PPUA 5264 Energy Transitions & Climate Resilience: Technology, Policy & Social Change

Graduate & Advanced Undergraduate Course, Northeastern University
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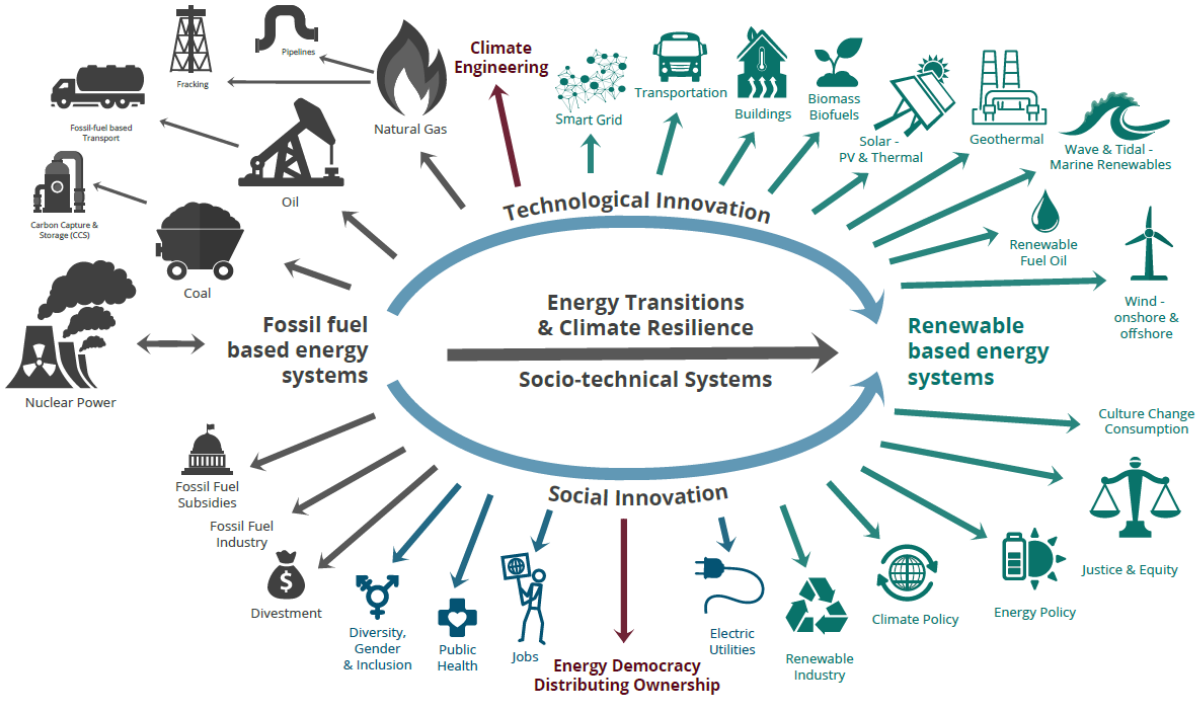
Spring 2018 Thursday 3:35-6:05 Classroom: Behrakis 220

Course Description: This course explores energy transitions from fossil fuels to renewables within the context of climate resilience. A socio-technical systems perspective is applied, with an emphasis on social innovations in energy systems for climate resilience and the interconnections among technology, policy, and social change. The transition away from fossil fuels toward more efficient, renewable-based energy systems includes much more than a technological substitution; this transition also involves social, institutional and cultural change in how individuals, households, communities, and organizations relate to and use energy. The emerging concept of energy democracy provides an innovative lens to explore the transformative potential of the renewable energy transition. Social structures, policy processes, and vulnerabilities that reinforce and perpetuate fossil fuel reliance will be interrogated, as will opportunities for energy system change to reduce inequalities and strengthen climate resilience. Tensions associated with system change and incremental change, centralization versus decentralization, and infrastructural lock-in versus flexibility will be explored through semester-long team projects in which students will contribute to existing, on-going, local energy transition initiatives. These projects provide an opportunity for students to contribute to energy system change and climate resilience right here in Massachusetts and learn through direct engagement with organizations involved in the renewable energy transition.

