Distributed Energy Resources

A primer for Missouri farmers

Extension
University of Missouri

MX99

The following authors contributed to this report:

Matt Ernst	Independent Writer
Joe Horner	Agricultural Economist, MU Extension
Ryan Milhollin	Assistant Extension Professor, Agricultural Business and Policy, MU Extension

Corresponding Author:
Joe Horner
University of Missouri Extension
223 Mumford Hall
Columbia, MO 65211

Contents

Introduction

Major changes are underway in how electricity is generated, distributed and used. These changes will impact rural Missourians. Renewable fuels, especially wind and solar, are continuing to increase in the U.S. New electricity storage systems and "smart grid" technologies are improving energy use and efficiency. These are just a few of the factors prompting energy suppliers to rethink centralized generation models and consider "distributed electricity resources" as a way to generate, store and deliver electrical power in the future.

Electricity usage is also changing. Electricity now powers more automobiles and machinery, and electric vehicle numbers are expected to keep increasing. Both consumers and suppliers continue adopting new technologies to improve energy efficiency and conservation. On-site ("behind-the-meter") electrical generation is more common, and there are various reasons and incentives for businesses and consumers to increase renewable energy use.

> Distributed energy resources are "a variety of small, modular power-generating technologies that can be combined with energy management and storage systems and used to improve the operation of the electricity delivery system, whether or not those technologies are connected to an electricity grid."
>
> (U.S. Department of Energy)

Changes in how electricity is supplied and used contribute to two common scenarios in rural Missouri. First, farmers and rural landowners are receiving land lease proposals from utility-scale wind and solar energy developers. Second, consumers are considering purchases of on-farm solar panels, generators, batteries and other behind the meter electrical systems. Both scenarios are likely to persist for several reasons:

- Plans for additional renewable energy development (wind and solar) published by some Missouri utility providers in their integrated resource plans on file with the Missouri Public Service Commission.
- Reports of private energy developers offering new lease proposals to landowners for utility-scale solar and wind installations in rural Missouri.
- Continued consumer interest in new electrical investments to produce their own power, create backup systems for power outages and charge electric vehicles. These investments can be incorporated into distributed energy resource systems.

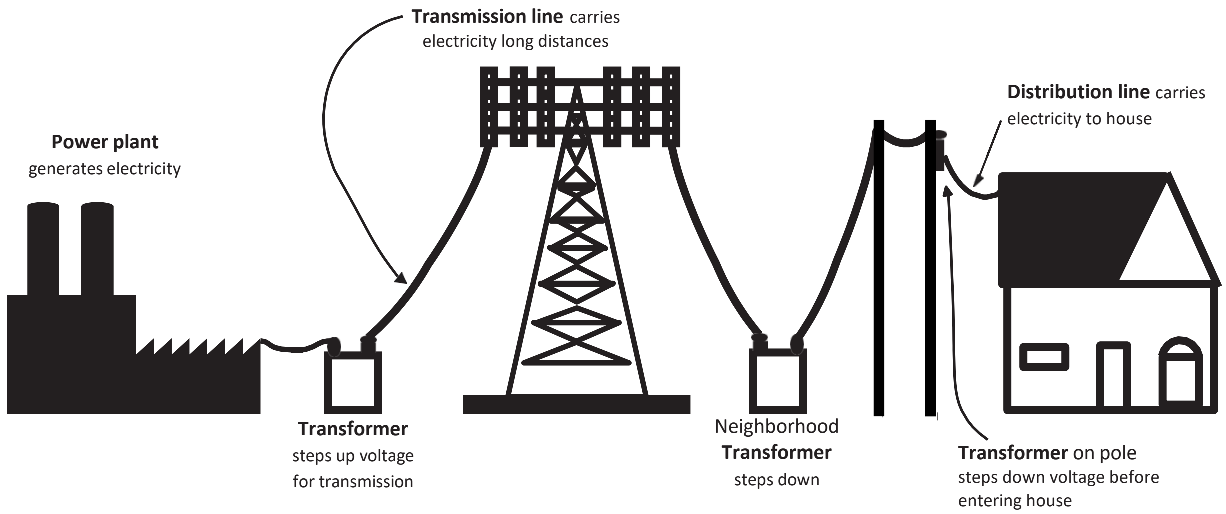
This guide offers a research-based, practical introduction for understanding differences between centralized and distributed electricity generation and how distributed energy resources – including renewables like wind and solar – could impact farmers and landowners in Missouri. Throughout the guide, you will find links to existing resources that may help you evaluate potential benefits and risks, relative to your specific situation, from changing energy systems.

DISCLAIMER: Energy industry changes often reflect changing policies and regulations. This publication is not a policy guide and should not be considered an endorsement for any particular energy source, model, product or company. As a primer and overview, it is intended to provide Missouri landowners and farmers with a background and starting point to learn more about changes in electricity generation that have impacted – and will likely continue impacting – rural Missouri lands, landowners, communities and farm operators.

1. Centralized and distributed electricity generation

Understanding some basics about how electricity is generated and distributed can help you recognize how changes in electricity generation, including distributed energy resources, could impact you and your farm. This section will present differences between centralized and distributed systems, summarize recent changes in fuel sources for Missouri electrical energy, and list some of the plans Missouri's major electricity providers have for future wind and solar expansion.

Figure 1. Illustration of typical centralized generation and distribution



Adapted from National Energy Education Development secondary electricity curriculum (https://www.need.org/need-students/energy-infobooks/)

1.1 Centralized generation and distributed electricity resources

For more than a century, U.S. energy consumers have been served by **centralized electricity generation**: generating electricity on a large-scale at centralized facilities and transmitting that electricity through high-voltage power lines for distribution (Figure 1). Centralized "power plants" in rural America include coal-fired plants, hydroelectric dams, nuclear sites like the Callaway Energy Center, and wind farms connected directly to transmission grids.

The **power grid** is the network transmitting and distributing electrical power from the generation site. The grid moves power from power plants to substations, through transmission power lines, then through distribution power lines. Electricity is transmitted through high voltage lines or subtransmission networks and is then delivered to distribution substations.

> The three different parts of the electricity system – generation, transmission and distribution – may be owned by the same utility or separate entities.

Substations reduce voltage and route the lower-voltage electricity to commercial and residential customers.[1] Managing and upgrading transmission and distribution systems involves multiple engineering challenges and significant costs. The three different parts of the electricity system – generation, transmission and distribution – may be owned by the same utility or separate entities.

Electricity can also be generated using **distributed energy resources** (DERs). The Department of Energy defines DERs as "a variety of small, modular power-generating technologies that can be combined with energy management and storage systems and used to improve the operation of the electricity delivery system, whether or not those technologies are connected to an electricity grid."[2] A similar definition states: "DERSs are power generation, storage, or demand-side management connected to the electrical system, either behind the meter on a customer's premises, or on a utility's distribution system."[3]

Around rural Missouri, you can already spot components of DERs like solar PV panels, small (or "distributed") wind turbines and emergency backup generators. Distributed electricity generation also includes combined heat and power systems, such as those used in biogas digestion. Biogas systems have long been of interest to animal agriculture.[4] Microturbines and fuel cells, fired by natural gas or biomass, may also be part of DERs.

Information systems and controls are a critical part of connecting DERs to a utility's distribution system. Some of these control systems are the same, or similar, as smart grid technologies and initiatives that make electricity delivery and use more efficient. In order to properly manage the use and supply of electricity within components of the grid or energy system, there must be a stable and complete way to manage and communicate information between the DERs generating energy and the utility systems using that energy. Proper communication and control systems are also necessary to implement the proper safety practices for DERs connecting to utility system infrastructure.

Illustrating centralized and distributed generation: electric fence chargers

You might better understand key differences between centralized and distributed electricity generation and production by looking at a common item on Missouri farms: an electric fence energizer.

Characteristics of a centralized generation system can be illustrated by a "plug-in" electric fence energizer, one charged using electricity from a 110V electrical outlet. Electricity comes from a centralized source—the fence charger connected to the outlet—and distributed through the fence charger connected to a fence.

A solar fence energizer can illustrate distributed generation. A solar panel that charges a battery in the field, so to speak, is energizing the battery with electricity generated "off the grid." (Of course, many electric fencing systems, including solar energizers, may combine both on- and off-grid power sources.)

