Driving Market Solutions for Clean Energy

New York University, Stern School of Business
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Syllabus

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Teaching Assistant: TBD
Lectures: Mondays, 6-9pm
Credits: 3 credits

A. Course Overview

This course is designed **to provide students with a rich understanding of the economy-wide energy transitions that are needed in the United States to help curb climate change, with an emphasis on how the private sector can drive such changes.** It will provide an overview while also diving deep selectively to illustrate key concepts. It will draw on the instructor's diverse experiences, Harvard Business School-style cases and discussions, readings and other media, visiting speakers, current events and trends, classroom debates, and group projects, to explore and analyze how such ambitious but necessary transformations may be brought about.

The course will cover four main themes associated with realizing the clean energy transformation**:** (1) **environmental and macroeconomic context** of the global climate problem; (2) the **U.S. energy system** and energy costs, and pathways to cutting emissions in the U.S.; (3) established and emerging **business models** for key clean energy drivers (outlined below), based on market trends and hurdles, growth potential, and surrounding policy environment; (4) **in-depth case studies** of exemplary pioneering clean energy companies (e.g., Tesla, Sunrun, Engie) or technologies, and learning from their successes and failures.

The bulk of the course will focus on the **five main clean energy drivers** – energy efficiency (in buildings, industry, and transportation), renewable energy, electrification (of cars and other end-uses), power grid modernization, and fuel decarbonization. For each, the course will step through the key concepts, market and policy contexts, and company/technology business models and case studies, generally closing with a visiting speaker.

The course will be **of interest to students wishing to**: understand the U.S. clean energy needs; develop a knowledge-base of sustainability solutions and clean energy strategies; contrast different business models, policy contexts, and implementation approaches; become aware of career options; and meet industry practitioners. The course should be relevant to a range of students including those who go on to the energy industry, consulting, financial services and investment banking (covers macroeconomic trends, investment potential, business models), as well as those with an interest in policy (clean energy policies and markets are closely interrelated).

B. Course Objectives

Students taking this course can hope to:

- Acquire an appreciation of U.S. clean energy needs and macroeconomics of global climate change;
- Develop a rich knowledge-base of clean energy and sustainability business opportunities, strategies and implementation approaches;
- Evaluate and contrast approaches for expanding clean energy and sustainability solutions, including their market potential and challenges, and policy contexts;
- Become aware of the near-term promise of clean energy and sustainability career options, as they (the students) take the next step in their careers; and
- Meet clean energy practitioners, and get their first-hand perspective.

C. Grading

Type	**Description**	**% of Final Grade**
Participation, Discussion and Reflection	Students should come prepared to actively engage in the classroom conversation of the day's topics, by reflecting on any assigned readings, engaging in group discussions and debates, asking probing questions, connecting to current energy events and news, providing perspectives from past experiences etc. Some pre-class preparation should be anticipated, typically by way of light assigned readings, HBS-style cases, or reviewing informational slides. Engaging with other students outside of class is also encouraged.	35%
Take-home Assignment	There will be one take-home assignment that will be due around two-thirds of the way through the course. The assignment's aim would be to reinforce some of the information and concepts covered until that time. *Deadline: Around class 8 (out of 12)*	25%
Group Project and Presentation	The theme of the group project would be to investigate in-depth any emerging or established business models for driving a range of clean energy needs such as energy efficiency, renewables, electric cars, grid modernization etc. Alternatively, the group may wish to take a more macro view and investigate portfolios of clean energy approaches with strong potential, along with policy or market needs. The project would be an opportunity for students to explore an area of interest further, to work with students of diverse backgrounds, and to be creative and have fun. Students will be able to form groups of 3-5 to work together on a chosen topic. (Exceptions can be made for fewer or more students.) They will have broad latitude to select the topic and define the scope, although some guidance will be provided for content and consistency with other groups/topics. In general, the group will be required to define a problem statement, analyze the challenges and potential solutions, connect concepts covered in class with its analysis, and develop recommendations. The preferred option is for the groups to make presentations to the class. *Deadline: last class*	40%

D. Grading Policy

Assessments will be done on an individual basis for class participation and the quiz. The entire group will be assessed collectively for the group project; each student is expected to contribute equally. Each item will be scored and weighted accordingly. The group project and quiz will have deadlines that will be finalized during class. Late submissions will incur a penalty, and after a final deadline will receive no score.

E. Course Materials

There is no textbook. Roughly 4 classes will have HBS-style case studies that will require some preparation beforehand. For other classes a few informational slides may be provided as a backgrounder, along with one or two light assigned readings generally in the form of news articles or short reports. These are meant to be easily digestible and will serve to provide context for the class and prime the students for in-class discussions.

