



## MGMT 7230X: STRATEGY AND ENVIRONMENTAL SUSTAINABILITY

Fall 2024 (Q2)

v. 9/10/24

### SYLLABUS

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Environmental sustainability issues are one of the defining problems of our time. While governments and NGOs will have to play important roles, without active involvement of businesses, it will be impossible to make sufficient progress on these issues. Globalization and Digitization have been two major disruptive developments that organizations have faced (and are still facing). ESG (Environmental, Social, and Governance) issues are the latest large-scale development that will shape companies' futures. This course will focus on the "E" of ESG. As with any large change, environmental sustainability poses significant business challenges but also tremendous opportunities. We will study these issues both from the perspective of incumbent firms that have to adapt their business practices and from firms (incumbents and new start-ups) that will take advantage of the new opportunities that are being created.

As this subject matter is changing rapidly, this course will have a large emphasis on "co-creation" of knowledge. Students will be engaged not only in absorbing knowledge about the topic of environmental sustainability, but also in actively gathering and disseminating knowledge to the class. In particular, each student will be part of a small team and each team will give a short presentations on a particular topic at the beginning of a specific class.

On the Canvas site, with the help of Penn Library, I have created a tab called Course Materials @ Penn Libraries (CM@PL), where I have collected a number of additional readings for each of the topics we cover in class (see the Additional Reading list at the end of the syllabus). If you're interested in a particular topic, please feel free to dig deeper into it. Over time, I hope we can add to this resource with readings that you suggest (in part through your research for the team presentations).

Your grade will be composed of an individual final paper (46%), a team presentation (15%), two short individual assignments (4%), and class participation (35%). In order to pass this class, you have to make a good-faith effort with respect to class attendance, participation and the paper.

**Please remember to check in to class using the aplus+ attendance app.** For details on the app, please see: <https://support.wharton.upenn.edu/help/aplus-canvas-students>. If you need to miss a class, it is mandatory to report this using this app. Students with excused absences will be provided access to class recordings. For requesting class recordings, please

see: <https://support.wharton.upenn.edu/help/class-recording-permissions-for-students>. If you have more than one unexcused absence, it will likely affect your grade. Following Wharton policy, absences are excused for personal illness, personal or family emergencies, and religious holidays.

**Electronics policy:** After you have checked in, please put your phones into your bag. When we have student presentations, or guest speaker presentations and Q&A, please close your laptops. During other class time, the use of laptops to pull up your notes, cases, or to take notes is permitted.

Please note that this syllabus is subject to change with prior announcements. All slides will be posted after each class on Canvas.

The TAs for this class are Brittany Mallory ([bmallory@wharton.upenn.edu](mailto:bmallory@wharton.upenn.edu)) and Emily Ulrich ([emulrich@wharton.upenn.edu](mailto:emulrich@wharton.upenn.edu)).

### **A short note on proper citations**

To most of you this will be probably self-evident, but I want to make sure that we all understand: Copying content from sources (magazine, newspaper articles, analyst reports etc.) without properly citing them is a SERIOUS offense! Properly citing means: if you copy word-by-word, you have to mark this by enclosing the copied text with quotation marks “ “ and citing the source. Even if you don’t copy word-by-word, but you take someone else’s idea, you have to indicate in a citation the source of that idea. This citation has to follow directly the idea (attach a footnote or an endnote). At the end of the paper, you should then list all sources that you have cited in the text.

Let me re-iterate: Non-proper citing is a very serious academic offense that in other courses has led professors to fail students and bring these students to the attention of Wharton’s Ethics Committee. I think all of us want to avoid any such incident – and it is really easy to avoid such problems. Simply be careful in your papers that you attribute ideas/frameworks etc. that you use to their respective sources.

### **GENERATIVE AI/CHATGPT POLICY**

If you think it’s helpful, you may use chatGPT or other generative AI tools (at your own peril). In the words of our colleague Ethan Mollick, “[chatGPT] is a consummate bullshitter, and I mean that in a technical sense. Bullshit is convincing-sounding nonsense, devoid of truth, and AI is very good at creating it.” The problem with chatGPT is that it will happily make up facts, does not reveal its sources, and/or make up sources (MLA formatted!). In other words, whenever it provides you with a “fact” assume it’s wrong unless you can double check it with another (more reliable!) source. If you copy AI-generated content and use it verbatim, you need to cite it as you would if you had copied content from another source. If you decide to use chatGPT (or another tool) please add one short paragraph at the end of your paper (which will not count against your word count) and describe how and for what purpose you used it (e.g., include the prompts you used).

