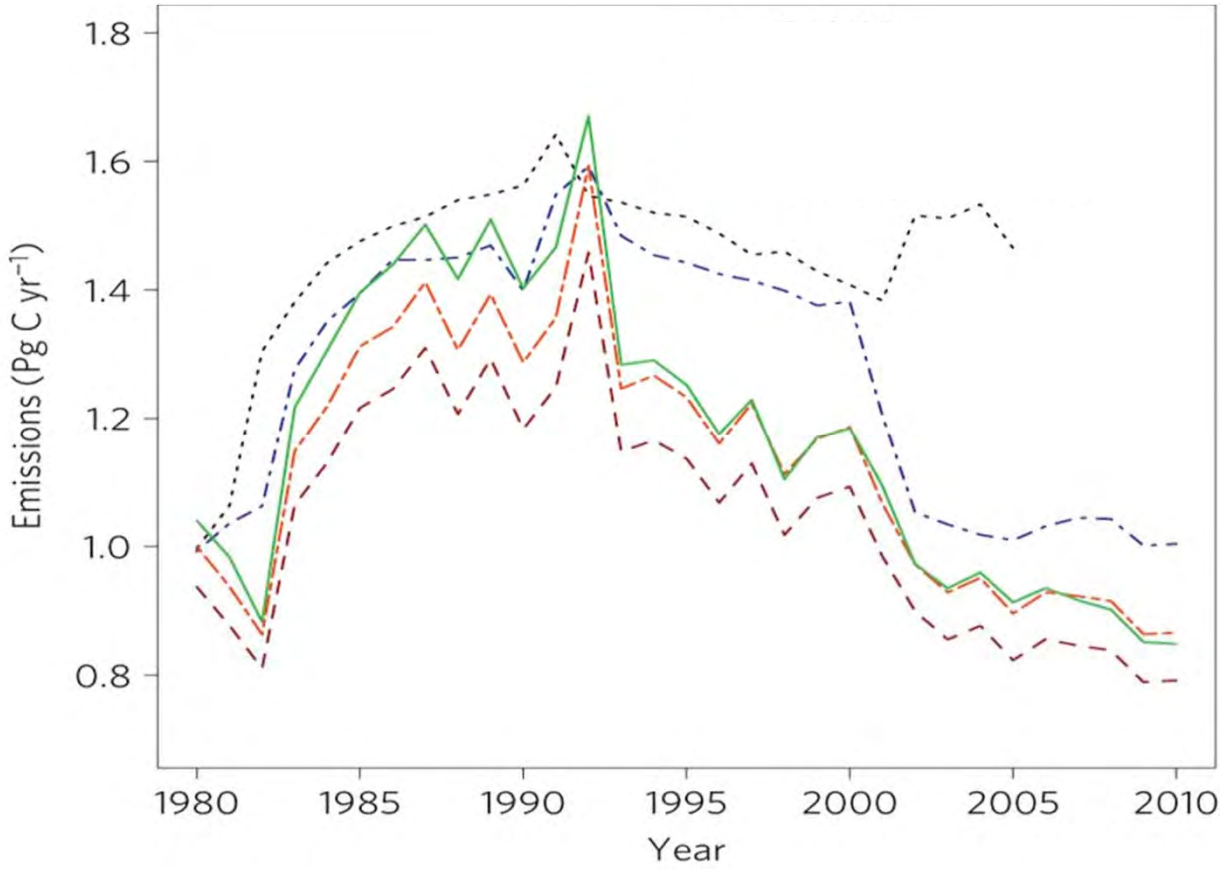


Stern Review, 2006. "The economics of climate change. Annex 7.f emissions from the land use sector" United Kingdom Treasury.

New research shows that initial estimates of emissions from deforestation were too high

Annual net emissions of carbon from land-use change in the tropics.

Recent estimates show lower rates of deforestation than initially anticipated, and confirm a general downward trend in emissions

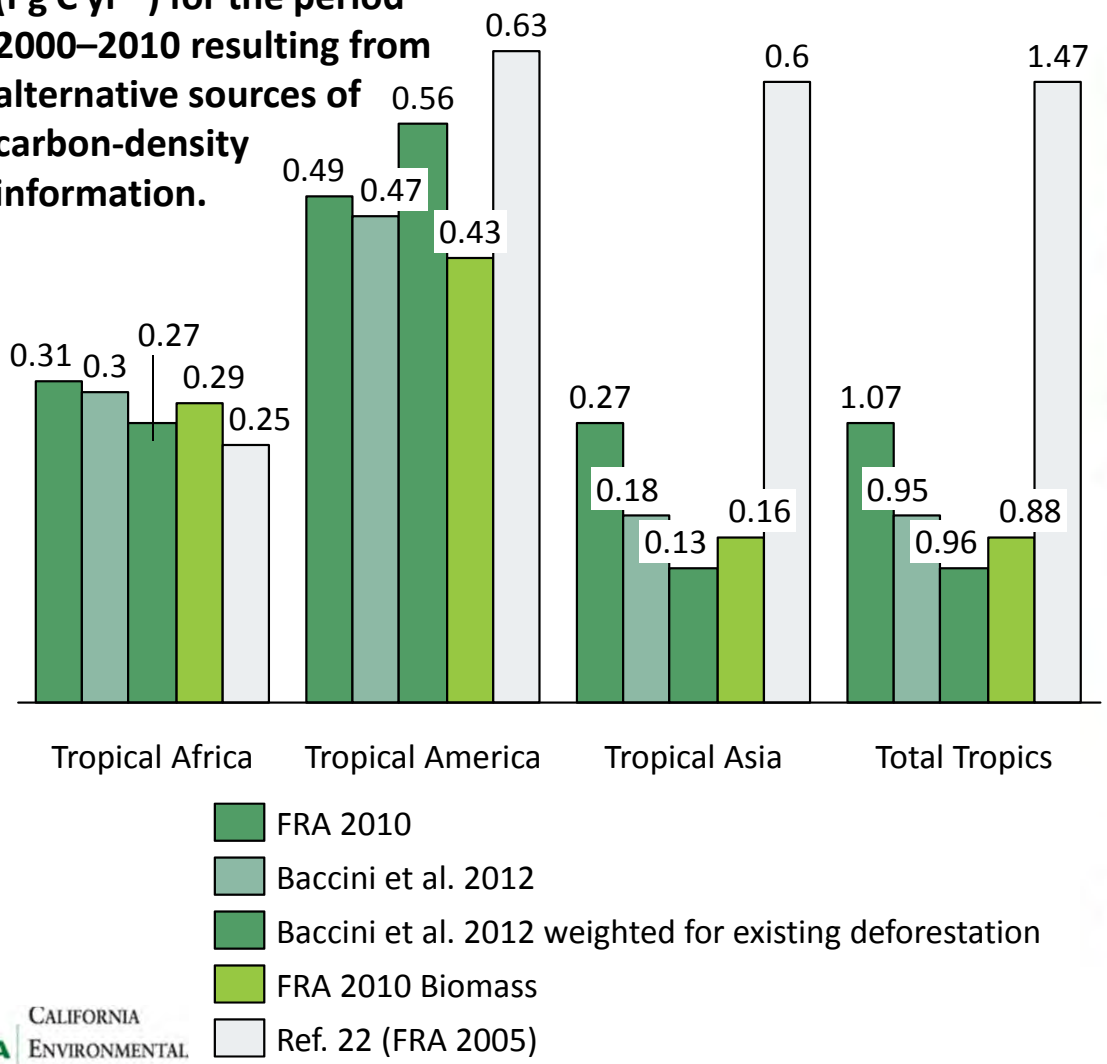


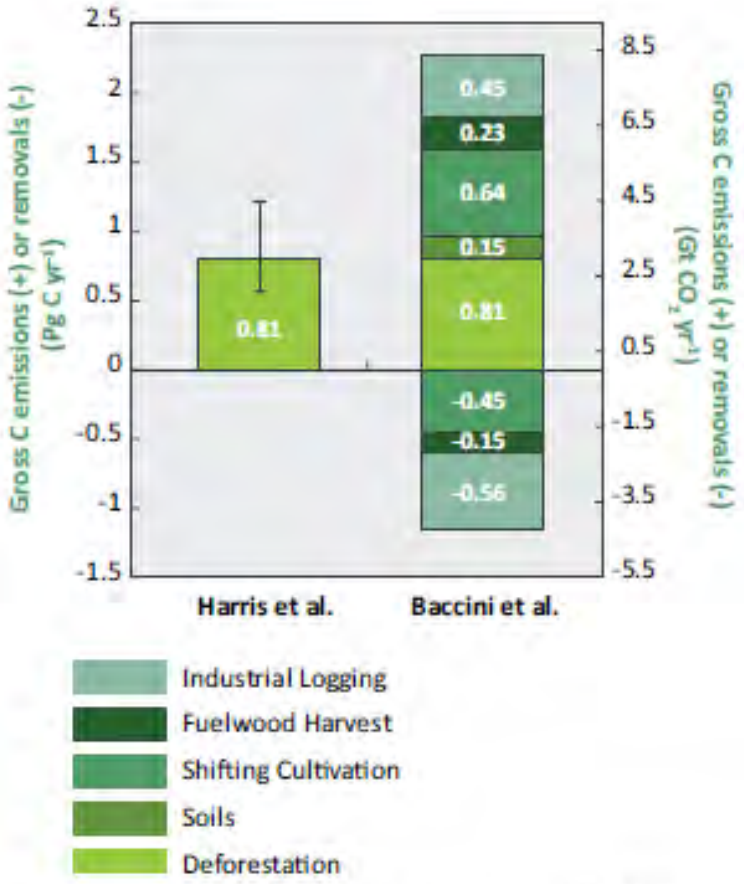
Baccini, et al. 2012. "Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps." Nature Climate Change. Vol. 2, 182-185 doi: 10.1038/NCLIMATE1354.

