

**Course Syllabus****ISEN 402 Fundamentals of Natural Resources Distribution (1.0 credit)
Northwestern University**

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Office Hours: By appointment

Class Assistant: TBD

Classroom: TBD

Class Timing: Fall Quarter

Course Synopsis: This course will cover the engineering fundamentals of natural resource distribution systems, spanning both energy (electricity, hydrocarbon fuels) and water. Basic theory and properties of electric energy and hydrology will be covered to provide underlying context as to how and why distribution systems are built and operate. Curriculum will focus primarily on current-state systems, whereas historical evolution and development are separately covered in *ISEN 401*.

Course Goals:

- Gain an Understanding of the technical fundamentals of the distribution and delivery of two primary natural resources – energy and water.
- **Energy:** includes topics such as primary vs .useful energy, generation and source, grid operation and management, transmission and distribution, distributed generation and distributed energy resources, etc. The differences across distribution for electricity and hydrocarbon fuels will be highlighted. Include recent trends in the future role of gas, including renewable hydrogen and decarbonization.
- **Water:** includes topics such as hydrology and the water cycle (surface- and groundwater), engineered distribution and treatment systems, management and urban planning, and water quality.

Grading/Assessment:

Grading will be based on the following rubric:



Component	Weight	Details	Due
Homework/Participation	20%	<p><i>Homework may consist of:</i></p> <ul style="list-style-type: none"> • <i>Problem sets</i> • <i>Case study analyses</i> • <i>Short essays</i> • <i>Reading responses/presentations</i> <p><i>Participation: Be present, prepared, and open to discussing the readings and other course content through summarizing content, expressing opinion, and posing pertinent questions.</i></p>	Ongoing
Midterm Exam	40%	<i>Serves as a benchmark of students' mastery of the basics of this fundamentals course (Topics 1-5)</i>	
Final Presentations	40%	<p><i>Serves as a benchmark of students' mastery of the basics of this fundamentals course (Topics 6-10).</i></p> <p><i>Presentation relevant to course topics based on hypothesis</i></p>	

All questions and problems regarding grades must be presented in writing within one week after the test, homework, or project has been returned. The grading scale is fixed; please do not wait until the end of the quarter if you are concerned about the direction of your grade. Grades will be assigned based on all the work you have completed during the quarter using the following scale:

A	93.333 to 100	C	73.333 to 76.666
A-	90.000 to 93.333	C-	70.000 to 73.333
B+	86.666 to 90.000	D+	66.666 to 70.000
B	83.333 to 86.666	D	63.333 to 66.666
B-	80.000 to 83.333	D-	60.000 to 63.333
C+	76.666 to 80.000	F	< 60.000

Course Readings:



Fundamental books: (books are recommended, also hold requested at library)

- *Electric Power Systems Basics for the Nonelectrical Professional*, 2nd Edition by Steven W. Blume, 2018 (recommended)
- *Renewable and Efficient Electric Power Systems*, 2nd Edition by Gilbert M. Masters (required)
- *Water and Wastewater Technology* by Mark Hammer Sr. and Mark Hammer Jr. (recommended)

Supplemental Videos:

Electric System:

- **Electricity Generation 101 (5 min.)** <http://www.youtube.com/watch?v=20Vb6hLQsG>
- **Overview of the Electricity Grid (4 min.)** <http://www.youtube.com/watch?v=38EEemWHIOc8>
- **Smart Grid (Institute of Electrical and Electronics Engineers, 9 min.)** http://www.youtube.com/watch?v=YrcqA_cqRD8&feature=related
- **A day in the life of the grid, July 21, 2011 (MISO, 33 min.) – Well worth the investment** <https://www.youtube.com/watch?v=RdrMpElZWSM>
- **Anatomy of a Transmission System (AEP, 4 min.)** http://www.youtube.com/watch?v=WTIQ_xcp0sU&feature=related
- **Anatomy of a Distribution System (AEP, 10 min.)** <http://www.youtube.com/watch?v=YcBgxVfD70Q&feature=relmfu>

By Power Source:

- **Coal Power Plant (MidAmerican Energy, 6 min.)** <http://www.youtube.com/watch?v=j0e772Vo73k>
- **Combined Cycle Natural Gas (Duke Energy, 7 min.)** http://www.youtube.com/watch?v=iNspo_s-1jY
- **Co-generation Plant at NYU (3 min.)** <http://www.youtube.com/watch?v=9m9SgsTTgiA&feature=related>
- **Biomass Co-Generation Plant at Nagda site (4 min.)** <http://www.youtube.com/watch?v=tARuhig03To>
- **Hydro Power (2 min.)** <http://www.youtube.com/watch?v=Pj4dZM4Slls>
- **Nuclear Power – How it works (5 min.)**
 - http://www.youtube.com/watch?v=_UwexvaCMWA Wind Turbines (UVSAR, 10 min.)
 - <http://www.youtube.com/watch?v=LNXTm7aHvWc&feature=related>
- **Offshore Wind Construction (Belwind, 14 min.)**
 - <http://www.youtube.com/watch?v=x9IntSh2K7c> Utility Scale Solar PV (ABB, 2 min.)
 - http://www.youtube.com/watch?v=edYNj_TrTXY&hd=1 Concentrating
- **Solar Thermal (2 min.)**
 - <https://www.youtube.com/watch?v=tdivW7inP0k> Geothermal (Chevron, 3 min.)
 - <http://www.youtube.com/watch?v=oVDpwwmNJVO>



- **Tidal and Wave Power (5 min.)** <http://www.youtube.com/watch?v=tSBACzRE3Gw&feature=related>
- **Columbia Social Enterprise Forum – Energy Storage and Battery Technology (56 min.)**
<http://www.youtube.com/watch?v=661-GlswZco&hd=1>
- **Pumped Hydro Storage – in German with translation (2 min.)** <http://www.youtube.com/watch?v=GJ7ItJIMY9E>
- **Grid Storage – A123 Batteries (DoE, 9 min.)** <http://www.youtube.com/watch?v=6C8Ji05UJaw>

Hydrocarbons:

- **Coal Power Plant (MidAmerican Energy, 6 min.)**<http://www.youtube.com/watch?v=j0e772Vo73k>
- **Full Oil Value Chain (Chevron, 6 min.)**<http://www.youtube.com/watch?v=KpxctsUJ3hw>
- **Refinery (14 min.)** <http://www.youtube.com/watch?v=9Py8-Xy9MKo>
- **Transportation Fuels – GHG implications (5 min.)**<http://www.youtube.com/watch?v=hq2uWWBqe4M>
- **Megastructures - Oil Sands (48 min.)**<https://www.youtube.com/watch?v=4sPJgmcYcQ4>
- **Shale Oil (Energy Now, 28 min.)**http://www.youtube.com/watch?v=U_T-AwYOhp4&feature=related
- **Ethanol from Sugar Cane- Production Process (15 min.)**<http://www.youtube.com/watch?v=kP1S2HGf5-E> Ethanol
- **From Corn – Production Process (5 min.)**<https://www.youtube.com/watch?v=uE7DJVCa5h0>
- **How it is made – Biodiesel (4 min.)**<http://www.youtube.com/watch?v=xLa83KlaEyw>
- **Biofuels, Beyond Ethanol (10 min.)**<http://www.youtube.com/watch?v=CkJJ-x7U5NI>
- **Natural Gas Production and Marketing (Chesapeake Energy, 10 min.)**http://www.youtube.com/watch?v=2Gw_Bn-JqDg
- **Natural Gas Pipelines Operation (9 min.)**<http://www.youtube.com/watch?v=aTTJeTaYDyc>
- **Hydraulic Fracturing (Marathon Oil, 3 min.)** <https://www.youtube.com/watch?v=VY34PQUiwOQ>
- **Natural Gas: The Energy to move Forward (Conoco Philips, 5 min.)**<http://www.youtube.com/watch?v=BzLZnidztpI>
- **LNG Value Chain (Chevron, 3 min.)**<http://www.youtube.com/watch?v=5LplbGd8aXI&feature=relmfu>
- **History – I am Natural Gas – 1959 (3 min.)**<http://www.youtube.com/watch?v=PKX0GeF9w-k>
- **History – Natural Gas Pipeline Development – 1959 (1 min.)**<http://www.youtube.com/watch?v=Wodvvh6WEs4>

Supplemental books:

- *Consuming Power: A social history of American energy* by David Nye
- *Electric Power Distribution System Engineering*, 2nd Edition by Turan Gonen

