ISEN 402 Fundamentals of Natural Resources Distribution
Northwestern University

Instructors:

John Dirkman (Links to an external site.), VP Product Management, Nexant
Dan Hahn (Links to an external site.), Partner, Guidehouse

NU Faculty Sponsor:

Ermin Wei (Links to an external site.), Assistant Professor of Electrical and Computer Engineering

Office Hours: TBD (Zoom preferred)

Classroom: Tech LR3

Class Timing: Fall Quarter (September 17 – December 7, 10 weeks); Tuesday and Thursday 9:40 to 11:00am.

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:

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<tr>
<th>Component</th>
<th>Weight</th>
<th>Details</th>
<th>Due</th>
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<tr>
<td>Homework/Participation</td>
<td>20%</td>
<td>Homework may consist of:</td>
<td>Ongoing</td>
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<td>• Problem sets</td>
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<td>• Case study analyses</td>
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<td>• Short essays</td>
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<td>• Reading responses/presentations</td>
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<td>Participation: Be present, prepared, and open to discussing</td>
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<td>the readings and other course content through summarizing content,</td>
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<td>expressing opinion, and posing pertinent questions.</td>
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<td>Midterm Exam</td>
<td>40%</td>
<td>Serves as a benchmark of students’ mastery of the basics of this</td>
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<td>fundamentals course (Topics 1-5)</td>
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<tr>
<td>Final Exam</td>
<td>40%</td>
<td>Serves as a benchmark of students’ mastery of the basics of this</td>
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<td>fundamentals course (Topics 6-10). Presentation relevant to course</td>
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<td>topics based on hypothesis</td>
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Grading/Assessment

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 semester using the following scale:

| Grade | Minimum Percentage |
|-------|--------------------|--------------------|
| A     | 93.33 to 100       |
| A-    | 90.00 to 93.33     |
| B+    | 86.66 to 90.00     |
| B     | 83.33 to 86.66     |
| C     | 73.33 to 76.66     |
| C-    | 70.00 to 73.33     |
| D+    | 66.66 to 70.00     |
| D     | 63.33 to 66.66     |
Course Readings

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

- *Water and Wastewater Technology* by Mark Hammer Sr. and Mark Hammer Jr.

Supplemental Videos:

*Electric System:*

- Electricity Generation 101 (5 min.) [Energy 101: Electricity Generation (Links to an external site.)](http://www.youtube.com/watch?v=38EEmWH10C8)
- Smart Grid (Institute of Electrical and Electronics Engineers, 9 min.) [http://www.youtube.com/watch?v=YrcqA_cqRD8&feature=related](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](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](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](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](http://www.youtube.com/watch?v=j0e772Vo73k)
- Combined Cycle Natural Gas (Duke Energy, 7 min.) [http://www.youtube.com/watch?v=iNsps_1jY](http://www.youtube.com/watch?v=iNsps_1jY)
- Co-generation Plant at NYU (3 min.) [http://www.youtube.com/watch?v=9m9SgsTTgiA&feature=related](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](http://www.youtube.com/watch?v=tARuhig03To)
- Hydro Power (2 min.) [http://www.youtube.com/watch?v=Pj4dZM4IIs](http://www.youtube.com/watch?v=Pj4dZM4IIs)
- 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=_UwexvaCMWA)
  - [http://www.youtube.com/watch?v=LNXTm7aHvWc&feature=related](http://www.youtube.com/watch?v=LNXTm7aHvWc&feature=related)
- Offshore Wind Construction (Belwind, 14 min.)
Utility Scale Solar PV (ABB, 2 min.)
http://www.youtube.com/watch?v=x9IntSh2K7c

Concentrating Solar Thermal (2 min.)
https://www.youtube.com/watch?v=tdivW7inP0k
http://www.youtube.com/watch?v=edYNj_TrTXY

Tidai and Wave Power (5 min.)
http://www.youtube.com/watch?v=tSBACzRE3Gw

Columbia Social Enterprise Forum – Energy Storage and Battery Technology (56 min.)
http://www.youtube.com/watch?v=661GlswZco

Pumped Hydro Storage – in German with translation (2 min.)
http://www.youtube.com/watch?v=GiJ7iJjMY9E

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=hqTuWWBqe4M
- 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-AwYOdhp4&feature=related
- Ethanol from Sugar Cane- Production Process (15 min.)
  http://www.youtube.com/watch?v=kP1S2HGf5-E
- 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=HzLZndztpI
- LNG Value Chain (Chevron, 3 min.)
  http://www.youtube.com/watch?v=5Lplb68aXlI
- 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=Wodvnxh6WEs4

Supplementary books:

