



BUILDING THE GRID OF THE FUTURE **HOW TECHNOLOGY CAN HELP**

Tuesday, Aug. 16, 2 p.m. EDT | *FREE CSG eCademy Webcast*

Building the Grid of the Future: How Legislators can Bring Advanced Transmission Technologies to their States

CSG eCademy Webcast

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AUGUST 16, 2016

Tom Sloan, Representative, State of Kansas Legislature

Introductory Points

- ▶ Legislators set numerous public policy goals that involve energy and describe approaches to achieve them.
- ▶ Legislators do not make investment and electric grid design decisions – but we are as responsible for affordability, reliability, and enhancing customer options as are utilities
- ▶ We need to establish policies to let utility project developers know that we want them to propose transmission projects that incorporate advanced technologies so their cost-effectiveness can be compared to conventional technologies
- ▶ We establish how utilities and customers can monetize the opportunities created by technological innovations and customer preferences – through statutes and “jawboning”
- ▶ Opportunities to monetize technological capabilities will continue to drive generation, renewable energy, and grid development – even if Clean Power Plan is overturned
- ▶ We must help utilities become more efficient to offset customer losses, flat growth, O&M demands, and replace and upgrade aging grid infrastructure.
- ▶ 60% of Fortune 100 companies and U.S. military bases have renewable energy targets

Pressures on Electricity Providers and the Grid

- ▶ **Aging Infrastructure** – 50+ years old, reliability and energy inefficiency issues
- ▶ **Crowded Utility Corridors** – Little room for expansion, little chance for new urban corridors, prohibitions for new rural corridors
- ▶ **Viewshed Pressures** – Rural and urban areas
- ▶ **Increased Demand for Renewable Electricity** – Clean Power Plan Rules, customer and shareholder demands, transmission capacity expansion needs, Federal and State requirements
- ▶ **Development of Transactive Energy System Capabilities** – Distributed generation, instantaneous communication between customers and utilities, monetization opportunities
- ▶ **Increased Cost of Electricity** – Environmental protections, generation & transmission construction, technology costs, operating budget pressures
- ▶ **Public Policy Uncertainty** – Anti-fracking efforts, lawsuits against EPA, fuel preferences
- ▶ **Siting, Regulatory Approvals** – Increased opposition to constructing anything, anywhere; electricity-gas systems interconnectivity issues

Technology

A POTENTIAL PATH TO
INCREASED EFFICIENCY,
RELIABILITY, RESILIENCE,
MANY OTHER STATE
PUBLIC POLICIES, AND
POLITICAL “GOOD WILL”

Technology

- ▶ **More Efficient Delivery of Electrons** – Reduce line losses, increase generation efficiency.
- ▶ **More Efficient Use of Rights-of-Way** – Live wire reconductoring, new composite wires, new types of transmission structures, etc.
- ▶ **Addressing Political Issues** – Reducing viewshed objections, slowing rate increase pressures by cost-effectively increasing delivery of electricity
- ▶ **Distributed Generation in the Evolving Grid**– Voltage management, impact on utility and regulatory planning accuracy
- ▶ **Permits Integration of Energy Storage and Yet to be Developed Operating Equipment**

Examples in Appendix

Legislators Role: Ask Questions, Demand Answers

- ▶ **Technology drives customer options** – Smart meters, smart appliances, “apps,” real time communications and data between customers and utilities, low-cost generation options
- ▶ **Monetization of opportunities** drives electric system changes, regulatory changes, utility policy changes
- ▶ **Are your utilities and regulators promoting technologies** capable of improving system performance cost-effectively, containing cost, managing increases, meeting customer expectations (including for self-generation and renewable energy)?
- ▶ **Are you listening** to your constituents’ (especially the business community’s) desires?
- ▶ **Have you passed legislation in your statehouse** that signals to project developers that regulators and grid operators are receptive to considering new, cost-effective technologies ala Arkansas’ resolution (see Appendix).
- ▶ **There are several policymaker association policies** that can help you in your next session (see Appendix).

Legislator Questions for Regulatory Sector

- ▶ Does PUC have regulatory tools and flexibility to address new customer options, such as the ability to require project developers to show a performance and cost comparison of conventional and advanced technologies?
- ▶ Does PUC have the knowledge and will to reward customer options, while protecting non-participating customers and the utility?
- ▶ Does the PUC recognize that customers will increasingly be able to make “side” deals for energy, demand side management, and ancillary services with each other outside the purview of PUC and utility?
- ▶ Are Commissioners and staff prepared to address equity issues within customer choice and utility requirements as “provider of last resort?”
- ▶ Are Commissioners and staff prepared to equitably address third party market entrants’ issues and safeguard consumers/utilities from predatory practices?

Legislator Questions for Utility Sector

- ▶ Are they proposing projects with innovative technologies to increase grid efficiency, reliability, public acceptability, and demonstrating they are cost-effective compared to conventional technologies?
- ▶ Are utility prices/needs transparent?
- ▶ Are the true costs associated with being the provider of last resort identified and in place?
- ▶ Are the costs to maintain transmission and distribution systems adequately covered by self-generators?
- ▶ Can utilities adapt to and monetize technological changes and opportunities (e.g., ownership of roof top solar on customer premises)?
- ▶ Can utilities easily accommodate and monetize individual customer capabilities to buy/sell energy, demand side capabilities, ancillary services (e.g., storage for frequency regulation)?
- ▶ Are low income customer interests protected?

