Duke | NICHOLAS SCHOOL of the ENVIRONMENT

Transportation and Energy

ENVIRON/ENERGY 630—Fall 2020

Discussions Sections Tuesday or Thursday, 3:30 to 4:45 in Grainger Hall 1112 (Field Auditorium)
Lectures Online Asynchronously

Instructor

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Teaching Assistant

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Course Description and Objectives

While our standard of living relies on affordable and independent mobility, our current transportation system produces environmental, economic, and social stresses that in turn pose challenges to its long-term viability. The movement of people and goods in the US, for instance, relies on petroleum for more than 90% of its energy needs and is responsible for nearly one-third of the country's greenhouse gas (GHG) emissions. In addition, transportation continues to have significant impacts on urban air quality and, through its interaction with land use, negatively affects water resources and ecosystem services. Beyond these concerns, the policy, planning, and environmental communities often link our current transportation system to a variety of negative social, health, and economic outcomes—most of which are due to our dependence on the automobile. And yet transportation as we have come to know it in the US supports a lifestyle with numerous benefits, and one to which people around the world aspire. As demand for mobility continues to increase worldwide, the challenge going forward will therefore be to develop transportation options that preserve the best of what works today while reducing negative impacts to sustainable levels.

This class focuses on an important piece of this challenge by examining transportation-related energy use and its impact on the environment. Understanding the transportation-energy linkage requires an awareness of how technology, infrastructure, and policy, as well as personal and cultural preferences, affect mobility demand. You will gain familiarity with each of these dimensions and their interactions through the study of: historical and current transportation trends, existing and emerging vehicle designs and fuel pathways, urban form and public transit, infrastructure planning and operation, and local to national policy frameworks. Cutting across these themes will be consideration of strategies to reduce transportation energy use and its environmental impacts, and the course will introduce information resources and tools for evaluating both. Finally, the class will provide you with opportunities to hone your problem solving and analytical skills, and will challenge you to think critically and creatively about the complex trade-offs among transportation options.

By the end of the semester, you will be able to:

- Describe historical and contemporary trends in global transportation demand and energy use, as well as related environmental impacts
- Explain the economic, social, and cultural factors that shape demand for personal mobility and freight movement
- Evaluate claims regarding the extent to which vehicle design changes, alternative fuel use, and urban planning strategies might reduce transportation energy use and GHG emissions
- Critique *and design* comprehensive strategies to reduce long-term transportation energy use and GHG emissions
- Locate transportation information and data resources, apply publicly available assessment tools, and perform basic scoping calculations related to transportation energy use and its environmental impacts

Course Format

This is a hybrid class. Each week I will post a series of recordings to Sakai that provide background content and supplement the assigned readings. We will use our scheduled class time for discussion of this material, small group problem solving, and other participatory exercises. The course will wrap up with presentations of your project work.

BUT! We need to be ready for anything this semester, including the possibility that the class will go entirely online at some point if regional and campus conditions warrant such a move, or if one or more of us in the class tests positive for COVID. Let's hope that doesn't happen, but we will adapt if it does.

I also ask that you remain flexible. I'm actually excited to try this class format, but it is an experiment and we may decide to make changes along the way if other means of achieving the course goals and learning outcomes look like they will be more successful.

Respect for Diversity and Honest Analysis

Transportation is inseparable from our daily lives and our lifestyle choices. Mobility needs, preferences, and options also vary regionally and across cultures. Hence, many of the topics we will cover have both a political and personal subtext and some of you may even arrive with strong opinions about the past, present, and future of transportation and all that it affects. My goal is to help you reason through the complexities of how we might balance conflicting societal goals that require more than technical problem solving or idealistic visions of how cultural change occurs. I also understand the temptation to see the issues we will encounter this semester in either-or terms (e.g., "cars are bad", "suburbs are worse"). While I will respect the individual conclusions you reach, I ask that you *lead with evidence and analysis rather than opinion* and will try to model this behavior in class. In short, let's strive to be honest brokers and respect differences in personal and cultural preferences. The fact that we come from many different places is an asset in a class on transportation, and I will draw on the diversity of your backgrounds as a valued resource.

