Syllabus—ESM 272: Energy and Resource Productivity

Instructor: Sangwon Suh
Instructor office and office hour: 12:30-1:00pm on Mondays and Tuesdays, or by appointment*
Meeting time: 3:30-4:45pm on Mondays and Wednesdays
Meeting location: BH 1424
* Please use Google calendar for any and all appointments outside the office hours. Email confirmations are not necessary.

Course description

In this course, fundamental concepts, principles, key trends, policy and tools in energy and resource productivity will be discussed. Topics to be discussed include: (1) Key concepts and definitions of energy and resource productivity; (2) fundamentals of coal, oil, natural gas and renewable energy resources; (3) fundamentals of metal and mineral resources; (4) improving energy and resource productivity: case studies; and (5) repercussions of energy and resource productivity improvement. Throughout the course, the students will run a term project on personal energy consumption and its reduction strategies.

Course objectives

The objectives of the course are:

- Be able to understand fundamental concepts and principles of energy and resource productivity;
- Be able to understand the strategies, techniques, and policies for improving energy and resource productivity;
- Be able to construct and interpret a supply cost curve for a relevant natural resource and/or energy category.

Course format

This course will be delivered by 50% lecture, 40% in-class discussion, and 10% student presentation. Student participation in the lecture and discussion is essential to this course.

Assessment

- Midterm: 20%
- Final: 30%
- Participation: 10% (based on contributions to in-class discussions)
- Final presentation: 40% (based on clarity of the presentation, soundness of the methodology, and significance of the results)

Term project description

The term project can be about (A) personal energy consumption or (B) analysis of a natural resource.

A. Personal Energy Consumption

(1) measuring / estimating the amount of weekly energy consumption of a student; (2) developing an intervention strategy to reduce energy consumption; (3) estimate the amount of energy and cost savings; (4) monitoring actual energy and cost savings after implementing interventions; (5) assessing the effectiveness of the strategies tested; and (6) drawing overall recommendations for personal energy saving strategies.

Form a group of 5 students, and identify the target student within the group whose personal energy consumption is to be measured / estimated. Use the materials provided to measure or otherwise estimate the amount of energy consumed over at least a week. Personal energy consumption includes (but not limited to) those for lighting, transportation, refrigeration, communication, computing. It will be often necessary to allocate collective energy consumption into individual level. Embodied energy in purchased goods and services may be included (optional). Collect information and develop strategies to reduce energy consumption. Factor in the behavioral aspects and incentive structure. Estimate the potential energy and cost savings from implementing the strategies. Monitor the changes and discuss any discrepancy between the predicted savings and actual savings. Draw conclusions and recommendations.

B. Analysis of a natural resource

Visit the Commodity Statistics and Information page of the U.S. Geological Survey (USGS) (https://minerals.usgs.gov/minerals/pubs/commodity/) and/or other relevant web sites; select one mineral of your interest and collect the following information (1) major uses/applications, (2) global reserve, (3) global production and consumption volume, (4) price(s), (5) major producing countries, and (6) future projections on production, demand, and price. Note that depending on the mineral in question, some information may be withheld (marked with “W”. Try to find a mineral that you can find decent amount of information). Discuss notable geopolitical and/or policy issues around the resource.

Presentation time will be 15 mins per group.

Class schedule by date (students are not expected to read all the reading materials from the beginning to the end. Use the material as a resource).

Date	Topic	Reading	Note
4/2	Introduction: • Course overview/objectives • Intro to reading materials and term project • Why energy/resource efficiency/productivity?	http://www.npr.org/sections/money/2013/12/31/258687278/a-bet-five-metals-and-the-future-of-the-planet	Ehrlich, P.R. and J.P. Holdren, 1972. Critique: One Dimensional Ecology. Bulletin of the Atomic Scientists 28(5): 16, 18-27 and the response by Commoner, B. in the same issue on p. 17 (https://e4anet.files.wordpress.com/2014/09/610_wk1-ehrlich-and-holdren-one-dimensional-ecology.pdf).
4/4	Key definitions and concepts • Energy/work • Resource v.s. waste; recycling • Sources and sinks/ metabolism • Efficiency and productivity	Wiedmann, T. O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., & Kanemoto, K. (2015). The material footprint of nations. Proceedings of the National Academy of Sciences, 112(20), 6271-6276. (http://www.pnas.org/content/112/20/6271.full.pdf)	Resource Efficiency: Potential and Economic Implications, UNEP International Resource Panel (http://www.resourcepanel.org/file/441/download?token=3IPv9vDL). Full report can be found at: http://www.resourcepanel.org/reports/resource-efficiency
4/9	Key definitions and concepts • Circular economy • Recycling, reusing, remanufacturing • Technology learning • Jevon's paradox/ Khazoom-Brookes postulate	http://ec.europa.eu/environment/circular-economy/pdf/AnalysisEUtarget.pdf http://www.sciencedirect.com/science/article/pii/S0306261916301362	Useful resources: http://ec.europa.eu/environment/circular-economy/index_en.htm http://www.theguardian.com/sustainable-business/series/circular-economy
4/16	Key definitions and concepts • Supply Cost-curve/ abatement cost-curve • Efficiency gap • Source reduction/ pollution prevention	http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/pathways-to-a-low-carbon-economy	

