Educational tools for teaching policy and science communication to engineering students

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Abstract

Literature and experience show that even though we train engineers to be society's problem solvers, we pay less attention to discussing scientists' and engineers' roles in developing and implementing the policies that ultimately determine society's well-being. We present experience from two courses we teach to science and engineering students, with the intention to cross the engineering-policy boundary. These courses are offered at the upper-level undergraduate and graduate levels and they have an environmental focus. The first course is focused on the policy making process at both the national and international levels and the role of science communication in policy making. The second course is focused on water technology and policies.

The challenge in introducing engineering students to policy is that it requires students to read non-technical references with a new vocabulary and style and to write in a different style and for diverse audiences (e.g., different social groups and their elected representatives). In a sense, while we teach students to communicate the rigor of their work in technical writing in other engineering courses, in the policy-oriented courses, we ask them to 'unlearn' complex phrasing, avoid professional jargon, leave the technical details for the Appendix, and invert the narration triangle, focusing on message first, with clarity and simplicity, in the most efficient communication mode with the shortest possible delivery time.

With reference to the pedagogical bases we have adopted, we present an overview of pedagogical approaches and resources we use in these two courses and share characteristic modules from our courses that demonstrate a) the use of case studies, and b) multi-modal approaches to teaching science-policy communication in engineering courses.

Introduction

From recruitment through graduation, a phrase engineering students hear multiple times is that "engineers are society's problem-solvers". Yet, traditional engineering training often does not explicitly address the connection and interdependence between engineering work and public policy [1] or more broadly societal needs [2]. Taking the example of environmental engineering, research has supported development of public policies for the protection of human health, while at the same time, new research is undertaken because of the need to comply with legislation. A characteristic example of this engineering-policy interface is the high engineering activity (in both academia and industry) following the passing of the Clean Air and the Clean Water Acts [3]. However, environmental engineering students often graduate with limited knowledge and insights about the pathways that lead from scientific knowledge to policy, and the role of other actors (constituents, industry, media, administrators), who can help or derail an effort to create policy consistent with the best scientific knowledge [4], [5], [6]. Gaps have also been identified regarding care-ethical responsibility of engineers toward the protection of human subjects, societal values and the environment [7].

Regarding interaction with other actors, a gap exists in the area of communication with non-engineers and non-scientists. In a National Academy of Sciences study [8], researchers found that people tend to believe that scientists and researchers are 'competent' and 'cold', with the latter leading to people not trusting scientists' intentions. With a trend of increasing mistrust of elites, experts, science and institutions, there is need for engineers and scientists to develop greater social and emotional intelligence and improved communication skills [8], [9]. In addition to the need for gaining people's trust, there is need to make knowledge usable by supporting legislative work. Legislators are called to legislate on a myriad of technical issues in areas where they have limited or no expertise. Therefore, there is need for researchers who are capable of not only designing technical solutions, compiling technical specifications, and performing the essentials of cost-benefit analysis, but who are also capable in transcribing scientific knowledge in concise, accessible ways. This knowledge broker role [6] is necessary for legislators and stakeholders to understand what is at stake, what can be done, what are the risks, how to interpret uncertainty in alternative solutions, and what criteria are used to evaluate solution pros and cons [10].

Science-policy needs be understood in the bi-directional and interdependent sense. It can be thought as 'science for policy' and as 'policy for science' [11]. Science for policy "concerns the use of knowledge to assist or improve decision making", while policy for science is "decision making about how to fund or structure the systematic pursuit of knowledge". While there exist several science-policy and policy-for-science focused undergraduate or graduate degree programs in the United States (examples are listed in https://www.science-policy.net/science-policy-degree-programs.html), our focus is teaching policy to students in traditional disciplinary engineering programs. In this effort, the difficulty stems from the difference in approach between engineering curricula and the nature of social and ethical problems. Traditional engineering curricula typically teach students to solve math- and science-based problems with one answer, whereas, social and ethical problems are contextual and complex and seldom have only one solution [12]. Environmental problems by their nature have the characteristics of "wicked problems" [13]. In addition to complexity and non-closure, topics like climate change are sources of mental stress for students, as we have noticed in the post-COVID semesters adding further cognitive challenges to students. From the pedagogical perspective, managing new terminology and voluminous reading assignments is a challenge on top of the inherent issue complexity, for students in the engineering-policy classrooms.

Based on Kolb's [14] experiential learning theory, learning is a process that involves a combination of grasping experience and transforming it. Individuals grasp experience either through conceptual interpretation and an analytical approach (i.e., comprehension) or through feelings and emotional reactions to the experience (i.e., apprehension). They later transform these experiences through internal reflection (i.e., intention) or manipulation of external phenomena (i.e., extension). In our courses, we use case studies and simulation/game-like activities. Prado et al. [15] found that both simulations and case studies as pedagogical tools worked well to convey the main ideas in a course on sustainable development.

In this paper, we describe our approach within a Civil and Environmental Engineering department, where we have developed two policy-oriented courses for upper-level undergraduate and graduate students. The primary questions we answered when developing the policy for engineers courses were 1) what learning objectives to prioritize and 2) what teaching and reading materials to use not to overwhelm students with sources that represent the scholastic vocabulary, approach, and cultures of disciplines students have not been exposed to before. In our instructional design approaches, we identified learning objectives with reference to broader curricular objectives and ABET [16] requirements and we chose instructional materials that originate in a number of sources including peer-reviewed literature and book excerpts that promote student engagement (such as role playing). Our instructional design approaches resemble Merrill's [17] focus on learner tasks. We target all levels in Bloom's taxonomy triangle [18]. Our classes are designed for students who already have fundamental disciplinary knowledge; that is, we assume students are prepared for the upper parts of Bloom's taxonomy ('Applying', 'Analyzing', 'Evaluating' and 'Creating') regarding disciplinary knowledge. We assume no background in the fundamentals of policy making, thus we start at the base of Bloom's pyramid ('Remembering', 'Understanding') regarding policy and legislation. We use assignment rubrics to evaluate student progress. Figure 1 depicts the major themes and activities for these two policy courses within the engineering-policy interface.

