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New Dynamics in Fossil Fuel and Renewable Energy for Rural America

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Abstract

In the early 2000s, the United States energy landscape began a transformation driven by a dual boom in the expansion of renewable power installations and the extraction of natural gas and oil from shale plays through hydraulic fracturing and horizontal drilling. In this paper, we discuss the multi-level regulatory context in which these two forms of energy development occur and review how they affect local communities, environment, and infrastructure, as well as government income and spending.

In comparing the two, we remark that long-term employment effects are relatively low for both forms of development, but unconventional fossil energy development has a heightened boom/bust potential with a large influx of workers spending a short amount of time on each well before moving on. Renewable power plants on the other hand can offer a steadier stream of income and tax revenue. Renewable power plants also have longer lasting visual impacts but lower environmental risks than unconventional fossil energy development.

Finally, we consider how communities will have to adapt to navigate legacy and infrastructure constraints that accompany the shift from fossil to renewable power generation and from conventional to shale oil and gas resources.

JEL Codes: R11, Q20, Q32, Q35

Preface

Rural America has experienced more than a decade of rapid growth in renewable power installations and drilling for oil and gas in shale plays with both positive and negative consequences on individual wealth and well-being, the local economy, the environment, and State finances. In this paper, we review how State and local regulations shape the impact of these two energy developments and assess how rural America can benefit from or weather the transition to a lower carbon economy. This review is intended for the interested public, energy economists, and rural development experts, as well as national and local policymakers and the communities that are at the centers of this energy transition.

Introduction

Hydraulic fracturing and horizontal drilling technology became commercially viable in the early 2000s, leading to a veritable boom in the development of natural gas and oil from shale plays. In 2015, about half of U.S. natural gas and crude oil production was from shale resources. This rapid expansion of “unconventional” oil and natural gas extraction is transforming the United States energy economy, and can have significant effects on local and regional communities in areas in which resource development activities were concentrated. These effects may include lease and royalty payments to land and mineral rights owners; increased demand for labor, land, housing, and infrastructure; increased truck traffic, air pollution, surface-level ecological disturbances; and the risk of soil or water contamination. Development is also associated with new sources of tax revenue for States and local governments, as well as strains on government resources to improve and maintain public infrastructure and services.

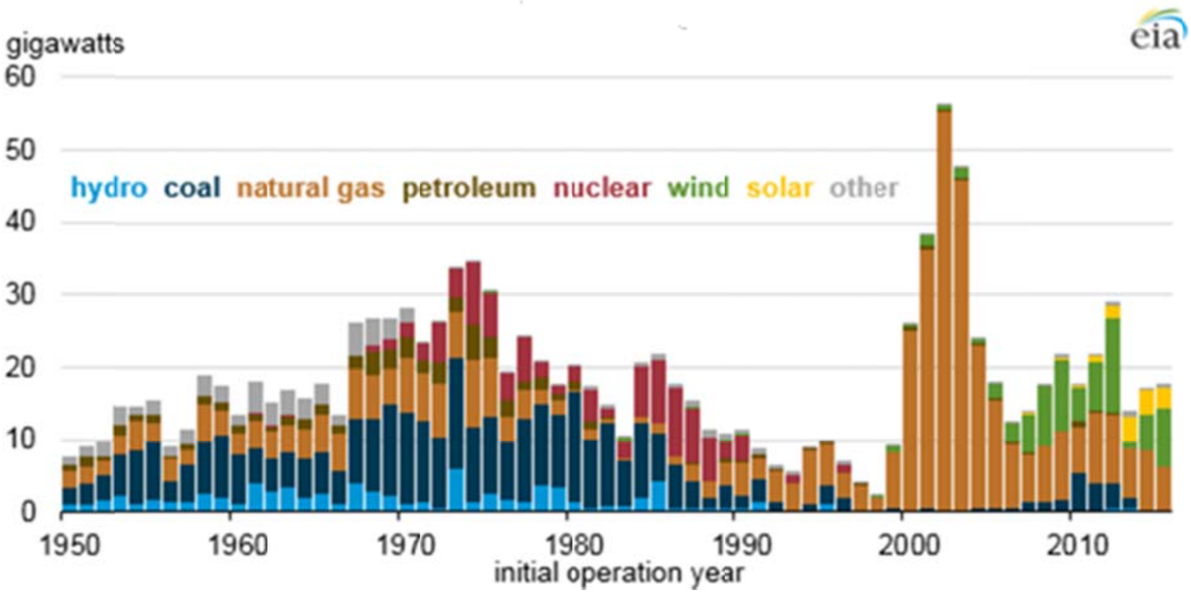
During approximately this same time period beginning in the early 2000s, a number of regions in the United States have also witnessed a rapid development of renewable power. In 2015, wind and solar power accounted for 41 percent and 26 percent of total additions to electricity-generating capacity (Figure 1). Over half of the electricity generated in non-hydroelectric renewable power plants was concentrated in eight States: California (17 percent of the U.S. total), Texas (15 percent), Iowa (6 percent), Oklahoma (5 percent), Minnesota (4 percent), Kansas (4 percent), Illinois (4 percent), and Washington (3 percent) (EIA 2015a). Similar to the advent of unconventional oil and gas development, the expansion of renewable energy since 2000 has translated into lease payment inflows for land owners hosting wind turbines, short and longer term labor market effects, and new sources of tax revenues for State and local governments. Large-scale renewable energy projects can also have visual and noise impacts, affect birds and other wildlife, and possibly displace other land use activities. The benefits of renewable power over fossil-fueled power generation include reduced particulate, nitrous oxide, and carbon emissions.

Shale development and utility-scale renewable power plants can have similar effects on State and local government finances, land and mineral rights owners, and communities during the drilling/construction period. At the same time, in both shale and renewable power, the distribution of potential costs and benefits of energy development can vary substantially both across and within local areas, and local tensions may arise when the opportunities to benefit from economic incentives surrounding this buildup are available to relatively few individuals. Renewable power plants can have large spatial footprints, while shale development is associated with surface disturbances, particularly during the drilling period. Additionally, both types of energy production also usually require expansions in energy infrastructure, such as natural gas pipelines for shale-based development and transmission lines for renewable electricity, which can include negative environmental impacts but also positive effects on employment.

Nonetheless, there also remain important differences in how shale and renewable power development impact communities. Previous research has noted that expansion of shale development may contribute most to short-term economic growth, with renewables having much more modest effects (Brown et al., 2013). There are several possible reasons. First, shale development is associated with drilling activity that is highly concentrated in a particular area and relatively short lived, thereby exhibiting a much greater potential to create localized boom-bust cycles than renewable power. For shale development, the potential for periods of rapid expansion as well as rapid decline is exacerbated by the sensitivity of oil and gas extraction activities to global markets and commodity price shifts. Second, oil and gas production from shale plays, and thereby the associated lease and royalty payments, typically decline rapidly once production begins to wane off, while lease payments from renewable power developers can offer a steadier stream of income over a longer time period.

In terms of environmental effects, those associated with shale development (water used for drilling, produced wastewater management, and truck traffic) may be larger and thus appear likely to pose a greater strain on nearby communities than renewable power development. Nonetheless, wind turbines and solar power plants represent a lasting change in the visual landscape. Much of the visible machinery required for drilling horizontal wells is dismantled after production begins, though the restoration of disturbed land can take time, particularly in forested areas.

Figure 1. Electricity-generating capacity additions by technology (1950–2015).



Source: Energy Information Administration (2016a)

While oil and gas production and renewable power owe much of their recent growth to technological advances (in each industry and in network technologies), their development comes also in response to recent and potential national and State policy changes aimed at reducing greenhouse gas (GHG) emissions in the power sector, typically by shifting away from coal-fired generation. Renewable energy technologies that are not yet competitive with conventional power generation technology (i.e., they have not yet reached cost parity) are particularly dependent on supporting policies and incentives. The Federal production tax credit supports renewable power in particular, while the 2015 Clean Power Plan Plan (CPP) would cap GHG emissions in the power sector and provide an incentive for renewable power and even natural gas plants to replace coal power plants, which have a higher emission rate than either of these technologies.* Initiatives at the State level include regional GHG emissions cap-and-trade programs, renewable portfolio standards, and a plethora of tax credits, subsidies, and grants.

This shift in U.S. energy production towards natural gas, solar, and wind (Figure 1) is likely to continue into the foreseeable future. For much of the past century, energy markets have remained relatively stable and insulated from competition with each other. However, the transition to a more decarbonized energy economy will be framed within higher competition among energy sources,

* Natural gas power plants emit about half as much carbon dioxide as coal power plants. Even accounting for leakage of methane, a potent GHG, in the natural gas production and distribution system, GHG emission estimates remain lower than for natural gas than for coal (Shearer et al., 2014).

increased interconnection of regional markets, and more complex regulatory decisions (Brognaux and Ward, 2015). The impacts on rural areas new to entering the energy market as well as areas downsizing or transforming their energy portfolios can be substantial. In this white paper, we provide an overview of some of the effects of this transition on local communities and land owners. We also discuss the regulatory context in which these two forms of energy development occur, and we consider how infrastructure and fiscal legacy issues constrain this transition.

Regulatory Context

The shale gas and oil boom, as well as renewable energy expansion, are occurring within preexisting yet changing regulatory frameworks. While local governance can influence the effect of this energy transition on local communities, local policies and fiscal choices are often bounded by state and federal regulations. Impacts at the local level will be shaped concurrently by the local, state, and federal regulatory framework.

Regulations exist at the Federal, State, and local levels with considerable variation both within and across each of those levels. Because of this multilevel regulatory governance, energy markets are highly fragmented. For example, the wholesale market for electricity is regulated by the Federal Government, while each State regulates its own retail market. On the other hand, facility siting requirements and requirements to assess and address environmental impacts may be regulated only at the local level, unless facilities are sited on federally managed lands (Lazar, 2011).

Federal oversight of energy has been mostly limited to interstate transmission and wholesale sales of electricity and natural gas. The Federal Energy Regulatory Commission (FERC) handles most of the Federal regulation of the energy sector, yet some activities are regulated by the U.S. Environmental Protection Agency (EPA), Federal land management agencies, such as the Bureau of Land Management (BLM), or other Federal bodies. Often a Federal agency such as the EPA, the Fish and Wildlife Service, or others will establish minimum regulatory requirements, and as long as these are met, the State government and local entities assume regulatory authority and implementation responsibilities. Of course, when energy development occurs on federally owned land or with federally owned mineral rights on private land, BLM or other Federal agencies administer the leases, inspect the operations, and collect royalties.

Coordinating between different levels of regulation can be challenging, but in many cases, traversing these levels of governance proves most beneficial because it provides a more consistent operating framework. As an example, FERC's authority (although limited) to override local authorities can provide for construction of interstate transmission lines, which can address issues of national interest, such as delivery of adequate and reliable power supplies, and attainment of national goals for shifting toward less carbon-intensive power generation technologies.

In terms of new and emerging policy frameworks, the CPP would likely have a considerable impact on increasing natural gas and renewable energy-based power generation, as well as transitioning away from coal.[†] The CPP would establish emission reduction targets by State and offer flexibility in meeting the targets with investments and/or emissions trading. Based on GHG accounting, the CPP prompts the transition from coal-fired to natural gas-fired electric power production as well as renewable energy installations, which may have important and lasting consequences for parts of rural America.

[†] The United States Supreme Court ordered a stay on the implementation of the Clean Power Plan in a 5–4 ruling on February 9, 2016. The outcome of the Clean Power Plan is uncertain until the Court issues a final ruling.

Renewable Energy

Large-scale renewable energy projects are subject to various levels of permitting, as is the case with other major industrial facilities. Projects on private land are usually subject to local zoning ordinances and permits. However, in some states, permitting requirements and ordinances are set at the state level (DSIRE, 2016). Renewable energy projects can also be subject to local property taxes, which can represent a considerable operating cost. For projects sited on federal lands, agencies such as the BLM and the USDA Forest Service (FS) are responsible for managing the planning and permitting processes.

Distributed power generation, which often involves rooftop solar installations, can also be subject to a variety of regulatory and permitting processes, including homeowners' association covenants or design review requirements. However, more than half of all states have passed solar rights laws that either limit the restrictions that private covenants can place on solar energy system installation or explicitly enable local governments to adopt regulations aimed at protecting solar access (DSIRE, 2016).

Many renewable resources are located in remote areas that lack ready or cost-effective access to transmission. In States where regulations do not enable reimbursement for transmission investments or support coordinated planning and permitting processes, development of utility-scale renewable projects can be slow or unrealized. In some States, authority for approving new transmission lines belongs to a single agency. However, in others, separate approval might have to be obtained from each governmental authority (state and/or federal) the lines pass through. Furthermore, most transmission facilities in the United States are owned by large regional utilities, federal power-marketing agencies, or other business entities that can charge for line use. Individual smaller utilities are unlikely to invest in transmission infrastructure based solely on the needs of their own service territories (Lazar, 2011).