Beyond that, I teach because I like spending time with students. If you all looked, felt, and thought like me it wouldn't be nearly as much fun and I wouldn't learn nearly as much as I continue to do after many years in the classroom. I enjoy getting to know you as individuals and will do whatever I can to create a comfortable environment in which we can all be challenged and learn together.

Prerequisites

This course does not have formal prerequisites. All students who are interested in the connection between transportation, energy use, and the environment are welcome.

Coursework and Grading

Your grade will be based on the following:

Assignments	35% (6 assignments)
Team Project	40% (all group members receive the same grade)
Lecture Quizzes	15%
Class Participation	10%

I will use the following rubric to translate cumulative scores into final grades:

[99 to 100]	A+	[80 to 83)	B-
[93 to 99)	A	[77 to 80)	C+
[90 to 93)	A-	[73 to 77)	C
[87 to 90)	B+	[70 to 73)	C-
[83 to 87)	B	Below 70	F

Assignments will consist of a mix of quantitative problem solving and reflective writing, and must be uploaded to Sakai by the posted deadline (see below for policy on late assignments). Due dates follow, though note that these are subject to change. **The assignments are to be completed individually. You may discuss assignment questions with your colleagues, but the work you submit must be your own (per the Duke Community Standard).**

Assignment	Due Date
1	27 Aug
2	10 Sep
3	24 Sep
4	08 Oct
5	22 Oct
6	12 Nov

The ***team project*** will give you a chance to synthesize and apply what we have learned in class. Working in groups of three, you will construct a scenario of how a country or region (e.g., state, province, or metropolitan area) of your choosing can achieve a 50% reduction in its annual transportation-related energy or greenhouse gas emissions by 2035, relative to a business as usual projection. I will provide specific details about the project and my expectations at the start of the semester. In short, you will need to consider all relevant factors (technology, economics, policy, and regulation, as well as social, cultural, and behavioral issues) and their interactions, though you are free to emphasize those strategies and approaches that you feel are most promising. You will need to back up your vision with solid analysis; and while this is meant to be a creative exercise, you will need to be realistic (i.e., you cannot rely on radical assumptions about technological breakthroughs or changes in human nature). Products include a preliminary baseline analysis due October 26, a presentation the last week of classes (either November 10 or 12), and a write-up due November 16.

Each recorded lecture will contain one or more embedded PlayPosit questions. These ***lecture quizzes*** will be graded pass/fail and all must be completed for full credit. This portion of your grade will be scaled by the percentage of quizzes that you complete. For instance, if you submit 80% of the quizzes, they will contribute 0.80 * 100 points * 0.15 = 12 points to your final class score, rather than the 15 point maximum.

Class participation will be based on attendance, contribution to class discussions, and evidence of having prepared for class. The more interactive the class is, the more we will all get out of it.

Policy on late assignments and absences

All assignments and reading summaries/discussion questions must be uploaded to Sakai by the deadline on the posted due date. Assignments handed in after the deadline will incur a 25 point penalty for each 24 hour period they are late (i.e. from 5:00pm to 5:00pm the next day). **Assignments submitted more than 3 days (72 hours) after the posted due date will not receive credit**.

If you know of conflicts with the assignment and project deadlines that will affect a majority of the students, please let me know in advance. I will make due date exceptions only for serious illnesses and personal emergencies.

Undergraduates: If you are sick and cannot complete assigned work, please contact me and submit a Short-Term Illness Notification Form (STINF) at: https://trinity.duke.edu/undergraduate/academic-policies/illness. The website provides instructions, but note the following text: **"**Definition of Incapacitation: An incapacitating health issue is one in which you are hospitalized, under medical care for a short-term condition, or otherwise sufficiently debilitated as to be unable to perform basic academic tasks. Colds, headaches, or other such mild complaints that result in your feeling less than 100% are not considered incapacitating, and you should not use the Incapacitation Form in such instances." In the event of something even more serious, of course, I will make every effort to accommodate your situation.