### **Individual final paper (Due 12/15 at noon)**

Select a firm that has engaged in a significant initiative around environmental sustainability. The “significant initiative” might be a new product or service offering, or a major modification of internal processes. It could also be the entire firm, if it is a start-up. The main idea is to analyze this initiative from a strategic perspective. To address the following questions, use whatever tools and frameworks we discussed in class that will help you make your point:

1. Briefly describe the strategic initiative.
2. What is the overarching strategy of the firm?
3. What environmental issue does this initiative address? Why is this an important issue?
4. How does the initiative address the environmental issue? What domains of actions are involved?
5. What is the effect of the initiative on WTP of the firm’s customers? What specific drivers of WTP are involved? For which customer segments would we expect the biggest impact?
6. What is the effect of the initiative on cost?
7. Does this initiative help the firm create a competitive advantage?
8. How sustainable is this advantage?
9. What are the risks of this initiative?

Please keep the maximum of the paper to 10 pages of text (plus 2-3 pages of exhibits if needed). Please use double spacing and 12 point font.

**Team presentations:**

At the beginning of the semester, you will sign up (first-come-first-serve) to be a part of a 3-student team to work on one of the following topics. Each team will present at the beginning of a particular class for 10 minutes. The presentation should start with a short overview of the environmental “problem” in the particular sector. Then, you can provide short examples of incumbent or new firms innovating with respect to sustainability in that space and highlight some of the challenges each firm/innovation is facing. Each team will also create an annotated reading list so that others can dig deeper into this topic if they would like to. (Please add one or two sentences providing a summary or description of each reading.)

1. Existing and upcoming E(SG) regulations and support (esp. IRA, CSRD)(Session 3)
2. Innovations around carbon sequestration (Session 3)
3. Plant and cell-based meat/dairy innovations (Session 4)
4. Innovations around reducing food waste (Session 4)
5. Innovations in fashion/clothing (Session 5)
6. Innovations with respect to sharing economy/extending product use (Session 5)
7. Innovations around steel (Session 6)
8. Innovations in urban design/green cities (Session 6)
9. Innovations in cars (Session 7)
10. Innovation around hydrogen and other non-battery energy storage (Session 8)
11. Innovations in trucks/buses/logistics (Session 8)
12. Innovations in aviation (Session 8)
13. Innovations in solar energy (Session 9)
14. Innovations in wind energy (Session 9)
15. Overview of ESG ratings and initiatives (esp. Science Based Targets) (Session 10)
16. Innovations in cargo ships/cruise boats (Session 11)
17. Innovations around plastics (Session 11)
18. Innovations in packaging (Session 11)
19. Innovations in cooling (buildings/servers) (Session 12)
20. Innovations around the electric grid/smart meters (Session 12)

## 10/21 Session 1: Course Logistics, Strategy Fundamentals

Michael Porter and Forest Reinhardt. 2007. “A Strategic Approach to Climate,” *Harvard Business Review*, October.

Michael Porter and Mark Kramer. 2011. “Creating Shared Value.” *Harvard Business Review*, January-February.

Rebecca Henderson, 2020. “Climate Change in 2020: Implications for Business” 9-320-087

Johan Rockström et. al. 2009. “A safe operating space for humanity” *Nature*, 461, September.

Optional:

Michael Porter and Class van der Linde. 1995. “Green and Competitive: Ending the Stalemate,” *Harvard Business Review*, September-October.

*Study questions:*

- 1) What are your reactions to the Porter & Kramer article?
- 2) How can firms justify investments that improve environmental sustainability?

**10/22, 8pm: Please sign up for one of the 20 teams. Please see above for the topics that each team is supposed to cover and the date at which each team presents. The sign-up is first-come, first-serve. There are three students per team. If you don't sign up, the TAs will assign you teams with open slots. Please only sign up for teams within your section.**

## 10/23 Session 2: Connected Strategy and Sustainability, Domains of Actions

**First individual assignment: Please write a short paragraph about your background and interest in the topic of the course and post it on the Discussion board in Canvas. Please post by 8am.**

Nicolaj Siggelkow and Christian Terwiesch. 2019. “The Age of Continuous Connection.” *Harvard Business Review*, May-June.