Course Map: The course is designed to explore the key concepts below.



Learning Outcomes

(1) Identify key concepts related to the renewable energy transition and climate resilience
(2) Synthesize technical and social knowledge about climate change & energy
(3) Integrate different perspectives, disciplines, scales & geographic contexts related to energy system change, the renewable energy transition, and climate resilience
(4) Analyze and articulate the complexities of energy system change and climate
(5) Present integrated analysis of the complexities of changing energy & climate systems

Expectations: This course is a service learning course in which students will be professionally engaging in semester-long team projects with local community partners. Students are expected to demonstrate consistent, responsive, and mature communication.

Justification: Two of the greatest challenges facing society are how to transition toward more renewables-based energy systems and how prepare for a changing climate. This course will empower student to appreciate the complexities and uncertainties of energy system change and climate resilience through their own experience with ongoing energy system transition initiatives. This course is timely as communities throughout the world grapple with implementing the 2015 Paris climate agreements and the United Nations General Assembly has declared 2014-2024 "The Decade for Sustainable Energy For All".

Course Philosophy: This course is designed as a collective endeavor, a shared-action-learning course in which the instructor guides and facilitates student engagement on semester-long team projects in addition to more conventional academic reading and writing assignments. Student-driven active learning and inquiry is encouraged through individual and group assignments inside and outside of class including role playing, problem-solving, field-trips, and student presentations. The success of the course depends on students preparing for each class session, being ready to participate fully, and taking responsibility for their learning.

Course Requirements and Grading Distribution

Participation, Attendance, Engagement	20%
Weekly Reading Response	20%
In Class Presentations	10%
Team Project (includes presentation, engagement, and final report)	50%

Required Reading:

Fairchild & Weinrub (eds). 2017. Energy Democracy: Advancing Equity in Clean Energy Solutions. Island Press. Available at the Bookstore

Inside Climate News, Clean Economy Weekly. Subscribe to "Week in Review" https://insideclimatenews.org/campaign-archive/clean-economy-weekly

All other readings will be posted on Blackboard.

Additional Reading for PhD Students & Students Enrolled in Additional One Credit Course:

Sovacool, B. and D. J. Hess (2017). "Ordering Theories: Typologies and conceptual frameworks for sociotechnical change." Social Studies of Science **47**(5): 703-750.

Weekly Reading Response: Each week students will post a reading response (2-3 well construed paragraphs) on the Tuesday before the Thursday class session. These reading responses should (1) critically discuss or reflect on specific themes, concepts or proposals presented in the readings, (2) demonstrate integrated thinking on each of the different readings, i.e. include some comparative assessment or identify connections among each of the different readings, and (3) include at least one thoughtful discussion question that explicitly relates to the readings. Each week students will be evaluated on their reading response and their peer engagement in the reading response process – earning a maximum of 3 points (3=excellent, 2=sufficient but did not integrate responses to all readings or did not include a discussion question, 1= needs improvement, 0= not submitted). Students are not required to post a reading response on the weeks when they are preparing an in-class presentation.

Semester-long Team Projects: Semester-long transdisciplinary team projects will engage students with community partner organizations working on energy transition issues. Through these projects, students will creatively contribute to ongoing initiatives. In the second week of the semester, students will submit to the instructor an application (resume & cover letter) expressing their preferred team project. Teams will be created and team project-work will begin in the third week of the semester.

Guest Speakers and Field Trips: Multiple guests will visit the class throughout the semester and short local field trips may be planned.

Outside of Class Seminars and Events: This semester there are multiple seminars and other events on campus that are intricately related to this course. Students are expected to attend as many of these as possible.

