THE ECONOMIC POTENTIAL FROM DEVELOPING NORTH CAROLINA'S ON-SHORE AND OFF-SHORE ENERGY RESOURCES

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April 2013

EXECUTIVE SUMMARY

Developing North Carolina's energy resources has the potential to create income, employment, and public revenues for the state. Using average (mean) estimates for economically recoverable supply and prices of energy resources, it is calculated that constructing the facilities to access North Carolina's ***off-shore*** **energy resources could create $181 million (2012$) of annual income, 1122 jobs, and $11 million of annual public revenues during the seven-year build-up period. Then during the estimated 30-year period of energy recovery, $1.9 billion of annual income, 16,910 jobs, and $116 million of annual public revenues would be generated**. All economic impacts include the direct impacts of the energy acitivities, the impacts from in-state suppliers and enhanced consumer spending, and account for losses of economic activity when benefits flow to input owners outside the state.

There would also be economic impacts from development of the state's *on-shore* energy resources. Again using average estimates for supply and prices, **during the construction of the needed infrastructure and facilities, $80 million of new annual income, 496 jobs, and $4.9 million of annual public revenues would be generated. Then during a projected 20-year energy production period, $158 million of new annual income, 1406 jobs, and $9.6 million of new annual public revenue would be generated.** Again, all impacts include direct effects of energy activities, impacts for in-state suppliers and greater consumer spending, and losses from benefits to out-of-state input owners.

These economic impacts were derived using average (mean) values for available energy resource quantities from government agencies and best-estimate energy price forecasts from government and international sources. However, changing these quantity and price projections were found to have significant effects on the size of the quantitative impacts – sometimes by a factor of more than 100.

There are also potential costs to North Carolina from development of energy resources. Unfortunately, these costs are difficult to estimate and are sometimes given only with a large range. **Coastal damage from spillage of recovered energy resources is the greatest threat from off-shore development. The potential average annual cost – using actual spillage rates for the past 40 years - is $83 million, primarily to coastal counties. The potential annual average on-shore costs from possible environmental damage could reduce property values in the affected counties by between $636 million and $4.7 billion.**

Acknowlegements: Kristin Bunn (North Carolina Dept. of Commerce), David Cooke (U.S. Bureau of Ocean Energy Management), Ted Feitshans (North Carolina State University), Brandon King (North Carolina State University), Derek Ramierez (North Carolina Dept. of Commerce) and Kenneth Taylor (North Carolina Department of Environment and Natural Resources) provided valuable information and comments on the report. Any errors, omissions, or miscalculations are the responsibility of the author.

Funding was provided by the North Carolina Agricultural Research Service project # NC02340, "The Changing Structure of the North Carolina Economy".

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INTRODUCTION

There is increasing optimism about the nation's ability to develop domestic energy resources. There are two components of these efforts. One is the development of non-traditional energy resources, such as solar, wind, and biomass power. The second is the increase in the quantities of energy from traditional sources, such as petroleum and natural gas, from domestic lands and waters. The increases in traditional energy quantities have been aided by new technologies allowing access to more reservoirs holding these sources.

This report focuses on the second component of energy development – access to traditional energy sources – in North Carolina. Recent discussions in the state have considered enhanced energy development from on-shore sites – specifically natural gas reserviors accessed by new hydraulic fracturing and horizontal technologies – as well as energy development from off-shore locations, such as oil and natural gas reservoirs in ocean areas off the coast of North Carolina. The study of on-shore energy development in North Carolina has proceeded more rapidly with the creation of the North Carolina Mining and Energy Commission in 2012.

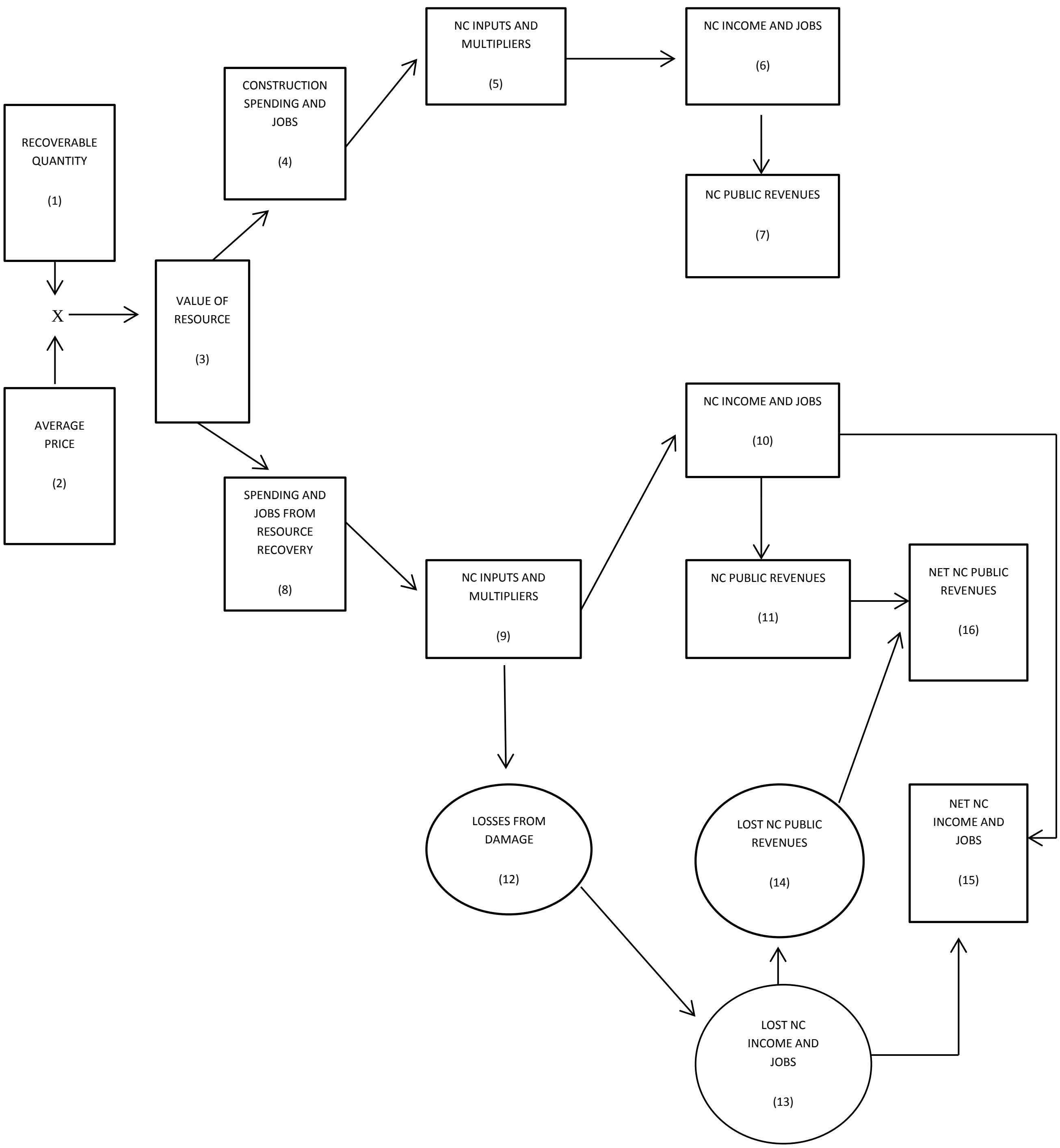
One reason for pursuing development of traditional energy sources in North Carolina is the potential economic development implications. Building and operating a new energy industy in the state should create income, employment, and public revenues. These possible benefits appear very appealing in the context of the challenging post "Great Recession" economy, with a recovery marked by relatively high unemployment and modest economic growth.

