NARUC

Summer Committee Meetings

Electric Transmission

Are We Building What We Need?

A POWERFUL PARTNER

DUKE American Transmission Co.®

JULY 27, 2016

NARUC-FERC Transmission Roundtable

Nashville, TN

DUKE ENERGY®

- Nation's largest electric power holding company, serving more than 7.5 million customers in six states
- Approximately $114 billion in assets
- Owns and operates 32,300 miles of transmission lines
- Interest in DATC is held by Duke Energy's Commercial Businesses
- Identified $8 billion of transmission infrastructure projects, including one approved MISO Multi-Value Project
- Transmission-owning member of the MISO and PJM regional transmission organizations
- Founded in 1904 and headquartered in North Carolina with more than 29,000 employees
- Fortune 250 company listed on the New York Stock Exchange under the symbol DUK

ATC AMERICAN TRANSMISSION COMPANY®

- Formed in 2001 as the nation's first multi-state transmission-only utility
- $3.8 billion in transmission assets
- Ownership group includes 22 municipalities and cooperatives
- Invested $3.5 billion in building more than 2,400 miles of transmission lines over the past 14 years in four Midwestern states: Wisconsin, Michigan, Minnesota and Illinois
- Projecting $3.3 billion to $3.9 billion in transmission infrastructure projects over the next decade in current service area, including three MISO Multi-Value Projects
- Owns and operates more than 9,500 miles of transmission lines and 530 substations
- Headquartered in Wisconsin with more than 650 employees
- Transmission-owning member of MISO

Are We Building What We Need?

It depends on the classification of projects and who you ask …

- Reliability projects get built because there is a clear understanding of violations and NERC requirements

- Economic / Market Efficiency projects are moving more slowly through the process because only a subset of total benefits are considered

- The next wave of Public Policy projects may not realize their full potential if we wait for the perfect time to study/build

How are needs identified and acted upon?

- Starts with the identification of constraints/violations by RTO/ISO
- RTO/ISO solicits solutions to the identified constraints/violations

Regional Variations among RTOs re: Project Evaluation and Selection

Sponsorship	Hybrid	Solicitation
•Developers provide solutions in form of project proposals •RTO evaluates project submittals and selects developer based on who submitted winning proposal.	•Developers provide project proposals •Proposals are vetted to determine preferred solution •RFP is issued to construct •RTO evaluates bids and selects developer based on scoring criteria	•Stakeholders submit ideas •Ideas are used to develop preferred solution •RFP is issued to construct solution •RTO evaluates bids and selects developer based on scoring criteria.

Process can take anywhere from 1 year to 2.5 years from the time the RTO commences its annual planning process until a developer is selected or assigned to construct the project.

Observations from the early going…

- Current trends suggest competition is lowering costs to consumers
- "Two guys and a laptop" is not a legitimate concern
- Sponsorship model stresses RTO/ISO resources
- Solicitation model is an inefficient use of resources
- Arbitrary thresholds (voltage, cost, b/c) limit transmission projects available for competition
- Benefits to consumers from Economic and Public Policy projects are being delayed as sub-optimal projects chip away at broader, more beneficial solutions
- Projects to address CPP / generation retirements / fuel shifts, will challenge the existing process (scope, schedule)

Opportunities for Improvement

- Study multiple future scenarios without bias for the status quo
- Shorten the timeframe from futures development to selection
- Increase transparency in the evaluation process
- Benchmark production cost models against actual market performance
- Recognize the broader range of benefits in transmission projects
- MISO MVP portfolio was a ground-breaking example of understanding the benefits and flexibility transmission provides
- Sponsorship model brings more innovation and efficiency
- Start now…or future projects will all be reliability projects!

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Are We Building What We Need?

