***analysis of The impacts of co2 capture and shale gas supply under a co2 tax scenario***

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## Overview

Security of energy supply and climate change are central concerns for policy makers and important dimensions of long-term energy sustainability. This paper examines the role of policy instruments in managing climate change and stimulating technological change towards a sustainable energy system in the long-term future. The approach, which makes use of the MARKet ALlocation (MARKAL) energy system model, allows policy instruments to be examined quantitatively in a dynamic energy system context.

The study is focused on the interaction between climate policies and energy security, and will help guide policy making by identifying areas, and the extent to which, climate policy can reinforce energy security objectives. The study discusses multiple scenarios, considering the synergistic effects of energy development objectives, diversification in energy supply and environmental regulations in the U.S. at the regional level.

The paper is organised as follows: After the introduction the second section gives a brief overview on the MARKAL) energy system model, the data sources and methods. The third section addresses the results. In the final section policy implications are derived.

## Methods

The primary objective of the analysis is to evaluate the techno-economic impacts of the CO2 taxation on the U.S. energy system, with a particular emphasis on the electricity sector. The paper presents the range of findings from a selection of model runs undertaken at the regional levels.

We adopt MARKAL because it is the most widely-applied energy-economy model in literature, and the latest, 2012, US EPA 9 Regions MARKAL database (EPAUS9r 2012) is available. MARKAL is a linear program that has energy producing, conversion, and use activities and capacities as decision variables, and constraints representing energy balances, capacity limits, and various policy considerations. The objective function is to minimize the cost of meeting those demands and this formulation simulates the operation of a competitive market. The analyses address only a subset of the CO2 taxation policy and possible effects on CO2 emissions reduction, energy costs and energy security. Energy security has multiple features, which cannot be easily combined into a single indicator, so energy security is not used as a quantitative target or a technical modelling constraint in the MARKAL’s scenarios.

## The EPAUS9r2012 database was slightly modified for one scenario (we changed the CCS technologies profile and included learning rates for coal and gas plants with CCS). The learning rates were derived from the Energy Information Administration’s (EIA) publication, Electricity Market Module of the National Energy Modeling System 2012 (see DOE/EIA-M068, 2012).

We analysed electricity mix, abatement costs, marginal energy costs at the residential sector and energy security under different scenarios projections. Long-term energy supply security is contingent on the establishment of “efficient” diversified portfolios of primary and secondary energy sources. A more diverse system is perceived as having a number of benefits that make it preferable to one that is less diverse. In particular, diversity is considered to contribute to achieving energy security since disruption of any one source will have a smaller impact on overall energy supply. Similarly, the effects of price volatility are likely to be mitigated where an increasing range of sources is employed in energy production.

We have examined the techno-economic impacts of these two climate change policies on carbon emissions reductions, electricity generation mix and energy security through analyzing various assumptions using the following scenarios (see Table 1):

**Table 1. Scenario Definitions**

|  |  |
| --- | --- |
| **Scenarios** |  **Descriptions** |
| BASE9R | Base case (BASE9r scenario from the EPAUS9r 2012 database) |
| BASE9RVT | Base case with CAIR-MATS |
| BASECO2 | Base case with CAIR-MATS and CO2 taxes from Sanders/Boxer Climate Legislation ($20/tCO2 in 2015 with 5.6% annual growth) |
| CO2CCS |

|  |
| --- |
| BASECO2 scenario with learning assumptions for CCS technologies |
|  |

 |
| CLOWGAS | BASECO2 scenario with lower EUR for shale gas |
| CLGCCS | BASECO2 scenario with lower EUR for shale gas and improved CCS technologies |

## Results

Results are presented in scenario format at the national and regional levels. The modelling scenarios results are compared to each other and a base case scenario. The reduced diversity in electricity input fuels is an important challenge in some scenarios. One aspect that is important to examine is whether gas and electricity markets continue to provide the required level of fuel diversity. In addition, diversification requires that all energy options keep open. The assessment of future energy scenarios shows that it is technically possible to achieve energy security while avoiding dangerous climate change. Electricity production provides a snapshot of both the effectiveness of CO2 mitigation actions and the level of energy security.

## Conclusions

There are the following substantial uncertainties facing the U.S. energy system: the risk of high energy prices, the risk of a disruption to energy supply and the risk of anthropogenic climate change. Failure to manage either of these risks may potentially result in large economic and social costs, so policies that effectively manage and reduce these risks may result in very large social benefits. We have compared policies that enhance long-term GHG emissions reductions, examined how these policies may interact with energy security, and the role of particular technologies in pursuing these policy goals.

As global gas demand and trade are expected to grow significantly, gas security will become increasingly important, not only for the gas industry but also for the energy industry. The expected increase in gas demand does not in itself have to constitute a security problem, provided that adequate security measures are in place. However, the larger the share of gas in the fuel balance, the more important gas security becomes.

The reduced diversity in electricity input fuels is rapidly becoming another important challenge. One aspect that needs to be watched carefully is whether gas and electricity markets continue to provide the required level of fuel diversity after they become deregulated. Diversification also requires that all energy options be kept open, including the nuclear power that is now facing a moratorium in several countries. Last but not least, efforts should be made to maintain sufficient operating margin, increase interconnections and technical compatibility among various networks and reduce barriers to cross-border trade in gas and electricity.

Identification of the consequences of these design features and alternative approaches requires additional modeling and analysis. However, it is clear that fossil fuels plants with CCS will play an important part under any GHG regulations strategy that address considerable CO2 reduction and acceleration support and funding for the large‐scale CCS demonstrations is crucial for the policies implementation. CCS technologies mitigated the increase in electricity prices and reduction in overall electricity generation driven by the various CO2 reduction scenarios we examined. Delays in CCS funding decisions that are caused by a number of factors must be addressed.

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