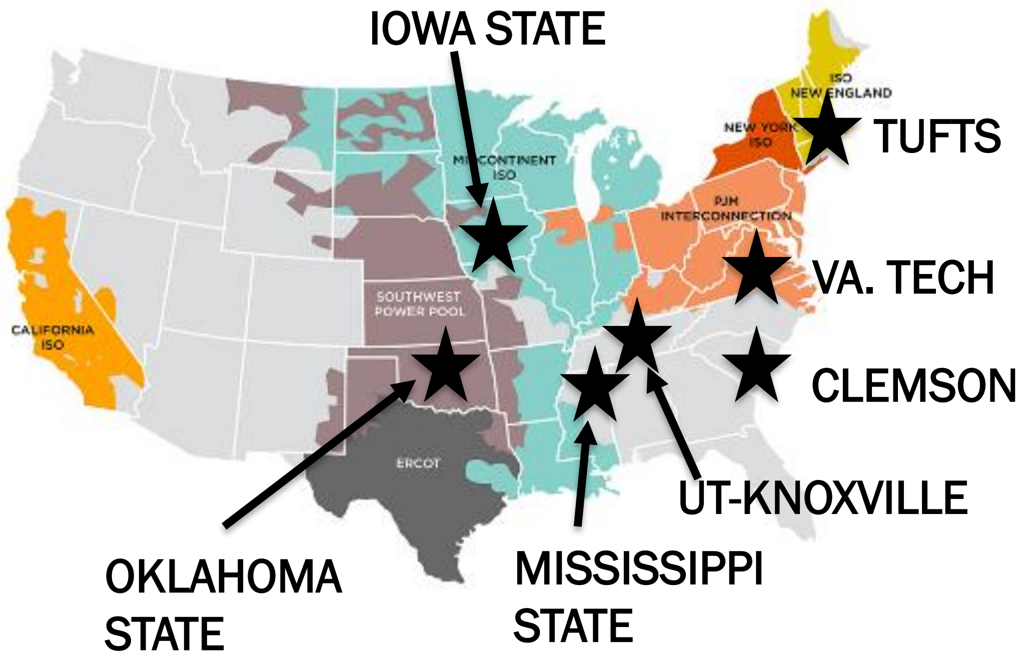
AGENDA, July 11, 2024 Bridgeport Meeting

1. Introductions - All
2. HVDC-Learn project overview – McCalley
3. Objective of this meeting and next steps - McCalley
4. Bridgeport overview - Chadwick Schroeder, Bridgeport Sustainability Manager
   - Chadwick's background
   - General overview of Bridgeport
   - Sustainability management/activities in Bridgeport

Project team

Power Systems

Hantao Cui, Assist. Prof., Oklahoma State
Xin Fang, Asst. Prof., Mississippi State
Eric Hines, Prof. of Practice, Tufts
Fran Li, Chaired Prof., U. Tenn.-Knox.
Per-Anders Lof, Lecturer, Tufts;
    Principal Engr, National Grid
James McCalley, Chaired Prof., Iowa State



Power Electronics

Leon Tolbert, Chaired Prof., U. Tenn-Knox.
Alex Stankovic, Chaired Prof., Tufts
Ali Mehrizi-Sani, Assoc. Prof., Virginia Tech
Johan Enslin, Chaired Prof., Clemson
Moazzam Nazir, Rsrch Scientist, Clemson

High Voltage Engineering

David Wallace, Asst. Clin. Prof. Miss. State

List of PAB Members

***Project board*:**

- 17 US industry organizations
- 3 European industry organizations
- 1 international organization

- 4 US community/vocational colleges
- 1 US university;
- 1 US vocational school;
- 4 European universities;