There is converging opinion that gross emissions from deforestation from 2000-05 totaled around 2.9 Gt CO_2/year

While the Tropical Americas remain a major area of flux, there is disagreement on relative gains and losses in Tropical Asia and Central Africa.

Estimates of carbon flux (Pg C yr^{-1}) for the period 2000–2010 resulting from alternative sources of carbon-density information.





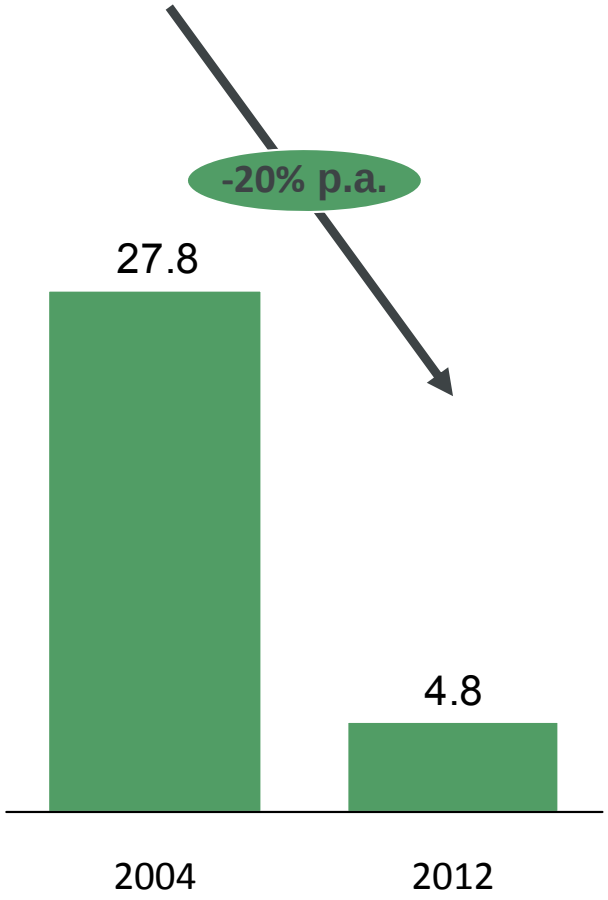
Note: Emissions and removals for Baccini et al. are reported in this figure by land-use process rather than by carbon pool, as reported in the original paper. Numeric values displayed in the bars are in units of Pg C yr^{-1}.

Harris et al., 2012. "Progress toward a consensus on carbon emissions from tropical deforestation." Winrock International and Woods Hole Research Center.

McKinsey assessment: In Brazil, deforestation has fallen significantly since 2004

Current state

Area deforested
'000 km2/year

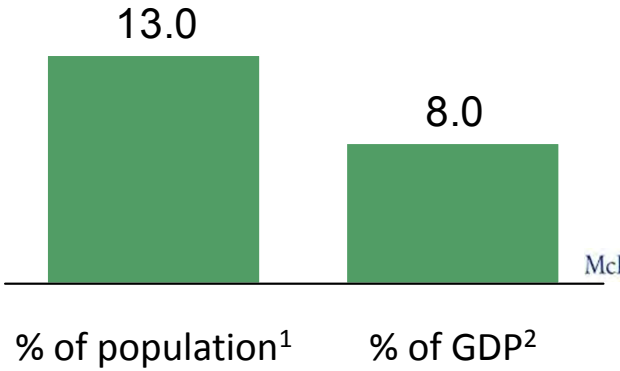


Barriers

Continued road opening, partly due to growth in hydroelectric power

Pattern of deforestation has changed significantly, shifting from large frontier clearing to **incremental dispersed advances and forest degradation,** which makes it **more difficult to track**

Population growth in the Amazon region, coupled with **un-sustainable livelihoods**



McKinsey&Company

Future outlook

Positive

- Government and private sector continue to show desire to address deforestation
- Strong monitoring and enforcement mechanisms are in place
- However, there are signs of returning deforestation in areas where it had been reduced, due to the lack of a replacement economic activity

1. 2007 figures; 2 2006 figure. Encompasses the states of Amapá, Amazonas, Acre, Roraima, Rondônia, Mato Grosso, Tocantins and part of Maranhão
2. McKinsey analysis based on Brazil's National Institute for Space Research, 2012. "INPE estimates a reduction of 11% in Amazon deforestation." Retrieved, November, 2012. http://www.inpe.br/ingles/news/news.php?Cod_Noticia=271 and expert interviews

McKinsey assessment: Indonesia has made some progress, but faces significant barriers

Current state

Annual deforestation of approximately 6,500 km^2, now out-stripping Brazil

Strong **political commitment** to combat climate change:

- Pledge to cut emissions by 26% by 2020 from "business as usual" levels
- Moratorium on concessions for exploitation of natural forests and peat lands

Recent or proposed regulations to create:

- National REDD+ Agency
- Updated Forest Law
- REDD+ financial transfer scheme
- Monitoring, reporting and verification institution

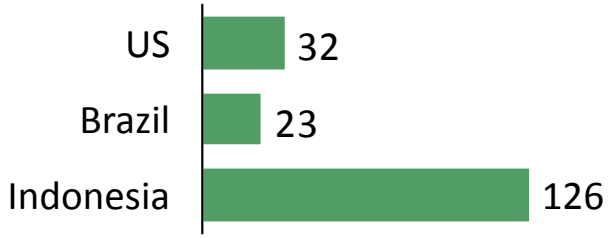
Barriers

Weak government institutional capacity as governance moved from central planning and control to the districts under the decentralization plan

Industry forces

- Palm oil is a significant contributor to deforestation
- Many natural resources (e.g. coal) are located in the forest

Population density (pop./km^2)



Future outlook

Moderately positive

- Strong, competent and willing **government leadership** on the issue
- **Indonesia-Norway Climate Partnership** ($1 billion deal), is attempting to address the issue
- Serious structural and institutional challenges remain

CEA California Environmental Associates

McKinsey analysis based on expert interviews

AGRICULTURE

Agriculture : main themes

- **Overarching trends:** Estimates of agricultural emissions have been revised downwards, although they still fall within previous confidence intervals. The reason for this revision is not entirely clear. Agriculture emissions continue to grow more slowly than fossil emissions.
- **Livestock:** Livestock are growing in quantity as the developing world demands more protein.
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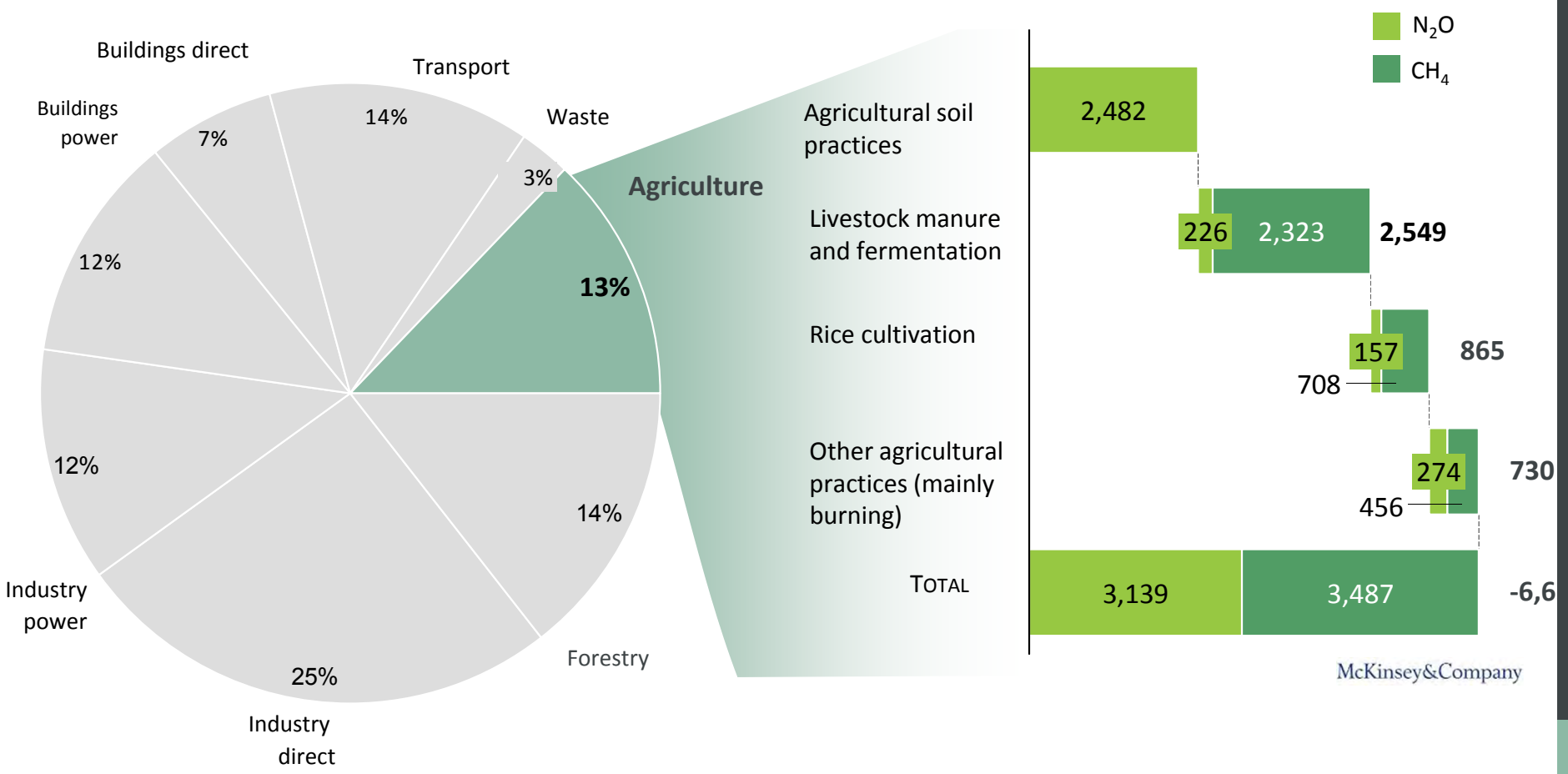
About one-seventh of global GHG emissions are directly from agriculture