The Public Utility Regulatory Policies Act (PURPA) of 1978 was the basic legislation that enabled qualified facilities of renewable energy providers to gain access in the market. Important federal policies have also included investment tax credits (ITC) for renewable energy installations and Production Tax Credits (PTC), which have been especially important in encouraging development of wind energy development. Historically, new wind power development has fluctuated considerably with the expiration and renewal of the PTC (Brown, 2013), and uncertainties regarding its continuation have undoubtedly placed some constraints on additional development. The PTC was last extended in December 2015 until December 2019 with a phase-down beginning in 2017: the PTC amount ($0.023/kWh in 2016) available to new wind power facilities is gradually reduced reaching 60 percent reduction in 2019.

Most of the policies supporting renewable energy in the United States originate at the State level. This will continue to some extent even if the CPP is implemented, since the EPA only sets the emission goal while regulatory choices and implementation authority rests at the State level. State-level renewable energy portfolio standards (RPS) have been a central State policy tool. Renewable portfolio standards require a minimum share of power or a minimum level of installed capacity in a given region or State to be met by renewable energy and have been shown to increase utility-scale capacity of renewable generation (Menz and Vachon, 2006; Adelaja and Hailu, 2008; Shrimali and Kniefel, 2011; and Yin and Powers, 2010). Currently, over 30 States and territories have established an RPS, while about 10 additional States have set goals for increased renewable energy production and use (DSIRE, 2016). Of these, almost one-third exempt rural electric cooperatives from the RPS.

Over 20 States also have specific RPS targets for solar or distributed generation, which, according to Xiarchos and Lazarus (2013), positively affect distributed solar and wind.

States have adopted a number of other policies to support greater investment in renewable energy technologies, with varying degrees of success (Shrimali and Kniefel, 2011; Yin and Powers, 2010, Xiarchos and Lazarus, 2013; Hitaj, 2013; Borchers, Xiarchos, and Beckman, 2014). Hitaj (2013) finds that State per-KWh production incentives and sales tax credits are significant drivers of investment in wind power capacity. Net metering and interconnection policies increase the likelihood of solar and wind power adoption on farms (Borchers, Xiarchos, and Beckman, 2014). Requiring electricity suppliers to provide green power options to customers is positively related to the development of wind energy (Menz and Vachon, 2006). Other examples of State-level incentives include public benefit funds for renewable energy, Property Assessed Clean Energy (PACE), and financial incentives such as production incentives; property, sales, and corporate tax credits; and rebates. In addition, a number of local financial incentives are sometimes provided.

Net metering and interconnection are policies that have been especially influential to the adoption of distributed generation (Carley, 2009; Borchers, Xiarchos, and Beckman, 2014). Interconnection policies stipulate the technical specifications and procedures by which the renewable energy system will connect to the grid. Net metering can allow compensation to utility customers for electricity generation in excess of consumption that flows back into the grid. The effectiveness of the rules varies considerably by State, and the structure of some policies can hamper adoption (Freeing the Grid). These two policies stem from a federal requirement established in the PURPA of 1978, which states that electric utilities must interconnect with renewable power production facilities and pay for the produced power a price mandated by their State equal to the avoided cost. PURPA has been integral in providing the necessary framework to support electricity production from renewable energy facilities (distributed and utility scale).

However, as distributed generation has become more widespread, several States are considering changing their net metering policies (NC Clean Energy Technology Center, 2015). With more customers opting for net metering, the burden of paying fixed costs for utilities falls on a smaller share of utility customers. While generating plants receive only the wholesale price under net metering, electricity customers generating electricity with, for example, their rooftop solar panels, can sell that electricity back to the utility at the retail rate. Nonetheless, utilities have to continue covering fixed costs and past sunk costs that make up the difference between the retail and the wholesale rate. While utilities could in response raise their rates, more customers might then be prompted to opt for metering, earning the issue the term "utility death spiral" (Borenstein, 2013).

This is a major concern for rural electric cooperatives, which have relatively high distribution costs: In 2010, rural electric cooperatives serviced, on average, 7.4 customers and collected $15,000 in revenue per mile of distribution line, compared with 34 and $74,500 respectively for investor-owned utilities (NRECA, 2016). At least partly in response to the growth in net-metered distributed generation and the "utility death spiral," in the third quarter of 2015, regulators and legislators in 27 States were reviewing or changing net-metering policies (NC Clean Energy Technology Center, 2015). In addition, 26 utilities in 18 States had ongoing or decided rate cases in which the utility proposed to increase fixed charges by 70 percent on average (NC Clean Energy Technology Center, 2015). Investments in distributed renewable power may decline as a result.

Unconventional Fossil Energy

The Interstate Commerce Act of 1887 governs the oil pipeline transportation, and since 1938, the Natural Gas Act federally regulates interstate transmission, transportation, and sale of natural gas; both are under the supervision of FERC (Federal Power Commission-FPC- until 1977). Pipeline safety is regulated separately by the Natural Gas Pipeline Safety Act under the auspices of the Office of Pipeline Safety (OPS) in the Pipeline and Hazardous Materials Safety Administration (PHMSA). While FERC regulates construction of natural gas pipelines as well as rates, tariff, and service agreements, the Commission does not regulate oil pipelines' entry or exit from the marketplace, rates, or terms and conditions of service. Consequently, pipelines for natural gas have federal eminent domain, while for oil they depend on the State rules and regulations for eminent domain and construction approval.

The removal of price ceilings by the Natural Gas Wellhead Decontrol Act of 1989 and FERC Order 636 deregulated natural gas pipeline development, increased interregional sales, and created a positive investment environment that allowed for the development of innovations in the demand and supply side of natural gas. Improvements in directional drilling and hydraulic fracturing fundamentally changed the way the industry does business (Trembath, 2012), and the ramifications of these changes led to the recent oil and gas boom in shale formations across the country.

States use various policies to regulate shale gas and oil activity. Richardson et al. (2013) identified 25 regulatory elements. Examples of such regulations include requirements for casing and cementing, wastewater storage and disposal, flaring and venting, building and water setback or water withdrawal limits. Richardson et al. (2013) found varying degrees of regulatory stringency by State, and identified some pervasive associations in terms of stringency. For example, States with larger oil and gas industries regulated more elements, and States that relied more on groundwater for water consumption had more stringent groundwater regulations.

While only Maryland and New York have imposed a statewide moratorium on the use of hydraulic fracturing processes for shale gas development, a number of local jurisdictions have passed shale gas development bans or moratoria. Local regulations can be important, relative to safety standards and production regulations. However, in many States, efforts by local jurisdictions to impose such regulations have been subject to litigation, and in Texas, such local ordinances have been invalidated due to updates to State law.

States predominantly regulate oil and gas extraction. The U.S. Interior Department's (DOI) Bureau of Land Management (BLM) is responsible for managing oil and gas resources on federal lands and federally owned mineral rights associated with land that is privately owned. Although the DOI released its final rule for regulating hydraulic fracturing activities on federal and Indian lands in 2015, the regulation never went into effect amid a legal challenge from the oil industry and the States of Colorado, North Dakota, Utah, and Wyoming. This rule included new well-bore integrity requirements; standards for interim storage of recovered waste fluids; reporting and management requirements for fluids used and produced in hydraulic fracturing operations; information concerning geology, integrity, and water used in the operation; as well as a mandated disclosure of the chemicals used in the process, which can be done via the industry-supported FracFocus website.

EPA regulation of shale gas and oil is also limited, as hydraulic fracturing is excluded from the Safe Drinking Water Act's Underground Injection Controls regulation, except when diesel is used.

However, in 2012, EPA issued air regulations for the oil and natural gas industry that included the first federal air standards for natural gas wells that are hydraulically fractured. In 2016, the EPA finalized updates to these standards that would reduce allowable emission levels, extend emission reduction requirements downstream, require leak detection and repair, and require methane and volatile organic compound (VOC) reductions from hydraulically fractured oil wells.

Hydraulic fracturing aside, reclamation and restoration regulations for land disturbance from oil and gas development are complicated by land ownership and split-estate issues. Two primary federal regulations requiring reclamation in oil and gas development are the Stock Raising Homestead Act of 1916 (SRHA) and the Mineral Leasing Act of 1920 (MLA) (amended and updated multiple times in subsequent years). The SRHA allowed non-surface owners access to subsurface mineral rights held by the Federal Government. The Act required that companies compensate surface owners for loss of use. Amendments to the Act in the latter half of the 20th century required that these compensations to surface owners be in the form of a bond. The MLA introduced reclamation bonding in order to ensure compliance with all lease terms. The bond is designed to provide an incentive either to reclaim the land or to use the bond for reclamation, should the operator not complete the reclamation (Perrings, 1989). Reclamation of land affected by the construction of renewable power plants, including recontouring the surface and revegetation, also involves reclamation bonds.

The use of a bond as an incentive for reclamation has been only partially successful. Shogren et al. (1993) argued that firms can face liquidity constraints in posting the bond up front. This is confirmed by Davis (2015), who noted that small- and medium-size firms can face a significant opportunity cost in raising funds for the bond. Since the repatriation of the bond occurs after the well is capped, there is a sunk-cost issue for bonds as incentives to finish reclamation. As such, bond values on average in some States can drift below the expected cost of reclamation (Andersen et al., 2009).

Moreover, requirements for reclamation have evolved. Under amendments to the MLA, the original expectation was that damage to the general area would be limited. More recently, the expectation has expanded to include re-establishment of native ecosystems (BLM, 2007).

State laws regulate reclamation on private or State land, and every State is different. The regulatory framework includes bonds and reclamation requirements, State agencies involved in everything from environmental protection to energy development regulation, industrial siting board approaches, insurance commissions, and more. Regardless of federal or state ownership or the particular approach in a State, completing surface and subsurface disturbance remediation implies that surrounding communities, landscapes, and ecosystems are necessarily affected by energy development.

Traditional approaches adopted by state and local governments to address some of the potential impacts of shale gas and oil development usually include bonding and other monetary instruments (insurance, impact fees, etc.) as well as State environmental regulatory requirements. Each State has a different set of regulatory monetary instruments that are used, while no State has a comprehensive bond that covers all disturbance costs. As shale development patterns have shifted production to some regions that have not historically been engaged in fossil fuel production, some local and state governments can lack the experience to foresee and manage short- and long-term issues.

Local Impacts on the Environment and Community

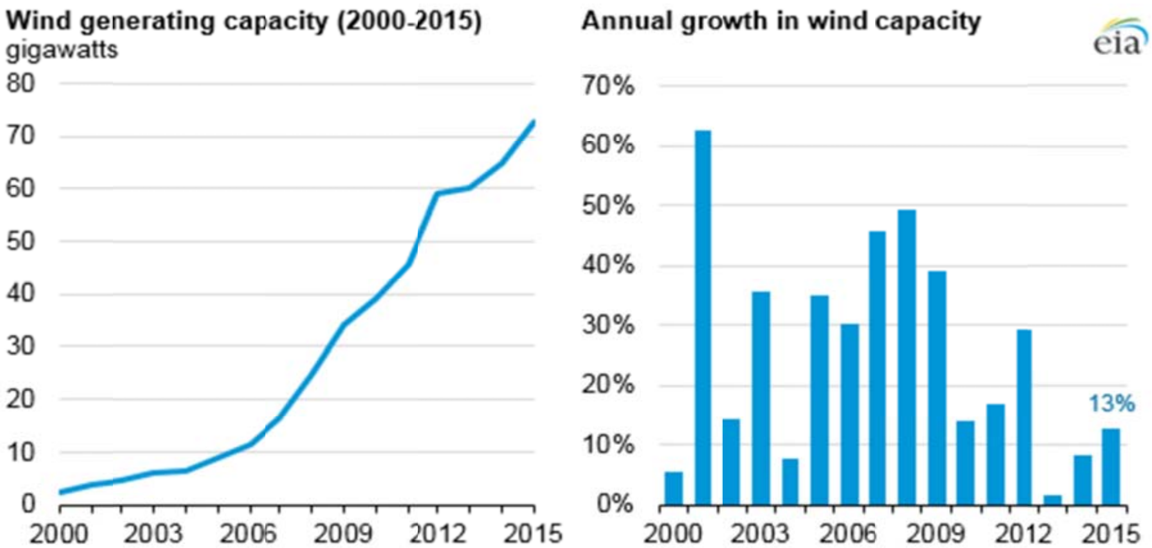
Local impacts from unconventional gas and oil or from wind turbine or solar power installations include employment effects, such as increased income, disproportionate benefit distribution among land owners, truck traffic, air pollution, viewshed alterations, and surface disturbances. Some negative impacts can be mitigated through the state and local regulations detailed in the previous section. In this section, we review selected findings from the literature on local impacts of energy production that has emerged over the last decade. In summation, utility-scale renewable power plants have longer lasting visual impacts but fewer types of environmental risks than unconventional fossil energy development. In both cases, lease and royalty income accrues only to participating land owners, or, in the case of fossil energy, mineral rights owners (for split estates, land owners will not correspond to mineral owners for unconventional fossil energy development). Additionally, renewable power plants can offer a steadier stream of income and tax revenue than natural gas or oil produced from wells in shale plays. Long-term employment effects are low for both forms of development, but unconventional fossil energy development has a heightened boom/bust potential, with a large influx of workers spending a short amount of time on each well before moving on.