Change is Inevitable

- ▶ Large customers will drive the process (e.g., mall anchor tenants, military,), but residential customers will closely follow
- ▶ Legislators, in partnership with utilities and regulators, must become policy engineers to protect and permit customers and utilities to monetize the options available through technological innovation
- ▶ Cost-effectiveness technological advances will permit re-engineering of the customer-utility and customer-customer relations
- ▶ Legislators must ask their utilities how they will become more efficient to address rate pressures and flat or declining customer energy demands and enable those corporate actions

The same questions and encouragement must be provided to non-PUC regulated municipal and cooperative energy providers

Economic Opportunities for your State

- ▶ We all want renewable energy jobs in our states, but if such generation is more costly than buying from High Plains States' wind farms and "moving" the energy to your state, other jobs are lost, consumers suffer, and tax revenues fall precipitously

Are you helping businesses, the military, and average citizens meet their energy and cost of energy goals? Are you helping your electric utilities meet their customer expectations in ways that let both parties monetize their strengths?

Legislative Example: Expediting Line Approvals Using Existing Rights of Ways

Excerpt from New York Policy

B. Eligibility. Applicants proposing a major electric transmission facility as defined by PSL Section 120 may request that that application be reviewed on an expedited schedule provided: **(1) the facility is proposed to be located wholly within existing transmission rights-of-way and/or buried within existing state-owned rights-of-way except for any de minimus deviations; (2) the facility would not result in structures taller than those presently located on the existing rights-of-way or the change in height is de minimus; (3) the facility would not require expanding the width of the existing rights-of-way or the change in width is de minimus; and...**

Excerpt from Kansas Policy

66-1,182. Same; exemption of certain lines from act, local jurisdiction and environmental study requirements, when. (a) The provisions of this act shall not apply to:
(1) That portion of any electric transmission line to be constructed on an easement where there currently exists one or more electric transmission lines if the easement is not within the corporate limits of any city;

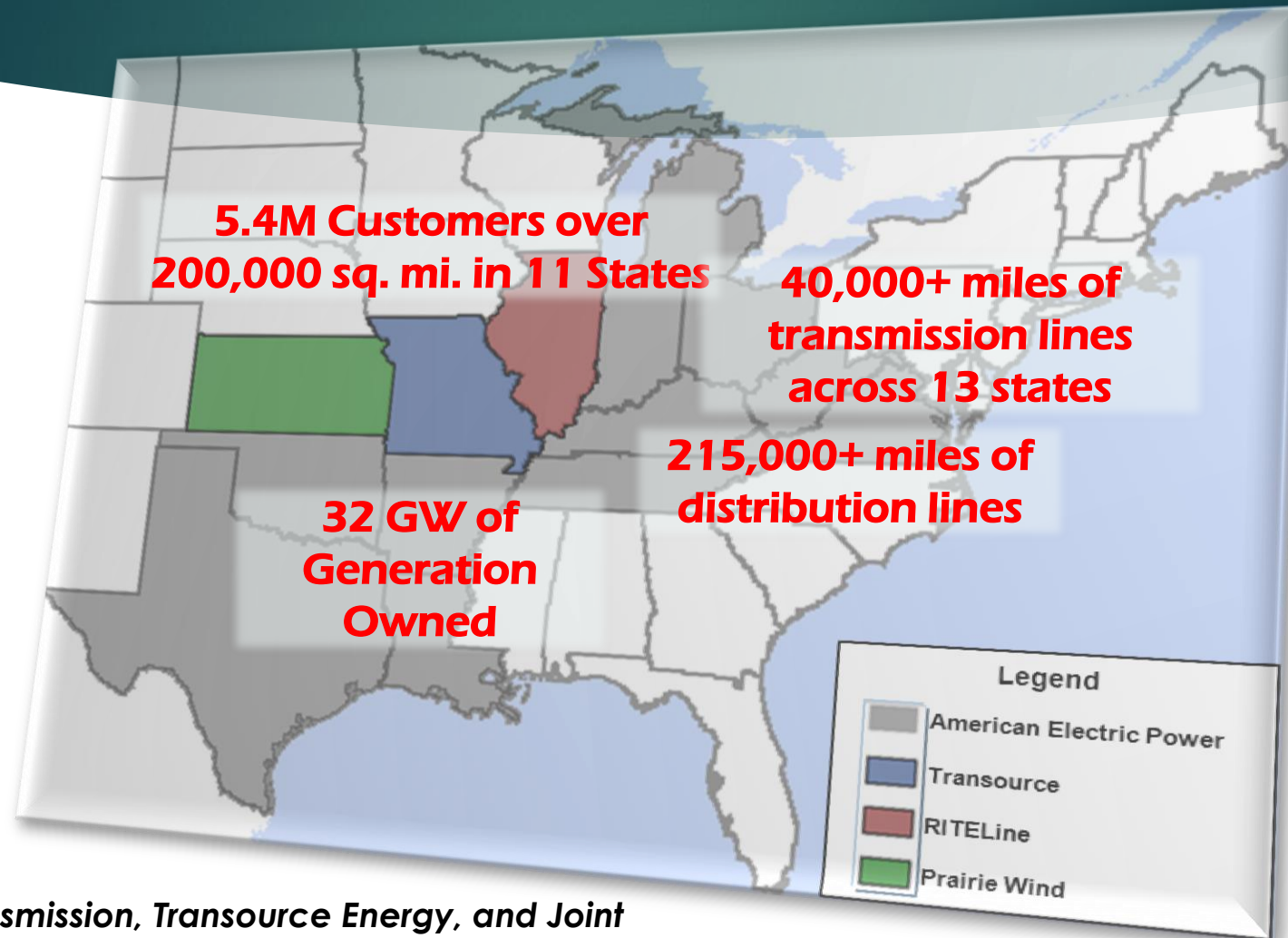
Legislative Example: Technologies are Situation and Location Specific to Provide Cost-Effective Benefits

- ▶ The New York State Legislature set many public policy goals.
- ▶ NY PSC issued a December 17, 2015 Order finding transmission needs driven by those public policy requirements. The Order is a rule in the state of New York.
- ▶ Numerous policies of the state of NY and the PSC (Order, pp. 66-67) that are similar to policies in other states such as job growth, increase fuel diversity including additional renewables, enhancing system reliability.
- ▶ The PSC directed the NY ISO regional operator to apply 13 additional criteria when it evaluates transmission solutions (Order, Appendix B) including:
 - “1. No transmission solution shall be selected that requires the acquisition of new permanent transmission rights of way...”, and
 - “10. The selection process for transmission solutions shall favor transmission solutions that result in upgrades to aging infrastructure.”