Semester Plan and Schedule (Expect some changes particularly in second half of semester)

WEEK 1 Introduction

1/11 Energy Transition & Climate Resilience. Review course structure and expectations.

Guests: Community partners introduce team projects (5-6pm)

Rich Rosen on IPCC Special Report
Ruby Woodside, Second Nature
Kathy Spiegelman, VP for Campus Planning & Development

WEEK 2 Energy Transitions & Climate Resilience

1/16 Due Reading Response #1

- Grayson, M. (2017). "Energy Transitions." Nature Outlook November 29, 2017
- Obama, B 2017. "The irreversible momentum of clean energy." Science.
- Fairchild & Weinrub, 2017, Energy Democracy (book) Prologue & Ch 1 Introduction
- Aldrich, D. P. (2018). "The Right Way to Build Resilience to Climate Change." Current History: 16-21.

1/18 – In-Class Discussion.

Guests: Community partners introduce team projects (5-6pm)

Eric Grunebaum, RENEW Energy Partners,
Jeannie Ramey & Jen Stevenson, Climable,
Ben Hellerstein, Environment Massachusetts
Olmis Sanchez, Alernatives for Community & Environment
Dan Gatti, Union of Concerned Scientists

1/19 Due: Resume and Cover Letter

WEEK 3 – Socio-Technical Transitions: Social & Technological Innovation

1/23 Due Reading Response #2

- Geels et al. 2017. "Sociotechnical transitions for deep decarbonization." Science **357**(6357): 1242-1244.
- Sovacool, 2014. "Energy studies need social science." Nature 511: 529-530.
- Brown, D. and J. Bozuwa. 2017. Renewable Energy is Preventative Medicine. The Next System Project.
- Stephens et al 2015. A Changing Climate and a Smarter Grid. Chapter 1 in Smart Grid (R)Evolution: Electric Power Struggles. Cambridge University Press.
- Fairchild & Weinrub, 2017, Prologue and Chapter 3 The Case for a Just Transition

1/25 – In-Class Discussion. Guest: Professor Shalanda Baker 4:30-5:30 Time for teamwork

WEEK 4 –Technological Innovation in Renewable-Based Energy Systems

1/30 Due Reading Response #3

- Jacobson, M. Z., et al. (2015). "Low-cost solution to the grid reliability problem with 100% penetration of intermittent wind, water, and solar for all purposes." PNAS **112**(49): 15060–15065.
- Videos on each technology on blackboard
- Clack, C. T. M., et al. (2017). "Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar." Proceedings of the National Academy of Sciences.
- Kaufman, L. (2017). Is 100% Renewable Energy Feasible? InsideClimate News. https://insideclimatenews.org/news/19062017/100-percent-renewable-energy-climate-change-targets.
- Graziano, M., et al. 2017. "A transformational paradigm for marine renewable energy development." Energy Research & Social Science **23**: 136-147.

2/1- In-Class Discussion.

WEEK 5 Social Innovation in Renewable-Based Energy Systems

2/6 Due Reading Response #4

- Burke & Stephens 2017 "Energy Democracy: Goals and Policy Instruments for Sociotechnical Transition." Energy Research & Social Science.
- Stokes, L. C. and H. L. Breetz (2018). "Politics in the U.S. energy transition: Case studies of solar, wind, biofuels and electric vehicles policy." Energy Policy **113**(Supplement C): 76-86.
- Cervas & Ciancatarino, 2017. Energy Democracy Through Local Energy Equity. Chapter 4 in Energy Democracy
- Farrell, J. (2017). What if... Your Electric Utility Was a Benefit Corporation? Clean Technica.

2/8 – In-Class Discussion

WEEK 6 Mid-Term Team Project Presentations

2/13 No Reading Response Attend Precarious Energy Futures.

Extra Credit Option: Attend Professor Shalanda Baker's seminar on Precarious Energy Futures. Tuesday 2/13 4:30-6, 909 Renaissance Park.

