Term Information

Effective Term	Autumn 2023
Previous Value	*Summer 2012*

Course Change Information

What change is being proposed? (If more than one, what changes are being proposed?)

Inclusion in the new GE as a course in the Sustainability Theme

What is the rationale for the proposed change(s)?

This existing Earth Science course is a natural fit as a 2000-level course in the new GE Theme Sustainability and has been updated to highlight how it fulfills the ELOs of the Theme.

What are the programmatic implications of the proposed change(s)?

(e.g. program requirements to be added or removed, changes to be made in available resources, effect on other programs that use the course)?

None

Is approval of the requrest contingent upon the approval of other course or curricular program request? No

Is this a request to withdraw the course? No

General Information

Course Bulletin Listing/Subject Area	Earth Sciences
Fiscal Unit/Academic Org	School of Earth Sciences - D0656
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	2210
Course Title	Energy, Mineral Resources, and Society
Transcript Abbreviation	Energy Min Res Soc
Course Description	Geologic origin, world distribution, and uses of mineral resources critical to society; topics include mineral and fossil fuels, metallic ores, and industrial minerals.
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 12 Week, 8 Week, 7 Week, 6 Week
Flexibly Scheduled Course	Sometimes
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	Yes
Admission Condition	Natural Science
Off Campus	Never
Campus of Offering	Columbus, Lima, Mansfield, Marion, Newark, Wooster
Previous Value	*Columbus, Lima, Mansfield, Marion, Newark*

Prerequisites and Exclusions

Prerequisites/Corequisites

Exclusions

Previous Value Not open to students with credit for EarthSci 210 or GeolSci 210.

Electronically Enforced No

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code 40.0601

Subsidy Level Baccalaureate Course

Intended Rank Freshman, Sophomore, Junior, Senior

Requirement/Elective Designation

Required for this unit's degrees, majors, and/or minors

General Education course:

Physical Science; Sustainability

The course is an elective (for this or other units) or is a service course for other units

Previous Value

Required for this unit's degrees, majors, and/or minors

General Education course:

Physical Science

The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- • Students understand the basic facts, principles, theories, and methods of modern science.
  • Students learn key events in the development of science and recognize that science is an evolving body of knowledge.
- • Students describe the inter-dependence of scientific and technological developments.
- • Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world

Previous Value

Content Topic List

- • Understand and apply four overarching concepts throughout the course where relevant - linked earth systems, population growth impact on supply and demand, sustainability, and DEI.
- • Obtain an appreciation for the occurrence and world distribution of critical energy and mineral resources, their uses in society, and environmental and societal impacts of their exploitation.
- • Describe common energy and earth materials, their mode of origin (genesis), and the technology used to develop them.
- • Articulate resource availability, production, and consumption (with sustainability and resilience in mind), current and impending mineral and fossil fuel shortages, & their possible political impacts.
- All these aspects are integral to the life cycle assessment approach (LCA) that students are introduced to in this class.
- • Describe the impact of resource development, implementation, and environmental impacts on underrepresented and marginalized peoples.

Previous Value

- *Classification of earth resources; world, U.S. production, consumption*
- *Coal, oil, and natural gas*
- *Oil shale and tar sand; exploration for oil & gas*
- *Alternative energy sources*
- *Water resources*
- *Metals and mineralizing processes*
- *Mineral leasing and mineral claims on federal lands*
- *Molybdenum and copper; lead and zinc; gold and silver*
- *Building materials and dimension stones*
- *Gems, kimberlite, and diamonds; fertilizer resources*
- *Sulfur, salt, asbestos, and resources for the future*

Sought Concurrence

No

Attachments

- Responses to the Theme II Panel Review.docx: response to Panel feedback

  (Cover Letter. Owner: Griffith,Elizabeth M)
- EARTHSC 2210 Theme Revised Syllabus June 23 2023.docx: revised syllabus - changes highlighted

  (Syllabus. Owner: Griffith,Elizabeth M)
- submission-sustainability June 23 2023.pdf: Theme application - revised

  (Other Supporting Documentation. Owner: Griffith,Elizabeth M)

Comments

- Please find revised documents following Panel feedback. *(by Griffith,Elizabeth M on 07/16/2023 03:01 PM)*
- Please see feedback email sent to the department 02-24-2023 RLS *(by Steele,Rachel Lea on 02/24/2023 12:48 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Griffith,Elizabeth M	01/31/2023 09:13 PM	Submitted for Approval
Approved	Griffith,Elizabeth M	01/31/2023 09:14 PM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	02/05/2023 10:09 PM	College Approval
Revision Requested	Steele,Rachel Lea	02/24/2023 12:48 PM	ASCCAO Approval
Submitted	Griffith,Elizabeth M	07/16/2023 03:01 PM	Submitted for Approval
Approved	Griffith,Elizabeth M	07/16/2023 03:02 PM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	07/17/2023 09:32 AM	College Approval
Pending Approval	Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	07/17/2023 09:32 AM	ASCCAO Approval

Responses to the Theme II Panel Review - Earth Sciences 2210: Energy, Mineral Resources and Society

We thank the Sustainability Themes Panel for its insightful and helpful assessment of this course. We have responded to each point below (responses in red) and highlighted changes to the revised syllabus in red as well. We hope the panels can review these in time for the course this Autumn to be included for students in the new GE if at all possible.

Sincerely,

Assoc. Prof. Liz Griffith

Associate Director of Administration

Chair Curriculum Committee School of Earth Sciences

with Prof. David Cole, Instructor of EARTHSC 2210

Subject: Earth Sciences 2210

Good afternoon,

On Tuesday, February 14th, the Themes II Panel of the ASC Curriculum Committee reviewed a course proposal for Earth Sciences 2210.

The Panel did not vote on the proposal as they would like the following points addressed:

i. The reviewing faculty ask that the department provide more information about the "mini-capstone"/group project (syllabus pg. 3 and pg. 4). Specifically, they would like more detail about how it is connected to the GEN Theme: Sustainability ELO's. The Panel also notes that the grading framework for the class (syllabus pg. 3) lists in-class presentations (which are presumably connected to the "mini-capstone"/group project) as being worth 15 points, but the description of the presentations and how they will be evaluated (syllabus pg. 4) has them at 32 points.

> *We appreciate the thoroughness of the syllabus review and have made the points consistent (20 points for the in-class team presentation). While this team (group) assignment/assessment occurs towards the end of the semester and integrates topics studied in this course, it is not a traditional "capstone" project and so this designation is removed (only having appeared in the Theme rationale). As stated in the syllabus, "*the students are asked to assess how earth processes, natural or anthropogenic, impact the environment and humankind and its desire for a sustainable future. They must discuss their topic in terms of frequency, magnitude, and scope of the impact on sustainable systems and, through critical thinking, provide possible strategies for mitigation and/or adaptation to minimize or eliminate the negative environmental impact." *In-class team presentations were never intended to connect with a specific lecture, but integrate what the students learned throughout the course and then apply in their research for the presentation. The team presentation can be on any topic relevant to either energy or mineral resources and is guided by a specific rubric that is provided in the syllabus as well as a special*

lecture designed to help the students in the process. The topics covered are related directly to the Sustainability Theme (and provide an opportunity to assess the students advanced research on sustainability as the students are asked to research and present (for their topic) information on the "Challenges in terms of supply and demand especially for non-renewables" and provide a "Summary and Future outlook". Thus, this assessment addresses the ELOs under the Sustainability Theme. We have included an Appendix which outlines these expectations as well (last page of the revised syllabus: Appendix 2). Appendix 1 outlines details on the individual TED talks.

In-Class Team Presentations

Outline:

Identify relevance to Energy and/or Mineral Resources

Key concepts being covered: Sustainability, Population, Linked Earth Systems, DEI

Earth resources and their formation - how, what, why, where, when

Impacts - Relevance to the U.S; global impact if any

Challenges in terms of supply and demand especially for non-renewables

Summary and Future Outlook [for the selected energy vector or metal(s)]

Supporting Informatics: References, relevant web sites

(Where appropriate, use of good visuals is highly encouraged: maps, videos, satellite images, data)

ii. The Panel asks that the department provide information on the required readings for the course and include those readings in the course calendar. Currently, the syllabus only lists recommended textbooks (pg. 1) and does not outline if there are any required textbooks, or any required reading of any kind. The Panel notes that the lack of information about what kinds of readings and other materials students will engage with on a day-to-day basis makes it difficult to evaluate the level of the course, and to ascertain whether it meets the requirements for an advanced study of the theme.

In the original submission we had indicated the textbook was optional although many of the lectures did follow the book identified at that time. And several copies of the book are made available On Reserve in Orton Library. After consideration of the Panel's comments, we've decided in the revised syllabus to select a newer book authored by Prof. John Walther at SMU and make it required to address the panel's concerns. Further we have now outlined the specific readings associated with each lecture. A one-page schedule of topics and readings with page numbers was also added at the end of the syllabus.

The Panel's comment was instrumental in shifting our thinking about how to get students to become more engaged in the details of the topics covered in the course. That said it is important to point out to the Panel that historically 90+% of the students have had no previous courses in the Earth Sciences such that several of the lectures early in the course also contain some foundational information to get everyone up to a level that builds for later more in-depth lectures that are key for a Theme-level course.

iii. The reviewing faculty request that the department provide more information about the quizzes, exercises/assignments, the TED talk, and the mini-capstone/group project, and how these will assess the students' engagement with the topic at an advanced level.

