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Oil shale and climate policy in the shift to a low carbon and more resilient economy

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ABSTRACT

Policy makers worldwide are recently debating options to implement an effective climate policy that would put a cap on green house gas emissions. At the same time, investors are carefully evaluating the profitability of unconventional fossil fuels such as shale oil. To enhance the understanding of the impacts of a climate policy such as the American Clean Energy and Security Act of 2009, on oil shale production – and vice versa – we have customized an integrated assessment model, the Climate and Energy Assessment for Resiliency model for Unconventional Fossil Fuels to the U.S. Western Energy Corridor. Our analysis indicates that while the bill would increase the production cost of oil shale, the industry remains highly profitable in the longer-term, generating a potential profit of about $10 to $16 billion per year by 2040 at 2.5 million barrels per day. These results suggest that the oil shale industry may comfortably face the enactment of a carbon policy, albeit with some caveats. Furthermore, while its potential economic impact on non-compliant industries may be severe, it would generate mounting profits for those achieving energy efficiency gains, thereby increasing the profitability of energy efficiency investments.

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1. Introduction

Due to the high volatility of energy prices and worrisome depletion of conventional liquid fuels, unconventional fossil fuels (UFF) such as shale oil, oil sands, and coal to liquids have gained the attention of investors in recent years, despite their environmental drawbacks. At the same time, a number of legislative proposals have been introduced and debated in Congress aimed at reducing greenhouse gas emissions (GHG) in the U.S. The larger policy debate has revolved around two approaches for achieving GHG reductions on an economy-wide basis: a carbon tax and cap-and-trade schemes. The former entails directly setting a fixed charge on carbon content, primarily placed on upstream suppliers of high-carbon content energy fuels. The latter attempts to harness markets by defining emission targets and allowing prices to respond, to achieve the same goals. In the current political environment a cap-and-trade mechanism over a carbon tax policy is favored. More specifically, as highlighted in the Waxman–Markey bill (W–M bill), H.R. 2454, the American Clean Energy and Security Act of 2009 [1], a mandatory cap would be placed on the total amount of GHG emissions to meet the long-term GHG emission reduction goal of 83% below 2005 levels in 2050. In theory, the additional costs rippling through the economy would prompt a shift toward the use of lower-carbon fuels, as well as substantial gains in energy efficiency in all economic sectors, thereby lowering GHG emissions.

Interestingly, as the debate continues on a national carbon policy and a possible international climate treaty (e.g. Conference of Parties, COP17 and United Nations Conference on Sustainable Development, RIO + 20), investors look to exploit the fact that one of the largest reserves of oil shale worldwide is in the western interior of North America. It is advocated that a large-scale development of oil shale in this area would

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significantly reduce U.S. oil imports and increase national security, while being profitable with sustained oil prices. However, oil shale production carries a number of negative potential environmental impacts. While domestic production of light oil from shale would create jobs and contribute to the gross domestic product (GDP) and federal and state finances, its production is energy and water intensive and could have negative impacts on air and water quality, habitat, and wildlife, further exacerbating climate change.

Given the complexity of the social, economic and environmental aspects of a large scale oil shale industrial development in the U.S., a science-based, integrated analysis of the cross-sectoral implications of oil shale production is necessary. An integrated approach is needed to inform local, state and federal policy makers and avoid serious potential and unexpected side effects of the policies currently being considered.

In this paper we apply an integrated assessment model, the Climate and Energy Assessment for Resiliency model for Unconventional Fossil Fuels, $CLEAR_{uff}$ [2], to support climate and energy policy formulation and evaluation. Specifically the goal of this study is to evaluate the impacts of the enactment of a carbon policy on the industrial development of oil shale production in the U.S., and vice versa. The $CLEAR_{uff}$, model evaluates the potential cross-sectoral impacts of a ramp up in oil shale production capacity as well as its implications on the implementation of a national cap-and-trade mechanism.

