FHWA Renewable Energy in Highway Rights of Way Peer Exchange
February 27-28, 2018
St. Louis, Missouri

Summary Report

U.S.Department of Transportation
Federal Highway Administration

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Cover Image: Solar-powered permanent traffic counter in Oakley, Kansas. Source: Kansas DOT

Introduction

This report summarizes a Federal Highway Administration (FHWA) peer exchange that was held on February 27-28, 2018 at the Missouri Department of Transportation's St. Louis Transportation Management Center in St. Louis, Missouri. The purpose of the peer exchange was to bring together practitioners to discuss issues related to and approaches for accommodating renewable energy technologies in highway rights-of-way (ROWs) and other State DOT property. Practitioners were interested to learn what neighboring states are doing in this area and to begin identifying possible next steps for their own agencies. It was the second such peer exchange in a series that FHWA is supporting.

This report summarizes the presentations and discussions at the peer exchange. Presenters from State Departments of Transportation (DOTs), and FHWA discussed their organizations' current thinking and activities in the highway renewable energy realm. One university graduate student also presented on her relevant research. Participants also discussed challenges and lessons learned. Organizations participating in the meeting included the DOTs from Arkansas, Illinois, Iowa, Kansas, Michigan, Minnesota, Missouri, and Oklahoma; several FHWA Division Offices; FHWA Office of Natural Environment; FHWA Office of Real Estate Services; Saint Louis University; the National Renewable Energy Laboratory (NREL); and the U.S. DOT Volpe Center. Appendix A lists the peer exchange participants, and Appendix B provides the agenda.

The peer exchange was one of many efforts of the FHWA Office of Real Estate Services and FHWA Office of Natural Environment to provide information and technical assistance to State DOTs about generating renewable energy in highway ROWs. FHWA's work has included the development of a number of resources, such as:

- A report, briefing book, and a question and answer quick guide on alternative uses of the ROW;
- A map of highway ROW renewable energy projects in the United States to which practitioners can submit projects for inclusion; and,
- White papers on photovoltaic noise barriers and sustainable rest area design and operations.

State DOT Presentations

After welcome and introductions from Missouri DOT St. Louis District Engineer and the FHWA Missouri Division Administrator, practitioners from State DOTs discussed their agencies' current thinking regarding renewable energy implementation, including their experiences and research on the topic as well as challenges that they have faced as they begin to explore options. Brief question and answer periods followed each presentation. This section summarizes the State DOT presentations.

Missouri DOT and FHWA Missouri Division Office

Jennifer Harper (Missouri DOT, or MoDOT) and Dawn Perkins (FHWA Missouri Division) discussed the history of renewable energy implementation at MoDOT and the outcomes of a recent trip to Georgia to visit innovations being deployed and tested by The Ray[1] in partnership with Georgia DOT.

[1] The Ray was one of the Ray C. Anderson Foundation's first funding initiatives, beginning with the 2014 naming of an 18-mile corridor on Interstate-85 in West Georgia as the "Ray C. Anderson Memorial Highway." In the year that followed, the Foundation

In 2008 Missouri voters passed a ballot initiative requiring investor-owned electric utilities to generate or purchase electricity from renewable energy sources such as solar, wind, biomass and hydropower with the renewable energy sources equaling at least 15 percent by 2021, including at least 2 percent from solar energy; and restricting to no more than 1 percent rate increases to consumers. Shortly thereafter, MoDOT made an early venture into the renewable energy area when it contracted to install two, 1.2 kilowatt (kW) wind turbines–one in each traveling direction–at a Welcome Center on I-44 in Conway, Missouri. Although the wind turbines, which powered lights at the Welcome Center's information counters, were recently taken out of operation due to the developer going out of business, the experience embodied one of MoDOT's seven core values: being bold.

That spirit, along with leadership support, has led MoDOT to develop its "Road to Tomorrow" initiative along Interstate 70. The Road to Tomorrow represents an innovative, forward-looking program that requires MoDOT to be flexible and take risks as it considers the highway of the future. It is leading MoDOT to look into any and all ideas that will lead to either an increase in revenue or a way for the department to more efficiently handle traffic. In 2015, the Missouri Highways and Transportation Commission asked the Road to Tomorrow team to look worldwide at highway innovations that were being deployed and think about how they might be applied in Missouri. In addition to opportunities such as truck platooning and electric vehicle infrastructure improvements, and despite the competing challenge of the state having relatively inexpensive electricity, MoDOT has considered alternative energy options as part of this effort.

For example, MoDOT has met with Solar Roadways, Inc. to discuss options for demonstrating the company's proof-of-concept work to replace current roadway surfaces with modular solar panels that can be driven upon. Solar Roadways has received several rounds of Small Business Innovation Research (SBIR) funding from the U.S. DOT and is now looking to continue developing and testing the innovation with a state DOT partner(s). Staff members on MoDOT's Road to Tomorrow team are excited about the possibility of a potential ancillary benefit of this technology - reduced winter plowing given the radiant heat expected from its surface.

