Fall 2022

Sustainability: The City

CEE 368 - 0 - 20
Tues., 3:30 – 6:30 pm
University Hall 102

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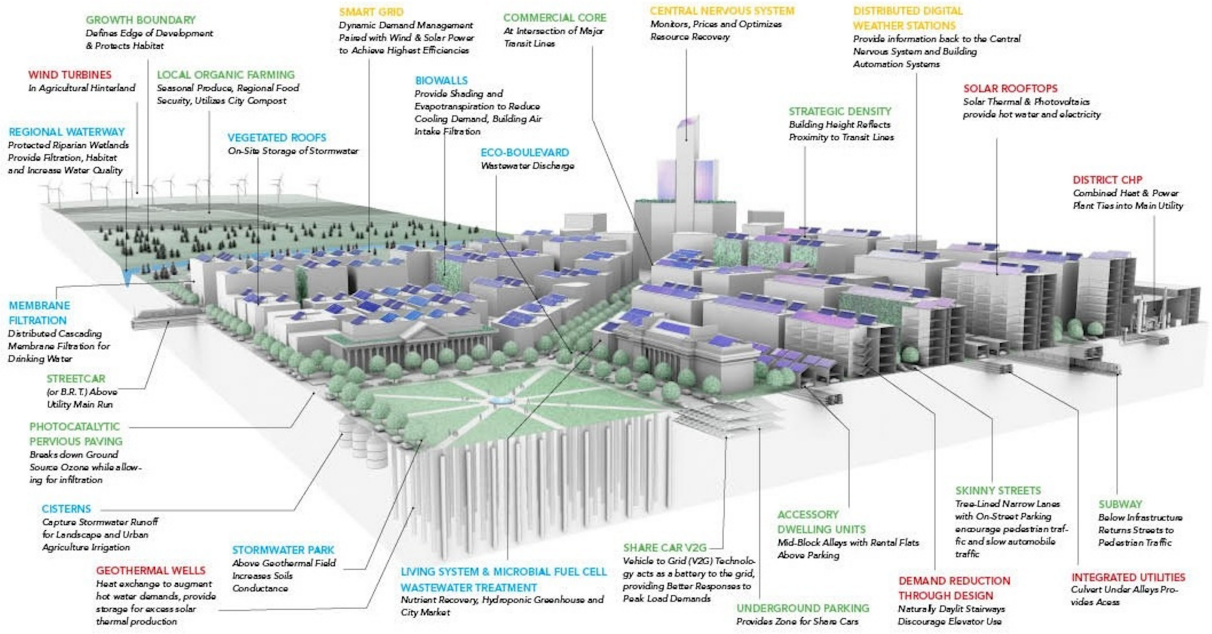
Course Description

Cities are ground zero for climate action.

Cities will shape our future. They are the world's economic engines, driving 75% of global productivity. Cities magnify human strengths and are "our greatest invention mak(ing) us richer, smarter, greener, healthier and happier." Cities may be our greatest invention, but in 2022 the typical city in U.S and elsewhere is woefully inefficient in the way it transports its citizens and goods, supplies information, manages its water supply, produces food and energy, and treats its wastes. The development and operation of today's cities injure ecosystems and contribute heavily to global climate change. We must reinvent our cities, both old and new, by devising strategies for sustainable, resilient and adaptive urban design that are based on the ecological principles of material and energy cycling and on policies and incentives that make business and social sense.



We have entered the age of cities. Since 2008 more than half the world's population, a proportion expected to grow to 70% by 2050, lives in cities, creating a precarious condition where 3.75 billion people occupy about 2% of the earth's land area. Although cities around the world are threatened by a rapidly changing climate, stressed ecosystems and altered environmental processes, they are also the locus of innovation and invention where solutions are created. The challenge for cities, then, is to grow in wealth and well-being without tipping. Sustainable urban design offers an adaptive and robust approach to the problems of demographic shifts, environmental dangers and equitable prosperity.

