GENERAL EDUCATION COURSE ENHANCEMENT GRANT COMPETITION 2021-2022

1. Proposer Name(s) and Academic Title(s)
   Oksan Bayulgen, Associate Professor of Political Science

2. Email Address(es)
   Oksan.bayulgen@uconn.edu

3. Is this a new course or a currently existing course?
   Currently existing course

4. List the course title and course number of the proposed/enhanced course and name of the sponsoring department or program.
   POLS/ENGR/HRTS 3209: Sustainable Energy in the 21st Century

5. Describe your project and the work that will be done during the grant period on course content, course design, and/or teaching approach. Provide a clear statement of the objectives of the project in terms of student learning.

I have originally developed this course with a colleague from the Department of Chemical and Biochemical Engineering (Prof Richard Parnas) in 2013. The rationale for this co-taught class emerged from our mutual observation that sustainable energy research operates in disciplinary silos and that researchers and practitioners from social sciences and hard sciences talk past each other. Such institutional silos start with college education and so students across different colleges and disciplines need to have more opportunities to learn together, exchange ideas, and solve important challenges facing humanity using their comparative skills and intellectual strengths. This course was one of the first of its kind at UConn in bringing together students, theories, and methodological approaches from two different colleges: CLAS and Engineering. A few years later the course was also adopted by the Human Rights Institute to meet a requirement for the innovative Human Rights Minor for Engineers.

Over the years, Prof. Parnas and I planned on revising and strengthening the content of the course to make it more interdisciplinary and compatible with general education requirements but for various reasons we could not get around to it. Last year, Prof. Parnas retired from the university and now I want to use this transition moment to revamp the course by utilizing the incredible expertise and resources that exist at UConn at the intersection of energy and environmental education.

Preparation and implementation of such a course is difficult because it involves diverse disciplines with specific technical languages and approaches. An additional difficulty is the lack of an adequate textbook that brings interdisciplinary topics together within a single volume. During the grant period, I want to expand the interdisciplinary content for the course, build on the existing course material (create a more eclectic and diverse reading list), consult with various UConn faculty who would be invited to co-teach or guest-lecture on energy topics of their expertise, create an energy research database for students where they can easily access scholarly work, institutional reports, statistics, videos, podcasts, news articles on energy issues and finally design assignments that will include collaborative research projects and field trips to observe first-hand energy technologies and infrastructure in nearby communities. UConn has a number of energy centers, i.e. Center for Clean Energy Engineering, Center for Energy and Environmental Law, Eversource Energy Center. I would like to connect our undergraduates to

these energy research hubs and help establish energy networks between students and researchers.

With this more updated and diversified version of the course, I expect students to have a fuller and a more balanced understanding of the pros and cons of each energy source and be equipped to evaluate the merits and feasibility of energy policies that governments (at various levels) have at their disposal to transition into sustainable energy. In addition to the technical characteristics of renewable energy, students will be trained to think across the ethical, social, political and economic dimensions of energy issues.

6. How do you intend to evaluate project objectives once the course, as proposed, is offered? Please identify intended learning outcomes and assessment tools.

Student learning outcomes:

Upon completion of the course, the students should be able to:

1) **List and explain the main sources of energy and their primary applications in the US and the world**
2) **Evaluate and compare the true costs of different energy sources on the economy, environment, society and geopolitics**
3) **Describe the principles of sustainability and compare the sustainability of different energy sources**
4) **Understand the basics of the science and engineering mechanisms behind different energy conversion technologies**
5) **Describe the technical challenges associated with the use of various energy sources**
6) **Understand the connection between energy, social justice, human rights, environment and public health**
7) **Compare different governmental approaches to energy policy and evaluate the sources of differences and similarities among them**

Assessment tools:

1) **Weekly journal entries: to assess students' ability to analyze the assigned readings and/or visual media.**
2) **Quizzes and/or midterms: to assess students' capacity to define key concepts, explain theories, compare and analyze case studies.**
3) **Collaborative research project: students will be assigned to groups (mixed disciplinary composition) and specific topics. Building upon the knowledge from weekly readings, class discussions as well as external research, groups will be asked to write a policy memo on their research question and then use visual media and oral communication skills to present their findings to class. Depending on the size of the class, we might also hold a poster session where each group presents their work to the broader UConn community. A component of this assignment will also be self and peer evaluation of presentations.**

7. Describe how the course will fit into UConn's General Education curriculum.

The topic of sustainable energy necessitates a holistic approach and crosses the lines of many traditional academic disciplines. Energy challenges facing the world cannot be effectively addressed from the perspective of only STEM disciplines. Energy education needs to move away from purely technical fields into a truly interdisciplinary arena where many kinds of students and faculty from different colleges examine all aspects of energy technology and its

relation to society. Similarly, pure social science education on energy that is completely divorced from physical sciences, engineering or life sciences can be just as incomplete and ineffective. Energy problems require that social scientists engage with physical scientists as well as the reverse.