<http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={6C092D3A-B4B5-4A1B-A7E4-4C531B109340}>

Evan Wilcox
President,
BOLD TRANSMISSION, LLC

About AEP



AEP Transmission, Transource Energy, and Joint Venture Projects provide service across the U.S.

Benefits of Compact Line Design

- ▶ BOLD is one example of an advanced technology that shows that the electric industry can provide states and customers with more benefits with support from policy makers and regulators
- ▶ BOLD is a well- tested (but new) technology that was first publicly announced in 2015 and is now being built by AEP in Indiana and in Texas
- ▶ Because BOLD has different modeling and design parameters, it is important for legislators, regulators and project developers to understand the technology

Comparison of BOLD vs. Conventional Design Benefits

BOLD can be used for new or replacement transmission circuits up to 400 kV.

BOLD is a cost-effective design, and results in a net savings when benefits are considered.

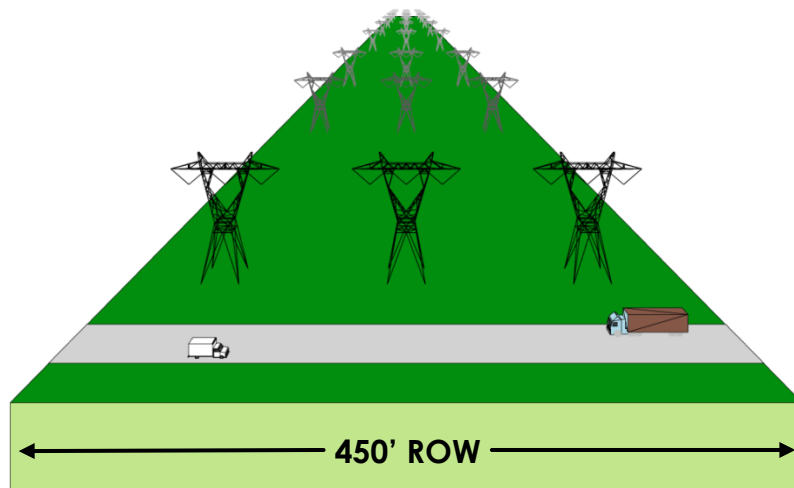
BOLD vs. Conventional Modern Designs

BENEFITS	BOLD 345 kV	BOLD 230 kV
Increased Capacity*	10-60%	15-75%
Lower Tower Height	(25-35%)	(20-30%)
Lower Magnetic Field Levels	(45-50%)	(45-50%)
Lower Energy Losses*	Up to (33%)	Up to (15%)

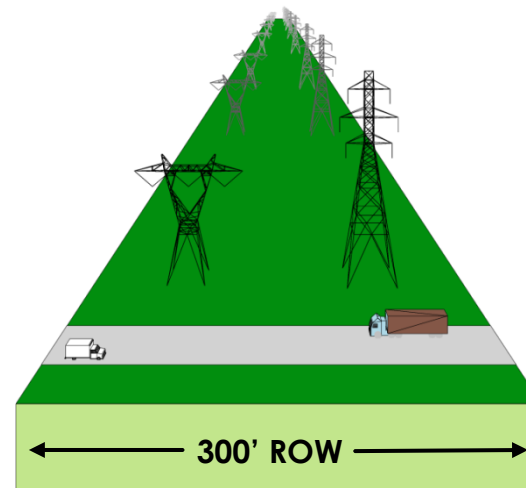
**Comparisons dependent on conductor selection.*

- Costs for BOLD differ depending on design standards, but current estimates range from -10% to +25% compared with conventional designs.
- BOLD is up to 33% less expensive than conventional on a cost per MW basis. This also means fewer lines are required to achieve the same level of capacity.
- Savings associated with reduced line losses further offset up-front material cost.

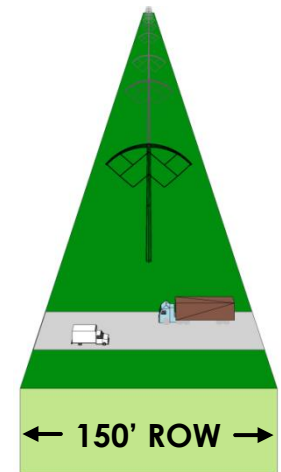
Benefit: Minimizing Utilizing Existing/ Space of New Right-of-Way