Now suppose this: What if a solar panel captures more energy than is needed to power the fence energizer, and what if that energy may be stored in a battery for future use? This is like what occurs in a distributed energy system. Instead of relying on a single centralized energy source (the power plant, or the "plug"), distributed energy systems use smaller and more diverse sources to generate electricity that is frequently stored for later use.

[1] United States Electricity Industry Primer (https://www.energy.gov/sites/prod/files/2015/12/f28/united-states-electricity-industry-primer.pdf)
[2] Solar Energy Glossary (https://www.energy.gov/eere/solar/solar-energy-glossary)
[3] MISO and DER Framing and Discussion Document (https://cdn.misoenergy.org/DER%20Framing%20Report%202019397951.pdf)
[4] Biogas Digestion: Economic and Asset Assessment for Missouri (https://extension.missouri.edu/media/wysiwyg/Extensiondata/Pro/AgBusinessPolicyExtension/Docs/MO-Biogas-Report.pdf)

Interconnecting DERs to the existing power grid is a complex task. The importance of managing DERs interconnections was emphasized in a report from the National Renewable Energy Laboratory:

> "Although some areas of interconnection have established standards, many are still nascent with no clear or accepted best practice. Additionally, the practice most suitable for a given situation will vary depending on the level of DER penetration; the utility, customer, and developer characteristics and preferences; the attributes of the electrical power system; and other factors."[5]

Solar panels and small wind turbines near New Bloomfield (Photo: DOE)

Renewable fuel sources like wind and solar are not necessarily distributed energy resources. Most of the electricity generated with wind and solar in Missouri and surrounding states is utility-scale development delivering power directly to transmission lines. However, some of the technologies important for the future of distributed energy resources, such as battery storage systems, will develop as wind and solar generation technologies advance.

Now that you understand some differences between centralized and distributed generation and distribution, let's take a closer look at how electrical energy is generated in Missouri.

1.2 Electricity generation in Missouri

Coal-fired power plants are the most important source of electricity generation in Missouri, fueling 70% of the state's net generation in 2020. Coal is, by percentage of net generation, comparatively more important in Missouri than in much of the U.S.[6] Much of the remaining electricity generated in Missouri in 2020 came from nuclear (11%) and natural gas-fired plants (11%).

Renewables, mainly wind and hydropower, made up most of the remaining 8% of Missouri's electricity generated. Missouri typically uses more electricity than it produces in-state and imports that electricity via the regional power grid.[7] States surrounding Missouri, in comparison, produced in 2020 the following percentages of their electricity generation from wind and solar: Iowa, 58%; Kansas, 43%; Oklahoma, 36%; Arkansas, 0.5%; Illinois, 10%.[8]

There are three major types of electricity providers in Missouri: investor-owned utilities, municipal-owned utilities, and electric cooperatives. **Investor-owned utilities** (like Ameren, Liberty, Evergy) provide most of the electricity to Missouri's metropolitan regions. **Municipal-owned** utilities (like

---

[5] "An Overview of Distributed Energy Resource (DER) Interconnection: Current Practices and Emerging Solutions" (https://www.nrel.gov/docs/fy19osti/72102.pdf)

[6] U.S. electricity generation by major energy source, 1950-2020 (https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php)

[7] Missouri State Energy Profile (https://www.eia.gov/state/print.php?sid=MO)

[8] State Electricity Profiles, 2020 (https://www.eia.gov/electricity/state/)

Springfield, Columbia, Trenton, etc.) distribute electricity in many smaller cities. **Electric cooperatives**, in the past frequently called rural electric co-ops, are non-profit businesses providing electricity to co-op members. The member-owners of the co-op receive any profits from the co-op activities in the form of patronage capital or more stable electric rates.[9] Missouri has 40 distribution electric co-ops ranging in membership from 2,000 to 40,000 members.[10]

Missouri's distribution co-ops purchase power from Associated Electric, the Springfield-based co-op comprised of Missouri's six generation and transmission electric co-ops. Associated Electric's coal-fired units provide the bulk of electricity to its member co-ops. Additional generation comes from natural gas, hydropower and wind.[11] Missouri's electric co-ops were the first electric providers in Missouri to buy power from utility-scale wind farms. Associated Electric in 2021 contracted 1,240 megawatts (MW) of wind energy from five wind farms in Missouri and two in Oklahoma and Kansas.[12]

1.3 Changes in electricity generation in Missouri

The Energy Information Administration reported Missouri's percentage of electricity net generation from coal decreased from a high of 81% in 2010 to 70% in 2020 "as older coal-fired plants have been retired, switched to natural gas, or were replaced with renewable generation."[13]

Three reasons for greater interest in renewables in Missouri and nationally:

1. The declining lifetime costs of wind and photovoltaic (PV) solar.
2. Economic incentives (often tax credits) for renewable energy investment and generation.
3. Increased costs for energy companies to maintain coal-fired generation.

A host of other factors influence the pace and scope of investment into new electricity generation technology. These factors include regulatory structures and policy determinations at the state, local and federal levels. Changes in policy and regulations can directly impact costs of energy generation. Retiring coal-fired plants, instead of installing "scrubbers" to reduce emissions to certain levels, is one example of how regulatory changes may impact energy generation costs. Energy companies in Missouri, as nationwide, may choose to simply retire older coal-fired plants and source electricity elsewhere instead of incurring scrubber upgrade costs.

Missouri landowners should understand that energy providers often contract renewable energy from "energy developers," companies that engineer and develop wind farms and solar arrays. This is a reason that lease proposals for wind and solar will come from firms other than the electric utilities and cooperatives well-known in Missouri. (Photo: DOE)

[9] "What is an Electric Cooperative?" (https://amec.org/who-we-are)
[10] "Distribution" (https://amec.org/distribution)
[11] "Resources" (https://www.aeci.org/resources/)
[12] "Alternative Energy" (https://www.aeci.org/resources/alternative-energy/)
[13] Missouri State Energy Profile (https://www.eia.gov/state/print.php?sid=MO)

Solar panels in Columbia, Mo., 2015 (DOE)

Each investor-owned utility (IOU) operating in Missouri must annually file or update a Renewable Energy Standard Compliance plan with the Missouri Public Service Commission (PSC). This plan is each company's projection for adopting renewable fuels into their electricity generation portfolio. The 2021 plans for Ameren, Evergy and Liberty were reviewed on the Missouri PSC website in November 2021. Some of the utility company Integrated Resource Plans (IRPs), also available publicly with some portions redacted for confidentiality, were also reviewed.

These documents indicated that in 2021 about 300 MW of wind capacity came online in Missouri from the North Fork Ridge and Kings Point wind farms. Liberty also reported adding an additional 300 MW of wind capacity in 2021 from a Kansas wind farm.

Ameren indicated the most specific plans for expanding solar, anticipating 50 MW of new solar capacity by 2023. Both Evergy and Liberty indicated they would continue to be able to meet Missouri regulatory requirements for solar by purchasing energy generated by customer-owned solar panels. Still, Evergy and Liberty IRPs indicated both companies are open to additional solar projects: For example, Liberty in 2021 added to its portfolio the 2.25 MW Prosperity Solar Farm near Joplin.