Global greenhouse gas emissions, 2010, %

$MtCO_2e$/year[1]

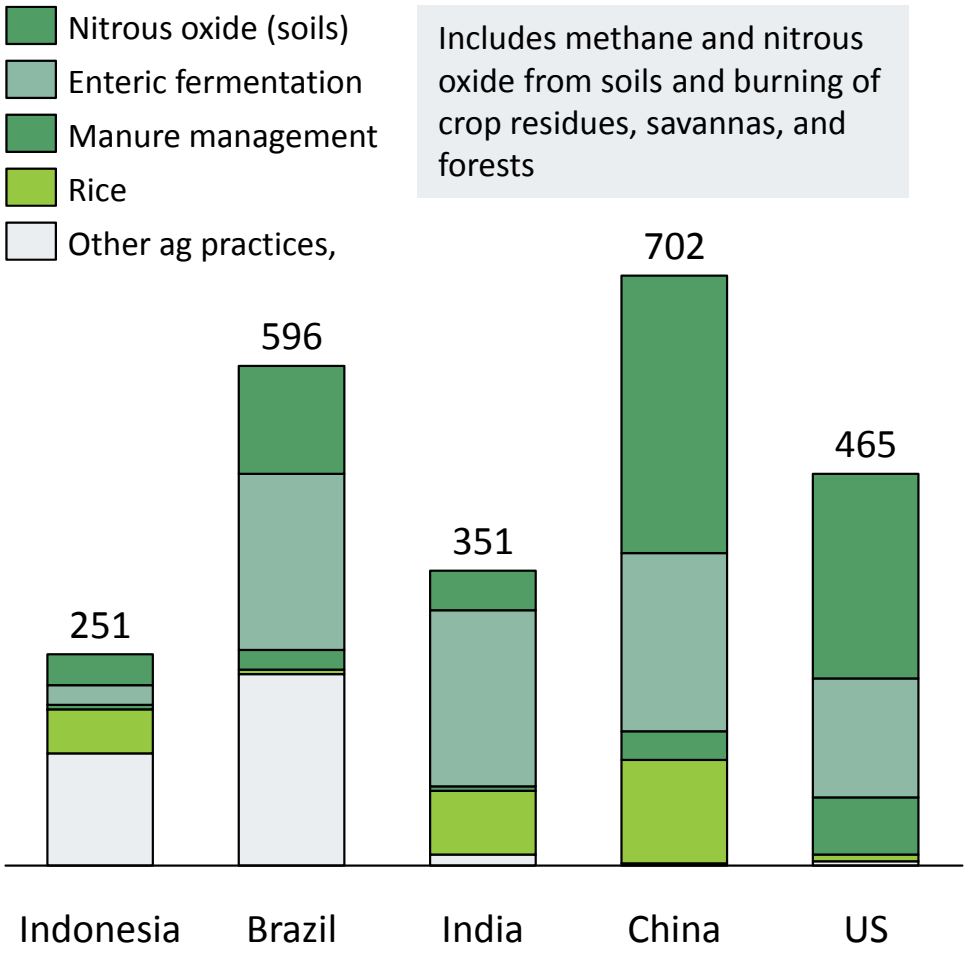


Note: There is on-going debate about the exact emissions from these areas.

McKinsey and Co. Analysis, based on:
- McKinsey Global GHG Cost Curve Version 3.0
- McKinsey experts
- Baccini, et al. 2012. "Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps." Nature Climate Change. Vol. 2, 182-185 doi: 10.1038/NCLIMATE1354.

Regional drivers of GHG emissions from agriculture vary between top emitting countries

Agriculture emissions profile of top land use emitters – 2010 (Mt CO_2e)



Note: CO_2 associated with land conversion, peat emissions, and afforestation is covered in the forestry section rather than the agriculture section.

Indonesia
- Burning of cleared forests are a large source of emissions

Brazil
- In the agricultural sector, emissions are primarily from cattle and burning of ag waste.
- Burning of cleared forests are a large source of emissions

India
- Rice emissions lead in India, although it is a growing hotspot for emissions from fertilizers

China
- Fertilizer use is a major contributor to China's high nitrous oxide emissions

US
- Fertilizer use and cattle are the primary drivers.

U.S. Environmental Protection Agency, 2012. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2030."

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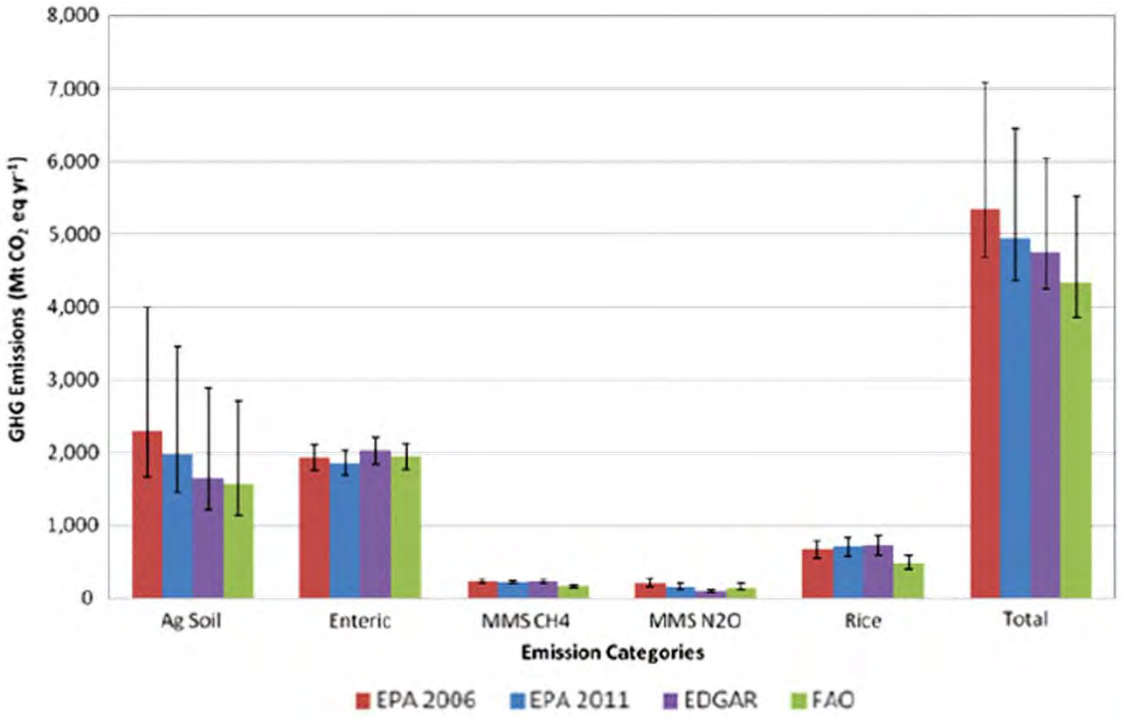
New estimates of agricultural emissions are lower than previous ones, although uncertainty remains high

- Newer estimates of agricultural emissions have been revised downward, particularly for agricultural soils, although they are still within the range of original uncertainty. The reasons for this are unclear, but probably methodological.

- The error bars in agriculture remain large, because of inconsistent data and methodological variability. Reputable estimates of global GHGs from agriculture range from 8%-18% of total human emissions.

- Agricultural emissions are rising slower than total emissions, so the ratio of agricultural to fossil fuel emissions has fallen from 17.2% to 13.7% over 2000-2010[1].

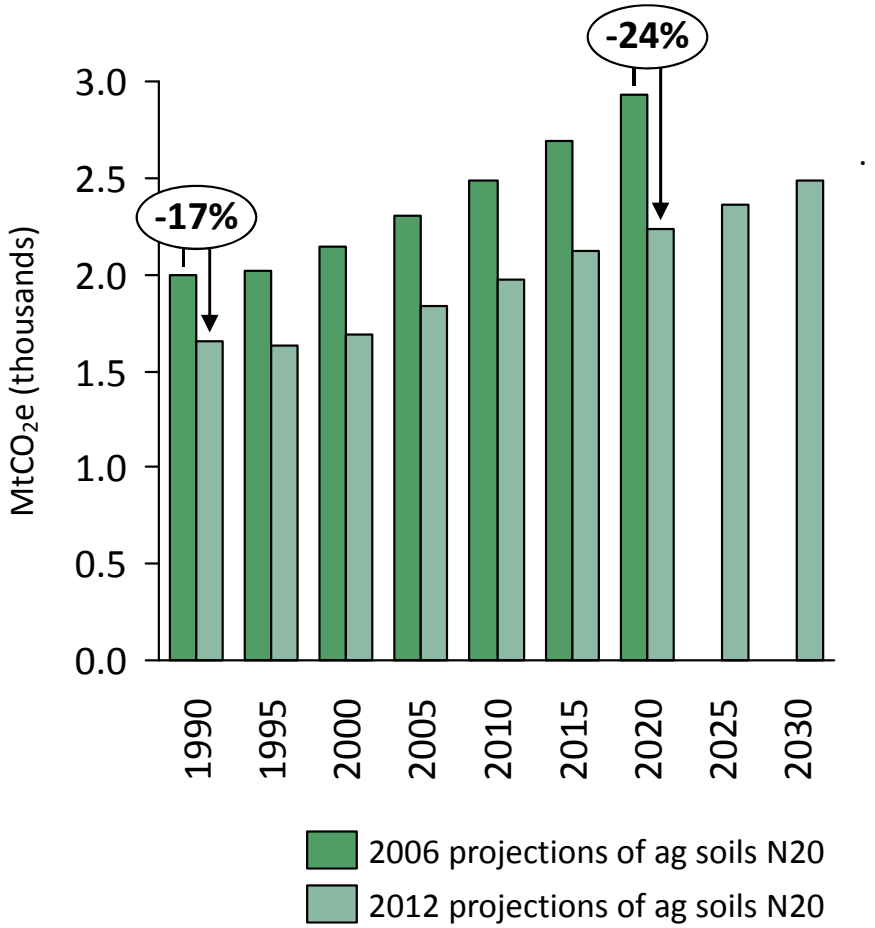
Estimates of 2005 agriculture GHG emissions from various publications.[2]



1. Note that this is not the percentage of total emissions from agriculture, but the ratio of agricultural to fossil emissions.
2. Tubiello et al., 2013. "The FAOSTAT database of greenhouse gas emissions from agriculture." Environmental Research Letters 8: doi:10.1088/1748-9326/8/1/015009.