In 2017, MoDOT and FHWA Missouri Division Office staff members viewed a similar technology firsthand when they visited The Ray in Georgia. There, The Ray and Georgia DOT have partnered with Colas to install the first demonstration of Colas' Wattway technology in the United States. The 538-square-meter Wattway pilot, which is located at the Georgia Visitor Information Center in West Point, Georgia is one of many innovations being trialed on The Ray. The average output is anticipated to be 7,000 kWh annually, which will help power the center. MoDOT staff look forward to learning more about The Ray's pilot as additional operational results are gathered. They also plan to follow up with Georgia DOT to learn more about the agreements that have been put in place with The Ray to better understand the creative ways the demonstration projects have been permitted and financed.

Minnesota DOT

A 2007 state greenhouse gas emissions reductions law and a 2013 law requiring state agencies to obtain 1.5 percent of their electricity from solar power were initial drivers motivating Minnesota DOT (MnDOT) to explore options for ROW solar. MnDOT's Siri Simons discussed lessons learned from a 2014 Request for Proposals (RFP) on renewable energy, a 2016 solar feasibility assessment, and current activities at

created The Ray as an independent nonprofit to fund research, pilot projects, and emerging technologies with the potential to shape the transportation infrastructure of the future.

MnDOT to consider and implement renewable energy projects.

In 2014, MnDOT released a two-stage RFP with the goals of demonstrating the feasibility of using MnDOT ROW for solar arrays and developing criteria for selecting and using ROW for 1 MW or greater of solar capacity. The first stage asked developers to identify potential sites for ROW solar that took into account the highway clear zone, avoided flood-prone areas, and were owned in fee by MnDOT. In stage one, 6 responders identified 34 sites, which MnDOT narrowed down to 4 responders and 13 sites using site selection criteria and feedback from district-level staff. The second stage involved these specific sites, including requesting detailed work plan and rent proposals. In stage 2, MnDOT received responses from two developers about six of the proposed sites. Ultimately, some proposals did not move forward due to local government opposition and the potential developers became less responsive, perhaps concerned about the MnDOT's potential need to remove any installed solar panels before 25 years for transportation system expansion. That is approximately the time horizon over which many solar developers base their economic viability estimates.

Despite this setback, MnDOT has recently reinvigorated its solar development process with a few changes. In 2016, it contracted to have a Solar Feasibility Assessment created. MnDOT identified and filtered three hundred fifty sites to ensure utility interconnection, adequate public space, and optimal energy generation. The costs and benefits of pursing solar projects were then estimated for the sites passing the initial filter, including a suggested lease rate range. Based on the analysis, one of the more financially viable options for solar at MnDOT involves taking advantage of the Solar Capacity Credit available to public entities in Minnesota.[2]

In 2018 and beyond, MnDOT anticipates completing a comparison of the pros and cons of power purchase agreement (PPA) and direct ownership business models; one of the major upsides of the former is no or low upfront costs and the latter potentially the best long-term savings, including retention of the renewable energy credits (RECs) generated. MnDOT is also drafting an RFP for one rooftop solar site. The agency also expects to solicit proposals for a rooftop and ground-mounted site through a collaborative purchasing process supported by the Minnesota Department of Administration and Clean Energy Resource Teams.

Michigan DOT

Matt DeLong presented on recent Michigan DOT (MDOT) thinking regarding renewable energy projects. Michigan has a mandate for the State to obtain 10 percent of its energy from renewable sources—a proportion to be raised but capped at 25 percent in the future.

Accordingly, many organizations have started to consider how renewable energy technologies might be integrated into their own operations, factoring not only costs but also social benefits in the decision-making equation. Michigan State University, for example, has a goal to convert to 100 percent green energy within five years. An initial activity has involved retrofitting all parking with solar canopies. Similarly, five years ago over half of Detroit's public street lights did not work. The city has replaced them with LEDs, which the city hopes to eventually offset with solar energy.

MDOT, too, is generally seeking to try innovative applications that reduce its carbon footprint. In 2012, the agency partnered with the Pure Michigan Energy Office to use a U.S. Department of Energy grant to

[2] Electricity in Minnesota is currently relatively inexpensive at $0.075/kWh.