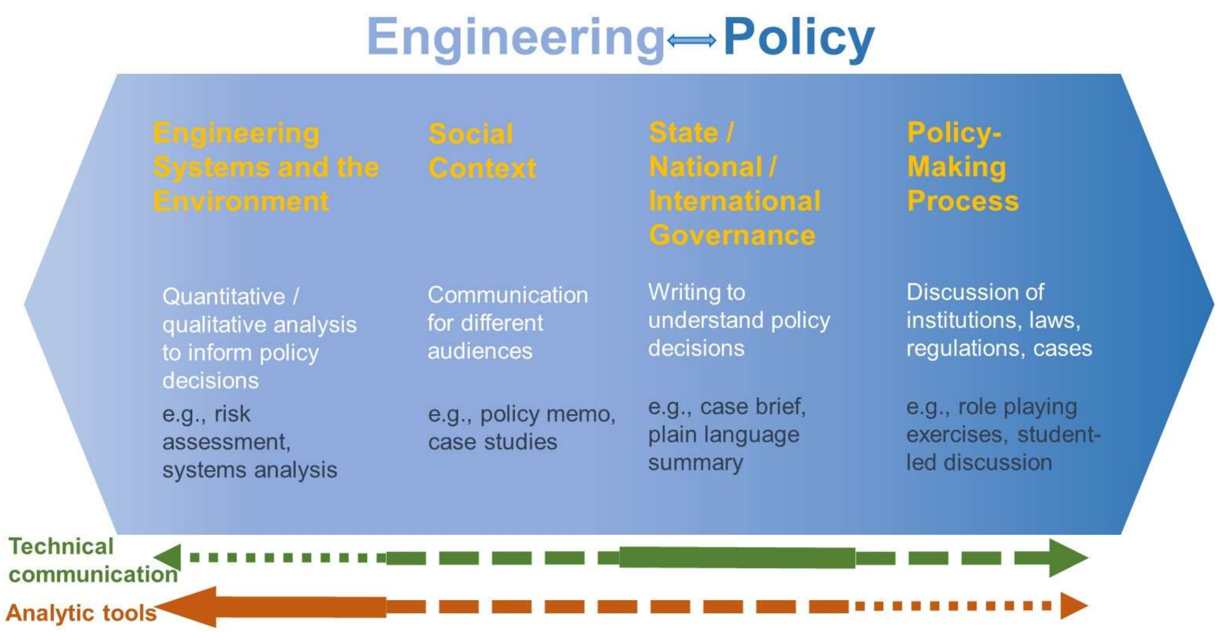

Figure 1. We cover four broad themes within the engineering-policy interface: 1) engineering systems and the environment, 2) social context, 3) state/national/international governance, and 4) policy-making process. Students demonstrate varying degrees of technical communication and analytic tools across these themes, designated by line thickness.

In the following sections, we share the instructional design of each course, and we provide example teaching modules focused on promoting effective communication with reflection of ethical aspects of social responsibility. We consider our work with these two courses as work that evolves as we learn by observing student difficulties and engagement. We present this paper to the community to invoke discussion about how to prepare engineering students so that terms such as “gap” or “valley of death” become meaningless, when referring to engineering and policy in the future. This challenge is important in view of the broader discussion about the future roles of engineers. We envision the future engineers as technologically agile, while being cognizant and responsive to societal needs and valuing work in diverse and multidisciplinary teams.

Course 1: Science and Environmental Policy

The Science and Environmental Policy course has evolved from one focusing on global environmental problems and international environmental governance, to one that includes both international and domestic environmental policy making and environmental justice. The course has a discussion and reflection format. Its central objectives are improved oral and written communication with various audiences (ABET student outcomes criterion 3) and development of critical thinking skills relevant to causes of environmental issues and how public environmental discourse influences the policies devised. The latter objective is relevant to general ABET student outcomes criteria 2 and 4 and to the specific ABET [17] curriculum criteria for civil and environmental engineering pertaining to public policy. The premise here is that for students to develop the abilities to produce solutions with “consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors” (ABET-criterion 2), and “make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts” (ABET-criterion 4), students need to be familiar with the cultural norms, the functions of administrative and regulatory institutions, and the roles of special interest groups in determining how societal problems are prioritized and how they are addressed. This course is open to senior and graduate students from all engineering and natural sciences disciplines for 3 hrs of credit. It has an average enrollment of 20 students. It is an introductory policy course tailored for engineering and natural sciences students with no previous policy background.

Learning objectives
The learning objectives are outlined in the Spring 2023 syllabus as follows:

After completing this course, you will be able to

- Answer (or debate about) key questions, such as: How does scientific expertise shape environmental policy decisions at the National level and within the United Nations System? What are the key barriers and opportunities for integrating scientific knowledge in environmental decision-making? How can the scientific community be better mobilized to contribute to environmental policy-making processes? How can scientific work contribute to environmental justice issues?
- Understand processes and nuances of national and international environmental legislation and treaty-making and the role of scientists and engineers in this process.

- Assess negotiation dynamics and the importance of technical evidence, through the study of select U.S. legislation and international agreements and through role playing and analysis of case studies.
- Identify opportunities where you as an engineer can create value for society.
- Construct oral and written communications for policy purposes, based on evidence-based, fully documented arguments.
- Improve time management and teamwork-toward-a-common goal skills, through practice of teamwork and self-reflection.

Course structure

The course includes an introductory background-building part and a student driven part. In the first part, students learn policy relevant terminology and the essentials of mechanisms in policy making institutions. The main reference for this part is 'The Environmental Policy Paradox" by Z. Smith [19]. In the second part, there is a pre-chosen sequence of teaching modules, but students have flexibility in the selection of topic for their case study (teamwork) and policy memo (individual) according to their interests. Flexibility is given so that students reflect and make connections to society, policy and ethical dilemmas within the context of their own engineering/science domains. This flexibility adds on to the instructor's workload, but it is consistent with the goals that motivated the creation of the course and it compensates with a riveting teaching experience, enriched by every new group of students. Appendix A1 lists the topics covered in Spring 2023 with the chosen reading assignments. The selection of readings aims to strike a balance between academic writing in the social sciences and topics of engineering interest. Choice of a textbook works better in the engineering classroom, compared to a combination of policy academic papers written for policy experts. Use of articles from publications of scientific organizations (such as AGU – American Geophysical Union), provide examples of scientific advocacy or scientific contributions to policy. Policy relevant, peer-reviewed research papers by civil and environmental engineers provide examples of policy relevant research. It is important to note that topic choice from the different modules remains an open question. For example, how much should policy analysis be emphasized in a beginning, 15-week policy relevant class for students in non-policy disciplines? In this class, the choice was made to expose students to policy relevant research, often by faculty in the same department. Students are called to interpret and translate such research in plain language.