2/15 Team Project Presentations

WEEK 7 Technological Innovation in Fossil-Fuel-Based Energy Systems

2/19 – Special Session 10-12am Location RP 310

2/20 Due Reading Response #5

- Sovacool, 2014. "Cornucopia or curse? Reviewing the costs and benefits of shale gas hydraulic fracturing (fracking)." Renewable and Sustainable Energy Reviews **37**(0): 249-264.
- Scott, V., et al. (2013). "Last chance for carbon capture and storage." Nature Clim. Change **3**(2): 105-111.
- Stephens, J. C. (2014). "Time to stop investing in carbon capture and storage and reduce government subsidies of fossil-fuels." Wiley Interdisciplinary Reviews: Climate Change **5**: 169-173.
- Burns, W. and S. Nicholson (2017). "Bioenergy and carbon capture with storage (BECCS): the prospects and challenges of an emerging climate policy response." Journal of Environmental Studies and Sciences.

2/22 In-Class Discussion – Debate about Carbon Capture and Storage & Time for Teamwork

WEEK 8 Social Innovation in Fossil-Fuel-Based Energy Systems

2/27 Due Reading Response #6

- Coady, D., et al. 2017. "How Large Are Global Fossil Fuel Subsidies?" World Development **91**: 11-27.
- Stephens, JC & S Jiusto. 2010. Assessing Innovation in Emerging Energy Technologies: Socio-Technical Dynamics of Carbon Capture and Storage (CCS) and Enhanced Geothermal Systems (EGS) in the USA. *Energy Policy*. 38: 2020-2031
- Healy, N. and J. Debski (2017). "Fossil Fuel Divestment: Implications for the Future of Sustainability Discourse and Action within Higher Education." Local Environment **22**(6): 699-742.
- Johnson and Lewis. 2017. Organizing for Energy Democracy in Rural Electric Cooperatives. Chapter 6 in Energy Democracy
- Supran, G. and N. Oreskes (2017). "Assessing ExxonMobil's climate change communications (1977–2014)." Environmental Research Letters **12**(8): 084019.

3/1 In-Class Discussion – Guest Eric Grunebaum, Screening of his film *The Last Mountain*

3/2 Mid-Term Team Project Proposals Due

SPRING BREAK – No Class March 8, 2018 – International Women's Day

WEEK 9 Energy Transitions & Climate Resilience Around the Globe: Comparative Perspectives

3/13 Due Reading Response #7

- Kejun and Woetzel. 2017. "How China is leading the renewable energy revolution." World Economic Forum
- Strunz, S. 2014. "The German energy transition as a regime shift." Ecological Economics 100: 150-158.
- Sarrica et al. 2016. "One, no one, one hundred thousand energy transitions in Europe: The quest for a cultural approach." Energy Research & Social Science **13**: 1-14.
- Londono, Ernesto, 2017. Chile's Energy Transformation is Powered by Wind, Sun and Volcanoes, New York Times. August 12, 2017
- Jairaj, Deka, & Boehm. 2017. India's Renewable Energy Push: A Win-Win for Job Creation and Electricity Access. World Resources Institute.

3/15 In Class Discussion.

WEEK 10 Radical Technological Change: Climate Engineering

3/20 Due Reading Response #8

- Keith, D. (2017). "Toward a Responsible Solar Geoengineering Research Program." Issues in Science and Technology **33**(3).
- Parson, E. A., et al. 2017. Forum on U.S. Solar Geoengineering Research: Background Paper. Forum on U.S. Solar Geoengineering Research Harvard & UCLA
- Frumhoff and Stephens 2017. "Toward Legitimacy in the Solar Geoengineering Research Enterprise." Philosophical Transactions of the Royal Society A
- Wetter, K. J. and T. Zundel (2017). The Big Bad Fix: The Case Against Geoengineering.
- Nicodema, Allie, 2017. Climate Engineering Risks of Manipulating the Global Thermostat. News at Northeastern December 12, 2017
- Jones, A. C., et al. (2017). "Impacts of hemispheric solar geoengineering on tropical cyclone frequency." Nature Communications **8**(1): 1382.