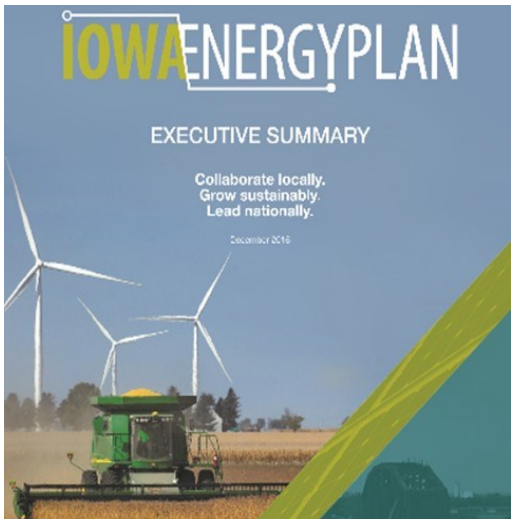
install 2 solar canopies at a parking lot at the interchange of State Route 44 and I–96 in Grand Rapids, MI. Electricity generated by the array powers the lighting at the interchange. The department has also decided to make its rest areas zero net energy buildings, a task that will be accomplished as rest areas are scheduled to be rebuilt (vs. retrofitting them). As automated vehicle concepts continue to emerge, MDOT has also started to consider how the vehicles and related infrastructure might be powered, even if just as a supplement, with alternative energy.

MDOT installed two solar-powered carports at a parking lot at the interchange of State Route 44 and I–96 in Grand Rapids, MI. Electricity generated by the array powers the lighting at the interchange. Source: Michigan DOT Photo Lab

To date, however, practical issues have prevented MDOT from taking a comprehensive look at highway ROW for renewable energy generating opportunities. In particular, MDOT has aimed to not lose sight of the fact that if renewable energy systems cannot be easily tied into transmission, the odds are against the project given the high costs of new interconnections. DOT sites that may be good from a renewable energy perspective can be far from transmission tie-ins and thus not currently viable. Another challenge is that budget constraints make it difficult for DOTs to fund positions or work, such as renewable energy development, outside of the traditional DOT positions and disciplines.

Iowa DOT

Tamara Nicholson gave an overview of the renewable energy industry in Iowa and discussed questions that Iowa DOT staff hoped to have answered during or after the peer exchange. The state of Iowa is a national leader in renewable energy production. The state currently generates 35.8 percent of its electricity from wind power—the most proportionally of any state and enough electricity to power the equivalent of more than 1.6 million average U.S. households. However, the state legislature is currently debating the potential elimination of a state solar tax credit, and no mandate for renewable energy production by Iowa state agencies currently exists. Therefore, there has not been top-down direction to Iowa DOT to develop larger scale renewable energy projects in highway ROW. Instead, Iowa DOT's use of renewable energy technologies has been generally limited to providing auxiliary power to traffic counter and variable message sign equipment. The Iowa DOT rest area in Adair also highlights the importance of the wind energy industry in the state. It features a towering wind blade that Siemens donated and installed as a statue, as well as artwork throughout explaining the wind energy industry, power grid, and renewable fuel production in Iowa.



The recently published Iowa Energy Plan will lay the groundwork necessary to reaffirm Iowa's energy leadership into the future, including collaborating locally, growing sustainably, and leading nationally.

From a practical standpoint, the emergence of the wind industry is impacting some of Iowa DOT's infrastructure. There has been an increase in the volume of oversized loads (carrying turbine components) plying the highways. Iowa DOT has also had to reconsider some rest area designs given the new need for parking for long trucks.

Other related activities that the Iowa DOT is considering pursuing include how to accommodate electric vehicle and alternative fuel technologies.

Solar-powered traffic counters in Dodge City, KS (left) and Topeka, KS (right). Source: Kansas DOT

Kansas DOT

Kansas DOT (KDOT) does not currently have any large ROW renewable energy projects in place, but the department does utilize renewable energy in small-scale applications. Joe McEvoy gave an overview of a selection of these more localized applications, focusing primarily on KDOT's permanent traffic counters.

Prior to 1992, all of KDOT's Permanent Traffic Counters were AC powered. This limited the locations where KDOT could place the counters since the agency was constrained by the need to tie into local utility lines and it typically needed agreements in place with utilities and/or landowners. Beginning in 1992, KDOT started utilizing state tax reimbursements to begin transitioning to solar powered traffic counters.

At first, the effort was modest. KDOT switched 4 of 110 permanent traffic counters to each use one 20-watt solar panel. Realizing the flexibility and benefits of solar power, KDOT continued transitioning more counters to solar, and, as costs decreased, began utilizing larger solar panels that are capable of providing more power. Now, 103 of KDOT's 110 permanent traffic counters are solar-powered. Most of the panels are 60- to 110-watt panels that allow "classification," "weigh-in-motion," and "speed" counters, and associated cellular modems, to be powered with renewable energy. The solar panels charge the devices' primary batteries. When fully charged, those primary batteries will last six days and can provide backup power during prolonged periods of cloud cover. KDOT gathers data from the counters to develop flow maps, determine growth factors, and develop future projects.

KDOT has faced some challenges regarding the permanent traffic counters, including vandalism and questions about how property instruments (e.g. permanent easement or fee title) affect the process to implement renewable energy projects.