Key elements employed in the class are:

1) Written response and discussion on readings from a mix of sources including a textbook, the peer-reviewed literature, reports from governmental and intergovernmental agencies (e.g., US Environmental Protection Agency, National Oceanic and Atmospheric Administration, US Congress, United Nations Environmental Program) and boundary organizations (e.g. AGU, Intergovernmental Panel on Climate Change, American Association for the Advancement of Science), newspapers and social media.
2) Case studies where students form teams around a case study topic, they study their chosen case study and then teach it to the rest of the class.
3) In-class thought provoking activities such as using US EPA's environment justice tool EJScreen and reporting on the results of their analysis [20].
4) Role playing where students assume the roles of stakeholders negotiating solutions to an environmental problem. An example is the "Mercury Game", a negotiation simulation to

teach people about the role of science in international environmental policy making [21]; and the En-ROADS simulation designed to explore multi-sector solutions for climate [22].
5) Writing a short policy memo on a topic of their choice, either advocating an issue or transcribing technical information about an issue, as an honest broker.

Grading
1) Class participation: 15% (class discussion questions, plain language summary, En-ROADS activity, EJ activity, quality participation in class activities and discussions)
2) Case study: 30% (summary and references 20%, presentation 10%)
3) Critical review of case study materials by another team: 5%
4) Memo writing: 45% (informational note 5%; memo outline: 5%; draft memo 5%; presentation/video: 10%; final paper: 20%)
5) Review draft memo of others: 5%

Example assignment
Appendix A2 includes an example Case Study assignment and the most recent rubric used to grade the teaching team and the reviewing/discussion team. Case study teams work closely with the instructor to prepare their teaching materials. The reviewing team acts as a committee that asks questions and evaluates the prepared materials. Final grading is always done by the instructor.

Course 2: Water Technology and Policy

The Water Technology and Policy course takes a mostly U.S.-focused approach to teaching engineering students the context and details of water policy and governance, as well as the relationship between water and other systems (e.g., infrastructure, energy, agriculture, etc.); see Appendix B1 for a list of course modules and reading materials. Similar to the Science and Environmental Policy course, the Water Technology and Policy course focuses on teaching engineering students to "speak" policy through writing assignments, a multimedia presentation, and an oral briefing. Upper-level undergraduate and graduate students build on core course knowledge of water resources, environmental, and systems engineering to explore nuances at the engineering-policy interface. Typical enrollment varies from 30-50 students, most of whom are enrolled in engineering degree programs.

As shown in Appendix B1, reading materials in the Water Technology and Policy course include a wide variety of sources. Students learn water policy from reading peer-reviewed journal papers published in both engineering and law/policy journals, editorial and perspective pieces in scientific journals, excerpts from popular interest science books, and formal policy documents. These formal policy documents include legislative language (e.g., Clean Water Act), administrative rules (e.g., Navigable Waters Protection Rule), and court case summaries (e.g., review of *Rapanos v. United States*), with the intent of introducing engineering students to policy/legal jargon and guiding them through translating policy details into plain language.

Learning Objectives
Learning objectives for Spring 2023 include the following:

After completing this course, you will be able to

- Independently research water technology- and policy-related topics,
- Analyze interrelated systems in a policy context,
- Synthesize policy ideas into technical analysis,
- Present results in a technology- and policy-related manner.

Course Structure

The course is organized around the main themes of U.S. water policy related to engineering, starting first with policy and governance of water quantity (e.g., water rights systems, definitions of "waters of the United States"), followed by water quality and engineered systems related to water (e.g., energy, agriculture). The progression of these themes throughout the semester (see Appendix B1) is intended to mimic the history of U.S. water policy development [23], [24]. In each of the course topics, discussion prompts lead students to make connections between engineering and policy, building on the concept of a "knowledge broker" who makes connections between scientific expertise and policy/decision making [6]. Critical thinking is a course expectation and students often need guidance and reassurance that most questions do not have a single correct answer. Context matters, and students learn to think broadly from multiple viewpoints.

Grading

3-credit students (upper-level undergraduates)	4-credit students (graduate students)
1) Project paper: 20% (proposal 3%, outline 7%, paper 10%) 2) Project video: 10% 3) Final exam: 20% 4) Midterm exam: 20% 5) Homework/quizzes: 10% 6) Case study: 10% 7) Participation: 10%	1) Project paper: 20% (proposal 3%, outline 7%, paper 10%) 2) Project video: 10% 3) Final exam: 20% 4) Midterm exam: 20% 5) Homework/quizzes: 10% 6) Case study: 5% 7) Policy memos: 5% 8) Briefing: 5% 9) Participation: 5%

Example assignments

Appendices B2-B3 include example assignments for Water Technology and Policy: a Case Study assignment focused on the Flint Water Crisis and the individual project assignment, including a written paper and a multimedia video. Through the individual project, students explore a topic of their choice related to both water technology and water policy, with both criteria interpreted flexibly. The individual project includes intermediate assignments (i.e., 1-page proposal, 3-page outline) to teach students elements of the writing process through scaffolded deliverables with instructor feedback.

Teaching approach for both courses – pedagogy

Promoting oral communication skills

Class discussions: Both policy-related courses include significant focus on discussion through guided discussion questions on assigned readings and open-ended questions to facilitate in-class/online discussion. In guided discussion, one student summarizes each reading and coordinates a discussion around a few of the discussion questions. Every student is invited to answer a question, share thoughts, connect with what previous speakers said, and link to the reading and lecture material. Participation in discussion is a class expectation and a portion of the grade.

Presentations: Students learn oral policy communication through team presentations of a Case Study, individual oral briefings/3-minute elevator speech summarizing their policy memo, and multimedia presentation of a technical/policy analysis.

Simulations and role playing: Students participate in role playing and simulation activities (e.g., EN-ROADS [22], EJScreen [20], informal water rights market game) where they articulate their role-determined positions and justify them or summarize the findings from the use of a simulation tool or character summary.

Promoting written communication skills

Written answers to discussion questions: Written discussion responses are required for online students and encouraged or required for in-class students. Online discussions tend to use special terminology and additional references to the course readings and external sources.

Plain language summary: Students are assigned to write a plain language summary for a paper from the peer-reviewed literature.

Case Study summary: Student teams prepare a written Case Study summary in both courses (Appendix A2, B2), along with a list of references, recommended readings, and discussion questions.

Policy Memo: Students choose an issue of interest to them and they write fully documented 2-3-page policy memos.

Case Briefs: Students read reviews of U.S. Supreme Court cases and summarize the cases in a standard case brief, including details on the facts, issue, holding, rationale, and opinions.

Promoting critical thinking skills

Addressing wicked problems requires astute critical thinking skills for “actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication as a means to recognize and solve problems” [25]. It also requires self-directed learning. Self-directed learning was defined in 1975 as “the process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" [26]. Competencies associated with self-directed learning include self-awareness, identification of their own learning gaps, setting learning goals, seeking and evaluating resources for learning, reflection and critical thinking, time management, information management, teamwork [27].