Renewable Energy

Development of utility-scale renewable energy facilities, primarily involving wind power installations, has expanded rapidly in the United States in recent years. Total installed wind power capacity increased from approximately 5 gigawatts (GW) in 2002 to over 69 GW in 2015 (Figure 2). Wind power has comprised one-third of all U.S. electricity-generating capacity additions since 2007, and, made up 24 percent of additions in 2014 (U.S. DOE, 2015a; U.S. DOE, 2015b). Although utility-scale solar energy installations expanded less rapidly, as of 2015 they provided roughly 11 GW of the nation's generating capacity, with nearly three times that level of additional capacity under development (Solar Energy Industries Association, 2015). In 2014, utility-scale solar installations comprised 18 percent of newly added generating capacity in the United States (Hales, 2015). Into the foreseeable future, both wind- and solar-power capacities are projected to increase substantially and account for growing proportions of the total U.S. electric power production (EIA, 2015b).

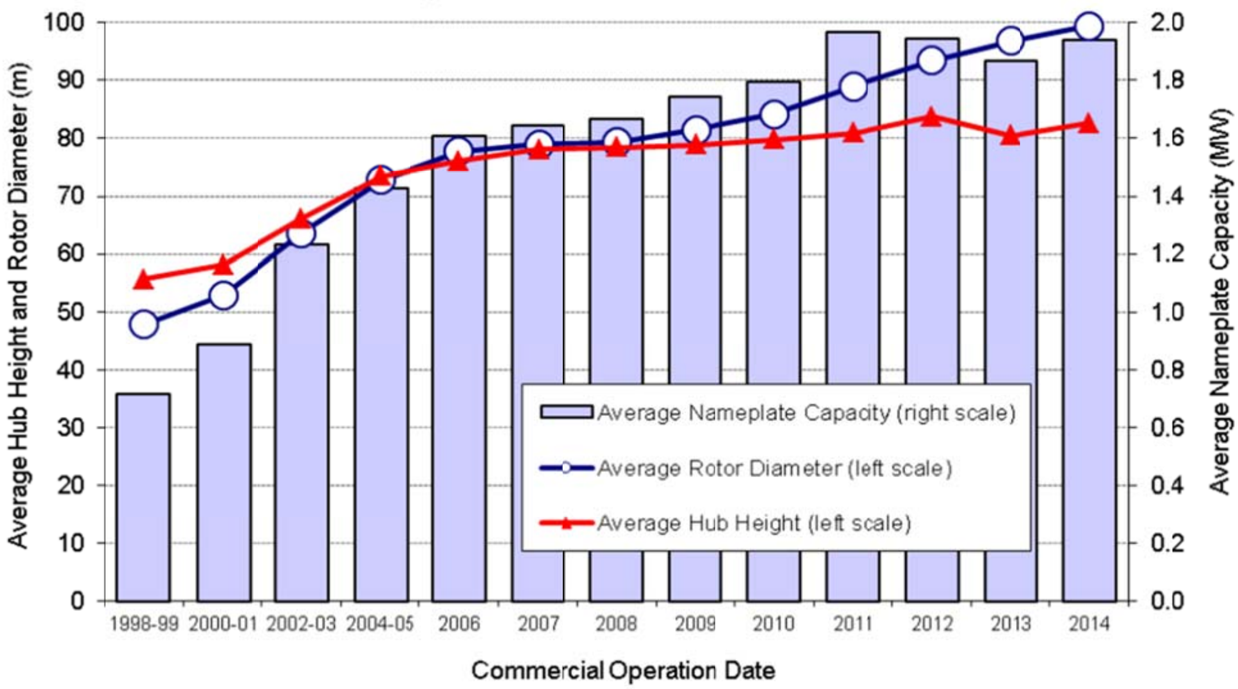
Utility-scale wind and solar facilities have come to occupy substantial and, in many instances, highly visible footprints on primarily rural landscapes across many portions of the United States. Utility-scale solar-generating facilities require an average of nearly 9 acres of land area per MW of generating capacity, and depending on facility size, may occupy anywhere from just a few acres to thousands of acres (Ong et al., 2013). Wind power plants require about 0.74 acres per MW of permanent area for turbines and access roads and an additional 1.73 acres per MW of temporary area during construction (NREL, 2009). Even small wind power installations may involve about a dozen turbines spread across land areas of about 100 acres, while the largest facilities can have as many as 1,000 turbines scattered across sites encompassing tens of thousands of acres. The size of individual wind turbines and towers has also increased substantially in recent years (Figure 3). For new installations occurring in 2014, the average per-turbine generating capacity was 1.9 MW, an increase of 172 percent from 1998–99; the average hub height was 82.7 meters in 2014, up 48 percent since 1998–99; and the average rotor diameter was 99.4 meters, up 108 percent since 1998–99 (U.S. DOE 2015a).

Figure 2. Wind-generating capacity (2000-2015).



Source: Energy Information Administration (2016b)

Figure 3. Average turbine nameplate capacity, rotor diameter, and hub height installed during period (only turbines larger than 100 kW).



Source: U.S. Department of Energy (2015a)

Environmental impact

Renewable energy projects are considered environmentally friendly alternatives to conventional power generation processes, since they do not contribute directly to air pollution or carbon emissions. Those environmental advantages help to account for the broad-based public support for increased utilization of wind and solar energy in the United States (Ansolabehere and Konisky, 2014). A recent study from the Yale Project on Climate Change Communication found that 79 percent of Americans either "strongly" or "somewhat" support Government funding of research to develop renewable technologies. Moreover, two-thirds support policies that would require electric utilities to source at least 20 percent of energy from renewable sources, even if doing so creates increased costs for their households (Leiserowitz et al., 2015).

Nevertheless, large-scale renewable energy projects do have the potential to cause a variety of negative externalities. Concerns about visual impacts often motivate local opposition to wind farms. Most concerns center around the substantial size and height of wind turbines and towers, the requirement for high-visibility nighttime strobe lighting to mark their locations, and siting patterns that often situate turbines along higher elevation ridgelines that can make such installations highly visible across substantial distances (Dai et al., 2015; Pasqualetti et al., 2002; Tabassum-Abbasi et al., 2014).

Another key set of concerns regarding some wind and solar power installations involves the potential for adverse effects on wildlife, due to habitat disturbance and fragmentation, possible displacement of some wildlife populations, and increased mortality, particularly among birds and bats from turbine blade strikes (Dai et al., 2015). Industry responses to environmental impacts include noise emitters to warn birds away, specially designed paint to make structures less attractive to insects, and efforts to make predatory perching more difficult.

Other possible, but less frequently cited, environmental concerns involve localized noise impacts, electromagnetic interference, and local climate change effects due to alteration of wind flow patterns in areas near large wind power installations (Dai et al., 2015). Local residents are also often concerned about the landscape changes that inevitably accompany the development of large-scale renewable energy facilities, which have the potential to disturb socially valued places and spaces and, in some cases, restrict access to previously accessible public and private lands (Devine-Wright and Howes, 2010; Jacquet and Stedman, 2013).

Finally, in many areas, expansions in transmission systems to move the power to urban load centers engender conflicting concerns from the public. Most concerns revolve around viewsheds, endangered species, birds or other terrestrial species that residents find important or that are protected under state and federal wildlife policies and statutes, and effects on wildlife populations that provide for recreational opportunities such as hunting and fishing. These issues can be similar to some of the issues that arise with the development of oil, gas, and coal-burning power plants.

Effects on income and employment

A number of studies have shown that community support for wind and solar farm development depends largely on the belief that it will result in increased employment and wages, increased economic activity for local businesses, and other local-area economic benefits (Bidwell, 2013; Brannstrom, Jepson and Persons, 2011; Fergen and Jacquet, 2016).

During the construction phase of project development, there are short-term job creation and employment opportunities linked to larger scale renewable energy installations, although a majority of those jobs typically go to non-local workers (Krannich et al., 2015). Over the longer term, even large-scale renewable energy facilities typically generate only a handful of operations-phase jobs for local area workers, with many facilities employing fewer than 10 persons onsite following the completion of construction activities (University of Nebraska Bureau of Business

Research, 2014). While some of these newly created jobs require specialized skills and tend to pay relatively high wages, others, such as onsite security, tend to provide more modest wage levels.

Brown et al. (2012) found an average aggregate increase in annual personal income in counties with wind turbines of approximately $11,000/MW of wind power capacity between 2000 and 2008, and an average aggregate increase in net county-level employment of 0.5 jobs per MW between 2000 and 2008. Those figures translate to a modest median increase in total county personal income and employment of 0.22 percent and 0.4 percent, respectively, for counties with wind power installed during the 2000 to 2008 period. Nevertheless, even a handful of new direct jobs can represent an economic boost in some rural areas. The largest boost is likely short term, via construction-related increases in sales for local-area materials providers and service-sector businesses.

Additionally, land owners of plots that house wind turbines can receive lease payments for wind farm developments ranging from $2,000 to $10,000/tower per year, or 2-5 percent of the produced electricity value in royalties ranging from $2,000 to $6,000/MW per year (Aakre and Haugen, 2009; Wind Easement Work Group, 2009). Spending in the local economy from these sources of income in addition to workers in the energy development activity can further invigorate local economies.

Local resident participation in energy development benefits

Support or opposition for many types of development activity, including large-scale renewable energy developments, will often revolve around beliefs and expectations concerning their possible consequences (Fergen and Jacquet, 2016). A key factor to influence whether development is viewed as an opportunity or not is the distribution of costs and benefits among local residents and between local and non-local populations. In some instances, local residents may find little reason to be supportive of proposed projects because they anticipate few local benefits. Such reactions are especially likely to occur if the lands to be developed are absentee-owned, or if newly generated electric power is slated for export to distant and, in most instances, urban areas (Ottinger, 2013; Phadke, 2013).

In addition, renewable (and other) energy developments may produce economic benefits for only a limited number of "participating" land owners who are able to lease their property for development. Meanwhile, non-participating land owners and other area residents receive few if any direct benefits, while they may collectively or individually experience the various disamenities that can be associated with such projects. The differentiated potential for wealth creation among local area residents can contribute to highly varied patterns of project support or opposition (Brasier et al., 2011; Fergen and Jacquet, 2016; Ladd, 2013; Perry, 2013).

Non-disclosure clauses associated with wind leases on private lands that prevent land owners from revealing the details of their agreements (e.g., fees, agreed-upon prices of trespass agreements) can also cause mistrust and residual negative perceptions to some land owners and residents.

Distributed renewable energy

The majority of the wealth benefits from renewable energy in rural areas are associated with the boom in commercial wind energy development on agricultural land. However, while only a small number of spatially concentrated land owners benefit directly from wind leases, many more widely distributed land owners are taking advantage of renewable energy through distributed generation installations. For example, in 2012, about 10,000 farmers held wind leases, and close to 60,000 farmers generated renewable energy on their property (NASS, 2013). Benefits of distributed generation include reduced energy expenditures, reliable energy supply, and protection from price volatility.

Depending on local energy prices, renewable energy resources, and available incentives, the payback period for distributed energy installations typically from 6 to 30 years. Renewable portfolio standards and combined best practices in net metering and interconnection policies positively influence adoption (Xiarchos and Lazarus, 2013; Borchers, Xiarchos and Beckman, 2014). The Federal Investment Tax Credit (ITC) has also had a positive impact; on farms, for example, over 50 percent of the wind turbine and solar panel installations occurred after 2005, when the ITC increased to 30 percent (Xiarchos and Lazarus, 2013). Distributed generation continues to grow, and in 2014, residential solar photovoltaic (PV) capacity surpassed commercial capacity; however, in 2015, new utility-scale solar capacity additions still exceeded distributed generation capacity additions (EIA, 2016c).

Zoning

People generally support renewable energy, but are usually considerably less enthusiastic about developments that might occur in close proximity to their residences. They are also less favorable of development in high-visibility or environmentally sensitive locations, or in places that are viewed as special in terms of their recreational, environmental, historical, or cultural importance (Mattmann, Logar, and Brouwer, 2016; Nkansah and Collins, 2014; Whitehead and Cherry, 2007; Mozumder, Vasquez, and Marathe, 2001).

Zoning ordinances and other siting regulations that require adherence to best practices with respect to minimization of visual impacts, wildlife impacts, and other potential liabilities have the potential to reduce levels of controversy and local opposition to the development of large-scale renewable energy facilities in many locations. Several studies in the United States and Canada have investigated how wind turbine placement affects property values and generally found no significant negative effect (e.g., Lang et al., 2014; Vyn and McCullough, 2014; Hoen et al., 2015). However, negative effects have been found in recent studies covering different parts of Europe (Sunak and Madlener, 2012; Gibbons, 2015), and realtor groups that have studied market-value losses argue that large utility-level wind farms can reduce market values between 12 and 40 percent, depending on the distance to the facility (Kielisch, 2009).