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

<table>
<thead>
<tr>
<th>Weekly Topics</th>
<th>Description</th>
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| **1: Understanding power; basic terminology and system overview**  
John Dirkman  
Guest: Laura Hannah, MISO  
17 September (Zoom), 22 September (Tech LR3)  
| • Electricity fundamentals  
  o Electromechanical generators  
  o Voltage, current, resistance; electric power flow  
  o AC vs. DC  
• Power vs. energy  
• Active and reactive power  
• Load by economic sector – residential, commercial, industrial, and transportation  
• Grid function and structure overview |
| **2: Electric Generation**  
John Dirkman  
Guests: Greg Adams, SRP  
Daniel Haughton, APS  
24, 29 September (Tech LR3)  
| • Fuel Source Comparatives  
  o Capacity Factor  
  o Dispatch Flexibility, intermittency  
  o Carbon intensity  
• Distributed generation  
  o C&I  
  o Residential  
  o DSM as a “negawatt”  
• Supply and demand  
  o Baseload vs. Peak  
  o Load profiles  
  o Forecasting  
• Regulation of power generation and backup power supply |
| **3: Electric Transmission and Distribution**  
John Dirkman  
Guests: Tom Bialek, SDG&E  
Ahmed Mousa, PSEG  
1, 6 October (Tech LR3)  
| • Transmission Infrastructure  
  o Substation equipment; step-up/-down transformers, voltage regulators  
• Distribution Infrastructure  
  o Distribution substation equipment; system redundancy; last-mile wires and poles; service drop; safety  
• Consumer metering & metering technology |
| **4: Grid management and control**  
John Dirkman  
Guests: Andrew Ingram, Southern Company  
Aleksandar Selakov, Schneider Electric  
| • North American power grid interconnections  
  o Grid stability  
  o load balancing  
  o real time network modelling  
  o SCADA  
  o fault detection / propagation prevention  
• Physical and cyber resilience |
<table>
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<tr>
<th>Date and Time</th>
<th>Topic</th>
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<tr>
<td>8 October (Tech LR3), 13 October (Zoom)</td>
<td>Impact of grid safety and regulation</td>
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<td>5: Smart grid, multidirectional flow, DERMS, DSM, behind the meter</td>
<td>Distributed resource integration and the impacts of bidirectional flow</td>
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<td>John Dirkman</td>
<td>IoT and “edge” device network communications</td>
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<td>Guests: Mark Esguerra, PG&amp;E</td>
<td>DERMS, Microgrids and partially/fully “islanded” systems</td>
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<td>Vahid Mehr, SCE</td>
<td>Behind-the-meter resource management</td>
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<td>15, 20 October (Zoom)</td>
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<td>6. Future Role of Gas – renewable hydrogen</td>
<td>Renewable (green) hydrogen principles</td>
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<td>Dan Hahn</td>
<td>Renewable hydrogen value chain</td>
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<td>Growth of renewable hydrogen in the markets globally</td>
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<td>Government efforts to support green hydrogen</td>
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<td>Future outlook for green hydrogen</td>
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<td>7. Decarbonization</td>
<td>Decarbonization principles</td>
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<td>Dan Hahn</td>
<td>Changing landscape of energy providers</td>
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<td>Low-carbon pathways</td>
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<td>8: Hydrocarbon distribution – oil &amp; gas</td>
<td>Hydrocarbon value chain: upstream (exploration, extraction/production) vs. downstream (refining, distribution, retail)</td>
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<td>Dan Hahn</td>
<td>Distribution – inter/intrastate pipeline infrastructure, product compression, refining hubs</td>
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<td>Physical storage options</td>
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<td>End user – domestic consumption vs. export</td>
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<td>Process impact of hydrocarbon safety and regulation</td>
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<td>9: Hydrology and human use; water system design and distribution, Water and wastewater treatment</td>
<td>Water cycle &amp; source - surface/groundwater (lakes, rivers/streams, reservoirs, icepack, wells/aquifers); salinity</td>
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<tr>
<td>Dan Hahn</td>
<td>End user – Public/Municipal Supply (residential, commercial, industrial), Mining, Agriculture/Irrigation, Livestock, Energy</td>
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<td>Guest: Andy Rea, Guidehouse</td>
<td>Distribution infrastructure: water pressure, flow under pressure, gravity flow, flow measurement, centrifugal pumps, water pressure requirements</td>
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<td>Water treatment: coagulation, sedimentation, filtration, disinfection</td>
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<td>Wastewater treatment: screening, grit disposal, clarification, aeration, disinfection; sludge treatment &amp; disposal</td>
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<td>Process impact of water quality standards, safety and regulation</td>
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10: Managing system stressors and Energy-water nexus
Dan Hahn

- 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

Statement on Spring 2021 COVID-19 Classroom Requirements

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:

- Students, faculty, and staff are required to wear a face covering in all public and shared environments on campus, including during class sessions when others are present.
  - Disposable face masks will be available at identified building entrances in all campus buildings.
  - Clear face coverings may be worn to improve ability to read lips; if an accommodation is needed, please contact Accessible NU (students) or Office of Equity (faculty).
  - Face shields are no longer allowed as an alternative to a face mask, per guidance from the CDC and Northwestern Medicine. This includes instructional spaces regardless of social distancing.

- Students, faculty, and staff are expected to observe the rules of social distancing, which require that you are no closer than six feet from other individuals.
- No food is allowed inside classrooms. Drinks are permitted, but please keep your face covering on and use a straw.
- Chairs and tables in classrooms are set to maintain a six-foot distance between individuals. Do not move chairs from their place in the room.
- There will be assigned seating in every class. Instructors may be asked to provide seating information to aid in contact tracing if a student tests positive for COVID-19.
- Class dismissals will start with the seat/row closest to the exit door and be managed by the instructor so as to minimize congestion near the exit.
- Students and faculty will allow those occupying rooms to fully exit before they enter the room.
- Faculty, students, staff and visitors are expected to use the daily symptom check web app for daily health monitoring on days they come to campus.
- As noted below, ALL graduate students must receive a negative test during Wildcat Wellness and before starting in-person classes April 6. Throughout the semester we expect MSES students to be tested weekly or bi-weekly. Please abide by the email reminders you receive from the
The University will again hold a Wildcat Wellness period from March 29 through April 5. During this time ALL graduate students must be tested for COVID-19 and ALL classes will be held remotely.

In the event that 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.

It is also the policy of the MSES Program that all lectures will be recorded and offered in a synchronous, hybrid format. In Winter Quarter 2021 this means that students are expected to attend class in-person on Mondays and Tuesdays and that class will be held completely remote on Wednesdays and Thursdays. On in-person days there will always be a synchronous Zoom option for any students that feel ill or are uncomfortable coming to class. If the professor needs to alter this schedule, they will aim to announce the changes at least 24 hours in advance.

**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.

**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: accessible@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.