A paragraph was added to provide more information about the quizzes – including the thematic areas that are covered and how they test each student's knowledge of more advanced topics including the application of the four key concepts in the course (linked Earth systems, sustainability, population growth and justice, equity, diversity and inclusion) in the context of energy and mineral resources. It is now clear in the quiz description that there is a similar 'cadence' in what is covered in each quiz that probes the students' knowledge about the geologic setting, distribution, supply and demand, cost, and life expectancy (i.e., sustainability and resilience) of each resource we are targeting in the lectures.

Additional details are provided in the two assignments (one assignment was changed). Each is designed to challenge the students to think quantitatively by applying some straightforward math to each problem – one dealing with electricity use and sustainability and the second assesses the impact on the carbon footprint of CO2 as a consequence of clear-cutting forests due to surface mining in the U.S. More detail is provided in the syllabus for each. These assignments are designed for students to delve deeper into a topic at a more advanced level than a foundational course.

The background on the Ted talk activity has been expanded with additional guidance on the slant, expectation, and a brief overview on how to approach the talk. At the end of the syllabus, we provide the grading rubric and a very in-dept narrative on how to approach a Ted talk. It is expected that this opportunity will provide students with an additional opportunity to investigate a course topic that is relevant to them at a more advanced level, i.e., beyond just learning isolated facts and information.

Regarding the Team Presentations, we challenge the students to conduct in-depth research into an Energy or Mineral Resource-relevant topic using an interdisciplinary and integrative approach that considers exploration and exploitation sustainability in the context of population growth, linked earth systems, and justice, equity, diversity, and inclusion (JEDI). These are advanced topics in our field which integrate information from multiple disciplines. A detailed grading rubric is provided at the end of the syllabus which assesses the presentation's thoroughness of material and knowledge of the topic (half of the grade).

iv. The reviewing faculty ask that the syllabus explicitly state which General Education categories (both New General Education (GEN) and Legacy General Education (GEL)) this course fulfills, include a listing of all the Goals and ELOs for both categories, and clearly label the goals and ELOs for both. The reviewing faculty also request that the statements explaining how the course fulfills the goals and ELOs be separated (i.e., one statement for GEL Natural Science: Physical Science and one statement for GEN Theme: Sustainability) and immediately follow the listing of the goals and ELO's for that General Education category. For reference, the goals and ELOs for the GEN categories can be found here:

https://asccas.osu.edu/new-general-education-gen-goals-and-elos, and goals and ELOs for the GEL categories can be found here: https://asccas.osu.edu/legacy-general-education-gel-goals-and-elos.

The GE categories that this course fulfills are now designated clearly on page 1 of the revised syllabus and detailed starting on page 2. The details for the Legacy General Education are added with a statement on how the course fulfills the goal and ELOs (separate from the New General Education, GEN which was already included).

v. The reviewing faculty recommend that the department use the most up-to-date version of the Student Life Disabilities Services statement (syllabus pg. 6 under "Students With Disabilities"). An up-to-date statement can be found here: https://asccas.osu.edu/curriculum/syllabus-elements.

Updated and font size increased to recommended 16 point font (highlighted in red in the revised syllabus).

vi. The reviewing faculty recommend that the department use the most up-to-date version of the Mental Health statement (syllabus pg. 6 under "Wellness and Mental Health"), as the phone number and name of the suicide prevention…

Updated (highlighted in red in the revised syllabus).

I will return Earth Sciences 2210 to the department queue via curriculum.osu.edu in order to address the Panel's requests.

Should you have any questions about the feedback of the Panel, please feel free to contact Bill Putikka and/or Maria Conroy (faculty Chair of the Themes II Panel and the Sustainability TAG respectively; cc'd on this e-mail), or me.

Best,
Rachel

Earth Sciences 2210
Energy, Mineral Resources and Society

Autumn 2023 - The Ohio State University - 3 credits

Time and Place
Three 55-minute classes per week (Monday, Wednesday, and Friday)
Location: Mendenhall Lab Room 129

Instructor: Prof. David R. Cole, Ph.D.
Email: cole.618@osu.edu
Phone: (614) 688-7407
Office: 305 Mendenhall Laboratory
Office Hours: By appointment

Catalog Course Description: Geologic origin, world distribution, and uses of mineral resources critical to society; topics include mineral and fossil fuels, metallic ores, and industrial minerals.

This course fulfills a 3-credit course in the **Sustainability Theme** of the New General Education (GEN) curriculum, and for students on the Legacy GE (GEL) this course is a GE **Natural Science: Physical Science** 3-credit course (i.e., without a lab). *Goals and expected learning outcomes with rationale are included in this syllabus starting on page 2.*

Course Description
In this course, students will learn about the occurrence and world distribution of critical energy and mineral resources and their uses in society. As the world's population grows and expands, humans are placing a greater demand on Earth's mineral and water resources, their sustainability, and increasingly the adverse impact of resource development on the environment and societies. Topics include fossil fuels (coal, oil, and natural gas) and other energy resources (e.g., wind, solar, nuclear, geothermal), metallic ores, and industrial minerals. The course discusses resource availability, production, and consumption (with economic viability, sustainability, and resilience in mind), current and possible mineral and fossil fuel shortages, and their possible impact on underrepresented peoples and the relationships between the U. S. and her global partners.

Course Rationale
As the world's population grows and expands, humans are placing a greater demand on the sustainability of earth resources and global economies, in addition to an increase in environmental impacts. The balance of supply and demand is also influenced by rapid change in the world's climate. College-educated consumers, voters, and decision-makers need to understand the scope and impact of these changes and the role that science and technology play in advancing society. Studying our global energy and mineral resource portfolio provides a valuable perspective for this understanding. Issues of Justice, Diversity, Equity, and Inclusion (JEDI) will also be covered in the course.

Textbook (required)
Earth's Natural Resources, 1st edition, 2014, 428 pgs.
John V. Walther, Jones and Bartlett Learning, LLC
ISBN 978-1-4496-3234-2
(A few copies are available on Reserve at the Orton Hall Geology Library)

Format of Instruction
This course will be taught in a lecture/discussion format illustrated with PowerPoint presentations, videos, maps, diagrams, digital photographs, and content on Web sites. Student learning will be assessed with in-class scheduled quizzes, in-class group presentations, and assigned exercises. Lectures and videos will be posted in Carmen.

Technology Requirements
Students should have a tablet, laptop, or desktop computer capable of accessing Carmen, and be able to read lecture-centric power points or pdf files, play associated videos, and be able to search the web for information as directed by the instructor.

For students in the new general education (GEN) curriculum, this course is designed to satisfy the Goals and Educational Learning Objectives (ELOs) of the Sustainability Theme.

GE Theme Goals and Expected Learning Outcomes:

As part of the **Sustainability** Theme of the New General Education (GEN) curriculum, this course is designed to prepare students to be able to do the following:

General Theme GOAL 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations.

ELO 1.1 Engage in critical and logical thinking (about the topic or idea of the theme).

ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or idea of the theme.

General Theme GOAL 2: Successful students will integrate approaches to the theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

ELO 2.1 Identify, describe, and synthesize approaches or experiences (as they apply to the theme).

ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.

Sustainability GOAL 3: Students analyze and explain how social and natural systems function, interact, and evolve over time; how human wellbeing depends on these interactions; how actions have impacts on subsequent generations and societies globally; and how human values, behaviors, and institutions impact multi-faceted, potential solutions across time.

ELO 3.1 Describe elements of the fundamental dependence of humans on Earth and environmental systems and on the resilience of these systems.

ELO 3.2 Describe, analyze, and critique the roles and impacts of human activity and technology on both human society and the natural world, in the past, currently, and in the future.

ELO 3.3 Devise informed and meaningful responses to problems and arguments in the area of sustainability based on the interpretation of appropriate evidence and an explicit statement of values.

We will achieve these goals and associated ELOs by viewing the varied Earth resources as complex interconnected systems that, when fully developed, exhibit both positive benefits and negative impacts to humankind. The students are exposed to not only the geological context regarding the formation and distribution of these but also the economics of development and exploitation that can improve a region or country's economic status but also can adversely impact its environment and people. Given that many resources are nonrenewable (i.e., finite), especially key metals and nonmetals, we discuss resource life expectancy and how this impacts the sustainable growth of a region or country. While many developed countries have robust and resilient infrastructure, developing countries rich in one or more natural resources are prone to ignore or minimize the environmental impacts of resource development and their effect on indigenous peoples.

Through the lectures, assignments, and presentations (individual and team), students are challenged to assess how Earth's natural resources can be exploited in both positive and negative ways from the consequences of the intersection of resource exploitation and humankind and their vulnerabilities. The in-class team presentation is of particular importance as it asks the students to identify a key energy or mineral resource and describe this topic in terms of the key concepts – sustainability, population growth, linked earth systems and justice, equity, diversity and inclusion (JEDI), assess the magnitude, frequency, and scope of its impact on economics, the environment, and people, and provide a synthesis of the future outlook.