345 kV Traditional
(3) Single Circuit Towers



345 kV Traditional
(1) Single Circuit Tower
(1) Double Circuit Tower

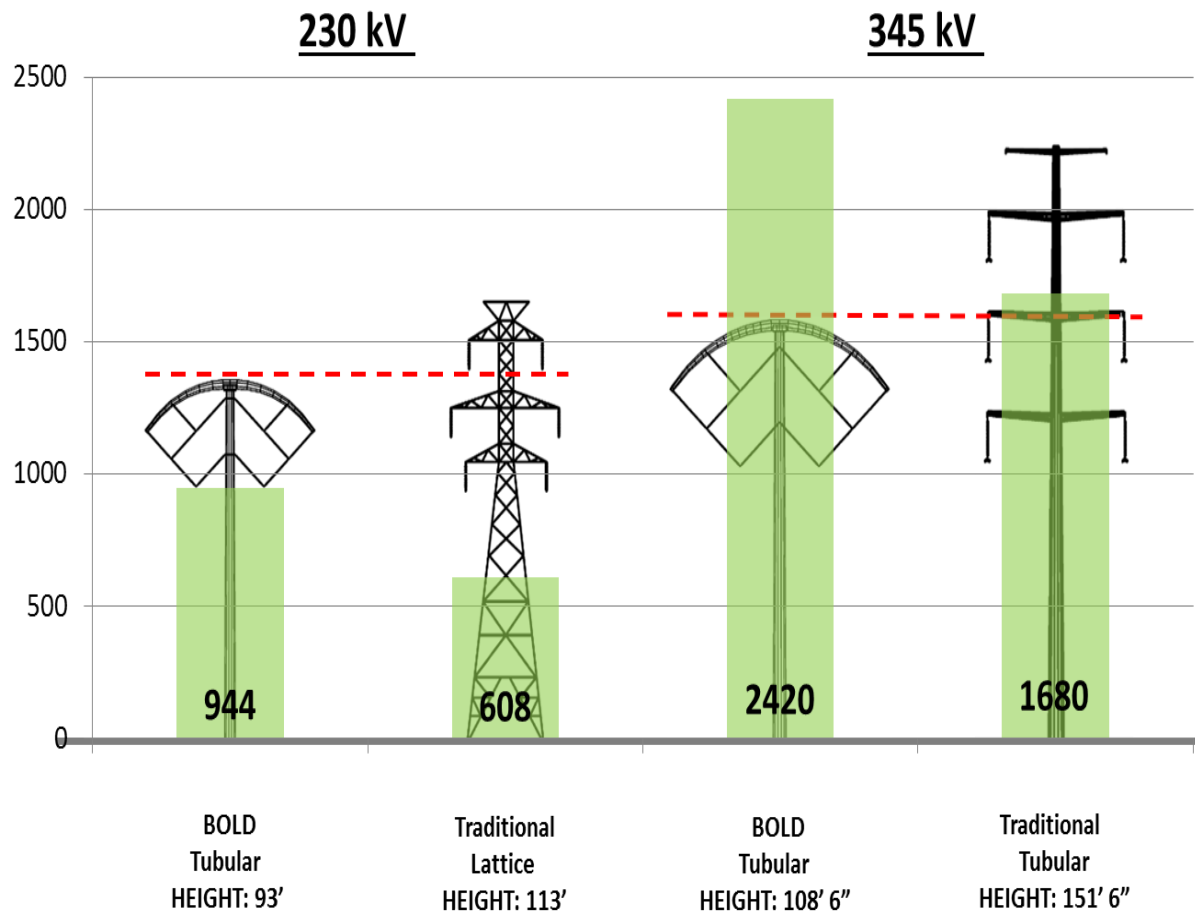


345 kV BOLD
(1) Double Circuit Tower

***BOLD can provide up to 60% more capacity in the
same right-of-way***

Profile vs. Power Delivery Capability

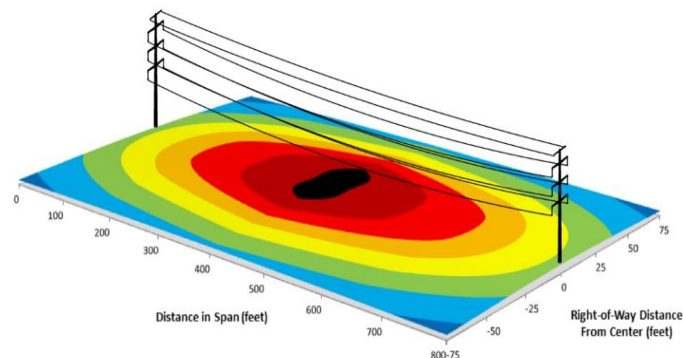
Loadability (MW @ 100 miles)



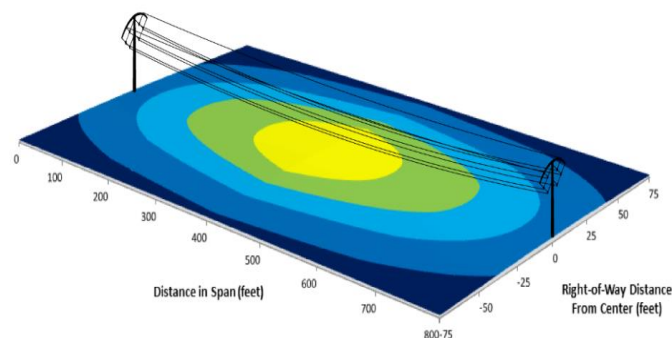
Magnetic Field Mitigation

The compact phase arrangement of the BOLD design can reduce the magnetic field zone by roughly 50%, addressing public concerns over the construction of new or rebuilt transmission lines.

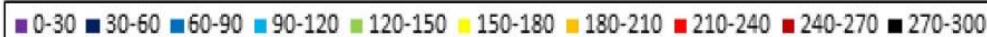
Magnetic Field Profile @ 1000 MVA Per Circuit
Conventional 345 kV 2-Cardinal 18" Bundle
Super Bundle Arrangement (A-B-C / A-B-C)



Magnetic Field Profile @ 1000 MVA Per Circuit
BOLD 345 kV 3-Cardinal 15' Phase Spacing 29" Bundle
Super Bundle Arrangement (A-B-C / A-B-C)



Magnetic Field Intensity (mG)



Reducing Line Losses

- ▶ Higher voltage lines experience lower energy losses, particularly over long distances or when lines are heavily loaded
- ▶ BOLD intentionally uses higher efficiency bundled conductors arrangements which can offer up to 33% less energy loss compared with conductors commonly used for traditional lines at the same voltage
- ▶ For a 50-mile 345 kV line, using more efficient conductors could save enough energy to power around 7,000 US homes each year
- ▶ Energy efficiency, while not often considered in transmission regulatory processes, can help offset costs of new technologies

Series Compensation & Harmonics

- ▶ Wind resources are often require long transmission lines for delivery
- ▶ Series compensation has been utilized to increase transfer capability for performance needs
- ▶ Series capacitors can create harmonic interference know as Sub-Synchronous Resonance (SSR) which can interfere with and even damage turbine generation facilities
- ▶ BOLD's compact line design, not requiring series compensation, is able to perform equal to or better than a traditional line with series compensation and avoid this potential complication