To promote development of critical thinking skills and self-directed learning, we provide guided assignments, starting with use of credible sources, and guiding students to ask questions such as: Who wrote this document? Why are they credible? What is their motivation? What arguments are they using? Are the arguments well supported by credible evidence and data? What did we learn? What can we do with this information? Are there conflicts arising from proposed solutions? Are solutions equitable? Our guidance includes continuous reminders for plagiarism avoidance, use of citation managers to streamline the citation process, and preventing copyright infringement. During discussion sessions, we encourage students to think: What is the theme of the discussion? Do I agree with what the author or other discussants say? Why or why not? How can I articulate my thoughts clearly, respectfully to opinions of others, and constructively? Is the solution to a problem a good one? Why? What criteria were used? What data? Are there other solutions? Is the solution equitable? Does the solution have unintended consequences? Who made decisions on a certain issue? What makes their decision-making process legitimate and credible?

Discussion

We think that teaching policy to engineers is a prerequisite for solving wicked problems for society's benefit. Students need to understand the societal and institutional contexts within which decisions are made. In this paper, we share resources and teaching approaches we have developed and used to help equip engineering students with this much-lacking knowledge.

Introducing science-policy in traditional engineering curricula is a challenging task because one first needs to convince engineering faculty that policy-literacy is an integral part of engineering education. Then, introducing science-policy in engineering is a complex task for both students and instructors. To date, we have chosen materials and teaching approaches assuming lack of policy awareness among senior undergraduate and graduate engineering students. Despite teaching with that lack of policy awareness in mind, we have witnessed student struggles with adapting to the culture, norms, and vocabulary of a new-to-them discipline and we keep modifying our approaches to achieve better student engagement and outcomes. For example, some students feel overwhelmed by the mere counting of the pages they are assigned to read. Not everyone is an avid reader and for some students, full pages of text feel impenetrable compared to pages that include figures and equations. To help students overcome the inertia and inaction this reading material might induce, we have leveraged dense policy reading materials to motivate action in the classroom. For example, we use:

1) structured discussions based on pre-assigned and/or open-ended questions;
2) concept mapping where students cooperate to discuss and link the concepts in an assigned reading;
3) jigsaw learning where readings are split, and students teach each other by contributing parts;
4) peer-reviewing where students provide feedback to each other;

5) role playing where students express unique views based on contextual policy and engineering considerations.

Concept mapping and peer reviewing have proven particularly helpful for students who struggle with reading comprehension.

The issues and materials at the science-policy interface are countless and dynamic. After observing students through several years, it seems that the primary question that is difficult to answer is not *what* our students learned by the end of the semester (though this question is important) but *how* they learn self-directed and continual learning skills for thinking about wicked problems and possible solutions. *What* students learn can be assessed through observation and the use of the assessment-specific rubrics; however, *how* students learn is less straightforward to quantify within the typical engineering curricula. Despite the pedagogical challenges, we support deeper integration of policy-literacy skills into engineering classrooms for preparing students as future societal leaders.

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APPENDIX A1. Science and Environmental Policy - Modules and Readings

Modules *(Number of 80 min class periods on module)*	***Readings*** *(Recommended to review the discussion questions attached to the weekly assignments before you start reading) be **updated)***
Introduction (1)	- Introduction: class format, team assignments finding information, avoiding plagiarism, teamwork, research ethics, organizing successful discussions in a group. - Class activity: FLOWER activity (by Multisolving Institute)
Ecosystem interdependence and environmental policies (1)	- (**textbook**) Smith Z. A., 2018. The Environmental Policy Paradox. 7th Ed., Routledge. Chapter 1, Ecosystem Interdependence.
Scientist roles in environmental policy making (1)	- Lubchenco, J., 1998, "*Entering the Century of the Environment: A New Social Contract for Science*", *Science* 279, no. 5350: 491-7. - Pielke Jr., Roger A., 2007, The Honest Broker: Making Sense of Science in Policy and Politics, Cambridge. Pielke Jr., R. A., 2007, Ch. 1, "*Four idealized roles of science in policy and politics*". - Schneider Stephen, 2010, "*What Roles Can Scientists Play in Public Discourse?*", *Eos*, Vol. 92, No. 16, 19 April 2011. - Buchanan, R., 2015, "*My life in baseball and earthquakes. (How earthquakes interrupted a Royals game and thrust me in a whirlpool of politics, media and law)*". *Eos, 96,* doi:10.1029/2015EO036091. Published on 25 September 2015.
Legislative environment Actors (1)	- Smith, 2018, Chapter 2, Changing Cultural and Social Beliefs: From Conservation to Environmentalism. - H.R.4174 - Foundations for Evidence-Based Policymaking Act of 2018, https://www.congress.gov/bill/115th-congress/house-bill/4174. - *David S. Meyer, 2020, Who Do You Trust?: Mobilization, Polarization and the Erosion of Public Expertise,* https://blog.ucsusa.org/science-blogger/mobilization-polarization-and-erosion-of-public-expertise. *Last Accessed Jan. 2021.* - Smith, 2018, Chapter 3, The Regulatory Environment. - Executive office of the President of the United States, 2023. *A Framework for Federal Scientific Integrity Policy and Practice*, Guidance by the Scientific Integrity Framework Interagency Working Group of the National Science and Technology Council
Environmental Assessments and Environmental Impact Statements (2)	- Smith, 2018, Chapter 4, The Political and Institutional Setting. - NEPA, https://www.epa.gov/nepa In teams choose and review one of the cases here: - https://cdxapps.epa.gov/cdx-enepa-II/public/action/eis/search?search=&__fsk=-760139907#results
International Environmental Governance (2)	- Smith 2018, Chapter 10, International Environmental Issues - Smith 2018, Chapter 11, International Environmental Management - Oran R. Young, 2011, Effectiveness of international environmental regimes: Existing knowledge, cutting-edge themes, and research strategies, PNAS, vol. 108, no. 50, 19853–19860, www.pnas.org/cgi/doi/10.1073/pnas.1111690108.