Ameren Missouri's 2020 IRP outlines an expected 10-year scenario for renewable generation capacity.[14] Ameren's plan adds 600 MW wind capacity and 1,400 MW solar capacity, as reported in Table 1.[15]

Table 1. Plans for new wind and solar indicated by Ameren Missouri's compliance model

	2021-2023	2023-25	2026-27	2028-30	TOTALS
Wind capacity (new)		300 MW		300 MW	600 MW
Solar capacity (new)	50 MW	250 MW	400 MW	700 MW	1,400 MW
Totals	50 MW	550 MW	400 MW	1,000 MW	2,000 MW

Source: Ameren Missouri. "2020 Integrated Resource Plan." Chapter 9, p. 7. (https://www.ameren.com/-/media/missouri-site/files/environment/irp/2020/ch9-integrated-resource-plan-risk-analysis.pdf)

[14] Ameren Missouri 2020 Integrated Resource Plan (https://www.ameren.com/missouri/company/environment-and-sustainability/integrated-resource-plan)

[15] Ameren Missouri 2020 Integrated Resource Plan (Chapter 9, p. 7. https://www.ameren.com/-/media/missouri-site/files/environment/irp/2020/ch9-integrated-resource-plan-risk-analysis.pdf)

Ameren also included in its 2020 IRP a separate, higher projection for wind and solar expansion. That projection included batteries and estimated a total of 3,100 MW from solar and wind by 2030. This is more than 50% above the baseline projection reported in Table 1. Ameren's 2021-23 Renewable Energy Standard Compliance Plan indicated "in the attached '10 yr MO Compliance Model 2021_30' a 200 MW solar farm is modeled to come on-line in late 2023 to meet the long term shortfall (in renewable energy credits). This will also offset the loss of the Pioneer Prairie II Wind farm PPA (power purchase agreement) which expires in 2024."[16]

You may wonder: How much acreage would it take for the expansion indicated in Table 1? Although site and equipment specifics determine exact wind capacity, around 130 wind turbines are needed for 300 MW of wind capacity, according to published estimates for Missouri. Ameren's High Prairie Renewable Energy Center is 175 turbines with a capacity of 400 MW across 50,000 acres, according to the Missouri PSC and Ameren's 2021-23 IRP. (Photos: DOE)

Acreage requirements vary per MW capacity of solar. The Solar Energies Industry Association estimates a requirement of 5 to 10 acres for each MW capacity of PV solar.[17] Acreage required depends on the project location, technology used, proximity to transmission lines or substations and land lease availability. You might assume 6 to 8 acres for each MW in Missouri, a figure cited in 2021[18] for the proposed Guthrie Solar Project in Callaway County.[19] Using these estimates, Ameren's plan for 1,400 MW of solar by 2030 could represent 8,400 to 11,200 total acres.

What does this mean for farmers and landowners in Missouri? One impact is that land lease proposals for wind and solar are likely to continue in Missouri. The potential land leased is a very small portion of Missouri's total land base. For example, the 8,400 to 11,200 acres estimated for Ameren's forecasted solar capacity would represent a tiny percentage of Missouri's 27.5 million acres of farmland – around 27.5 million acres in 2020, including some 800,000 acres enrolled in the Conservation Reserve Program.[20]

[16] 2021-2023 Ameren Missouri Renewable Energy Standard Compliance Plan (https://psc.mo.gov/Electric/Renewable_Energy_Standard_Compliance_Reports)
[17] "Siting, Permitting & Land Use for Utility-Scale Solar" (https://www.seia.org/initiatives/siting-permitting-land-use-utility-scale-solar)
[18] Hart, J. "Solar energy company lays out plans for Callaway County project," Nov. 18, 2021. (https://krcgtv.com/news/local/solar-power-could-be-developed-in-callaway-county)
[19] "Guthrie Solar Project" (https://www.nexteraenergyresources.com/guthrie-solar/project-overview.html)
[20] The Conservation Reserve Program 54th Signup Results (https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/su54book.pdf)

Farmland is not the only possibility for solar installations. There are 2,357 brownfield and unused industrial sites identified as potential solar farm development sites in Missouri.[21] Furthermore, new generation sites supplying power to Missouri utilities may be located outside Missouri, like the Kansas and Oklahoma wind farms contracted to Missouri's investor-owned utilities and electric cooperatives.

Another impact of increased wind and solar generation could be felt at the farm or rural firm level. Declining costs of battery storage and advances in battery technology, which are attracting interest in distributed wind and solar development, have implications for how electricity could be generated and stored at the farm and firm level. Advancement in battery storage technologies, as well as how electric vehicles could be integrated into local power grids, will be significant for the future of DERs.

The remainder of this publication provides further background about the electricity industry that may be useful to landowners considering either leasing land to energy developers or incorporating newer, distributed energy resources on their land or farming operation.

Above: Solar project on a Pennsylvania farm; note proximity to transmission lines.
Below: Solar panels on Iowa farm. (Photos: DOE)

[21] United States Environmental Protection Agency, RE-Powering America, Site Identification, (https://www.epa.gov/re-powering/how-identify-sites#looking)

2. The power grid and components of electricity costs

Transmission and delivery represented 43% of the U.S. average retail cost of electricity in 2020, according to the Energy Information Administration.[22] Power providers place high priority on improving and maintaining transmission and delivery systems, especially where there are aging lines and older infrastructure. Since DERs can create transmission and distribution efficiencies, DERs could help both producers and consumers realize potential cost savings. This section will provide some basic information about how the power grid is managed.

2.1 Interconnections, RTOs and ISOs

The power grid in the U.S. and Canada is divided into four **interconnections**. Utilities in each interconnection are "electrically tied together during normal system conditions."[23] Missouri is part of the Eastern Interconnection, which consists of most of the U.S. and Canada east of the Rockies.

Managing an interconnection is a complex task. Transmitting and distributing electrical power requires sophisticated engineering. Electricity markets are complex and vary by region. Navigating the engineering and economic complexities of electricity supply is a multifaceted task for electricity providers.

The Federal Regulatory Energy Commission (FERC) regulates the interstate transmission of electricity. The FERC has formed regional transmission organizations (RTOs) and independent system operators (ISOs) to operate regional electricity grids, administer wholesale electricity markets and provide reliability planning for a region's bulk electricity system. An RTO or ISO can include multiple states; however, interconnection boundaries do not always fall along state lines.

Interstate transmission is important to understanding Missouri's place in the U.S. energy market. Missouri is usually an electricity importer and does not generate enough electricity to meet statewide demand. Missouri is also located at an intersection of two RTOs: the Southwest Power Pool (SPP) and the Midcontinent Independent System Operator (MISO). The SPP and MISO work to ensure reliable supply, adequate infrastructure and competitive wholesale electricity prices for their members (power companies, municipalities and large commercial customers).[24]

Part of Missouri is also served by the SERC Reliability Corporation, labeled "Southeast" in Figure 2. SERC Reliability Corporation members are vertically integrated power companies. Rather than wholesaling electricity to utilities or cooperatives, vertically integrated companies generate and own the energy until delivery to the end user.

[22] "Electricity explained: Factors affecting electricity prices" (https://www.eia.gov/energyexplained/electricity/prices-and-factors-affecting-prices.php)
[23] United States Electricity Industry Primer (https://www.energy.gov/sites/default/files/2015/12/f28/united-states-electricity-industry-primer.pdf)
[24] United States Electricity Industry Primer (https://www.energy.gov/sites/default/files/2015/12/f28/united-states-electricity-industry-primer.pdf)

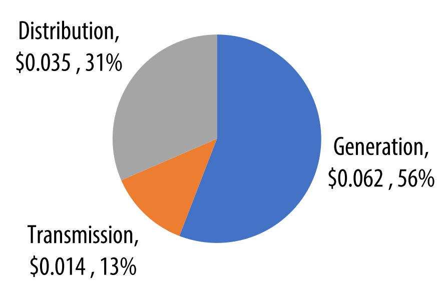
Figure 2. Map of regional transmission organizations and independent system operators

2.2 Electricity cost components

As you learned in the section above, different regions in the same state can be served by different kinds of energy distributors. Each distributor must manage the engineering challenges of reliably delivering electricity while navigating energy market complexities. In this section, you will gain an overview of the three main components of electricity cost – generation, transmission and distribution – and learn how these costs can vary between different types of energy resources.

Missouri residential customers paid an average of 11.22 cents per kilowatt-hour (kWh) in 2020.[25] Generation is slightly more than half (56%) of the average residential retail cost of electricity in the U.S. Applying this national average to Missouri's retail price, an estimated cost of generation is about 6.2 cents per kWh. The other components of price, illustrated in Figure 3, are distribution (31%) and transmission (13%).[26]

Figure 3. Components of the average U.S. retail cost of electricity, 2021



Source: https://www.eia.gov/energyexplained/electricity/prices-and-factors-affecting-prices.php

[25] "2020 Total Electric Industry –Average Retail Price (cents/kWh)" (https://www.eia.gov/electricity/sales_revenue_price/pdf/table4.pdf)
[26] "Electricity explained: Factors affecting electricity prices" (https://www.eia.gov/energyexplained/electricity/prices-and-factors-affecting-prices.php)

It is important to remember these are *retail* price averages. Wholesale electricity prices can range widely. For example, the wholesale price reported from the MISO Illinois hub was about $0.02 per kWh in 2020; the same hub reported a wholesale price up to $0.04 in 2018-19.[27] Wholesale prices that change considerably from year to year can create pricing challenges for the energy provider.