Grad students: If you are sick and cannot complete assigned work, please contact me. If your illness will affect multiple classes and you are a Nicholas School MEM or MF, you should also notify Cynthia Peters, Nicholas School Assistant Dean Student Services, at petersca@duke.edu or 919-613-8071.

Readings

Readings are available on Sakai or via web links to public documents and information resources (we will not use a separate textbook). The schedule below lists reading assignments, which you must complete prior to each day's class. I may also assign additional readings based on your interest in related topics.

Note that the readings are intended to introduce a variety of viewpoints, some contradictory, and not all of which I share. Your job is to read critically and use the factual basis we develop in class to reach your own conclusions about the issues we discuss.

Sakai

If you are registered for the class, you will have complete access to our Sakai website. All course materials, including this syllabus, recorded lectures, assignments, and readings, are available on Sakai.

Classroom Etiquette

Please arrive on time and refrain from checking email and social media, texting, and websurfing while we are together. These activities are more obvious that you might think, and I will not hesitate to cold call anyone who appears to be using their device for anything other than notetaking or researching the occasional discussion question. If I feel that electronic media are becoming too much of a distraction, I will ask you to turn off and store all phones, tablets, and laptops during class.

Safety Measures

While I am excited to be in the classroom this fall, *all of us* (including me) will need to observe several rules to keep us safe:

- Each of us must be cleared to come to campus each day
- Each of us must wear a mask in the classroom at all times
- You must attend the discussion section for which you are registered and may not move between sessions, even for a single week in which you might have a conflict
- You may not eat or drink in the classroom
- You should clean your desk area before and after class with the solution provided
- You must sit in designated seats
- All of us must maintain social distance (i.e. a minimum 6 foot separation) from each other at all times
- We all must follow the other terms of the Duke Compact as they pertain to classroom activity
- We all should do our best to maintain a sense of humor about this situation ☺

My Expectations of You

This is your course. At minimum, I expect you to attend class and be an active participant, which, in turn, requires that you prepare for each class in advance, having completed the readings and other assignments. I also expect you to have an open mind, but to think critically and use what we learn in making your own judgments.

In addition, if you have suggestions on how to improve the course, please let me know. Feedback received midstream can be more useful (to you and me) than end-of-term evaluations, and I am happy to make reasonable changes if a majority concurs.

What You Can Expect from Me

I'm here to help you learn. I appreciate the diversity in your backgrounds, interests, learning styles, and analytical strengths, and have tried to design the course to accommodate these differences while providing opportunities to help you develop in new areas. Again, I appreciate feedback. I'm available during my office hours if you have questions about the class (or life in general), and am happy to find mutually agreeable times outside of these windows to meet. Just let me know what works best for you.

Nicholas School Honor Code and the Duke Community Standard

All activities of Nicholas School students, including those of you in this course, are governed by the Duke Community Standard (https://integrity.duke.edu/new.html), which states:

"Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit

to reflect upon and uphold these principles in all academic and nonacademic endeavors, and to protect and promote a culture of integrity.

To uphold the Duke Community Standard:

• I will not lie, cheat, or steal in my academic endeavors;
• I will conduct myself honorably in all my endeavors; and
• I will act if the Standard is compromised."

Please add the following affirmation to the end of all assignments and your projects, and sign your name beside it: "I have adhered to the Duke Community Standard in completing this assignment."

The Nicholas School Honor Code (https://nicholas.duke.edu/about/policies/nicholas-school-honor-code) describes implementation of the Duke Community Standard and its terms govern violations related to this class.