3/22 In-class Discussion/Debate about Climate Engineering

WEEK 11 Radical Social Change: Energy Democracy

3/27 Due Reading Response #9

- Jenkins, K., et al. 2016. "Energy Justice: A Conceptual Review." Energy Research & Social Science **11**: 174-182.
- Burke, MJ and JC Stephens 2017. "Energy democracy: Goals & policy instruments for sociotechnical transitions." Energy Research & Social Science **33**: 35-48.
- Tishman, Maggie. 2017. Community Anchor Strategies for Energy Democracy. Chapter 9 in Energy Democracy
- Benander, Horowitz and Baker, 2017. Chapter 10 in Energy Democracy
- Schoolman & Delman, 2017. Building Power Through Community-Based Project Development. Chapter 10 in Energy Democracy
- Fairchild, 2017. Conclusion, Building an Energy Democracy Movement. Chapter 12 in Energy Democracy

3/29 In-class discussion. Play game with Deck of Cards on Energy Democracy

WEEK 12 Jobs, Livelihoods & Energy-Climate Careers

4/3 Due Reading Response #10

- International Renewable Energy Association (IRENA) 2017. Renewable Energy & Jobs Annual Review 2017.
- Pearl-Martinez, R. JC Stephens. 2016. Toward a Gender Diverse Workforce in the Renewable Energy Transition. *Sustainability: Science, Practice and Policy*. 12 (1)
- Louie, E.P. and J.M. Pearce, *Retraining Investment for U.S. Transition from Coal to Solar Photovoltaic Employment.* Energy Economics, 2016.
- Sweeney 2017. Conflicting Agendas: Energy Democracy and the Labor Movement. Chapter 7 in Energy Democracy

4/5 RISE Research Innovation and Scholarship Expo. 10-2

4/5 In-class Discussion. Career Advice Session.

WEEK 13 – FINAL PRESENTATIONS

4/10 No Reading Response due

4/12 In class final presentations – Last Class

4/20 – Final Projects Due

Semester-Long Team Project Options

Northeastern 100% Renewable Energy Campaign
Organization: Environment Massachusetts
Contact: Ben Hellerstein, ben@environmentmassachusetts.org
Website: www.environmentmassachusetts.org
Project Description: Environment Massachusetts is advocating for a 100% renewable energy across all sectors for the state of Massachusetts. Part of the strategy to build support for a state goal is to get institutions within the state to commit themselves to the 100% goal. Institutions of higher education are key organizations within the state of Massachusetts, and colleges and universities have unique potential to be innovative when it comes to sustainability and climate change. Boston University, a neighboring university, recently committed to 100% renewable electricity by the end of 2018 as part of their climate action plan, but Northeastern has not yet thought strategically about this opportunity. This team of students will work with Environment Massachusetts to explore the opportunities and challenges of Northeastern University committing to the 100% renewable goal.

Microgrid Implementation
Organization: Climable.org
Contact: Jeannie Ramey or Jen Stevenson, info@climable.org cc: jr@climable.org
Website: www.climable.org
Project Description: As the macrogrid evolves to meet the needs of constituents and overcome the challenges of energy reliability, microgrids are uniquely positioned to help ease the transition. Microgrids, when powered by renewable energy and paired with battery storage, can offer multiple benefits to end users in the form of cleaner energy sources, reliability, shelter-in-place, and peak-shaving savings to name a few. The idea of a microgrid, which is tied to the larger grid yet islandable if necessary, is rather new and implementation faces three main challenges: financial, technical, and legislative/regulatory. The financial challenges are related to how to make them either financially attractive to investors given the high up-front capital costs or to prove how they will create revenue for the utility if they are footing the bill. The technical challenges abound, but one of the biggest is how to prevent backfeed and ensure that the microgrid doesn't create issues for the macrogrid. Perhaps even more challenging however, are the legislative and regulatory hurdles that must be overcome to allow a microgrid to be installed in the first place. These hurdles include legislation surrounding storage to how FERC, ISO-NE, and NEPOOL rules impact feasibility. This team of students will work to determine which NEPOOL rules could pose a threat to microgrid implementation. All rules relevant to this issue will be identified, and then after this initial step, reasonable alternatives/suggestions will be created that will be proffered to NEPOOL in a formal presentation.