Cropland N_20 emissions forecasts have been revised downwards, but this is due to changes in the methods for estimating emissions rather than changes in fertilizer use

New estimates and forecasts for N2O emissions from agricultural soils have been revised downwards



Recent data suggests the nitrous oxide emissions, driven primarily by fertilizer application to crop lands, may be lower than we thought. The reasons are unclear, and experts suggested the change may not be significant given the high uncertainty associated with agricultural emissions generally

U.S. Environmental Protection Agency, 2006. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2020."
U.S. Environmental Protection Agency, 2012. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2030."
FAOStat online database. Retrieved March, 2013. http://faostat.fao.org/
Food and Agriculture Organization, 2007. "Total fertilizer consumption outlook."

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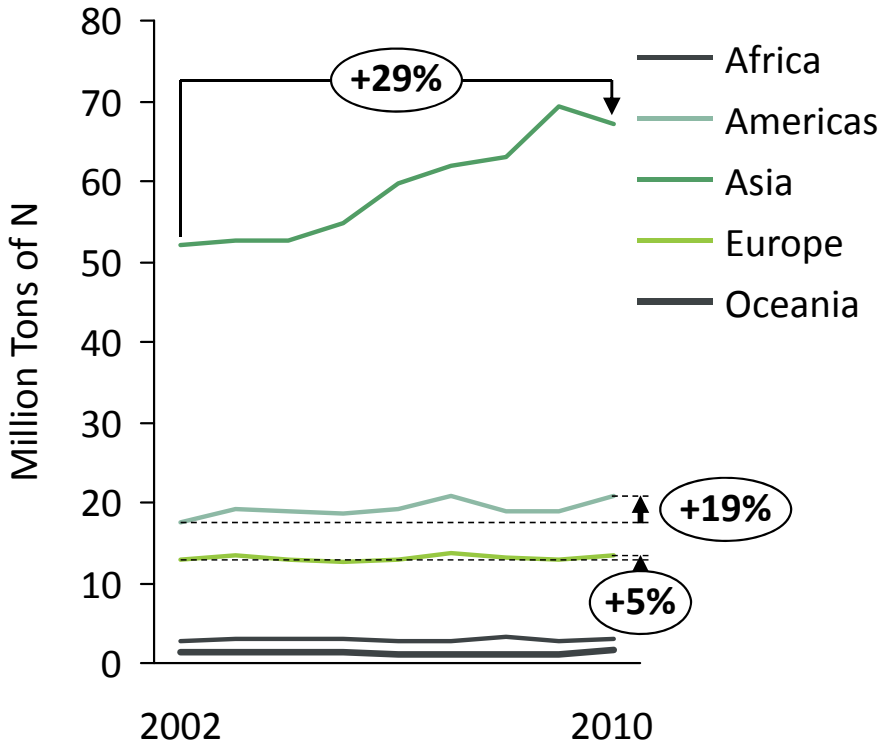
N consumption, 2002-2010



Previous estimates had predicted a ~45% increase in Chinese and ~25% increase in Indian fertilizer use by 2030. Asian fertilizer use has already increased 29% from 2002-2010.

The downward revisions not be reflective of on-the-ground trends, such as continued and increasingly high levels of overuse of fertilizers in China and India. Further research is needed to get a clear understanding of emissions levels and trends for fertilizers globally.

U.S. Environmental Protection Agency, 2006. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2020."
U.S. Environmental Protection Agency, 2012. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2030."
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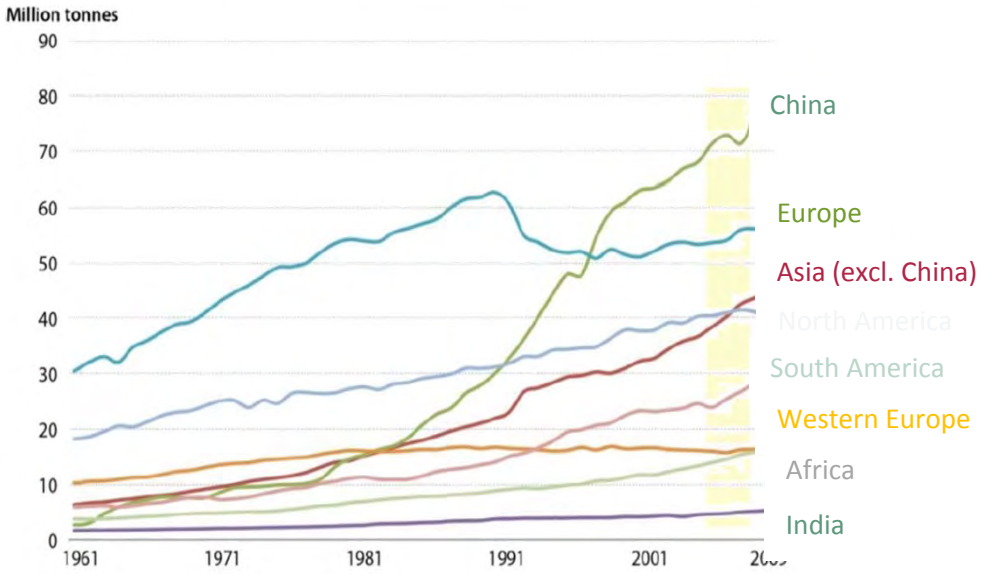
Growing demand for meat in the developing world

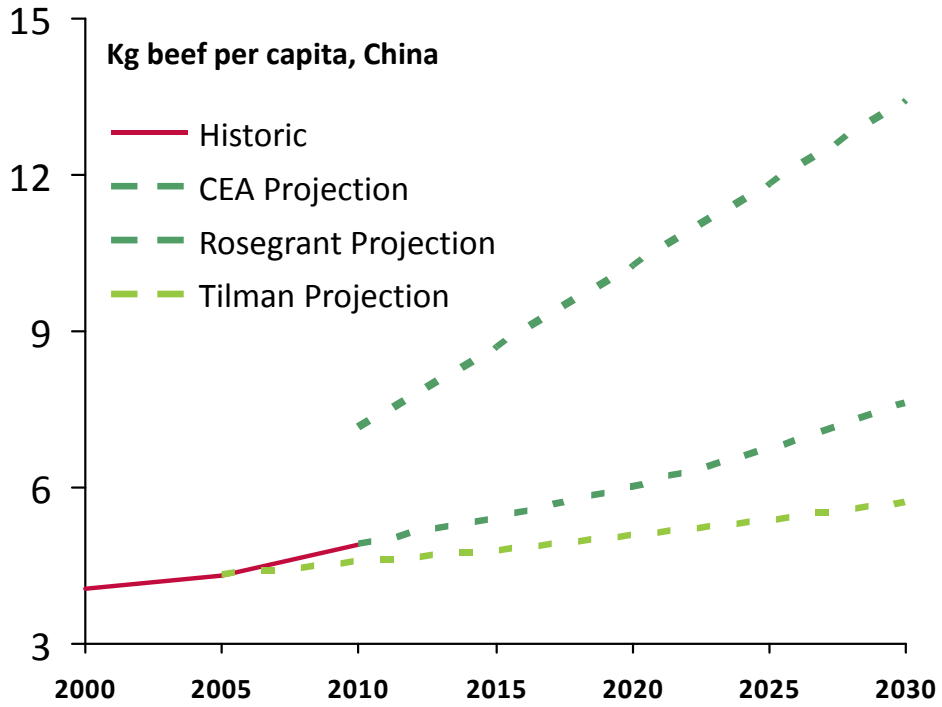
- Rising meat demand from the developing world is the key driver of change in livestock quantity, and associated emissions.
- Factors effecting livestock GHG efficiency include
  - Production efficiency (inputs/ unit output), driven by breeding, nutrition, and welfare (*science continues to drive increasing efficiencies*)
  - Feed, both digestibility (enteric fermentation) and upstream emissions (*increased understanding in recent years*)
  - Pasture/ rangeland management (*increased understanding in recent years*)
  - Manure management (*knowledge transfer in recent years*)
- Although GHG efficiency of livestock production appears to be increasing rapidly according to some measures[1], increasing use of cultivated feed is likely more than offsetting industrialization/ efficiency gains.[2]
- It is not clear whether meat consumption is outpacing expectations from 2007. Projections of meat and dairy consumption in 2007 (anticipating a 57% increase in meat production 2001-2020) were too coarse to benchmark against recent trends.

