The Global Context of Clean Energy Materials

GSVS 3210 / STS 3210

Course details: 3 credits collab.itc.virginia.edu

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COURSE OVERVIEW

Brief Description

Clean energy (CE) systems require far more minerals than their fossil fuel-based counterparts, minerals sourced, refined, and disposed of globally. The course examines which minerals are needed for the CE transition and why. It considers social, economic, and environmental sustainability challenges from use of these materials and highlights the sociotechnical reality of sustainability, i.e., Success depends upon social and technical advance.

Pre- or co-requisite courses or topics

3rd year standing or instructor permission. Students should be comfortable with chemistry, physical science, and algebra concepts from high school or early college studies.

INSTRUCTIONAL MATERIALS

This is an open content course. All instructional materials will be provided as needed at no cost. Students may find the following books relevant and interesting.

McDonough, W., & Braungart, M. (2010). *Cradle to cradle: Remaking the way we make things*. North Point press.

Ramirez, A. (2020). *The Alchemy of Us: How humans and matter transformed one another.* The MIT press.

LEARNING OBJECTIVES

Students should be able to:

1. Identify material properties relevant to clean energy systems and describe their scientific basis. Explain how material properties link to clean energy system performance.
2. Use material life cycle analyses to identify sustainability challenges associated with the use of engineered materials in contemporary clean energy system designs.
3. Illustrate the equivocal impacts of materials used in clean energy systems - from sustainable social, economic, and environmental perspectives.
4. Describe how the accelerating clean energy transition could be strengthened as the result of both social and technical corrections to its current trajectory.
5. Communicate effectively regarding the global nature and sustainable use of materials in clean energy systems and regarding the ethical dilemmas embedded within the accelerating clean energy transition.

COURSE CONTENT

In each course module, relevant clean energy material properties will be introduced and their scientific basis illuminated. Clean energy devices that exploit the property will be explained. Selected life cycle stages will be examined to highlight the emerging social, economic, and environmental impacts of clean energy materials development. Students wll be challenged to appreciate the scale of the proposed clean energy transformation and to grapple with the social and cultural, economic, and environmental impacts of achieving the envisioned transformation. Examples of social and technical strategies for moderating those impacts will be examined (e.g., global governance frameworks, materials research and development, and industrial ecology best practices).

Order	Material property	Clean energy devices and applications	Key Materials
I.	Optoelectronic	Photovoltaics, LED lighting	Si, Rare earths
II.	Magnetic	Electric generators and motors	Rare earths
III.	Electrochemical	Rechargeable batteries	C, Li, Ni, Mn, Co
IV.	Electrical	Power electronics, Electrical wiring	Cu, SiC
V.	Mechanical	Wind turbine blades, Transport system bodies	C, Epoxy, Al
VI.	Thermal	Heat pumps, Concentrating solar power	Refrigerants
VII.	Chemical	Power-to-X, Carbon capture and utilization	Pt, C, H_2, N_2, O_2
VIII.	Optical	Atmospheric seeding	S

ASSESSMENT & MEASUREMENT

How course outcomes will be assessed

Homework quizzes (20%)

Critical materials analysis assignment (10%)

Personal learning experience

- Mid-term project prospectus (5%)
- Final project (20%)

Final exam, comprehensive (25%)

Class discussion and participation (20%)

Academic rigor

While the course does not introduce concepts difficult for University of Virginia-caliber students to grasp, it expects successful students to demonstrate conceptual fluency in the course's subject matter - both the vocabulary and mathematical underpinnings of the topic. University of Virginia students need to be conversant and comfortable with the foundations of this technology-centric subject area. Students who are prepared to build upon their math and science studies from high school and / or early college will be academically successful in this course.

Class schedule and time commitment

This course is a 3 credit hour college course. Students should understand that the U.S. federal government mandates a certain *minimum* student workload for each credit hour earned. By the federal definition, each credit hour should require a minimum of two hours of out of class student work each week for approximately fifteen weeks. So, in addition to attending class regularly (as part of class participation), set aside 6+ hours per week outside of class to engage with this course. The course content is not difficult, yet there is much to learn. Organize your schedule to allow you to put in the expected study time! The expectation is that you will attend class every day. Class session recordings will be available for illness and emergency misses.

Late policy

All graded assignments in this course will have specific due dates and times listed in the weekly handouts provided by your instructor. Untimed assignments may be turned in up to 72 hours after the assigned due date and time. When such assignments are turned in late (by any amount of time), a 10% grade penalty will be assessed. After a student misses the 72 hour "late submission" window, assignments may be turned in at any time before the official end of the semester, receiving a 30% grade penalty. If students believe they need a deadline extension, they must request and receive written approval for such an extension, prior to the original submission deadline.