Developing Renewables in a Local Urban Garden
Organization: Alternatives for Community and Environment (ACE)
Contact: Olmis Sanchez olmis@ace-ej.org exkluziive@gmail.com
Website: https://www.ace-ej.org/
Project Description: This team will work with local youth in the Roxbury Environmental Empowerment Project (REEP) as they develop a plan for integrating solar and wind into a community garden. We are youth of color focusing on creating different ways to reclaim the community with renewable things that people necessarily take for granted, to make an impact in thriving not just surviving in our communities

Funding & Business-Model Innovation for Campus Energy Efficiency, Resiliency & Renewables
Organization: RENEW Energy Partners / Cambridge Energy Advisors (business dev't consultant to RENEW)
Contact: Eric Grunebaum, eric.grunebaum@gmail.com
Website: Renewep.com
Project Description: This team of students will work with RENEW Energy Partners in collaboration with Cambridge Energy Advisors to explore options for impact investment in energy efficiency, resiliency and renewable energy projects on the Northeastern campus. Students will learn about the rates of return for different options and explore barriers and opportunities for investing in energy infrastructure improvements that provide emissions reductions and resiliency, while also reducing operating costs for the university. Students will look at the economics for clean energy projects, comparing using NU's borrowing capacity vs using third-party impact investment funding ("off balance sheet.") Students will engage with RENEW, a Boston-based energy efficiency, clean/on-site energy finance and development firm serving the retrofit market for Commercial, Industrial & Institutional buildings. RENEW was cofounded in 2014 by NU engineering grad Steve Pritchard and is a leader in the CI&I energy efficiency sector with over $15M in projects completed, in construction and in final contracting across the Mid-Atlantic and Northeastern US.