Interdisciplinary approach to energy education offers the best path forward but it also poses many challenges to long ingrained teaching habits and methods. This is why very few universities in the United States (and in the world) offer interdisciplinary energy studies courses at the undergraduate level. A general education sustainable energy course is needed not only as an introductory/core course for those who are interested in energy specialization at the graduate and post-graduate levels but also because basic energy and environmental literacy is needed for achieving a wider acceptance of clean energy technologies that will be key to solving climate problems. Energy literate citizens will better understand energy dilemmas, the costs of transition and the costs of failing to make a transition.

This course will help UConn students 1) articulate the technical merits and feasibility of clean energy technologies 2) acquire the necessary intellectual breadth from a wide range of fields to analyze energy challenges facing our world today 3) use critical judgment to compare the pros and cons of different technologies and government policies 4) acquire sensitivity to think across the ethical, social, political and economic dimensions of energy issues in ways that are necessary to inform difficult choices and formulate good energy policy 5) acquire awareness of how their way of life and energy choices shape the environmental and energy justice challenges facing their society 6) appreciate the diversity of energy consumption patterns as well as political structures that prioritize certain energy pathways over others and 7) develop the research and presentation skills necessary for professional development. Finally, this large course will be accessible to students from a wide range of majors, including students at regional campuses.

8. Describe how the course meets the specific criteria for the given priority areas of this year's competition (EL, JEDI).

This course fits two of the three specific priority criteria for this year's competition. Environmental Literacy (as will be discussed below) and courses that seek to build bridges between disciplines. As discussed earlier, a sustainable energy future can be realized by providing a holistic education and integrating insights from the physical and social sciences. Typically in energy courses, technological solutions are prized while ignoring the socioeconomic, cultural and political processes that determine their acceptance and use. Including social science and humanities allows us to pay attention to market adoption and diffusion of new technologies and the sociopolitical environment in which energy policies are designed and implemented. It also helps us understand energy injustice issues such as energy poverty, inequitable energy access, and disproportional environmental and health impacts of energy use. Purely technical approaches cannot account for the multilayered nature of social forces. Energy problems require that diverse disciplines engage each other and bring specialized skills and methods to find common solutions.

9. Describe how the course will fit into the general education plan for any departments involved in its development.

1) **For the Political Science Department, this course will offer a much-needed EL designation in addition to enriching the Pols subdivision course offerings. I believe so far we have only 1 other Pols course that is designated for EL.**
2) **For Human Rights and Engineering programs, this course is an integral part of the Human Rights Minor for Engineers (in fact it was one of the two courses that inspired this minor) as it explores human rights and sustainability in the renewable energy sector. Students gain the skills to assess the risks that energy businesses pose to the environment and the ability to reengineer product design and production processes to render them more socially and environmentally sustainable. Having this course satisfy CA2, CA3 and EL will provide additional flexibility in this minor's curriculum.**
3) **I am currently part of a group of faculty working on a new Energy Minor at UConn. We envision this course to be one of the – if not *the*- core course for the minor. Having the Gened designations will make this class more accessible and useful for students who are interested in pursuing a minor in Energy at UConn.**

10. For which content areas (CA1-4), competencies (W, Q), or literacies (Environmental – E) will the course be proposed and how will it address the specific criteria for courses in these content areas and/or competencies?