Topic and Reading Schedule

This schedule below is subject to change, and I may modify it as we go along if extra time is needed (or desired!) for particular topics. I'll provide updates to the schedule in class and via email.

Week 1
Aug 18/20

Transportation trends: Historical perspectives and current issues; Transportation demand: Factors affecting activity and preferences

Reading

- Pages 23 to 43 from Chapter 2 (The Global Demand for Passenger Travel) of: Andreas Schäfer, John B. Heywood, Henry D. Jacoby, Ian A. Waitz (2009). Transportation in a Climate-Constrained World. Cambridge, MA: MIT Press. Available through the Duke Library at https://ieeexplore-ieee-org.proxy.lib.duke.edu/book/6267203
- Chapter 3, pages 25 to 56 (Vehicle Demand) from MIT Energy Initiative (2019). Insights into Future Mobility. Cambridge, MA: MIT Energy Initiative. http://energy.mit.edu/insightsintofuturemobility

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Week 2 **Aug 25/27**	**Technology change; Petroleum overview; CAFE standards** **Introduce project** **Assignment 1 due Thursday, August 27 by 5:00 pm EDT** *Reading* • Chapter 2 (Gasoline and Oil) from: Martin, Jeremy (2016). Fueling a Clean Transportation Future: Smart Fuel Choices for a Warming World. Cambridge, MA: Union of Concerned Scientists. https://www.ucsusa.org/resources/fueling-clean-transportation-future • Pages 61 to 68 from Robin Cowan and Staffan Hultén (1996). Escaping Lock-in: The Case of the Electric Vehicle. Technological Forecasting and Social Change 53(1):61–79. https://www.sciencedirect.com/science/article/pii/0040162596000595 • *Optional*: US Department of Energy, Energy Information Administration (n.d.). Energy Explained: Your Guide to Understanding Energy. Oil and Petroleum Products sections. https://www.eia.gov/energyexplained/
Week 3 **Sept 1/3**	**Light duty vehicle: Design and other factors affecting efficiency, power, and energy requirements** *Reading* • Pages 103 to 118 and 125 to 130 from Chapter 4 (Road Vehicle Technology) of: Andreas Schäfer, John B. Heywood, Henry D. Jacoby, Ian A. Waitz (2009). Transportation in a Climate-Constrained World. Cambridge, MA: MIT Press. Available through the Duke Library at https://ieeexplore-ieee-org.proxy.lib.duke.edu/book/6267203 • Richard P. Larrick and Jack B. Soll (2008). The MPG Illusion. Science 320(5883):1593-1594. http://science.sciencemag.org/content/320/5883/1593.full

Week 4 **Sept 8/10**	**Light duty vehicles: Internal combustion engines, how to improve conventional vehicle design** **Assignment 2 due Thursday, September 10 by 5:00 pm EDT** *Reading* • Section 1 (Introduction, pp. 268 to 275) from Timothy E. Lipman (2017). Emerging Technologies for Higher Fuel Economy Automobile Standards. Annu. Rev. Environ. Resour. 42:267–88. https://doi.org/10.1146/annurev-environ-110615-085844. • *Optional*: Chapters 2, 3, and 4 (pages 9 to 62) from: John Heywood and Don MacKenzie (Editors) (2015). On the Road toward 2050: Potential for Substantial Reductions in Light-Duty Vehicle Energy Use and Greenhouse Gas Emissions. MIT Energy Initiative Report. Cambridge, MA: Massachusetts Institute of Technology. http://energy.mit.edu/publication/on-the-road-toward-2050/
Week 5 **Sept 15/17**	**Emerging transportation energy pathways: Electric vehicles** *Reading* • Chapter 1 (Trends in electric mobility, pp. 39 to 85) and Chapter 4 (Batteries: An essential technology to electrify road transport, pp. 185 to 225) from IEA (2020). Global EV Outlook 2020: Entering the decade of electric drive?. Paris: IEA, https://www.iea.org/reports/global-ev-outlook-2020
Week 6 **Sept 22/24**	**Emerging transportation energy pathways: Electric vehicles (continued)** **Assignment 3 due, Thursday September 24 by 5:00 pm EDT** *Reading* • See Week 5