Case: Climate change (3)	- IPCC 2021, Climate Change 2021: The Physical Science Basis. Working Group I Contribution to the IPCC Sixth Assessment Report. Technical summary and summary for policy makers. https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/ - UNEP, State of the climate. https://www.unep.org/explore-topics/climate-action/what-we-do/climate-action-note/state-of-climate.html - Text of the UNFCCC Convention http://unfccc.int/resource/docs/convkp/conveng.pdf - Kyoto Protocol http://unfccc.int/resource/docs/convkp/kpeng.pdf - Paris 2015 agreement http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf
Communication of scientific information – culture and perceptions mishaps and experiential advice (2)	- Lawrence Susskind, 2008, Arguing, Bargaining, and Getting Agreement, The Oxford Handbook of Public Policy, Edited by Robert E. Goodin, Michael Moran, and Martin Rein. - Dabelko, 2005, "Speaking Their Language: How to Communicate Better with Policymakers and Opinion Shapers – and Why Academics Should Bother in the First Place", Internat. Environm. Agreements, 5:381–386. - Jamieson, K. H. (2018), Crisis or self-correction: Rethinking media narratives about the well-being of science, Proceedings of the National Academy of Sciences, 115, 11, 2620-2627, www.pnas.org/cgi/doi/10.1073/pnas.1708276114. - Boykoff, M. T., & Boykoff, J. M. (2004). Balance as bias: global warming and the US prestige press. Global Environmental Change, 14(2), 125-136. doi:10.1016/j.gloenvcha.2003.10.001. - NAS (National Academy of Sciences), 2014, "The Science of Science Communication II: Summary of a Colloquium", Arthur M. Sackler Colloquia of the National Academy of Sciences. The National Academies Press. Chapter 1, p. 1-14. - US Congress, H.R.946 - Plain Writing Act of 2010 111th Congress (2009-2010). https://www.congress.gov/bill/111th-congress/house-bill/946. - Flemming D, Cress U, Kimmig S, Brandt M and Kimmerle J (2018) Emotionalization in Science Communication: The Impact of Narratives and Visual Representations on Knowledge Gain and Risk Perception, Frontiers in Commun. 3:3. doi: 10.3389/fcomm.2018.00003 - Corner, A., Shaw, C. and Clarke, J. (2018). Principles for effective communication and public engagement on climate change: A Handbook for IPCC authors. Oxford: Climate Outreach. - Somerville, R.C.J., Hassol S.J., Communicating the Science of Climate Change, Physics Today, October 2011. - Vargas Zeppetello L. (2020), Don't @Me: What happened when climate skeptics misused my work, https://eos.org/opinions/ The original paper is available on Canvas. - Loomis I. (2018), Scientific row over renewables leads to free speech legal fight, https://eos.org/articles/.
Communicating scientific uncertainty (1)	- NAS (2013), *Environmental Decisions in the Face of Uncertainty*, Committee on Decision Making Under Uncertainty; Board on Population, Health and Public Health Practice; Institute of Medicine, Institute of Medicine of the National Academies. National Academies Press. Pages 19-28, 32-42 and 47-69.

	- Carslaw Kenneth S., Lee Lindsay A., Regayre Leighton A., and Johnson Jill S. (2018), *Climate models are uncertain, but we can do something about it*, Eos, 99, https://doi.org/10.1029/2018EO093757. - ApSimon Helen M., Warren Rachel F., Serpil Kayin (2002), *Addressing uncertainty in environmental modelling: a case,study of integrated assessment of strategies to combat long-range transboundary air pollution*, Atmospheric Environment 36, 5417–5426. - Fleerackers A, Riedlinger M, Moorhead L, Ahmed R, Alperin J P. (2021) *Communicating Scientific Uncertainty in an Age of COVID-19: An Investigation into the Use of Preprints by Digital Media Outlets.* Health Commun. doi:10.1080/10410236.2020.1864892. - Fischhoff B., Davis A.L. (2014) *Communicating scientific uncertainty*. Proc Natl Acad Sci. doi: 10.1073/pnas.1317504111.
Quantitative models as communication tools (3)	- Czaika E., Selin N. E. (2017). *Model use in sustainability policy making: An experimental study*. Environmental Modelling & Software 98, 54-62. - John Sterman, Thomas Fiddaman, Travis Franck, Andrew Jones, Stephanie McCauley, Philip Rice, Elizabeth Sawinband Lori Siegel, Climate interactive: the C- ROADS climate policy model Syst. Dyn. Rev.28, 295–305 (2012), DOI: 10.1002/sdr.1474 - Class activity C-ROADS https://c-roads.climateinteractive.org/scenario.html?v=22.3.0 - Harvey H., Orr F. M., Jr. and Vondrich C.*,* A Trillion Tons, 2013, Dædalus, the J. of the American Academy of Arts & Sciences, 142 (1). - Lila Warszawski et al., 2021. All options, not silver bullets, needed to limit global warming to 1.5 °C: a scenario appraisal. Environ. Res. Lett., 16, 064037. DOI 10.1088/1748-9326/abfeec - Class activity EN-ROADS - EN-ROADS User's guide https://docs.climateinteractive.org/projects/en-roads/en/latest/index.html
Environmental Justice (3)	Read before class. Write plain language summary in class. - Tessum C. W., D. A. Paolella, S. E. Chambliss, J. S. Apte, J. D. Hill, J. D. Marshall (2021). *PM2.5 polluters disproportionately and systemically affect people of color in the United States*. Sci. Adv. 7, eabf4491. - Lane Haley M., Rachel Morello-Frosch, Julian D. Marshall, and Joshua S. Apte (2022) *Historical Redlining Is Associated with Present-Day Air Pollution Disparities in U.S. Cities*, Environmental Science & Technology Letters Article ASAP, DOI: 10.1021/acs.estlett.1c01012. - Sabapathy, A., Saksena, S. & Flachsbart, P. (2015). *Environmental justice in the context of commuters' exposure to CO and PM10 in Bangalore, India.* J Expo Sci Environ Epidemiol 25, 200–207. https://doi.org/10.1038/jes.2014.34 - Jing Ma, Bochu Liu, Gordon Mitchell & Guanpeng Dong (2019). *A spatial analysis of air pollution and environmental inequality in Beijing*, 2000–2010, Journal of Environmental Planning and Management, 62:14, 2437-2458, DOI: 10.1080/09640568.2018.1560003. - Wing, O.E.J., Lehman, W., Bates, P.D. et al. (2022). *Inequitable patterns of US flood risk in the Anthropocene*. Nat. Clim. Chang. 12, 156–162. https://doi.org/10.1038/s41558-021-01265-6 - (Example that includes plain language summary) Alizadeh, M. R., Abatzoglou, J. T., Adamowski, J. F., Prestemon, J. P., Chittoori, B., Akbari Asanjan, A., & Sadegh, M. (2022). *Increasing heat-stress inequality in a*