But at the same time, there have been several "caution signs" thown up against expanding the traditional energy sector in North Carolina, primarily centered around envionmental issues. The state has significant tourist and fishing industries on the Atlantic coast. If a substantial off-shore energy recovery industry is developed, there is the risk of accidents, both from natural sources (storms) and man-made sources (collisions, fires, equipment leakage). These accidents could create environmental damage and threaten the tourist and fishing economies. On-shore extraction of natural gas resources in other states has been associated with concerns over impacts on water quality and water usage as well as other issues.

Estimating both the potential economic benefits and costs to on-shore and off-shore development of traditional energy resources in North Carolina is complex. For benefits, quantification of economic gains depends on several unknowns, including the future price of the resource (oil price, natural gas price), the quantity of the energy resource available and feasible for development, and the availability of inputs in North Carolina required for use in the energy industry. For costs, the unpredictabilities of storms and natural disasters in off-shore energy development and incidences of water and soil contamination in on-shore energy development make calibrating these costs very challenging. This report will utilize established techniques to address these complexities and uncertainities.

Figure 1 presents a schematic model for the investigation of North Carolina's economic energy potential presented in this report. The model is applied separately for on-shore and off-shore energy development. Economic impact is prompted by the estimate of recoverable quanity (1) of the energy resource (barrels of oil, cubic feet of natural gas) and the price (2) of the resource. Together (quantity x price) these elements give the estimated market value of the recoverable energy resource (3). Since there is uncertainty about both the quantity of the recoverable resource and the future price of the resource, there is also necessarily uncertainty

Figure 1. Model of Analyzing the Economic Impact of Developing North Carolina's Energy Resources.



about the market value of the recoverable energy resource.[1] The procedures for estimating economic impact are clearly identified in the report and can be easily altered to utilize alternative quantity and price assumptions.

The market value of the resource (3) leads to two economic impacts. The first is spending and employment on *constructing infrastructure* for the recovery, processing, and transportation of the energy resource (4). Activities include placing drilling rigs, drilling access to the resource, laying pipeline, constructing compression processing facilities, and constructing access roads. The ultimate effect of these activities on the North Carolina economy depends on the proportion of inputs producing the activities that come from North Carolina as well as the re-circulation of spending ("multiplier") within the state's economy. Using values for both of these parameters (5), the total economic impacts of the construction activities on North Carolina are calculated (6). From these values are estimated the effect on North Carolina public revenues (7). The economic impacts from construction activities are limited – lasting only until the infrastructure is completed and ready for operation.[2]

The second economic impact is termed the *production* impact, and it is the periodic (e.g., annual) economic effects from the recovery of the energy resource and from tasks associated with the recovery, like transport and processing. It follows the same logic and procedure as the first impact. The estimated value of the energy resource (3) prompts spending and employment effects in recovering the resource (8). Based on the proportion of North Carolina inputs and multiplier effects from the recovery operations (9), there are economy-wide impacts on North

[1] There can also be uncertainty about the *quality* of the resource with respect to specific chemical characteristics of the resource that can affect its use and value.
[2] Over time there may be upgrades and maintenance spending on the infrastructure that generate economic impacts. These are not considered in the report.

Carolina income and employment (10). From these are derived changes to North Carolina public revenues (11). The production impacts occur as long as there is profitable energy resource recovery.

There are further potential economic effects from the production impact, and these are related to possible environmental and economic damage from accidents and other adverse results from the recovery process (12). These losses can lead to lost income and jobs in the state (13) and lost public revenues (14). Combined with the benefits to North Carolina income and jobs (10) and public revenues (11), there are net effects to income and jobs (15) and to public revenues (16).

The process outlined in Figure 1 is implemented in the remainder of the report in several sections. Section two is a review of previous studies of the economic potential for energy resource development in North Carolina. The results from these studies will serve as benchmarks for evaluating the findings from this report. Section three considers alternative projections for the two key elements of the economic impact calculations – the quantity of recoverable energy resources in North Carolina (both off-shore and on-shore) and the average future price of these resources. The fourth section presents the results of the estimates for the positive economic impacts of developing and recovering the state's energy resources, including the sensitivity of the results to changing the energy quantity and price assumptions. The fifth section examines the potential economic costs to the state of both off-shore and on-shore energy development. Conclusions, implications, and recommendations are offered in the final section.

PREVIOUS STUDIES

There are several recent studies estimating the economic potential of energy development in North Carolina. Some assess only on-shore energy development, some only off-shore energy development, and some both. In evaluating these estimates, it is important to consider the assumptions used about the quantity of the recoverable energy resource and the price of the resource.

The key assumptions and results of the studies are in Table 1. Complete economic impacts (income, employment, public revenues) include those directly associated with the energy resource activity (termed the *direct effect*) and also those associated with supplier firms (termed *indirect effects*) and with the additional spending from increased labor income and returns to other input owners (called *induced effects*). The estimated economic impacts are only for those occurring within North Carolina.

The Mason study is the most detailed in providing information for both the quantity and price assumptions as well as estimates for the three impact measures. However, both prices (for oil and natural gas) are above the prices existing in early 2013 (mid-$90 range for oil and mid-$3.00 range for natural gas). Mason also does not make a distinction between “technically-recoverable” resource quantity and “economically-recoverable” resource quantity – an important difference discussed later in this report. The Wood-MacKenzie study is the most comprehensive in including both on-shore and off-shore energy resource development. But the study did not release its price assumptions. IHS-Global Insight used price assumptions for natural gas closer to the actual price in early 2013, but no information is available on their assumptions about available quantity. The study from the North Carolina Department of Environment and Natural

Table 1. Summary of Previous Studies Estimating the Economic Potential of Energy Resource Development in North Carolina. (2012$)[1]

Study[2]:	**Mason**	**Wood-MacKenzie**	**IHS Global Insight**	**NC DENR**	**American Chemistry Council**
Energy Resource	Off-shore oil and gas	On-shore and off-shore oil and gas	On-shore gas	On-shore gas	On-shore gas
Assumed Quantity	957 million barrels of oil; 9.65 trillion cubic feet of gas	382 million barrels of oil equivalent per day at peak	Not available	Construction impact of drilling 368 on-shore wells	Not available
Assumed Price	$122.48 oil; $7.56 gas	Not available	$87.18 oil; $4.04 gas	Not applicable	Not available
Income Impact	Construction: $966 million annually over 7 years; Production: $9.3 billion annually	Not available	Production: $2.2 billion annual in 2030	$42 million annual average over 7 years	Construction: $1.8 billion total spending; Production: $6.9 billion annually
Job Impact	Construction: 3214 jobs; Production: 30,979 jobs	Production: 40,398 jobs	28,271 maximum jobs in 2035	387 jobs annual average	Construction: 12,962 jobs annual average Production: 15,422 jobs
NC Public Revenue Impact	Construction: $80 million annual average over 7 years; Production: $762 million annual average	Not available	Production: $184 million in 2035	Not available	Construction: $61 million total Production: $149 million annually

[1]All dollar values in the studies have been updated – where necessary – to 2012 purchasing power dollars.

[2] Mason, Joseph R. *The Economic Contribution of Increased Offshore Oil Production in Regional and National Economies*, American Energy Alliance, February 2009; Wood-MacKenzie Energy Consulting. *U.S. Supply Forecast and Potential Jobs and Economic Impacts (2012-2030),* September 2011; IHS Global Insight. *America's New Energy Future: Unconventional Oil and Gas*, October 2012; IHS Global Insight. *The Economic and Employment Contributions of Unconventional Gas Development in State* Economies, June 2012; North Carolina Department of Environment and Natural Resources, North Carolina Department Of Commerce, North Carolina Department of Justice, and RAFI-USA. *North Carolina Oil and Gas Study under Session Law 2011-276*, March 2012; American Chemistry Council. *Shale Gas Can Lead to New Investment, Jobs, Wages, and Tax Revenue for North Carolina*, August 2012.