Toffel & van Sice. 2013. “Carbon Footprints: Methods and Calculations” (9-611-075)

*Study questions:*

- 1) In what ways can firms improve their environmental impact?
- 2) In what ways might connected strategy help firms improve their environmental impact?

### **10/28 Session 3: Connected Strategy and Sustainability applied**

Team presentations:

1. Existing and upcoming E(SG) regulations and support (esp. IRA, CSRD)
2. Innovations around carbon sequestration

*Case:* Indigo Agriculture: Harnessing Nature, 9-620-024

*Study questions:*

- 1) What is Indigo's strategy?
- 2) Where on the connected strategy matrix do they operate?
- 3) What are the pros/cons of the Terraton initiative? Should they pursue this initiative?

### **10/30 Session 4: Sustainability from Consumer Behavior to the Supply Chain**

Team presentations:

1. Plant and cell-based meat/dairy innovations
2. Innovations around reducing food waste

Delmas & Colgani. "What Sustainability has Come to Mean" and "The Green Bundle," Chapters 1 & 2 in: *The Green Bundle*, Stanford University Press, Stanford, 2018.

*Case:* Sustainable Tea at Unilever, 9-712-438

*Study questions:*

- 1) What are the key points (for you) from the Delmas & Colgani chapters?

- 2) Why did Unilever commit to sustainably source 100% of its tea?
- 3) Has the introduction of certified tea been a success?

Guest Speaker: Julia Kurnik, WG 14, Senior Director Innovation Start-Ups, World Wildlife Fund

#### **11/4 Session 5: Consumer Behavior**

Team presentation:

1. Innovations in fashion/clothing
2. Innovations with respect to sharing economy/extending product use

Allbirds Moonshot Recipe Book. 2023.

*Case:* Allbirds: Decarbonizing Fashion, 9-622-024

*Study questions:*

- 1) What is Allbirds' strategy?
- 2) Map out the domains of action for Allbirds.
- 3) What new ideas do you have for them? How can connected strategy help?

Guest Speaker: Mike Bufano (WG 01), former CFO-Plus Allbirds

#### **11/6 Session 6: Life Cycle Analysis and Sustainable Buildings**

1. Innovations around steel
2. Innovations in urban design/green cities

Buxel, Esenduran, Griffin. 2015. "Strategic sustainability: Creating business value with life cycle analysis." *Business Horizons*, 58, 109-122.

*Case:* Process Innovation for Efficiency and Environmental Sustainability in the Building Industry (Stanford OIT-113)

*Study questions:*

- 1) What are highlights (for you) from the Buxel et al. paper?

- 2) What are the advantages of pre-fab construction?
- 3) What are the challenges of pre-fab construction?
- 4) Please have a good look at the LCA in the case (Exhibit 6). What are the insights from it? What would you have done differently?

Guest Speaker: Cindy McLaughlin, Head of Product, CarbonBuilt

### **11/11 Session 7: Innovation in Transportation**

Team presentation:

1. Innovations in cars

Case: Driving Decarbonization at BMW (9-123-008) and BMW spreadsheet

*Study questions:*

- 1) Why is BWM focusing on carbon emissions in the full value chain?
- 2) Using the supporting spreadsheet, calculate and compare the life cycle carbon emissions of an internal combustion engine (ICE) vehicle versus a battery electric vehicle (BEV). In the spreadsheet, choose assumptions that you think reflect economic reality. What conclusions do you reach?

Guest Speaker: Nitin Tyagi (WG 24), VP of Supply Chain at One (formerly at Rivian and Apple)

### **11/13 Session 8: Wood and Retail**

Team presentations:

1. Innovations around hydrogen and other non-battery energy storage
2. Innovations in trucks/buses/logistics
3. Innovations in aviation

Serafeim. 2020. "Social-Impact Efforts that Create Real Value," Harvard Business Review, September-October.



*Case:* Sustainability at IKEA Group, 9-515-033

*Study questions:*

- 1) What is IKEA's strategy?
- 2) How can IKEA improve its impact on the environment?