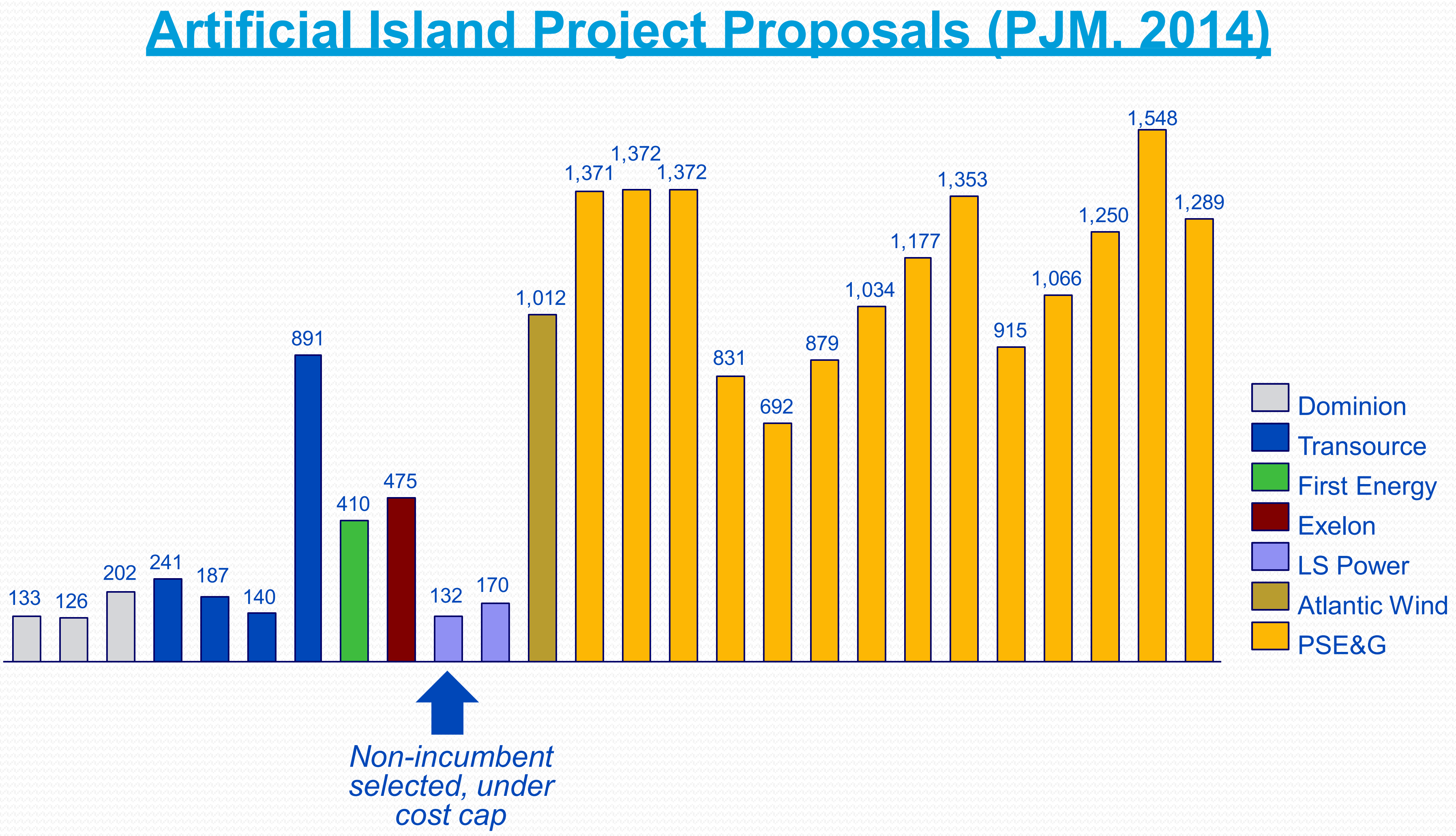
What do we need to build? How to evaluate transmission needs

Mark Vannoy, Chairman

Maine Public Utilities Commission

NARUC Transmission Roundtable July 27, 2016

Vignette 1: PJM received a wide variety of proposals for Artificial Island…all addressing the same reliability need



Deterministic Needs Analysis

N-1 Voltage Violations

Bus Name	Worst- Case Contingency	Worst- Case Voltage Violations (One Unit OOS)	Worst Case Voltage Violation (Two Units OOS)	Comments
Biddeford – 115 kV	Loss of XYZ Transformer	.92	.92	Violation not seen if local Jet in service
Chestnut Hill – 115 kV	Breaker Failure	.93	.93	Not seen with Jet on
Rumney 115 kV	Double Circuit failure	.92	.92	Not seen with Jet on