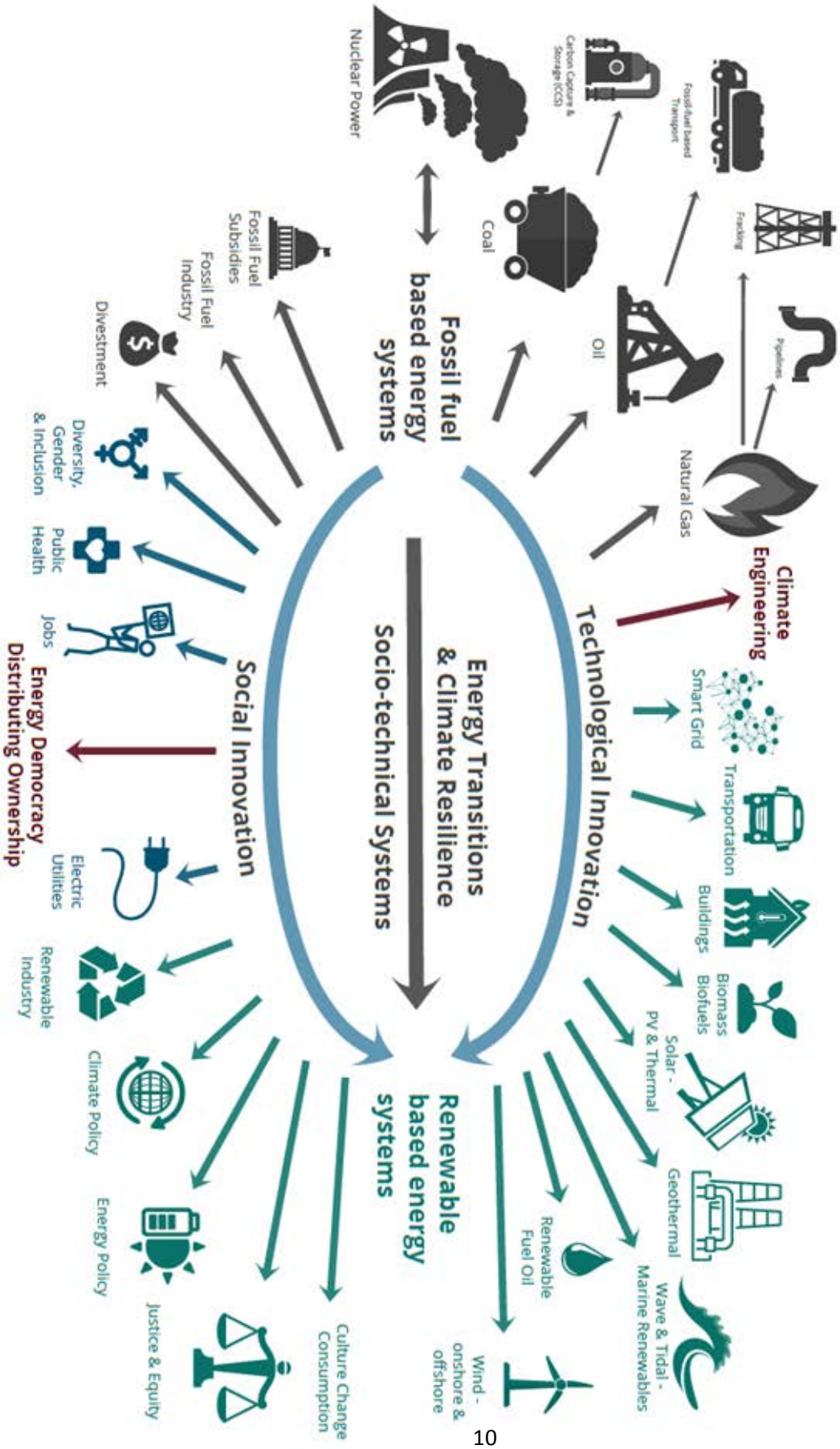
Review of the Intergovernmental Panel on Climate Change Special Report on 1.5 Degrees
Organization: Independent Scientist
Contact: Richard Rosen rrosen10435@gmail.com
Website: http://www.ipcc.ch/report/sr15/
Project Description: Project Description: The Intergovernmental Panel on Climate Change (IPCC) is in the midst of a multi-year process following from the Paris Climate Agreement of 2015, drafting a special report reviewing what is known about the impacts and feasibility of limiting global warming to 1.5 degrees C above pre-industrial levels, and related global greenhouse gas emissions pathways. The report is also supposed to identify the incremental issues involved in pursuing a 1.5 degree scenario versus a 2.0 degree scenario. This report is charged with reviewing the science in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (all the SDGs). Some scientists are concerned that the special report does not adequately review the full spectrum of possible actions for climate policy, and, in particular ones that do not involve extensive investments in somewhat hypothetical "negative" emissions technologies. This team of students will work with independent scientist, Rich Rosen, to develop a strategy for responding to the draft report released in January 2018. Official expert reviewer comments are due to be submitted to the IPCC by the end of February, but further responses may be needed and appropriate.