CLASS OUTLINE

Weekly Topic	Description
<p>1: Understanding power; basic terminology and system overview</p> <p>John Dirkman</p> <p>Guests: TBD</p> <p>21, 23 September</p>	<ul style="list-style-type: none"> • Electric fundamentals • Electromechanical generators • Voltage, current, resistance; electric power flow • AC vs. DC • Power vs. energy • Active and reactive power • Load by economic sector – residential, commercial, industrial, and transportation • Grid function and structure overview
<p>2: Electric Generation</p> <p>John Dirkman</p> <p>Guests:</p> <p>Laura Hanah, MISO</p> <p>Paula Gold-Williams, CPS Energy</p> <p>28, 30 September</p>	<ul style="list-style-type: none"> • Fuel Source Comparatives • Capacity Factor • Dispatch flexibility, intermittency • Carbon intensity • Distributed generation • C&I • Residential • DSM as a “negawatt” • Supply and demand • Baseload vs. Peak • Load profiles • Forecasting • Regulation of power generation and backup power supply
<p>3: Electric Transmission and Distribution</p> <p>John Dirkman</p> <p>Guests:</p> <p>Ahmed Mousa, PSEG</p> <p>5, 7 October</p>	<ul style="list-style-type: none"> • Transmission Infrastructure • Substation equipment; step-up/-down transformers, voltage regulators • Distribution Infrastructure • Distribution substation equipment; system redundancy; last-mile wires and poles; service drop; safety • Consumer metering & metering technology
<p>4: Grid Management and Control</p>	<ul style="list-style-type: none"> • North American power grid interconnections • Grid stability • Load balancing



<p>John Dirkman</p> <p>Guests:</p> <p>Elad Shaviv, EnergyCom</p> <p>Aleksandar Selakov, University of Novi Sad</p> <p>12, 14 October</p>	<ul style="list-style-type: none"> • Real time network modeling • SCADA • Fault detection / propagation prevention • Physical and cyber resilience • Impact of grid safety and regulation
<p>5: Smart grid, multidirectional flow, DERMS, DSM, behind the meter</p> <p>John Dirkman</p> <p>Guests:</p> <p>Reji Kumar, India Smart Grid Forum and Global Smart Energy Federation</p> <p>Doug Cook, Ofgem</p> <p>19, 21 October</p>	<ul style="list-style-type: none"> • Distributed resource integration and the impacts of bidirectional flow • IoT and “edge” device network communications • DERMS, Microgrids and partially/fully “islanded” systems • Behind-the-meter resource management
<p>6: Future Role of Gas – renewable hydrogen</p> <p>Dan Hahn</p> <p>26, 28 October</p>	<ul style="list-style-type: none"> • Renewable (green) hydrogen principles • Renewable hydrogen value chain • Growth of renewable hydrogen in the markets globally • Government efforts to support green hydrogen • Future outlook for green hydrogen
<p>7: Decarbonization</p> <p>Dan Hahn</p> <p>2, 4 November</p>	<ul style="list-style-type: none"> • Decarbonization principles • Changing landscape of energy providers • Low-carbon pathways



<p>8: Hydrocarbon distribution – oil & gas</p> <p>Dan Hahn</p> <p>9, 11 November</p>	<ul style="list-style-type: none"> • Hydrocarbon value chain: upstream (exploration, extraction/production) vs. downstream (refining, distribution, retail) • Distribution – inter/intrastate pipeline infrastructure, product compression, refining hubs • Physical storage options • End user – domestic consumption vs. export • Process impact of hydrocarbon safety and regulation
<p>9: Hydrology and human use; water system design and distribution, Water and wastewater treatment</p> <p>Dan Hahn</p> <p>Guest: Andy Rea, Guidehouse</p> <p>16, 18 November</p>	<ul style="list-style-type: none"> • Water cycle & source - surface/groundwater (lakes, rivers/streams, reservoirs, icepack, wells/aquifers); salinity • End user – Public/Municipal Supply (residential, commercial, industrial), Mining, Agriculture/Irrigation, Livestock, Energy • Distribution infrastructure: water pressure, flow under pressure, gravity flow, flow measurement, centrifugal pumps, water pressure requirements • Water treatment: coagulation, sedimentation, filtration, disinfection • Wastewater treatment: screening, grit disposal, clarification, aeration, disinfection; sludge treatment & disposal • Process impact of water quality standards, safety and regulation
<p>10: Managing system stressors and Energy-water nexus</p> <p>Dan Hahn</p> <p>23 November (Thanksgiving 25 November)</p>	<ul style="list-style-type: none"> • Stormwater runoff control systems and management practices • Managing drought/inadequate supply re: conflicting need • Addressing source contamination (either in the watershed, or via distribution infrastructure) • Safety, flooding and water systems • Defining key contributors to WEN • Water for energy – thermoelectric cooling, extraction, hydropower • Energy for water – water supply and treatment, distribution, irrigation, desalination, fertilizer
<p>Final Presentations</p> <p>29 November to 10 December</p>	<ul style="list-style-type: none"> • 40 minute presentations by groups of students followed by 20 minutes of Q&A

COVID-19 Classroom Expectations Statement

Students, faculty, and staff must comply with University expectations regarding appropriate classroom behavior, including those outlined below and in the [COVID-19 Code of Conduct](#). With respect to classroom procedures, this includes:

- Policies regarding masking and social distancing evolve as the public health situation changes. Students are responsible for understanding and complying with current masking, testing, Symptom Tracking, and social distancing requirements.
- In some classes, masking and/or social distancing may be required as a result of an Americans with Disabilities Act (ADA) accommodation for the instructor or a student in the class even when not generally required on campus. In such cases, the instructor will notify the class.
- No food is allowed inside classrooms. Drinks are permitted, but please keep your face covering on and use a straw.
- Faculty may assign seats in some classes to help facilitate contact tracing in the event that a student tests positive for COVID-19. Students must sit in their assigned seats.

