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Climate Change Today

A look at new lessons from ongoing global change research

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MIT Joint Program on the
Science and Policy of Global Change

The MIT Joint Program on the Science and Policy of Global Change conducts detailed studies on many aspects of the climate issue—but often it can be difficult to piece the results of these various reports together to form a comprehensive picture of the current state of global change research. This short note offers observations based on our research and that of others on how the climate issue has changed over the last two years, and what these changes mean for industries and government. We follow these general observations with more detailed supporting material that references recent Joint Program research.

Observations:

- As global greenhouse gas emissions continue to rise, recent data indicate that the risks of significant climate change are greater than we believed as little as five to ten years ago. The urgency for action has thus increased.

- The likelihood of realizing a uniform global climate policy architecture, such as that envisioned in the Kyoto Protocol and with near-term accession of a large portion of the world's largest emitters, appears vanishingly small. At best, a mosaic of policies and measures will emerge, which may be costly and have limited effectiveness.

- Closer scrutiny of advanced technologies (renewables, carbon capture and storage, nuclear, electric vehicles) has revealed higher costs than initially believed. Apart from cost, issues of reliability, safety, siting, and other environmental concerns may limit the acceptability and availability of these technologies over the next few decades.

- Climate change endangers forests, biodiversity, and terrestrial ecosystems but land use change probably poses a more immediate threat to these systems. The threats posed by land use change could be exacerbated by a large push to biofuels and biomass energy in the absence of effective protection of forests and valuable natural ecosystems.

Implications for policy and investment:

- Political realities likely dictate that, at least over the next few years, mitigation efforts may need to utilize existing policy mechanisms. While we need to continue to strive for a comprehensive and unified global policy architecture, near-term actions are likely to come though national energy, environmental, and agricultural ministry and departmental regulations and measures. These policies will require careful examination to ensure that they are designed to achieve mitigation targets as cost effectively as possible.

- Policy and investment attention needs to focus on measures that are proven and exist now, even if they are only a partial solution to the climate issue. For example, given advances in the recovery of unconventional natural gas sources, substitution of gas for coal in power generation is a low cost option for dramatically reducing emissions. There are also significant opportunities for efficiency improvement.

- Investment in carbon-intensive fossil sources (coal-to-liquids, oil sands, shale oil, and new coal power generation) carries an extra risk, as countries will likely strengthen mitigation measures in the future.

- Significant climate change now seems inevitable; investments and assets need to be evaluated to identify possible vulnerabilities, or with an eye toward investments that might take advantage of the changing climate. Regional predictions remain highly uncertain but investments affected by sea level rise, tropical storms, and Arctic melting may be particularly vulnerable.

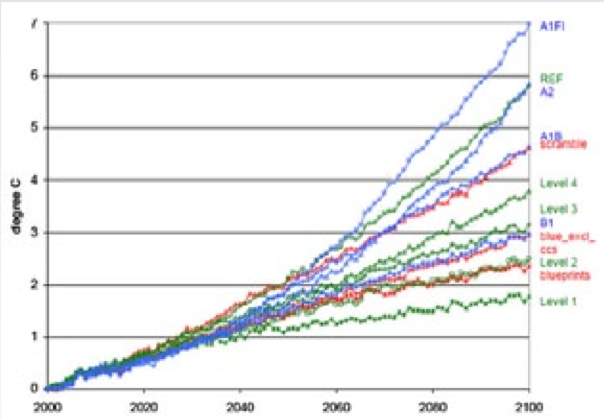
Supporting Material

Assessing the scientific evidence for environmental change

As global greenhouse gas emissions continue to rise, research indicates the risks of significant climate change are greater than we believed as little as five to ten years ago. Nine out of the 10 warmest years in the instrumental record have occurred since 2001; 2010 is tied with 2005 as the warmest year since 1880 (NOAA, 2011).

We project global median temperature increase between 1990 and 2100 to be above 5°C, with a 90% probability range of 3.5°C to 7.4°C (Sokolov et al., 2009; Webster et al., 2009). This projection updates a 2003 study (Webster et al., 2003), which projected a median temperature increase of 2.4°C by 2100. There is no single factor primarily responsible for the increase in temperature estimates between 2003 and 2009—instead many different factors have acted multiplicatively to alter the 2100 temperature projections. In other research, we have shown that different emissions scenarios developed by industrial, academic, and government entities all result in a temperature increase of at least 3°C by 2100, absent significant climate policy (Prinn et al., 2011).

The potential risks inherent in these projections signify that the urgency for action has increased.