4/18	Understanding energy and resources • Global energy systems • Fossil energy • Renewable energy • Emerging energy technologies	http://www.pnas.org/content/112/20/6277.full.pdf	Useful resource: http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf
4/23	Understanding energy and resources • Energy efficiency • Natural resource landscape • Bulk material resources	http://www.pnas.org/content/112/20/6271.full.pdf	
4/25	Understanding energy and resources • Exotic/critical materials • eWaste • Land use • Water • Natural capital	https://www.youtube.com/watch?v=dd_ZttK3PuM	

4/30	How to improve energy/resource efficiency/productivity: case studies
	• Technological approaches
	  ○ Motor vehicles
	  ○ Paints
		http://www.unep.org/resourcepanel/Portals/24102/PDFs/IRP_DECOUPLING_2_REPORT.pdf
		
		Used throughout the second half of the class.	

5/2	<Midterm: first 45 min>
	How to improve energy/resource efficiency/productivity: case studies
	• Technological approaches
	  ○ Barrel Painting
	  ○ Calendar Process
	  ○ Electroplating		

5/4	How to improve energy/resource efficiency/productivity: case studies • Technological approaches ○ Drip irrigation and partial root-zone irrigation		Useful resource: http://vancouver.ca/files/cov/passive-ome-design.pdf

	○ Passive housing Steel industry ○ Food and hospitality		
5/7	How to improve energy/resource efficiency/productivity: case studies • Economic approaches ○ Pricing ○ Tax/incentives ○ Sustainable Purchasing	Nematchoua, Modeste Kameni, et al. "Study of the economical and optimum thermal insulation thickness for buildings in a wet and hot tropical climate: Case of Cameroon." Renewable and Sustainable Energy Reviews 50 (2015): 1192-1202. (https://www.researchgate.net/profile/Modeste_Nematchoua/publication/278030057_Study_of_the_economical_and_optimum_thermal_insulation_thickness_for_buildings_in_a_wet_and_hot_tropical_climate_Case_of_Cameroon/links/557a773e08ae7536375701ed.pdf)	
5/9	How to improve energy/resource efficiency/productivity: case studies • Regulatory/planning approaches ○ Densification ○ Building codes ○ RFP/RFS ○ Efficiency targets	http://pubs.acs.org/doi/pdf/10.1021/es4040792	
5/14	How to improve energy/resource efficiency/productivity: case studies • Closing the knowledge gaps, information dissemination		
5/16	Repercussions of efficiency and productivity improvement: case studies • Rebound effects • Productivity-growth dilemma • Design v.s. practice gaps	http://www.sciencedirect.com/science/article/pii/S0301421508007131	
5/21	Final		SW out of town for a conference

5/23	No Class		SW out of town for a conference
5/28	No class (preparation for the final presentation)		
6/4	Final presentations		

Additional resources

- Graedel, T. E., Harper, E. M., Nassar, N. T., Nuss, P., & Reck, B. K. (2015). Criticality of metals and metalloids. Proceedings of the National Academy of Sciences, 112(14), 4257-4262. (http://www.pnas.org/content/112/14/4257.full.pdf)
- Jones, A. D., Hoey, L., Blesh, J., Miller, L., Green, A., & Shapiro, L. F. (2016). A Systematic Review of the Measurement of Sustainable Diets. Advances in Nutrition: An International Review Journal, 7(4), 641-664. (http://advances.nutrition.org/content/7/4/641.full.pdf)
- Tom, Michelle S., Paul S. Fischbeck, and Chris T. Hendrickson. "Energy use, blue water footprint, and greenhouse gas emissions for current food consumption patterns and dietary recommendations in the US." Environment Systems and Decisions 36.1 (2016): 92-103. (http://joe.nothingman.info/V/Fishbeck.pdf)
- Graham Hill, Living With Less. A Lot Less, NY Times, 2013 March 9th. (http://www.nytimes.com/2013/03/10/opinion/sunday/living-with-less-a-lot-less.html)
- Fagnant, Daniel J., and Kara M. Kockelman. "The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios." Transportation Research Part C: Emerging Technologies 40 (2014): 1-13. (http://www.caee.utexas.edu/prof/kockelman/public_html/TRB14SAVenergy_emissions.pdf)
- Demailly, D., & Novel, A. S. (2014). The sharing economy: make it sustainable. Studies, (03/14), 30. (http://www.phibetaiota.net/wp-content/uploads/2014/10/The-Sharing-Economy-and-Sustainability.pdf)
- Lusty, P. A. J., & Gunn, A. G. (2015). Challenges to global mineral resource security and options for future supply. Geological Society, London, Special Publications, 393(1), 265-276. (http://sp.lyellcollection.org/content/393/1/265.full.pdf+html)
- Forbes, Toyota On Mirai Vs. Tesla: Battery Electric Vehicles Have 'Fundamental' Physics Problem (https://www.forbes.com/sites/brookecrothers/2015/07/20/toyota-on-mirai-vs-tesla-battery-electric-vehicles-have-fundamental-physics-problem/#75b7a2f46af0)
- Joe Romm, 2015: Elon Musk Is Right: Hydrogen Is 'An Incredibly Dumb' Car Fuel (https://thinkprogress.org/elon-musk-is-right-hydrogen-is-an-incredibly-dumb-car-fuel-d0f37a4c9bee)