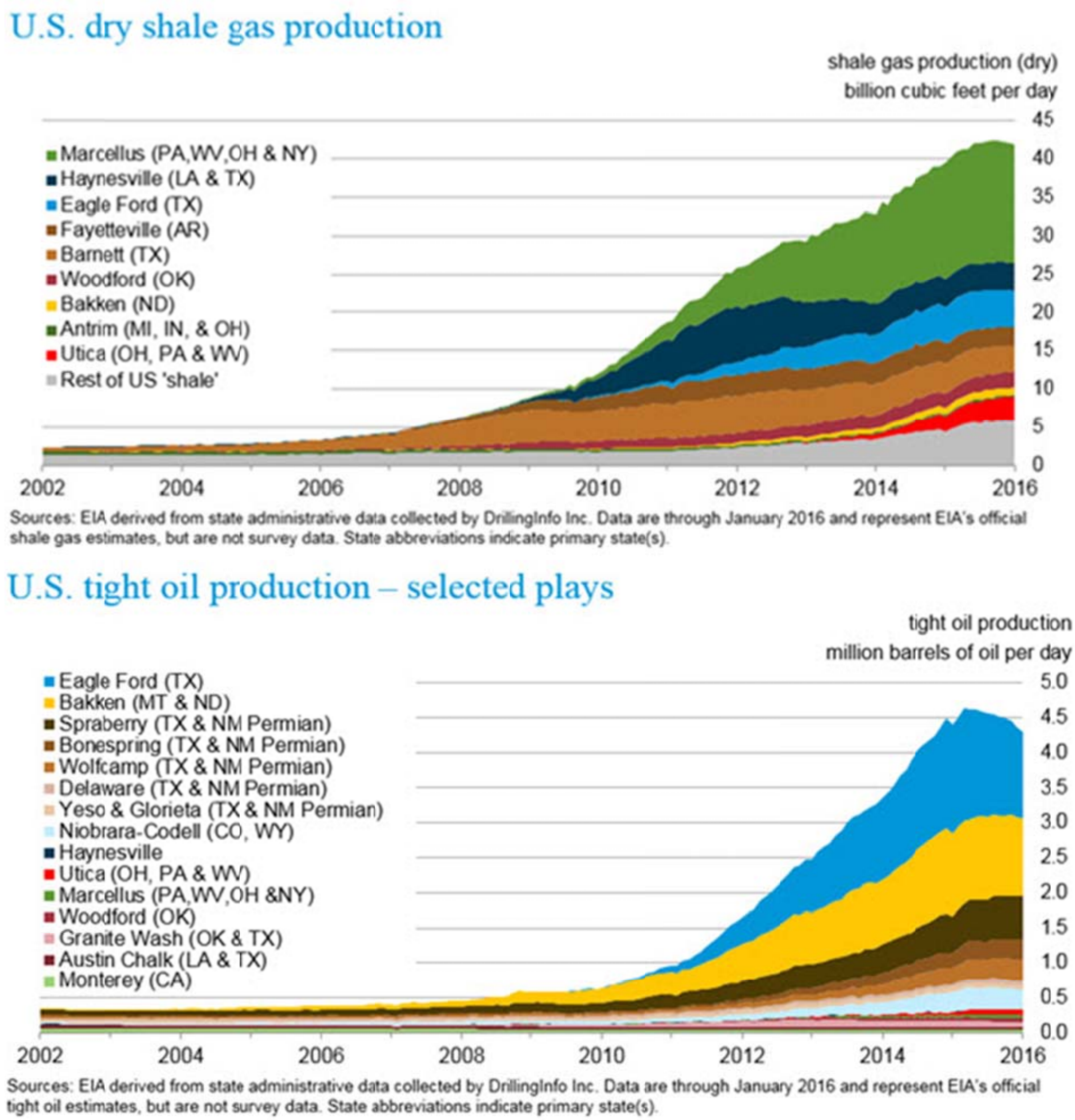
Unconventional Fossil Energy

In the early 1980s, Mitchell Energy & Development Corporation, led by George P. Mitchell, drilled the first well in the Barnett shale field in western Texas. Instead of encountering the typical, highly porous rock of conventional formations, Mitchell Energy encountered shale. Shale has the potential to hold vast amounts of natural gas; however, it is highly nonporous, which causes the gas to be trapped in the rock. Over the next 20 years, Mitchell Energy experimented with different techniques and found that hydraulic fracturing could break apart the rock to free natural gas. Hydraulic fracturing consists of injecting a mixture of water, chemicals, and sand into wells under high pressure to create fissures in rock formations in order to free the trapped gas.

Over the same period, Devon Energy Corporation had been developing horizontal drilling techniques. Advances in controls and measurement allowed operators to drill down to a certain depth, and then drill further at an angle or even sideways, exposing more of the reservoir and allowing much greater recovery. In 2002, Devon acquired Mitchell Energy (Yergin, 2011) and combined its expertise in directional drilling with Mitchell Energy's knowledge of hydraulic fracturing. By 2003, Devon had found a successful combination of the two technologies. Suddenly, natural gas that had been commercially inaccessible was now exploitable. By the late 2000s, the combination of the two technologies was also being used for extraction of tight oil in shale formations.‡ Figure 4 shows how unconventional gas development began in the Barnett shale and spread to the Haynesville and Marcellus shales beginning in 2009, while fracking for tight oil picked up in 2009, with the majority of production coming from the Bakken and Eagle Ford plays. Shale development patterns have shifted production to some regions that have not historically been engaged in fossil fuel production, such as northeastern Pennsylvania in the Marcellus shale.

‡ The oil extracted from shale formations is referred to as tight oil, since the term shale oil was already in use to describe a different type of oil (kerogen) that can also be found in shale formations. However, the terms tight oil and shale oil are often used interchangeably.

Figure 4. U.S. dry shale gas and tight oil production by shale play.



Source: Energy Information Agency (2016d)

In contrast to conventional oil or natural gas wells, production from a horizontal hydraulically fractured well declines rapidly after the first year (King, 2014). This means that new wells are drilled continuously and over a greater geographical area in order to maintain overall production levels. The drilling of wells has increased steadily since the early 2000s and only recently declined in 2015 in response to global market prices.

Environmental impacts

The growth of unconventional oil and gas extraction has raised concerns about potential effects on the environment both directly and indirectly. Direct environmental effects encompass the potential for groundwater contamination as well as surface-level ecological disturbances, both terrestrial and riparian. In addition, fugitive methane from operations, as well as the accumulation of volatile organic compounds (VOCs) and ozone, can affect air quality (Edwards and Field, 2014; Field et al., 2014; Field et al., 2015; Rappenglück et al., 2014). Methane leakage is of particular concern, since methane is a potent GHG. Indirect effects of the growth in oil and gas extraction include an increased likelihood of substituting natural gas for coal-fired generation in the power sector as gas prices continue to decline. This would reduce carbon emissions in the power sector.

The environmental debate has mostly centered on water quality in the new gas developments in the Eastern and Southern gas plays but also includes surface remediation challenges in the West, where semi-arid conditions and endangered species play a major role in environmental damage assessment as well. The rush to extract can lead to well linings insufficiently designed or built to withstand the high pressures associated with hydraulic fracturing within the well itself. Evidence from Colorado, Ohio, Pennsylvania (Lustgarten, 2009a; Ohio Department of Natural Resources, 2008; Thyne, 2008), and Wyoming (Folger et al., 2012; Ruckelshaus Institute, 2005) demonstrates that wells can leak and contaminate aquifers used by surface owners. Moreover, ownership transfers and poorly designed liability contracts can exacerbate remediation and compensation issues with regard to third-party private land impacts (Folger et al., 2012; Ruckelshaus Institute, 2005; Burgess, 2013).

Drilling companies must capture and manage produced wastewater from the hydraulic fracturing process in order to avoid contaminating surface water and, potentially, even shallow aquifers, as occurred in Dimock, Pennsylvania (Lustgarten, 2009b), and in coal bed natural gas examples in Wyoming and Montana (Ruckelshaus Institute, 2005; Burgess, 2013). Once captured, the water requires treatment to remove dissolved solids, disposal through evaporation methods, or transportation to a designated wastewater injection site. In areas where re-injection is allowed, the procedure has been linked to increases in earthquakes (Fischetti, 2012) or surface upwelling of brine through unmapped fractures as far as 10 miles from the injection points (BLM, 2005).

In areas with threatened and endangered species or intensive use (e.g., grazing, housing, recreation, etc.), surface disturbances caused by well pads, access roads, and pipelines are often a major focus of controversy. Soils can be contaminated through spills and fugitive leakages from machinery. In addition, in heavily forested areas, like Pennsylvania, there are concerns about increasing forest fragmentation and the impact on ecosystems, particularly for deep-forest-dwelling species (Drohan et al.; 2012). Allred et al. (2015) conclude that vegetation removal to construct drilling pads and roads during oil and gas development is likely long lasting and potentially permanent. They find that development between 2002 and 2012 affected about 3 million hectares (Mha) of land, of which about 1.4 Mha was rangeland, 1.1 Mha cropland, 0.5 Mha forestland, and 0.1 Mha wetland. New York State Department of Environmental Conservation (2015) estimates the average total surface disturbance associated with a multi-well pad at 7.4 acres and with a single well pad at 4.8 acres, which are reduced to 5.5 and 4.5 acres, respectively, during the production phase.

Aside from water issues, diesel truck exhaust and emissions of volatile organic chemicals from natural gas processing plants can decrease air quality (Kargbo, Wilhelm, and Campbell, 2010), with associated adverse health consequences for workers and nearby populations (Health Effects Institute, 2015). Water and air contamination may explain one study that suggests that unconventional gas development is associated with lower infant birth weight for babies born to mothers residing within 2.5 km of gas wells (Hill, 2012). However, it is unclear if these environmental and health effects from unconventional gas or oil development are different from possible health effects from traditional drilling operations. More research is needed to determine whether there are any long-term environmental and health effects across multiple regions where extraction is occurring in shale and tight gas formations.

Attempts to try to bring companies and communities together to work on environmental impacts of oil and gas development are not well documented and often informal. One such effort was the Coal Bed Methane Coordination Coalition, which formed during the growth of coal-bed methane development in Wyoming and Montana. The group worked to provide a forum for land owners and the energy industry to solve problems (States et al., 2003). The coalition was the outgrowth of development occurring in three counties in Wyoming and had some success mitigating the effect of the rush of gas development. It was successful in dealing with local road infrastructure issues.

No State has a comprehensive bond that covers all the disturbance costs (for a Wyoming case study, see Andersen et al., 2009), which then leaves responsibility for some cleanup costs to land owners, or to local or federal government. Furthermore, a review of bonding rules in States that that do use bonds shows that aquifer damages are not always covered.

Effects on income and employment

Land owners with mineral rights often receive lease and royalty payments, which they may spend in the local economy. Severance taxes paid on extracted natural gas can contribute to higher revenues for state and local governments. Spending on goods and services in the local economy by local residents and governments from these additional sources of income, as well as by workers involved in construction or operations activities, can further affect local economies.

Oil and natural gas extraction directly affects the employment and income of those working in the industry, particularly during exploration and drilling. Additionally, expenditures on oil and natural gas well construction and operations may generate indirect demand for goods and services (for example, gravel, concrete, vehicles, fuel, hardware, and consumables) produced or sold by other industries in the local economy, contributing to increased employment and income in those industries.

Most of the recent literature has found positive benefits to total local employment, wages, and population growth in areas that experienced unconventional oil and gas development (Weber, 2012; Weber 2014; Brown, 2014, 2015; Allcott and Keniston, 2014; Munasib and Rickman, 2015, Wrenn et al., 2015). However, the employment effects are modest and perhaps not as large as the effects generated by positive shocks to other portions of the economy (Tsvetkova and Partridge, 2015). As with renewable energy development, the majority of the employment effects occur during the development (drilling) phase, with significantly less employment after wells are brought online. For example, Brundage et al. (2011) estimate that drilling a well in the Marcellus shale in Pennsylvania requires the equivalent of 13 full-time employees, spread across more than 420 individuals and 150 different occupations, yet only requires 0.2 to 0.4 full-time job equivalents per year once the well begins to produce. The large influx of workers who spend a relatively short amount of time on each well increases the potential for boom/bust cycles.

Oil and gas development does have sizeable wage and income effects. Weber (2012) found that each million dollars of natural gas produced from 1999 to 2007 increased county wage and salary income in shale counties experiencing a production boom by $91,000 over the same period. The annualized increase in wage and salary income was $8.62 million, which is about 2.6 percent of wage and salary income prior to development in 1998. Brown (2014) found that each billion cubic feet of natural gas produced between 2001 and 2011 increased average wages by $43 per job annually. Relative to wages in 2001, the average gas-producing county experienced a 5.8 percent increase in wages over the 2001 to 2011 period.

Only a few academic studies of the economic effects of oil and natural gas extraction have considered the impact of lease and royalty payments to mineral right owners. Weber, Brown, and Pender (2013) found that such payments positively affect farmers' wealth, mainly through higher farmland values, while Hardy and Kelsey (2015) found that increases in lease and royalty income to residents in high-drilling counties can exceed local employment and wage effects. Feyrer et al. (2015) found that each million dollars of oil and gas extraction produced $132,000 in royalty payments and business income within the county in the year production occurs. These results suggest that focusing only on employment misses an important potential economic effect on residents. Weber, Burnett, and Xiarchos (2016) also suggest that wealth increases from housing appreciation closely followed the oil and gas property tax base in the Barnett shale basin, which expanded the total tax base by 23 percent at its height. However, as the tax base is reduced in later years, so are housing prices, with 1 to 2 years of lag.