For students in the legacy general education (GEL) curriculum, this course is designed to satisfy the Goal and Educational Learning Objectives (ELOs) of a Natural Science: Physical Science course.

Legacy General Education (GEL)

Natural Science

GOAL: Students understand the principles, theories, and methods of modern science, the relationship between science and technology, the implications of scientific discoveries and the potential of science and technology to address problems of the contemporary world.

Expected Learning Outcomes

- **PHYSICAL SCIENCE**

    1. Students understand the basic facts, principles, theories and methods of modern science.
    2. Students understand key events in the development of science and recognize that science is an evolving body of knowledge.

3. Students describe the inter-dependence of scientific and technological developments.
4. Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.

We will achieve this GEL goal and associated ELOs by examining the basic facts, principles and theories of the formation and distribution of the varied Earth resources. This includes a study of the scientific methodology – including our evolving understanding of this body of scientific knowledge. Students will learn and discuss the occurrence and distribution of critical energy and mineral resources, their availability, production, and consumption which relates the inter-dependence of scientific and technological developments. Students are exposed to not only the geological context regarding the formation and distribution of these but also the economics of development and exploitation that can improve a region or country's economic status as well as adversely impact its environment and people.

Course Specific Learning Outcomes

Upon successful completion of the course, students will:

- Understand and apply four overarching concepts throughout the course where relevant - linked earth systems, population growth impact on supply and demand, sustainability, and DEI.
- Obtain an appreciation for the occurrence and world distribution of critical energy and mineral resources, their uses in society, and environmental and societal impacts of their exploitation.
- Describe common energy and earth materials, their mode of origin (genesis), and the technology used to develop them.
- Articulate resource availability, production, and consumption (with sustainability and resilience as a focus), current and impending mineral and fossil fuel shortages, and their possible impact on relationships between the U.S. and our global partners. All these aspects are integral to the life cycle assessment approach (LCA) introduced to in this course.
- Describe the impact of resource development, implementation, and environmental impacts on underrepresented and marginalized peoples.

Course Grade
Your final course grade will be calculated based on total points as follows:

Quizzes (6)	120 (20 points each)
Assignment 1	15
Assignment 2	10
Ted Talks	10
In-class team presentations	20
TOTAL	**175**

Quizzes

The quizzes are designed to test each student's general as well as detailed knowledge in six thematic areas: (1) Key Concepts, Resource Classification, Mining, Nonrenewable Energy, (2) Nonrenewable Energy Continued Including Nuclear, (3) Renewable Resources – Solar, Wind, Hydroelectric, and Water, (4) Mineral Resources for a Sustainable Future – Metals, (5) Non-Metals, Industrial minerals, Building Materials, and (6) Chemical Minerals, Future Trends in Resources, and Energy and Resource Justice (JEDI). Each quiz will probe your understanding of the application of the four Key Concepts (linked earth systems, sustainability, population growth and JEDI) in the context of energy and/or mineral resources. This is in addition to testing your knowledge of the fundamental aspects of a given resource: its geologic setting, distribution, supply and demand, cost, life expectancy (i.e., sustainability and resilience), extraction and development impact on the environment, and impact on people (JEDI). A Study Guide is provided in Carmen for each quiz.

All quizzes will be performed in-class. Each quiz will consist of a mix of multiple choice, true/false and fill-in-the-blank with short answers. Each scheduled quiz will be taken twice on the same day. The first time taken will be with no notes, and students will not be permitted to receive assistance or take the quiz as part of a group. Students will then re-take the quiz, and this time notes and discussion among fellow students will be permitted. The overall grade for each quiz will consist of 70% from the first take, and 30% from the second take. There will be no cumulative final exam. Dr. Cole will provide more details about each quiz in class.

Due the nature of quizzes, make-up quizzes will only be available in extenuating circumstances (that is, illness, unanticipated life event, NCAA athletic event, etc.). In this case a late request must be made to the instructor within one week of the exam. *If you are sick, you MUST have a note signed by your medical doctor (i.e., a licensed physician) and* **dated the same day as the quiz**.

Assignments (two)

Assignment 1 – Sustainable energy usage (15 points) (assigned during Lecture 11, due in two weeks)

The students quantitatively evaluate what kind of light bulb makes the most energy and financial sense, or if the choice does not really matter. Three types are identified – traditional incandescent, compact fluorescent and LED. Some factors that they need to be considered: How much does each bulb cost? How often do you need to replace a bulb, how much electricity does each kind use? How much of a cost savings is significant enough? The instructor provides an information sheet that describes the properties of each bulb – e.g., how long each one lasts, wattage, cost, etc. The assignment is for each student to have 5 lamps throughout their dorm/apartment. Each lamp uses 1 bulb. You must consider using all 5 lamps/per bulb type for an average of 6 hours per day, every day over a 4-year degree period. A work sheet (with one example) and a set of questions will be provided to each student via Carmen. The exercise should take between 2 and 3 hours to complete.

Assignment 2 – How much area of the U.S. is mined and what is the ecosystem impact? (10 points) (assigned during Lecture 18, due in two weeks)

This math exercise challenges the students to assess how much land area of the U.S. is currently surfaced mined (i.e., open pit) and how this may impact the potential for terrestrial sequestration of CO_2. A short power point presentation during class will provide the background on this exercise and the template they can use. Students are given the starting point that 0.25% of the land surface is being mined. They are then asked to estimate (a) what is this total in square miles and acres for the U.S. (b) what states are closest to this area within a factor of ±10%, (c) how many Ohio Stadiums does this equal knowing it occupies 14.5 acres, (d) estimate how much CO_2 is not sequestered per year assuming the surface mining land could have been completely forested (approx. 50 trees per acre, average mature tree takes up ~50 lbs of CO_2/year), and (e) using this on-line article briefly describe four sustainability challenges for the mining industry.
https://www.ey.com/en_us/mining-metals/critical-minerals-supply-and-demand-issues
Area of the states can be found at:
https://simple.wikipedia.org/wiki/List_of_U.S._states_and_territories_by_area
This activity should take between 2 and 3 hours to complete.

In-class presentations:

Short "TED" talks: Held after Lectures 1-5 and Quiz 1 (5 minutes plus 2-3 minutes for questions) will be presented by each student on a topic of their choosing that falls within the limits of the course syllabus – energy or mineral resources – and its relationship to a sustainable and resilient society. This activity challenges the students to review the syllabus, select a topic which we probably have not yet touched upon in lecture, and use the textbook and/or web to gain a preliminary understanding of the topic. We will discuss this more during Lectures 1-3, but there is an aspirational goal that the students introduce a course-relevant topic that has impacted them or those they know – drawing the societal link. The following general guidance is provided:

(a) Choose a topic of interests to the student, or they may be passionate about.
(b) Explore different ways to articulate their path of discovery around the topic.
(c) Stay focused on the most important point.
(d) Consider what may resonate with the audience.

A grading rubric will be provided to the students (see **Appendix 1**). In addition, a summary is provided in the Appendix on tips on how to organize and deliver a good Ted talk.

In-class team presentations: Held before Thanksgiving break, approx. after Lecture 25. The purpose of the In-Class Group Presentation is to challenge the students to conduct in-depth research into an Energy or Mineral Resource-relevant topic using an interdisciplinary and integrative approach that considers exploration and exploitation sustainability in the context of population growth, linked earth systems, and justice, equity, diversity, and inclusion (JEDI). Besides the experience gained from working in a team environment and sharing responsibility in the effort, the students are asked to assess how earth processes, natural or anthropogenic, impact the environment and humankind and its desire for a sustainable future. They must discuss their topic in terms of frequency, magnitude, and scope of the impact on sustainable systems and, through critical thinking, provide possible strategies for mitigation and/or adaptation to minimize or eliminate the negative environmental impact.

Operationally, depending on enrollment, the class will be split into teams of approximately 3 students. Each team will be expected to present a 12-minute talk plus 3 minutes for Q&A on a particular topic that falls under 'Energy, Mineral Resources and Society' with the focus on sustainability, economic and environmental impacts. This may include topics such as – a given energy vector like coal, oil, natural gas, geothermal, etc., a specific metal commodity like gold, copper or zinc, the economics of a specific resource, environmental impacts of resource extraction and use, and whether they are sustainable. The instructor will provide more details in class, including the group breakdowns and ideas for presentation topics. A grading rubric will be provided to the students (see **Appendix 2**).

Academic Misconduct

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the University's Code of Student Conduct, and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the University's Code of Student Conduct and this syllabus may constitute "Academic Misconduct."

The Ohio State University's Code of Student Conduct (Section 3335-23-04) defines academic misconduct as: "Any activity that tends to compromise the academic integrity of the University or subvert the educational process." Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the University's Code of Student Conduct is never considered an "excuse" for academic misconduct, so I recommend that you review the Code of Student Conduct and, specifically, the sections dealing with academic misconduct.

If I suspect that a student has committed academic misconduct in this course, I am obligated by University Rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the University's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the University. For additional information, see the Code of Student Conduct (http://studentconduct.osu.edu (Links to an external site.)).