N-1-1 Thermal Violations

Element ID	Overloading Element	Initial Element OOS	Worst Case Contingency	Highest Loading (One Unit OOS)	Highest Loading (Two Units OOS)	Comments
1333-2	Orrington - Surroweic	XYZ Autotransformer	Breaker failure	126%	133%	Highest loadings when local gen out of service
1333-3	Harpswell - Poland	Line 1756	Breaker Failure	133%	159%	Highest loadings when local gen out of service
1859	Chester – Bolt Hill	Line 1792	Double Circuit Tower	120%	135%	Highest loadings when local gen out of service
1150	Maxcies-Buxton	Local fast start	Three phase ground fault	119%	130%	

Probabilistic Reliability Analysis

Expected Energy Not Served (MWh/year)

Year	EENS Do Nothing Option	Looping Option (a.1)	Tapping Option (a.2)	Station Option (a.3)
2010/11	4215	1567	1633	1623
2011/12	4635	1598	1660	1650
2012/13	4958	1625	1679	1668
2013/14	5463	1663	1708	1697
2014/15	5993	1702	1743	1730
2015/16	6532	1752	1777	1764
2016/17	7121	1787	1802	1788
2017/18	7972	1841	1842	1828
2018/19	8984	1906	1879	1863
2019/20	10062	1974	1919	1902
2020/21	11383	2044	1968	1950

BC Hydro Central Vancouver Island Transmission Project

https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/suppliers/transmissionsystem/engineering_studies_data/studies/probabilistic_studies/selected_tech_reports/ProbabilisticReliabilityAssessmentforCVITpart1.pdf

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CHANGING WHAT'S POSSIBLE

Electricity network optimization technologies

Tim Heidel

Program Director

Advanced Research Projects Agency – Energy (ARPA-E)

U.S. Department of Energy

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Nashville, TN
July 27, 2016

U.S. DEPARTMENT OF ENERGY

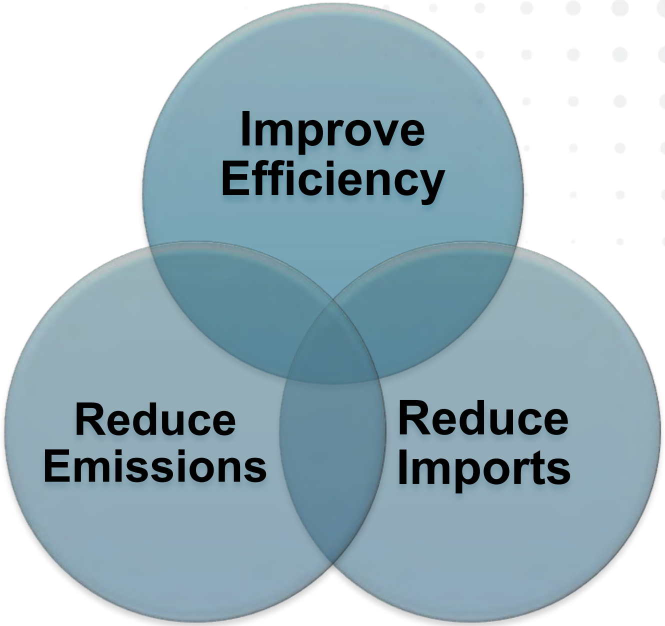
ARPA-E catalyzes and supports development of transformational, disruptive energy technologies

Goals: **Ensure America's**

- Economic security
- Energy security
- Technological lead in advanced energy

Means:

- Identify and promote revolutionary advances in fundamental and applied sciences
- Translate scientific discoveries and cutting-edge inventions into technological innovations
- Accelerate transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty

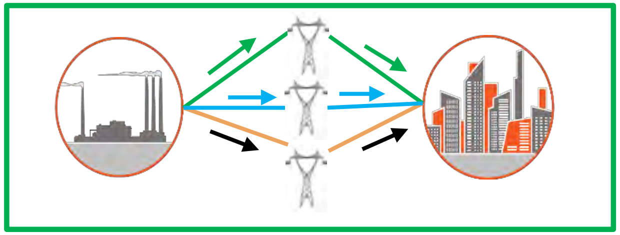


If it works…

will it matter?