- 1 DEIA expert
- 1 envrnmntl justice advocacy grp

INDUSTRY

Hitachi Energy, Jiuping Pan
GE Vernova, Carl Barker
Nexans in Charleston, Gregory M. Smith
HVDC Centre Scotland, Simon Marshall. Ben Gomersall
Electric Power Research Institute (EPRI), Ram Adapa
Duke Energy
Dominion, Kevin Jones
Mitsubishi, David Roop Jr
Energy System Integration Group (ESIG), James Okullo
National Grid, Jim McGrath
Eversource, Oluwaseyi Olatujoye
Southern Company, Jason Autrey, Glenn Wilson
National Renewable Energy Lab (NREL), Ben Kropowski
ISONE, Xiaochuan Luo
WindGrid, Ervin Spahic. Dennis De Decker
Global Power System Transformation (G-PST) Mark O'Malley
New York Power Authority (NYPA), Bruce Fardenesh
Midcontinent Independent System Operator (MISO), Armando Figueroa
American Electric Power (AEP), Kamran Ali
PJM, Paul McGlynn, Kenneth S. Seiler
Southwest Power Pool (SPP), Antoine Lucas

EDUCATIONAL INSTITUTIONS

Bristol Community College, MA, Yashwant Sinha
Trident Technical Community College, Tom Fulford
Northern Virginia Community College, John Sound
Centura College, Joel English
Mid-Atlantic Maritime Academy, Raymond Blanchet
Farmingdale State College, Jeff Hung
KU Leuven, Dirk Van Hertem
Strathclyde, Lie Xu
KTH, Lina Bertling
Imperial College, London, Balarko Chaudhuri
Tufts University, Samantha Fried

DEIA & env justice

Salem Alliance for the Environment (SAFE) Betsy Frederick, Bonnie Bain

HVDC-LEARN Project objective

HVDC-LEARN: Develop/deploy 35 modules to elevate the electric power community's (engineering, regulatory, policy) awareness/understanding of HVDC domain & increase HVDC presence as a transmission solution, for both onshore and offshore applications.

– Enable *ongoing* resource development
– Reflect integrated academic & industry expertise

What is a module?

➔A "mini-textbook"

- Self-contained
- 5-30 pages
- Address an HVDC feature/issue
- Clear learning objectives
- Both on/offshore applications
- Targets
  - university engineering courses
  - industry-focused short courses
  - community colleges
  - Regulatory & policy groups
  - individual learning.

HVDC LEARN

Modules for Maturing HVDC Electric Transmission Knowledge

Module 7a
Point-to-Point HVDC Configurations

Primary Author: James D. McCalley, Iowa State University
Email Address: jdm@iastate.edu
Co-author:
Last Update: March 31, 2024

Prerequisite Competencies:
1. Motivating needs for high-capacity electric transmission
2. HVDC converter types and operations as found in Modules 1a, 1b, 1c.

Module Objectives:
1. Identify features of point-to-point HVDC transmission
2. Distinguish from multi-terminal HVDC systems.
3. Identify point-to-point applications and describe implementations of each

7a.1 Introduction

High voltage direct current (HVDC) transmission has seen applications since the early 1950s. The first such line for commercial purposes was installed in 1954 to interconnect the Swedish mainland 98 km (61 miles) to the island of Gotland in the Baltic Sea; a monopole design employing mercury-arc valves, its capacity was 20 MW at a voltage level of 100 kV [1]. The

…

MODULE LIST

(1) Introductory/Overview Coverage;
(2) Station components;
(3) Converters;
(4) Control;
(5) HVDC Protection;
(6) HVDC Line and Cable Technologies;
(7) Point-to-Point HVDC Configurations;
(8) Multi-Terminal HVDC Networks;
(9) Planning and Design;
(10) HVDC System Simulation and Analysis;
(11) Regulatory Permitting Processes/Procedures;
(12) Energy Equity and Environmental Justice.

(yellow to be completed year 1; blue in year 2; white in year 3)