## **11/18 Session 9: Recycling and Circular Economy**

Team presentation:

1. Innovations in solar energy
2. Innovations in wind energy

Pullman & Sauter. "Sustainable Product End-of-Life Management," Chapter 5 in: *Sustainability Delivered: Designing Socially and Environmentally Responsible Supply Chains*, Business Expert Press, New York, 2012.

*Case:* First Solar: The Solar Module Recycling Opportunity (Ivey: 9B16M042)

*Study questions:*

- 1) What are highlights (for you) from the Pullman & Sauter chapter?
- 2) How important is recycling to the solar industry?
- 3) How sensible is it for First Solar to enter the recycling industry?

Guest Speaker:

Jason Dymbort (Penn Law 04), EVP, General Counsel & Secretary at First Solar.

## **11/20 Session 10: Financing ESG projects**

Team presentations:

1. Overview of ESG ratings and initiatives (esp. Science Based Targets)

MacMahon. 2020. "The Challenge of Rating ESG Performance" Harvard Business Review, September-October

Optional: Serafeim & Grewal. 2019 "ESG Metrics: Reshaping Capitalism?" (9-116-037)

Guest Speakers:

Katy Boettcher (WG 16), Principal Ara Partners

Sam Gabbita (WG 04), Co-founder and Managing Director, Qell Partners.

Iain Ware, Partner Bain Capital Double Impact

### 11/25 Session 11: Open Innovation

<b>Please submit 2nd individual assignment by 8am</b>
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The University of Pennsylvania is a large incumbent organization. How should Penn (and Wharton) try to reduce its carbon footprint? Please focus on two or three ideas, and provide one paragraph of why this would be an important initiative. One page of text suffices! We will discuss your answers to this assignment in the last session of the course.
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Team presentations:

1. Innovation in cargo ships/cruise boats
2. Innovations around plastics
3. Innovations in packaging

Lacy, Long & Spindler. "The Circular Business Models," Chapter 2 in: *The Circular Economy Handbook*, Palgrave: London, UK, 2020.

*Case:* Sustainability Through Open Innovation: Carlsberg and the Green Fiber Bottle (Berkeley: B5922)

*Study questions:*

Please ignore the questions at the end of the case and focus on:

- 1) Why is Carlsberg pursuing the Green Fiber Bottle project?
- 2) How are they going about to achieve this innovation?
- 3) What obstacles are they facing?

## 12/2 Session 12: Bringing the learning home & Wrap-Up

Team presentations:

1. Innovations in cooling (buildings/servers)
2. Innovations around the electric grid/smart meters

Guest Speakers:

Nina Morris, Sustainability Director, University of Pennsylvania

*Final Paper Due 12/15 at noon!*

## **Additional Reading List**

### **Session 1: Strategy and Sustainability**

#### **1A) General Background**

- McKinsey & Company. 2022. “The Net Zero Transition Report.”
- “Making the Business Case for ESG”, Knowledge at Wharton.
- Larry Fink’s 2022 Letter to CEOs: The Power of Capitalism.
- United Nations. 2022. “The Sustainability Development Goals Report.”
- P. Dasgupta. 2021. “The Economics of Biodiversity: The Dasgupta Review”
- Bill Gates. 2021. *How to Avoid a Climate Disaster*
- Rebecca Henderson. 2020. *Reimagining Capitalism in a World on Fire*.
- Michael Lenox & Rebecca Duff. 2021. *The Decarbonization Imperative*.
- William McDonough & Michael Braungart. 2002. *Cradle to Cradle*.
- IPCC Full Report Physical Science
- IPCC Final Physical Science
- IPCC Full Report Impact
- IPCC Summary For Policymakers

#### **1B) Strategy and Sustainability**

- Ioannis Ioannou and George Serafeim. 2021. “Corporate Sustainability: A Strategy?” working paper.
- Morelli, John. 2011. “Environmental Sustainability: A Definition for Environmental Professionals” *Journal of Environmental Sustainability*, 1, 1, 1-9.

### **Session 2: Connected Strategy and Sustainability**

#### **2A) Connected Strategy and Sustainability**

- Nicolaj Siggelkow & Christian Terwiesch. 2019. *Connected Strategy*. HBS Press.
- McKinsey. (2022). A Digital Path to Sustainability.