Concluding Thoughts from Representative Sloan

- ▶ When commercial and residential customers state their generation and grid preferences they exercise customer choices based on economics and policy preferences.
- ▶ Those actions can cause problems for utilities and non-self-generating customers.
- ▶ You have just heard how important legislation in your state is to project developers who are willing to take a risk proposing projects with innovative technologies.
- ▶ How you help utilities improve system efficiency, provide monetization opportunities to utilities and customers, and help both embrace technological innovations will determine your electric system's affordability, reliability, resiliency, and your state's economic health

Q&A – Thank You

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APPENDIX

The Council of State Governments Midwest

Resolution Supporting the Deployment of Advanced, Innovative Electric Transmission Technology

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WHEREAS, a secure, reliable and resilient power grid integrating generation resources serves as a foundation of a growing economy and is critical to our national security; and

WHEREAS, regulators, policy-makers, and consumers expect generating resources and the grid to perform extremely reliably; and

WHEREAS, a significant portion of the nation's transmission facilities are aged and will require a replacement strategy; and

WHEREAS, environmental regulations, state renewable energy portfolio standards, state and federal tax policies, other economic factors and technology developments are causing some electric generation resources to retire, while replacement generation, some of it fueled by intermittent resources, is being sited at other locations on the electric grid; and

WHEREAS, new innovative cost-effective transmission technologies (including, but not limited to, high-capacity/high-efficiency conductors, and compact transmission towers) are commercially available that can increase grid capacity, improve energy transfers, promote greater stability and resiliency, make more efficient use of rights-of-way, reduce transmission line losses and help to streamline siting and construction activities; and

WHEREAS, the policy of the National Association of Regulatory Utility Commissioners recognizes the benefits of these technologies to modernize the grid and improve generating resource integration and encourages electric utilities, grid operators and state public service commissions to consider the cost-effective use of these technologies; now therefore be it

RESOLVED, that the Midwestern Legislative Conference encourages state legislatures and public service commissions to support utility efforts to: 1) investigate and consider new advanced transmission technologies when replacing aged transmission infrastructure; 2) evaluate new transmission technologies to determine whether they can cost effectively ensure the continued reliable delivery of electricity while providing greater capacity and enhanced efficiency; 3) consider the ability of these technologies to reduce environmental and visual impacts to communities; and 4) consider the ability of these and other technologies to reduce the overall cost of energy delivery; and be it further

RESOLVED, that the MLC encourages state legislatures and public service commissions to work with Regional Transmission Organizations/Independent System Operators and other planning authorities to support and encourage consideration of those cost-effective advanced electric transmission infrastructure options that can increase grid capacity, reduce transmission line losses, improve energy transfers, make efficient use of rights-of-way, improve energy efficiency, and help to streamline siting and construction activities in their planning, evaluation and oversight of transmission grid development, especially by utilizing existing transmission corridors; and be it further

RESOLVED, that the MLC encourages state legislatures and public service commissions to include in their oversight of transmission facilities the consideration and promotion of the appropriate use of advanced electric transmission technologies in support of their interest in the continued provision of affordable, reliable electricity to consumers; and be it further

RESOLVED, that this resolution be submitted to appropriate state, federal and provincial officials.

CSG Southern Legislative Conference

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POLICY POSITION SUPPORTING THE DEPLOYMENT OF ADVANCED, INNOVATIVE ELECTRIC TRANSMISSION TECHNOLOGY

BACKGROUND

A secure, reliable and resilient electric power grid integrating generation resources serves as a foundation of a growing economy and is critical to our national security; and regulators, policymakers, and consumers expect generating resources and the grid to perform extremely reliably. A significant portion of the nation's transmission facilities are aged and will require a replacement strategy. Environmental regulations, state renewable energy portfolio standards, state and federal tax policies, other economic factors, and technology developments are causing some electric generation resources to retire, while replacement generation, some of it fueled by intermittent resources, is being sited at other locations on the electric power grid.

New innovative cost-effective transmission technologies (including, but not limited to, high-capacity/high-efficiency conductors, and compact transmission towers) commercially are available that can increase grid capacity, improve energy transfers, promote greater stability and resiliency, make more efficient use of rights-of-way, reduce transmission line losses, and help to streamline siting and construction activities. New and advanced replacement transmission facilities can be designed to enable a wide variety of new generating resources as well as address technical, environmental and aesthetic issues that might impede or limit the development and operation of these resources. Crowded utility corridors often allow little room for expansion.

Some states have established policies that encourage the use of advanced transmission line technologies. The policy of the National Association of Regulatory Utility Commissioners recognizes the benefits of these technologies to modernize the grid and improve generating resource integration, and encourages electric utilities, grid operators and state public service commissions to consider the cost-effective use of these technologies.

RECOMMENDATIONS

The Southern Legislative Conference of The Council of State Governments encourages state legislatures and public service commissions to support utility efforts that: 1) investigate and consider new advanced transmission technologies when replacing aged transmission infrastructure; 2) evaluate new transmission technologies to determine whether they can cost-effectively ensure the continued reliable delivery of electricity while providing greater capacity and enhanced efficiency; 3) consider the ability of these technologies to reduce environmental and visual impacts to communities; and 4) consider the ability of these and other technologies to reduce the overall cost of energy delivery.

The Southern Legislative Conference of The Council of State Governments encourages state legislatures and public service commissions to work with Regional Transmission Organizations/Independent System Operators and other planning authorities to support and encourage consideration of those cost-effective advanced electric transmission infrastructure options that can increase grid capacity, reduce transmission line losses, improve energy transfers, make efficient use of rights-of-way, improve energy efficiency, and help to streamline siting and construction activities in their planning, evaluation and oversight of transmission grid development, especially by utilizing existing transmission corridors.