Increase in the Global Mean Temperature (°C relative to 2000). Red lines represent data from Royal Dutch Shell plc (2008), green lines represent data from the United States Climate Change Science Program (updated from 2007), and blue lines represent data from the Special Report on Emissions Scenarios prepared for the Intergovernmental Panel on Climate Change (2007). These different approaches paint a similar picture of a world at risk from climate change even if there is substantial effort to reduce emissions (Prinn et al., 2011)

Meeting the climate challenge with effective policy

The likelihood of achieving a uniform global climate policy architecture, such as that envisioned in the Kyoto Protocol and with near-term accession of a large portion of the world's largest emitters, appears vanishingly small. At best, a mosaic of policies and measures will emerge, which may be costly and have limited effectiveness.

International climate policy nominally accepts the risks inherent in climate projections by setting a temperature-increase goal of no more than 2°C warming from pre-industrial times. However, the national emissions reductions pledged in the Copenhagen Accord would not achieve this goal, even if fully realized (Paltsev and Jacoby, 2010).

The Copenhagen Accord has taken us closer to a policy-and-measures architecture. The European Union has pursued the Emissions Trading Scheme, a classic cap-and-trade system, but also has renewable energy targets and efficiency goals. Moreover, the EU ETS only covers about half of Europe's emissions. In the US, renewable fuel mandates, Corporate

Average Fuel Economy (CAFE) standards, and various state-level initiatives are employed. China has put forward an intensity-based emissions target, but as yet has not fully specified the mechanisms to meet it. Brazil's commitment largely involves avoided deforestation.

When some nations or regions enforce a climate policy while others do not, the options for avoiding leakage are limited to border carbon adjustments. However, border carbon adjustments have been shown to impose much greater costs on non-cooperating countries than if they took climate actions that achieved the same mitigation benefits (Winchester et al., 2010b).

Securing a low-carbon energy future

Closer scrutiny of advanced technologies (renewables, nuclear, carbon capture and storage, and electric vehicles) has revealed higher costs than initially believed (Paltsev et al., 2010). Recent wind pattern studies have shown there may be large periods of time when no wind would blow over large areas of the US, including the Midwest (Bhaskar and Schlosser, 2010). It would thus be difficult to rely on wind as a baseload power supply; gas or nuclear backup power sources would be needed to address intermittency issues (Brun, 2010; Morris et al., 2010).

However, the aftermath of the earthquake and tsunami damage to the Fukushima Daiichi Power Station in Japan will surely include a significant reanalysis of the safety and public acceptance of nuclear power as a very-low-emissions alternative energy source. While the final outcome of this reanalysis is unclear, it is likely to slow investment in this technology in the near future.

Much attention has focused on electric vehicles, but research has shown that their commercial viability requires substantial reductions in battery costs. In addition, their effectiveness at reducing emissions is limited if coal generation without carbon capture and storage is a major source of electricity (Karplus et al., 2010). Another promising option for transportation is biofuels. However, large-scale biofuel production can contribute to deforestation, limiting climate benefits (Melillo et al., 2009). In addition, food prices would be affected by expanded biofuel production (Gurgel et al., 2011; Reilly et al., in review).

Food, fuel, and forestry conflicts

Climate change is a threat to forests, biodiversity, and terrestrial ecosystems, but human-driven land use change probably poses a more immediate threat.

This realization necessitates a refocusing of research efforts towards broader resources management concerns, such as water, agriculture, and health. For example, long-term trends in water supply are affected not only by climate change but also by economic development and urbanization. Greater demand for water by cities, industry, and energy-generation plants will likely come at the expense of agriculture, particularly in the developing world (Hughes et al., 2010). In addition, increased development of biofuels and biomass energy and the absence of effective protection of forests also threaten valuable natural ecosystems (Gurgel et al., 2010). Finally, studies of the long-term impacts of air pollution show high costs, both in terms of health care expenses and losses in productivity and economic growth (Matus et al., 2011; Nam et al., 2010; Selin et al., 2010).

Resource management work is important for adapting to the effects of climate change, but it does not change how we view the prevention of climate change: despite political momentum moving in the opposite direction, the most effective and efficient climate policy remains a cap-and-trade policy or a carbon tax, combined with REDD-like mechanisms to prevent deforestation.