Table 2. Ranges of levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) for new resources entering service in 2023 (2020 dollars per megawatthour)

	Without tax credits				With tax credits			
Plant type	**Minimum**	**Simple average**	**Weighted average**	**Maximum**	**Minimum**	**Simple average**	**Weighted average**	**Maximum**
Dispatchable technologies								
Combined cycle	$29.17	$34.78	$33.28	$43.47	$29.17	$34.78	$33.21	$43.47
Combustion turbine	$85.11	$97.32	$97.50	$117.72	$85.11	$97.32	$97.50	$117.72
Battery storage	$106.63	$117.59	$121.85	$127.64	$106.63	$117.59	$121.85	$127.64
Non-dispatchable technologies								
Wind, onshore	$25.09	$33.53	$30.44	$56.12	$17.10	$25.55	$22.46	$48.14
Solar, standalone	$27.65	$33.13	$30.63	$44.46	$21.61	$25.89	$23.92	$34.49
Solar, hybrid	$40.10	$48.16	N/A	$62.97	$32.19	$38.58	N/A	$50.02

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2021*, Table A2 (https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf)

Wholesale prices also vary depending on the source and system of electricity generation. Established fuels, like coal and natural gas, historically have been more cost-efficient than renewable fuels. Improvements in utility-scale wind and solar systems, combined with market incentives, may enable Midwestern energy producers to generate and deliver renewable electricity more competitively to in-state and regional markets. Utility-scale wind and PV solar systems are now estimated to be comparable and, in some cases, more economical than combined-cycle natural gas per megawatt hour (Table 2). Once wind and solar generating capacity is built, the marginal cost of operating wind turbines and solar arrays is very low compared to generation that requires purchased fuels.

Future movement toward DERs presents possible benefits and challenges for electricity cost structures. For example, integrating smart grid technologies and battery storage systems into the power grid could create cost savings for transmitting and delivering power, particularly during peak load periods. On the other hand, according to a 2019 MISO report, electricity market design "may need modifications to enhance participation options and capture benefits of DERs."[28] The importance of considering DERs for existing energy market structures was underscored in September 2020 when the FERC issued Order No. 2222, "Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators."[29] This order will allow RTOs and ISOs to aggregate several sources of distributed energy "in order to satisfy minimum size and performance requirements that each may not be able to meet individually."[30] Energy providers are still sorting out

[27] "Wholesale U.S. electricity prices were generally lower and less volatile in 2020 than in 2019" (https://www.eia.gov/todayinenergy/detail.php?id=46396)

[28] "MISO and DER Framing and Discussion Document" (https://cdn.misoenergy.org/DER%20Framing%20Report%202019397951.pdf)

[29] "FERC Order 2222 Recommendations for the U.S. Department of Energy" (https://www.energy.gov/sites/default/files/2021-04/EAC%20FERC%20Order%202222%20Recommendations%202021-04-15_finalDraft.pdf)

[30] "FERC Order 2222: A New Day for Distributed Energy Resources" (https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet)

short-term and long-term implications of the FERC order; both MISO and SPP received extensions for filing their compliance plans for Order No. 2222.[31]

In summary, DERs will likely play a greater role in the future U.S. power supply. Specific impacts remain to be sorted out as DERs generation and technology advances. It is still yet to be determined how energy markets will respond to DERs technologies and how willing consumers will be to adapt behind-the-grid DERs generation. We will now look at some additional terms important for understanding DERs, especially wind and solar components.

2.3 Definitions of key terms

This section introduces additional important terms for understanding the power grid and DERs. Understanding these terms can help you identify different ways in which DERs could help electricity producers and users reduce future costs and improve efficiency.

Load is the amount of electricity consumed during a given period. Electrical power distribution networks are designed and rated for reliability at all times, including at **peak load demand**: sustained periods during which users are requiring the most electrical power on the network.[32] Electricity use is usually the greatest during the late afternoon in summer months. Increases in peak load demand can introduce power quality and reliability issues, require network upgrades and reduce energy efficiency.[33]

Distributed storage refers to electricity storage devices located nearby the site of generation, such as battery storage systems by solar panels. Distributed storage allows the electricity to be stored before – or instead of – delivery to the grid. That electricity may then be accessed at times when electricity is more expensive or most needed.

Challenges for providers using DERs

Storage systems for electrical power from DERs are very important for determining how energy providers can integrate DERs into the power grid. Related challenges energy providers will need to solve include:

- How to integrate DERs into the transmission and delivery system
- How to determine whether electrical energy from DERs should be sold retail or wholesale
- How to navigate differing energy policies and incentives between states and regions

Remember: Distributed energy resources encompass a broad swath of established and emerging energy technologies. While this publication focuses on DERs used in generating electricity (supply-side), there are numerous demand-side initiatives for DERs. According to DOE, these may include energy efficiency technologies and initiatives, load-modifying resources and demand response. Smart thermostats and recharging batteries at off-peak times are examples of demand-side initiatives. DERs also include "distributed storage," in which energy generated is stored to be later used when most needed.

[31] "Are We There Yet? Getting Distributed Energy Resources to Markets" (https://www.law.nyu.edu/sites/default/files/AreWeThereYet-GettingDistributedEnergyResourcestoMarkets-TheStateImpactCenter.pdf)
[32] "Hourly electricity consumption varies throughout the day and across seasons" (https://www.eia.gov/todayinenergy/detail.php?id=42915)
[33] "Peak Load Management" (https://www.nrel.gov/docs/fy21osti/78798.pdf)

Understanding electrical generation capacity and energy

To better understand the difference between generation capacity and energy, you might think about a portable backup generator for a farm. The generator may have the **capacity** to generate 12,000 watts of running power. However, that capacity does not actually become **energy** until the generator is connected and started up to transmit the electricity for home or farm use.

Similarly, centralized generation is not always working at a plant's full capacity. Power plants often operate below their full capacity, and it takes some time for generation to increase and electricity to become available for transmission. Furthermore, operation at greater capacity may be more expensive per unit of electricity, and the generator may not be able to recoup that expense.

Distributed energy resources, by creating electricity generation potential "behind the grid," can help manage risks of power outages that occur during periods of extreme demand. Newer technologies such as fuel cells and solar PV could also have potential as economical backup electricity sources on farms. Advances in energy technologies have declined costs of renewable energy sources over time.

Load management is how energy providers manage networks to meet demand peaks. DER systems offer an improved ability to store and/or manage electricity for use at demand peaks. DER systems can also help energy providers solve the challenge of wind and solar power not being available at times of peak load demand. Storing energy from renewables, and drawing upon it during demand peaks, can allow more efficient sourcing.[34]

Demand response refers to a wholesale electricity customer reducing electric energy consumption and receiving compensation based on wholesale prices. Such agreements can then be used to control the total load in a system. There are potential demand response benefits and challenges from DERs, as noted in a May 2021 National Renewable Energy Laboratory publication:

> "With rapid growth of emerging technologies, including battery storage and hybrid resources…DERs and demand-side flexibility—all technologies with very different operational characteristics from conventional thermal generation modes—the ability of current wholesale electricity market structures to ensure both long-term and operational reliability is unclear."[35]

The **smart grid** refers to the whole set of technologies and practices which improve the efficiency and reliability of the U.S. electric power grid through reinforced infrastructure, sophisticated electronic sensors and controls, and two-way communications with consumers. Improved communication between energy producers and users is a big part of the smart grid. For example, smart grid control systems that more quickly locate and report electrical outages can help providers make sure energy is available at critical times to healthcare and emergency services.

