39-613 Energy Transport & Storage
Course Syllabus, Fall 2018

Time:	Tuesdays & Thursdays, 9:30-11:20AM
Place:	5409 Wean Engineering Hall
Instructor:	Dr. Paul Ohodnicki
Office:	(Offsite, Please Email or Call)
Phone:	412-386-7389 (Office), 412-973-4416 (Cell)
Email:	pohodnic@andrew.cmu.edu
Office Hours:	Roberts Hall 149
	Tuesdays & Thursdays 8:00am - 9:30am, Before Class; Also by appointment.
Required Text Book:	*NONE (See CANVAS for required and supplemental reading assignments)*
Evaluation:	Homework Assignments 30%
	Class Participation 10%
	Quizzes 10%
	Comprehensive Final 25% (at time scheduled by registrar)
	Project Poster Presentation 15% (individual evaluation)
	Project Poster 10% (group evaluations)

Admission & Prerequisites: Students enrolled in EST&P master's program; others with engineering BS degree and the permission of the instructor.

Communications: CANVAS postings and email announcements will be the primary communications medium. You are responsible to read your Andrew account email announcements and to check the course CANVAS site.

Attendance: Attendance and class participation is required. Active participation in class is an essential component of the course and your grade. This includes energy news / topics discussions, course subject matter discussions, and project presentation Q&A. You are responsible to contact the instructor in advance regarding excused absences.

Academic Integrity: Students in 39-613 must adhere to all EST&P, CIT and University policies on academic integrity. You are advised to pay strict attention to rules and penalties regarding plagiarism, cheating, and unauthorized assistance. Homework must be your own individual work; project reports / presentation materails must be yours and your team members' work with proper reference citations. TurnItIn.com

may be used by the instructor to evaluate any and all written reports submitted for credit. http://www.cmu.edu/academic-integrity/index.html http://engineering.cmu.edu/current students/graduates/policies academic integrity.html

Other: All Carnegie Mellon academic policies will be followed in 39-613, including reasonable accommodations for students with disabilities who are registered with the EOS office.

Learning Objectives: Students will gain a fundamental understanding of technologies, costs, and benefits involving various alternatives for energy transport and storage. These include energy carriers (hydrogen and electricity) as well as traditional fossil fuel and renewable energy delivery alternatives. In addition, students will be able to:

- **i)** **Perform technical / economic analysis of the transport and storage of fossil and nuclear fuels for energy generation;** including infrastructure costs and options in fuel transport & storage and storage / disposal costs for combustion byproducts and spent fuel;
- **ii)** **Identify the various components of electric power transmission and distribution systems;** calculate the effects of power factor on transmission / distribution sizing and delivered power costs;
- **iii)** Perform tradeoff analysis comparing long distance High Voltage AC vs. High Voltage DC transmission and given requirements and constraints, calculate the optimal low cost solution for power transmission;
- **iv)** Can identify the appropriate electric storage technologies for applications including frequency regulation, day / night load shifting, upgrade deferral, and smoothing of intermittency with renewables (Given system constraints on cost, location, size, intermittency, and cycle time). Perform tradeoff analysis considering cost and performance of specific technology solutions using electric power storage methods including pumped hydro, CAEO, and batteries (Lithium-Ion, Lead-Acid, redox-flow, etc.);
- **v)** Can explain the fundamentals of Smart Grid technology in electric power transmission and distribution, and the role that smart grid plays in managing electric power storage. Can explain the benefits of distributed energy resources and microgrid technology and where it is feasible to be applied;

Team Projects Assignment: Evaluate regional energy Transport & Storage infrastructure & status for an assigned region. Make projections of future regional T&S needs, challenges and shortfalls (~25 years). Evaluate options (qualitatively and quantitatively) and recommend optimal new and modified energy transport & storage infrastructure and practices needed for the assigned region.

An important message from CMU's Provost (and your instructor): *"Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone. There are many helpful*

resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help."

Course Topics- Tentative Schedule

Date	No.	Topic	Assignment	Instructor
Tuesday, 10/23	1.	Overview, Motivation, and Context What happens between supply and demand?		Ohodnicki
Thursday, 10/25	2.	Centralized vs. Distributed Energy Fossil, renewables & micro-grids	HW #1 assigned: (fossil + HOMER intro),	Ohodnicki
Tuesday, 10/30	3.	TRANSPORT & Storage: Coal and Natural Gas Processing, transportation & storage	Project team + region assignments	Ohodnicki
Thursday, 11/1	4.	TRANSPORT & Storage: Nuclear & Petroleum Processing, transport & storage, fuel cycle		Ohodnicki
Tuesday, 11/6	5.	Electricity TRANSPORT I : Electrical Grid, Power Transmission / Distribution, Smart Grid	HW #1 due HW #2 assigned ; Pwr. Dist.	Landis (Guest Lecture)
Thursday, 11/8	6.	Electricity TRANSPORT II: Issues Connecting Renewables to the Grid e.g. solar, hydro, wind, geotherm, biomass – variable; intermittent	Quiz #1?	Ohodnicki
Tuesday, 11/13	7.	Project PDRs (5 min, designated facilitator) STORAGE : overview: alternatives, options, physical / electrical characteristics, tradeoffs	Project PDR: 2-3 slide due 11/12 5pm: scope + preview	Ohodnicki
Thursday, 11/15	8.	STORAGE: grid scale and distributed storage state-of-the-art		Viswamanathan (Guest Lecture)
Tuesday, 11/20	9.	Micro Grids: distributed generation & storage; distributed energy resources	HW #2 due HW #3 assigned (HOMER)	Williams (Guest Lecture)
Tuesday, 11/27	10.	Smart Grid (power + information flow) Stakeholders; T&D, AMI, energy informatics	Quiz #2?	Ohodnicki
Thursday, 11/29	11.	Special Topics in energy transport and storage (CCUS, Hydrogen, others…)	HW #3 due	Ohodnicki
Tuesday, 12/4	12.	Final Poster Session for Project Teams	All poster pptx files due Friday 11/30 by 5pm	Ohodnicki
Thursday, 12/6	13.	Course Final Exam		Ohodnicki