Oil and natural gas extraction may also have some drawbacks, depending on the level and pace of activity. An influx of workers into a local area typically leads to temporarily higher demand for local housing. Drilling activity often occurs in sparsely populated areas where the supply of housing is low, especially in rural areas. As a result, housing rental rates may rise in the short term, leading people on low or fixed incomes to become unable to afford their housing (Williamson and Kolb, 2011). In Bradford County of Pennsylvania, short-term demand from the drilling industry for housing increased considerably; houses that previously rented for $500 per month could rent for $4,500 per month (Drohan et al., 2012). Increased truck traffic as a result of drilling may cause public infrastructure, such as roads and bridges, to degrade faster and require more maintenance, and it can contribute to traffic safety concerns. Development-induced population growth can lead to increased demands on a variety of local private and public-sector service providers, including, in particular, public safety and health care services (Health Effects Institute, 2015). The short-term demand for labor can affect the labor costs of non-energy businesses: Hitaj et al. (2014) find that agricultural operations in the South-Central United States and the Western Plains have greater hired labor costs in shale counties than non-shale areas, while Xiarchos et al. (2017) show lower hired labor in agriculture for shale counties in the Appalachian region.

Local governments may find it difficult to respond to such needs and manage impacts. More generally, extraction may negatively affect the desire of people to live, visit, or work in a community, in turn affecting migration and commuting flows and income from tourism as well as demand for land, with subsequent potential effects on property values, property tax revenues, and other aspects of the local economy. But, perhaps most importantly, natural resource extraction could potentially lead to the "natural resource curse," involving a tendency toward limited long-term economic opportunity and slowed economic growth in areas characterized by resource dependency (James and Aadland, 2011).

Local resident participation in energy-development benefits

As with renewable energy development, unconventional methods of gas extraction may have dissimilar impacts on community residents, with some residents receiving significant benefits while others experience mostly the inconveniences or costs of development. For example, Kelsey, Metcalf, and Salcedo (2012) found that about half the land area in Pennsylvania's top drilling counties is owned by 10 percent of resident land owners, while non-residents own a little less than

40 percent of the land area. Lease and royalty payments, which are based, in part, upon acreage owned, will follow these ownership patterns, suggesting that half of such payments go to a relatively small share of the population, and almost 40 percent of these dollars immediately leave the counties in which drilling occurs. A national study of farm households and energy development found a similar concentration of lease payments among a relatively small number of land owners (Weber, Brown, and Pender, 2013). In fact, the energy payments were more concentrated than farm support payments.

The majority of oil and gas production in the United States occurs via oil and gas leases as opposed to direct mineral ownership of the extracting firm (Fitzgerald and Rucker, 2014). Leasing contracts are signed before drilling occurs and are generally structured as multi-year-option contracts that provide the firm with the right, but not the obligation, to explore for oil and gas. Companies agree to pay mineral rights owners a fixed percentage of the value of production from the area leased. In 2014, the six largest oil and gas plays in the United States generated an estimated $39 billion in gross royalties owed to private mineral owners (Brown et al., 2015). In more rural areas, private royalties rival government transfer income and are considerably larger than total farm program payments. Hitaj and Suttles (2016) find that 6 percent of farm businesses received about $56,000 each on average in lease and royalty income associated with energy production. However, it is unclear how much of this wealth is captured where production occurs as opposed to more distant locations. Brown et al. (2015) observe that local ownership of mineral rights varies substantially across plays, from an average low of 12 percent in the Permian in Texas to a high of 55 percent in the Marcellus in Ohio and Pennsylvania.

Similar questions about the distribution of benefits arise with employment and wage income from unconventional energy development. As noted earlier, academic studies of employment effects suggest that development has modest positive impacts on employment. With the exception of Wrenn et al. (2015), these studies have relied upon federal employment data. Employment data can be based upon place of residence or place of work. Federal employment data that are based upon place of work (which count jobs without regard to the workers' place of residence) can result in misleading conclusions about local impacts of sectors that are heavily reliant upon a transient workforce. Wrenn et al. (2015) used State tax data to consider employment effects on county residents, and, contrasting this with federal data, found that about half of the created jobs go to non-residents. They conclude that much of the increase in employment from Marcellus shale development in Pennsylvania has benefited out-of-county and out-of-state residents.

Mineral rights ownership

In the United States, ownership of mineral resources was originally granted to the individuals or organizations that owned the surface. These property owners had both "surface rights" and "mineral rights." However, mineral rights can be sold or conveyed independent of surface rights. For this reason, the ownership of most prospective oil and gas acreage is highly fragmented among numerous private owners competing with one another to negotiate with companies (McKie, 1960). Oil and gas extraction historically has involved thousands of small "independent" companies, which yields a high degree of competition in the leasing market (Davidson, 1963).

Both surface and mineral rights owners are potentially affected by oil and gas development. In some cases, the persons who own the surface and mineral rights are not the same individuals who own the given acreage (split estate). Mineral rights are considered the dominant estate, meaning that they take precedence over other rights associated with the property, including those associated with owning the surface (BLM, 2009). Such split estates potentially create equity issues, in that the mineral rights owners receive some financial benefits of oil or gas development, in the form of lease and royalty payments, while the surface owners often do not receive compensation. Moreover, surface owners may experience some temporary or permanent loss of the use of their land or experience inconveniences or nuisances while development is occurring on their land. Mineral owners must show due regard for the interests of surface estate owners and occupy only those portions of the surface that are reasonably necessary to develop the mineral estate (BLM, 2009). However, in an analysis of a survey of West Virginia land owners with completed shale gas wells located on their property, Collins and Nkansah (2015) found that surface owners of split estates had a statistically greater number of reported problems with drilling than surface owners who also owned their mineral rights and that dissatisfaction was explained by a perception of compensation inadequacy. Some States, such as Colorado, New Mexico, Utah, and Wyoming, have responded to split-estate issues with legislation to expand surface owner rights (Collins and Nkansah 2015).

The prevalence of split estates is an unknown quantity across much of the United States. Most records of mineral rights ownership are in county offices in paper format and can date back several decades. The Homestead Act of 1862 disbursed both land and minerals to settlers, but after the Stock-Raising Homestead Act of 1916, the Federal Government no longer disbursed mineral ownership along with the land rights. Thus, properties in the Western United States homesteaded after 1916 are split estates. Split estates are also common in areas with historical oil, gas, or coal development, such as in Texas and southwest Pennsylvania, and are less common in areas with no prior drilling history, such as northeastern Pennsylvania. Unlike most countries, private individuals own most of the subsurface resources in the United States (Williamson and Daum, 1959). For privately held mineral rights, state and local governments handle most of the laws and regulations. In communities where split estates are common, the lack of readily accessible public information about mineral rights ownership makes it very difficult to accurately understand the extent of local ownership, and thus what percentage of the lease and royalty dollars is going to local residents.

Zoning and other local regulation

Richardson et al. (2013) find that 65 percent of shale States have building setback restrictions, ranging from 100 to 1,000 feet from the wellbore, with an average of 308 feet. Setback provisions regulate how far away oil and gas wells must be from a person's residence or any other commercial structure. While these laws are passed at the State level, the local city or county government often handles zoning and other land-use issues. As a result, there is considerable variation in the types of laws and degrees of regulation placed on oil and gas development across the United States.

How much control local governments should have to regulate gas or oil development activities has been a source of major contention in some States, with States providing varying local authority (and experiencing court cases). Several States, including New York and Pennsylvania, have had recent court rulings that overrode State laws preempting local control of gas development, with the courts explicitly stating that such preemption of local control shifts major risks onto local communities (see *Robinson v. Commonwealth of Pennsylvania;* and *Norse Energy Corp. v. Town of Dryden*). Local control, such as zoning authority, raises several issues, including local capacity to effectively wield that authority and the difficulty of implementing zoning rules when the decisions in question potentially affect millions of dollars in royalty payments, as well as environmental justice and equity issues across communities (Kelsey et al., 2016).

Local Fiscal Issues

The impact of energy development on state and local governments depends critically upon the structure of taxation and expenditures in affected jurisdictions, in addition to the level, pace, and duration of the development activity. In most States, State governments set and modify the fiscal codes. Consequently, local governments typically are only able to choose from the tax options granted to them by their State government. Thus, policy decisions at the State level have a significant effect on both state-level and local fiscal outcomes. These involve decisions regarding the types of fiscal instruments, such as taxes and fees, used by the State; how the dollars collected through instruments are used; and the types of fiscal instruments, including taxes and fees that are available to local governments and school districts.

Most States with fossil fuel extraction have mechanisms for tax collection, although the specific policies, rates, and revenues vary considerably across States. Usually the State-level policies are some form of a severance or production tax based on the value or quantity of the resource extracted. In some oil- and gas-producing States (e.g., Texas, Wyoming, Arkansas, and Colorado), extraction is also subject to local property taxes that help support local finances. In other States (e.g., Louisiana, North Dakota, and Pennsylvania) they are not, and finances must be redirected to local communities only through State funding-distribution mechanisms (Raimi and Newell, 2014; Newell and Raimi, 2015). Some States, such as Pennsylvania, levy an impact fee on a per well basis, with the schedule of fees determined by the price of natural gas and age of the well. States also levy a number of other taxes and fees, not specifically targeted to energy development, but that can often be affected by energy development activities. Examples include sales taxes, liquid fuels (gasoline and diesel) taxes, State income taxes, and corporate income taxes. In the midst of changes brought about from the shale gas and oil boom, a number of States have also been revising their oil and gas tax policies (Rabe and Hampton, 2014).

State governments make critical policy decisions in their choices about where tax and fee dollars generated from energy development go. The choices involve at least two major dimensions, including the extent to which the dollars are targeted to specific purposes, and whether these are spent in the year they're collected or instead are set aside to be spent over multiple years. In practice, dollars go into the State's General Fund, and are used to either support overall State spending, or are targeted to specific programs (such as environmental remediation or open space purchases) or specific geographic locations within the State, such as the counties and local communities where development is occurring. The choice can be politically sensitive; in 2010, legislation to implement a State severance tax in Pennsylvania was unsuccessful, in part due to disagreements regarding the allocation of such dollars (Law360, 2011).

Local jurisdictions, such as county and municipal governments and school districts, have less flexibility in developing policy alternatives, and are typically limited to the tax choices granted them by their State government. The types of taxes local jurisdictions are allowed to impose has a significant effect on the local fiscal impact of energy development. For example, oil and gas production are subject to the real property tax in Texas, which means that local governments and school districts there can reap significant windfalls from development (Weber, Burnett, and Xiarchos, 2016). In West Virginia, the value of the mineral resource underground is also subject to the real property tax, which can lead to similar windfalls. However, in some other States, such as Louisiana and Pennsylvania, neither production nor the resource is subject to the real property tax, and local funding relies on state funding distribution. Property taxes collected by local governments are used to cover current costs of local public services and education. They can represent local preferences and may even affect where extraction occurs and externalities are experienced;

however, ultimately, firms go where resource extraction is economically most feasible, making taxes a less important factor in the location decision (Brown and Lambert, 2016). Montana and North Dakota are examples of States that levy a higher severance tax in lieu of property taxes in order to redistribute some of the revenue to local schools and governments (Newell and Raimi, 2015). Wyoming and Colorado set state-assessed valuations for minerals and then use fiscal means to redistribute revenues across the State.

Similarly, there is considerable variation in how utility-scale renewable energy facilities are taxed, and how and when funds are available to local jurisdictions where such facilities are sited. Currently, at least two States (Wyoming and Minnesota) impose an energy production tax, with a substantial portion of the produced revenues distributed back to the counties in which wind power facilities are located. State, county, and municipal governments also can receive a short-term boost in revenues from increased sales taxes generated by spending associated with construction-phase wage and salary earnings, and longer-term increases resulting from taxes on real property and capital equipment, including the wind turbines.

However, there is a great deal of variation in state property tax systems and associated county-level tax revenue generation from renewable energy facilities. In some States, such as Oregon and Wyoming, counties may experience very large tax revenue benefits, while in other States, like Colorado, Idaho, and Montana, local revenue effects are much more limited. For example, Haggerty et al. (2014) estimated potential property tax revenue from a $100 million investment in renewable energy generation facilities across 17 nonmetropolitan counties in 11 Western States, and found that hypothetical property tax revenue in the first year would range from $32,000 to nearly $850,000, based on very different taxation systems. In addition, depreciation schedules applied to taxable capital equipment and facilities can, in some instances, cause a steep decline in the amounts of tax revenues collected within just a few years of project completion; in their analysis of western counties, Haggerty et al. estimated that revenues would drop by nearly 50 percent after only 10 years (see also Krannich et al., 2015). Because of this, what might initially appear to be a financial windfall for local governments can fade to relative insignificance over a relatively brief period.