A **microgrid** is a localized grid that can disconnect from the traditional grid to operate autonomously.[36] Some farms have established their own microgrids, including hog farms in North Carolina that generate electricity from biogas produced from manure digesters.[37]

[34] Research Priorities and Opportunities in United States Competitive Wholesale Electricity Markets (https://www.nrel.gov/docs/fy21osti/77521.pdf)
[35] Research Priorities and Opportunities in United States Competitive Wholesale Electricity Markets (https://www.nrel.gov/docs/fy21osti/77521.pdf)
[36] "How Microgrids Work" (https://www.energy.gov/articles/how-microgrids-work)

Net metering refers to electricity providers crediting a customer's account for electricity generated from renewable energy sources. In Missouri, solar panels are commonly installed for net metering purposes. A law passed in 2007 required Missouri utilities to offer customers a simplified process to connect to the grid in order to transmit electricity generated from renewable energy systems on their property.

Net metering systems use meters that measure electricity sent to and used from the grid. The electricity sent to the grid is credited against the energy used to arrive at the "net" meter reading. Most PV solar installed in Missouri is not a true "distributed" energy resource because there is no way for the electricity to be stored at or nearby the site of the solar panels to be used at times of greater demand. In Missouri, net metering only applies to systems with generation capacity of 100 kW or less.

As residential PV solar installations become a larger component of the energy generation mix, state net metering laws have come under scrutiny by industry and lawmakers. Some energy providers, including Missouri's electric cooperatives, support legislation to change the 2007 law. According to these providers, the current compensation structure does not adequately account for the costs of the distribution and transmission lines that connect PV solar on private property to the power grid. This relates to crediting net metering customers at "avoided cost" versus "retail price" for electricity.

Another issue for utilities related to net metering is establishing different monthly connect charges for customers using PV solar. These charges can compensate the utility for essentially serving as a battery for the customer. Some investor-owned utilities are more positive toward net metering installations because of the impact these investments have upon their regulated rate structures. Electricity customers considering a PV system should discuss their plans with their utility and not rely entirely upon information from a solar installer.

Bi-directional, fast-charging electric vehicle stations are capable of supplying power back to the Ft. Carson Army Base microgrid to help address demand or enhance overall power quality. (Photo by Dennis Schroeder /DOE-NREL)

---

[37] "Distributed Energy Award Goes to Unique Hog Farm Microgrid" (https://www.powermag.com/distributed-energy-award-goes-to-unique-hog-farm-microgrid/)

Electric vehicles and DERS

Electricity providers to densely populated areas are expecting electric vehicles (EVs) to provide potential benefits for future grid management. That's because major automobile manufacturers are designing charging systems that can draw on EV battery energy to provide electricity for a home's needs when the EV is parked.

Consider this scenario: a very cold winter morning where weather has made most roadways impassable. In the future, using smart grid technologies, it is possible that an electricity provider could signal for households with an EV parked to draw on its battery energy to reduce the load demand by that home. This is called "peak shaving." The EV could also serve as a backup electricity source during a power outage.

EVs are not widely adopted in rural America. However, a 2021 CoBank report notes that this could change with the introduction of Ford's F-150 Lightning. The pickup has a 300-mile battery life and can be used as a portable generator, which could appeal to farmers needing to power tools or recharge portable electrical tools on-site. The Ford F-150 was the best-selling vehicle in Missouri in 2020.

The implications for EVs in rural America are still to be determined. The CoBank report suggests that rural electric cooperatives and rural users could benefit from EVs. The U.S. electricity grid could handle the increase in electricity needed for EVs, if they are charged during off-peak electricity usage hours, according to most estimates.

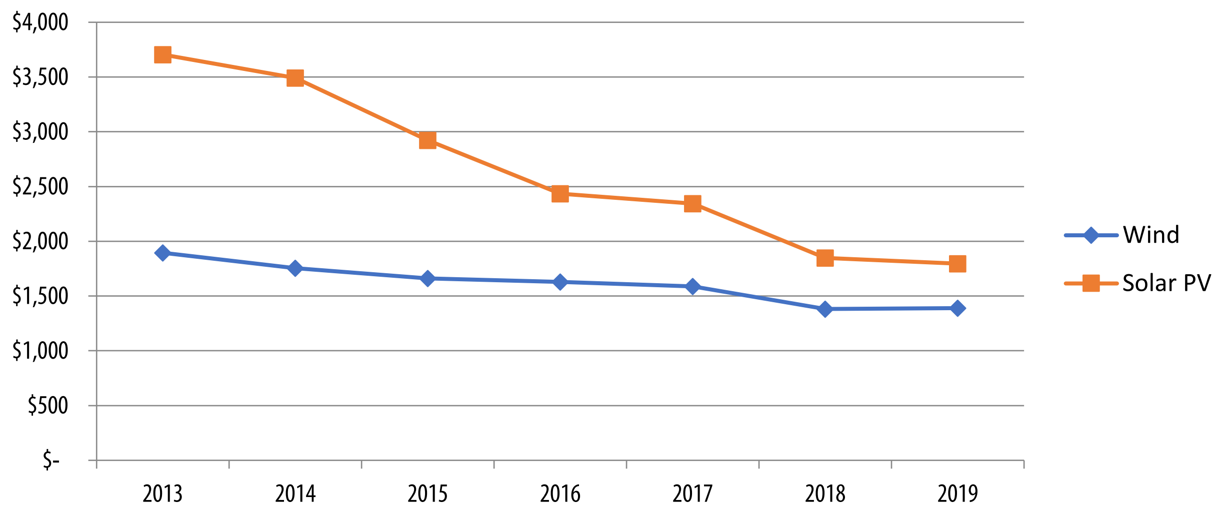
For more information on how EVs could impact rural America, read the report:
Co-op EVolution – Bridging the Rural-Urban Divide on EV Adoption
(https://www.cobank.com/knowledge-exchange/power-energy-and-water/co-op-evolution-bridging-the-rural-urban-divide-on-ev-adoption)

Distributed energy resources often are defined by which side of the meter they are on. A **behind-the-meter** resource, like many rooftop solar installations, is always connected to the local distribution grid behind a utility meter. Solar or wind installations behind-the-meter offset the customer's electricity usage. Any excess output flows back onto the grid, and this can be net metered so that the customer receives a credit for the energy produced.

When thinking about behind-the-meter resources, it is important to understand the difference between **interruptible** and **uninterruptible** power. **Uninterruptible** power means the electricity user is always able to pull or send electricity back to the grid, and it is up to the electricity customer to disconnect from the grid. A common example is the National Electrical Safety Code requirement for a double-throw, double-pole transfer switch when using a standby generator during power failures.[38] This disconnects the user from the grid, which prevents excess power from flowing onto the grid and possibly electrocuting workers repairing lines. **Interruptible** power means the user can be disconnected from the grid by the grid manager. This is more common for larger electricity customers with regularly available behind-the-grid generation. Utilities may offer significant rate breaks for users willing to move to interruptible status. Changes in how the grid is managed, including new smart grid technologies, will continue to impact how electricity users and providers are managing interruptible and uninterruptible power.

[38] "Sizing and Safety Tips for Standby Power Generators" (https://extension.missouri.edu/publications/emw1015)

Figure 4. U.S. capacity-weighted average construction costs, $/kW



Source: Energy Information Administration, *Annual Electric Generator Report* (https://www.eia.gov/electricity/data/eia860/)

Front-of-meter distributed energy resources are connected directly to the local distribution grid. The natural gas turbines that provide steam for use at some ethanol plants are an example of a front-of-meter resource; the electricity generated by the turbines flows out to the local distribution grid. Some DER systems may be designed so that front-of-meter generation can be switched to provide emergency backup power for a specific customer.

We will now look at some major distributed energy generation technologies with potential for rural Missouri farmers and landowners. There is a focus on wind and solar because of the existing market penetration for renewable generation. Utility-scale wind and solar generation have increased in the Midwest, especially as construction and establishment costs decline per kW (Figure 4). The advance in battery storage and other DER technologies, relevant to wind and solar systems, creates a very real possibility that distributed wind and solar resources could be incorporated into microgrids as well as the whole power grid.

3. Distributed energy resource technologies

Distributed energy resources can be divided into three categories: demand-side management, distributed storage and distributed generation. We will now look at distributed generation systems, first focusing on three types with both current and future applications in Missouri: solar, wind, and combined heat and power. We will then look at generators, a common DER in place on many farms, and then at DER systems using fuel cells and microturbines to generate electricity.

3.1 Photovoltaic (PV) solar

Photovoltaic, or PV, solar panels are now found on rooftops and elsewhere in rural and metropolitan Missouri. There are both tax incentives and energy cost savings for consumers from PV solar panels because of Missouri's net metering policy, as explained previously. The increase in net metering in Missouri during recent years corresponds with the increase in rooftop solar panels.

