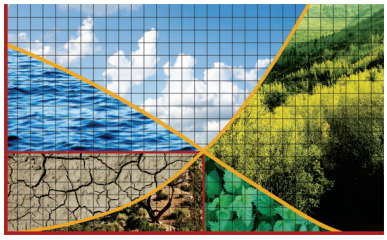
Harvard Environmental Economics Program



Harvard Project on Climate Agreements

Summary of Discussion Paper 63

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THE OPTIMAL ENERGY MIX IN POWER GENERATION AND THE CONTRIBUTION FROM NATURAL GAS IN REDUCING CARBON EMISSIONS IN 2030 AND BEYOND

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Overview

There is considerable tension between climate-policy goals and actual energy trends in the European Union (EU). On the one hand, the EU has pledged a 40% reduction in carbon dioxide emissions by 2030, relative to 1990, and its Emissions Trading System is the largest cap-and-trade program for carbon dioxide emissions in the world. On the other hand, EU energy consumption tilted toward *more* emissions-intensive sources from 2010 to 2012, not less: natural gas usage dropped 14% in that period, while coal usage rose 8%.

Given these trends, there is significant interest in a *normative* analysis of energy markets – that is, what energy mix is optimal for achieving a given environmental target. The authors conduct this type of analysis, focusing on EU power generation in the years 2010–2050. They begin by identifying a set of climate policy scenarios that vary along four primary dimensions: overall stringency of emissions-reduction targets; reliance on specific renewable energy requirements; the price of natural gas; and the scope of future energy efficiency regulation. Using an integrated model of global energy markets and economic outcomes, they then calculate the most cost-effective mix of coal, natural gas, nuclear, and renewable power generation that satisfies each policy scenario. Their findings highlight the importance of strong carbon pricing and natural gas in the cost-effective attainment of climate goals.

Background

The authors analyze four scenarios representing different levels of overarching policy stringency: A no-policy baseline; two EU-specific policy scenarios, with "moderate" and "stepped up" emissions reductions goals; and a global policy scenario, based on pledges made at the Durban Climate Change Conference of 2011, which aimed to restrict global temperature rise to 2° Celsius. Combining these policy goals with assumptions about technical and economic constraints on power systems, the authors compute optimal shares for each major power source over time, where "optimal" is defined as the least-cost energy mix that achieves the emissions target of each policy scenario. By varying three key model parameters – the presence of renewable energy requirements, the price of natural gas, and the scope of energy efficiency improvements – the authors also examine the effects of plausible deviations from the four basic scenarios.

The analysis reveals a general trend of decreasing coal and nuclear use and increasing natural gas and renewables use in the optimal energy mix across all policy scenarios. However, this realignment of the energy market and climate objectives takes place only after 2020, when higher carbon prices (in $/ton of carbon dioxide ($tCO_2$)) are expected. Renewable requirements, gas prices, and energy efficiency improvements have a large effect on the precise price,

quantity, and cost consequences of optimizing under each scenario. The 2020 targets for renewable energy, for instance, suppress the overall carbon price by an estimated 10 $/tCO$_2$, which in turn slows the substitution of natural gas for coal and reduces revenues generated by auctioning off emissions allowances. Lower natural gas prices, on the other hand, have the effect of speeding up the penetration of natural gas into European power markets. Finally, the impact of energy efficiency improvements depends on the source of these improvements: efficiency gains due to reductions in emissions intensity (emissions per unit of power) produce cost savings relative to efficiency gains from reductions in overall energy demand (total power consumed).

Key Findings and Recommendations

1. **A strong, sustained carbon price is necessary to realign market incentives with climate objectives.** A price on carbon emissions incentivizes cleaner power generation regardless of fuel source. Furthermore, carbon pricing can generate revenues for financially stretched governments.

2. **Natural gas is likely to be a key transitional fuel for reaching the optimal energy mix in a variety of policy scenarios.** Even if renewable power targets restrict natural gas expansion in the near future, cost-effective achievement of *all* climate targets considered involves steep increases in gas consumption between 2020 and 2050.

3. **Subsidies for renewable power generation should be discontinued after 2020 if the carbon price is sufficiently high.** Subsidies dampen carbon prices, increase policy costs and reduce public revenues. Wind and solar power generation has the potential to rise over time even without subsidies, due to increasing cost-competitiveness and the incentives provided by a general carbon price.

Conclusion

The future of energy markets is highly uncertain, because it is inherently difficult to forecast energy demand growth, technological change, and the economic damages of climate change. Regardless of the EU's specific climate targets, however, this analysis suggests that a few conceptual guidelines can go a long way toward producing an energy mix that reduces emissions at minimum cost. Carbon pricing should be emphasized; subsidies for renewables or other specific fuel sources should be reduced over time; and energy efficiency policies should be designed to complement market based interventions.

Full paper available at: http://belfercenter.ksg.harvard.edu/publication/23833

About the Project

Established in 2007, the goal of the Harvard Project on Climate Agreements is to help identify and advance scientifically sound, economically rational, and politically pragmatic public policy options for addressing global climate change. Drawing upon leading thinkers in Argentina, Australia, China, Europe, India, Japan, and the United States, the Project conducts research on policy architecture, key design elements, and institutional dimensions of international and domestic climate policy.

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