Implications for Policy and Investment

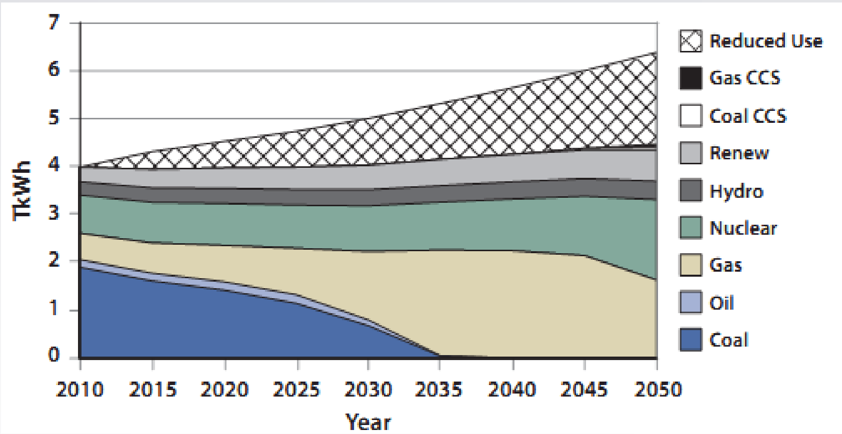
Utilizing existing policy mechanisms

Political realities likely dictate that, at least over the next few years, mitigation efforts may need to utilize existing policy mechanisms. While we need to continue to strive for a comprehensive and unified global policy architecture, near-term actions are likely to come through national energy, environmental, and agricultural ministry and departmental regulations and measures. These policies will require careful examination to ensure that they are designed to achieve mitigation targets as cost effectively as possible.

Our research shows that regulatory climate policies are often less effective and, when combined with a cap-and-trade system, increase costs without any additional mitigation benefits. For example, Morris et al. (2010) demonstrated that combining a US cap-and-trade policy with a renewable portfolio standard is more expensive than implementing only a cap-and-trade policy, while achieving no greater reductions in emissions. Other work is being done to investigate the complicated interactions between the European renewable fuel standard and fuel taxes and tariffs (Gitiaux et al., 2010). Karplus et al. (2010) showed that US CAFE standards would be 7 to 12 times as expensive as a gasoline tax in achieving reductions in gasoline use.

Focusing on proven solutions

Policy and investment attention needs to focus on measures that are proven and exist now, even if they are only a partial solution to the climate issue. For example, given advances in the recovery of unconventional natural gas sources, substitution of gas for coal in power generation is a low-cost option for dramatically reducing emissions. There are also



US energy mix in the electric sector, under an economy-wide price-based climate policy. Demand in the electricity sector is effectively flattened at 4TkWh. (Moniz, et al., 2011) significant opportunities for efficiency improvement. We estimate that by 2050 total US energy consumption could fall by about 20% from today's levels if a carbon-pricing policy were put in place, even with a growing economy and population (Paltsev et al., 2010). In the MIT Future of Natural Gas study, Moniz et al. (2011) found that reducing energy use and switching from coal to natural gas in the electricity sector could serve as relatively inexpensive bridges to a low-carbon future.

Resource risks

Absent climate policy, some of the least-expensive energy options are coal-to-liquids, oil sands, shale oil, and coal power generation. However, investments in these sources carry an extra risk. If countries impose tougher mitigation measures in the future, then these energy sources cannot continue to compete (Chan et al., 2010; Chen et al., 2010). For example, Chen et al. (2011) found that without climate policy coal-to-liquid (CTL) conversion may become economic as early as 2015 in coal-abundant countries like the US and China, and has the potential to account for about a third of global liquid fuels supply by 2050. However, the viability of CTL would become highly limited in regions that adopt climate policies, especially if low-carbon biofuels are available.

Climate vulnerability

While the architecture of future climate policies is uncertain, significant climate change now seems inevitable; investments and assets need to be evaluated to identify possible vulnerabilities, or with an eye toward investments that might take advantage of the changing climate.

The 5°C temperature increase we project for 2100 would likely have dramatic impacts on many aspects of the world around us. For example, if high temperatures were sustained, large portions of the Greenland and West Antarctic ice sheets would melt. These ice sheets contain enough water to raise sea level by about 39 feet if totally melted, causing severe damage to vulnerable coastal cities and infrastructure (IPCC, 2007). Already, observations indicate more rapid melting of ice sheets than previously expected (Rignot et al., 2011). In addition, satellite observations show a rapid decrease in summer Arctic sea ice cover (Perovich et al., 2011) and earlier spring greening of the Northern Hemisphere has been documented (Wang et al., 2011). Regional predictions remain highly uncertain but investments sensitive to sea level rise, tropical storms, and Arctic melting may be particularly vulnerable.

The Joint Program on the Science and Policy of Global Change integrates natural and social science to produce analyses relevant to climate and energy policy debates

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