Resources (NC DENR) only estimated the infrastructure impacts from well drilling related to on-shore natural gas exploration. The American Chemistry Council impacts are based on constructing a petro-chemical refinery and assuming production will be forthcoming.

Although the studies are varied in their assumptions and focus, there is some consistency in the results. For example, Wood-McKenzie estimates 40,398 jobs from on-shore and off-shore oil and gas production. Mason calculated 30,979 jobs from off-shore oil and gas recovery operations, and IHS-Global projects 28,271 maximum jobs in 2035 from on-shore production. These results suggest a range of 40,000 to 60,000 jobs in North Carolina related to annual on-shore and off-shore energy resource production.

QUANTITY AND PRICE ASSUMPTIONS

The quantity of recoverable resource and the price of that resource are the driving factors behind determining the economic potential of energy resource development in North Carolina (see Figure 1).

Unfortunately, they are also the most uncertain factors. The energy resource (oil, natural gas) exists either beneath the ocean or underground, and therefore quantities cannot be easily viewed and assessed. The recoverable quantities will therefore be – by definition – estimates. Technologies are constantly evolving to better calibrate the quantities of recoverable energy resources, which means the available quantities are changing over time. Also, better estimates of recoverable quantities can be made once wells are drilled.

Energy prices are known today, but they are certainly unknown for the future. Future energy prices are determined by the complex interactions between the demand (use) of the resource and the supply (production) of the resource. Simple economics suggests anything that increases demand relative to supply will increase the resource price, while – conversely – anything that increases supply relative to demand will decrease the resource price.

The complexity in predicting prices arises because numerous exogenous (independent) factors can affect both the demand and supply of energy and – by their nature – these factors are highly uncertain and therefore difficult to predict. Complex economic models are often used to develop price forecasts. But even these models have difficulty accounting for future developments in such areas as changing energy usage, the prices of energy alternatives, innovations in energy efficiency and production technologies, and newly discovered energy supplies.

To complicate matters even further is an *interaction* between the price of an energy resource and the recoverable quantity of the resource. Holding other factors constant, the profitability of energy resource development will increase with the price of the energy resource. There is a difference between the "technically recoverable" quantity of the energy resource and the "economically recoverable" quantity of the energy resource. The technically recoverable quantity is the quantity of the resource that can be recovered using current technology. The economically recoverable quantity is the quantity of the resource that is both technically and economically profitable to recover. With a given state of production technology, the ratio of economically recoverable quantity to the technically recoverable quantity rises as the resource price increases.

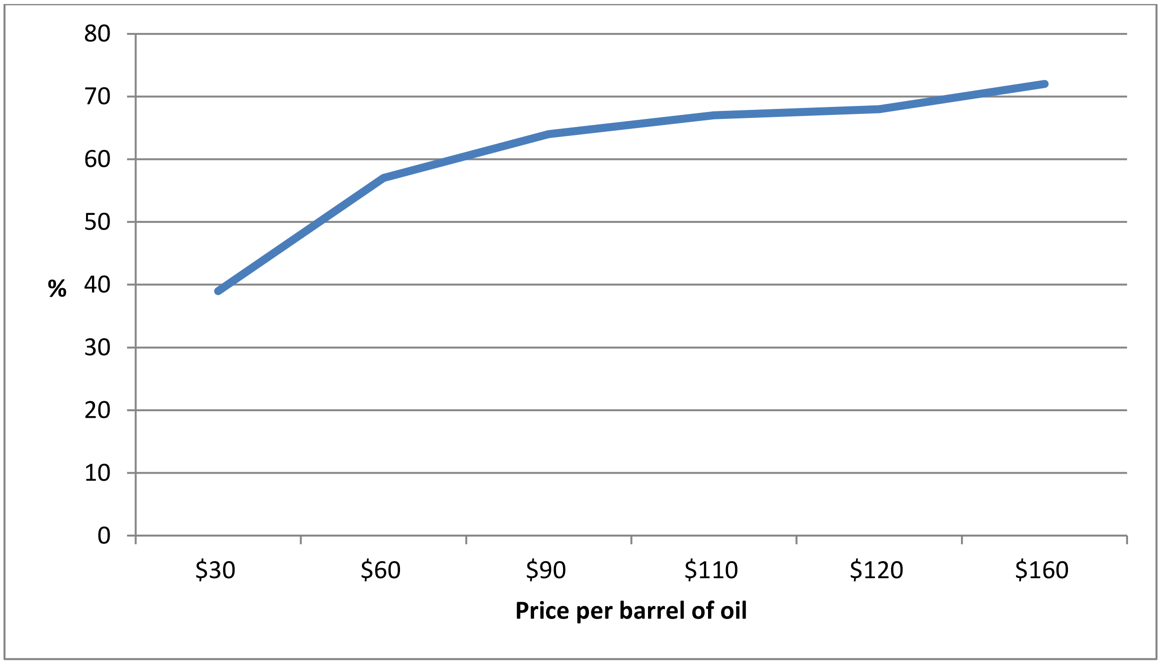
One objective of this report is to be transparent and flexible for values of quantity, price, and the ratio of economically recoverable quantity to technically recoverable quantity (termed the *economic recovery rate*). Forecasts are noted below with their sources. Readers can access the sources in the future for forecast updates and then make adjustments to the estimates presented in the report.

Two respected and regularly updated sources for energy price forecasts are the Energy Information Administration (EIA) of the U.S. Department of Energy and the World Bank. EIA forecasts an average oil price (per barrel) for the 2013-2035 period of $121 (2012$) and an average $5.25 (2012$) per 1000 cubic feet of natural gas over the same period.[3] The World Bank's average oil price forecast is more modest, at $81 (2012$) per barrel for the 2013-2035 time period, but their natural gas price forecast is very similar at $5.17 (2012$) per 1000 cubic feet for the same period.[4] Taking the simple average of these two forecasts for oil and for natural gas gives $101 per barrel of oil and $5.21 per 1000 cubic feet for natural gas – both in 2012$.

The U.S. Bureau of Ocean Energy Management (BOEM) forecasts both technically and economically recoverable oil and gas resources in the nation's off-shore outer continental shelf.[5] Figure 2 and Figure 3 show the economic recovery rates for different oil and natural gas prices estimated by BOEM for the mid-Atlantic region that includes North Carolina. Following Mason's methodology, North Carolina's share of the mid-Atlantic quantity estimates are taken as