The theme of this course is urban reinvention and the sustainable, resilient and adaptive reinvention of cities must integrate ecological, economic and socially just principles. Cities are dynamic and constantly changing. They behave much more like living organisms than machines, and their functions are mediated by metabolic processes governed by a central nervous or information system that controls energy, material and economic flows. Among the many questions we will ask in this course, are "smart cities" also sustainable cities?

The concept of sustainability is fuzzy. In many cases, sustainability efforts are focused on being "less bad" or a "little better" than current practice. Sustainability often concentrates on the technical performance of individual devices or buildings to reduce energy or water use, rather then the larger system into which these pieces fit. In the absence of clear and rigorous definitions, metrics and targets, sustainability has come to mean vaguely, almost anything and a growing number of environmental experts are beginning to question whether it is even possible any more. Sustainability is dynamic, rather than a fixed state or destination and is a process of learning to detect, interpret and act to promote the long-term health of human and natural systems. Urban sustainability, then, must promote the dynamic potential of adaptation and resilience synergistically between human and natural systems.

There are many divergent views on what sustainability means to scientists, social scientists and engineers. The purpose of this course is to explore the issues that drive and the various approaches to sustainable urban development. First we will consider the why and the how of redesigning cities or human settlements to be adaptive and resilient, and to function via coupled cycles of energy, water, food/materials and waste. We will make use of published research, popular media, case studies and current project examples. Students will work in teams on short and long-term projects throughout the course. Weekly readings will be assigned and discussed, and presentations will be made by students throughout the quarter. This class is modeled on a seminar style, although there will be weekly lectures. Active student participation is required.

Course Objectives

1. Develop understanding of general principles of Sustainability, Resilience & Adaptation (SRA).
2. Tailor general understanding of SRA to urban systems; can they be adapted to transform cities to become C-neutral and/or C-negative?
3. Delve deeply into key urban energy or material cycle – metrics, coupling, C-zero or negative
4. Explore paths to achieving sound ecological, viable economic & socially just urban design.

Suggested:

- Under a White Sky, Elizabeth Kolbert (Penguin Random House, 2021).
- The Sixth Extinction, Elizabeth Kolbert (Henry Holt & Co., LLC, 2014).
- Losing Earth: A Recent History, Nathaniel Rich (MacMillan, 2019).
- The Uninhabitable Earth: Life After Warming, David Wallace-Wells (Tim Duggan Books, 2019).
- Collapse, Jared Diamond (Penguin, N.Y., 2005).
- Can a City Be Sustainable, State of the World, 2016, Worldwatch Institute (Island Press, Washington, D.C. 2016).
- Is Sustainability Still Possible? The State of the World 2013, The Worldwatch Inst. (Island Press, Washington, D.C., 2013).
- Natural Capitalism, P. Hawken, A. Lovins, L.H. Lovins (Little, Brown & Co., N.Y., 2000).
- Cradle to Cradle: Remaking the way we make things, W. McDonough, M. Braungart (North Point Press, NY, 2002).
- The Upcycle, W. McDonough, M. Braungart (North Point Press, NY, 2013).
- Sustainable Urbanism: Urban design with nature, D. Farr (John Wiley, NY, 2008).

Evaluation:

- Participation + Group Work – 20% (Graded for each class meeting & progress presentations)
- Short Position Papers on Readings or weekly assignments (7/8) – 35%
- Final Project – presentation/report 25% + 20% peer evaluation - 45%

Class Schedule

1. Sept. 20 - Introduction; what is sustainability?

2. Sept. 27 - Drivers of Change; Project & Organize Groups

Readings:
- J. Rockström et al. (2017). A roadmap for rapid decarbonization. *Science,* 355:6331:1269-1271. https://science.sciencemag.org/content/355/6331/1269/tab-pdf
- Johan Rockström et al. (2009) "A safe operating space for humanity," *Nature,* 461, 472- 475. (Canvas) https://www.nature.com/nature/journal/v461/n7263/full/461472a.html
- G. Ceballos, P.R. Ehrlich, A.D. Barnosky, A. Garcia, R.M. Pringle, T.M. Palmer (2015) "Accelerated modern human-induced species losses: Entering the sixth mass extinction," *Sci. Adv*. 1, e1400253. https://www.science.org/doi/epdf/10.1126/sciadv.1400253
- IPCC Sixth Assessment Report, Working Group III (04/2022); Mitigation of Climate Change; Press Release*; Summary for Policy Makers; Chapter 1 (Introduction & Framing) & 2* (Emission Trends & Drivers); https://www.ipcc.ch/report/ar6/wg3/