CA2: Social Sciences

1) **This course introduces students to social science theories and concepts such as resource curse, Dutch disease, democratic accountability, energy justice, energy poverty, resource nationalism, sustainable development, levelized cost, externalities in energy supply systems, etc.**
2) **It uses comparative methods to analyze how different societies generate and consume energy, how they establish institutions to design energy policies, create incentives for technology development and manage the distributional fallouts from particular energy choices. We discuss at length the ethical, economic, geostrategic and social challenges created by each energy source and technology.**
3) **It clearly delineates the links between human agency, social norms and practices and environmental outcomes. It addresses the social, economic and political changes that accompany technological changes and why particular policy instruments are chosen over others to promote certain technologies.**
4) **It provides students with a basic and holistic foundation to examine the complicated energy challenges facing humanity. It alerts them to resources that are available at the individual, local, national, international and transnational levels so that they can develop robust and constructive answers to pressing societal issues.**

CA3: Science and Technology

1) **This course explores the fundamental laws, principles and methods that govern energy sources, conversions and uses (such as 1st law of thermodynamics, efficiency of heat engines, engine cycles, cellular metabolisms, anerobic fermentation, steam power cycle, etc.)**
2) **It demonstrates the application of scientific theories to specific energy technologies and engineering. Through collaborative projects it also promotes an understanding of the process of investigation.**

3) **It introduces new technological developments in the energy sector, analyzes the potential challenges in their widespread deployment and offers areas where more research and development is needed to solve emerging problems.**
4) **This course also aims to promote interest among students to continue to specialize in energy science and technologies. It provides them with brief introductions to a menu of sustainable energy research projects.**

EL: Environmental Literacy

1) **Energy sector is the biggest contributor to climate change. This course starts with examining the basic science of human induced climate change and identifies corresponding impacts at global, regional and local levels. Then, it analyzes how energy production and consumption choices affect the environment and public health. We spend some time on the environmental implications of conventional energy sources (fossil fuels, nuclear), i.e. greenhouse gas emissions, air and water contamination, water depletion, toxic waste, land impact, destruction of habitat, etc. Then we investigate the environmental and public health trade-offs for each renewable energy technology.**
2) **A part of the course also focuses on specific energy policies as well as broader climate mitigation policies and the legal, institutional and socioeconomic contexts in which they are formulated and implemented.**
3) **The course also pays special attention to energy poverty and justice issues and maps out the disproportionate environmental impacts of energy choices on vulnerable communities. We highlight the role of agency i.e. responsibility and accountability of energy companies in sustainable energy development, government greenwashing strategies, clean energy champions, environmental movements, etc.**

11. How will the course add to and/or enhance existing course offerings? Does the course fill other important curricular gaps? How does it compare to current offerings or pedagogy? What will be distinctive about the course?

I already discussed the curricular contributions of this course in question #9. It will enhance course offerings in the Political Science Department (as a logical follow up to my other course Pols 3208 Politics of Oil class but also for increasing the number of EL designated Pols courses). As mentioned before, it is also one of the elective courses in the Human Rights for Engineers Minor and it is being discussed as a core course for the new Energy Minor. Overall, it is a very unique course as it brings together faculty and students from a number of colleges and programs to cover a truly interdisciplinary and problem-oriented topic. By the way, there is another Sustainable Energy Sources and Systems course on the books (ME 3285). But it is tailored specifically for mechanical engineering students and does not have an interdisciplinary focus. The faculty who is teaching that course, Ugur Pasaogullari, will be joining me this spring to co-teach POLS/ENGR/HRTS 3209 and he has expressed interest (among other colleagues) in helping me restructure this class for next time around.

12. Why are you the most qualified person/team to teach this course? If this is not your primary field of study, what resources will you use to help you develop this course?

My area of specialty is on energy and environmental politics. I have written 2 books (one forthcoming) and numerous articles on energy transitions. And I have been teaching energy

courses at UConn since 2008. While being the main instructor for this course, I hope to expand the team of faculty who would be involved in this course. I believe that active team-teaching broadens students' perspectives and helps them gain a better appreciation of the complexity of energy technologies and how they impact society and the environment. I am in contact with faculty from different disciplines (e.g. Ugur Pasaogullari, Joseph Macdougal, Ioulia Valla, Carol Atkinson-Palombo, Alexander Agrios, Emmanouil Anagnostou, Ranjan Srivastava). I am confident that these researchers will complement each other's expertise to make the whole bigger than its parts.

13. Will your course serve as a model to assist others in their efforts to improve the general education curriculum? If so, how?

This course has already been used as an inspiration and a model for the creation of the Human Rights minor for Engineers. Bringing together students with such diverse skill sets and backgrounds has its challenges but this class has been successfully creating an institutional space for students to learn from different disciplines as well as from each other to find common solutions to the existential challenge of climate change.