Week 7 **Sept 29/Oct 1**	**Emerging transportation energy pathways: First-generation and second-generation biofuels, hydrogen, and other alternative fuels** *Reading* • Dennis Keeney (2008). Ethanol USA. Environmental Science & Technology 43(1):8-11. https://pubs.acs.org/doi/abs/10.1021/es8016182 • Pages 10-11, 35-38, and 48-60 from International Energy Agency (2017). Technology Roadmap: Delivering Sustainable Bioenergy. https://www.ieabioenergy.com/publications/technology-roadmap-delivering-sustainable-bioenergy/ • Pages 31 to 36 and 124 to 143 from International Energy Agency (2019). The Future of Hydrogen: Seizing Today's Opportunities, Report prepared by the IEA for the G20, Japan, https://www.iea.org/reports/the-future-of-hydrogen • *Optional*: Robert F. Service (2014). Stepping on the Gas. Science 346(6209): 538-541. DOI: 10.1126/science.346.6209.538. http://science.sciencemag.org/content/346/6209/538.full

Week 8

Oct 6/8

Urban design: Mobility, behavior, zoning, and suburbia; Urban form and mobility demand, alternatives to sprawl

Assignment 4 due Thursday, October 8 by 5:00 pm EDT

Reading

- Robert Fishman (2017). The Divided Metropolis: The Suburb and the Explosion of Global Urbanization. In Infinite Suburbia, ed. By Alan M. Berger and Joel Kotkin, with Celina Balderas Guzman, NY: Princeton University Press, pp. 38 to 50.
- Pages 1 through 54 from Todd Litman (2020). Land Use Impacts on Transport: How Land Use Factors Affect Travel Behavior. Victoria Transport Policy Institute. https://www.vtpi.org/landtravel.pdf
- Chapter 11 (Federal Subsidy and the Suburban Dream: How Washington Changed the American Housing Market) from Jackson, Kenneth T. (1985). Crabgrass Frontier: The Suburbinzation of the United States. NY: Oxford University Press, pp. 190 to 218.
- Chapter 9 (Cities on the move: global exemplars of more sustainable transportation) from: Shiller, Preston L. and Kenworthy, Jeffery R. (2018). An Introduction to Sustainable Transportation: Policy, Planning, and Implementation, Second Edition. NY: Earthscan (Routledge), pp. 290 to 336.

Week 9 **Oct 13/15**	**Urban design: Alternatives to sprawl, sustainable planning paradigm; Alternative modes, public transit; Critique of design strategies** *Reading* • William J. Mallett (2018). Trends in Public Transportation Ridership: Implications for Federal Policy. Washington, DC: Congressional Research Service, Report R45144. https://crsreports.congress.gov/product/pdf/R/R45144 • UITP (2017). (Statistics Brief:) Urban Public Transport in The 21st Century. Brussels: Union Internationale des Transports Publics (International Association of Public Transport) https://www.uitp.org/urban-public-transport-21st-century • Mark R. Stevens (2017). Does Compact Development Make People Drive Less? Journal of the American Planning Association, 83(1):7-18, DOI:10.1080/01944363.2016.1240044 https://www.tandfonline.com/doi/full/10.1080/01944363.2016.1240044 • *Optional for those who want to learn more about transportation planning:* Selections from Chapter 5 (The Urban Transportation Planning Process by Robert A. Johnson, pp. 115-134 only) from: Susan Hanson and Genevieve Giuliano (eds.) (2004). The Geography of Urban Transportation (Third Edition). NY: The Guilford Press.