Recommended:
- A. Lustgarten (07.23.20). The Great Climate Migration, NYT, https://www.nytimes.com/interactive/2020/07/23/magazine/climate-migration.html
- A. Lustgarten (09.15.20). How Climate Migration Will Reshape America, NYT, https://www.nytimes.com/interactive/2020/09/15/magazine/climate-crisis-migration-america.html
- J. Zalasiewicz, M. Williams, W. Steffen, P. Crutzen (2010). "The New World of the Anthropocene," *Environ. Sci. Technol*., 44:2228-2231. https://pubs.acs.org/doi/pdf/10.1021/es903118j

Assignment 1– Position paper (Reflect on these readings – What are the most compelling drivers for transforming our economy, industry, cities, etc? What is it going to take to accelerate change, if change is required? Does it make sense to focus on cities as the locus of change? These position papers should be short and personal – what are your thoughts in response to the readings, how do the readings connect to your personal experience or to items in the news – 1-2 pages) – REQUIRED

3. Oct. 4 – Urban Systems, Sustainability Metrics, & Net Zero

Readings:
- Focused adaptation. A strategic approach to climate adaptation in cities (July 2021). C40 Cities & McKinsey Sustainability. https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/how%20cities%20can%20adapt%20to%20climate%20change/focused-adaptation-a-strategic-approach-to-climate-adaptation-in-cities-vf.pdf
- Envisaging the Future of Cities. World Cities Report 2022. UN Habitat. https://unhabitat.org/wcr/ (Chapter 1, Chapter 6, Chapter 9*)
- IPCC Sixth Assessment Report, Working Group III (04/2022); Mitigation of Climate Change; Chapter 8 (Urban systems & other settlements); https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter_08.pdf
- Social Costs of Carbon
  - https://news.stanford.edu/2021/06/07/professors-explain-social-cost-carbon/
  - https://news.climate.columbia.edu/2021/04/01/social-cost-of-carbon/
- F. Pearce 92021) Net-zero emissions: Winning strategy or destined for failure; Yale Environment 360; https://e360.yale.edu/features/net-zero-emissions-winning-strategy-or-destined-for-failure
- S. Schonhardt (2021) 5 things to know about the global race to net zero. Climatewire; https://subscriber.politicopro.com/article/eenews/1063734067?utm_campaign=edition&utm_medium=email&utm_source=eenews%3Aclimatewire
- Embodied Carbon 101, Carbon Leadership Forum; https://carbonleadershipforum.org/embodied-carbon-101/

Recommended:

- K. Gray, D. Farr, et al. (2011) Living Cities: Transforming APEC Cities into Models of Sustainability by 2030. Report to Business Advisory Committee of Asia Pacific Economic Cooperation, Nov, 2011. (Canvas)
- H. Suzuki et al. (2010) Eco^2 Cities – Synopsis (p. 1 – 16) & Ecological Cities as Economic Cities; Part 3, The Field Reference Guide (The World Bank) p. 165 – 224. (Canvas)
- Global Climate Action from Cities, Regions, and Businesses; Data Driven Yale, NewClimate Institute, PBL Environmental Assessment Agency, 2018, https://datadrivenlab.org/wp-content/uploads/2018/08/YALE-NCI-PBL_Global_climate_action.pdf
- B. Plumer, N. Popovich, (08.29.20) The Climate Legacy of Racist Housing Policies, NYT - https://www.nytimes.com/interactive/2020/08/24/climate/racism-redlining-cities-global-warming.html
- Life cycle assessment (LCA) explained - https://pre-sustainability.com/articles/life-cycle-assessment-lca-basics/
- G. Finnveden et al. (2009). Recent developments in Life Cycle Assessment, *Journal of Environmental Management*, 91.1-21. (Canvas)

Assignment 2 – Write a letter to the editor of the Chicago Tribune or NYT about the need for establishing sustainable urban neighborhoods underpinned by metrics. What metric(s) do you support.