Photovoltaic solar panels are also used in much larger, utility-scale installations. As of December 2021, examples in Missouri include a solar farm in Nixa, with a 7.9 MW capacity that serves electricity needs in Springfield, and a 10.0 MW capacity solar farm east of Columbia serving Columbia. PV solar is also used by large commercial users, such as the installations in St. Louis at the IKEA retail store and AB InBev.[39]

Battery storage technology improvements and declining costs are expanding opportunities for PV solar. **Battery energy storage systems (BESS)** store electrical energy generated by renewable energy sources. According to a 2020 USDA report:[40]

> "Adding BESS to solar or wind energy projects can thereby lead to more utility-scale land leases on agricultural lands and, under certain circumstances, better system economics for entity-scale PV systems at rural households and businesses….While the benefits of PV + BESS have been known for years, what has changed recently is the cost-effectiveness of BESS."

The overall system cost for lithium-ion BESS declined 74 percent between 2012 and 2018, according to a study cited in the USDA report. Declining BESS costs create more potential for utility-scale distributed solar systems because the solar energy can be stored for transmission to the grid during demand peaks. In addition, declining BESS costs create greater potential for "entity-scale" solar installations, including farm and rural home energy needs.

Battery energy storage systems are improving (DOE)

[39] "State Solar Spotlight Missouri" (https://www.seia.org/sites/default/files/2021-09/Missouri.pdf)
[40] Renewable Energy Trends, Options and Potentials for Agriculture, Forestry and Rural America (https://www.usda.gov/sites/default/files/documents/renewable-energy-trends-2020.pdf)

3.2 Wind

In late 2021, Missouri had an installed wind energy capacity of almost 2,000 MW with an additional 500 MW under construction.[41] Missouri's utility-scale wind farms generate and transmit energy directly onto the distribution grid. The wind farms located in northern Missouri are examples of centralized generation.

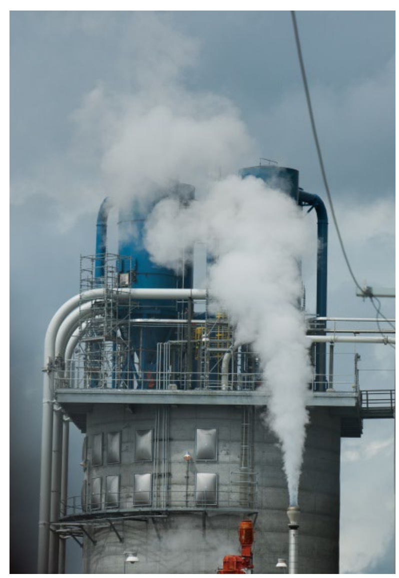
Distributed wind resources are defined by the DOE as wind turbines connected at the distribution level of an electricity system, or in off-grid applications, to serve specific or local loads.[42] Distributed wind turbines are typically grouped in three size categories:[43]

- Small wind turbines (up through 100 kW)
- Mid-size wind turbines (101 kW to 1 MW)
- Large-scale wind turbines (greater than 1 MW)

Missouri had 5.1 MW of distributed wind capacity in 2021. By comparison, Iowa (which leads the nation in distributed wind) had 185 MW of established distributed wind resources and 8.0 MW under development in 2021, according to the DOE.

Like solar, improvements in battery technology are increasing possibilities for wind as a distributed energy resource. Future wind energy installations could incorporate BESS technology so that energy could flow to the grid during periods of peak demand.

3.3 Combined heat and power (CHP)



Combined heat and power systems, also called cogeneration, are the most common type of distributed energy resources in the U.S. A combined heat and power system (CHP) occurs when both electricity and thermal energy are produced from a single fuel source. The most common CHP systems are a gas turbine or engine with heat recovery unit and a steam boiler with steam turbine. Diesel engines, microturbines and fuel cells are other types of CHP systems.[44] Two other well-known CHP systems include boilers fired by methane gas, as used at some landfills, and steam boilers fired by incinerating solid wastes like waste wood products. (Photo: Dennis Schroeder, DOE/NREL)

Businesses requiring heat for industrial processes are major users of CHP. These include ethanol plants like the POET Biorefining ethanol plants in Macon and Laddonia.[45] A natural gas-fired

[41] "Wind Energy in Missouri" (https://windexchange.energy.gov/states/mo)
[42] "Distributed Wind Market Report: 2021 Edition" (https://www.energy.gov/eere/wind/wind-market-reports-2021-edition#distributed)
[43] "Distributed Wind Market Report: 2021 Edition" (https://www.energy.gov/eere/wind/wind-market-reports-2021-edition#distributed)
[44] "Combined Heat and Power Basics" (https://www.energy.gov/eere/amo/combined-heat-and-power-basics)
[45] "POET Biorefining's Ethanol Power Plant Laddonia, Missouri" (https://chptap.lbl.gov/profile/185/POETLaddonia-Project_Profile.pdf)

turbine at each ethanol plant is paired with a heat recovery steam generator. The CHP gas turbines provide electricity to local utilities, and the process steam from the turbine is used in ethanol processing. The CHP system at the Macon plant was designed to be disconnected from the local power grid and then used to provide the ethanol plant with electricity during local power grid outages.

3.4 Other DERs

Other distributed generation categories include reciprocating engines, microturbines and fuel cells. These technologies have both immediate and future applications for farmers and farmland owners.

Many farms already have **reciprocating engines**, or generators. These are usually diesel-powered; natural gas is also common. Farms and rural families have long relied on generators for emergency power.

Generator energy is comparatively more expensive than that bought from the grid. Reciprocating engines do have the potential to provide power that can be accessed by an energy grid. Generator technology already allows for remote activation, and this could allow them to be incorporated into distributed electricity system designs.

A **microturbine** is a scaled down gas turbine, usually 25 to 500 kW in size. They are usually fired by natural gas. Microturbines, like reciprocating engines, are not usually connected to energy grids. Microturbines are often used to generate electricity from methane gas at landfills and are also used to generate energy from biogas in other settings, including agriculture and industry.

Fuel cells convert chemical energy to electricity. Fuel cells can run on hydrogen, natural gas and a variety of other fuels. Fuel cells can vary in size, from the size to power a small appliance to an automobile to even larger cells.

Hydrogen fuel cells can store electricity that has been generated by wind and solar. The capital costs for fuel cells are presently higher than other technologies, but much research and development is underway to develop fuel cells for larger-scale adoption. Fuel cells are attractive as a future source of energy because they generate heat and oxygen as byproducts, not carbon emissions.[46]

Hydrogen fuels can be generated using solar or wind, which produced the hydrogen used in this NREL research vehicle in Colorado. (Photo: DOE)

[46] "Fuel Cells" (https://www.energy.gov/sites/prod/files/2015/11/f27/fcto_fuel_cells_fact_sheet.pdf)

4. Future implications of DERs

Utility providers are anticipating various scenarios for how DERs may impact power generation and power grid management. Multiple energy sources can offer advantages to both suppliers and consumers; but ISOs, RTOs and investor-owned utilities must navigate engineering, marketing and system design challenges presented by incorporating more DERs.

The greatest immediate impact of DERs may be from components of DERs used in existing and utility-scale applications. For example, energy developers are continuing utility-scale wind and solar projects as energy providers look to satisfy market demands and regulations. This makes land lease possibilities from utility-scale wind and solar projects immediately relevant to Missouri landowners and farmers. Landowners near existing transmission lines and substations are most likely to be approached by project developers.

Distributed wind and solar projects are likely to become more frequent as battery storage costs decline. Projects that may be designed specifically to incorporate DERs systems into a microgrid are likely to become more common in the U.S. These microgrid systems could have applications on farms and rural lands in Missouri.

Finally, there are numerous wildcards that make it difficult to predict the future impact of DERs in the U.S. For example: If the electric vehicle adoption proceeds as expected, both consumers and producers will likely be attracted to systems drawing on EV batteries for electrical power during demand peaks or power outages.