Arkansas DOT

Jennifer Williams described some of the questions that Arkansas DOT is grappling with as it begins to consider renewable energy options. To date, the agency has had limited experience with renewable

energy applications. With 16,000 highway miles – the 12th most among state DOTs – the potential for ROW renewable energy generation may be significant. There have been preliminary discussions about how such activities might fit under the department's mission statement to "provide safe and efficient transportation solutions to support Arkansas' economy and enhance the quality of life for generations to come."

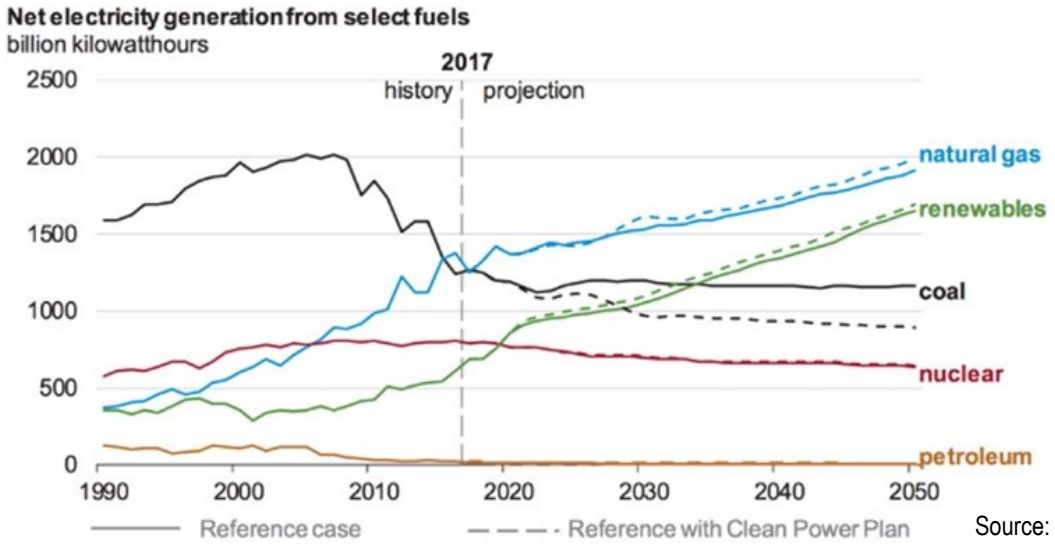
State law in Arkansas encourages renewable energy generation, and there is a growing sentiment among some DOT staff that a "dollar saved is a dollar earned." These notions have added a new dimension to conversations among Arkansas DOT realty staff as they consider what do with remnant properties (properties of insufficient size to be a buildable lot)—an activity that has often resulted in sold values below appraised values. One opportunity that may be particularly compelling in Arkansas is the possibility of growing crops, such as soy beans, in the ROW for bioenergy or feedstock.

If the department does implement a renewable energy project(s), it will need to address the perception that those activities stray from the DOT's core goal of maintaining the highway system. There is also a concern that with staff already over-extended, it may be difficult to find time or support for taking on additional, non-mission critical job responsibilities such as implementing renewable energy projects.

National Presentations

NREL: Solar Market Trends and Costs

Lori Bird of the NREL's Strategic Energy Analysis Center presented on solar market trends and costs. In 2017, solar and wind represented approximately 52 percent of all new sources of generation. The price of solar systems is dropping. Many states are also increasing their renewable portfolio standards. These conditions have led to burgeoning renewable energy market that is projected to continue to grow.



Source: NREL

Renewable energy generation can reduce energy bills through net-metering, or other bill credit mechanisms. When the electricity generated from renewable sources is sold, it is typically at prices lower than retail rates. For this reason, it can be better to use the energy on-site—something that is not

always an option for a state DOT. Federal incentives and accelerated depreciation schedules can also alleviate some cost burden. Currently, developers can take advantage of a Federal tax credit worth 30 percent of the cost of system. That amount is scheduled to phase down starting in 2020.[3] Additionally, a 5-year accelerated depreciation schedule allows owners to write-off a significant amount of expenses in a short amount of time, rather than over the life of the asset. When paired with any state and local incentives that may exist, such as tax exemptions, grants, and Renewable Energy Certificates (RECs), renewable energy development can be a more than competitive option. The NC Clean Energy Technology Center hosts the Database of State Incentives for Renewables and Efficiency (DSIRE), which allows users to find policies and incentives in their areas. See http://www.dsireusa.org/ for more information.

Common financing methods for commercial renewable energy systems, including host-ownership and third-party ownership, were also discussed. Characteristics of these are summarized in Table 1.