4. **Oct. - 12** **Climate, Energy & Storage – Rapid & Deep Decarbonization**

Readings:

- K.A. Gray (2021). Climate Strategies: The Feasibility of Interventions on a Global Scale, in **Climate Geoengineering: Science, Law and Governance**, Wil Burns, David Dana and Simon James Nicholson eds., Springer Publisher, in press. (Canvas)
- IPCC Sixth Assessment Report, Working Group III (04/2022); Mitigation of Climate Change; Chapter 6 (Energy Systems); https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter_06.pdf
- Net Zero by 2050; A road map for the Global Energy Sector, IEA, May 2021; https://www.iea.org/reports/net-zero-by-2050
- CCU v CCS – 4 part series by Vox –
  - https://www.vox.com/energy-and-environment/2019/9/4/20829431/climate-change-carbon-capture-utilization-sequestration-ccu-ccs
  - https://www.vox.com/energy-and-environment/2019/10/2/20838646/climate-change-carbon-capture-enhanced-oil-recovery-eor
  - https://www.vox.com/energy-and-environment/2019/11/13/20839531/climate-change-industry-co2-carbon-capture-utilization-storage-ccu
- M. Hutson (2022). The renewable-energy revolution will need renewable storage, *The New Yorker,* https://www.newyorker.com/magazine/2022/04/25/the-renewable-energy-revolution-will-need-renewable-storage
- How America can leave fossil fuels behind, in one chart: Sankey Diagram; https://www.youtube.com/watch?v=QfAXbGInwno

Recommended:

- R.J. Lazarus (2009). Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future. 94 Cornell L. Rev. 1153-1234. (Canvas) OR http://www.law.harvard.edu/faculty/rlazarus/docs/articles/Lazarus_WickedELRArticle.pdf
- EIA Annual Energy Outlook 2021 with projections to 2050. https://www.eia.gov/outlooks/aeo/
- CCUS in Power; IEA, June, 2020; https://www.iea.org/reports/ccus-in-power

Assignment 3 – Rapid & Deep Decarbonization – What are the projections for fossil fuel use over next 30 years? Given these projections, what in your opinion will it take to achieve decarbonization targets or can we just keep using fossil fuels and capture to either reuse or bury?

5. Oct. 19 - Closed-loop Water -- Nature-Based Systems/Ecosystem Good & Services & the value of biodiversity

Readings:

- M. Lafforgue & V. Lenouvel (2015). Closing the urban water loop: lessons from Singapore and Windhoek, *Environmental Science: Water Research & Technology*, 1:622-631. https://pubs.rsc.org/en/content/articlepdf/2015/ew/c5ew00056d
- K. Brauman (2016). We're (not) running out of water – a better way to measure water scarcity. The Conversation; https://theconversation.com/were-not-running-out-of-water-a-better-way-to-measure-water-scarcity-58699
- Z. Ghofrani, V. Sposito, R. Faggian (2017) A Comprehensive Review of Blue -Green Infrastructure Concepts. International Journal of Environment and Sustainability ISSN 1927-9566 Vol. 6, No. 1, pp. 15-36; https://pdfs.semanticscholar.org/4052/eb537c5edad387f889e247a1fade83bdf0be.pdf
- K.R. Zodrow et al. (2017). Advanced materials, technologies, and complex systems analyses: Emerging opportunities to enhance urban water security, *Environmental Science and Technology,* 51:10274-10281; https://pubs.acs.org/doi/pdf/10.1021/acs.est.7b01679
- The Value of Green Infrastructure (2010), Center for Neighborhood Technology, Chicago, IL. https://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf (Canvas)
- B. Stutz (03.29.2018). With a green makeover, Philadelphia is tackling its stormwater problem. Yale Environmental 360. https://e360.yale.edu/features/with-a-green-makeover-philadelphia-tackles-its-stormwater-problem
- A.R. Siders et al. (2019) The case for strategic and managed climate retreat. *Science*, 365(6455):761-763. https://science.sciencemag.org/content/sci/365/6455/761.full.pdf
- L. Koslov (2016). The Case for Retreat. Public Culture, 28 (2 (79)): 359–387. (Canvas)
- C.A.J. Girardin et al. (2021). Nature-based solutions can help cool the planet – if we act now, *Nature,* 593:191-194; https://media.nature.com/original/magazine-assets/d41586-021-01241-2/d41586-021-01241-2.pdf
- Loss of biodiversity poses as great a risk to humanity as climate change, Technology Quarterly, The Economist (June 19, 2021), https://www.economist.com/technology-quarterly/2021/06/15/loss-of-biodiversity-poses-as-great-a-risk-to-humanity-as-climate-change
- C. Einhorn (06.10.21) Our response to climate change is missing something big, scientists say; https://www.nytimes.com/2021/06/10/climate/biodiversity-collapse-climate-change.html
- D. Roberts (04.11.18) This company wants to build a giant indoor farm next to every major city in the world. Vox, https://www.vox.com/energy-and-environment/2017/11/8/16611710/vertical-farms