Fiscal impacts for local governments will depend on revenues and increased needs for service provision. Demand for road maintenance and repair increases with industry traffic especially in cases of insufficient infrastructure (Abramzon et al., 2014). Rapid population growth, especially in more remote and rural settings, puts pressure on sewer and water services, often necessitating upgrades and expanded investment (Kolb and Williamson, 2012). Spending often involves long-term commitments and risk. Police, hospital, and emergency services also increase because of increased industry activities, as well as increased and more heterogeneous populations. Small, rural communities with limited staffing will experience staffing pressures and have to reshuffle responsibilities and hire additional staff (Jacobson and Kelsey, 2011). While local community revenues can benefit from the industry activity, revenues often lag service needs. Environmental costs can arise contemporaneously or in the future as legacy costs. The danger is that choices about infrastructure and service expenditures might be made without consideration of future needs. Even with prudent governance, decisions will need to be made under uncertainty about the future (e.g., the revenue potential, and the length of play productivity).

Raimi and Newell (2016a, 2016b) find that while the net fiscal impact of oil and gas development has been mostly positive for local governments between 2013-2015, regions that are more rural have experienced fiscal challenges. Additionally, regions with lower economic diversity, and with fiscal dependence on oil and gas activity, will face fiscal challenges due to revenue volatility, especially if lower oil prices continue for prolonged periods.

A critical factor is whether the funds derived from taxes and fees are all to be spent in the year in which they are collected, or alternatively, are to be set aside for use in future years and to address future needs. By their nature, revenues from the development of nonrenewable energy sources, such as shale gas or oil, will similarly be nonrenewable and will ebb and flow with development and production activity. Using the dollars in the year in which they are collected helps short-term needs, yet leaves nothing to address costs in future years that may result from the current activities. There are prime examples of such legacy issues, including mining-related acid mine drainage and abandoned and orphaned well remediation (U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, 2016), that strongly suggest that there could be future costs due to current activities and that perhaps little revenue may be left at that time to pay for them.

Some States, such as North Dakota and Wyoming, have explicitly recognized this temporal disconnect between revenues and expenditures by setting dollars aside in a mineral trust fund with rules that make it difficult for the dollars to be raided for current short-run needs. Other States have variations on mineral trust funds that set aside similar amounts but limited financial instruments. New Mexico, Utah, and Montana have limited trust funds that rely primarily on a severance tax as a source; in Montana, such a fund is only used for coal, while other States have funds for a mix of minerals. In fact, what is taxable under severance tax varies quite a bit across States. State regulations can include requirements for supermajority approval in the legislature to allocate funds, restrictions on spending the principal, or designation of the year in which funds can be accessed. Other States have instead largely spent such funds in the year in which they are collected, leaving nothing for future years (or future generations) to cover any long-run costs.

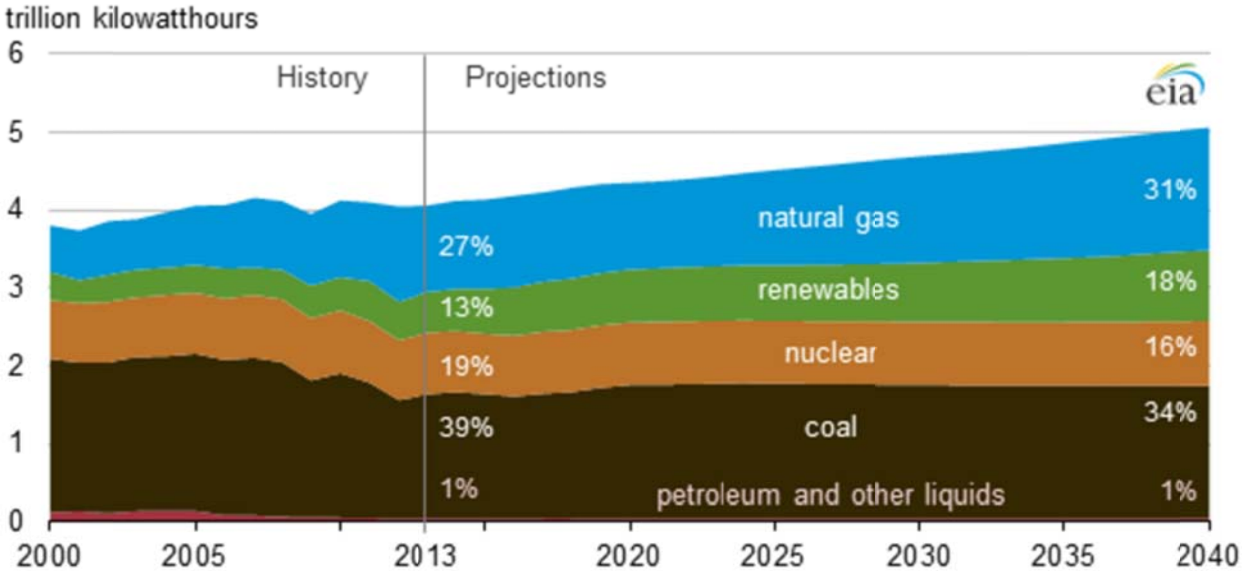
Another fiscal issue is the extent to which local spending during oil and gas development is on operational expenses, such as paying employees' salaries and the costs of current operations, or on capital costs or improvements, such as new equipment, buildings, or infrastructure. Operational expenses typically provide value in the year in which they occur and may be warranted if the employees are engaged in tasks associated with the development activity, such as regulatory enforcement and compliance, planning, or services affected by the development. Operational expenses typically leave little long-run legacy, compared to capital spending, which can provide the state or jurisdiction with better infrastructure, equipment, or other assets which may contribute to the community over multiple years.

Reliance on tax and fee dollars from energy development raises several difficulties unique to the source. Energy prices are highly variable, reflecting changes in market supply and demand. High energy prices spur development activity, while low prices typically lead to a major (and sometimes sudden) decline in activity, both with possible major effects on tax and fee collections. From a fiscal perspective, this means that tax and fee revenues can be highly variable from year to year, making it difficult for policymakers to budget accurately. This can make it very difficult for state and local jurisdictions to plan accurately; not only is it difficult for them to predict how long specific services might be needed (and in what quantity), but it is similarly difficult to predict how long the revenues will flow to cover long-run financial commitments. In addition, some revenues generated by new energy development tend to be relatively short-lived, as in the case of taxes on capital facilities and equipment that typically decline substantially after just a few years due to accelerated depreciation schedules. Investing in capital needs that become most pressing during a period of rapid growth and development accompanying an energy boom, such as expanding a sewerage plant or building new schools, can be risky for a local community. If the energy activity in the community slows or ends before that investment is fully paid off, local residents may be stuck with the entire bill for infrastructure that they no longer need or are able to afford.

Transition Considerations

Weaving in and out of the current discussions and debates surrounding the impacts of unconventional oil and gas and renewable energy development on communities is the broader issue of the present transition to lower-GHG forms of electricity.

Figure 5. Electricity generation by fuel type in the Annual Energy Outlook 2015 reference case, 2000–2040.



Source: Energy Information Agency (2015b).

The transition to a lower carbon-energy economy began in the early 2000s. According to Energy Information Agency data and analysis, coal-based electricity has declined by 12 percent since 2001 while natural gas has increased by 46 percent. Its plentiful supplies, low price, and distributional ease has propelled the increased share of natural gas. Utility-level electricity generation from wind and solar has increased by factors of 2.5 and 3.1 in that same period. Natural gas and renewables are expected to grow further in the future, while it is projected that nuclear and coal will account for a smaller share of generation (Figure 5).

Additions to future power generation are expected solely from gas and renewables. In 2015, coal-fired capacity dropped by 5 percent as 14 GW of capacity retired, and an additional 26 GW of retirements are expected by 2025 (EIA, 2015b). Coal-plant retirements are driven by plant age, a corresponding decline in efficiency (and increase in per-MWh generation cost), and the cost of expected upgrade requirements from the 2015 CPP. The transition to a lower carbon economy will be facilitated by coal power plants reaching the ends of their lives in the coming 15 years. However, as the United States replaces coal with natural gas and renewables, legacy issues from retiring fossil fuel-based economies will have to be addressed and structural changes in the national energy system will be required, with local implications for rural America.

Legacy Issues

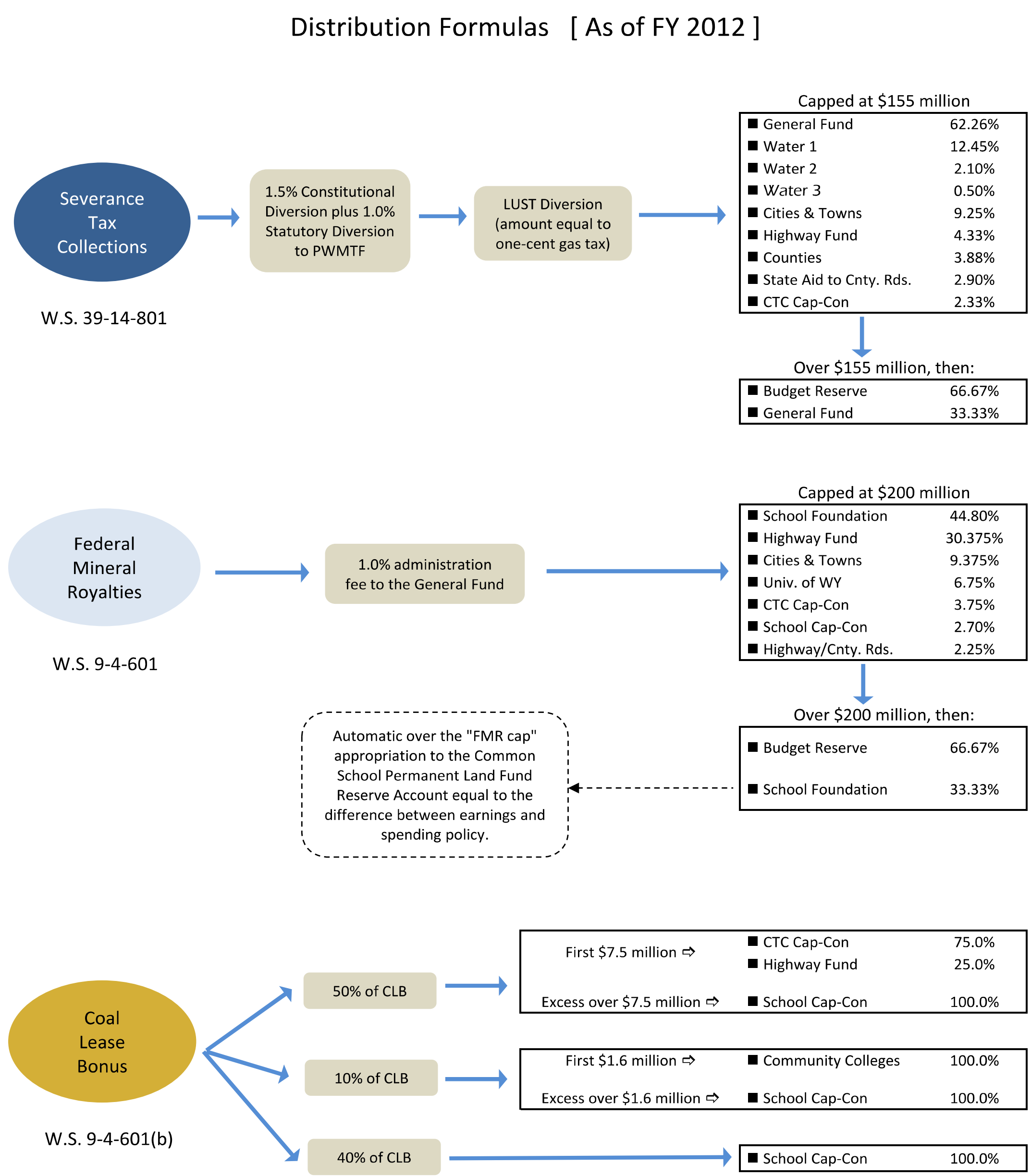
A set of challenges to the transition away from coal relates to both state and local governments' fiscal dependencies on revenues generated by fossil fuels. Since, in the medium term, natural gas will likely continue to be a backstop for renewables, fiscal linkages with natural gas will still be important. However, the move away from coal in areas where coal has traditionally been mined will require considerable political reconsideration of sources of state and local government funding. Wyoming's linkages can provide an example of this challenge. Figure 6 maps the linkages between some of the major tax sources generated by coal, oil, and gas and vital state and local government services. It also shows how complicated transitioning can be. Dependencies cover education, water development, roads, and state and local government general funds. Not included are ad valorem taxes, which fund primarily local government and K–12 public education. The degree to which these revenues change can vary considerably across States. While, where resources allow, opportunities in renewables can be pursued in areas with traditional coal dependence, renewables are not as connected to the tax system as fossil fuels have been.

As demand for natural gas replaces the demand for coal, increases in natural gas production can potentially mitigate some of the decline in revenues from coal in areas rich in both resources. However, revenues from one industry may not match reductions from the other, and transition costs can still arise. For example, a recent analysis of Wyoming's proposed CPP illustrates that the shift away from coal and towards renewables and natural gas helps but does not compensate for the loss of coal tax revenues (Godby, et al., 2015).