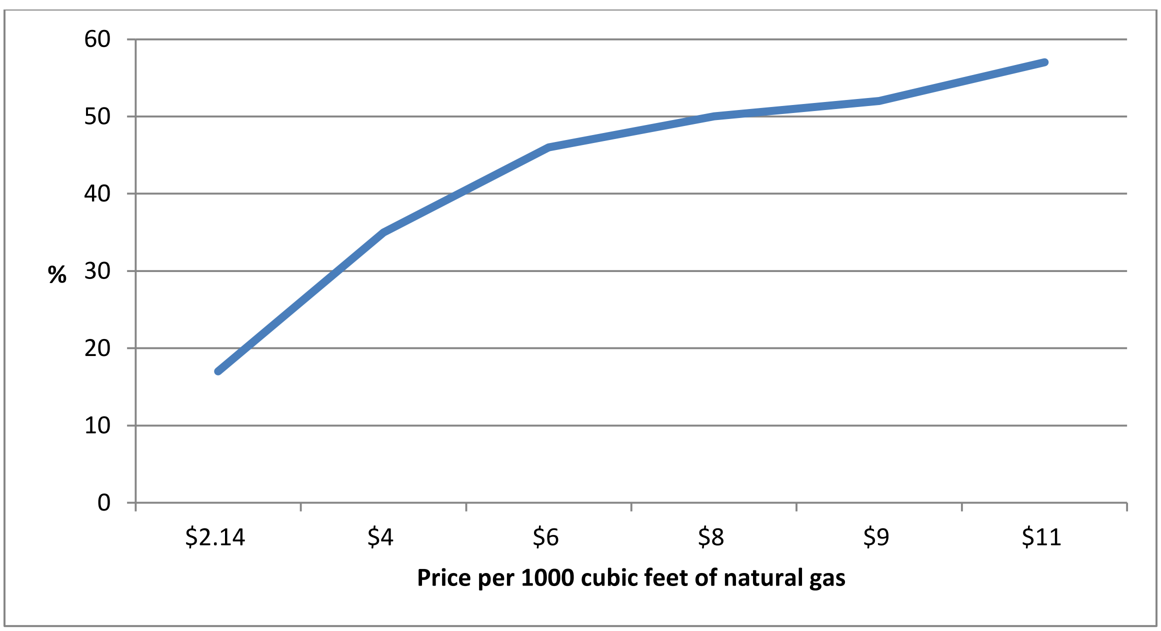
[3] U.S. Energy Information Administration. *Annual Energy Outlook 2013*, DOE/EIA-0383ER (2013), December 5, 2012. The oil price is for West Texas intermediate spot crude, and the natural gas price is the Henry Hub value.
[4] World Bank Development Prospects Group. *Commodity Outlook, January 2013,* (www.worldbank.org/prospects/commodities). The World Bank's forecasts only extend to 2025. The forecasted price change for 2015 to 2025 was used to project the 2035 price.
[5] U.S. Bureau of Ocean Energy Management. *Assessment of Undiscovered Technically Recoverable Oil and Gas Revenues of the Nation's Outer Continental Shelf, 2011,* BOEM Fact Sheet RED-2011-01a, November 2012.

Figure 2. Economic Recovery Rates for Off-Shore Oil.



Source: U.S. Bureau of Ocean Energy Management, *op cit*.

Figure 3. Economic Recovery Rates for Off-Shore Natural Gas.



Source: U.S. Bureau of Ocean Energy Management, *op cit*.

proportional to the state's coastline as a percentage of the total coastline in the four mid-Atlantic states of North Carolina, Virginia, Maryland, and Delaware.[6] Using a price per barrel of $101, the estimated economically recoverable off-shore quantity of oil for North Carolina is 595 million barrels. Also, using a price of $5.21 per 1000 cubic feet of natural gas, the estimated economically recoverable off-shore quantity of natural gas is 5.1 trillion cubic feet.[7]

The U.S. Geological Service (USGS) has provided estimated quantities of technically recoverable natural gas and natural gas liquids from on-shore energy basins on the east coast, including North Carolina.[8] The methodology developed by BOEM for off-shore natural gas can be used to derive the economic recovery rate for on-shore gas.[9] At the forecasted price of $5.21 per 1000 cubic feet of natural gas, the procedure results in a recovery rate of 40% (see Figure 3), resulting in an economically recoverable quantity of 0.66 trillion cubic feet.[10]

USGS also shows 83 million barrels of technically recoverable natural gas liquids available in North Carolina. Due to their liquid nature, these energy sources are considered similar to oil. However, their prices are significantly lower than the oil price. In 2012, the blended price of a barrel of natural gas liquids – based on the typical composition of a barrel of natural gas liquids – was $36.41. Assuming the future prices of natural gas liquids track the

[6] The proportion for North Carolina is 0.64, or 64%.
[7] For a price of $101 per barrel, BOEM shows an economically recoverable quantity of oil in the Mid-Atlantic region of 930 million barrels. Applying North Carolina's share (0.64) gives 595 million barrels. Likewise, at a price of $5.21 per 1000 cubic feet of natural gas, BOEM shows 8 trillion cubic feet of economically recoverable natural gas. Applying the North Carolina share of 0.64 results in a quantity of 5.1 trillion cubic feet.
[8] U.S. Geological Service. *Assessment of Undiscovered Oil and Gas Resources of East Coast Mesozoic Basins of the Piedmont Blue Ridge Thrust Belt, Atlantic Coastal Plain, and New England Provinces*, *2011*, U.S. Department of the Interior, Fact Sheet 2012-3075, June 2012. Natural gas liquids typically include natural gasoline, isobutane, normal butane, propane, and ethane.
[9] This assumes the underlying economic recovery rates for off-shore and on-shore energy resources are the same.
[10] The calculation is 1.66 trillion cubic feet of technically recoverable natural gas in the Deep River Basin of North Carolina multiplied by 0.4, to equal 0.66 trillion cubic feet of economically recoverable natural gas. Using an alternative methodology, the North Carolina Geological Survey of the Department of Environment and Natural Resources estimated an available quantity of 0.58 trillion cubic feet of natural gas for the Deep River Basin (personal communication with Dr. Kenneth Taylor, State Geologist of North Carolina, March 11, 2013).

future price of oil, the expected future price of natural gas liquids is set at $39.[11] Using the economic recovery rate for off-shore oil associated with a price of $39 (from Figure 2),[12] the result is 36 million barrels of economically recoverable quantity of on-shore natural gas liquids.[13]

The summary of the price and quantity forecast assumptions are in Table 2.

Table 2. Price and Quantity Assumptions for North Carolina Energy Resource Development.

Category	**Price**	**Economically Recoverable Quantity**
Off-shore oil	$101 per barrel	595 million barrels
Off-shore natural gas	$5.21 per 1000 cubic feet	5.1 trillion cubic feet
On-shore natural gas	$5.21 per 1000 cubic feet	0.66 trillion cubic feet
On-shore natural gas liquids	$39 per barrel	36 million barrels

Sources: Energy Information Agency; World Bank; U.S. Bureau of Ocean Energy Management; U.S. Geological Service; author's calculations.

ESTIMATES OF ECONOMC BENEFITS FROM DEVELOPING NORTH CAROLINA'S ENERGY RESOURCES

Reviewing Figure 1, values have now been provided for components 1 and 2, and – after combining them – for component 3. This section presents the methodology and results for components 4 through 11. The analysis is done separately for off-shore energy resource development and for on-shore energy resource development.

[11] The average price of oil in 2012 was $94 per barrel, and the forecasted future price used in the report is $101 per barrel, a 7% increase. This 7% increase is applied to the $36.41 price to derive the forecasted price of $39.
[12] The source for natural gas liquid prices is the U.S. Energy Information Administration, *2012 Brief: Natural Gas Liquid Prices Down in 2012*, January 15, 2013. The typical composition of a barrel of natural gas liquids is natural gas (13%), isobutene (9%), normal butane (8%), propane (28%), and ethane (42%) (Keller, Anne. *NGL101 – The Basics*, Midstream Energy Group, June 6, 2012, p. 17
[13] The calculation is 83 million barrels multiplied by an economic recovery rate of 0.43 to equal 36 million barrels.

Off-Shore Energy Resource Development

As Figure 1 shows, there are two parts to calculating economic impact once the value of the recoverable resource is projected. The first is the spending and employment related to the development of the infrastructure needed to access, extract, process, and deliver the energy resource (component 4 in Figure 1). The second is the spending and employment from the production of the energy resource (component 5 in Figure 1) using the infrastructure developed in the first phase.[14] Each of these parts is addressed separately below.