Recommended:

- M. Grunwald (08.29.17). How Washington Made Harvey Worse, Politico, http://www.politico.com/magazine/story/2017/08/29/a-storm-made-in-washington-215549
- C.L. Weber, H.S. Matthews (2008). Food-miles and the relative climate impacts of food choices in the United States. *Environmental Science & Technology*, 42:3508-3513. (Canvas)
- L. Palmer (2014). How weed could help feed billions in a warming world, Yale Environment 360, 06/05/14; http://e360.yale.edu/feature/how_weeds_could_help_feed_billions_in_a_warming_world/2772/
- M. Pollan (2006). The Omnivore's Dilemma (Penguin Books, NY).
- Polyface Farm "the farm of many faces" - http://www.polyfacefarms.com

Assignment 4 – Position paper – What kind of actions should we take to manage water – how can we engineer* our way out of the various water hazard issues? (*Consider nature-based v technology-based or combination).

Progress Reports from each group – Project progress – 10 min each

6. Oct. 26 – Materials & Shelters

Readings:

- P. Anastas, J.B. Zimmerman (2003). "Design Through the 12 Principles of Green Engineering," *Environ. Sci. Technol*. 37:95A-101A. (Canvas).

- W. McDonough, M. Braungart, P.T. Anastas, J.B. Zimmerman (2003). "Applying the Principles of Green Engineering," *Environ. Sci. Technol*., 37:434A-441A. (Canvas).
- IPCC Sixth Assessment Report, Working Group III (04/2022); Mitigation of Climate Change; Chapter 9 (Buildings); https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter_09.pdf
- M. Renner (2016). "Reducing the Environmental Footprint of Buildings," plus City View – Freiburg, Germany, in Can a City Be Sustainable? State of the World 2016, Worldwatch Inst. (Island Press, Washington, D.C., 2016) Ch. 8, p. 115- 140. (Canvas) https://link.springer.com/content/pdf/10.5822%2F978-1-61091-756-8_9.pdf
- G. H. Kats (2016). "Energy Efficiency in Buildings: A Crisis of Opportunity," plus City View – Melbourne, Australia, in Can a City Be Sustainable? State of the World 2016, Worldwatch Inst. (Island Press, Washington, D.C., 2016) Ch. 9, 141-160. (Canvas) https://link.springer.com/content/pdf/10.5822%2F978-1-61091-756-8_11.pdf
- M.F.L. Mallo & O. Espinoza (2015). Awareness, perceptions and willingness to adopt Cross-Laminated Timber by the architecture community in the United State. *Journal of Cleaner Production,* 94:198-210. https://www.sciencedirect.com/science/article/pii/S0959652615001031
- ARUP (2017). The Urban Bio-Loop: Growing, Making and Regenerating (Canvas) https://www.arup.com/perspectives/publications/research/section/the-urban-bio-loop

Assignment 5– Find an example of a "high-performing" building; write a 2 page description of its sustainable, adaptive, resilient features; does it include any of the features described in readings; is social equity addressed?