14. Is your proposal linked to any others being submitted in this competition? If so, explain the added benefits that will accrue to students from taking the courses as a group.
    No
15. Has this course even been submitted for this grant in the past? Yes / No / Unsure
    No
16. Has this course been funded ***by this grant*** in the past? Yes / No / Unsure
    No
17. Has this course or will this course be funded ***by any other non-departmental source***, e.g. CETL grant, non-university grants, etc? Yes / No / Unsure
    No
18. If you answered "Yes" to questions 13 or 14, please explain why the additional changes and funding are needed to further enhance this course.

As I mentioned in the beginning, this is an existing course but needs to be developed more to include a wider range of disciplinary perspectives and materials. I want to utilize the rich resources and faculty expertise that exists in the University to make this class a more collaborative, foundational and accessible course.

19. **Complete the Budget Form** (found at http://geoc.uconn.edu/course-development-grant-competition/) where you will explain how the funds will be used to support the course development activities.

Please see attached.

20. ***For an existing course that you are revising***, attach a sample syllabus with your proposal. Include a short note at the beginning or add comments within the syllabus indicating how you anticipate the syllabus may change based on work you will do if the proposal is funded.

Please see attached.

21. Arrange for your program director/department head to email a statement of support verifying that they will provide resources for offering the course every, or every other, academic year for the

duration of five years beginning 2022-2023, if the project is funded and completed. This statement should be emailed to GEOC@uconn.edu.

2021-2022 GENERAL EDUCATION ENHANCEMENT GRANT COMPETITION

Proposer Name (s): Oksan Bayulgen

Course Proposal Title: Sustainable Energy in the 21st Century

Email Address of *Department Fiscal Manager*: Carly.koebel@uconn.edu

Fiscal Year 2022	**Amount Requested**	**Fringe for Summer Salary ***	**Total**
Faculty Salary (calculate a fringe rate of 25.8%)	5,724.83	1,477	7,201
Student Labor (calculate a fringe rate of 18% for Grads)			
Supplies		N/A	
Travel		N/A	
Research (Faculty Account)		N/A	
Other		N/A	
Total	5,724.83	1,477	**7,201**

Justification:

I have asked for ½ month of summer salary to expand the interdisciplinary content for the course, build on the existing course material, consult with various UConn faculty who would be invited to co-teach or guest-lecture on energy topics of their expertise, create an energy research database for students where they can easily access scholarly work, institutional reports, statistics, videos, podcasts, news articles on energy issues and finally design assignments that will include collaborative research projects and field trips to observe first-hand energy technologies and infrastructure.

NOTE: This was the syllabus for the course in Spring 2020. It is heavy on social science, especially political science, literature on energy transitions as well as Prof. Parnas' expertise area of biofuels. I would like to diversify the course material by including readings from other disciplines such as geography, anthropology, business, law, civil and environmental engineering, material sciences, natural resources, resource economics and environmental sciences. I would like to reorganize the structure of the course where we focus less on problems with fossil fuel dependency (Part 1) and more on the multitude of opportunities and challenges that are created with renewable energy options. For example, I would like to put more attention on cutting-edge renewable technologies, energy storage systems, grid modernization and energy resiliency. Finally, I would like to include more resources for the last section of the class on energy and environmental law from around the world.

SUSTAINABLE ENERGY IN THE 21st CENTURY
POLS 3209/ENGR 3209/ HRTS 3209
TuTh 11-12:15 (AUST 110)
Spring 2020

Instructors:

Prof. Oksan Bayulgen (Political Science) Oksan.bayulgen@uconn.edu
Office hours: TuTh 1:00- 2:30 (OAK 409A); please make appointments on nexus: https://nexus.uconn.edu/secure_per/schedule1.php?stser=2260

Prof. Richard Parnas (Chemical Engineering) Richard.parnas@uconn.edu
Office hours: Tu 1:00 – 2:00, or by appointment (IMS 206).

Course Description:

States are increasingly under pressure to reform their energy policies given the concerns with global climate change, declining sources of affordable fossil fuels and the geopolitics of supply security. While the need for clean energy seems obvious, the transition to a low-carbon, sustainable economy in many countries has been neither inevitable nor smooth. Needless to say, there are many technological and economic challenges: which energy sources provide the most viable and affordable replacement for fossil fuels? What are the potential and pitfalls of different energy technologies? To what extent can alternative energy sources be integrated into our existing technical and economic systems? How sustainable are they? What would be the cost and benefits to the citizens and the economy in general of reliance on alternative energy sources?