Disability Services

The University strives to make all learning experiences as accessible as possible. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the

university's request process, managed by Student Life Disability Services. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Wellness & Mental Health

As a student you may experience a range of issues that can cause barriers to learn, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614-292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on-call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available 24/7 by dialing 988 to reach the Suicide and Crisis Lifeline.

Diversity Statement

As your instructor in this course, I strongly support OSU's general commitment to diversity:

The Ohio State University affirms the importance and value of diversity in the student body. Our programs and curricula reflect our multicultural society and global economy and seek to provide opportunities for students to learn more about persons who are different from them. We are committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among each member of our community; and encourages each individual to strive to reach his or her own potential. Discrimination against any individual based upon protected status, which is defined as age, color, disability, gender identity or expression, national origin, race, religion, sex, sexual orientation, or veteran status, is prohibited.

If you experience any lack of respect in this context either by myself or any of your fellow students, please do not hesitate to reach out to me (by Carmen email) or a neutral party (e.g., the Office of Diversity and Inclusion: odi@osu.edu). Also, if you have a name and/or set of pronouns that differ from those apparent to me on Carmen, please let me know!

Sexual Misconduct/Relationship Violence

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu.

Other: Communication

For periodic announcements to the entire class, I will send a mass email to all students via Carmen. I will use your **OSU email account** for this purpose. I realize that many of students have other email accounts through services such as Goggle, Yahoo, or Hotmail. You must remember to check your OSU email account, or you may miss important announcements such as a change in Lecture topic or my absence due to sickness or unscheduled travel (e.g., family emergency).

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Course Schedule & Lecture Outline

(Refer to spreadsheet schedule with reading assignments**)**

PART 1: Key Concepts, Resource Classification, Mining, Nonrenewable Energy

Lecture 1: Introduction, syllabus, resource classification, key concepts
Overview of the types of resources (e.g., non-renewable, renewable). Humanity's top ten problems for the next 50 years – energy is identified as first, then water, food, and environment/climate round out the top five. Four key concepts – linked earth systems, sustainability, human population, and justice, equity, diversity, and inclusion. Introduce sustainability and resiliency concepts in the context of varied earth resources development. Review the syllabus and the breakdown of lectures into five themes. (Chap. 1)

Lecture 2: US and world population, resource production and consumption patterns
Historical overview of science and technology relevant to resource exploration, exploitation, and societal and environmental impacts. Examples of supply and demand driven by population growth, resource life cycle. (Chap. 1)

Lecture 3: Resource exploitation and impacts
Overview of mining technology and challenges. Generation of waste and environmental and health impacts. Importance of government policy and regulations on domestic and global production and consumption. (Lecture only)

Lecture 4: Non-renewables, intro to fossil fuels, Petroleum, Part 1
Overview of the types and quantities of fossil fuels that we use to drive society. In this lecture we introduce some of the history behind the discovery of oil in the U.S. and its impact of U.S. economy. Global occurrences, production and uses by society of oil are highlighted. The

geological 'ingredients' necessary to form an oil deposit are reviewed. Exploration strategies are discussed. Students are directed to watch the PBS series via Youtube on 'The Prize. The Quest for Oil, Money, and Power'. Based on Daniel Yergin's Pulitzer Prize winning book of the same name. (Chap. 2)

Lecture 5: Petroleum, Part 2
Details are presented on the formation of oil in marine and lake environments. The concept of geologic traps to host oil are outlined (e.g., faults, anticlines). Domestic and global reserves, production and consumption through time are presented along with the concept of "peak oil"- can oil be sustainable. Environmental issues are highlighted like nature oil leakage at the surface, oil spills from shipping accidents and operational disasters like the Deepwater Horizon in the Gulf of Mexico. (Chap. 2)

Quiz 1 – Lectures 1-5

Ted Talks (typically takes up two class periods depending on number of students enrolled)

PART 2: Nonrenewable Energy Continued Including Nuclear

Lecture 6: Coal Part 1
This lecture outlines coal formation processes, modern day analogue environments, classification, and the global and U.S. distributions. We will also touch on some aspects of environmental impacts. Coal resources and use in Ohio are detailed along with Ohio's CO_2 emission footprint. We discuss the sustainability and fate of the coal industry in Ohio given the energy transition to natural gas and renewable energy. (Chap. 3)

Lecture 7: Coal Part 2
This lecture outlines coal mining technologies, coal mine disasters, environmental and health effects, contribution to global CO_2 emissions and climate change. We address the question is use of coal wise and sustainable for future generations. (Chap. 3)

Lecture 8: Natural gas-hydraulic fracturing
Overview of how hydrocarbon-bearing shale deposits formed? Where they are located in the US. Summary of the hydraulic fracturing technology. Why it needs to be used for oil and gas recovery from shales. Highlights the benefits and concerns associated with hydraulic fracturing – shift in the US economy – less reliant on foreign oil and gas making us more resilient and sustainable - 'the energy transition', economic boom and bust cycles for regions and communities, issues of water use and environmental contamination – a regional and local problem. (Chap. 3)

Lecture 9: Nuclear energy, Part 1
This lecture explores what is nuclear energy with a review of atoms and radioactivity. What mineral resources are used to produce nuclear energy – uranium, where are the reserves and who produces it. What is its contribution to the Ohio energy portfolio, the U.S., and the world. How does a nuclear reactor work – water use is a key aspect. (Chap. 5)

Lecture 10: Nuclear energy, Part 2
Part 2 of nuclear energy covers the environmental issues associate with mine wastes and uranium in groundwater, disposal of radioactive waste, water consumption required to produce energy, accidents and concern about natural disasters that could disrupt energy production and environmental consequences. (Chap. 5)

Quiz 2 – Lectures 6 - 10

PART 3: Renewable Resources – Solar, Wind, Hydroelectric, and Water

Lecture11: Renewable energy overview with focus on solar, wind
This lecture addresses the current energy transition to the use of renewable technologies. Discussion topics focus on: Role of solar and wind in the energy mix of the U.S. and globally. Accessibility of both in the U.S. and globally. Description of the different types of solar energy – passive, thermal photovoltaic. How a solar PV cell works. How does a wind turbine work - both require natural resources – metals and nonmetals? Domestic trends in cost and number of installations through time. Projections for solar and wind use in the future and their role in energy sustainability and DEI in the U.S. (Chap. 4)

Assignment 1 – Light bulb efficiency (due two weeks from the day assigned)

Lecture 12: Hydroelectric
Introduces the importance of hydro in the U.S. and global energy electricity mix relative to solar and wind. A summary of the types of dams are presented with examples from the U.S. and China. We discuss how climate change and how the shift in drought conditions in the U.S. can threaten hydro power production, hence an impactor on sustainability. Environmental impact of dams on land use and ecosystems is also touched on. (Chap. 4)

Lecture 13: Geothermal and ocean tides
While not a renewable, geothermal is known to have a minimal environmental impact – i.e., very clean. It is not a major contributor to the electricity mix but is growing in popularity. This lecture outlines the types of geothermal systems, their occurrence whose relationship is linked to plate tectonics and high heat flow regimes, and how energy is extracted from water and steam. Tidal energy which is a renewable to discussed – how it works, where and which counties are starting to take advantage of its potential. (Chap. 4)

Lecture 14: Biofuels, U.S. energy geographic distribution
The biofuels portion of this lecture covers what it is, the different types of plant and organic matter used to make fuel, the life cycle of biofuel production from source to processing to the varied products. The notion it is a carbon-neutral or a negative carbon energy vector is dispelled as combustion of biofuels does produce CO_2. The second part of this lecture brings full circle the discussion of renewable energy in the U.S., where we can find it, and are we on an ascending trajectory in the implementation that drives the U.S. to be more sustainable. (Chap. 4)

Lecture 15: Water resources
Outlines several interconnected topics including: Water properties (it is a unique molecule); U.S. resources and use (Who has (clean) water and who does not – a JEDI issue in part); Groundwater concepts (e.g., vadose zone, water table, draw down); Example of a regional aquifer under stress due to over use and climate change - Ogallala Aquifer; a revisiting of the California Drought – farm produce productivity impacts; the global deployment of desalination for sustainable agriculture, industry, and the health and well-being of communities. Introduces what we mean by water pollution and the various types of pollutants (e.g., heavy metals, agriculture runoff – fertilizers, synthetic chemicals). We discuss the global problem of poor-quality water for disadvantaged people and the impact on their health and well-being. (Chap. 12)

Lecture 16: **Switch On** documentary from Prof. Scott Tinker (UT Austin)
We view portions of this video and then discuss key aspects that delve into how disadvantaged people access energy, what kind and their attempts to gain access to modern technology. We focus on barriers to achieving energy equity. https://switchon.org/films/switch-on/

Quiz 3 – Lectures 11-16

PART 4: Mineral Resources for a Sustainable Future - Metals

Lecture 17: Metals and mineralization processes
This lecture provides an introductory overview of - why we care about mineral resources. We summarize the different classifications of metallic and non-metallic earth materials and the varied processes that formed them. Their role in U.S. and global economy and what is our net import reliance, their role in everyday lives, the production and consumption in the U.S. and globally, recognizing that not all countries who mine resources also refine them and/or lead in their consumption. No one country has economic deposits of every metal and non-metal. Of particular concern is how we lack sustainability in most metal commodities, hence our increased reliance on foreign sources. (Chap. 6, mostly lecture based)

Lecture 18: Iron and manganese
The topics covered in this lecture act as a template for succeeding lectures on different metals or non-metals: what forms do the metals come in - i.e., mineralogy, what types of deposits host the minerals, how did they form, where are they located especially in the U.S., what is the current estimate of U.S. and global reserves (addresses life expectancy of the resource), what is the U.S. reliance on imports (sustainability and resilience issues), current trends in cost, what technology is used to refine or process ore, who leads in production and consumption of products, what are the advantages of exploiting the resource (country GDP, workforce development) and disadvantages (land, water and ecosystem impacts, displaced population, pollution, adverse health effects especially for underrepresented peoples).