Transportation Policy Options
Organization: Union of Concerned Scientists
Contact: Daniel Gatti DGatti@ucsusa.org
Website: www.ucsusa.org
Project Description: This team of students will work with the Union of Concerned Scientists to provide input on options for how states expand the Regional Greenhouse Gas Initiative (RGGI) to include transportation. Over the past decade, the states of the Northeast region have successfully reduced pollution from power plants thanks in part to the help of a critical climate program, the Regional Greenhouse Gas Initiative (or “RGGI”). RGGI is a cap and invest program (aka “cap and trade”) which creates a regional limit on global warming emissions from electricity, requires power plants to purchase

allowances from a limited pool in periodic regional auctions, and invests the funds generated by these auction sales into renewable energy and efficiency programs. This policy model has successfully reduced emissions while creating jobs and reducing costs for consumers. States are now considering an expansion of this cap and invest model into transportation, which is now the largest source of pollution in the Northeast region. With state leaders just starting to focus on fleshing out what this policy could do, work by Northeastern students could be immediately put to use by advocates and stakeholders. Some potential project questions include: What are some programs that currently exist that would be good models for new investments in clean transportation? What would be the benefits of expanding some of the identified programs with additional funding and in the transportation sector? What are some specific local transportation projects that could be supported by a new investment in clean transportation?

Climate Resilience Planning: Resources for Universities and Colleges
Organization: Second Nature
Contact: Ruby Woodside rwoodside@secondnature.org
Website: www.secondnature.org
Project Description: This team of students will work with Second Nature, a national organization based in Boston that is committed to accelerating climate action in and through higher education. Second Nature's main program is the Presidents' Climate Leadership Commitments, through which presidents and chancellors commit their schools to achieving carbon neutrality and/or increasing campus climate resilience. The project will focus on compiling resources that colleges and universities can use to strengthen their climate resilience planning efforts. A particular need the team could fill is to research and review potential financial models for funding adaptation and climate resilience projects. A deliverable for the end of the semester will be a report or compilation of resources and best practices that will be made publicly available through Second Nature's network and website. The audience is colleges and universities across the US (primarily sustainability officers, campus master planners, financial officers, energy managers) that are in the process of developing climate action plans that include resilience goals and targets.

Innovation in Sustainability and Resilience at Northeastern
Organization: Northeastern Campus Planning and Development
Contact: Kathy Spiegelman Kathy kathy.spiegelman@gmail.com
Website: https://camd.northeastern.edu/architecture/people/kathy-spiegelman/
Project Description: This team of students will work with Northeastern faculty, staff, and the administration to develop a strategic plan to strengthen the coordination of sustainability and resilience initiatives throughout the university. As a leader in experiential learning, Northeastern University is well-positioned to become a pre-eminent global leader demonstrating the innovative potential for higher education to advance societal sustainability and resilience. The opportunity to synergistically connect excellence in research, teaching, campus operations and community engagement requires a new level of university-wide commitment to elevate and support existing and new initiatives throughout Northeastern. This effort involves research and teaching faculty, students studying in multiple disciplines and programs, staff who plan for and maintain our campus facilities as well as the multiple communities connected to Northeastern that are also engaged with confronting climate change, strengthening social and environmental resilience, and advancing innovative approaches for resource stewardship to provide for the future. This team will work to develop a strategy to elevate Northeastern's leadership and ensure excellence in these integrated areas. The work will involve outlining specific strategies and innovations that will elevate excellence in how Northeastern engages with the critical societal issues of sustainability and resilience.


Energy Transitions
& Climate Resilience
Socio-technical Systems
Fossil fuel based energy systems
Nuclear Power
Carbon Capture & Storage (CCS)
Fossil-fuel based Transport
Coal
Oil
Fracking
Pipelines
Natural Gas
Fossil Fuel Subsidies
Fossil Fuel Industry
Divestment
Diversity, Gender & Inclusion
Public Health
Jobs
Technological Innovation
Climate Engineering
Smart Grid
Transportation
Buildings
Biomass Biofuels
Solar - pv & Thermal
Geothermal
Renewable Fuel Oil
Wave & Tidal - Marine Renewables
Wind - onshore & offshore
Social Innovation
Energy Democracy
Distributing Ownership
Electric Utilities
Renewable Industry
Climate Policy
Energy Policy
Justice & Equity
Culture Change
Consumption
Renewable based energy systems