Table 1. Common Financing Methods for Commercial Systems

Host-ownership	○ Purchase system through funds from balance sheet or receive bank loan – Loan has no significant upfront capital expenditures. Can be cash flow neutral/positive if payments are offset by reduction in electricity expenses. – Low-interest financing can make this approach worthwhile ○ Utilize tax benefits, lower energy bills
Third-party ownership (TPO)	○ Third-party purchases PV system and receives all tax benefits, grants, RECs, etc. ○ Third-party either sells electricity generated by system, or leases the system, to host, ideally at a lower rate than what is paid to electric utility (saving host money from day one) – Host also often has the option to pre-pay some portion of contract at a lower rate, and then pay little or nothing for the remainder of the contract – Many factors dictate the PPA price ○ Third-parties are typically profit-driven, so are likely to have a higher cost of capital ○ Not available in every state
Offsite	○ Most PV systems used by commercial customers are onsite; however, a growing trend within the industry is for organizations to buy electricity from offsite systems (virtual PPA)

Since 2015, a number of states have lowered the credited value of exported electricity from distributed PV. In the third quarter of 2017 alone 17 states took action related to the development of a net metering successor tariff or adjusting credit rates for excess generation. If the successors involve lower rates for renewable energy, renewable projects can be less attractive. Meanwhile, some states have developed systems other than net metering to compensate solar exported onto the grid, and states with a large deficit between retail and "exported" rates may provide incentive for storage or self-consumption.

NREL has made available several energy systems analysis models and tools to assess, analyze, and optimize renewable energy and energy efficiency technologies for a given project. Examples include REopt™, which is helps users optimize energy systems for buildings, campuses, communities, and microgrids to meet cost savings and energy performance goals, and the Community Solar Scenario Tool, which allows users to evaluate a range of financial scenarios regarding the viability of a solar garden in a given community.[4] More information these and other tools is available at

[3] In 2020, owners of new residential and commercial solar will be able to deduct 26 percent of the cost of the system from their taxes. In 2021, the deduction is 22 percent. In 2022 onwards, the deduction is 10 percent.
[4] Also known as "community," or shared, solar, solar gardens entail an off-site PV array with multiple subscribers; subscribers receive bill credits for the production of their share.

https://www.nrel.gov/analysis/data-tools.html.

FHWA: Other States' Activities

Tina Hodges of the FHWA Office of Natural Environment presented on case study examples of renewable energy projects that other state DOTs have underway. She also described the variety of reference resources that FHWA has developed over recent years to help state DOTs interested in developing their own renewable energy projects.

Generally, there is significant and growing interest among state DOTs about what their peers are doing in terms of renewable energy implementation and alternative uses of ROW. To date, most state DOT renewable energy projects have involved deploying solar technologies along highway ROW and at rest areas. Currently, there is approximately 5.25 MW of solar installed across all DOTs, with at least 2 MW more planned in the next 12-24 months.

To date, most state DOT renewable energy projects have involved deploying solar technologies along the ROW and at rest areas. FHWA maintains a map of known highway renewable energy projects at https://www.fhwa.dot.gov/real_estate/right-of-way/corridor_management/alternative_uses.cfm.

The DOTs in Oregon and Massachusetts have been early adopters of highway renewable energy projects and have deployed the most capacity among DOTs. As a result of its two demonstration projects, Oregon DOT developed a *Guidebook for Departments of Transportation to Develop Solar Photovoltaic Systems in the Highway Right-Of-Way* (revised 2016). The book is intended to help other transportation agencies navigate the process towards a successful solar PV installation by providing step-by-step information, case studies and additional resources.[5] In 2013, the Massachusetts DOT (MassDOT) issued a request for response (RFR) for the development of 6 MW of ROW solar projects across multiple sites. In October 2014, MassDOT awarded a contract and worked with the contractor to establish a master license agreement and PPA. The projects, each of which was implemented as a public private partnership whereby the developer is responsible for project design, construction, operations, maintenance, and decommissioning of the solar panels at the contract's end, include site-specific addenda within the broader master license agreement.

MassDOT did not put down any money up front; instead, the DOT leased the sites to the developer for 20-years, and agreed to purchase all of the energy generated. MassDOT also benefits from a net metering policy in which the agency sells power back to the grid at the retail rate. The developer benefits through the guaranteed sale of electricity to MassDOT and by taking advantage of State RECs and Federal tax incentives.

Most of MassDOT's current solar projects are on the Massachusetts Turnpike, which was built before January 1, 1960, and thus did not require FHWA approval. One project in Plymouth, MA (Route 3, exit 5),

[5] Oregon DOT's guidebook is available at http://www.oregon.gov/ODOT/Programs/Solar%20Highway%20documents/Solar-Highway-Program-Guidebook.pdf.

however, did proceed with FHWA's approval. That site is within a ramp with local street access and is close to a service plaza and park-and-ride lot.