Another major challenge to transitioning away from coal has been the environmental legacy that remains. This legacy has been managed, for coal, by the Surface Mining and Control Act (SMCRA) and the corresponding Abandoned Mine Land Fund (AML). The law coordinates the funding of both reclamation and mitigation activities with AML funds from State agencies. The regulation is framed around cleanup and mitigation financed by a viable functioning industry. Current industry revenues finance both mitigation of current environmental spillovers and legacy issues surrounding abandoned coal mines, most notably in Appalachia. The AML fund is designed to provide compensation to miners' health funds, funding for reclamation problems of abandoned mines, and assistance to communities in transitioning to a post-coal economy. Its weakness is that it relies on the industry remaining economically viable—the fund depends on revenues generated from mining to finance reclamation and other environmental costs, as well as legacy costs. If a State has to take over reclamation, general State funds are used.

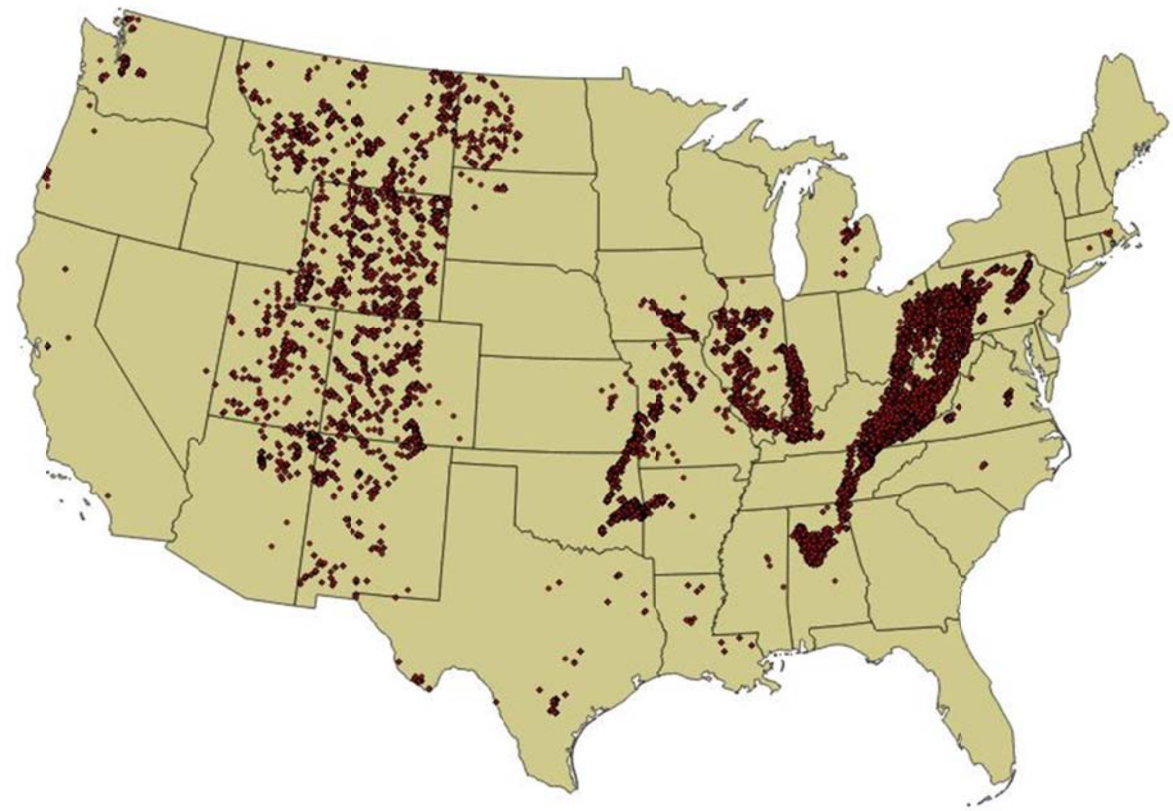
During the transition to less carbon-intense production, the pace of impacts may not parallel the pace of revenue changes. For example, in Wyoming, net land disturbance is increasing, while production is decreasing. When changes in the industry are structural rather than cyclical, the resulting revenue shortfalls can affect both States and the industry in fulfilling their agreements to clean up. Furthermore, the management of abandoned mine lands can be influenced by changes in the industry, as well as by environmental and social objectives. Figure 7 identifies the current inventory of the variety of abandoned mine land problems. The federal Office of Surface Mining Reclamation and Enforcement (OSMRE) identifies over 53,000 separate sites ranging from contamination to unstable hillsides. Approximately 83 percent of those identified sites are in the Midwest and Appalachia. Notably, much of the work on the sites is financed by the generation of AML funding in the West from active coal mines. Issues of subsidence, open portals, and vertical openings (for underground mines) comprise the largest component of what OSMRE has identified as high priority. These, by their nature, impose significant risks to nearby communities and are expensive to fix. Other identified hazards and problems include unstable slopes and highwalls, hazardous equipment and facilities in old mining staging areas, and riparian problems. The cost of remediating these hazards can be substantial and can vary considerably according to the particular type of problem that communities and OSMRE encounter.

Figure 6. Fiscal linkages between energy resources and vital Government services.



Note: PWMTF is the acronym for Permanent Wyoming Mineral Trust Fund, LUST is the acronym for Leaking Underground Fuel Storage Tank, FMR is the acronym for Federal Mineral Royalties, CLB is the acronym for Coal Lease Bonus, CTC is an acronym for Cities, Towns, and Counties, Cap-Con is the acronym for Capital Construction.
Source: Wyoming State Government (2012)

Figure 7. Locations of abandoned mine land (AML) problem sites in the lower 48 States in the United States.



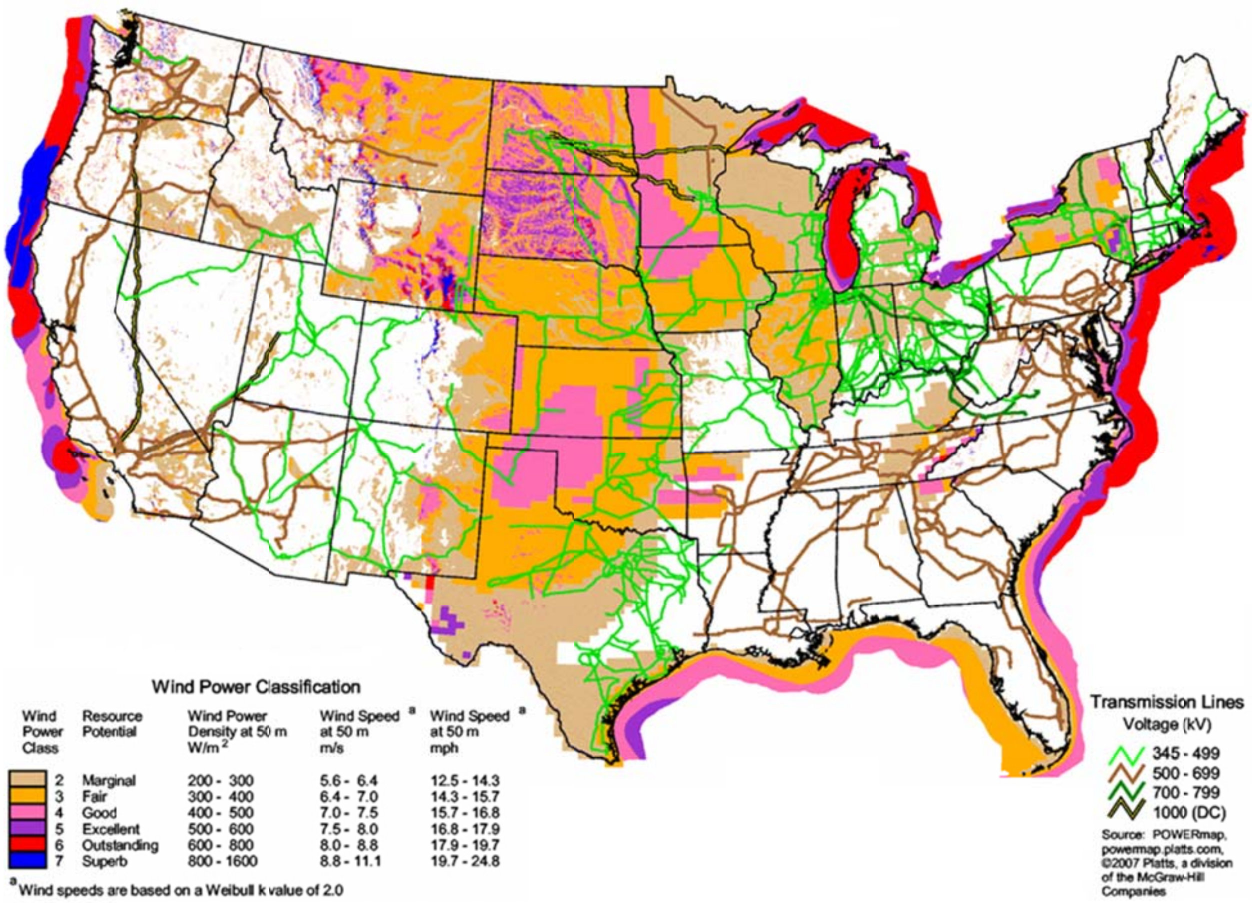
Source: U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, 2016

Infrastructure

Several challenges for infrastructure arise in the transition to a lower carbon-energy economy. Transmission investments to integrate renewable energy resources remain a major obstacle. In the Western United States, private property concerns and endangered species are often part of the reason why transmission is not fully developed. Connecting geographically disparate sources with concentrations of electricity demand will require a more extensive and "smarter" grid in which consumer demands can coordinate with the stochastic aspects of renewable energy. Both renewables and natural gas are less storable, which increases variability risks. Variability in both production and load means extra coordination and control technologies that were not part of the original creation of the grid. The grid which was originally designed in the 1890s has grown and developed considerably to over 9,200 production nodes. Meeting the demands that a more electrified society with inherently variable energy capacity utilization will require significant new investment and technologies.

The power system's historical reliance on hydropower and coal means that areas rich in wind and solar resources are not as well connected to the existing electricity transmission grid. Figure 8 shows that the Great Plains area of high wind-power potential contains transmission lines with less than 500 kV capacity, in contrast to the Eastern United States, where 500–700 kV transmission lines predominate. However, the institutional framework in the United States does not allow sufficient authority, even coordination for timely system planning (Jimison and White, 2013), given that lines literally cross many land owners' property and fall into the jurisdiction of many regulatory and government agencies. The coordination costs of large-scale transmission can be a challenge. For example, Pacific Corp, in the Rocky Mountain West, is facing opposition in parts of the planned route of Gateway West, 1,000 miles of 230–500 kV. Another challenge to expanding transmission is, ironically, development of renewable portfolio standards and the desire for local energy sources. Early work by Godby et al. (2013) estimated that Colorado ratepayers would benefit by expanding transmission capacity from lower cost production in Wyoming, but the State has yet to agree to expanding capacity, in part because of a preference for local control of production.

Figure 8. Access of wind resources to existing transmission lines



Source: National Renewable Energy Laboratory (2014)

Distributed generation (DG) can be utilized as a supplement and alternative to large conventional central power stations by delaying distribution system upgrades, reducing the need to build new transmission lines to carry power from distant grid-scale generation, and spatially diversify generation for better system balancing and more resiliency. The drawback of DG is that small renewable energy systems cost considerably more than grid-scale systems. For example, small solar PV installations of less than 10 kW cost about $4/W compared to $3/W for installations larger than 100 kW, while for wind, the difference is even greater, with small wind (less than 10 kW) involving costs that are more than double the cost of systems greater than 100KW—$8/W versus $3.5/W (NREL, 2013).

Another barrier comes from the intermittency of wind and solar energy that can increase system costs, as output fluctuations must be balanced with other generators, mostly fast-ramping natural gas power plants. Intermittency can be mitigated with cost-effective energy storage or with integrated landscape-level developments that can account for temporal variations in energy production (Ananthanarayanan and Naughton, 2013; Naughton et al., 2013; NREL, 2014). While investment in energy storage continues to hold promise for the future, MacDonald et al. (2016) recommend the use of new high-voltage direct current power lines (HVD.C.) to move renewable power across the Nation based on existing technologies. Their proposition is based on the fact that renewable energy output might be intermittent on a local or regional scale but would have a more constant flow at a national scale.