The Southern Legislative Conference of The Council of State Governments encourages state legislatures and public service commissions to include in their oversight of transmission facilities the consideration and promotion of the appropriate use of advanced electric transmission technologies in support of their interest in the continued provision of affordable, reliable electricity to consumers.

The Southern Legislative Conference of The Council of State Governments requests that a copy of this policy position be forwarded to the governors, lieutenant governors, applicable state and regional regulators including but not limited to public service commissioners, energy department directors, regional transmission operators and legislative presiding officers and energy committee chairs of the member states.

Adopted by the Southern Legislative Conference in Lexington, Kentucky, July 12, 2016.

Joint Committee on Energy

State of Arkansas

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INTERIM RESOLUTION 2015-004 SUPPORTING THE DEPLOYMENT OF ADVANCED, INNOVATIVE ELECTRIC TRANSMISSION TECHNOLOGY.

WHEREAS, a secure, reliable, and resilient power grid integrating generation resources in Arkansas serves as a foundation of a growing economy and is critical to the state's energy security; and

WHEREAS, regulators, policy-makers, and consumers expect generating resources and the grid to perform extremely reliably in Arkansas; and

WHEREAS, a significant portion of the state's transmission facilities are aged and will require a replacement strategy; and

WHEREAS, environmental regulations, state and federal tax policies, other economic factors, and technology developments are causing some electric generation resources to retire, while replacement generation, some of it fueled by intermittent resources, is being sited at other locations on the electric grid; and

WHEREAS, new, innovative and cost-effective transmission technologies, including without limitation high-capacity/high-efficiency conductors, and compact transmission towers, that are commercially available may increase grid capacity, improve energy transfers, promote greater stability and resiliency, make more efficient use of rights-of-way, reduce transmission line losses, and help to streamline siting and construction activities; and

WHEREAS, new and advanced replacement transmission facilities may be designed to enable a wide variety of new generating resources and may address technical, environmental, and aesthetic issues that might impede or limit the development and operation of these resources; and

WHEREAS, crowded utility corridors often allow little room for expansion; and

WHEREAS, some states have established policies that encourage the use of advanced transmission line technologies; and

WHEREAS, the policies of the National Association of Regulatory Utility Commissioners, the Southern Legislative Conference, and the Southern States Energy Board recognize the benefits of these technologies to modernize the grid and to improve generating resource integration and encourage electric utilities, grid operators, and state public service commissions to consider the cost-effective use of these technologies,

NOW THEREFORE BE IT RESOLVED BY THE JOINT INTERIM COMMITTEE ON ENERGY OF THE NINETIETH GENERAL ASSEMBLY OF THE STATE OF ARKANSAS: THAT the Joint Committee on Energy of the Ninetieth General Assembly encourages the Arkansas Public Service Commission to support utility efforts to:

- (1) Investigate and consider cost-effective new and advanced transmission technologies when replacing aged transmission infrastructure;
- (2) Evaluate new transmission technologies to determine whether they can cost-effectively ensure the continued reliable delivery of electricity while providing greater capacity and enhanced efficiency;
- (3) Consider the ability of these technologies to cost-effectively reduce environmental and visual impacts to communities; and
- (4) Consider the ability of these and other technologies to cost-effectively reduce the overall cost of energy delivery.

BE IT FURTHER RESOLVED THAT the Joint Committee on Energy of the Ninetieth General Assembly encourages the Arkansas Public Service Commission to work with regional transmission organizations and other planning authorities as needed to support and encourage consideration of those cost-effective advanced electric transmission infrastructure options that can increase grid capacity, reduce transmission line losses, improve energy transfers, make efficient use of rights-of-way, improve energy efficiency, and help to streamline siting and construction activities in their planning, evaluation, and oversight of transmission grid development, especially by utilizing existing transmission corridors.

BE IT FURTHER RESOLVED THAT the Joint Committee on Energy of the Ninetieth General Assembly encourages the Arkansas Public Service Commission to include in the commission's oversight of transmission facilities consideration of the cost-effective and appropriate use of advanced electric transmission technologies in support of the commission's interest in the continued provision of affordable, reliable electricity to consumers.

BE IT FURTHER RESOLVED THAT upon adoption of this resolution, the staff of the Bureau of Legislative Research shall transmit a copy to the Governor, the Lieutenant Governor, and applicable state and regional regulators, including without limitation public service commissioners, energy department directors, and regional transmission operators.

National Association of State Regulatory Commissioners (NARUC)

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EL-1 Resolution Supporting Advanced Electric Transmission Technology

WHEREAS, A secure, reliable, and resilient power grid integrating generation resources serves as a foundation of a growing economy and is critical to our national security; and

WHEREAS, Regulators, policymakers, and consumers expect generating resources and the grid to perform extremely reliably; and

WHEREAS, A significant portion of the nation's transmission facilities are aged and will require a replacement strategy; and

WHEREAS, Environmental regulations, State renewable energy portfolio standards, State and federal tax policies, other economic factors, and technology developments are causing some electric generation resources to retire, while replacement generation, some of it fueled by intermittent resources, is being sited at other locations on the electric grid; and

WHEREAS, New innovative cost-effective transmission technologies (including, but not limited to, high-capacity/high-efficiency conductors, compact transmission towers, and variable frequency transformers) are commercially available that can increase grid capacity, improve energy transfers, promote greater stability and resiliency, make more efficient use of rights-of-way, reduce transmission line losses, and help to streamline siting and construction activities; and

WHEREAS, New and advanced replacement transmission facilities can be designed to enable a wide variety of new generating resources and can address technical, environmental, and aesthetic issues that might impede or limit the development and operation of these resources; and

WHEREAS, Crowded utility corridors often allow little room for expansion; and

WHEREAS, Some States have established policies that encourage the use of advanced transmission line technologies; now, therefore be it