In addition to the topics outlined above, this lecture also draws the link between the emergence of an oxygen rich atmosphere and banded iron formations, and the fact that relatively young Mn nodules found on the ocean floor (a few million years old) occur as far back as 540 million years ago. (Chap. 6)

Assignment 2 – Mining area-CO_2 cycle impact (due two weeks from the day assigned)

Lecture 19: Aluminum, silicon, and titanium
(Lecture topic template outlined above is used)
This lecture emphasizes the importance of silicon and aluminum as the first and second most abundant metals on Earth, and their importance in everyday life. Aluminum is the 'poster child' element in terms of the success of recycling (circular economy) and its impact on sustainability. The extraordinary number of uses of titanium are highlighted. (Chap. 6)

Lecture 20: Ferro-alloy metals – nickel, chrome, tungsten, molybdenum
(Lecture topic template outlined above is used)
Nickel, chrome, tungsten, and molybdenum are introduced as examples of the scare ferro-alloy metals (<1% by weight in Earth's crust) that commonly occur together in high temperature magmatic deposits. We discuss how at low temperature they occur as the weather products of high energy deposits either in soil or metal rich oxidized zones, thus illustrating the concept of linked earth systems – geosphere, hydrosphere, and atmosphere (with climate change integral to this). (Chap. 7)

Lecture 21: Scarce Base Metals: copper, zinc and lead, and Precious Metals: gold and silver
(Lecture topic template outlined above is used)
This lecture continues the coverage of other scarce metals – zinc and lead - which commonly occur together is certain types of metallic ore deposits and are observed in sea floor hydrothermal vents. Sea floor hydrothermal vents known as 'black smokers' are highlighted as a modern-day source of copper, zinc, and lead. The U.S. continues to mine both from sedimentary-hosted deposits located dominantly in Missouri and Tennessee. Australia and China lead the world in zinc and lead ore reserves.
We cover the history of gold and silver mining in the US, where the U.S currently mines these metals mostly in Nevada, the decline in South African gold and the emergence of China as a major player on the global market. (Chap. 8, 9)

Quiz 4 – Lectures 17 – 21

PART 5: Non-Metals, Industrial minerals, Building Materials

Lecture 22: Rare earth elements
(Lecture topic template outlined above is used)
This lecture highlights how vital rare earth elements are to renewable energy and communications hardware like the cell phones. This lecture also devotes some time to the emergence of China as the most important global player in rare earth mining and production – i.e., controls the global market and hence cost. It also has the worst record for environmental impact due to egregious dumping of toxic process waste fluids onto the land surface in Inner Mongolia. (Chap. 9)

Lecture 23: Kimberlites and diamonds
(Lecture topic template outlined above is used)

This lecture deals with the origin of diamonds, their occurrences worldwide, and the types of deposits in which they are found. It also covers great discoveries through time, including very recent ones, the concern over the use of 'blood or conflict diamonds' to finance war and terror chiefly in Africa, and at the recent developments in diamond technology, including the formation of synthetic micro-diamonds at high temperatures but atmospheric pressures. (Chap. 10)

Lecture 24: Industrial rocks and minerals
(Lecture topic template outlined above is used)
This lecture covers lesser-known industrial rocks and minerals that are used every day in drilling for energy and non-energy resources; and as filters for such things as swimming pool water, cooking oil, and wine, and for processes that require molecular-level control – i.e., natural sorbents and membranes. (Chap. 10)

Lecture 25: Building materials and historic sites
(Lecture topic template outlined above is used)
Almost every known rock type has contributed in some way to the construction of homes, civic buildings, roads, bridges, and dams. As a group, this is by far the largest volume solid mineral commodity that we extract from Earth, second only to the fossil fuels in value. The lecture discusses crushed stone (road, building foundations, concrete), the most widely used building material and limestone (calcium carbonate) the most common rock type in building materials. (Chap. 10)

Quiz 5 – Lectures 22 - 25

In-class Team Presentations (before Thanksgiving break)

Special Lecture - Presentation Instructions and Planning

Groups 1 – 5 Presentations

Groups 6 – 10 Presentations

PART 6: Chemical Minerals, Future Trends in Resources, and Energy and Resource Justice (DEI)

Lecture 26: Evaporite minerals – lithium, boron. fluoride, iodine
(Lecture topic template outlined above is used)
This lecture focuses on a very diverse set of chemical minerals derived from evaporite deposits that run the gamut from use in batteries and related devices (lithium) to cleaning aids (borax) to elements vital to human health (fluorine, iodine). We discuss the issue US import reliance but fortunately compared to lithium, which is controlled by China and Bolivia, we are far less dependent on imports for B, F, and I. (Chap. 8, 11)

Lecture 27: Salt plus nitrates and phosphates
(Lecture topic template outlined above is used)

This lecture centers on three very important earth materials that most are very familiar with. Salt (NaCl) is clearly used in everyday life, and so to are nitrates and phosphates, indirectly via their application as fertilizers for plant and crop growth. We address the downside for the use of fertilizes that promote algal growth in streams, rivers and lakes that pose a risk to humans as certain types of algae are toxic. N and P carried by river systems into oceans can cause algal blooms that lead to oxygen dead zones adversely impacting various ecosystems such as fish breading grounds. (Chap. 11)

Lecture 28: Asbestos; other industrial minerals
(Lecture topic template outlined above is used)
This lecture describes a group of fibrous silicate minerals that are widely used for industrial purposes because they are incombustible, nonconducting and chemical resistant. We explore the advantages and disadvantages of using asbestos-class materials with special focus on the health effects such as Mesothelioma. We also discuss alternative synthetic materials that have taken the place of asbestos. (Chap. 10)

Lecture 29: Mineral resources and energy sustainability for the future
This lecture uses a broad array of statistics and their time dependent trends to chart what the future might hold for both energy and mineral resources. For energy we consider two approaches in how data are modeled to give us this futuristic perspective – (a) Stated Policies Scenario that reflects the impact of existing policy frameworks and today's announced policy intentions and (b) Sustainable Development Scenario (SDS) outlines a major transformation of the global energy system, showing how the world can change course to deliver on the three main energy-related UN Sustainable Development Goals simultaneously: (a) to achieve universal access to energy, (b) to reduce the severe health impacts of air pollution and (c) tackle climate change. For mineral resources we evaluate the role of population growth on supply and demand, the life expectancy of mineral deposits, changing landscape of costs as new technologies come online and automation becomes more pervasive, expansion of the types of metals that can be recycled, and new synthetic substitutes. Finally, we make some predictions on how government control and regulation may evolve in the future. (Lecture only)

Lecture 30: Diversity, equity and inclusion across the energy and mineral resource sectors
The effects of climate change on sustainable energy and resource infrastructure and people are covered in this final lecture. We focus on Energy Justice which refers to the goal of achieving equity in both the social and economic participation in the energy system. It recognizes disadvantaged communities and regions historically marginalized and overburdened by pollution, underinvestment in clean energy infrastructure, and lack of access to energy-efficient housing and transportation. We integrate this with Environmental Justice to highlight the requirements of remediation of the disproportionately high and adverse human health or environmental effects on communities of color and low-income communities. Of particular interest in this context is the issue of access to safe water and other natural resources needed to sustain any population group. (Lecture only)

Quiz 6 – Lectures 26-30 (last week of classes or finals week depending on the calendar dates)

There is no cumulative final.