Meat supply has grown in developing countries in recent years



1. CEA analysis based on Tubiello et al., 2013. "The FAOSTAT database of greenhouse gas emissions from agriculture." Environmental Research Letters 8: doi:10.1088/1748-9326/8/1/015009.and FAOStat online database. Retrieved March, 2013. http://faostat.fao.org/
2. California Environmental Associates, 2013. "Projected emissions from meat consumption in Asia." Presentation prepared for The Packard Foundation.

The rise of the middle class in the developing world has lead to rapid increase in meat consumption, but it is not clear whether meat consumption is outpacing expectations from 2007.



- Though protein demand rises relatively predictably with incomes, it is uncertain how much consumers in places like China will demand specific products (i.e. milk versus poultry versus beef).
- Beef consumption in China, one of the primary drivers of changes in livestock quantity, has risen faster than one model predicted, and slower than another (left)

CEA Projections: Consumption growth rates were calculated by taking the average annual growth rate over ten years (1999-2009) for each meat type, by country. This rate was then applied as a fixed growth rate every year.

Rosegrant Projections: Projections for China per capita consumption of different meat types in 2030 from the IFPRI IMPACT model baseline scenario. NB: The 2010 beef consumption levels projected by the IMPACT model are 40% higher than the reported beef consumption levels in 2009.

Tilman Projection: Dr. David Tilman projected that countries with an economic profile like China's would experience an 80% growth in demand in total crop protein between 2005 and 2050. CEA applied the 80% growth as a proxy for animal protein demand. Use of this growth rate needs testing.

UNEP, 2012. "Growing GHGs due to meat production."
Tilman et al., 2011. "Global food demand and the sustainable intensification of agriculture." PNAS 108(50):20260-20264 www.pnas.org/cgi/doi/10.1073/pnas.1116437108.
California Environmental Associates, 2013. "Projected emissions from meat consumption in Asia." Presentation prepared for The Packard Foundation.

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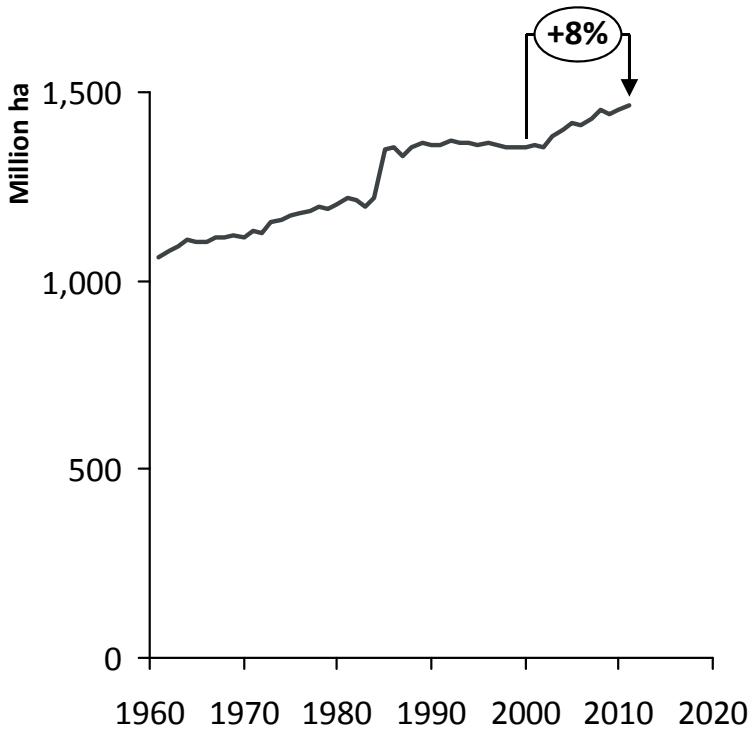
Crops - overview

- Historically, yield gains have been a key driver in improving GHG efficiency, allowing a significant expansion of production without a consequent expansion of land under cultivation
  - Because deforestation is such a large source of emissions, avoiding forest conversion to crop land is a key factor in reducing agricultural emissions
  - Slowing yield gains would mean that more land may have to be converted and marginal lands may have to be put into production (which further decreases yields) to keep up with increasing demand
- Nitrogen application and management practices also effect cropland emissions
  - In some areas of the world, agricultural lands are under-producing because they are not applying enough nitrogen fertilizers. In these areas, fertilizers are not a GHG driver
  - However, nitrogen is frequently over-applied in many agricultural regions, especially those that are rapidly developing (e.g. China and India)
  - Management practices that affect GHG flux include precision nitrogen application, conservation tillage, water use, cover crops, hedgerows, mid-season drainage of rice fields, etc.
- Demands on croplands are increasing
  - Growing demands from the developing world are a strong driver
  - Growing demand for biofuels, driven by policies in the US and EU, have put fuel crops in competition for food crops. Recent estimates suggest that for every hectare of U.S. maize put into production for biofuels results in 0.3 hectare of gross land conversion.
  - Rising demand for animal feed is creating additional demand for key crops

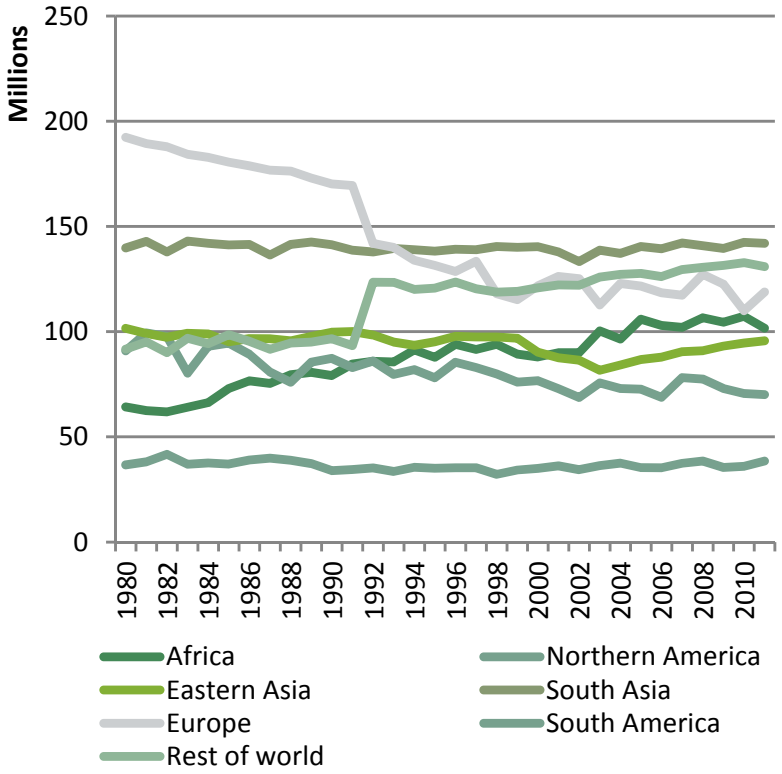
Area under cultivation has increased rapidly

Recent estimates predict a 5% increase in land under cultivation 2000-2020.[1] According to FAO data, land under cultivation for primary crops has already increased 8% 2000-2011. Total area under cultivation for cereals, however, has stayed flat or fluctuated up and down– except in East Asia, where it has risen in recent years.

Global area under cultivation for primary crops has increased

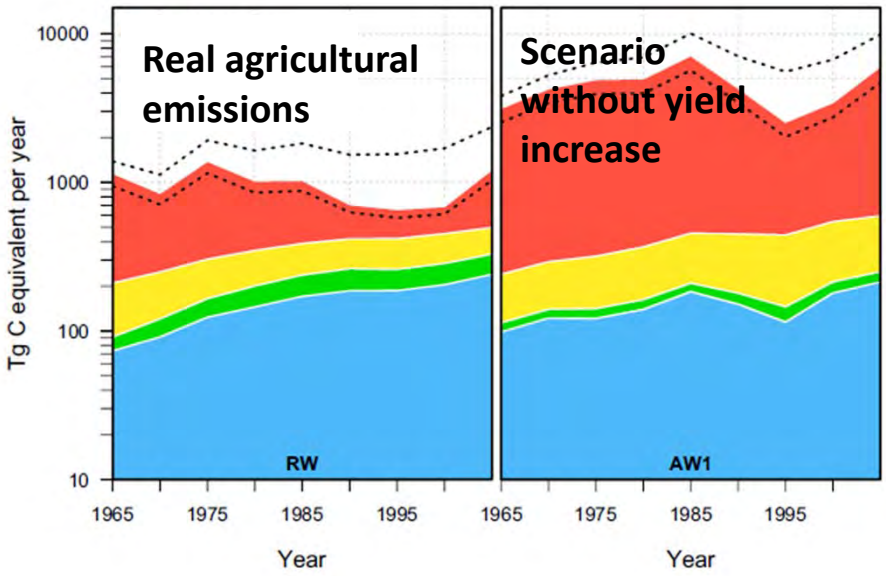


Cereal area harvested (ha)

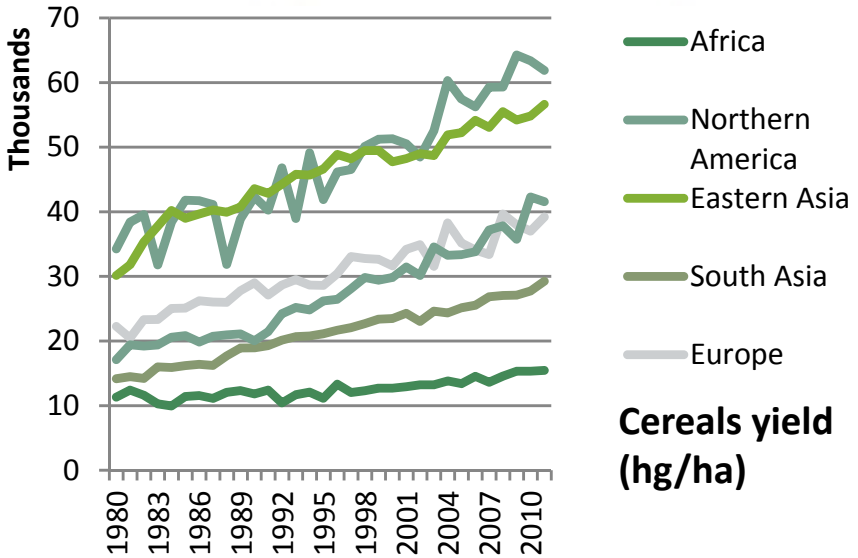


Fischer, 2009. "World Food and Agriculture to 2030/50."
FAOStat online database. Retrieved March, 2013. http://faostat.fao.org/

Increases in land productivity have limited the growth in agriculture emissions



- Yield increases since 1961 have limited growth in GHG emissions from agriculture.
- Without yield improvements (chart on right), GHG emissions in 2005 would have been several times higher than they actually were (chart on left).