RESOLVED, That the Board of Directors of the National Association of Regulatory Utility Commissioners (NARUC), convened at its 2016 Winter Committee Meetings in Washington, D.C., encourages utility efforts to: 1) investigate and consider new advanced transmission technologies when replacing aged transmission infrastructure; 2) evaluate new transmission technologies to determine whether they can cost-effectively ensure the continued reliable delivery of electricity while providing greater capacity and enhanced efficiency; 3) consult with the Department of Energy and its National Laboratories to understand advancing transmission technologies; and 4) consider the ability of these technologies to reduce environmental and visual impacts to communities; and be it further

RESOLVED, That NARUC encourages Regional Transmission Organizations/Independent System Operators and other planning authorities to support and consider cost-effective advanced electric transmission infrastructure options that can increase grid capacity, reduce transmission line losses, improve energy transfers, make efficient use of rights-of-way, improve energy efficiency, and help to streamline siting and construction activities in their planning, evaluation and oversight of transmission grid development; and be it further

RESOLVED, That NARUC encourages State public service commissions to include in their oversight of transmission facilities the consideration of cost-effective use of advanced electric transmission technologies in support of the continued provision of affordable, reliable electricity to consumers.

Sponsored by the Committee on Electricity

Adopted by the National Association of Regulatory Utility Commissioners Board of Directors on February 17, 2016

<http://pubs.naruc.org/pub/66436AF7-DFB2-C21E-43B2-1AE83A02D8F5>

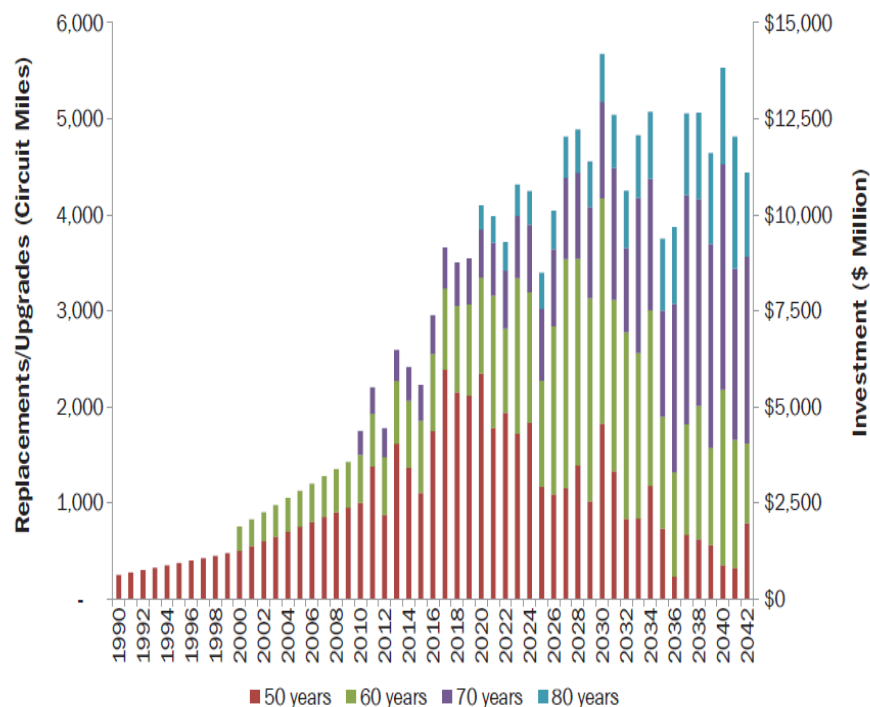
US Infrastructure Investment Needs

230 kV originated in late 1920's and early 1930's with a large portion built before 1950.

345 kV originated in the mid-1950's with the bulk of lines built between 1960 and 1970.

Data shows a significant increase in line miles to be replaced or upgraded as these facilities already exceed 50 years of age and many approach 70-100 years of age.

Projected Circuit Miles Replaced/Upgraded and Total Projected Investment (\$m)



Source: The Brattle Group, December 2014, "Dynamics and Opportunities in Transmission Development"

Examples of Technological Innovations Benefitting Electricity Customers and Providers

- ▶ **Volt-Var Optimization** – Averages 3+% reductions in energy demand and customer bills, eliminates air emissions associated with foregone energy production
- ▶ **Compact Line Design** – Provides more capacity in same right-of-way, reduces electro-magnetic fields, less viewshed impairment with lower tower height, less line loss, up to 33% lower delivered energy costs per MW.
- ▶ **Live Wire Reconductoring and Composite Wires** – Improve operational efficiencies, reduce line losses
- ▶ **Energy Storage** – Voltage support, resiliency within distribution systems, address transmission constraints, address renewable energy intermittency issues

Example Advanced Transmission Line Technologies

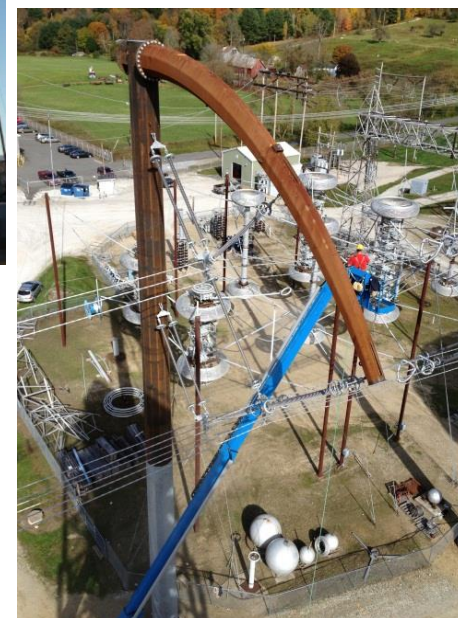
- ▶ **Advanced Conductors** – New materials can provide increased capacity, lower line losses; lighter weight can be beneficial in reconductor projects (re-use of existing towers).
- ▶ **FACTS (Flexible Alternating Current Transmission Systems) Devices** – These device, such as Static Var Compensators (SVC) and STATic Synchronous COMPensator (STATCOM) provide reactive power and dynamic regulation of voltage and frequency to maintain power system stability. They can also be used to control power flows and optimize system performance.
- ▶ **Dynamic Line Rating Systems** – Devices can be used to determine capacity and apply line ratings in real time. This enables system operators to take advantage of additional capacity when it is available based on actual conditions, rather than fixed assumptions.
- ▶ **Asset Health Monitoring Systems** – These real-time information systems help reduce maintenance costs and proactively prevent equipment failures in T&D substations.
- ▶ **Fiberoptic Protection and Control Systems** – Used with digital relays, these systems replace much of the copper control wiring in substations (e.g., between circuit breakers and the relays in the control house) with fiberoptics, reducing overall costs. The added benefit is there is less cyber security risk with point-to-point fiber optic topology.