### **Session 3: Connected Strategy and Sustainability applied**

#### **3A) Agriculture/Aquaculture**

- Kurnik, J., Devine, K. 2022. “Innovation in Reducing Methane Emissions from the Food Sector”, World Wildlife Fund.
- Free, et al. 2022 “Expanding Ocean Food Production under Climate Change.” *Nature*, April.
- Ahmed, J., Almeida, E., Aminetzah, D., et al. 2020. Agriculture and Climate Change. McKinsey.
- Bai, Yonfei; Cotruffu, Francesca. 2022. “Grassland soil carbon sequestration” *Science*, 377, 603-608.
- McKinsey. 2023. “The agricultural transition: Building a sustainable future.”

#### **3B) Existing and upcoming E(SG) regulations**

- Paul Weiss. 2022. “A guide to the SEC’s proposed Climate Disclosure Requirements.”
- SEC. 2022. “The Enhancement and Standardization of Climate-Related Disclosures for Investors”
- “10 recent climate policies that could make a difference”, Washington Post, April 21, 2022.
- McKinsey. 2022. Understanding the SEC’s Proposed Climate Risk Disclosure Rule.
- Meyer. “The Climate Economy is about to Explode” The Atlantic, October 5, 2022

### **3C) Innovations around carbon sequestration**

- Kaplan, S. (2021). “Is ‘hacking’ the ocean a climate change solution? U.S. experts endorse research on carbon-removal strategies.” The Washington Post.
- Myer, R. 2022. “We’ve never seen a carbon removal plan like this before.” The Atlantic, April 13.
- Peplov, M. 2022. “The race to recycle carbon dioxide.” Nature, 603, March.
- “Volcanic microbe eats CO2 astonishingly quickly” The Guardian, April 19, 2023 <https://www.theguardian.com/environment/2023/apr/19/volcanic-microbe-eats-co2-astonishingly-quickly-say-scientists>
- Smith et. al, 2022. “The State of Carbon Dioxide Removal”
- Groom, and Venmans. 2023. “The social value of offsets” Nature, July.

## **Session 4: Sustainability from Consumer Behavior to the Supply Chain**

### **4A) Supply Chain**

- McKinsey & Company. 2021 “Making Supply Chain Decarbonization Happen”
- Verlinvest; Bain & Company. 2022. “Purpose-led brands can reshape the consumer-goods industry if they can scale”
- World Economic Forum & BCG. 2023. “Winning in Green Markets: Scaling Products for a Net-Zero World”

### **4B) Plant and cell-based meat/dairy innovations**

- McKinsey. 2021. “Exploring Cultivated Meat”

### **4C) Food (general) and food waste:**

- Clark et al. 2022. “Estimating the environmental impacts of 57,000 food products” PNAS, 119, no 33.
- “What Is Food Waste?” Refed.org. [https://refed.org/food-waste/the-challenge/#what\\_is\\_food\\_waste](https://refed.org/food-waste/the-challenge/#what_is_food_waste)
- EPA. 2021. From farm to kitchen the environmental impacts of U.S. food waste

## **Session 5: Consumer Behavior**

### **5A) Consumer Behavior**

- Chater, Nick and Loewenstein, George F. 2022. “The i-Frame and the s-Frame: How Focusing on Individual-Level Solutions Has Led Behavioral Public Policy Astray” (March 1, 2022).
- Cronin, Gonzales, Sterman. 2009. “Why don’t well-educated adults understand accumulation? A challenge to researchers, educators, and citizens.” *Organizational Behavior and Human Decision Processes*, 108, 116-130.
- Zhao, J., Luo, Y. 2021. “A framework to address cognitive biases of climate change.” *Neuron*.
- Ivanova et al 2020. “Quantifying the potential for climate change mitigation of consumption options.” *Environmental Research Letters*, 15.
- White, K et al. 2019. “How to SHIFT consumer behaviors to be more sustainable” *Journal of Marketing*, 83 (3), 22-49.

### **5B) Innovations in fashion/clothing**

- Bozarth, D., Hoffman, S., Siccardo, G. (n.d.). Closing the Loop: Increasing Fashion Circularity in California. McKinsey.
- Cheah, L et al. 2013. “Manufacturing-focused emissions reductions in footwear production.” *Journal of Cleaner Production*, 44.
- Alon, Gad. “The fashion industry’s dirtiest secret” *Business Insider*, Dec 22, 2022.
- Franklin-Wallis, Oliver. 2023. “What really happens to the clothes you donate” *GQ*, July 20. <https://www.gq.com/story/oliver-franklin-wallis-wasteland-excerpt>

### **5C) Innovations with respect to sharing economy/extending product use**

- Mi, Zhifu, Coffman, D’Maris. 2019. “The sharing economy promotes sustainable societies.” *Nature Communications* (10): 1214.