Different geographies will likely see different rates of consumer adoption of EVs, as well as local integration of EVs into the power grid. Rural Missourians make initially be expected to take a "show me" approach to EV adoption. Electric car and pickup purchases will increase as purchase prices decline, reliability becomes proven, and if on-farm recharging proves to be cheaper than refueling with gas or diesel.

This section will summarize possible major impacts of DERs in Missouri for landowners and farmers.

4.1 DERs and grid management

Utility providers are keenly interested in DERs because distributed systems can help solve a major challenge for grid management: how to source electrical energy during periods of peak demand.

Demand response refers to a wholesale electricity customer reducing electric energy consumption and receiving compensation, based on wholesale prices, from the energy provider. Demand response agreements are used to control the total load in a system. For example, a grocery store chain large enough to purchase electricity at wholesale prices could agree to slightly increase store temperatures in summer afternoons to reduce electricity usage, at peak usage times on the transmission grid, in exchange for a reduced rate. Similarly, a Missouri utility offered discounts to customers who buy smart thermostats that allowed the utility to make slight temporary adjustments to house temperatures during high demand events. (Photo: USDA)

Megawatts from demand management is the total megawatts in a system that can be redirected to other users (or "saved") from demand response.[47] Developing and managing megawatts from demand management is complex because energy demand may outpace the total capacity of the grid during emergencies or unusual weather conditions. Power outages may occur even when factoring in the available megawatts from demand management.

The U.S. utility sector generally has the capacity to keep up with total electricity demand. But the complexity of transmitting and delivering electricity can create shortages in available energy – especially during peak demand times. For this reason, energy providers are increasingly interested in integrating DERs that might supply electricity to distributors from "off the grid" or nearby sources.

Distributed energy technologies are emerging in a period where much of the U.S. electric power grid is in need of modernization. According to research cited in a September 2021 article from the National Council of State Legislatures, more than half of U.S. distribution lines have surpassed their 50-year life expectancy, and utility providers will spend more than $1.5 trillion to modernize the grid before 2030.[48]

Local utility situations, as well as state and local energy policy, affect how farms and other rural utility users can economically adopt DERs at their locations. Congestion in the transmission grid can also affect the viability of DERs. For example, transmission congestion already impacts the value of energy produced by land-based utility-scale wind installations in the U.S.[49]

With so many possible changes for energy production and consumption, not every promising technology or idea will emerge as a winner. Farmers and landowners should examine each opportunity carefully and identify farm-level costs and benefits from each new technology. (Photo: USDA)

---

[47] New England ISO Glossary (https://www.iso-ne.com/participate/support/glossary-acronyms/#d)
[48] "Modernizing the Electric Grid: State Role and Policy Options" (https://www.ncsl.org/research/energy/modernizing-the-electric-grid-state-role-and-policy-options.aspx)
[49] Land-Based Wind Market Report 2021 (https://www.energy.gov/sites/default/files/2021-08/Land-Based%20Wind%20Market%20Report%202021%20Edition_Full%20Report_FINAL.pdf)

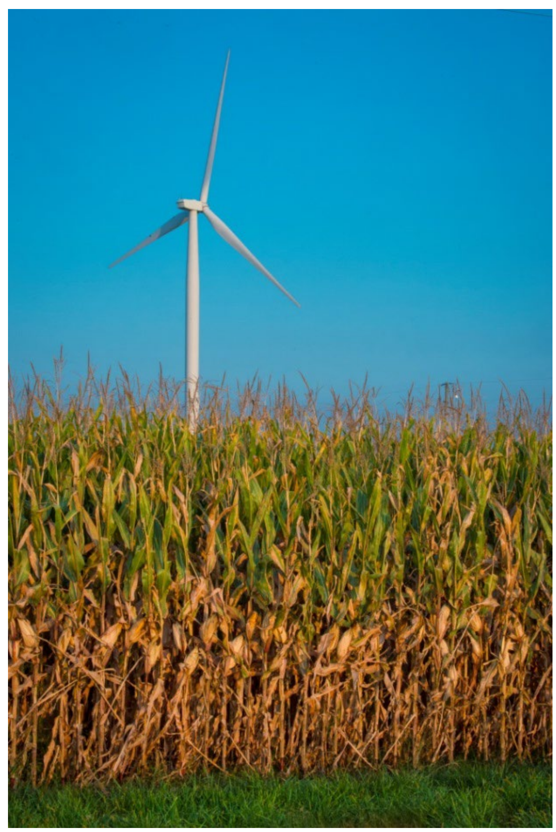
4.2 Opportunities from DERs for Missouri farmers and landowners

Missouri farmers and landowners have already experienced benefits to farm income from linkages between farm commodities and energy demand spurred by new energy technologies. These include commodity crop price increases from in-state biofuel production, land leases from wind and solar farms, and cost savings or tax credits from on-farm solar panel installations. Most of the opportunities related to electricity have, so far, come from centralized generation models.

Distributed energy systems present some similar opportunities, such as potential leases for distributed wind and solar installations. Farmers and rural landowners will also have new opportunities to benefit from DERs. The following section will profile three opportunities: land leases, behind-the-meter electricity generation, and managing farm-level risks such as power outages.

4.2.1 Land leases

Some Missouri farmers and landowners have already leased land to companies generating electricity from wind energy. In 2021, energy developers for utility-scale solar installations were also proposing leases to some Missouri landowners. As improvements in battery storage are improving the outlook for new, distributed wind and solar installations, energy providers will likely expand their search for land on which to locate renewable generation. (Photo: USDA)



Landowners must weigh many considerations when leasing their land for new uses. An attorney experienced in reviewing land use contracts can help you understand implications of specific lease proposals. The Corn Belt already has a comparatively long history of leasing land for wind installations, and university extension resources from other states are available for helping landowners evaluate implications in their situation. Purdue University's *A Landowner's Guide to Commercial Wind Energy Contracts*[50] is a four-page guide with key considerations for Indiana. Missouri readers may benefit from this overview that includes the difference between a lease and easement, sections of typical wind contracts, common payment terms, and implications for landowner property rights.

The 66-page *Wind Energy Leasing Handbook*[51] provides considerations from workshops held in 2012 in Arkansas and Oklahoma. Although now ten years old, this publication provides extensive background about electricity generation and how wind energy leases fill a role in electricity generation in the Midwest.

[50] "A Landowner's Guide to Commercial Wind Energy Contracts" (https://www.extension.purdue.edu/extmedia/ABE/RE-5-W.pdf)
[51] "Wind Energy Leasing Handbook" (https://nationalaglawcenter.org/wp-content/uploads/assets/articles/rrumley_windenergyhandbook.pdf)

Considerations for solar land leases are detailed in another National Agricultural Law Center publication, *Farmland Owner's Guide to Solar Leasing*.[52] Developed by Ohio State University (OSU) Extension, the 48-page guide contains extensive information and considerations for landowners whom may be considering solar leases. A companion checklist[53] from OSU Extension provides a shorter list of important solar lease considerations. These include what to do before signing a lease, including many tasks that can be accomplished before meeting with an attorney who will review the lease. The checklist also includes terms common or specific to a solar lease.

4.2.2 Behind-the-meter generation

Two-way meters and net metering can allow surplus electricity to be delivered onto the grid. Missouri's net metering law is found in section 386.890 of Missouri Revised Statutes.[54] Farms can also be prime locations for DERs generating electricity for use beyond the farm.

The key to making distributed energy work beyond the farm, firm or residential level is the ability to store and draw the power that has been generated. New batteries and storage systems, including electric vehicle batteries, are helping engineers solve these challenges in DER system design. Safety on the farm, and in interconnections with the power grid, is always a vital consideration when designing DER systems.

Electricity users, including farms, may be able to take advantage of communication technology central to many DER projects. Adjusting variable electric use via load management practices to different times of the day could lead to pricing benefits, especially for larger electricity users like animal agriculture. Farms with distributed wind and solar resources – or other DERs that could be switched to serve a local grid or entity – could help suppliers manage peak demand. (Photo: DOE)

[52] Farmland Owner's Guide to Solar Leasing (https://nationalaglawcenter.org/wp-content/uploads/assets/articles/hall_solar_Leasing.pdf)
[53] The Farmland Owner's Solar Leasing Checklist (https://energizeohio.osu.edu/sites/energizeohio/files/imce/The_Farmland_Owner%27s_Solar_Leasing_Checklist%202.pdf)
[54] Missouri Revised Statutes (https://revisor.mo.gov/main/OneSection.aspx?section=386.890)

4.2.3 DERs and farm risk management

Many farms must have some source of backup electricity during power outages. Heating, milking systems, milk cooling, barn ventilation, water, feed and other systems require electricity to function. Power outages can impact animal health. Crop irrigation systems can also be affected, especially when the well pump uses an electric motor.