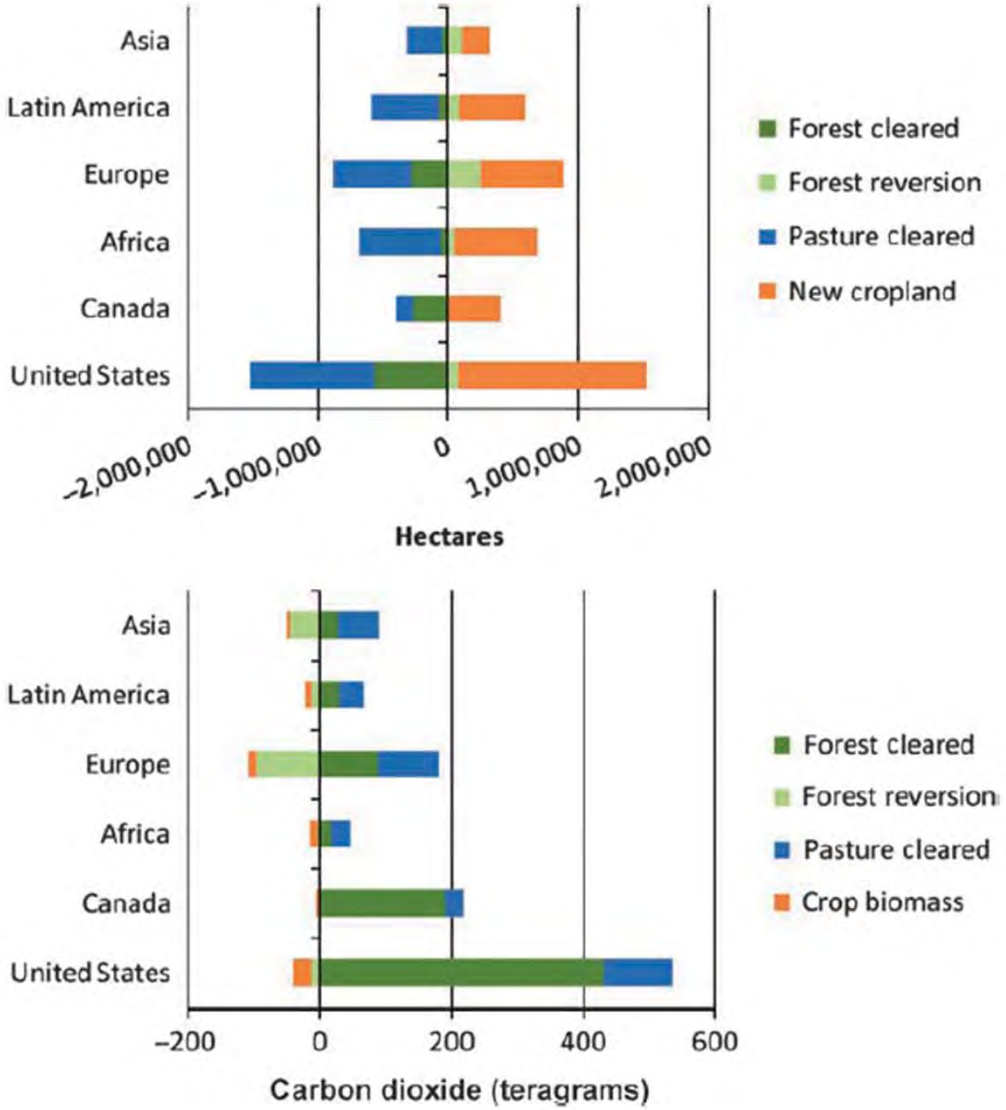


- IPCC AR4 predicted that land productivity (a factor of yield and GHG efficiency) would continue to increase, albeit at a declining rate, due to decreasing returns from technology and use of marginal land. As of yet, however, there is little sign that long-term yield gains are flattening for the cereals that play a critical role in feeding the world.

Mueller et al., 2012. "Closing yield gaps through nutrient and water management." Nature 490: 254-257 doi:10.1038/nature11420.
Burney et al., 2010. "Greenhouse gas mitigation by agricultural intensification" PNAS 107(26):12052-12057 www.pnas.org/cgi/doi/10.1073/pnas.091421610
FAOStat online database. Retrieved March, 2013. http://faostat.fao.org/

Growing biofuel production is driving land conversion

Pressure from biofuels has contributed to global land conversion and deforestation.[1]



Modeled global land conversion from increased biofuel production (left); modeled GHG emissions associated with this land conversion (bottom left).

Changes due to increased US maize ethanol production of 50.15 gigaliters per year at 2007 yields, by region.[2]

agriculture

CEA California Environmental Associates

1. Note that there is not a one-to-one conversion between land put into biofuels and land conversion elsewhere.
2. Hertel et al., 2010. "Effects of US maize ethanol on global land use and greenhouse gas emissions: estimating market-mediated responses." BioScience, 60(3):223-231.

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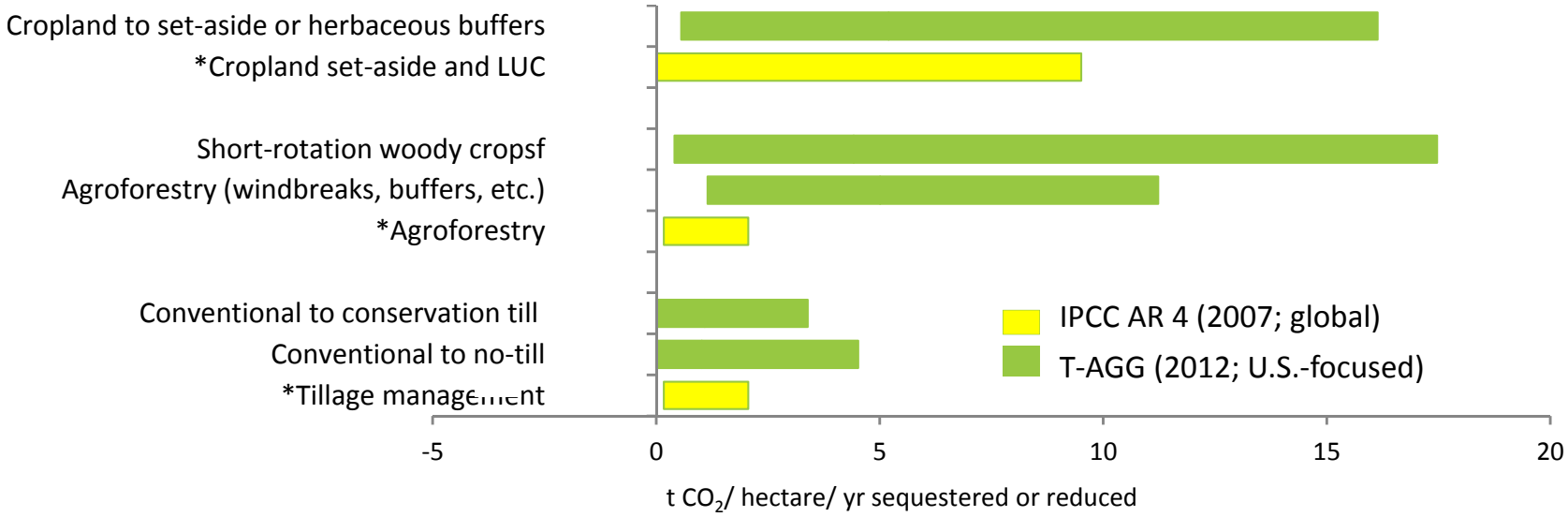
Uncertainty around the mitigation potential of interventions in the agriculture sector remains high

Although we are gradually improving the understanding of mitigation opportunities in the agricultural sector, the uncertainty associated with any specific mitigation option remains high and, in certain cases, has increased compared to 2006 (below).