## **Session 6: Life Cycle Analysis and Sustainable Buildings**

### **6A) Life Cycle Analysis**

- Svoboda, S. 1995. “Note on Life Cycle Analysis”, *Pollution Prevention in Corporate Strategy*.
- Franklin Associates. Examples of life cycle evaluation projects. <http://www.fal.com/projects.html>
- Morelli, B., Cashman, S., Ma, C., et al. 2020. “Food Waste Recycling — Environmental And Economic Assessment” July 14, 2020.
- Morelli, B., Cashman, S., Ma, C., et al. 2020. “Cost, Environmental Impacts Of Food Waste Recycling Options” *Biocycle.net*. July 14, 2020.

- EPA. 2019. "Life Cycle Assessment and Cost Analysis of Municipal Wastewater Treatment Expansion Options for Food Waste Anaerobic Co-Digestion"
- Peters, Jens. 2023. "Best practices for lifecycle assessment of batteries." *Nature Sustainability* 6, June.

### **6B) Buildings**

- Akbarnezhad & Xiao. (2017). "Estimation and Minimization of Embodied Carbon of Buildings: A Review," *Buildings* 7 (5),
- Ramesh, Prakash, Shukla. 2010. "Life cycle energy analysis of buildings: An overview" *Energy and Buildings* 42, 1592-1600.
- John, J. (2022). "How to get New York City's biggest buildings to zero carbon" *Canary Media*. January 20, 2022.

### **6C) Innovations in urban design/green cities**

- McKinsey (2015). "Building the cities of the future with green districts."

### **6D) Innovations around steel**

- McKinsey. 2022. *Net-Zero Steel in Construction: The Way Forward*.
- McKinsey. 2022. *Safeguarding green steel in Europe: Facing the natural gas challenge*.

### **6E) Innovations around cement**

- McKinsey. (2020). *The 21<sup>st</sup>-Century Cement Plant: Greener and More Connected*.
- Czigler, T., Reiter, S., Schulze, P., et al. (2020). *Laying the Foundation for Zero-Carbon Cement*. McKinsey.
- "Set in Green Concrete", *Economist* Nov 6, 2021.
- Hundertmark et al (2021). *Green growth avenues in the cement ecosystem*, McKinsey.

## **Session 7: Innovation in Transportation**

### **7A) Innovations in cars**

- MacDuffie & Engine No 1. 2021. "Mobility Becomes Electric: The Role of Automotive OEMs in Speeding the Battery Electric Vehicle Future."
- McKinsey. 2023. "Automotive powertrain suppliers face a rapidly electrifying future."

### **7B) Innovations around batteries**

- Degen, F., Schütte, S. 2022. "Life cycle assessment of the energy consumption and GHG emissions of state-of-the-art automotive battery cell production." *Journal of Cleaner Production*, 330.

- Service, R. 2022. “California EV Rules Jolt Battery Science”, *Science*, 377, issue 6611 (September 9)
- “Beyond Li-ion batteries: Performance, Materials Diversification, and Sustainability” <https://batteriesnews.com/li-ion-batteries-performance-materials-sustainability/>
- “Lithium Iron Phosphate set to be the next big thing in EV batteries” *Forbes* 2023. <https://www.forbes.com/sites/samabuelsamid/2023/08/16/lithium-iron-phosphate-set-to-be-the-next-big-thing-in-ev-batteries/>
- “Tracking the EV battery factory construction boom across North America” *Techcrunch* 2023. <https://techcrunch.com/2023/08/16/tracking-the-ev-battery-factory-construction-boom-across-north-america/>

## Session 8: Wood and Retail

### 8A) Wood

- McGahan, Pongeluppe. 2020. “There is no Planet B: Stakeholder Governance that aligns Incentives to preserve the Amazon Rainforest.” Working paper.
- Coalition for Negative Emissions. (2021). *The Case for Negative Emissions*.
- McKinsey. 2021. *Consultation: Nature and Net Zero*.