In addition to the technical and economic challenges, there are also many sociopolitical factors that explain why some countries are successful at promoting clean energy alternatives while others continue to perpetuate the dominance of fossil fuels in their economies. This raises questions such as: how are governments responding to opposing pressures to reform their energy policies? Who are the key players in energy debates and who are excluded? What are the human rights concerns associated with access to sustainable energy sources? How are energy issues framed by different interest groups? What are the public perceptions of energy choices and what do governments do to secure public legitimacy for long-term energy reforms? What is the appropriate role of government in supporting the development of alternative energy sources? How are political decisions on energy reform made? Which political institutions make the adoption of energy reforms more likely?

This course provides an interdisciplinary approach to understanding current energy issues and covers the science, engineering, economics and politics behind alternative energy sources. By the end of this course, students will have a fuller understanding of the pros and cons of each energy source and will be equipped to evaluate the merits and feasibility of energy policies that governments have at their disposal to transition into clean energy.

Course Requirements:

A. **2 Midterms (100 pts each):** The exams will consist of short answer questions. We will provide a review sheet for the exams and distribute them a week before the exams. The

questions on the exams will come from the review sheet. The midterms will be on **Feb 20th** and **Apr 9th.**

B. Final Exam (100 pts): The final exam will be the same format as the midterms. Check the final exam schedule for date and time.

C. **Participation (extra credit up to 10 pts):** You are expected to come to every class, complete the assigned readings, and participate in class discussions. Occasionally (up to 10 times) we will give you a take-home assignment in class about the lecture that day and/or readings that are due for the next class time and you will have to turn in your responses on huskyct before the start of the next class. The more you turn in, the more extra credits that you will accrue. These will be the only chance you will have to improve your overall grade.

Required Readings:

There is no textbook for the class. For most of the readings, the links are provided next to the citation. For others with asterisk (*), please check huskyct under *course readings.*

Schedule of Topics and Readings for the Course

PART 1
NONRENEWABLE ENERGY SOURCES: FOSSIL FUELS AND NUCLEAR

Week 1: (Jan 21, 23)

Introduction

Energy Profile of the World, US, CT, and UConn

Distribution of reserves (conventional vs. unconventional), energy production and consumption patterns, key energy actors

Readings:

*Key World Energy Statistics 2019. *International Energy Agency* (IEA),

US Energy Facts Explained. *US Energy Information Administration, at* *https://www.eia.gov/energyexplained/us-energy-facts/*

Connecticut State Energy Profile. *US Energy Information Administration*, at https://www.eia.gov/state/print.php?sid=CT

UConn Sustainability Progress Report 2017-2018. *Office of Sustainability*, at https://docs.google.com/viewerng/viewer?url=https://ecohusky.uconn.edu/wp-content/uploads/sites/2041/2018/12/2018-Sustainability-Progress-Report.pdf&hl=en

Week 2: (Jan 28, 30)

Fossil Fuel Dependence 1: Environmental, Public Health and Human Rights Consequences

Fossil fuels: meaning, types, and uses; environmental and public health impact of fossil fuels: spills, accidents, air/water/land pollution, greenhouse gas emissions, work safety risks, production and consumption risks to human health, environmental injustice, energy poverty

Readings:

"The hidden costs of fossil fuels," *Union of Concerned Scientists* (30 Aug 2016), at https://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels/hidden-cost-of-fossils#.WlUsfWUryfQ

Special Report of The Intergovernmental Panel on Climate Change (IPCC): Global Warming of 1.5°C, https://www.ipcc.ch/sr15/ (Read only the *Summary for Policymakers*)

"The localized health impacts of fossil fuels," *Climate Nexus* (27 September 2017), https://climatenexus.org/climate-issues/health/the-localized-health-impacts-of-fossil-fuels/

"It's a vast, invisible climate menace. We made it visible," *The New York Times* , (Dec 12, 2019) https://www.nytimes.com/interactive/2019/12/12/climate/texas-methane-super-emitters.html

*Karlsson, Gail, "A Human Rights Approach to Energy, Poverty and Gender Inequality," in Cindy Holder and David Reidy (eds.) *Human Rights: The Hard Questions* (Cambridge University Press 2013), pp. 231-245

Week 3: (Feb 4, 6)

Fossil Fuel Dependence 2: Socioeconomic, Political and Geopolitical Consequences

Volatility of oil prices, resource curse, Dutch disease, democracy deficit, fossil fuels and conflict, resource nationalism, geopolitics of energy transition

Readings:

*McNally, R. and Levi, M., "A Crude Predicament: The Era of Volatile Oil Prices," *Foreign Affairs* (July/August 2011)

* Ross, Michael L. "What have we learned about the Resource Curse?" *Annual Review of Political Science* 2015, 18:239-59.