Mod #	Lead-auth /Lead-rvwr	Module title	# of 1-h lectures	Comp date
1. INTRODUCTORY/OVERVIEW COVERAGE, Li				
1a	T2/UT1	Intro to HVDC technology	3	Q4
1b	UT1/T2	Application Guide for HVDC Transmission	3	Q2
1c	M1/T1	Intro to HVDC for offshore wind	3	Q2
1d	T1/C1	HVDC for executives	2	Q9
2. STATION COMPONENTS, Cui				
2a	V1/O1	HVDC reactive power, EMI, and filter design	4	Q3
2b	O1/C1	VSC-HVDC converter station technologies	3	Q4
3. CONVERTERS, Enslin				
3a	C2/C1	Interoperability between different HVDC converter technologies/vendors	3	Q12
3b	V1/M1	Power electronics 101: Fundamentals of switching pwr conv+EMT	3	Q5
3c	M1/UT2	Operation of thyristors & IGBTs in converters	4	Q7
3d	UT2/M1	Modular multilevel converter as HVDC cnvrtr interface and its control	3	Q3
4. CONTROL, Mehrizi-Sani				
4a	UT2/O1	Cnvtr cntrl fundamentals	4	Q6
4b	V1/C2	Dynamic modeling/cntrl of HVDC converters and grid-forming functions	4	Q8
4c	O1/V1	Control of multiterminal HVDC networks	4	Q8
4d	C2/C1	Offshore HVDC cnvrtr grid forming controller design for black start capability	3	Q4
5. HVDC PROTECTION, Nazir				
5a	M2/UT2	HVDC fault management & protection systems	6	Q4
5b	V1/UT1	HVDC measurements, faults, and misoperation	3	Q9
5c	C1/C2	Protection for multi-terminal HVDC networks	3	Q7

Mod #	Lead-auth /Lead-rvwr	Module title	# of 1-h lectures	Comp date
5d	UT2/M2	Protection: ability to ride through faults in HVDC	3	Q9
5e	V1/UT1	Cybersecurity in HVDC systems	3	Q11
6. HVDC LINE & CABLE TECHNOLOGIES, Wallace				
6a	M2/C1	Insulation - HVDC cables	5	Q10
7. POINT-TO-POINT HVDC CONFIGURATIONS, McCalley				
7a	I1/UT1	Onshore & offshore apps	2	Q3
8. MULTI-TERMINAL HVDC NETWORKS, Tolbert				
8a	UT2/O1	Design/operation of multiterminal HVDC grids	3	Q12
9. PLANNING AND DESIGN, McCalley				
9a	T2/O1	HVDC in pwr sys.; meshed HVDC systems	3	Q8
9b	I1/T1	Processes for planning & building offshore HVDC	3	Q2
9c	I1/T1	Expansion planning for offshore HVDC, topology/ capacity design for HVDC interregional transmission	5	Q6
9d	I1/M1	Macrogrid & HVDC offshore networks	4	Q8
9f	UT1/T2	A long-term planning study of offshore HVDC	4	Q8
10. HVDC SYSTEM SIMULATION & ANALYSIS, Fang				
10a	O1/C2	Hardware-in-the-loop electromag transient sim	3	Q12
10b	I1/T3	Large-sys analysis of multiterminal HVDC grids	4	Q10
10c	V1/M1	Frequency-dependent representation of AC syst	4	Q12
10d	M1/O1	Modeling of HVDC grids	6	Q11
10e	T3/I1	Reactive power & harmonics	6	Q8
11. REGULATORY/PERMITTING PROCESSES & PROC, McCalley				
11a	T1/T2	Offshore transmission development processes	3	Q5
11b	I1/UT1	HVDC right-of-way	3	Q12
12. ENERGY EQUITY & ENVIRONMENTAL JUSTICE, Hines				
12a	T1/V1	Effects of HVDC on enrgy equity & env. justice.	3	Q11

Three other project features

- HVDC short courses: 1 per year, using modules.
- Multi-school (17!) design projects
  - All schools perform a part of a high-level energy-related problem
  - Each year, for 3 yrs, teams at each school maintain websites on their progress; all students benefit from info posted by current & past student teams.
- Engagement with Bridgeport, CT.

Engagement with Bridgeport

1. Objective: In partnership w/ Bridgeport,
   - identify ways to decrease energy burden (energy cost/income)
   - while enhancing sustainability & mitigating environmental impacts.
2. Follow four-thrust strategy to accomplish the objective.
   1. Characterize existing conditions (energy resources, demand characteristics, previous and current efforts)
   2. Identify choices: onshore local, distributed, or distant (with transmission); offshore; battery/hydrogen storage; demand-side.
   3. Understand and speak to community concerns
   4. Develop useful materials:
      - Value to project team – identify local needs/interests, reflect in modules
      - Value to Bridgeport – info xfer during discussions; access to all modules; engage in multi-school design projects.
3. Objective of this meeting: gain insight towards 2-i, 2-ii.
4. Next steps: Distribute meeting slides/summary, collect/send further comments.