Examples in the Works

- **The Ray**. In 2014, the Georgia legislature named an 18-mile stretch of Interstate 85 in west Georgia in honor of the late Ray C. Anderson, a leader in industrial sustainability. To align with its goals of enhancing environmental stewardship and sustainability, the Ray C. Anderson Foundation (Foundation) labeled the I-85 section "The Ray" to be a living laboratory for emerging innovations related to sustainable transportation. The Foundation set a goal for The Ray to become a "net zero" highway that eliminates all deaths, waste, and carbon emissions. It has partnered with the Georgia DOT and other stakeholders to test innovations along the highway and at a visitor center on the highway segment.

- **Maryland DOT**. In 2016, the Maryland DOT conducted a preliminary solar evaluation in which it identified 86 sites for potential solar development, representing 60 MW of capacity. In June 2017, Maryland DOT released an RFP through which it will prequalify master contractors to develop solar, geothermal, and micro-hydro projects on DOT property. The RFP will likely lead to Master Services Agreements with the selected contractor(s), while standard power purchase and lease agreements will be developed for each site. Maryland DOT plans to incur no upfront costs, and the selected contractor(s) will be responsible for operations and maintenance of the systems. More information on Maryland DOT's recent activities in this area is available at https://news.transportation.org/Pages/022318mdsolar.aspx.

- **Texas DOT**. Texas has abundant solar resources and volatile natural gas prices, which have motivated the Texas DOT (TxDOT) to explore renewable energy project possibilities. Since 2006, State agencies in Texas have utilized a State procurement contract to purchase electricity in the deregulated market from retail electric providers—typically using contract terms of up to four years. In 2015, TxDOT partnered with other state agencies to request a new state contract or changes to the current contract to allow expanded purchasing opportunities. In the meantime, TxDOT negotiated a new contract at a historic low rate ($0.03/kWh for electricity, not including transmission charges) for 100 percent renewable sourced energy with the renewable energy credits to be placed in Texas. This led to TxDOT savings of $5 million over the previous year. In 2017, a new statewide contract was implemented, including opportunities for PPAs for wholesale renewable energy, coordinating on-site solar with energy contracts, and financial incentives for conserving energy during times of peak demand. With the new electricity procurement contract in place, TxDOT can now more easily pursue ROW renewable energy opportunities. Accordingly, TxDOT is currently planning a ROW solar project in partnership with the Central Texas Regional Mobility Authority adjacent to Austin Bergstrom International Airport at the intersection of two state highways. The project will be the first highway ROW solar project in the state.

- **Utah DOT**. The Utah DOT recently issued a Request for Information to the private sector for an effort to determine whether it is feasible for Utah DOT to generate all of its power renewably at or below the current price it is paying for electricity.

FHWA: Regulatory Environment

Lindsey Svendsen of the FHWA Office of Real Estate Services presented on Federal regulatory requirements that guide alternative uses of the highway ROW. She discussed the:

- Federal interest in the ROW
- Federal statutory and regulatory requirements affecting the use of the ROW
- Utility Accommodation Policy (UAP) and ROW use agreement provisions
- The new final rule and its effect on alternative uses of the ROW

For Federal-aid highway projects, ROW property must be devoted exclusively to public highway purposes,[6] but some exceptions exist. Non-highway uses may be approved by FHWA if the use is in the public interest, will not impair the highway, and will not impede the free and safe flow of traffic on the highway.[7]

The Federal definition for "utility" is broad in scope, and includes facilities that produce, transmit or distribute power and electricity which directly or indirectly serves the public. A small utility company servicing a small community or limited number of neighborhoods would normally meet the test of providing service to the public. In contrast, if a facility provides direct, dedicated services to a private corporation with no service to the public at large, the line is considered private. If the line is for the use of a State or local governmental unit, then the line is viewed as a utility facility.[8] Since the Federal definition for "utility" is so broad, if a State has a more restrictive definition FHWA allows that definition to determine qualification.

The FHWA-approved State UAP regulates utility installations on all highways.[9] If the State definition of a utility includes renewable energy projects, a State can approve installation of these projects in accordance with the process outlined in the UAP without referral to FHWA. The State DOT then enters into written arrangements with a utility (generally in the form of special use permits or joint use agreements). The FHWA Division Office reviews and approves new UAPs and revisions to UAPs for compliance with Federal requirements.

If a project does not qualify as a utility under State law, the project may request to use the ROW through a ROW Use Agreement (previously called Air Space Agreement),[10] which involves a site-specific Federal approval. Fair market rent is required for land, unless the project is in the public interest based on social, environmental, and economic considerations, in which case an exception must be approved. An application for a ROW Use Agreement approval must include planning and design details about the project, including provisions for maintenance access, terms of use, maps, plans, and sketches.