1. Impact of Infrastructure Development for Off-Shore Energy Production

Using data from recent off-shore energy projects, Mason uses annual infrastructure costs of $1.65 (2012$) per barrel of oil and $0.30 (2012$) per 1000 cubic feet of natural gas during a construction period of seven years.[15] Applying these costs to the off-shore quantities given in Table 2 results in total costs of $982 million (595 million barrels x $1.65) for oil and $1.5 billion (5.1 trillion cubic feet x $0.30 per 1000 cubic feet) for natural gas. Dividing these totals by seven gives $140 million for oil and $214 million for natural gas – or a total of **$354 million of annual infrastructure spending for each of seven years.**

Factors (component 5 in Figure 1) are then applied to the annual $354 million infrastructure spending to account for two economic elements: the proportion of inputs available from North Carolina for the infrastructure development, and the "multiplier" effects of spending by suppliers and workers in the state economy during the infrastructure phase. These factors – one for spending and one for employment – are unique for each state.

[14] In this report, spending and income can be viewed as identical. Spending by one entity becomes income to another entity.
[15] Mason, *op. cit*., p. 7. Mason's 2007 dollar values have been updated to 2012 dollar values.

Two commonly used sources for the factors are the U.S. Department of Commerce's Regional Input-Output Modeling System (RIMS) and the private regional input-output modeling system called IMPLAN (*IM*PACT for *PLAN*NING) from Mig., Inc. For the latest year available (2011) from IMPLAN, the spending factor for energy infrastructure development is $0.51 per $1 of annual energy infrastructure spending, and the employment factor is 6.2 jobs per $1 million of infrastructure and related spending occurring in North Carolina (termed "value-added").[16] Unfortunately, there are no separate RIMS factors for energy infrastructure development. One concern is that North Carolina's energy development industry is small and undeveloped. However, North Carolina's factors from IMPLAN are very close to the averages for the same factors for the ten largest energy production states; hence the factors of $0.51 and 6.2 are used.[17]

Applying these factors to the annual infrastructure spending of $354 million gives:

$354 million x 0.51 = **$181 million of new North Carolina spending for each of seven years associated with off-shore energy infrastructure development (2012$),**[18] **and**

181 x 6.2 = **1122 North Carolina jobs during the infrastructure development period.**

[16] For users of input-output models, the spending factor ($0.51) is the product of the proportion of initial (direct) energy infrastructure spending paid to North Carolina input owners and the value-added multiplier (incorporating direct, indirect, and induced effects) associated with energy infrastructure spending. Readers should also be aware of the limitations of these factors in input-output models. Among the more important assumptions are fixed purchase patterns that do not change over time, no supply constraints on the availability of inputs, and unchanging input prices (U.S. Bureau of Economic Analysis, *RIMS II: An Essential Tool for Regional Developers and Planners*, www.bea.gov).

[17] The ten largest energy production states, based on value of oil and gas extraction, are Alaska, Arkansas, California, Colorado, Louisiana, New Mexico, Oklahoma, Pennsylvania, Texas, and Wyoming. The ten-state averages are a spending factor of $0.69 and an employment factor of 5.6 (U.S. Bureau of Economic Analysis).

[18] It could be argued that federal tax payments should be deleted in the calculation because these monies are not available for "re-circulating" in the North Carolina economy. However, recent analysis shows North Carolina actually receives back in federal spending as much as the state pays in federal taxes, so the federal taxes and federal spending cancel each other (The Tax Foundation. *Federal Spending Received per Dollar of Taxes Paid*, October 9, 2007).

To be clear, the job calculation means 1122 employment positions will be created and sustained over the seven-year infrastructure development period.

To find the value for component 7 in Figure 1 (public revenues to North Carolina from the off-shore infrastructure development), Mason's procedure is also followed. Public revenues are calculated by applying an average rate of state and local tax revenue per dollar to the dollars of gross state product generated by the economic activity. For North Carolina for the recent thirty years (1982-2012), this rate has averaged 6.1%, or 0.061. Using the $326 million of additional annual spending in North Carolina resulting from off-shore energy infrastructure development as annual gross state product[19], the calculation is 0.061 x $181 million, or **$11 million of additional annual state and local public revenue in North Carolina during each of the seven years of off-shore energy infrastructure development.** It should be emphasized this public revenue is *not* in addition to the total calculated benefits ($181 million), but it is an *allocation* of the total benefits to public revenues.

2. Impact of Production of Off-Shore Energy

The procedure for estimating the economic impacts from producing oil and natural gas resources from reservoirs off North Carolina's coast follows the same logic and process as for the impact of infrastructure development. Using the assumed quantities and prices in Table 2, there is an estimated $60 billion ($101 per barrel x 595 million barrels, 2012$) of economically recoverable oil reserves and $27 billion ($5.21 per 1000 cubic feet x 5.1 trillion cubic feet, 2012$) of economically recoverable natural gas reserves. Assuming a thirty year production

[19] Gross state product is the aggregate measure of economic activity taking place in North Carolina. Since the spending amount has been specifically calculated to be additional spending in the state, it meets the definition of gross state product.

period, this implies a $2.9 billion annual production value from both resources (($60 billion + $27 billion)/30).[20]

Both RIMS and IMPLAN provide spending and employment factors for energy production (extraction). The latest (2010) RIMS spending factor for North Carolina is $0.94, and the employment factor is 6.6 These values are almost exactly the same as the factors averaged for the top ten energy states ($0.90, 7.2). The latest (2011) comparable values from IMPLAN for North Carolina are a spending factor of $0.38 and an employment factor of 11.2. These compare to an average spending factor of $0.75 and an average employment factor of 5.8 from IMPLAN for the top ten energy states. Since there is substantial difference between the RIMS and IMPLAN values, a simple average of the two alternatives is used, resulting in a spending factor of $0.66 (($0.94 + $0.38)/2) and an employment factor of 8.9 ((6.6 + 11.2)/2).

Applying these factors to the estimated $2.9 billion annual production value yields:

$2.9 billion x 0.66 = **$1.9 billion of new North Carolina spending for each of 30 years associated with off-shore energy production, and**

1900 x 8.9 = **16,910 North Carolina jobs during the production period.**

Once again, the 16,900 jobs are those created and sustained over the production period. Using the average state and local tax rate of 0.061 and applying it to $1.9 billion yields **$116 million of additional annual state and local public revenues for each year of the 30-year production life.**[21]

[20] The $2.9 billion is an average annual production value. Receipts in any year will depend on the rate of production from, and depletion of, the energy reservoirs. The timing of the receipts will not affect the average value but will impact the present value of the receipts. Present value accounts for the time value of money.

[21] There is the potential for royalty payments from off-shore energy producers to the state. However, federal government approval would be needed for such payments, and any royalty payments would also depend on where

Table 3 summarizes the estimated economic impacts from both off-shore energy resource infrastructure development and off-shore energy resource production.

Table 3. Estimated Economic Impacts to North Carolina from Off-Shore Development of Energy Resources (all dollars are 2012$).

Infrastructure Development	
Spending	$181 million for each of 7 years
Employment	1122 jobs for 7 years
State and local public revenues	$11 million for each of 7 years
Production	
Spending	$1.9 billion for each of 30 years
Employment	16,910 jobs for 30 years
State and local public revenues	$116 million for each of 30 years

Source: Author's calculations

On-Shore Energy Resource Development

The estimates of the economic impact of on-shore energy resource development in North Carolina begin with the estimated quantity of economically recoverable natural gas and its associated price from Table 2 (0.66 trillion cubic feet of natural gas at $5.21 per 1000 cubic feet and 36 million barrels of natural gas liquids at $39 per barrel). Economic impacts for infrastructure development and for production are developed below.

(miles from the shore) the production occurred. Therefore, no reliable estimates of royalty payments to North Carolina from off-shore energy development can be calculated.