Course grade scale

A+	> 97%	**B+**	87 – 90%	**C+**	77 – 80%	**D+**	67 – 70%
A	93 – 97%	**B**	83 – 87%	**C**	73 – 77%	**D**	63 – 67%
A-	90 – 93%	**B-**	80 – 83%	**C-**	70 – 73%	**D-**	60 – 63%

F <60%

LEARNING COMMUNITY INTERACTION & ENGAGEMENT

Individual student engagement

Success in this course will depend on *your* individual efforts and on *our* ability to work together to build a cooperative learning environment. Questions and sharing of beliefs, opinions, and feelings are strongly encouraged. To maximize learning, we need to create a safe community in which we will feel comfortable sharing thoughts and ideas even when those thoughts and ideas are not in full agreement with the thoughts of others in the course. Achieving a safe learning environment requires practice and effort. It will require each of us to behave professionally and respectfully at all times, and to adhere to our course norms. As you learn in this course and learn about your classmates, you are encouraged to respect and appreciate differences.

Learning community values

Meaningful and courteous dialogue is expected in this course. Healthy dialogue will require a degree of respectful understanding and a willingness to listen to all course participants. You may not agree with another person's point-of-view, or you may already understand a concept and feel frustrated with the pace of class discussion at times. Give others a chance to contribute and learn. Encourage one another politely. Seek to understand and appreciate the ideas of others. Learn from one another. Be patient and encouraging as we *all* seek to advance our

knowledge of important sustainable energy system concepts. Since every student is entitled to full participation in this course without interruption, all students are expected to come to class sessions prepared and on time. You are always expected to refrain from undertaking any activities that might be considered disruptive.

Use of email

Your instructor will minimize course related emails. Still, email messages will be necessary from time-to-time. Your instructor expects you to check your university email account at least one time each day, Monday – Friday during the semester. If an email includes a specific request for a response, your instructor expectation you to respond in two business days from the time that the email was *sent*. Failure to read and respond to emails in a timely manner (as defined here) will have a negative impact upon your class participation grade.

The Honor System and the School of Engineering and Applied Science

The School of Engineering and Applied Science relies upon and cherishes its community of trust. We firmly endorse, uphold, and embrace the University of Virginia's Honor principle that students will not lie, cheat, or steal, and we expect all students to take responsibility for the System and the privileges that it provides. We recognize that even one Honor infraction can destroy an exemplary reputation that has taken years to build. Acting in a manner consistent with the principles of Honor will benefit every member of the community both while enrolled in the Engineering School and in the future.

If you have questions about the Honor System or would like to report suspicions of an Honor offense, please contact Professor Groves <jgroves@virginia.edu>. For more information on the UVA Honor System, please visit the following web resource: http://www.virginia.edu/honor/

Accessibility

It is my goal to create a learning experience that is as accessible as possible. If you anticipate any issues related to the format, materials, or requirements of this course, please meet with me outside of class so we can explore potential options. Students with disabilities may also work with the Student Disability Access Center to discuss a range of options to removing barriers in this course, including official accommodations. Please visit their website for information on this process and to apply for services online: sdac.studenthealth.virginia.edu. If you have already been approved for accommodations through SDAC, please send me your accommodation letter and meet with me so we can develop an implementation plan together.

Discrimination and power-based violence

The University of Virginia is dedicated to providing a safe and equitable learning environment for all students. To that end, it is vital that you know two values that I and the University hold as critically important:

1. Power-based personal violence will not be tolerated.
2. Everyone has a responsibility to do their part to maintain a safe community on Grounds.

If you or someone you know has been affected by power-based personal violence, more information can be found on the UVA Sexual Violence website that describes reporting options and resources available - www.virginia.edu/sexualviolence.

As your professor and as a person, know that I care about you and your well-being and stand ready to provide support and resources as I can. As a faculty member, I am a responsible employee, which means that I am required by University policy and federal law to report what you tell me to the University's Title IX Coordinator. The Title IX Coordinator's job is to ensure that the reporting student receives the resources and support that they need, while also reviewing the information presented to determine whether further action is necessary to ensure survivor safety and the safety of the University community. If you wish to report something that you have seen, you can do so at the **Just Report It** portal (http://justreportit.virginia.edu/). **The worst possible situation would be for you or your friend to remain silent when there are so many here willing and able to help.**

Religious accommodations

It is the University's long-standing policy and practice to reasonably accommodate students so that they do not experience an adverse academic consequence when sincerely held religious beliefs or observances conflict with academic requirements.

Students who wish to request academic accommodation for a religious observance should submit their request in writing directly to me as far in advance as possible. Students who have questions or concerns about academic accommodations for religious observance or religious beliefs may contact the University's Office for Equal Opportunity and Civil Rights (EOCR) at UVAEOCR@virginia.edu or 434-924-3200.

Recording of classroom activities

I will be recording the live sessions in this course to ensure equitable access to course content. Because recorded sessions will include fellow students, you and they may be personally identifiable on the recordings. These recordings may only be used for the purpose of individual or group study with other students enrolled in this class during this semester. You may not distribute them in whole or in part through any other platform or to any persons outside of this class, nor may you make your own recordings of this class unless written permission has been obtained from the instructor and all participants in the class have been informed that such recording will occur. For additional details, see Provost Policy 005.