	warming climate. Earth's Future, 10, e2021EF002488. https://doi.org/10.1029/2021EF002488. - Guo S., Kontou E., (2021). Disparities and equity issues in electric vehicles rebate allocation. Energy Policy, 154. https://doi.org/10.1016/j.enpol.2021.112291. - Class activity: In teams, use EJScreen: https://ejscreen.epa.gov/mapper/; https://ejatlas.org/. Write the EJ story for the area you analyzed with EJScreen.
Environment and other issues (2)	Environment and Security - Conca and Dabelko, 2004, *Green Planet Blues*, 3rd edition, Westview, part six, "*From Ecological Conflict to Environmental Security*". - Dumaine C., "Redefining Security", National Security, Issues in Science and Technology, Winter 2022. Environment and Trade - UNEP, 2007, "*Trade-related Measures and Multilateral Environmental Agreements*", 2nd edition. - Yamaguchi Shunta, "*International trade and the transition to a more resource efficient and circular economy – Concept paper*". OECD Trade and Environment Working Paper 2018/03 © OECD 2018. - CHIPS and Science Act: "Episode 28: Finding Collective Advantage in Shared Knowledge," Issues in Science and Technology (March 28, 2022). https://issues.org/episode-28-michael-crow-chips-science-collective-advantage-shared-knowledge/
Student teams teach their case studies (4 or 5)	- Case study team submitted study documents and discussion questions.
Memo pitch presentations (1)	

APPENDIX A2. Science and Environmental Policy - Case Study Assignment

CASE STUDY 3: The Stockholm Convention on Persistent Organic Pollutants (POPs)

http://chm.pops.int/

Case Team: 3

Reviewer Team: 2

Dates:

Assigned: Feb. xx

Paper due: Mar. xx

Presentation and Discussion: Mar. xx

Before you get started:

- Refer to the instructions in the general Case Study document on Canvas).
- Schedule a meeting with your instructor

Introduction

The Stockholm Convention on Persistent Organic Pollutants (POPs) is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. Exposure to POPs can lead to serious health effects including certain cancers, birth defects, dysfunctional immune and reproductive systems, greater susceptibility to disease and damages to the central and peripheral nervous systems.

Given their long-range transport, no one government acting alone can protect its citizens or its environment from POPs. In response to this global problem, the Stockholm Convention, which was adopted in 2001 and entered into force in 2004, requires its parties to take measures to eliminate or reduce the release of POPs into the environment (http://chm.pops.int/TheConvention/Overview/tabid/3351/).

Your task

A. Provide an informative review of the Convention:

- History (how it was decided to have a convention on POPs, who initiated the discussion, who were the lead states, who were opposing)
- Main provisions
- How many countries are parties to the Convention
- How POPs are identified and classified for inclusion in the Annexes of the Convention
- Implementation
- Effectiveness

B. Article 8 of the Convention mandates the establishment of the Persistent Organic Pollutants Review Committee (POPRC) to examine proposals for the listing of chemicals, in accordance with the process set out in the Article.

- Investigate how the POPRC works in order to reach decisions about inclusion of different POPs in Annexes A, B or C. After a general review of the steps they take, you may isolate the case of one POP as an example (often the steps and effort required may be different for different POPs, depending on variable layers of resistance by stakeholders for inclusion in the Convention). Examine who are the experts (what scientific backgrounds they have)? Are they representing different country groups (why is this important)? What scientific information and/or models they use (consider the OECD tool, and an example of risk assessment for a certain chemical: endosulfan)? What steps are taken to establish transparency and legitimacy of POPRC decisions?

Case Study Teaching Team Grading Criteria	**Case Study Reviewer Team Grading Criteria**
Report	
Clear, correct writing and formatting, grammar and spelling are correct.	Comments demonstrate thoughtful review
Demonstrates understanding of the environmental problem and how society became aware of it.	Comments are constructive and useful for the Case Team
Demonstrates understanding and clearly describes who the actors are/were, what their roles were and what was the basis for conflict (if any) among them.	
Demonstrates understanding and clearly describes what role scientists played, and clearly demonstrates what tools scientists used to help formulate policy or resolve the issue.	
Concluding statement is succinct and clear and summarizes what we learn from this case study.	
Citations are used correctly and are consistently formatted.	
Presentation	
Introduced the issue, its geographical area of relevance and the main stakeholders.	Reviewer team contributed insightfully to the class discussion of the Case.
Covered essential points without unnecessary detail.	
Ideas in talk were connected and easy to follow.	
Special terms were defined.	
Conclusion strong, main points summarized.	
Audience was able to understand the importance of the issue and why it deserved attention.	
Presenters conveyed enthusiasm for the topic.	
Captured and maintained audience's interest.	
Questions answered well.	
Slides were easy to read illustrated points well.	
Speakers kept to time limit.	
Talk seemed practiced.	
Teamwork (self- and peer evaluation, same criteria)	
Always on time	
Always prepared, helps keep team on track	
Cooperative spirit, respectful attitude	
Initiative and motivation to improve knowledge and skills for self and team	
Contributed fair share of high-quality work	

APPENDIX B1. Water Technology and Policy - Modules and Readings

Week	Topic	Reading
1	Importance of water	
	Water and civilization	Fagan; Pennell et al.
2	Hydrology: surface water	
	Hydrology: groundwater	
3	Water management case studies	
	Water law: Clean Water Act	(skim) CWA; Papacostas
4	Water law: water rights systems	Podolak & Doyle; Schutz
	Water law: water rights systems (continued)	
5	Water law: waters of the United States (WOTUS)	Acuña et al.; (skim) WOTUS rules (2015 and 2018)
	Water law: WOTUS (continued)	
6	Water financing: cost-benefit analysis	Liu et al.
	Water financing: economics (price, cost, value)	Bickel et al.
7	Water financing: markets	Howe; Jones
	Water financing: privatization	
8	**Midterm exam**	
	Video-making tutorial	
9	**Spring Break**	
10	Treatment: drinking water; desalination	
	Treatment: water quality in distribution systems	Edwards & Pruden; Wang et al.
11	Treatment: wastewater treatment	
	WWTP field trip (tentative)	
12	Energy: hydraulic fracturing	Stokstad
	Energy: power generation	Grubert & Sanders; Gerbens-Leenes et al.
13	Energy: renewables and the grid	(read in order): Jacobson et al. (2015); Clack et al.; Jacobson et al. (2017); Rhodes
	Energy: biofuels	
14	Power plant field trip	
	Water and food	Springer & Duchin; West et al.
15	Bottled water	Gleick
	Bottled water (continued)	
16	Water at the movies	

Learning resources

• Acuña, V., T. Datry, J. Marshall, D. Barceló, C. N. Dahm, A. Ginebreda, G. McGregor, S. Sabater, K. Tockner, and M. A. Palmer. (2014) "Why Should We Care About Temporary Waterways?" *Science*. 343(6175), 1080-1081.