EA 2210 Summary of Lectures and Reading		
Lecture No.	**Lecture Topic**	**Reading**
	Part 1: Key Concepts, Resource Classification, Mining, Nonrenewables	
1	Introduction, syllabus, resource classification, key concepts	Chap. 1, pg. 1-26
2	US and world population, resource production and consumption patterns	Chap. 1, pg. 1-27
3	Resource exploitation and impacts	Lecture only
4	Non-renewables, intro to fossil fuels, Petroleum, Part 1	Chap. 2, pg. 44-54
5	Petroleum, Part 2	Chap. 2, pg 31-44
	Quiz 1 Lecture 1-5	
	Ted Talks (approx. two class periods depending on enrollment)	Refer to grading rubric
	Part 2: Nonrenewable Energy Continued Including Nuclear	
6	Coal Part 1	Chap. 3, pg. 61-74
7	Coal Part 2	Chap. 3, pg. 65-77
8	Natural gas-hydraulic fracturing	Chap. 3, pg. 55-61
9	Nuclear energy, Part 1	Chap. 5, pg. 101-112
10	Nuclear energy, Part 2	Chap. 5, pg. 112-124
	Quiz 2 – Lectures 6 - 10	
	Part 3: Renewable Resources – Solar, Wind, Hydroelectric, and Water	
11	Renewable energy overview plus solar, wind; **Exercise 1 – Light bulb efficiency**	Chap. 4, pg. 84-86
12	Hydroelectric	Chap. 4, pg. 75-85
13	Geothermal and ocean tides	Chap. 4, pg. 84-85, 93-97
14	Biofuels, U.S. energy geographic distribution	Chap. 4, pg. 91-93
15	Water resources	Chap. 12, pg. 291-322
16	**Switch On** documentary from Prof. Scott Tinker (UT Austin)	https://switchon.org/films/switch-on/
	Quiz 3 – Lectures 11-16	
	Part 4: Mineral Resources for a Sustainable Future - Metals	
17	Metals and mineralization processes	Chap. 6, pg. 125-126, mostly lecture
18	Iron and manganese; **Exercise 2 – Mining area-CO2 cycle impact**	Chap. 6, pg. 127-138, 147-148
19	Aluminum, silicon, and titanium	Chap. 6, pg. 138-142, 145-146
20	Scarce Ferro-alloy metals – nickel, chrome, tungsten, molybdenum	Chap. 7, pg. 153-158, 164-168,
21	Scarce Base Metal: copper, s zinc and lead, and Precious Metals gold and silver	Chap. 8, pg. 177-192; Chap. 9, pg. 204-215
	Quiz 4 – Lectures 17 – 21	
	Part 5: Non-Metals, Industrial minerals, Building Materials	
22	Rare earth elements	Chap. 9, pg. 226-228
23	Kimberlites and diamonds	Chap. 10, pg. 252-254
24	Industrial rocks and minerals	Chap. 10, pg. 240-241, 243-245, 254-257
25	Building materials and historic sites	Chap.10, pg. 235-239, 241-243, 245-247
	Quiz 5 – Lectures 22 - 25	
	Presentations	Refer to grading rubric
Special	Presentation Instructions and Planning	
	First Group	
	Second Group	
	Part 6: Chemical Minerals, Future Trends in Resources, and JEDI	
26	Evaporite minerals – lithium, boron. fluoride, iodine	Chap. 8, pg. 270-271; Chap. 11, pg. 263-267, 270-271
27	Salt plus nitrates and phosphates	Chap. 11, pg. 267-283
28	Asbestos; other industrial minerals	Chap. 10, pg. 247-248
29	Mineral resources and energy sustainability for the future	Lecture only
30	Diversity, equity and inclusion across the energy and mineral resource sectors	Lecture only
	Quiz 6 – Lectures 26-30 (last week of class or finals week)	
	There is no cumulative final	

Appendix 1: TED Talk Grading Rubric

Total points = 10

Will be presented by each student on a topic of their choosing that falls within the limits of the course syllabus (energy or mineral resources), and its relationship to a sustainable and resilient society. This activity challenges the students to review the syllabus, select a topic which we probably have not yet touched upon in lecture, and use the test book and/or web to gain a preliminary understanding of the topic. We will discuss this more during Lectures 1-3, but there is an aspirational goal that the students introduce a course-relevant topic that has impacted them or those they know – drawing the societal link. The following general guidance is provided:

(e) Choose a topic of interests to the student, or they may be passionate about.
(f) Explore different ways to articulate their path of discovery around the topic.
(g) Stay focused on the most important point.
(h) Consider what may resonate with the audience.

Content: In-depth, insightful information that connects directly with the course
Identify one key take-away point (**3 points**)
Organization: Logical order of presentation
Dynamic introduction, interesting details, and strong closing (**3 points**)
Time Limits: Presentation was within the time limits specified. (**1 point**)
Voice & Eye Contact: Presents in a loud, clear voice and maintains constant eye contact. Does not read directly from slides if they are used. Did not rush. (**1 point**)
Inspiration/Subject Matter: The presentation was inspirational and/or thought-provoking. Connect with the audience – engage in a Q&A (**2 points**)

Helpful Discussion on How to Deliver a TED Talk (you do not need to follow all of these)

Part I: Content Story and Structure

How to Select Your Topic

- Inspire your audience with a single idea that either changes the way people think about their world or persuades them to take action
- Create an audience centric narrative layered with stories and facts
- Connect with "belonging, self-interest, self-actualization, or hope in the future"

How to Craft Your Catchphrase

- Make it between 3 to 12 words
- Make it action-oriented and rhythmic
- Repeat your catchphrase at least three times during your presentation

How to Introduce Yourself

- Write a one-to-two-minute introduction for your emcee that connects to your core message

- Ensure that your introduction shares why you are the right person to share your idea with the audience
- Craft and introduction that positions you as a credible guide not as a super-human

How to Open Your Talk

"Just remember that the first ten or twenty seconds of your speech is the peak of your audience's engagement level." "Hook them fast with benefits by giving them an implicit or explicit reason to pay close attention."

The most consistently successful opening is the personal story. Tell your own story and share your observations. It is a good idea to make others the heroes in your stories.

Though shocking statements most frequently rely on statistics, they can also express strong opinions that challenge conventional wisdom.

- Start with a pre-opening if there is a mismatch between the tension in the audience and the tone of your speech
- Open either with a personal story, a shocking statement, or a powerful question (particularly "why?" and "how?" questions)
- Deliver a post-opening that provides an explicit promise of the benefits that your audience will get and how long it will take to get them

How to Build your Speech and Body Transitions

Tell the audience what you are going to tell them, tell them, then tell them what you told them.

I strongly recommend that you build the body of your speech with three sections regardless of the length of your speech.

Regardless of the narrative structure chosen, the best TED speeches treat each section as a bundle of "right brain" and left brain" stimulation. Stories or activities pique the emotional right brain. Facts, strategies, tips, and techniques convince the left brain. You need either to persuade people to change their perception or to incite them to action.

During each section, you should frequently ask questions to get the audience to reflect on their own lives. This is a way to transform a speech into a conversation. Audience members are still able to reply in their minds and with their body language.

- Construct transitions that reinforce the key message of the preceding section and tease your audience with benefits to be gleaned the next section.
- Build the three-part body of your speech using the situation-complication-resolution narrative flow.
- Couple rational facts with emotional stories

How to Conclude Your Talk

"And so we come to the end of our journey today and to the beginning of your future …"
"Now it is time for you to make a decision … "
"And that, I think, is an idea worth spreading."
"But there is another way …"
"I leave you with this …"

"This is what I have found."

- Employ language that clearly signals you are concluding your talk
- Share the "why" that powers your single unifying idea
- Call the audience to action with an easy next step and a sense of urgency

How to Tell Stories

The easy answer is that it is always best to tell stories drawn from your personal experience or observation.

As a speaker, one of the worst things you can do is put yourself on a pedestal. Position yourself as an equal, perhaps a guide, but not superior to your listeners. Making someone else the hero in your personal stories or in the stories of others you choose to tell is a great way to do that. That allows you to become human by sharing your failures, your flaws, and your frustrations.

Invite the audience into your story to relive it with you by re-enacting characters and their reactions. each character should have a distinct personality. This includes: what is seen including posture, gestures; what is heard, the tone of their voice, what is implied such as their traits and desires. Instead of narrating what the characters do, give them dynamic, conversational dialogue. It is alright to embellish to a degree.

Note that your characters should also have fixed locations on the stage. When you embody a particular character, go stand in his or her spot on the state. When you need to narrate, a nice technique is to step forward toward the audience and then step back into character.

Stories with positive endings are highly effective for inspiration. In contrast, cautionary tales are more effective for teaching.

Above all, you will be far more successful with upbeat stories than with negative ones, even in an environment of disillusionment.

In your talk, every key point should be delivered with a powerful one-two punch of story and fact.

- Tell stories drawn from your personal experience or observation
- "Show, don't tell" using highly sensory description, authentic characters, and rich dialogue.
- Take your audience on an emotional journey as your characters encounter and overcome obstacles on an ultimately successful quest.

Part II: Delivery and Design

How to Master Your Verbal Delivery

Speak in your own voice with authenticity, interest, and humility. Use clear, everyday, jargon-free language packed into short, complete sentences. The average TED Talk employs language at a sixth-grade level.

Even the whiff of self-promotion will turn off your audience

Speak in bursts punctuated by pauses. The pause not only replaces filler words, but also gives you an aura of self-control. Beyond personal benefits, the pause gives your audience the time they need to

process what you are saying.

- Adopt the tone of a passionate one-on-one conversationalist
- Add vocal variety by modulating your volume and pace
- Make liberal use of the word "you" in the singular

How to Add Humor to Your Talk

The fundamental principle to remember is that humor is rooted in surprise. As human beings, we delight in a twist that challenges our expectations and our sensibilities.

In my moderately scientific analysis, the most viewed TED speakers deliver an average of one joke per minute in their keynote speeches. The best deliver around two jokes per minute. The secret is that the jokes are not evenly spread out. When they hit a funny theme, they "riff' on the these with clusters of three, progressively funnier quips.