History of BOLD Transmission Design

- ▶ CREZ experience in Texas showed need for long high capacity lines, but also need to mitigate interference issues between series capacitors and wind farms
- ▶ BOLD was envisioned to address these issues, but with additional focus on improving efficiency and environmental impact
- ▶ Over 3 years spent in development:
 - ▶ Required significant electric simulation studies in collaboration with vendors
 - ▶ Prototype testing included structural integrity/stress tests and electrical tests to validate studies
- ▶ 14 worldwide patents (granted or pending)
- ▶ See October 26, 2015 article:
<http://tdworld.com/overhead-transmission/aep-s-bold-response-new-industry-challenges>



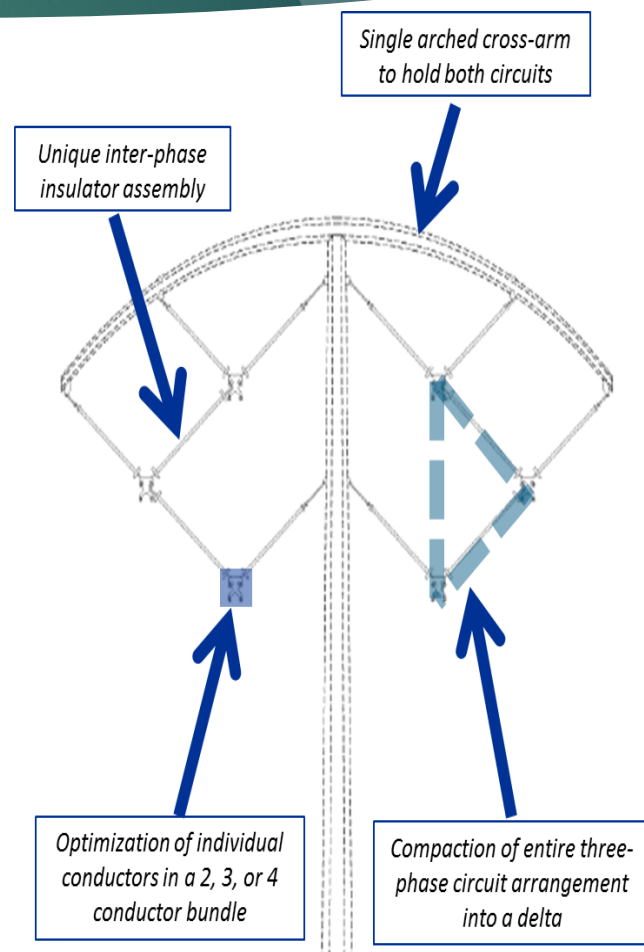
← **Structural Tests (Valmont)**



Electrical Tests (EPRI) →

How BOLD Works

- ▶ BOLD's compact design leverages physics associated with the line's geometry to lower line impedance and optimize electrical performance
- ▶ Unique single cross arm and inter-phase insulators designed to hold conductors in exact locations
- ▶ Result is a combination of superior power carrying capability combined with a smaller, lower profile structure



BOLD Applications: - Indiana

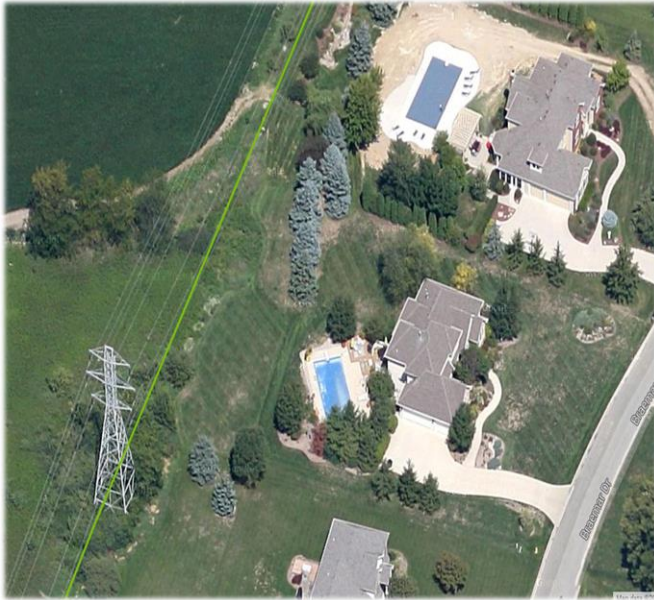
AEP's Robison Park-Sorenson
rebuild - Fort Wayne, IN

Building 345 kV and 138 kV
BOLD on existing 138 kV right-
of-way

Project approved by PJM

Line is partially in service as of
June 2016; final completion
October 2016







BOLD Applications: Indiana

Lafayette, Indiana (20 miles)

First double-circuit 345 kV
application with lattice
towers

Rebuild of initial segments of
longer corridor

Line scheduled in service
June 2018



BOLD – Texas

- ▶ Lower Rio Grande Valley Project (Southeast Texas)
- ▶ 130-mile 345 kV line addresses reliability and supply concerns
 - ▶ 20-mile BOLD segment approved by ERCOT regional regulator for wind interconnection
 - ▶ BOLD helps regulate voltage and avoid series compensation
 - ▶ Full BOLD project under ERCOT review

