

Course Syllabus – DRAFT

ISEN 422 Electrify Everything: Beneficial Electrification, EVs and Beyond
Winter 2020

Northwestern University

Course Synopsis

This class introduces the concept of beneficial electrification -- the idea that switching from fossil energy to electricity in transportation and buildings holds tremendous potential to dramatically increase grid flexibility, reduce total household and business energy costs, and reduce air pollution and greenhouse gas emissions. We will explore the emerging state of electricity consumption and review how it relates to changing transportation markets.

Course Goals

- Build a foundation of understanding about beneficial electrification & its impact on energy markets
- Set a baseline knowledge level about electric vehicle technology, products and EV charging
- Understand the opportunities and risks associated with the emerging trends around beneficial electrification, electric vehicles, electric vehicle charging infrastructure, and impacts to popular services such as ridesharing and emerging technologies such as autonomous vehicles.

Students interested in energy, new technology and transportation should consider this course. It will also appeal to students intrigued by material market shifts that will impact greenhouse gas emissions and global warming. Those who may want to explore a career in transportation, sustainability and energy should find the seminar helpful in preparing for many types of professions across disciplines.

Students will be exposed to topics such as evolving business models, GHG emissions, vehicle supply change, the electric grid, electrification options and EV technology. A common theme throughout the quarter will be the changing nature of the electric grid and the demands of the users of the grid. It will be up to participants to identify emerging issues and an opportunities associated with this evolution and their impact on society.

This will **not** be a seminar grounded in heavy technical economic and financial analysis or market theory. You will not need an academic background in engineering or materials science to understand the topics of the class. No pre-requisites are necessary.

Because students are not expected to have previous knowledge of these topics, the reading list is significant. Students are expected to complete readings prior to class. Please refer to the reading list for primary texts that will be used for the class. There will also be supplemental readings, including articles and essays, that will be provided by the instructor.

As part of the class, we will have a series of guest panels and lectures by business professionals from a variety of major players in the EV space, including car manufacturers, EV charging companies, utilities,

rideshare / car share companies and software businesses. Speakers will include engineers, utility professionals, startup CEOs and other business executives.

Required Readings

The following readings are required for the class. Other articles and essays will be updated upon class scheduling.

- Seba, Tony. Clean Disruption of Energy and Transportation: How Silicon Valley Will Make Oil, Nuclear, Natural Gas, Coal, Electric Utilities and Conventional Cars Obsolete by 2030 , May 20, 2014.
- Bakke, Gretchen. The Grid. Reprint, July 11, 2017
- Gowrishankar, Vignesh. “Beneficial Electrification: Plug In for the Greener Grid!” National Resources Defense Council. *NRDC Blog*. September 27, 2018.¹
- Bade, Gavin. “The oil industry vs. the electric car”. Politico, September 16, 2019. ²

- Electrification: Emerging Opportunities for Utility Growth, The Brattle Group
- Environmentally Beneficial Electrification: Electricity as the End-Use Option, *The Electricity Journal*
- Environmentally Beneficial Electrification: The Dawn of ‘Emissions Efficiency,’ *The Electricity Journal*

Supplemental Reading List

The following readings are optional research on clean energy, advanced transport, digital industry, innovative materials, and commodities.

- <https://about.bnef.com/electric-vehicle-outlook/>
- <https://www.navigantresearch.com/research-solutions/electric-vehicles>
- Beneficial Electrification and Energy Efficiency Policy, ACEEE. ³

Course Grading:

Area	Weighting	Timing
Class Participation	20%	Ongoing
Papers (x2) roughly 3-5 pages	40% (20% for each paper)	Week #3, #7

¹ <https://www.nrdc.org/experts/vignesh-gowrishankar/beneficial-electrification-plug-greener-grid>
² <https://www.politico.com/story/2019/09/16/oil-industry-electric-car-1729429>
³ <https://aceee.org/sites/default/files/electrification-dc.pdf>

Final Paper & Presentation	40% (20% on paper, 20% on presentation)	
Total	100%	

Grading Policy:

- 10% will be deducted from late homework assignments turned in within 24 hours of the deadline. 50% will be deducted from late homework assignments that are more than 24 hours but less than 7 days late. No credit will be given for homework turned in more than 7 days after the deadline.
- All questions and problems regarding grades must be presented in writing within one week after the test, homework, or project has been returned. Grades will be assigned based on all the work you have completed during the semester following the traditional practice of A=90-100, B=80-89, C=70-79, D=60-69, F<60.