• Bickel, Ashley K., Dari Duval, and George B. Frisvold. (2019) "Simple Approaches to Examine Economic Impacts of Water Reallocations from Agriculture." *Journal of Contemporary Water Research & Education*. 168, 29-48.

• Clack, Christopher T. M., Staffan A. Qvist, Jay Apt, Morgan Brazilian, Adam R. Brandt, Ken Caldeira, Steven J. Davis, Victor Diakov, Mark A. Handschy, Paul D. H. Hines, Paulina Jaramillo, Daniel M. Kammen, Jane C. S. Long, M. Granger Morgan, Adam Reed, Varun Sivaram, James Sweeney, George R. Tynan, David G. Victor, John P. Weyant, and Jay F. Whitacre. (2017) "Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar." *Proceedings of the National Academy of Sciences*. 114(26), 6722-6727.

• Clean Water Act (CWA), Federal Water Pollution Control Act. U.S. Congress. http://www.epw.senate.gov/water.pdf. (skim)

• Clean Water Rule: Definition of "Waters of the United States" (WOTUS). (2015) U.S. Federal Register, Vol. 80, No. 124. (skim)

• Edwards, Marc A. and Amy Pruden. (2016) "The Flint Water Crisis: Overturning the Research Paradigm to Advance Science and Defend Public Welfare." *Environmental Science & Technology*. doi:10.1021/acs.est.6b03573.

• Fagan, Brian. (2011) <u>Elixir: A History of Water and Humankind</u>. Bloomsbury Press, New York. ISBN: 978-1-60819-003-4. (ch. 13-14)

• Gerbens-Leenes, Winnie, Arjen Y. Hoekstra, and Theo H. van der Meer. (2009) "The water footprint of bioenergy." *Proceedings of the National Academy of Sciences*. 106(25), 10219-10223.

• Gleick, Peter H. (2010) <u>Bottled and Sold: The Story Behind Our Obsession with Bottled Water</u>. Island Press, Washington. ISBN: 978-1-59726-528-7. (ch. 7)

• Grubert, Emily, and Kelly T. Sanders. (2018). "Water Use in the United States Energy System: A National Assessment and Unit Process Inventory of Water Consumption and Withdrawals." *Environmental Science & Technology*. 52(11), 6695-6703.

• Howe, Ben Ryder. (2021) "Wall Street Eyes Billions in the Colorado's Water." *New York Times*, January 3, 2021. https://www.nytimes.com/2021/01/03/business/colorado-river-water-rights.html.

• Jacobson, Mark Z., Mark A. Delucchi, Mary A. Cameron, and Bethany A. Frew. (2015) "Low-cost solution to the grid reliability problem with 100% penetration of intermittent wind, water, and solar for all purposes." *Proceedings of the National Academy of Sciences*. 112(49), 15060-15065.

• Jacobson, Mark Z., Mark A. Delucchi, Mary A. Cameron, and Bethany A. Frew. (2017) "The United States can keep the grid stable at low cost with 100% clean, renewable energy in all sectors despite inaccurate claims." *Proceedings of the National Academy of Sciences*. 114(26), E5021-E5023.

• Jones, P. Andrew. (2015) "Colorado Water Markets." *Proceedings of the American Bar Association Water Law Conference*. June 4-5, 2015, Denver, CO.

• Liu, Jianguo, Harold Mooney, Vanessa Hall, Steven J. Davis, Joanne Gaskell, Thomas Hertel, Jane Lubchenco, Karen C. Seto, Peter Gleick, Claire Kremen, and Shuxin Li. (2015) "Systems integration for global sustainability." *Science*. 347(6225), 1258832.

• Navigable Waters Protection Rule: Definition of "Waters of the United States." (2018) Department of the Army, Corps of Engineers, Department of Defense; and Environmental Protection Agency (EPA).
• Papacostas, C.S. (2014) "Traditional water rights, ecology and the public trust doctrine in Hawaii." *Water Policy*. 16(1), 184-196.
• Pennell, Kelly G., Marcella Thompson, James W. Rice, Laura Senier, Phil Brown, and Eric Suuberg. (2013) "Bridging Research and Environmental Regulatory Processes: The Role of Knowledge Brokers." *Environmental Science & Technology*. 47(21), 11985-11992.
• Podolak, Charles J.P., and Martin Doyle. (2015) "Conditional Water Rights in the Western United States: Introducing Uncertainty to Prior Appropriation." *Journal of the American Water Resources Association*. 51(1), 14-32.
• Rhodes, Joshua D. (2017) "Energy wonks have a meltdown over the US going 100 percent renewable. Why?" *The Conversation*. June 22, 2017.
• Schutz, Jonathan R. (2012) "Why the Western United States' prior appropriation water rights system should weather climate variability." *Water International*. 37(6), 700-707.
• Springer, Nathaniel P. and Faye Duchin. (2014) "Feeding Nine Billion People Sustainably: Conserving Land and Water through Shifting Diets and Changes in Technologies." *Environmental Science & Technology*. 48(8), 4444-4451.
• Stokstad, Erik. (2014) "Will fracking put too much fizz in your water?" *Science*. 344(6191), 1468-1471.
• Wang, Tianqi, Jooho Kim, and Andrew J. Whelton. (2019) "Management of plastic bottle and filter waste during the large-scale Flint Michigan lead contaminated drinking water incident." *Resources, Conservation & Recycling*. 140, 115-124.
• West, Paul C., James S. Gerber, Peder M. Engstrom, Nathaniel D. Mueller, Kate A. Brauman, Kimberly M. Carlson, Emily S. Cassidy, Matt Johnston, Graham K. MacDonald, Deepak K. Ray, and Stefan Siebert. (2014) "Leverage points for improving global food security and the environment." *Science*. 345(6194), 325-328.

APPENDIX B2. Water Technology and Policy - Case Study Assignment

CEE 433 Water Technology & Policy
Case Study

The Flint Water Crisis was, and continues to be several years later, a high-profile disaster related to both water technology and policy. Many failures – related to infrastructure, operations, and governance – contributed to the severity of the disaster. Yet the lead poisoning in Flint, MI, is not an isolated incident. Lead is present in many forms in the environment, including water infrastructure.

Public policy in the United States is often enacted in response to such disasters. In a team of 2-3, **complete a case study of the Flint Water Crisis** that addresses the following questions:

- What went wrong in Flint? Briefly describe both the engineering failures and the policy/governance failures.
- How could we avoid such a disaster from happening again? Formulate a policy that could prevent lead-related water contamination disasters in the future. Be specific in the policy description, implementation, and funding (if applicable).