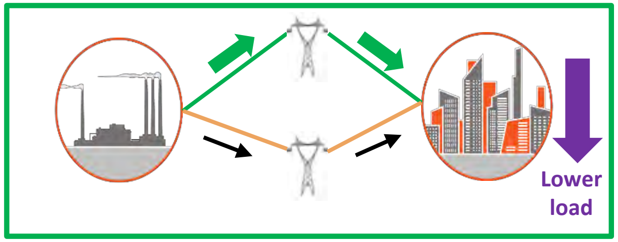
Network optimization technologies are an attractive complement to traditional transmission investments

Transmission capacity additions



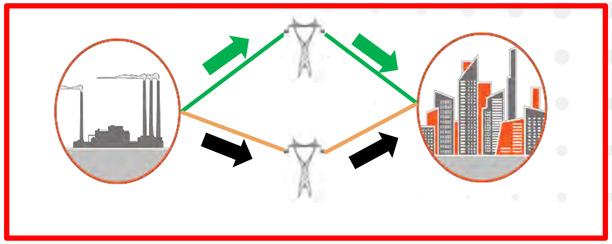
Solves overload by building new lines

Non-transmission alternatives



Solves overload by modulating generation and load up/down

Network optimization



Solves overload by moving power to underutilized line

- ARPA-E has funded development of a wide variety of network optimization technologies (both software and hardware) based on recent advances in power electronics, applied mathematics, optimization, and high performance computing
- The emerging network optimization technologies funded by ARPA-E have been successfully validated by ARPA-E and industry partners via field pilots and/or large-scale software simulations
- Network optimization technologies can increase the value of both existing and new facilities, thereby making transmission more cost effective on a $/MW-mile basis. This may allow for additional transmission investments that reduce overall system-wide costs

Cost effective, reliable power flow controllers

Power flow controllers enable power to flows to be adjusted in real-time throughout transmission networks:

- Impedance control
- Series voltage injection
- Reactive voltage support

New generation of hardware promises lower cost and higher reliability:

- Fractionally rated converters (limited power device ratings)
- Modular designs (increases manufacturability)
- Series connected equipment with fail normal designs (gradual degradation)

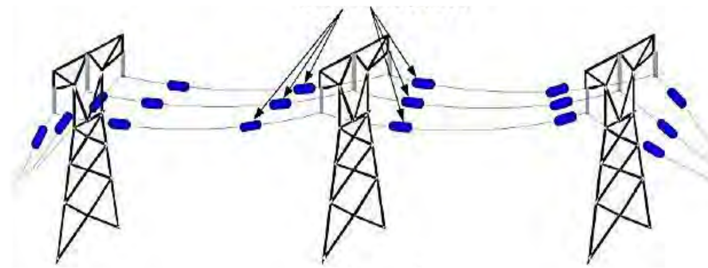
Distributed Series Reactors

(PI: Dr. Frank Kreikebaum, Smart Wires)

SMART WIRES

REIMAGINE THE GRID

www.smartwires.com



Compact Dynamic Phase Angle Regulator

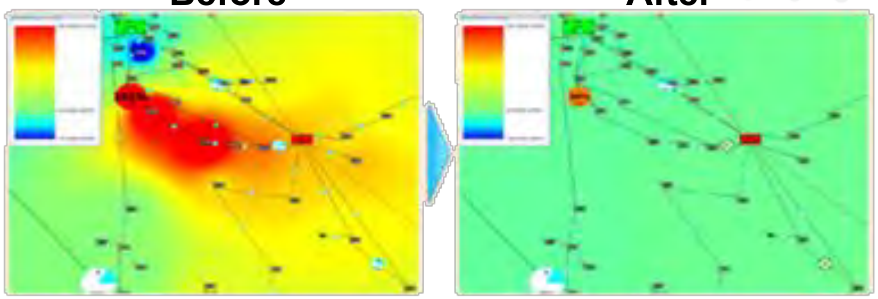
(PI: Dr. Deepak Divan, Georgia Tech & Varentec)

Prototype:
1 MVA Transformer
+ 33 kVA converter

Network optimization software tools

Transmission topology control algorithms *(PI: Dr. Pablo Ruiz, Boston University & NewGrid)*