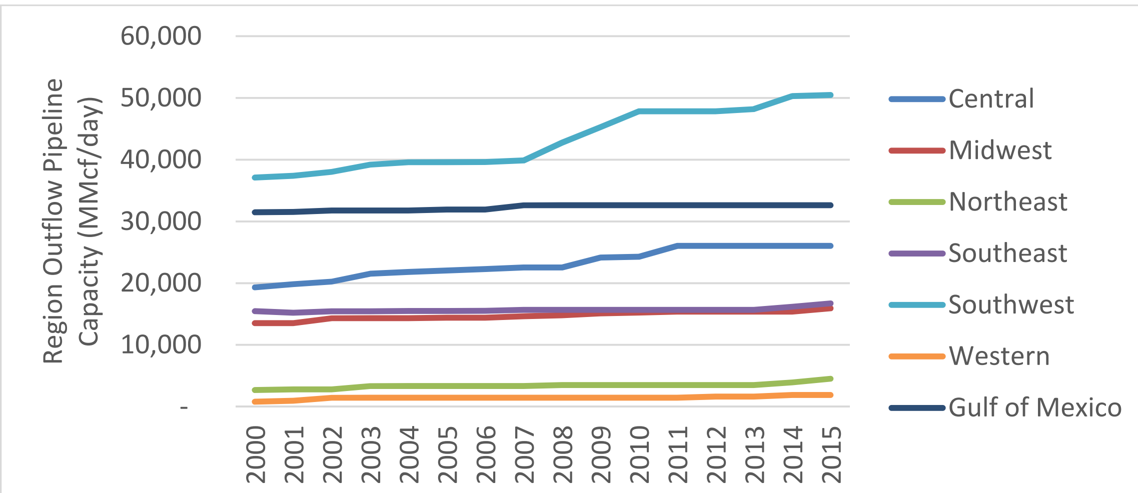
Expansion of wind and solar power is possible with improved transmission system integration and technological advances in power storage systems. A study by the National Renewable Energy Laboratory on part of the Western Grid encompassing Nevada, Arizona, New Mexico, Colorado, and Wyoming estimated that a penetration rate of 30 percent for wind and 5 percent for solar was feasible, assuming a set of conditions summarized as more transmission and more intensive management (NREL, 2014). For example, a larger geographic area to draw wind and solar from can reduce variability, demand response programs can provide flexibility, scheduling sub-hourly generation can reduce fast-ramping reserve needs, and weather forecast use can reduce operational costs (NREL, 2014). An emerging opportunity for renewables that encompasses the issue of geography, cost, and enhancing reliability is the notion of the smart grid. NREL's Smart Grid initiative identifies seven goals for improving the Nation's grid: (a) more efficient transmission of electricity; (b) quicker restoration of electricity after power disturbances; (c) reduced operations and management costs for utilities, and, ultimately, lower power costs for consumers; (d) reduced peak demand, which will also help to lower electricity rates; (e) increased integration of large-scale renewable energy systems; (f) better integration of customer-owned power generation systems, including renewable energy systems, and (g) improved security. Components of this new design of an electricity grid are already being tested in locations across the country, such as the Pacific Northwest Smart Grid Demonstration Project (BPA, 2016).

Correspondingly, the pipeline network, which was designed to transport oil and gas produced in conventional fields to demand centers, is now struggling to adapt to new movements from shale plays and ship increasing amount of oil and gas, with insufficient existing lines. In 2015, pipelines over land cost on average $5.24 million/mile (Smith, 2015). While new natural gas pipelines are reviewed and permitted at the federal level by the Federal Energy Regulatory Commission (FERC), interstate oil pipelines are reviewed and permitted almost exclusively at the State level (Klass and Meinhardt, 2015). As shown in figure 9, natural gas pipeline capacity expansion has been more flexible than interconnection of renewables on the grid.

Additionally, with new production areas becoming net exporters, the direction of flow was reversed on eight natural gas pipelines from 2013 to 2015 (EIA, 2015c).

Oil can be moved economically by means other than a pipeline, such as rail, barge, and ship. In 2015, 19 percent of crude oil shipments from the Rocky Mountain region, which includes the Bakken shale play, were shipped by rail (EIA, 2015d). However, natural gas that is produced along with oil in the Bakken shale was flared because of its low market value in that region and lack of pipeline capacity to transport natural gas to other regions. While rail shipments have relieved bottlenecks in oil pipelines, they have contributed to congestion in the rail network and have raised safety concerns; especially in rural areas where there may be less oversight and fewer resources to respond to a serious incident (GAO, 2014). For example, derailments and resulting cleanup costs have increased, and more stringent safety requirements were necessary. Oil by rail shipments through Chicago have increased from just 3,000 carloads in 2006 to 650,000 carloads in 2014, as oil produced in the Bakken shale play is transported by rail from North Dakota to refineries and ports in the Northeast (Amtrak 2015).[§] The agriculture industry in the Upper Midwest has also been impacted by the new demand for rail freight services from oil producers in the Bakken. Oil shipments from the Bakken and a record crop year in 2014 caused a backlog in grain shipments, depressing local crop prices by $0.11 to $0.18 per bushel and reducing cash receipts of grain and oilseed producers by 3 percent (USDA, 2015).

Figure 9. Region outflow natural gas pipeline capacity.



Source: Energy Information Administration pipeline State-to-State capacity data (EIA, 2015e).

Drilling and producing unconventional oil and gas tend to have a larger impact on local infrastructure than the development of renewable power (BLM, 2016; Godby et al., 2009). The drilling rig, water, chemicals, and sand used to drill and hydraulically fracture a well must be transported to the drilling site, and the produced wastewater, natural gas, and tight oil must be transported away from the site over highways, pipelines, and rail. One of the most commonly expressed concerns of local government officials regarding unconventional gas development is the impact on roads and traffic due to significantly increased truck traffic (Raimi and Newell, 2014; Jacobson and Kelsey, 2011). For example, traffic volume on secondary roads in one Pennsylvania county increased from 150 vehicles a day to an additional 700 trucks per day (Murkawski, 2013), which can affect road maintenance and traffic safety. The effect on local expenditures varies by State. In some jurisdictions, such as Colorado, Montana, and Texas, local governments had to substantially increase their road repair and maintenance expenditures (Raimi and Newell, 2014). In contrast, local governments in Pennsylvania report that gas companies are covering repair costs, in part due to road use agreements between the companies and governments (Jacobson and Kelsey, 2011; Raimi and Newell, 2014).

[§] This mirrors the effects of the EPA's Acid Rain Program, which regulated sulfur dioxide emissions from coal power plants. The result of the program was a new demand for shipping low-sulfur coal from Wyoming's Powder River Basin to coal power plants in the East. Freight trains carrying low-sulfur coal passed through Chicago.

Concluding Remarks

The energy sector of the United States economy is in the midst of a deep transformation, which is substantially affecting rural areas. This transition has come with, potentially, both positive and negative changes to rural communities. Moreover, it has implications not only for communities where new energy production is expanding but also for communities where traditional energy sectors are contracting. This paper summarizes some of the major issues that rural communities are confronting as new production technologies and policy incentives lead the expansion in oil and gas development and the transition to renewables. It also identifies some of the environmental and fiscal spillovers from moving towards a lower carbon energy economy, touching on legacy issues and structural dependencies in parts of the fossil fuel industry.

Energy investments, especially in unconventional oil and gas extraction, can provide a new source of economic activity, jobs, and income to local communities. However, the fiscal complexities of rapid deployment bring about the risk of a boom-and-bust cycle, which can alter the composition of local economies and unravel the seams of local communities. Various approaches to taxation exist, both at the local and state level, across the United States, ranging from impact fees to severance, use, or property taxes. The management of these funds is instrumental in determining how communities cope with short-term needs and, most importantly, how they direct long-term outcomes.

Booms can generate short-term benefits for communities in greater tax revenues. Fiscal agents can spend these revenues for needed education and infrastructure improvements. However, local jurisdictions, driven by policy approaches of State legislatures, typically have less flexibility regarding how they can tax oil and gas development or renewables. For example, in some States, like Texas and Wyoming, extraction is subject to local property taxes, while in others, like North Dakota and Pennsylvania, it is not. Since impacts are local, this can limit the ability of communities to manage development. Boom times can become an important source of improved livelihood for rural areas without dynamic job markets. However, the overall impacts of development may be temporary. Impacts eventually depend on local and state policies' ability to transform short-term windfalls into long-term benefits for local residents. Planning current expenditures with consideration for future expenses is indispensable for fiscal stability and health.

Expansion in oil and natural gas and renewables has a number of other local impacts as well. Environmental effects of unconventional oil and gas development can include increased congestion on roads, dust and transportation-based pollution, and risk of groundwater contamination with faulty well development, among others. Fugitive emissions from unconventional oil and gas development can end up countering efforts to reduce GHG impacts. Other impacts of unconventional natural gas and oil development include pressure on local housing, rent, wages, public infrastructure and public services, as well as concerns about local area quality of life. Local impacts of utility-scale renewable systems include visual (aesthetic) effects, land fragmentation, and risk of mortality to migratory and upland game birds. Concerns over the impacts on housing values have also been debated, both for fossil and renewable installations.

More intentional and creative solutions can be warranted. There are some examples of successful coordination with industry to address road issues, for example, the Coal Bed Methane Coordination Coalition in Wyoming and Montana provided a forum for land owners and the energy industry to solve problems (States et al., 2003) and road-use agreements between the gas companies and governments in Pennsylvania that report to cover road-repair costs. In terms of reclamation, approaches adopted by state and local governments include different sets of bonding and other monetary instruments (insurance, impact fees, etc.) as well as State environmental regulatory requirements; however, no State has a comprehensive bond that covers all disturbance costs, and the use of a bond as an incentive for reclamation has been only partially successful. Some States, like North Dakota and Wyoming, recognize future needs and set funds aside in a dedicated mineral trust fund. Across State lines, the Abandoned Mine Land Fund (AML) provides an archetype for reclamation and mitigation relative to coal mines, yet it also highlights how energy source transition can limit reclamation funds.

Local reactions are influenced by the distribution of associated benefits and costs—between local and non-local populations and interests, and also among local residents. In both shale and renewable power, the distribution of potential costs and benefits of energy development can vary substantially both across and within local areas. While social and environmental costs can be experienced broadly in the community, or close to energy installations, energy payments are concentrated, and mineral rights can be split from surface rights. Also, residents of rural areas may see themselves as disproportionately bearing the costs and impacts of siting renewable and other energy production sources, while expanded energy supplies are used primarily to meet the needs of distant urban populations (Ottinger, 2013; Phadke, 2013). Such concerns will increase as the rural population in the United States is projected to decrease from about 19 percent in 2015 to about 13 percent in 2050 (United Nations, 2014). These differences in local benefits and cost participation may contribute to tensions between owners and non-owners and also between local communities and other regions. Those tensions can represent important impacts in their own right and may become barriers to further energy development in some areas.

Another impediment can be infrastructure constraints, both for oil and natural gas and for renewables. Transmission lines and pipelines cross State borders, public lands, and private properties. While utilities and pipeline builders have eminent domain rights and can, in theory, acquire private property for the public good with just compensation, the process of building and expanding these types of energy infrastructure networks is lengthy and expensive, and can often be controversial in the communities in which infrastructure building projects have been planned. Specifically, oil can be transported via pipeline, rail, or truck. The existing transmission infrastructure for electric power represents a much greater constraint for expansion and will require new transmission corridors and more coordination.

The regulatory framework that has developed around the fossil fuel industry and the transition to renewables can vary substantially from State to State. Unconventional gas and oil does not have legislation similar to SMCRA to establish how energy development and cleanup are conducted. Regulatory structures range from local development impact fees to insurance fees to direct taxes on the value of commodities removed. Coordination and collaboration can be contentious when national initiatives and local impact management collide. Renewable energy is even less coordinated. Wind and solar regulation, in particular, have been a state and local government affair, but are partially federally regulated on the transmission side.

Finally, the move to natural gas and renewables cannot be put into perspective without identifying legacy issues that remain while transitioning out of a more traditionally coal-based energy economy. States and communities have become dependent on fiscal structures and reclamation policies that only provide funding as long as industries remain economically viable. Energy taxes in coal country States are sometimes wired directly to state allocation accounts that end up at the county or community level, local infrastructure spending, or local education. Rules that govern mitigation and reclamation and their financing are also built around an economically viable industry. Economic diversification can help local economies overcome fiscal and economy resource dependence.

The transformation in the energy environment is restructuring the geographic composition of energy-producing locales. Rapid expansion has brought new regions into the energy market with less experience in the industry and in managing activities and impacts associated with it in the short and long run. On the other hand, traditional coal producing regions are feeling the economic pressures of industry decline. Additionally, this transformation is influencing the transportation network of the country. Rail shipments of coal are declining while shipments of oil are increasing and contributing to congestion in the rail network, especially the BNSF Railway and Union Pacific Railroads. More characteristically, the direction of flow has reversed on a number of gas pipelines. The deployment of renewable resources will further influence the geographic composition of the grid by bringing completely new nodes onto the electric grid system. Renewable developments occurring in areas that have traditionally focused on fossil energy production may provide opportunities for a smoother transition away from coal- and oil-based local economies; however, significant reformation of the local economic and financing makeup will still occur.

In closing, it is important to underline that this report assumes that the transition to lower GHG forms of electricity will continue to weigh more heavily towards natural gas and renewables. However, climate, policy, and technological influences can change future energy composition and distribution. For example, critical mineral constraints can change the pricing and distribution of renewable energy. Additionally, whether natural gas may delay renewable energies from becoming economically competitive is still debated in the literature (Shearer et al., 2014); this can also influence the future energy configuration in terms of resources, geographic distribution of production, and rural impacts. On the other hand, investments in low-emission technologies, such as high-efficiency, low-emission (HELE) coal technologies and carbon capture, use, and storage (CCUS) may rebalance the energy composition further. The dynamics in the energy configuration will continue to evolve with different potential impacts in rural America.

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