2. Background

Few valuable qualitative studies and reports focused on unconventional fossil fuels are available [3–7], but only one study [8] proposes a computer simulation model, the National Strategic Unconventional Resources Model (NSURM), which is relevant concerning scope, analysis and level of aggregation, to the work presented in this paper. NSURM, developed to support the Task Force mandated by Congress as part of the Energy Policy Act of 2005 [9], presents an aggregated picture of the potential development of the unconventional fossil fuel industry in the U.S. and is used to evaluate the potential for domestic oil production from unconventional fossil fuels. More specifically, NSURM is an optimization model that determines the potential production, reserves, economic statistics, and national benefits. The model identifies the most economically viable recovery technology based on the geological characteristics of the area analyzed and carries out a standard cash flow analysis. Results evaluate the potential benefits resulting from unconventional fossil fuel production, including direct federal and state revenues, as well as broader GDP benefit (mostly resulting from the domestic production of otherwise imported oil). NSURM allows one to simulate changes in assumptions about oil prices, desired rate of return, production and investment tax credits and adopted depreciation schedule, among others. NSURM also adds an economic component to its optimization engine, effectively presenting a partial equilibrium analysis. In addition the model, as well as conventional optimization models, uses economic profitability – and the choice of the most economical technology – as the main drivers of the industry's development. However, recent reports [3,6,4] highlight the importance of other factors for the success of the unconventional fossil fuel business, such as the availability and cost of the basic inputs to production (e.g. energy and water), and the potential regulation of emissions [1]. Furthermore, local policy makers have to carefully evaluate the social and demographic impact of the large-scale development of unconventional fossil fuel production, as stated in a recent comprehensive report from the Bureau of Land Management [6].

The $CLEAR_{uff}$, model uniquely integrates the oil shale industry-related sectors with key causally related macro sectors to perform an industry wide analysis of the production requirements (capital, labor, energy and water requirements) and economics of oil shale production, as well as an analysis of local and regional economic and environmental impacts.

3. The $CLEAR_{uff}$, model

The general goal of the $CLEAR_{uff}$, model is to investigate both sectoral and broader implications of unconventional fossil fuel production in geographical areas that would be impacted by the exploitation of unconventional fossil fuel reserves. These consequences range from environmental (e.g. water quality, land use, GHG emissions) to socio-economic ramifications (e.g. job creation, contribution to GDP, state and federal revenues). The model consists of several modules. The center piece is the fuel production process module that models the specific process phases calculating the fuel production. This module also computes the demands for energy and water that allow for the oil recovery through a specific extraction process. Inputs for the oil production, such as available installed production capacity, and energy and water availability are calculated in the economic, energy, and water modules respectively. In the analysis here presented, we assume that the energy and water demands needed during the production process are always met. The model also estimates the oil industry GHG emissions mostly due to electricity generation. The oil production drives new employment and, as a consequence, the impact on the population as well as on the regional GDP.

The broader impacts of the fuel industry development, energy and water demands, as well as CO_2 emissions are calculated for the agriculture, commercial, industrial, residential and transportation sectors. The model allows for a partial equilibrium, macro analysis of the production requirements and economics of fuel production and for the analysis of social, economic and environmental impacts at the local, state and federal levels. Fig. 1 represents a schematic representation of the primary $CLEAR_{uff}$ model modules used for the present analysis. This figure also shows the links among these modules and the main model inputs and outputs as well.

The potential development of oil shale resources faces a number of questions regarding the costs, energy inputs, GHG emissions, and potential impacts on land and water resources. According to the U.S. Geological Survey [10], the U.S. oil shale resource exceeds 1.5 trillion barrels of oil, most being present in the Green River formation that underlies parts of Colorado, Utah, and Wyoming. We focus our study on this whole area since it would be most impacted by the exploitation of oil shale reserves. As an extraction process we model the Shell in situ conversion process (ICP), which is technically feasible in deep deposits like those in this studied area. In the ICP retorting method, electric heaters are placed within the oil shale deposits in wells and slowly heat the oil shale to a sufficiently high temperature to convert the kerogen contained in oil shale into liquid hydrocarbons, a form of

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