- Fast optimization algorithms allow grid operators to optimize transmission network topology in day ahead and real time
- > $100M / year estimated production cost savings in PJM RT markets (50% cost of congestion) based on 2010 conditions[a]
- 40% reduction in renewable curtailments[b]

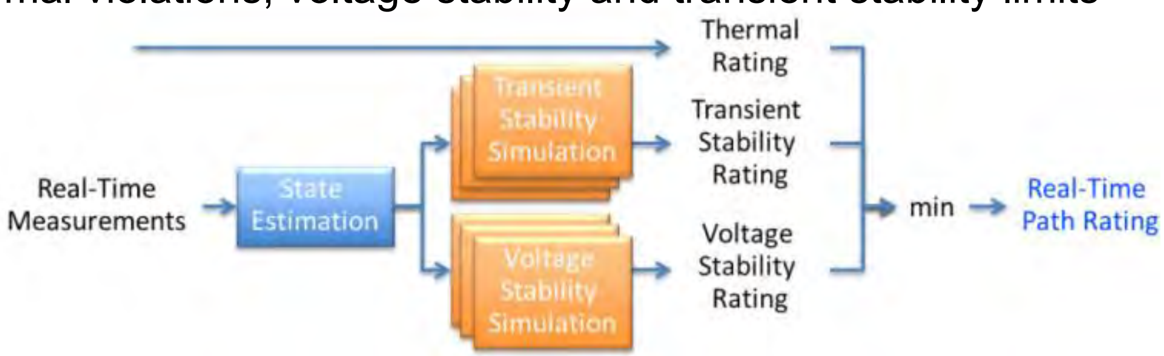


newgrid www.newgridinc.com/

Real-time dynamic transmission path ratings *(PI: Dr. Henry Huang, PNNL)*

Pacific Northwest NATIONAL LABORATORY

- Software to calculate transmission path limits in real time (e.g. every 10 min)
- Considers voltage violations, thermal violations, voltage stability and transient stability limits
- Previous BPA/CAISO study using real-time EMS snapshots indicated 340 – 670 MW increase in the California-Oregon Intertie (COI) path rating under certain conditions



http://energyenvironment.pnnl.gov/highlights/highlight.asp?id=2315

[a] Based on simulation results for three historical weeks

[b] PJM Integration Study Scenario: 30% low off-shore best sites on-shore

Classes of transmission congestion relief investments

Offline applications → **Reliability options** → **Market operations**

Offline applications

- Outage scheduling & coordination
- Operational planning

Reliability options

- Remedial action plans for contingencies
- Emergency procedures

Market operations

- Transmission flexibility
- devices in grid dispatch
- Effect on congestion (LMPs/FTRs)

Barriers to adoption:

Reliability options:

1. Technical validation
2. Operator confidence
3. Business process changes

Market operations:

1. Validation of net benefits
2. Stakeholder acceptance
3. Market design changes

- Network optimization technologies (hardware or software) could be an effective and low cost investment option in many circumstances

- Many industry, government, and regulatory decision makers have limited awareness of network optimization alternatives to transmission expansion
- Existing state and federal policies typically recognize only traditional (“wires”) solutions and non-transmission alternatives
- These and other yet to be understood factors appear to be slowing the adoption of cost-effective network optimization technologies

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U.S. Department of Energy

Proposed Integrated Interagency Pre-Application Process for Transmission

Samuel Walsh, Deputy General Counsel for Energy Policy

Overview

- Section 216(h) of the Federal Power Act directs DOE to coordinate federal authorizations and related environmental reviews for electric transmission projects requiring multiple federal authorizations
- In February 2016, DOE published a proposal rule creating an integrated, interagency pre-application (IIP) process for transmission projects
- Purpose is to facilitate better coordination and information sharing among agencies, leading to better-informed applications and shorter permitting times

Key Features of the IIP Proposal

- Two pre-application meetings attended by all affected agencies
- Agencies provide feedback to applicant on environmental concerns, data gaps, and other issues to might slow processing of an application
- IIP process culminates in DOE preparing a Final IIP Resources Report, which is intended to enable more efficient preparation of environmental review documents
- Process is *voluntary*

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