- Leverage self-deprecation exaggerated reality, and challenges to authority to add humor
- Embed humor in dialogue
- Riff on themes with clusters of three, progressively funnier quips to deliver an average of one joke per minute

How to Manage Your Physical Delivery

- Starting with hands down comfortably at your sides, make natural gestures above the waist and below the neck.
- Synchronize your facial expressions with your message
- Hold eye contact with individuals for three to five seconds. In larger settings, engage sections for one to three minutes.

How to Create Visuals that Inspire

"less is more" in terms of image, text, font, color, orientation

1. Seth "Godin Method": fill an entire slide with a fully licensed photograph of sufficiently high resolution. A nice trick is to have the photograph bleed off the page, thus prompting the audience to use their imagination to complete the picture.

2. Masayoshi "Takahashi Method": This method simply requires you to build slides with a few words of very large text. It is a design enlightened update to the very inelegant 7x7 rule. The 7x7 rule calls for creating slides with no more than seven bullets and no more than seven words per bullet.

3. The "Lessig Method" is a hybrid of the "Godin Method" and the "Takahashi Method". It involves blending a full screen image with very simple text.

Regardless of which method you use, the most critical rule of graphic design that applies to slide building is "less is more." Be generous with whitespace. Minimalism also applies to concept density. Great slides only have one "so-what" message.

Most designers employ just a single font in design. Since many slides have titles or short key headline style messages, your best choice is a variant of Helvetica, including its cousin Ariel. For Helvetica, the

mood is neutral yet authoritative--hence a good choice for most presentations. Nearly every sign you see and company logo you come across is constructed with this font.

Consequently, if you look closely at most advertisements, you will see Helvetica for titles and Times New Roman for body text.

Rule of Thirds: Just divide a slide into a three-by-three grid of nine equal sized boxes, using this grid to align both text and images. The grid is your guide to where the focal points are on the slide. There are five of them. The first four are at the intersections of the grid lines and make excellent places to place an image. The fifth one is more subtle and is at the visual center of the slide just up and to the right of the true center.

- Give your talk with no slides at all
- Produce simple, image-rich, text-light slides if you must create them.
- Emphasize key points using sparing and intentional contrast in color, font, or placement

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Appendix 2: In-class Team Presentation Rubric

Total points = 20

Plan for about a 12-minute presentation leaving time for 3 minutes of discussion,
total not to exceed 15 minutes. Rule of thumb – average roughly 1 minute per slide.
Each Team member is required to take part in the presentation so be sure each member has their assigned task.

Outline: Topic area/title slide (identify team members)
Identify relevance to Energy and/or Mineral Resources
Key concepts being covered: Sustainability, Population, Linked Earth Systems, DEI
Earth resources and their formation - how, what, why, where, when
Impacts - Relevance to the U.S; global impact if any
Challenges in terms of supply and demand especially for non-renewables
Summary and Future Outlook [for the selected energy vector or metal(s)]
Supporting Informatics: References, relevant web sites

(Where appropriate, use of good visuals is highly encouraged: maps, videos, satellite images, data)

Presentations Assessment:
[Grade will be based on 20 points]:

Quality of slides (4 points)

Knowledge of topic (5 points)

Thoroughness of the materials (don't gloss over) (5 points)

Smoothness of the presentation (3 points) (e.g., team coordination; continuity)

Level of interaction generated with class (3 points)

GE Theme course submission worksheet: Sustainability

Overview

Courses in the GE Themes aim to provide students with opportunities to explore big picture ideas and problems within the specific practice and expertise of a discipline or department. Although many Theme courses serve within disciplinary majors or minors, by requesting inclusion in the General Education, programs are committing to the incorporation of the goals of the focal theme and the success and participation of students from outside of their program.

Each category of the GE has specific learning goals and Expected Learning Outcomes (ELOs) that connect to the big picture goals of the program. ELOs describe the knowledge or skills students should have by the end of the course. Courses in the GE Themes must meet the ELOs common for **all** GE Themes and those specific to the Theme, in addition to any ELOs the instructor has developed specific to that course. All courses in the GE must indicate that they are part of the GE and include the Goals and ELOs of their GE category on their syllabus.

The prompts in this form elicit information about how this course meets the expectations of the GE Themes. The form will be reviewed by a group of content experts (the Theme Advisory) and by a group of curriculum experts (the Theme Panel), with the latter having responsibility for the ELOs and Goals common to all themes (those things that make a course appropriate for the GE Themes) and the former having responsibility for the ELOs and Goals specific to the topic of **this** Theme.

Briefly describe how this course connects to or exemplifies the concept of this Theme (Sustainability)

In a sentence or two, explain how this class "fits' within the focal Theme. This will help reviewers understand the intended frame of reference for the course-specific activities described below.

(enter text here)

This course deals with the occurrence and world distribution of critical energy and mineral resources and their uses in society. Topics include fossil fuels (coal, oil, and natural gas) and other energy resources (e.g., wind, solar, nuclear, geothermal), metallic ores, and industrial minerals. The course discusses resource availability, production, and consumption (with economic viability, sustainability, and resilience in mind), current and possible mineral and fossil fuel shortages, and their possible impact on relationships between the U.S. and her global partners. The availability and exploitation of natural resources are critical topics given the impact on supply and demand of a growing global population that now exceeds 8 billion with the realization that nearly 2 billion people do not have adequate access to these resources to support a healthy sustainable lifestyle.

We explore in depth how development and extraction of earth resources can benefit a region or country in terms of their economics but also can lead to negative effects to our environment such as water and land use, pollution, and climate change. Throughout the course we reinforce four intersecting key concepts – linked earth systems, sustainability, human population, and justice, equity, diversity, and inclusion (JEDI). The evolution of varied Earth systems that result in economically viable resources is detailed both from a geological perspective as well as a historic one in terms of how technological advances over time have been beneficial to humans but also detrimental to our environment and its health and well-being. Students in the course are provided detailed data-informed overviews of the different resource types – fossil fuels, renewable energy, metallic ore deposits, industrial minerals and building materials. We discuss technological advances that have led to more efficient, cost-effective recovery that improves on sustainable development with minimization of adverse environmental impacts. We also delve into the limitations that science and technology have in reducing their negative effects and improving societal adaptation. Assigned exercises, individual Ted talks, and group research presentations challenge the students to identify and describe a key renewable or non-renewable resource and associated environmental issues in the context of the four overarching concepts the course emphasizes.

Connect this course to the Goals and ELOs shared by *all* Themes

Below are the Goals and ELOs common to all Themes. In the accompanying table, for each ELO, describe the activities (discussions, readings, lectures, assignments) that provide opportunities for students to achieve those outcomes. The answer should be concise and use language accessible to colleagues outside of the submitting department or discipline. The specifics of the activities matter—listing "readings" without a reference to the topic of those readings will not allow the reviewers to understand how the ELO will be met. However, the panel evaluating the fit of the course to the Theme will review this form in conjunction with the syllabus, so if readings, lecture/discussion topics, or other specifics are provided on the syllabus, it is not necessary to reiterate them within this form. The ELOs are expected to vary in their "coverage" in terms of number of activities or emphasis within the course. Examples from successful courses are shared on the next page.

Goal 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations. In this context, "advanced" refers to courses that are e.g., synthetic, rely on research or cutting-edge findings, or deeply engage with the subject matter, among other possibilities.

Goal 2: Successful students will integrate approaches to the theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

	Course activities and assignments to meet these ELOs
ELO 1.1 Engage in critical and logical thinking.	This course has several learning objectives the students need to articulate: (1) understand and apply four overarching concepts throughout the course where relevant - linked earth systens, population growth impact on supply and demand, sustainability, and DEI, (2) obtain an appreciation for the occurrence and world distribution of critical energy and mineral resources, their uses in society, and environmental and societal impacts of their exploitation, (3) describe common energy and earth materials, their mode of origin (genesis) and the technology used to develop them, (4) articulate resource availability, production, and consumption (with sustainability and resilience in mind), current and impending mineral and fossil fuel shortages, and their possible impact on relationships between the U. S. and our global partners, (5) describe the impact
ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or ideas within this theme.	The students in this class are given two assignments that challenge their reasoning and analytical skills. This is in addition to the Ted talks and group research project they are required to do on a topic of their choosing within the broad landscape of energy and mineral resources. This first exercise is designed to challenge the students to explore the sustainability of electricity use by having them quantitatively assess how much they may use across a hypothetical 4 years at OSU for each type of light bulb currently available in the marketplace. This exercise is tied to a series of lectures on Renewable Energy. The second exercise challenges the students to assess how much land area of the U.S. is currently surfaced mined (i.e., open pit) and how this may impact the potential for terrestrial sequestration of CO2 as a consequence of clear-cutting mature forests. Collectively, these assignments, the Ted talks, and the group project probe the students' ability to demonstrate an understanding of one or more of the key concepts covered in the class, namely, linked earth systems, sustainability, population growth, and JEDI. All four class activities require a modest level of research. Requiring students to do data assessment and associated calculations also nudges them to realize the value of simple but effective quantification of data.
ELO 2.1 Identify, describe, and synthesize approaches or experiences.	Earth Sciences 2210 familiarizes students with how to view varied Earth resources as complex interconnected systems that, when fully developed, exhibit both positive benefits and negative impacts to humankind. The students are exposed to not only the geological context regarding the formation and distribution of these but also the economics of development and exploitation that can improve a region or country's economic status but also can adversely impact its environment and people. Given that many resources are nonrenewable (i.e., finite), especially key metals and nonmetals, we discuss resource life expectancy and how this impacts the sustainable growth of a region or country. While many developed countries have robust and resilient infrastructure, poor developing countries rich in one or more natural resources are prone to ignore or minimize the environmental impacts of resource development and their effect on indigenous peoples. Through the lectures, assignments, and the group research projects, they are challenged to assess how Earth's natural resources can be exploited in both positive and
ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.	The syllabus outlines two assignments that collectively challenge the students to quantitatively evaluate key aspects of sustainability – specifically, the energy use and cost of electricity dependent on decision-making in selecting the light bulbs used by a student across a hypothetical four year stay at OSU, and the climate implication the clear-cutting forests has led to for development of surface mining in the U.S. These assignments require a modest level of critical thinking and straightforward data assessment to quantify the collective impact of land use and development from an economic resource perspective. The group research project is the culmination of the learning trajectory they are on wherein they can apply the past experiences and skills to explore development of a specific energy or mineral resource important to a sustainable society. Working in a team they identify a resource relevant to the course, describe its mode of formation, the distribution of occurrences (U.S., global), estimated reserves, extraction technologies, resulting products, current economics, economic forecasting of its long-term viability, and associated impacts on the environmental and people. They must design a strategy for how and who will describe the various aspects of topic to their peers in the class. Each team member is required to contribute equally to the research effort and is graded on the quality and effectiveness in their role in the project. This requires each participant to reflect on the value of their own effort as the grading is done on the basis on individual performance as well as how their team did overall.