State DOTs should determine whether accommodation as a utility or using ROW Use Agreements better suits the conditions in their respective states. If renewable energy is not currently included in a State's UAP, the State could consider including it during a UAP update. ROW Use Agreement processes should be included in the State DOT's ROW Manual.

Saint Louis University: Median Wind Turbine Research

[6] 23 CFR 1.23(b)
[7] 23 U.S.C. 111
[8] 23 CFR 645.207
[9] 23 CFR 645 Subpart B
[10] 23 CFR 710.405

Leah Kunkel presented on her capstone Masters project at Saint Louis University to build a multi-criteria and analytic hierarchy assessment tool to determine ideal sites for highway micro-vertical axis wind turbines (VAWTs) in the United States. Most wind energy systems today are large horizontal-axis wind turbines (HAWTs) located far from cities. Human-generated wind, such as the turbulence along highways, is one often overlooked resource that could be tapped using VAWTs, especially given that they can operate in lower wind speeds, gather wind from any direction, and are small and thus less constrained from a siting perspective than HAWTs.

The dimensions of the proposed technology is likely 15 inches in diameter and approximately 24 inches tall. The researcher's envisioned design would have them located roughly 3 to 5 feet apart on a length of highway median that is between 2 and 10 feet wide. The wind turbines would be very lightweight and be made breakaway to maximize their ability to spin while minimizing their effects on the crashworthiness of the physical median environment.[11] The research to date has kept two questions in mind: (1) can the technology fit, and then, (2) should it fit?

At this stage, a flowchart and spreadsheet tool have been developed to help practitioners assess whether they may have a site theoretically conducive to deploying median VAWTs. The flowchart focuses on characteristics such as whether there is a renewable portfolio standard or a mandatory green power option, both of which are important early indicators as to the potential viability of the median VAWT concept. The price of electricity is also vital; currently, the draft model uses an average national electricity price of $0.11/kWh. The draft spreadsheet tool ranks potential sites based on variables such as median width, vehicle volume, and vehicle speed. Future criteria for the tool might include vehicle mix and crash rates.

U.S. DOT Volpe Center: PV Noise Barriers

Carson Poe of the U.S. DOT Volpe Center described a recent FHWA/Volpe Center research paper on PV noise barriers (PVNB).[12]

PVNBs represent the combination of noise barrier systems designed to lower noise levels between noise sources and sensitive receptors such as hospitals, schools, and residential areas, and PV systems designed to convert light energy directly into electricity. First deployed in Switzerland in 1989, PVNBs are now found in several countries where transportation agencies have sought to abate noise and produce renewable energy simultaneously.

The literature on PVNBs, most of which is several years old, generally agrees that there is great potential to use both existing and planned new noise barriers to produce solar power. Professionals from select transportation agencies who provided information to the project team echoed these views, especially when the integration of solar technologies is part of a holistic approach to design and construction. According to information collected, noise barriers can be designed to produce power without compromising their abilities to safely reduce noise, and in some cases may improve their performance. In terms of the business case for a PVNB, transportation agencies in countries or states with attractive subsidies or other incentives available to promote the renewable energy market will likely find PVNB

[11] Section 2A.19 of the Manual on Uniform Traffic Control Devices states that, "Postmounted sign and object marker supports shall be crashworthy (breakaway, yielding, or shielded with a longitudinal barrier or crash cushion) if within the clear zone.
[12] The report is available at www.fhwa.dot.gov/environment/sustainability/energy/publications/photovoltaic/.

An example PVNB along a highway in Switzerland. Source: TNC Consulting

implementation more feasible and economically self-sustaining than agencies in places where the regulatory environment is not as favorable to renewable energy developers.

Although the first highway PVNB is yet to be constructed in the U.S., at least two state DOTs are currently working with partners to pursue highway PVNB pilots. Given the substantial extent of noise barriers in the U.S. (nearly 3,000 linear miles), coarse estimates done as a part of the study suggest that the potential for solar energy production on American noise barriers is at least roughly equivalent to the annual electricity use of 37,000 homes, and perhaps much higher.

Discussion and Takeaways

At the conclusion of the peer exchange, participants were asked to elaborate on the motivations for considering renewable energy projects, the top challenges in doing so, and what resources might help them realize projects.

Motivators

Several participants began the discussion by pointing out that having leadership (e.g., DOT director or Governor) that is supportive of trying innovative technologies or business approaches can go a long way toward helping get a renewable energy project in place. Missouri DOT, for example, described how "being bold" is one component of the agency's value statements, a notion that helped set the stage for MoDOT to undertake the Road to Tomorrow initiative. Other state DOTs noted that their commissioners have real estate backgrounds and may be receptive to concepts related to alternative uses of the ROW. When leadership promotes forward-looking strategies, it can facilitate staff level efforts to explore opportunities for new sources of economic and environmental benefits, such as implementing renewable energy applications. One participant added that DOT staff might consider looking outside of the DOT for additional potential champions.