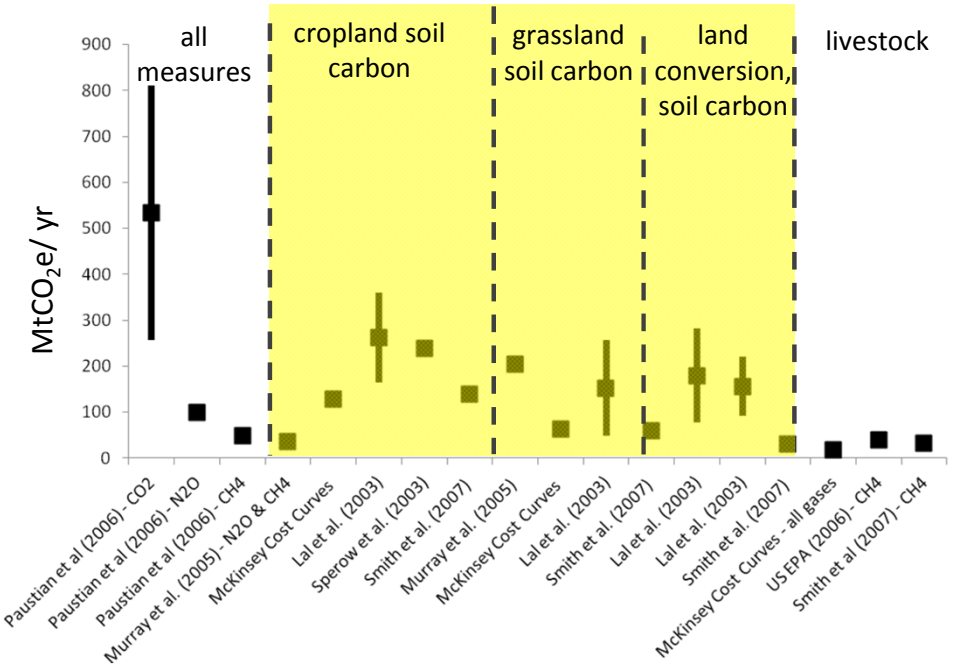
Recent estimates suggest that the magnitude and range of emissions reductions for agricultural mitigation opportunities may be larger than previously thought



Olander & Eagle, 2011. "Greenhouse gas mitigation opportunities for agricultural land management in the United States." Technical Working Group on Agricultural Greenhouse Gases.

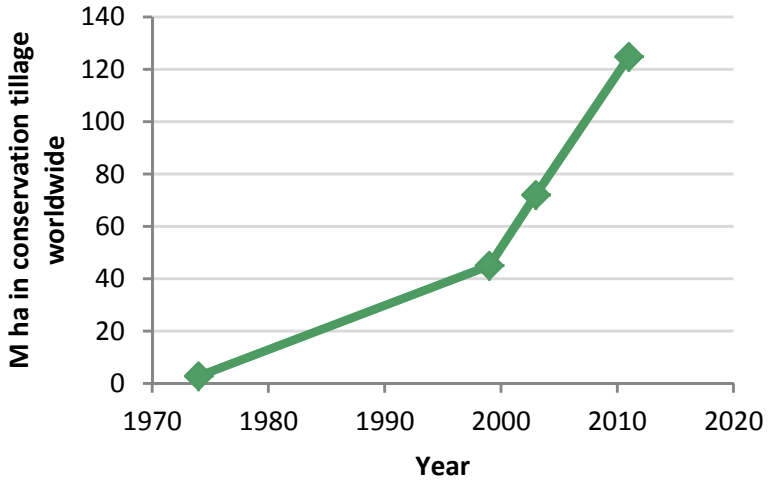
There is substantial mitigation potential in soil sequestration, but the net impact some of these practices, like conservation tillage, is dependent on many factors

Soil carbon comprises a large share of the sector's mitigation potential in the United States (highlighted, right).



The global use of conservation tillage has continued to increase rapidly, a trend that was recognized in the 2007 IPCC report

Conservation tillage has continued to increase worldwide (bottom right) as predicted. However, IPCC AR4 warns that because conservation tillage is frequently paired with periodical tillage, the greenhouse gas effects of the this trend are uncertain.

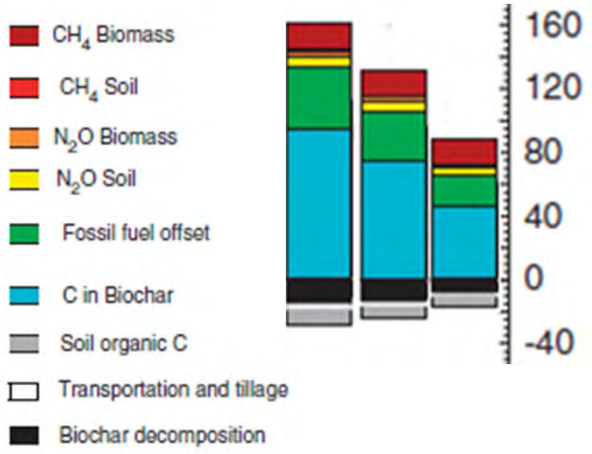


Friedrich et al., 2012 "Overview of the global spread of conservation agriculture" Field Actions Science Report 6.

Biochar has emerged as a mitigation tool, but its realistic mitigation potential remains highly uncertain

Biochar is an agricultural mitigation tool that has gained prominence since 2007 (it was not mentioned in the 2007 IPCC report). Although it is still very much an emergent technology, proponents argue that biochar has the technical potential to offset one tenth of current human GHG emissions, depending on biomass availability. Realistic potential may be much lower.

Biochar used for energy production avoids emissions primarily through sequestering carbon in the soil and avoiding fossil fuel emissions.



Cumulative avoided emissions (Pg CO_2-Ce)

The three bars represent three different scenarios of biomass availability

agriculture

Woolf et al., 2009. "Sustainable biochar to mitigate global climate change." Nature Communication 1:56 DOI: 10.1038/ncomms1053.
Brown et al., 2010. "Improving estimates of rangeland carbon sequestration potential in the US Southwest." Rangeland Ecology & Management, 63(1):147-154. DOI: http://dx.doi.org/10.2111/08-089.1

Agricultural offset protocols have matured since 2007

The use of agricultural offsets has grown significantly since 2007, when only a few agricultural carbon offset protocols existed. More protocols are in development.

Voluntary agricultural protocols

- American Carbon Registry
  - Approved methodologies
    - N2O emissions reductions through changes in fertilizer management (**2010**)
    - N2O emissions reductions through reduced use of fertilizer on agricultural crops (**2012**)
  - Pending/ under development
    - *Emissions reductions in rice management systems*
    - *Avoided conversion of grasslands and shrublands to crop production (ACoGS)*
    - *Grazingland and livestock management*
- Climate Action Reserve
    - Nitrogen management project protocol (**2012**)
    - Rice cultivation project protocol (**2011**)
    - US livestock project protocol (biogas/ methane digesters) (**2007**)
- Verified Carbon Standard
  - Land management and avoided conversion
    - Adoption of sustainable agricultural land management (**2011**)
    - Methodology for soil carbon (**2012**)
  - Under assessment
    - *Methodology for sustainable grassland management*
    - *ALM adoption of sustainable grassland management through adjustment of fire and grazing*
    - *Quantifying N20 emissions reductions in US agricultural crops through N fertilizer rate reduction*

The Coalition on Agricultural Greenhouse Gases. Retrieved March, 2013. http://aginnovations.org/projects/c-agg/

Developed by 2007
Developed since 2007

Agricultural offset protocols have matured since 2007

The emergence of more protocols for compliance markets, especially in CA, has driven new demand for both mandatory and voluntary protocols, as corporations look to adhere to or get out in out in front of regulation.

Mandatory program protocols

- Australian Carbon Farming Initiative (CFI)– "Destruction of methane generated from manure in piggeries" (**2013**)
- CA GHG Cap-and-Trade Program– "Capturing and destroying methane from manure management systems– livestock projects." (**2011**)
- Clean Development Mechanism (CDM) methodologies (220
  - Multi-site manure collection and treatment in a central plant (**2008**)
  - Offsetting synthetic nitrogen application (**2009**)
  - Adjusted water management in rice cultivation (**2012**)
  - Methane recover in animal manure management systems (**2012**)
  - Nitrogen-efficient seeds (**2012**)
  - Methane recovery in agricultural activities at household/ small farm scale (**2009**)
  - Methane recovery in manure management (**2003**)
  - Consolidated methodology for improved manure treatment on livestock farms (**2006**)
- Alberta, Canada
  - Conservation cropping (**2012**)
  - Dairy cattle (**2010**)
  - Reducing days on feed beef cattle (**2011**)
  - Reducing age at harvest beef cattle (**2011**)
  - Low residual feed intake in beef cattle (**2012**)

agriculture

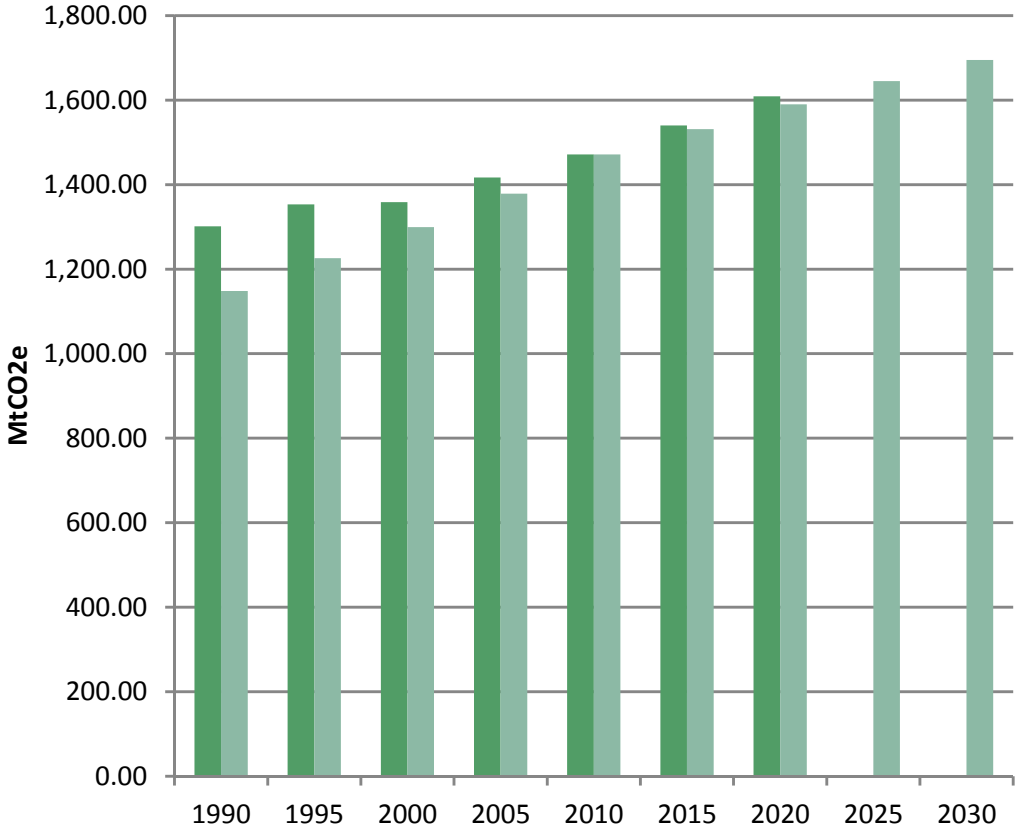
The Coalition on Agricultural Greenhouse Gases. Retrieved March, 2013. http://aginnovations.org/projects/c-agg/

Developed by 2007
Developed since 2007

WASTE

Total waste emissions projections remain essentially unchanged

About 3% of global greenhouse gas emission are estimated to come from waste. Estimates of historical emissions from waste have fallen, but projections moving forward remain the same.