Class Schedule - DRAFT

Weekly Topic	Description
<p>1: <i>Business Models and Beneficial Electrification</i></p>	<ul style="list-style-type: none"> • Course Introduction and Expectations • Fundamentals of Beneficial Electrification (BE) • Key business models & stakeholders in BE • Brief Discussion: Transportation 101 -- basic business economics, regulation • Utility readiness for increased electrification (transportation, other) • Current electric utility barriers requiring resolution
<p>2: <i>Carbon / GHG Impact of electrification</i></p>	<ul style="list-style-type: none"> • Scale – How big of an impact does BE have on climate? How does it split out for various “measures” (heating, cooling, water, electric transportation?) • Variability – What are the regional / other variations in carbon impact? • Stakeholders & Incentives – Who cares about carbon / GHG? Why? anyone opposed to BE? Who and why? • Barriers – What are the challenges associated with beneficial electrification?
<p>3: <i>The Evolution of Transportation</i></p>	<ul style="list-style-type: none"> • Rail • Sea • Air • Road <p>Opinion Paper #1 Due at beginning of class: <i>Is beneficial electrification a viable path to address climate change? Why / why not?</i></p>
<p>4: <i>Fundamentals of EV cars</i></p>	<ul style="list-style-type: none"> • Global Trends – what are the global trends on cars? How does that impact the N. American market? • Paris Climate Accord, California, 2030 Districts • Customer Experience & Education – how do drivers learn about EVs? What tools do dealers and other stakeholders offer to help buyers understand the value proposition? • Regulation / Market Incentives – what impact do EVs have on GHG / energy efficiency? How are tax credits and other incentives structured to get people into cars? • Technology – how have EVs evolved? How is the newest Honda different than the first generation Leaf? What does the roadmap for EVs look like?
<p>4: <i>Fundamentals of EV charging & utility distribution</i></p>	<ul style="list-style-type: none"> • Technology – what are the types of EV chargers? Who makes them? How many companies are out there? • Business Models & Costs – who owns chargers? What does EV charging cost?



	<ul style="list-style-type: none"> • Regulation – who is allowed to own EV charging? How is it regulated? Does it vary state to state?
<p>5: Economics of Electrification & EV markets</p>	<ul style="list-style-type: none"> • Economics – for private owners & rideshare drivers – do EVs make sense? • The EV value chain – who makes money? How? • The EV charging value chain – who makes money? How? • Who will fund EV charging infrastructure? <ul style="list-style-type: none"> ○ Environmental Mitigation Trust ○ Electrify America ○ Utility Filings ○ DOT ○ Private / non-profit funds
<p>6: Technology of EV markets (cars & charging)</p>	<ul style="list-style-type: none"> • How do PHEVs / EVs work? What is different from ICE? • How do chargers work? How are the wall chargers different from chargers in cars or charging pads? • What technologies are in development? • What is the relative importance of SW vs HW for both cars and charging?
<p>7: Adjacent Trends in Transportation: Electric Mobility, Connected Mobility, Autonomous Mobility</p>	<ul style="list-style-type: none"> • Ride Share • Car Share • Autonomous • Other solutions such as Lillium, air taxi service <p>Opinion Paper #2 Due at beginning of class: <i>What is the most disruptive component of the EV market for the economy, regulation or social norms / consumers?</i></p>
<p>8: Electric Heating & other BE technologies</p>	<ul style="list-style-type: none"> • Heating • Hot Water • Other Shifts • Supporting technology needed for BE • Review of expectations for final presentations on Risks & Opportunities in Beneficial Electrification
<p>9: Presentations - Risks & Opportunities in Beneficial Electrification</p>	<p>Heavy class discussion – each student team should be prepared to give an oral presentation on a major risk or opportunity (linked to their paper – x6 presentations of 25 min each including Q&A)</p>
<p>10: Presentations - Risks & Opportunities in Beneficial Electrification</p>	<p>Remaining presentations (x3 @ 25 min each) BREAK Class wrap up</p>