Example responses for proposals within "Citizenship" (from Sociology 3200, Comm 2850, French 2803):

***ELO 1.1** Engage in critical and logical thinking.*	*This course will build skills needed to engage in critical and logical thinking about immigration and immigration related policy through:* *Weekly reading response papers which require the students to synthesize and critically evaluate cutting-edge scholarship on immigration;* *Engagement in class-based discussion and debates on immigration-related topics using evidence-based logical reasoning to evaluate policy positions;* *Completion of an assignment which build skills in analyzing empirical data on immigration (Assignment #1)*

	Completion 3 assignments which build skills in connecting individual experiences with broader population-based patterns (Assignments #1, #2, #3) *Completion of 3 quizzes in which students demonstrate comprehension of the course readings and materials.*
***ELO 2.1** Identify, describe, and synthesize approaches or experiences.*	*Students engage in advanced exploration of each module topic through a combination of lectures, readings, and discussions.* *<u>Lecture</u>* *Course materials come from a variety of sources to help students engage in the relationship between media and citizenship at an advanced level. Each of the 12 modules has 3-4 lectures that contain information from both peer-reviewed and popular sources. Additionally, each module has at least one guest lecture from an expert in that topic to increase students' access to people with expertise in a variety of areas.* *<u>Reading</u>* *The textbook for this course provides background information on each topic and corresponds to the lectures. Students also take some control over their own learning by choosing at least one peer-reviewed article and at least one newspaper article from outside the class materials to read and include in their weekly discussion posts.* *<u>Discussions</u>* *Students do weekly discussions and are given flexibility in their topic choices in order to allow them to take some control over their education. They are also asked to provide* *information from sources they've found outside the lecture materials. In this way, they are able to* *explore areas of particular interest to them and practice the skills they will need to gather information* *about current events, analyze this information, and communicate it with others.* *Activity Example: Civility impacts citizenship behaviors in many ways. Students are asked to choose a TED talk from a provided list (or choose another speech of their interest) and summarize and evaluate what it says about the relationship between civility and citizenship. Examples of Ted Talks on the list include Steven Petrow on the difference between being polite and being civil, Chimamanda Ngozi Adichie's talk on how a single story can perpetuate stereotypes, and Claire Wardle's talk on how diversity can enhance citizenship.*
***ELO 2.2** Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.*	*Students will conduct research on a specific event or site in Paris not already discussed in depth in class. Students will submit a 300-word abstract of their topic and a bibliography of at least five reputable academic and mainstream sources. At the end of the semester they will submit a 5-page research paper and present their findings in a 10-minute oral and visual presentation in a small-group setting in Zoom.* *Some examples of events and sites:* *The Paris Commune, an 1871 socialist uprising violently squelched by conservative forces*

	Jazz-Age Montmartre, where a small community of African-Americans–including actress and singer Josephine Baker, who was just inducted into the French Pantheon–settled and worked after World War I. *The Vélodrome d'hiver Roundup, 16-17 July 1942, when 13,000 Jews were rounded up by Paris police before being sent to concentration camps* *The Marais, a vibrant Paris neighborhood inhabited over the centuries by aristocrats, then Jews, then the LGBTQ+ community, among other groups.*

Goals and ELOs unique to Sustainability

Below are the Goals and ELOs specific to this Theme. As above, in the accompanying Table, for each ELO, describe the activities (discussions, readings, lectures, assignments) that provide opportunities for students to achieve those outcomes. The answer should be concise and use language accessible to colleagues outside of the submitting department or discipline. The ELOs are expected to vary in their "coverage" in terms of number of activities or emphasis within the course. Examples from successful courses are shared on the next page.

GOAL 3: Students analyze and explain how social and natural systems function, interact, and evolve over time; how human wellbeing depends on these interactions; how actions have impacts on subsequent generations and societies globally; and how human values, behaviors, and institutions impact multi-faceted, potential solutions across time.

	Course activities and assignments to meet these ELOs
ELO 3.1 Describe elements of the fundamental dependence of humans on Earth and environmental systems and on the resilience of these systems.	Fundamentally, Earth Sciences 2210 explores three overarching domains: (1) the nature, occurrence, and development of energy and mineral resources, (2) the relationship between population growth, supply and demand of resources, and adequate societal access to them, and (3) impacts to the environment and humankind, especially those who are underrepresented and marginalized. Within these three domains, four key concepts - namely linked Earth systems, sustainability, population growth (or lack thereof), and JEDI - are continually reinforced in various ways via lectures, assignments, Ted talks, and the group research projects. Collectively, these three domains constitute the essential ingredients for our continuing discussion in class of the life cycle of any developed resource. For example, we emphasize the fact that despite the tremendous value obtained from the development of a renewable resources like solar and wind to free us from the use of fossil fuels, there is "no free lunch", the components used in these new technologies still depend on the availability of metals and non-metals which have varying types of environmental impact due to mining practices. Thus, in addition to problematic land and water use issues, developing countries are commonly guilty of exploiting underrepresented peoples as part of the work force including
ELO 3.2 Describe, analyze and critique the roles and impacts of human activity and technology on both human society and the natural world, in the past, currently, and in the future.	Throughout this course we continually explore in some detail how resource development and exploitation, enhanced by technological advancements, result in both positive and negative impacts on humans. We discuss how "Faster, cheaper, safer" has been the recent battle cry for may resource extraction industries driven in part by using automation and leveraging rapid real-time assessment of 'big data'. Driving costs down but not at the expense of the environment is an observable trend in the resource development portfolio of many but not all developed countries. Students are exposed to the unfortunate fact that the opposite is commonly true for developing countries aspiring to be like the U.S. Transitioning energy production from coal, oil and natural gas to renewables is underway globally but at different rates with different levels of success. Several key lectures delve into the issue of energy equity and how despite technological advances, many of these simply do not reach people in developing countries expect those of privilege that run the country. Lectures and the group research projects converge to inform the students that an ever-increasing global population places greater demand on energy and earth resources, and in turn, leads to environmental, economic, and health stresses that vary widely from very local to a global scale. Through in-class discussions and assignments, the students are challenged to assess the frequency, magnitude, and scope of varied environmental
ELO 3.3 Devise informed and meaningful responses to problems and arguments in the area of sustainability based on the interpretation of appropriate evidence and an explicit statement of values.	An important thread that connects the various aspects of the course is a discussion on strategies forecasting the sustainable future of resource development. Using a broad array of statistics and their time dependent trends we chart what the future might hold for both energy and mineral resources. For the energy sector, the students are presented two approaches in how data are modeled to give us this futuristic perspective – (a) Stated Policies Scenario that reflects the impact of existing policy frameworks and today's announced policy intentions and (b) Sustainable Development Scenario (SDS) outlines a major transformation of the global energy system, showing how the world can change course to deliver on the three main energy-related UN Sustainable Development Goals simultaneously: (a) to achieve universal access to energy, (b) to reduce the severe health impacts of air pollution and (c) tackle climate change. For mineral resources we evaluate the role of population growth on supply and demand, the life expectancy of mineral deposits, changing landscape of costs as new technologies come online and automation becomes more pervasive, expansion of the types of metals that can be recycled, and new synthetic substitutes. Finally, we make some predictions on how government control and regulation need to evolve in the future to achieve a better balance in sustainable systems. The students are exposed to the concept that "good intentions do not always lead to good outcomes" for human activities that on one hand seem beneficial to energy and mineral resource development but can lead to longer term deleterious effects to the environment. The students explore the scale and effectiveness of specific environmental