1. Impact of Infrastructure Development for On-Shore Energy Production

Economists at the North Carolina Department of Commerce (DOC) estimated the economic impacts from infrastructure spending based on drilling 368 wells.[22] This is a reasonable number based on drilling plans in other states.[23] After consulting with industry experts, DOC used a direct infrastructure cost of $3 million per well with a seven-year period of completion for the wells. The total direct infrastructure spending is thus $1.1 billion (368 x $3 million). Spread over seven years, the average annual direct infrastructure spending is $157 million. Using the same spending and employment factors for on-shore activity as for off-shore development, the total economic impacts are:[24]

$157 million x 0.51 = **$80 million of annual spending for each of seven years, and**

80 x 6.2 = **496 jobs during the infrastructure period.**

Applying the state and local tax rate of 0.061 to $80 million gives **$4.9 million of annual state and local public revenue during each of the seven years of infrastructure development.**

2. Impact of Production of On-Shore Energy

At $5.21 per 1000 cubic feet of natural gas, the total value of the estimated 0.66 trillion cubic feet of economically recoverable natural gas is $3.4 billion. Also at $39 per barrel of natural gas liquids, the total value of the estimated 36 million barrels of natural gas liquids is

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[22] North Carolina Department of Environment and Natural Resources, North Carolina Department of Commerce, and North Carolina Department of Justice, *op. cit.*

[23] Kleinhenz and Associates. *Ohio's Natural Gas and Crude Oil Exploration and Production Industry and the Emerging Utica Gas Formation*, Prepared for the Ohio Oil and Gas Education Program, September 2011. This study uses a much greater number of wells drilled (4000), but the estimates of natural gas deposits in the drilling area are possibly twenty-times greater than in North Carolina (United States Geological Service. *National Assessment of Undiscovered Oil and Gas Reserves of the Ordovician Utica Shale of the Appalachian Basin Province*, 2012).

[24] *IMPLAN* makes no distinction in multipliers for on-shore and off-shore energy infrastructure development.

$1.4 billion. Assuming a twenty year production period[25], this means the total on-shore energy value of $4.8 billion ($3.4 billion + $1.4 billion) generates $240 million of annual revenue. Applying the same spending and employment factors as used for off-shore energy resource production,[26] the total spending and employment impacts on the North Carolina economy are:

$240 million x 0.66 = **$158 million of annual spending for each of 20 years, and**

158 x 8.9 = **1406 jobs during the production period.**

Multiplying the state and local tax rate (0.061) by $158 million gives **$9.6 million of additional annual state and local public revenues during each year of the 20 year estimated production period.**[27]

The summary of the on-shore energy development economic impacts is in Table 4.

Table 4. Estimated Economic Impacts to North Carolina from On-Shore Development of Energy Resources (all dollars are 2012$).

Infrastructure Development	
Spending	$80 million for each of 7 years
Employment	496 jobs for 7 years
State and local public revenues	$4.9 million for each of 7 years
Production	
Spending	$158 million for each of 20 years
Employment	1406 jobs for 20 years
State and local public revenues	$9.6 million for each of 20 years

Source: Author's calculations.

[25] Begos, Mark. "Marcellus Gas for How Long?" *Associated Press*, October 28, 2012.
[26] Again, there is no distinction in *IMPLAN* and in *RIMS* between multipliers for on-shore and off-shore energy production.
[27] This total does not include any possible royalty (lease) payments to the landowner. However, such payments are not additional economic impact but are an allocation of economic returns.

Sensitivity Analysis

Although forecasts have been used from respected and competent organizations for the two key components of the economic impact analyses – energy prices and energy quantities – considerable potential variation still exists with these values. Mean (average) forecast values were used for the energy quantities in the analyses.[28] However, both BOEM (for off-shore energy quantities) and USGS (for on-shore energy quantities) give two other estimates – a high quantity value associated with at least a 5% chance of occurring, and a low quantity value associated with at least a 95% chance of occurring. Likewise, there are a range of possible future energy prices.

Higher quantities of energy resources will directly increase economic impacts by increasing the economic recoverable quantity of energy resources for any price. Conversely, lower quantities of energy resources will reduce economic impacts. Higher forecasted energy prices will increase economic impact in two ways – from the higher monetary value of the energy resource, and from the increase in the economic recovery rate. Lower forecasted energy prices will reduce economic impact due to the lower monetary value of the energy resource and from the decline in the economic recovery rate.

This section of the report shows the spending (gross domestic product) and employment impacts for off-shore energy production and on-shore energy production using the high, mean (baseline) and low quantity estimates provided by BOEM and USGS and using six alternative oil

[28] Although a simplification, the mean values can be interpreted as those with at least a 50% chance of occurring.

and natural gas price forecasts.[29] The six price pairs are those used by BOEM and for which BOEM derived economic recovery rates. For comparison, the baseline prices are also cited.

The results of the sensitivity analysis for off-shore energy production are in Table 5. Clearly the assumed quantity of available energy resources used as well as the price forecasts applied make significant differences in the results. For reference, the previously calculated mean (baseline) annual spending impact of $1.9 billion is shown in **bold** (upper panel of Table 5). Using different combinations of energy quantity and forecasted prices, the annual spending impact can be as low as $0.01 billion ($10 million) and as high as $8.1 billion. Similarly, the employment impact from annual production (lower panel of Table 5) ranges from a low of 118 to a high of 72,005 compared to the baseline result of 16,910 jobs (in **bold**).

The findings for the sensitivity analysis of on-shore energy production are in Table 6. Again, there is a considerable range in the results based on the quantity and price assumptions used. The baseline annual spending impact is $158 million (in **bold**) but the range is a low of $15 million to a high of $896 million (upper panel of Table 6). The baseline employment impact is 1406 jobs (in **bold**) with a range of 132 jobs to a high of 7994 jobs (lower panel of Table 6).

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[29] The natural gas liquids price is determined by assuming it is 39% of the oil price – the same relationship used for the baseline (or mean) analysis.

Table 5. Annual Economic Impact from Off-Shore Energy Production under Various Quantity and Price Assumptions.

Annual Spending Impact (2012 billions $)

Technically discoverable quantity:	low	mean	high
Price ($ oil, $ natural gas)[a]			
$30, $2.14	0.01	0.4	0.6
$60, $4.27	0.05	1.1	2.1
$101, $5.21 (baseline)	-	**1.9**	-
$90, $6.41	0.09	2.0	3.9
$110, $7.83	0.11	2.5	5.0
$120, $8.54	0.13	2.8	5.7
$160, $11.39	0.19	4.0	8.1

[a] price of oil per barrel; price of natural gas per 1000 cubic feet

Employment Impact (number)

Technically discoverable quantity:	low	mean	high
Price ($ oil, $ natural gas)[a]			
$30, $2.14	118	2900	5902
$60, $4.27	472	9595	19,224
$101, $5.21 (baseline)	-	**16,910**	-
$90, $6.41	809	17,437	34,400
$110, $7.83	1046	22,428	45,024
$120, $8.54	1163	25,126	50,252
$160, $11.39	1686	35,918	72,005

[a] price of oil per barrel; price of natural gas per 1000 cubic feet

Table 6. Annual Economic Impact from On-Shore Energy Production under Various Quantity and Price Assumptions.