Colgan, Jeff, "Oil, Conflict, and US National Interests," *Policy Brief: Belfer Center for Science and International Affairs*, Harvard Kennedy School (Oct 2013), at https://www.belfercenter.org/publication/oil-conflict-and-us-national-interests

"Russia and China battle US in race to control Arctic" *CNBC.com* (Feb 6, 2018), https://www.cnbc.com/2018/02/06/russia-and-china-battle-us-in-race-to-control-arctic.html

"Redrawing the geopolitical map," *A New World: The Geopolitics of the Energy Transformation"* (IRENA 2019) https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Jan/Global_commission_geopolitics_new_world_2019.pdf (you are welcome to read all of the report but you are responsible from pp.26-55)

Week 4: (Feb 11, 13)

Nuclear Energy Alternative: The good, the bad and the ugly

Nuclear fuel cycle, nuclear waste, cost of nuclear energy, nuclear accidents, nuclear weapons proliferation

Readings:

Nuclear Explained at Energy Information Administration, at https://www.eia.gov/energyexplained/index.cfm?page=nuclear_home

Explore this web site and follow the links to gain an understanding of the nuclear fuel cycle, and relative benefits and problems of nuclear generated electric power compared to fossil fuel generated electric power.

Rhodes, Richard, "Why nuclear power must be part of the energy solution," *Yale Environment 360* (July 19, 2018) https://e360.yale.edu/features/why-nuclear-power-must-be-part-of-the-energy-solution-environmentalists-climate

Jacobson, Mark Z. "The 7 reasons why nuclear energy is not the answer to solve climate change," *Leonardo DiCaprio Foundation* (June 20, 2019), https://www.leonardodicaprio.org/the-7-reasons-why-nuclear-energy-is-not-the-answer-to-solve-climate-change/

"Chernobyl all-time worst nuclear accident*," EarthSky Voices in Human World* (April 2016), at http://earthsky.org/human-world/chernobyl-worst-nuclear-accident-of-all-time

Week 5: (Feb 18, 20)

Catch up/ Review Session (Feb 18)

MIDTERM I (Feb 20)

PART 2
RENEWABLE ENERGY SOURCES: PROS AND CONS

Week 6: (Feb 25, 27)

Hydropower

Readings:

Guide to Hydropower, at http://www.canyonhydro.com/guide/index.html

Look through all the slides in this guide to building your own small hydropower system. Identify the critical concepts and the practical considerations.

"Environmental impacts of hydroelectric power," *Union of Concerned Scientists*, at https://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-hydroelectric-power.html#.WlUoDWUryfQ

International Rivers, at www.internationalrivers.org

Read through Rivers in Crisis links on the right hand side.

Watch:

"A river runs through us" https://www.youtube.com/watch?v=WxereGwgJyU

"The wrong climate for damming rivers" https://vimeo.com/147261951

Week 7: (Mar 3, 5)

Solar, Geothermal

Readings:

Solar Energy, at http://en.wikipedia.org/wiki/Solar_energy

Geothermal Energy, at https://en.wikipedia.org/wiki/Geothermal_energy

Explore these web sites and follow the more detailed links to photovoltaics, concentrated solar power and geothermal to gain an understanding of the major technologies and relative benefits compared to other forms of energy production.

McKibben, Bill, "The race to solar-power Africa," *The New Yorker* (June 26, 2017), at https://www.newyorker.com/magazine/2017/06/26/the-race-to-solar-power-africa

Dominish, E.,N. Florin and S. Teske. *Responsible Minerals Sourcing for Renewable Energy.* Report prepared for Earthworks by the Institute for Sustainable Futures, University of Technology Sydney (2019), at https://earthworks.org/cms/assets/uploads/2019/04/MCEC_UTS_Report_lowres-1.pdf (you are responsible for executive summary and chapter 1)

Watch:

"Solar power revolution: Here comes the sun" https://www.youtube.com/watch?v=nr-grdspEWQ

"Geothermal Kenya" https://www.youtube.com/watch?v=P9X9rhMEo1A

Week 8: (Mar 10, 12)

Wind

Readings:

Wind Turbine, at http://en.wikipedia.org/wiki/Wind_turbine
Explore this web site and follow the more detailed link to wind turbine design to learn the key design requirements. Focus especially on the materials and production of the blades using composite materials.