Projections of global waste emissions have not changed significantly

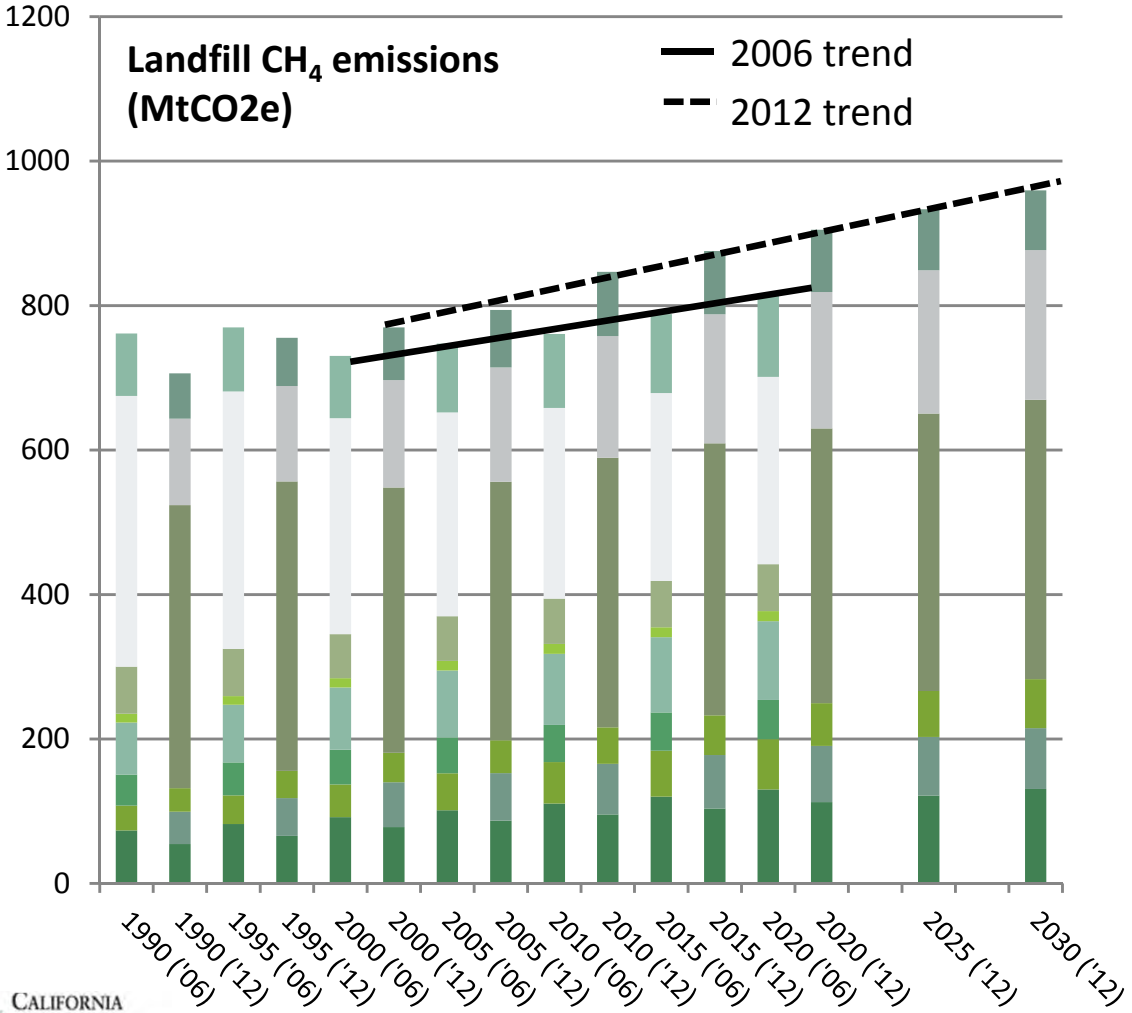
EPA 2006 estimates

EPA 2012 estimates

U.S. Environmental Protection Agency, 2006. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2020."
U.S. Environmental Protection Agency, 2012. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2030."

Forecasted emissions from landfills have been revised upwards, while estimates for wastewater emissions have gone down

Growth in landfill emissions will be slower than previously thought; flat emissions in developed countries will be offset by increased emissions from developing countries, which continue to experience major population growth and urbanization, and associated waste emissions.

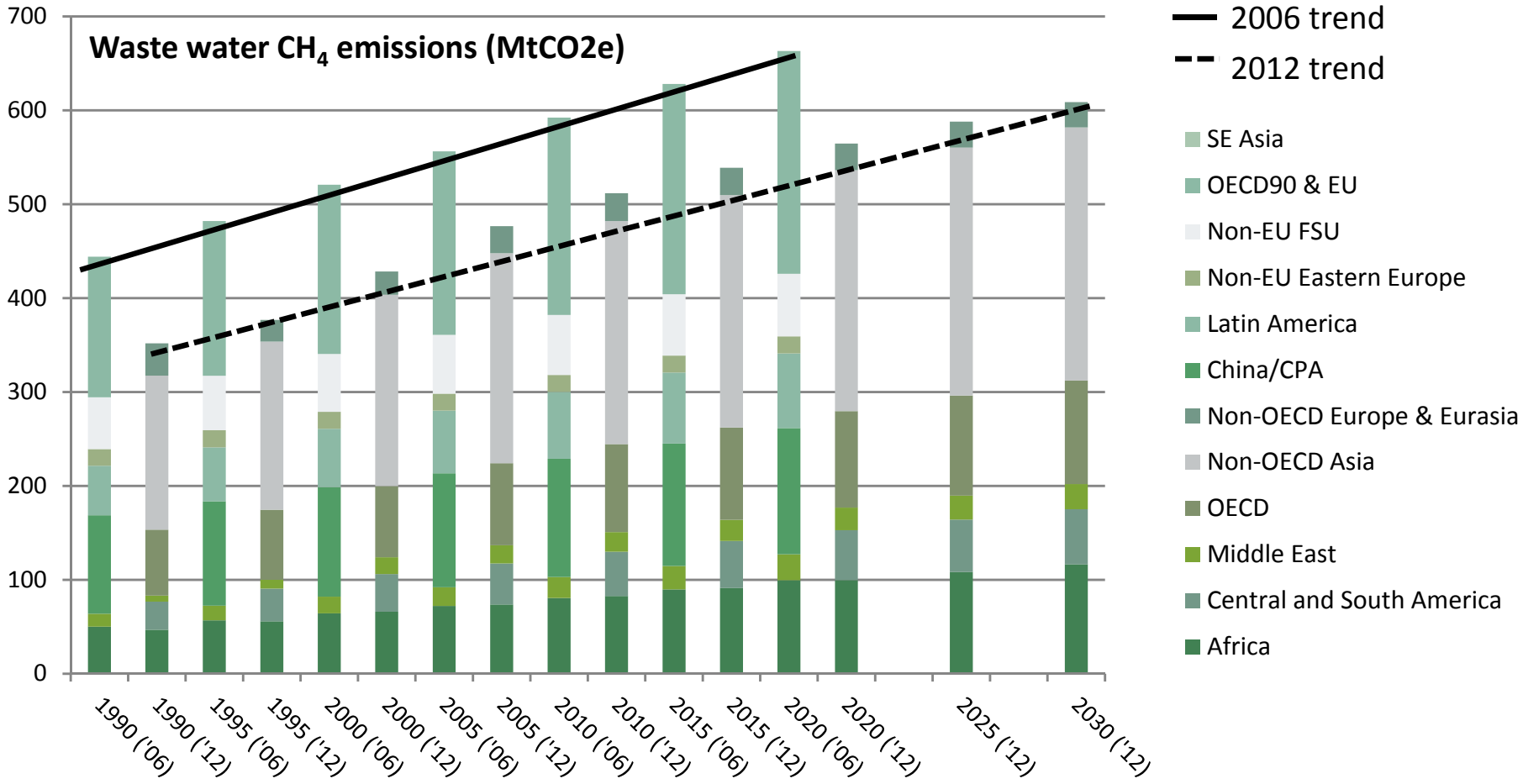


Landfill emissions are disproportionately dominated by OECD countries. Landfill emissions are expected to increase more than previously thought (EU and OECD countries remain flat rather than reducing emissions.)

U.S. Environmental Protection Agency, 2006. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2020."
U.S. Environmental Protection Agency, 2012. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2030."

Forecasted emissions from landfills have been revised upwards, while estimates for wastewater emissions have gone down.

Reductions in landfill emissions are largely offset by larger growth in wastewater emissions.



Roughly 2/3 of wastewater emissions originate from non-OECD Asia and Africa.
New projections of wastewater emissions have been revised downwards.

U.S. Environmental Protection Agency, 2006. "Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2020."
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