Annual Spending Impact (2012 millions $)

Technically discoverable quantity: low mean high

Price ($ natural gas, $ nat. gas liquids)[a]

$2.14, $8	15	33	62
$4.27, $23	55	121	223
$5.21, $39 (baseline)	-	**158**	-
$6.41, $35	105	229	421
$7.83, $43	141	300	549
$8.54, $47	154	339	621
$11.39, $62	222	490	896

[a] price of natural gas per 1000 cubic feet; price of natural gas liquids per barrel

Employment Impact (number)

Technically discoverable quantity: low mean high

Price ($ natural gas, $ nat. gas liquids)[a]

$2.14, $8	132	293	555
$4.27, $23	497	1082	1987
$5.21, $39 (baseline)	-	**1406**	-
$6.41, $35	936	2046	3756
$7.83, $43	1257	2674	4896
$8.54, $47	1374	3025	5539
$11.39, $62	2017	4370	7994

[a] price of natural gas per 1000 cubic feet; price of natural gas liquids per barrel

POTENTIAL ECONOMIC COSTS FROM DEVELOPING NORTH CAROLINA'S ENERGY RESOURCES

Most economic endeavors involve risk and uncertainty. Although the two concepts are often used interchangeably, there is a key distinction. With *risk*, a specific outcome cannot be guaranteed, but using past information, the *likelihood* of alternative outcomes occurring can be calculated. So, for example, a meteorologist may not be able to guarantee a sunny day, but using historical information when similar conditions prevailed, she can predict the chance of a sunny day.

In contrast, while *uncertainty* also means a specific outcome cannot be guaranteed – even worse – unlike risk, not enough information and knowledge exists to know the chances of a particular outcome occurring. A good example is terrorist attacks. We simply do not have adequate information and history to provide good probabilities for specific types and locations of terrorist events.

Various levels of both risk and uncertainty exist in developing energy resources, with regard to weather, geology, ocean topography, and technology. Weather most affects off-shore energy development. Severe storms – especially hurricanes – have the potential to disrupt and damage off-shore energy recovery operations and create harm to both the ocean environment as well as nearby coastal areas. The coast of North Carolina has, historically, been in the path of Atlantic hurricanes.

Geological issues mainly impact on-shore energy development. There have been numerous reports of hydraulic fracturing technology – used to access on-shore energy deposits -

damaging water quality in some areas.   There is a further concern about the quantity of water used in the hydraulic fracturing process.

To evaluate the potential economic costs of energy development in North Carolina, two approaches are used. First, the size of the economic base at risk to damage – such as income, property value, and employment – is presented.   Second, where data are available, the *expected value* of damage is estimated. Expected value is the product of the amount of damage and the likelihood of that damage occurring; therefore, it is a measure of risk.   However, potential damage from uncertain events still remains unmeasured.

Size of the Economic Base at Risk to Damage

North Carolina's coastal counties are most at risk to any losses or other damage from off-shore energy resource development.   Specifically, the tourist and fishing industries in coastal counties would most likely suffer losses.

For the seven key coastal counties in North Carolina engaged in tourism and fishing enterprises – Brunswick, Carteret, Currituck, Dare, New Hanover, Onslow, and Pender – Table 7 shows the estimated annual spending, employment, and real estate value in 2011.   Importantly, these numbers include both direct spending, jobs, and real estate values related to tourism and fishing and indirect (supplier) and induced (consumer spending) impacts from those direct effects.

Table 7. Key Economic Values for Tourism and Fishing in North Carolina Coastal Counties At-Risk from Damage from Off-Shore Energy Recovery Activities, 2011.

Annual Spending	Annual Employment	Associated Property Value[1]
$3.1 billion	37,872	$34.4 billion

Source: *IMPLAN* for North Carolina; North Carolina Department of Commerce, *The 2011 Economic Impact of Travel on North Carolina Counties*. Tourism values are based on county numbers from the "travel economic impact model", then augmented to include multiplier effects using the state "travel satellite model".

[1] Based on capitalization rate of 9%, from *Cap Rate Survey*, CBRE, February 2012.

The Deep River basin in North Carolina – the geographic region evaluated for on-shore energy development – includes parts of eight counties: Anson, Chatham, Durham, Granville, Lee, Montgomery, Moore, and Wake. Of these, Chatham, Lee, and Moore have attracted most of the attention for drilling. Therefore, Table 8 shows three economic bases – income, employment, and real estate values – for the latest year available for the core counties of Chatham, Lee, and Moore. The values are the aggregate, economy-wide values for each measure, so no "multipliers" have been applied.

Table 8. Economic Values in Core North Carolina Counties Affected by On-Shore Energy Development.

	Personal Income (2011)	Employment (2011)	Real Property Value (2009)
Key	$8.5 billion	112,435	$21.2 billion

Sources: U.S. Department of Commerce; North Carolina State Data Center

Potential Costs from Off-Shore Energy Development

Spillage rates for off-shore oil development are collected and available. The spillage rate during the period 1964-2010 for U.S. outer continental shelf platform and pipeline operations with losses greater than 1000 barrels was 0.6 spills per billion barrels of oil produced. The average loss per spill was 547,163 barrels.[30] Applying the rate of 0.6 spills per billion barrels of oil to the average 20 million barrels (0.02 billion barrels) of North Carolina off-shore oil to be annually pumped yields 0.012 spills (0.02 x 0.6) spills per year with an average annual spill loss of 6566 barrels (0.012 x 547,163 barrels). Using a clean-up cost of $12,600 per barrel,[31] **the expected annual loss from oil spillage related to off-shore energy development in North Carolina is $83 million** (6566 barrels x $12,600 per barrel**). This loss is 2.7% of the total annual spending related to tourism and fishing in the affected coastal counties (from Table 7).**

It should be noted the expected annual loss is much more modest if the Deepwater Horizon spill is excluded from the calculations. Then the national average annual spill loss is 3058 barrels (instead of 547,163 barrels), and the comparable annual North Carolina annual cost from oil spills is $462,196.

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[30] Anderson, Cheryl, Melinda Maynes, and Robert LaBelle. *Update of Occurrence Rates for Offshore Oil Spill,* Bureau of Ocean Energy Management, and Bureau of Safety and Environmental Enforcement, Report 2012-069, June 2012, Table 9. The data include the Deepwater Horizon spill in the Gulf of Mexico in 2010.

[31] Chen, Allen. *Final Cost-Benefit and Least Burdensome Alternative Analysis, Chapter 173-183*, WAC, *Oil Spill Natural Resource Damage Assessment*, Dept. of Ecology, State of Washington, Publication No. 12-08-103, November 2012. The $12,600 cost per barrel is based on $300 per gallon and 42 gallons per barrel. The $300 cost per gallon of oil spill is for spills exceeding 1000 gallons and is at the top of a cost range of $3 per gallon to $300 per gallon. Other studies are consistent with this cost range (Etkin, Dagmar. *Modeling Oil Spill Response and Damage Costs,* Environmental Research Consulting, Cortlandt Manor, New York, 2005; Oxford Economics. *Potential Impact of the Gulf Oil Spill on Tourism*, 2010; Cohen, Mark. *A Taxonomy of Oil Spill Costs*, Resources for the Future Backgrounder, June 2010).

Potential Costs from On-Shore Energy Development

Potential on-shore costs are related to the hydraulic fracturing procedure for accessing and recovering underground energy resources. Hydraulic fracturing is a drilling process that uses high-powered injections of water and chemical additives to dislodge (fracture) formations having oil and gas deposits and then recover them to the surface. Potential costs are related to possible groundwater contamination, damage to natural habitats, excessive water usage, disposal of waste water, use and damage of infrastructure (mainly roads), and reduction in residential property values.[32] The initial question is – what is the likelihood of these adverse consequences occurring – that is, how frequently do they happen? The most comprehensive analysis of this question – to date – is from a study of Pennsylvania shale gas wells.[33] Pennsylvania has experienced extensive hydraulic fracturing activity for natural gas production over the last several years.