"Anti-wind activism is sweeping Europe- and the US could be next," *GIZMODO* (October 9, 2018), https://earther.gizmodo.com/anti-wind-farm-activism-is-sweeping-europe-and-the-us-c-1829627812

"Limits to growth: resistance against wind power in Germany," *Cleanenergywire.org* (March 27, 2019), https://www.cleanenergywire.org/factsheets/fighting-windmills-when-growth-hits-resistance

"Renewable energy job boom creates economic opportunity as coal industry slumps," Forbes (Apr 22, 2019), https://www.forbes.com/sites/energyinnovation/2019/04/22/renewable-energy-job-boom-creating-economic-opportunity-as-coal-industry-slumps/#211dba253665

Watch:

"Industrial Wind Turbines-Nimby= Not in my backyard or next it might be you" https://www.youtube.com/watch?v=WJgYZfX4lLc

Week 9: (Mar 17, 19)

Spring Break – No classes

Week 10: (Mar 24, 26)

Biomass

Readings:

Alternative Fuels Data Center, US Department of Energy, at http://www.afdc.energy.gov/
Explore this web site and follow the more detailed links to gain an understanding of relative benefits and deficiencies of the different types of fuels compared to standard petroleum fuels such as gasoline and diesel

*Parnas, R.S, M. Pomykala, I. Noshadi, Ch.12. Processing Issues in Biofuels Production, in *New and Future Developments in Catalysis. Catalytic Biomass Conversion*, S.L. Suib, Ed., Elsevier, Amsterdam, 2013.

"Palm oil was supposed to help save the planet. Instead it unleashed a catastrophe." *The New York Times* (Nov 20, 2018), https://www.nytimes.com/2018/11/20/magazine/palm-oil-borneo-climate-catastrophe.html

Week 11: (Mar 31, Apr 2)

Electricity Grid and Distributed Energy Resources (DERs)

Readings:

"Electrical Energy Storage," *International Electrotechnical Commission (IEC) White Paper*, at http://www.iec.ch/whitepaper/pdf/iecWP-energystorage-LR-en.pdf

Smart Grid, at http://en.wikipedia.org/wiki/Smart_grid
Explore this web site and the links to more detailed descriptions of smart meters and phasor measurement unit to develop an understanding of the evolution of our electrical system in the 21st century.

"The role of distributed energy resources in today's grid transition," *GridLab* (August 2018), http://gridlab.org/wp-content/uploads/2019/04/GridLab_RoleOfDER_online-1.pdf

"Clean energy technologies threaten to overwhelm the grid: Here is how it can adapt," *Vox* (Nov 11, 2019), https://www.vox.com/energy-and-environment/2018/11/30/17868620/renewable-energy-power-grid-architecture

Watch:

"How does the power grid work?", https://www.youtube.com/watch?v=v1BMWczn7JM

Week 12: (Apr 7, 9)

Catch up/ Review Session (Apr 7)

MIDTERM II (Apr 9)

PART III
Challenges to Clean Energy Transition

Week 13: (Apr 14, 16)

Energy Transitions and Government Policy Tools

Readings:

Sovacool, Benjamin. 2016."The history and politics of energy transitions: comparing contested views and finding common ground*." WIDER Working Paper* 2016/81, https://www.wider.unu.edu/sites/default/files/wp2016-81.pdf

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Week 14: (Apr 21, 23)

Sociopolitical Barriers to Energy Transitions

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Week 15: (Apr 28, 30)

What is the future of sustainable energy? Is a *Green New Deal* possible? What are the geopolitical challenges with renewable energy?

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Grundwald, Michael, "The Trouble With the "Green New Deal," *Politico Magazine* (Jan 15, 2019), https://www.politico.com/magazine/story/2019/01/15/the-trouble-with-the-green-new-deal-223977

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O'Sullivan, Meghan, Indra Overland and David Sandalow, "The Geopolitics of Renewable Energy," Working Paper, Belfer Center for Science and International Affairs, Harvard Kennedy School (2017), https://www.belfercenter.org/sites/default/files/files/publication/Geopolitics%20Renewables%20-%20final%20report%206.26.17.pdf (you can read the whole paper but you are responsible for pp. 11-34).