Another prominent driver of renewable energy activities at DOTs is a desire to use resources efficiently. Participants suggested so implementing renewable energy is an effective way to show taxpayers that DOTs are being good stewards and have authentic desires to design and operate more sustainable transportation systems.

Top Challenges

One of the primary concerns that participants voiced was setting precedents in a time when competing interests for ROW are increasing. Some participants noted that pressures for alternative ROW uses—not just for renewable energy generation—are growing, and DOTs are being appropriately cautious in their

decision-making regarding what activities to allow and pursue or not. One participant rhetorically asked, "How do DOTs as generally risk averse agencies go about deploying innovation?"

Participants agreed that even when DOTs do decide to move forward with an alternative use of ROW, it can sometimes be difficult to get all stakeholders to understand or appreciate the specific regulatory environment under which DOTs manage the ROW. In short, the regulatory protections in place will likely mean that implementing renewable energy projects will require time and ample interdisciplinary discussion. Such projects are not simply real estate transactions and might be viewed as somewhat ancillary to core DOT activities. Being able to clearly answer the "why is this being done?" question will likely be key to propelling renewable energy projects at DOTs.

Technical Assistance Opportunities

Participants suggested that more information on various business model opportunities would be helpful—particularly the implications of the direct ownership model and additional guidance on PPA options. Some participants believed a benefit-cost analysis tool that helped users compare business models would be especially useful. One attendee pointed out that state DOTs that had not already done so might consider completing an energy efficiency assessment for DOT facilities. Such an assessment could help identify possible efficiency upgrades, which would in turn make the margins from renewable energy projects greater.

The group agreed that FHWA could work to promote more consistency on the topic of renewable energy implementation among FHWA Division Offices, although they recognized the difficulties associated with this request given that the renewable projects do not fit squarely in simply one discipline. Others wanted to read about more "success stories," which could entail new case studies and better outreach regarding the case studies that already exist, and examples of right of way use agreements between DOTs and FHWA Division Offices. Participants also suggested that FHWA consider changing the title of its effort from "Renewable Energy in Highway ROW" to something broader that could include buildings and small-scale applications, such as "DOT Uses of Renewable Energy."

Appendix A: Participants List

Arkansas DOT	Jennifer Williams
Illinois DOT	Laura Mlacnik
Iowa DOT	Tamara Nicholson
Kansas DOT	Joe McEvoy
Michigan DOT	Matt DeLong
Minnesota DOT	Siri Simons
Missouri DOT	Tom Blair Jennifer Harper Brenda Harris Stacey Smith
Oklahoma DOT	Robert Blackwell Chad Parsons
Saint Louis University	Leah Kunkel
Tennessee DOT	Brian Dickerson
FHWA Arkansas Division	Amy Heflin
FHWA Illinois Division	James Kyte
FHWA Kansas Division	David LaRoche
FHWA Missouri Division	Dawn Perkins
FHWA Headquarters	Tina Hodges Lindsey Svendsen
National Renewable Energy Laboratory	Lori Bird
USDOT Volpe Center	Carson Poe

Appendix B: Peer Exchange Agenda

St. Louis Transportation Management Center, Room 207

Objective: Meaningful exchange among practitioners on issues and approaches for accommodating renewable energy technologies in highway rights-of-way (ROW).

Goals: Increased awareness of current practice and considerations related to accommodating renewable energy technologies in highway ROW; enhanced community of practice.

Tuesday, February 27 *For those staying at the SpringHill Suites St. Louis Chesterfield, meet in hotel lobby at 8:30 am.*

Welcome and Introductions 9:00 am
Missouri DOT
FHWA Division Administrator
FHWA HQ/USDOT Volpe Center

State Presentations on Highway Renewable Energy 9:15–10:45
Missouri, Minnesota, Michigan

Break

National Renewable Energy Laboratory Presentation and Discussion 11:00–12:00
NREL

Lunch

State Presentations *[continued]* 1:00–2:30
Iowa, Kansas, Arkansas

Break

Alternative Uses of Right-of-Way: Regulatory Environment and Other States' Highway Renewable Energy Activities 2:45–3:15
FHWA Headquarters

Discussion 3:15–3:45 pm
- State and Federal regulatory requirements
- Drivers for highway renewable energy efforts
- Building internal support

Adjourn

Wednesday, February 28

Day 1 Recap 9:00 am

Median Wind Turbine Research 9:15–9:45
Saint Louis University

Photovoltaic Noise Barriers 9:45–10:15
USDOT Volpe Center

Break

Discussion 10:30–11:30
- Constraints and challenges
- Opportunities, gaps/needs analysis
- Business models (including public private partnerships)
- Revisit issues & questions from presentations

Closing Remarks and Next Steps 11:30–11:45 am

Adjourn