Table 9 shows the incidence rate of environmental issues in the Pennsylvania Marcellus shale drilling region, the largest on the east coast. The distinction between "major" and "minor" issues is – by implication – subjective. Combining the two classifications, the total issue incidence rate is almost 24% (0.7% + 23.2%). That is, during the period 2008 to 2011, almost one-quarter of the wells in the Pennsylvania Marcellus share drilling region had some type of environmental issue. Looking at the incidence rate by year, the study did find a decline in the rate over time.

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[32] Putzik, Tony, Elizabeth Ridlington, and John Rumpler. *The Costs of Fracking*, Penn Environment Research and Policy Center, Fall 2012.

[33] Considine, Timothy, Robert Watson, Nicholas Considine, and John Martin. *Environmental Impacts During Marcellus Shale Gas Drilling: Causes, Impacts, and Remedies*, Shale Resources and Society Institute, June 2012. The U.S. Environmental Protection Agency is in the process of conducting a national study on the topic, particularly focusing on the potential impacts of hydraulic fracturing on drinking water resources.

Table 9. Environmental Incidence Rates from Natural Gas Wells in Pennsylvania.
(3533 wells drilled from 2008 – 2011)

0.7% (25 wells) had major environmental issues

* 2 wells had significant site restoration issues
* 8 wells had significant surface water contamination issues
* 9 wells had significant land spill issues
* 4 wells had significant blowout and venting issues
* 2 wells had significant gas migration issues

23.2% (820 wells) had minor environmental issues

* 328 wells had minor site restoration issues
* 258 wells had minor surface water contamination issues
* 149 wells had minor land spill issues
* 85 wells had cement and casing issues

Source: Considine, Watson, Considine, and Martin, *op. cit.*

If environmental damage does result from on-shore energy development, assessing the costs are difficult. One indirect method for estimating such costs is to examine the impact of on-shore energy recovery projects on residential property values. If buyers of residential property perceive energy recovery activities create non-trivial risks of environmental and health costs, then these costs will be reflected in lower values for properties. However, the relationship relies on including enough information on all other major factors affecting residential property values such that a “spurious correlation” between on-shore energy recovery activities and residential property values does not result. Also, the relationship between drilling activities and property values is driven both by perception and reality, and the two may not match. This means the drilling impact revealed with property values may either over-estimate or an under-estimate the true impact.

With these caveats, Table 10 shows the results of several recent studies linking on-shore energy recovery activities and residential property values. The cited studies have all "controlled" for other relevant factors – in addition to drilling – which can impact property values. The studies show a negative association – that is – a reduction in residential property values – in the presence of energy drilling and recovery activities.

Based on the results, a range for the adverse impact of drilling is a 3% to 22% reduction in residential property values in the immediate vicinity of the drilling. Applying these results to the property values for the core counties in Table 6 implies a **property value reduction of between $636 million and $4.7 billion.**[34] Recent research also shows annual household spending falls at the approximate rate of 5 cents per dollar reduction in wealth.[35] This implies a reduction of between **$32 million and $235 million in annual spending, and a corresponding loss of jobs of between 320 and 2350.**[36]

[34] The calculation assumes the drilling wells are spread uniformly in the counties.
[35] Case, Karl, Johy Quigley, and Rober Shiller. *Wealth Effects Revisited*, NBER Working Paper 18667, January 2013; Walden, Michael L. "Where Did We Indulge? Consumer Spending During the Asset Boom", *Monthly Labor Review*, forthcoming 2013.
[36] Using jobs at the rate of 10 per $1 million of spending

Table 10. Results of Studies Linking On-Shore Energy Recovery Activities and Residential Property Values.

Study	**Finding**	**Geographic Range**
Muehlenbachs, et al.	12% reduction	Within 2 miles of wells
BBC Research and Consulting	22% reduction	Within ½ mile of wells
Boxall, et al.	4% to 16% reduction	Within 2.5 miles of wells
Integra Realty Resources	3% to 14% reduction	Within 1000 to 1500 feet of wells

Sources: Muehlenbachs, Spiller, and Timmons. *Gas Development and Property Values*, Resources for the Future, Report 12-40, July 2012; BBC Research and Consulting, *Measuring the Impact of Coalbed Methane Wells on Property Values*, Working Paper, November 11, 2001; Boxall, Peter, Wing Chen, and Melville McMillan, *The Impact of Oil and Natural Gas Facilities on Rural Residential Property Values: A Spatial Analysis*, Evsevier, 2005; Integra Realty Resources, *Florence Mound Well Site Impact Study*, Dallas/Ft. Worth Texas, 2011

CONCLUSIONS

Accessing and producing North Carolina's off-shore and on-shore energy reservoirs holds both the potential of economic benefits but also the possibility of economic costs. The largest benefits appear to be from off-shore development**.** Using average (mean) values for energy supply and future energy prices, during the seven year construction period of facilities for off-shore energy recovery**, annual economic activity in North Carolina would increase by approximately $181 million (2012 $), and 1122 jobs would be created in the state. This enhanced economic activity would be associated with new annual public revenue of $11 (2012 $) million.** The economic impacts would be even larger during the estimated 30 year period of energy recovery. Using recognized forecasts of energy prices and economically viable quantity, annual economic activity in the state would increase by **$1.9 billion (2012 $) and would be associated with 16,910 jobs. Annual public revenues would increase by $116**

million. All of these estimates account for economic returns flowing outside the state from to non-North Carolina input owners as well as the "re-circulating" of economic returns remaining in the state.

The economic benefits from on-shore development are estimated to be more modest. Also using average quantity and price values, during the seven year build-up of facilities to access the energy reservoirs, **$80 million of new annual economic activity would be created in the state, along with 496 jobs and $4.9 million in annual public revenues.** During each year of a 20 year production period, the annual increase in statewide economic activity would **be $158 million, and this spending would generate 1406 jobs and $9.6 million in annual public revenues.**

These average (baseline) economic impact results were generally smaller than those found in other studies focusing on energy development in North Carolina. However, it was not apparent those studies were careful to consider the interaction between the level of forecasted energy prices and the economically recoverable quantity of energy. This interaction was a key component of the current study.

Also, these results were obtained by using the average (mean) estimates of available energy resource quantities and the best single estimates of future energy prices. However, sensitivity analysis using ranges of both energy quantity and energy price forecasts showed significant variability in the results, in some cases by a factor of more than 100.

Hence, the estimated impacts are subject to specific forecasts for energy prices and available viable energy quantities. However, if the forecasts are changed, the methodology outlined in this report can be easily modified to generate new estimates.

But along with the potential economic benefits to North Carolina from energy recovery must be considered possible costs. Off-shore energy resource recovery faces the threat of spillage from natural disasters or man-made errors. Spillage could threaten North Carolina's coastal counties and especially the tourism and fishing industries in those counties. Using average spillage rates for the last forty years of off-shore oil production in the U.S. and estimates of spillage costs, it is calculated that off-shore energy recovery could impose **average annual costs of $83 million for North Carolina coastal counties.**

There are also potential economic costs related to on-shore energy development. Previous studies have measured these as reductions in property values in counties where the on-shore energy development occurs. Using these studies as a guide, **the North Carolina counties where on-shore energy development happens could see a reduction in residential property values of between $636 million and $4.7 billion, with an associated annual loss of spending of between $32 million and $235 million and job reductions ranging from 320 and 2350.**

The result is that there are both potential "upsides" and potential "downsides" to energy resource development in North Carolina, and neither the "ups" nor the "downs" should be ignored. Benefit estimates should be continually refined as updated price and quantity information becomes available. Potential cost information should also be reviewed with the goal of narrowing the range of estimates. Plans, procedures, and contingencies for both reducing potential costs as well as addressing costs when they occur should be developed and debated.