Present your case study in a ***written document of no more than 5 single-spaced pages*** (11- or 12-point font, 1-inch margins; include page numbers and all group member names). References may extend beyond 5 pages.

RESOURCES
Many resources are available regarding lead contamination in drinking water in general and the Flint Water Crisis specifically. You may use any resource that you deem reliable and trustworthy. You will likely encounter biased information, which you are welcome to use after you critically sort out fact and opinion.

Resource suggestions to get you started:

- Edwards, Marc A. and Amy Pruden. (2016). "The Flint Water Crisis: Overturning the Research Paradigm to Advance Science and Defend Public Welfare." *Environmental Science & Technology*. 50(17), 8935-8936. https://pubs.acs.org/doi/full/10.1021/acs.est.6b03573
- Many other recently published peer-reviewed journal articles by Marc Edwards and Amy Pruden; both have Google Scholar profiles.
- Hohn, Donovan. (2016). "Flint's Water Crisis and the 'Troublemaker' Scientist." *The New York Times Magazine*. August 16, 2016. http://www.nytimes.com/2016/08/21/magazine/flints-water-crisis-and-the-troublemaker-scientist.html
- Davey, Monica and Mitch Smith. (2016). "What Went Wrong in Flint." *The New York Times*. March 3, 2016. http://www.nytimes.com/interactive/2016/03/04/us/04flint-mistakes.html
- Flint Water Study webpage: http://flintwaterstudy.org.
- Subbaraman, Nidhi. (2018). "A Scientist Is Suing Flint Activists For Defamation. They Say His Ego Is Out Of Control." *BuzzFeed News*. July 26, 2018. https://www.buzzfeednews.com/article/nidhisubbaraman/marc-edwards-flint-lawsuit (note: *BuzzFeed* is historically left-leaning.)
- Carmody, Steve. (2019). "Judge dismisses defamation lawsuit involving Flint water crisis figures." *Michigan Radio*. March 21, 2019. https://www.michiganradio.org/law/2019-03-21/judge-dismisses-defamation-lawsuit-involving-flint-water-crisis-figures
- Open letter to STEM from academics: https://flintaccountability.org

APPENDIX B3. Water Technology and Policy - Individual Project Assignment

CEE 433: Water Technology & Policy
Individual Project

The main assignment of this course is an individual project, including an analytical paper and video (multimedia presentation). Length requirements vary for 3-credit and 4-credit students:

3-credit students	Paper: ≤ 8 single-spaced pages	Video: 3 ± 0.5 minutes
4-credit students	Paper: ≤ 12 single-spaced pages	Video: 5 ± 0.5 minutes

Use an Appendix for large tables/figures that are not vital to the main content of the paper.

PAPER
The project should be an original analysis (beyond a literature review) of a water-related topic, including elements of both technology and policy. Papers that focus completely on technologies with no consideration for policy or analyze policy without including engineering elements will not score highly. Both engineering and policy concepts must be present in the analysis.

Note about design credit: This course has 0.5 hours of design credit. To fulfill the design credit requirement, the analysis in your project should combine 2 or more traditional areas of civil engineering (environmental, water resources, structural, transportation, geotechnical, construction management, construction materials).

For example, if your project topic is investigating the cost-benefit analysis of a new desalination options, you might include aspects of benefits to water supply (water resources) or water quality (environmental), or costs of energy and air emissions (environmental), along with infrastructure capital and O&M costs (construction management) or risk of infrastructure damage from a storm surge or climate change (structural).

Specifications: Use 12-point font, 1-inch margins, single spacing with double spacing between paragraphs, page numbers, and organizational headings. Include an abstract. You may use either numbered or author-date references in your style of preference. Include your first and last names in the document and your last name in the file name (e.g., WTP_AnAwesomePaperTopic_Stillwell.pdf).

Tips for writing: Plan ahead. Use the Writers Workshop on campus for help. Have a peer review drafts of your paper and incorporate their feedback.

VIDEO

The video (multimedia presentation), meeting the time requirements above, should describe the main points of the analysis covered in the paper. The video should use both audio and visual elements to convey information. Think of the video as a chance to be more creative than a traditional PowerPoint presentation to the class.

Be conscious of copyright requirements and do not use copyrighted material (such as music or other videos) without proper permissions. Photos with proper credit are generally acceptable based on fair use. Include your first and last names in the video.

Tips for video-making: Plan ahead. Collect information early. Use a written script and combine words and images.

POSSIBLE TOPICS

- Advantages and disadvantages (legal, ecological, economical) of prior appropriation water rights
- Issues surrounding construction of dams worldwide
- Whole-system challenges of failing water distribution infrastructure
- Cost-benefit analysis of human health risks from drinking water contaminants
- Effects of legislation on water withdrawal and consumption in hydraulic fracturing
- Advances in agriculture and water efficiency
- Challenges in regulating bottled water
- Virtual flows of water in specific commodities
- Historical portrayal of water resources in popular media

Many other topics are within the realm of possibilities.

RESOURCES

- Recorded Media Commons tutorial presentation
- Scholarly Commons at the Main Library: https://www.library.illinois.edu/sc/
- iMovie help: https://support.apple.com/imovie
- Recording through Zoom: https://support.zoom.us/hc/en-us/articles/201362473-Local-recording

DELIVERABLES

- **1-page project proposal**: Due at 8:00 AM on February 23, *submitted via Canvas as a PDF document*. The proposal should include 1) a brief synopsis and scope of the proposed project, 2) an outline of the methodological approach, and 3) pertinent data sets to complete the analysis.
- **Detailed 3-page outline**: Due at 8:00 AM on March 30, *submitted via Canvas as a PDF document*. The outline should include complete sentences of the main points of each section and references.
- **Final paper and podcast**: Both due at **5:00 PM on May 2**, paper *submitted via Canvas as a PDF document*, podcast *submitted online at the course MediaSpace site* (upload instructions will be available on Canvas).

Individual Project: Evaluation criteria

Paper (100 points)	**Weight**	**Points**
Analysis		**70**
Description of analysis	10%	
Assessment of results	20%	
Addresses 2+ CEE areas	10%	
Addresses technology + policy	20%	
Critical discussion	10%	
Written presentation		**20**
Writing skill	10%	
Appropriate length	5%	
Format per assignment specifications	5%	
References		**10**
Appropriate references (15+ references)	5%	
Uses in-text citations	5%	
Paper Total	100%	**100**

Video (100 points)		
Analysis		**70**
Presents high points of paper	50%	
Addresses technology + policy	20%	
Multimedia presentation		**30**
Communication skill	15%	
Appropriate length	5%	
Includes audio and video	10%	
Video Total	100%	**100**