### 8B) Innovations around hydrogen and other non-battery energy storage

- (2022). *Houston as the Epicenter of a Global Clean Hydrogen Hub*. Center for Houstons Future., Greater Houston Partnership., Houston Energy Transition Initiative.
- Ma, T. Jodie Lutkenhaus. 2022. “Hydrogen power gets a boost” *Science* 378 (6616), 138-139
- Harper 2023. “Upcycle for enhanced performance.” *Nature Sustainability*, 6, July.
- Zhou et al. 2023. “Solar-to-hydrogen efficiency of more than 9% in photocatalytic water splitting” *Nature*, January 5, 2023.
- Palladino, Camilla “Lex in Depth: The staggering cost of a green hydrogen economy” *Financial Times*, May 28, 2023. <https://www.ft.com/content/6e22930b-a007-4729-951f-78d6685a7514>

### 8C) Innovations in trucks/buses/logistics

- World Economic Forum, Mission Possible Partnership, Road Freight Zero, McKinsey. 2021. *Road Freight Zero: Pathways to Faster Adoption of Zero-Emission Trucks*.

### 8D) Innovations in aviation

- World Economic Forum (2020), “Clean Skies for Tomorrow”
- McKinsey. 2023. “Decarbonizing aviation: Executing on net-zero goals”



- “Which flying taxi will take off first?” Financial Times, June 14, 2023  
<https://ig.ft.com/flying-taxis/>

## Session 9: Recycling and Circular Economy

### 19A) Recycling

- Bennett. “Plastic Recycling ‘Does Not Work,’ Environmentalists Stress as US Recycling Rates Drop to 5%.” *Beyond Plastics.org*. May 4, 2022.
- Sullivan, L. (2020). “How Big Oil Misled The Public Into Believing Plastic Would Be Recycled.” NPR, September 11, 2020.
- PBS Frontline. (2020) Plastic Wars Documentary.  
<https://www.pbs.org/wgbh/frontline/film/plastic-wars/>
- Crockett, Z. “The surprising afterlife of used hotel soap.” The Hustle.co, April 22, 2022.
- Circular Electronics Partnership (CEP). “Circular Electronics Roadmap.” 2020
- Jehanno, C., Alty, J.W., Roosen, M. *et al.* Critical advances and future opportunities in upcycling commodity polymers. *Nature* **603**, 803–814 (2022).
- Maani, T, Celik, I, Heben, N, Ellingson, R, Apul, D. 2020. “Environmental impacts of recycling crystalline silicon (c-SI) and cadmium telluride (CDTE) solar panels.” *Science of the Total Environment*, 735
- Yan, Ning. 2022. “Recycling plastics using a hybrid process.” *Science* 378 (6616), 132-133.
- Sullivan, K. *et al.* 2022. “Mixed plastics waste valorization through tandem chemical oxidation and biological funneling.” *Science* 378, 207-211.
- Althaf, Shahana. 2023. “New pathways for e-waste recycling” *Nature Sustainability*, January
- Geng, Yong *et al.* 2023. “How to build a circular economy for rare-earth elements.” *Nature* (619), July, 248-251.
- Anhassi, M *et al.* 2023. “The hidden economic and environmental costs of eliminating kerb-side recycling.” *Nature Sustainability* (6), August 919-928.

### 9B) Innovations in solar energy

- Laing. 2022. “Solar Power Challenges.” *Nature Sustainability* (5)
- Lenon, Lunardi, Hallam, Dias. 2022. “The aluminium demand risk of terawatt photovoltaics for net zero emissions by 2050.” *Nature Sustainability* (5). 357-363.
- Almeida, R., *et al.* 2022. Floating Solar Power: Evaluate Trade-Offs. *Nature*.
- Jin *et al.* 2023 “Energy production and water savings from floating photovoltaics on global reservoirs.” *Nature Sustainability*, 6.

### 9C) Innovations in wind energy

- “Wind Market Reports: 2022 Edition” <https://www.energy.gov/eere/wind/wind-market-reports-2022-edition>

- Markham, Derek. 2018. “The future of wind power: 9 cool innovations.” <https://www.treehugger.com/future-wind-power-cool-innovations-4858207>
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## Session 11: Open Innovation

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## Session 12: Bringing the learning home

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