DERs could help operators manage such risks, especially when new technologies can be integrated with older or existing systems. One example is electricity "islanding," which creates a microgrid at the farm level that can function apart from the distribution and transmission grid. DERs have other benefits beyond financial. Hog farms in North Carolina have adapted DERs electricity generation from biogas in ways that have reduced odor and other local concerns.

Table 3 provides a *sample* of some threats, opportunities, weaknesses and strengths (SWOT analysis) for land leasing for renewable generation and other opportunities related to DERs.

Table 3. Sample SWOT analysis for DERS

Threats
• Eminent domain used by power developers to cross property lines • Decreased reliability of electricity due to congestion from DER providers • Increasing utility bills as farmers produce more themselves and cost burden of maintaining transmission and distribution lines shifts to remaining users • Neighboring farms build facilities negatively impacting land values or aesthetics
Opportunities
• Land ownership offers place for self-production of on-farm energy using farm energy grants • Lucrative cash flow from leasing to wind, solar and energy storage project developers • Electricity costs for larger users may drop with time of use pricing, sensors and controllers to manage demand • Electrification of auto and farm machinery opens path to cut costs through on-farm energy production
Weaknesses
• Leasing to developers is location-specific • Net metering policies may favor landowners in areas served by investor-owned firms, not rural electric cooperatives • Capital costs are significant • Larger energy developments encounter neighbor resistance
Strengths
• Renewables associated with DERs are land intensive, pushing development to rural areas • "Not in my backyard" sentiment in denser rural areas will push developers to least-settled areas • Parts of Missouri have significant potential to develop wind, solar, storage and transmission

Conclusion

The electrical power industry is undergoing important changes as energy providers reevaluate the long-term viability and profitability of existing centralized generation power plants. Electrical energy providers in the past 30 years have added newer electricity generation technologies such as utility-scale wind and solar. The cost of establishing new, non-subsidized utility-scale wind and solar generation has emerged to be, in some locations, comparable or even lower than costs of generation in legacy power plants. Investor-owned utilities in Missouri must meet certain requirements for sourcing from renewable sources, which has created an environment where solar and wind development is actively pursued in and around Missouri. Land lease proposals from energy developers are the most visible and immediate impact of wind and solar development upon Missouri farmers and farmland owners.

Distributed energy resources (DERs) can include wind and solar as well as technologies that can generate and improve power quantity – whether or not the DERs are connected directly to the power grid. Since they are smaller and modular technologies, DERs can have significant implications at the farm/firm level. Impacts of DERs can include providing new or more efficient sources of backup energy power, potential reductions in utility costs, creation of farm "microgrids," and integrating newer, electricity-intensive technologies such as electric vehicles.

This publication presents a foundation for understanding DERs and some affiliated changes in the structure of the energy industry relative to Missouri farmland. Eventual impacts and adoption of DERs are yet undetermined. Still, major power providers are actively factoring DERs into their long-range plans. For some Missouri farmland owners and farmers, the potential benefits from DERs and other changes in electricity generation could present real opportunities for managing risks and diversifying farmland revenue streams.

Additional resources from MU Extension

E3A Solar Electricity: Introduction
(https://extension.missouri.edu/publications/em300)

E3A Solar Electricity: Building and Site Assessment
(https://extension.missouri.edu/publications/em301)

E3A Solar Electricity: System Options
(https://extension.missouri.edu/publications/em303)

E3A Solar Electricity: System Components
(https://extension.missouri.edu/publications/em304)

E3A Solar Electricity: System Sizing
(https://extension.missouri.edu/publications/em305)

E3A Small Wind: Understand Small Wind
(https://extension.missouri.edu/publications/em501)

E3A Small Wind: Electricity Consumption and Installation Options
(https://extension.missouri.edu/publications/em502)

E3A Small Wind: Economic Considerations and Incentives
(https://extension.missouri.edu/publications/em506)

E3A Small Wind: Siting and Permitting
(https://extension.missouri.edu/publications/em507)

Glossary

Associated Electric Cooperative – The cooperative, headquartered in Springfield, Mo., provides wholesale power and support services to six generation and transmission cooperatives.

Battery energy storage systems (BESS) – Battery systems storing electrical energy generated by renewable energy sources.

Behind-the-meter – Connected to the local distribution grid behind the utility meter, like rooftop solar; excess energy may flow through the meter back onto the grid.

Centralized electricity generation – Generating electricity on a large-scale at centralized facilities and transmitting electricity through high-voltage power lines for distribution.

Demand response – The process of using voluntary load reductions during peak hours.

Distributed energy resources (DERs) – A variety of small, modular power-generating technologies that can be combined with energy management and storage systems and used to improve the operation of the electricity delivery system, whether or not those technologies are connected to an electricity grid.

Distributed storage – Electricity storage devices located nearby the site of generation, such as battery storage systems for solar panels.

Electric cooperatives – User-owned, non-profit businesses that provide electrical power to their member-owners and return profits in the form of patronage dividends or lower rates.

Federal Regulatory Energy Commission (FERC) – The government commission regulating interstate transmission of electricity.

Front-of-meter – Resources are connected directly to the local distribution grid. Some DER systems may enable switching front-of-meter generation to a specific customer or customers.

Interconnections – The North American power grid is divided into four interconnections which tie utilities together during normal system conditions.

Investor-owned utility – Large electric distributors that issue stock owned by shareholders.

Independent system operator (ISO) – An organization formed under FERC regulatory authority to operate regional electricity grids, administer wholesale electricity markets and provide reliability planning for a region's bulk electricity system.

Load – The amount of electricity consumed during a given period.

Load management – How energy providers manage networks to meet demand peaks.

Megawatt (MW) – 1,000 kilowatts or 1 million watts; standard measure of electric power plant generating capacity.

Megawatts from demand management – The total megawatts in a system that can be "saved" from demand response actions.

Microgrid – A localized grid that can disconnect from the traditional grid to operate autonomously.

Midcontinent Independent System Operator (MISO) – An RTO responsible for power grid operation in 15 U.S. states and Manitoba.

Missouri Public Service Commission (PSC) – The Missouri PSC regulates investor-owned utilities and regulates the operational safety of the state's rural electric cooperatives.

Net metering – Crediting a utility customer's account for electricity generated from renewable energy sources.

Peak load demand – A sustained period during which users are requiring the most electrical power on the network.

Power grid – The network that transmits and distributes electricity.

Renewable energy – Naturally replenished energy generated from natural resources such as sunlight, wind, rain, tides, biomass and geothermal heat.

Regional transmission organization (RTO) – Like an ISO, an RTO is formed under FERC regulatory authority to operate regional electricity grids, administer wholesale electricity markets and provide reliability planning for a region's bulk electricity system. RTOs have greater responsibilities concerning regional transmission networks.

SERC Reliability Corporation – The SERC Reliability Corporation manages the power grid in much of the southeastern United States, extending into Missouri and Illinois. It differs from an RTO/ISO in that it is formed of vertically integrated power companies.

Smart grid – The whole set of technologies and practices which improve the efficiency and reliability of the U.S. power grid.

Southwest Power Pool (SPP) – An RTO responsible for power grid operation in 17 U.S. states.

Storage battery – A device capable of transforming energy from electric to chemical form and vice versa. The reactions are almost completely reversible. During discharge, chemical energy is converted to electric energy and is consumed in an external circuit or apparatus.

Extension
University of Missouri

Issued in furtherance of the Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Director, Cooperative Extension, University of Missouri, Columbia, MO 65211 • MU Extension provides equal opportunity to all participants in extension programs and activities and for all employees and applicants for employment on the basis of their demonstrated ability and competence without discrimination on the basis of race, color, national origin, ancestry, religion, sex, sexual orientation, gender identity, gender expression, age, genetic information, disability or protected veteran status. • 573-882-7216 • extension.missouri.edu