If a student fails to comply with the [COVID-19 Code of Conduct](#) or other University expectations related to COVID-19, the instructor may ask the student to leave the class. The instructor is asked to report the incident to the Office of Community Standards for additional follow-up.

Class Recording

This class or portions of this class will be recorded by the instructor for educational purpose and available to the class during the quarter. Your instructor will communicate how you can access the recordings. Portions of the course that contain images, questions or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.

Unauthorized student recording of classroom or other academic activities (including advising sessions or office hours) is prohibited. Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact [AccessibleNU](#). Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University's [Copyright Policy](#), faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office for follow-up.

Expectations for Class Participation



Being prepared for class is about more than just showing up, it's also about making sure you've completed the readings, homework, etc. so that you are able to make thoughtful contributions during class. Sitting silently and/or being unprepared can damage your participation grade. When in a virtual class, we expect students to keep their camera and mute on as much as possible. When in the classroom, we expect students to keep their phones off and put away.

Academic Integrity

Academic integrity is taken very seriously at Northwestern. Students are responsible for reading and understanding Northwestern's Academic Integrity policies. All suspected violations will be reported to the McCormick College of Engineering's Dean's Office. These include cheating, plagiarism, fabrication, unfair advantage, unauthorized collaboration, and aiding and abetting of academic dishonesty. Students found in violation of academic integrity may receive a zero on the assignment or a failing grade for the course and may be suspended or permanently expelled from the University. See [Academic Integrity: A Basic Guide](#) for more information.

The Writing Place

When working on writing assignments for this class, I encourage you to visit the Writing Place, Northwestern's peer writing center. You will work with juniors and seniors who have been trained to provide you feedback and assistance on any type of writing at any stage in the writing process. They will not edit your work. Rather, they will work with you to brainstorm ideas, organize or outline an essay, clarify your argument, document your sources correctly, or refine grammar and style.

Accessibility Statement

Northwestern University is committed to providing the most accessible learning environment as possible for students with disabilities. Should you anticipate or experience disability-related barriers in the academic setting, please contact AccessibleNU to move forward with the university's established accommodation process (e: accessiblenu@northwestern.edu; p: 847-467-5530). If you already have established accommodations with AccessibleNU, please let me know as soon as possible, preferably within the first two weeks of the term, so we can work together to implement your disability accommodations. Disability information, including academic accommodations, is confidential under the Family Educational Rights and Privacy Act.

Illness and Medical Leave of Absence



Review the University's [policy](#) on missing academic work due to illness. Your instructor cannot waive an assignment missed due to illness unless the illness can be verified (e.g., by University Health Services or other licensed health professionals).

Discrimination and Sexual Harassment

Northwestern's Policies on Discrimination, Harassment, and Sexual Harassment apply to all members of the University community, including students, staff, faculty, and third parties. Any student, staff, faculty member, or third party who believes that they have been discriminated against or harassed on the basis of their race, color, religion, national origin, sex, sexual orientation, gender identity, gender expression, pregnancy, parental status, marital status, age, disability, citizenship, veteran status, genetic information or any other classification protected by law, should contact the Office of Equity at (847) 467- 6571. Additional information about the University's discrimination and harassment policies, including the campus resources available to assist individuals with discrimination or harassment concerns, is available online on the [Office of Equity Website](#). Students, staff, and faculty who report harassment, discrimination, or sexual misconduct are also protected under the [University's Policy on Non-Retaliation](#).

Sexual Misconduct and Reporting

Northwestern University is committed to fostering an environment where students are safe and free from sexual misconduct. [Confidential resources](#) are available to those who have experienced sexual misconduct. Faculty and instructors are not confidential resources and are required to report incidents of sexual misconduct, whether discussed in your assignments or in person, to the Office of Equity, which can provide information about resources and options. We encourage students who have experienced sexual misconduct to talk with someone to get support. For more information, including how to request interim protective measures and academic accommodations or file a complaint, see the [Get Help page](#).

Other Resources

Students can find useful resources for safety and security, academic support, and mental and physical health and well-being at the [NUhelp website](#).