Week 10

Oct 20/22

The future of personal mobility: Intelligent transportation systems, autonomous vehicles

Air travel

Assignment 5 due Thursday, October 22 by 5:00 pm EDT

Reading

- Executive Summary from Lew Fulton, Jacob Mason, and Dominique Meroux (2017). Three Revolutions in Urban Transportation. New York: Institute for Transportation and Development Policy and The University of California Davis Institute of Transportation Studies. https://www.itdp.org/2017/05/03/3rs-in-urban-transport/
- Pages 1 through 15 from Scott Corwin, et al. (2015). The future of mobility: How transportation technology and social trends are creating a new business ecosystem. Deloitte University Press. https://www2.deloitte.com/content/dam/Deloitte/ru/Documents/manufacturing/dup-future-of-mobility.pdf
- Richard Ezike, et al. (2019). Where Are Self-Driving Cars Taking Us? Washington, DC: Union of Concerned Scientists, https://www.ucsusa.org/resources/where-are-self-driving-cars-taking-us
- *Optional:* Zia Wadud and Jillian Anable (2016). Automated Vehicles: Automatically Low Carbon? London: Institution of Mechanical Engineers. https://www.imeche.org/policy-and-press/reports/detail/automated-vehicles-automatically-low-carbon
- Andreas W. Schäfer, Antony D. Evans, Tom G. Reynolds, and Lynnette Dray (2015). Costs of Mitigating CO2 Emissions from Passenger Aircraft. Nature Climate Change 6:412-417, doi:10.1038/nclimate2865 https://www.nature.com/articles/nclimate2865

Week 11

Oct 27/29

Transportation Life Cycle Assessment; Moving things: Freight vehicle and logistics design

Preliminary project work due Monday, October 26 by 11:59 pm EDT (email to Tim)

Reading

- Kaack, Lynn H. et al. (2018). Decarbonizing Intraregional Freight Systems with a Focus on Modal Shift. Environmental Research Letters 13, https://doi.org/10.1088/1748-9326/aad56c
- Carrie Denning and Camille Kustin (2015). The Good Haul: Innovations That Improve Freight Transportation and Protect the Environment. New York: Environmental Defense Fund. http://www.edf.org/sites/default/files/10881_EDF_report_TheGoodHaul.pdf
- P. van Loon, A.C. McKinnon, L. Deketele, and J. Dewaele (2014). The Growth of Online Retailing: A Review of its Carbon Impacts. Journal of Carbon Management 5(3):285-292, DOI:10.1080/17583004.2014.982395 https://www.tandfonline.com/doi/full/10.1080/17583004.2014.982395
- *Optional*: Mikhail V. Chester and Arpad Horvath (2009). Environmental assessment of passenger transportation should include infrastructure and supply chains. Environ. Res. Lett. 4 (2009) 024008 (8pp), doi:10.1088/1748-9326/4/2/024008 http://iopscience.iop.org/article/10.1088/1748-9326/4/2/024008/meta

Week 12 **Nov 3/5**	**Wrap up: Other environmental impacts of transportation; Climate impact on transportation; Transportation policy revisited** *Reading* • Chapter 6 (Policies for Reducing GHG Emissions from and Petroleum Use by Light-Duty Vehicles, pp. 131-151) from: National Research Council (2013). Transitions to Alternative Vehicles and Fuels. Committee on Transitions to Alternative Vehicles and Fuels; Board on Energy and Environmental Systems; Division on Engineering and Physical Sciences; National Research Council. Washington, DC: National Academies Press. https://www.nap.edu/catalog/18264/transitions-to-alternative-vehicles-and-fuels • Shanjun Li, Jianwei Xing, Lin Yang, Fan Zhang (2020). Transportation and the Environment in Developing Countries. Annual Review of Resource Economics 12:10.1–10.21. https://doi.org/10.1146/annurev-resource-103119-104510
Week 13 **Nov 10/12**	**Project Presentations** **Assignment 6 due Thursday, November 12 by 5:00 pm EDT** **Project write-ups due Monday, November 16 by 11:59 pm EDT (email to Tim)**