7. Nov. 1 – The Circular Economy - Waste & Resource Recovery

Readings:
- D. Roberts (2020). How to build a circular economy that recycles carbon. https://www.vox.com/energy-and-environment/2020/1/8/20841897/climate-change-carbon-capture-circular-economy-recycle
- U. Wang (10.16.2018). Why aren't we mining landfills for valuable materials like metals and soils? Ensia, https://ensia.com/features/landfill-mining/
- T. Schlossberg & N. Raza (12.09.19). The Great Recycling Con. NYT; https://www.nytimes.com/2019/12/09/opinion/recycling-myths.html
- C. Katz (03.07.19). Piling Up: How China's ban on importing waste has stalled global recycling, Yale Environment 360, https://e360.yale.edu/features/piling-up-how-chinas-ban-on-importing-waste-has-stalled-global-recycling
- Circular Economy, Ellen MacArthur Foundation; Concept – https://www.ellenmacarthurfoundation.org/circular-economy/concept
- Cities and the Circular Economy - https://www.ellenmacarthurfoundation.org/explore/cities-and-the-circular-economy

Assignment 6 – Select a material (paper, glass, plastic, metal, etc.) – Sketch a circular economy for that material and discuss benefits and obstacles.

8. Nov. 8 – Mobility

Readings:
- IPCC Sixth Assessment Report, Working Group III (04/2022); Mitigation of Climate Change; Chapter 10 (Transport); https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter_10.pdf
- N. Chokshi (03.31.21). Biden's push for electric cars: $174 billion, 10 years and a bit of luck, NYT; https://www.nytimes.com/2021/03/31/business/biden-electric-vehicles-infrastructure.html
- A. Peters (04.04.17). Inside Paris Mayor Anne Hidalgo's ambitious plans to create the post-car city. Fast Company. https://www.fastcompany.com/3069004/the-mayor-of-pariss-quest-to-get-rid-of-cars
- V. Yurk (05.24.21) Self-driving EVs could spike CO_2 – study; https://subscriber.politicopro.com/article/eenews/1063733275

- D. Roberts (2017). A fascinating new scheme to create walkable public spaces in Barcelona; Vox - https://www.vox.com/2016/8/4/12342806/barcelona-superblocks
- D. Roberts (2019). Barcelona's radical plan to take back streets from cars; five-part series (watch the video); Vox; https://www.vox.com/energy-and-environment/2019/4/9/18300797/barcelona-spain-superblocks-urban-plan

Recommended:

- K.A. Gray (2016). "Transportation Infrastructure and the Future of Cities" in Mobility 2050. A vision for transportation infrastructure. Ch. 9, p, 109-135. (Canvas)

Assignment 7 – Position paper – Is a walkable/bikeable community the result of culture or design?

9. **Nov. 15 – NO CLASS**

10. **Nov. 23 - Social equity & Limitations of reason**

Readings:

- E. Kolbert (2017). Why facts don't change our minds, *New Yorker, 2/27/17;* https://www.newyorker.com/magazine/2017/02/27/why-facts-dont-change-our-minds
- J. Svara et al. (2015). Advancing social equity as an integral dimension of sustainability in local communities, *Cityscape*, 17: 2:139-166; https://www.jstor.org/stable/pdf/26326943.pdf
- K. Takai (2014). Pursuing sustainability with social equity goals, ICMA, https://icma.org/articles/pm-magazine/pursuing-sustainability-social-equity-goals
- N. Dempsey et al. (2009). The social dimension of sustainable development: Defining urban social sustainability, Sustainable Development, DOI: 10.1002/sd.417; https://onlinelibrary.wiley.com/doi/epdf/10.1002/sd.417

Assignment 8 – Your opinion – Is it important to evaluate the social equity of sustainability policies? Why is it so challenging to convince people that this is important?

11. **Nov. 29– Class Presentations (4)**

12. **Dec. 9 (Friday)– Class Presentations (4) – 12 - 2 pm**

Written final reports – Friday, December 9th 5 pm.