For those interested in exploring further, an illustrative list of *suggested extra* readings is provided below, and others may be shared in class. Almost all readings will be available through the course website, online, via the library, or through NYU resources.

Illustrative list of *suggested extra* readings:

- "The Energy System: Technology, Economics, Markets, and Policy", Travis Bradford, July 2018 – selected sections
- "The Climate Casino", William D. Nordhaus, 2013 – selected chapters
- "Climate Change 2014, Synthesis Report", IPCC, 2014 – Summary for Policymakers only
- "The Stern Review: The Economics of Climate Change", Nicholas Stern, 2006 – Executive Summary
- "America's Clean Energy Frontier: The Pathway to a Safer Climate Future", NRDC, September 2017
- "Sustainable Energy in America: Factbook", Bloomberg New Energy Finance and The Business Council for Sustainable Energy, 2019 (expected) – select pages
- "The Power of Change", National Academies of Sciences, Engineering, and Medicine, 2016, at http://www.nap.edu/21712 – select chapters
- "A Vision for the Future of the Electric Industry", NRDC, December 2015
- "Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles", NRDC, 2016
- "Teaching the "Duck" to Fly (Second Edition)", Jim Lazar (Regulatory Assistance Project), February 2016
- "The Economics of Battery Energy Storage", Rocky Mountain Institute, October 2015
- "From Gas to Grid", Rocky Mountain Institute, September 2017
- "The Quest: Energy, Security, and the Remaking of the Modern World", Daniel Yergin, 2011 – select pages

F. Guest Speakers

To bring a practical and real-world dimension to the course, it will aim to have 5-7 guest speakers share their views and experiences with the class, on a range of topics (examples in outline below), spread throughout the course. Some may be by video.

G. Course Outline

A course outline is below. While a reasonable representation of topics to be covered, it is subject to change.

The Climate Context (~1 week)

1. The climate problem
    a. Brief background on climate change
    b. Costs of climate change, climate externalities
    c. Assessing the value of reining in climate change
    d. Economics of climate change and the social cost of carbon
2. High-level solutions to the climate problem
    a. Mitigation, adaptation and geoengineering
    b. Need for international coordination
    c. Price on carbon as an overall lever

U.S. energy system and introduction to clean energy in the U.S. (~1 week)

3. The energy system in the United States
    a. Energy demand by sector
    b. Levelized cost of energy, energy supply
    c. Oil and gas, use and demand
4. Pathways for deep decarbonization in the United States
    a. Four main clean energy drivers + modernized grid
5. Electric utilities
    a. Utility business model and implications
    b. Emerging utility business models and case studies: e.g., strategies of different U.S. utilities, international examples
    c. Visiting speaker slot

Clean energy deep dives – potential, policy levers, market trends, business models, case studies (~6-7 weeks)

6. Energy efficiency – buildings and utilities
    a. Potential for energy efficiency in buildings, and via utility sector
    b. Policy levers for energy efficiency: energy efficiency resource standards, utility programs, building codes, appliance standards
    c. Emerging business models and case studies: e.g., comparison of utility programs, equipment manufacturers (e.g., Whirlpool), OPower
    d. Visiting speaker slot
    e. Field trip (if possible)
7. Energy efficiency – industry and transportation
    a. Potential for energy efficiency in industry, and energy transformation in transportation sector
    b. Policy levers for improving energy use in these sectors
    c. Emerging business models and case studies: e.g., Johnson Controls, Schneider Electric, Patagonia, sustainability in cities,
    d. In-depth HBS-style case study
8. Renewables
    a. Major trends in renewable energy
    b. Potential for renewables

c. Policy levers for largescale renewables: utility investments, enabling corporate investment
d. Policy levers for distributed generation: net metering, value of solar
e. Emerging business models and case studies: e.g., NRG, rooftop solar (e.g., SunEdison, SunRun), NextEra, regulated utilities
f. In-depth HBS-style case study
g. Visiting speaker slot

9. Electrification – residential, commercial and industrial sectors
    a. Trends in building electrification
    b. Potential for electrification, in all sectors
    c. Emerging business models and case studies: e.g., Stanford University's SESI
10. Electrification – electric vehicles
    a. Major trends in electric vehicles
    b. Policy levers and market drivers for electric vehicles: incentives, infrastructure investments, improvements in EVs
    c. Focus on grid integration: managed charging, value of storage, vehicle-to-grid
    d. Emerging business models and case studies: e.g., Tesla, BMW, ChargePoint, CA utilities
    e. In-depth HBS-style case study
    f. Visiting speaker slot
11. Organized electricity markets
    a. Where they exist, how they work
    b. Case studies: e.g., PJM, NYISO, comparison of the markets
12. Modernized power grid
    c. Principles of a "modernized power grid" to support clean energy
    d. Underlying technologies and their potential: batteries, storage, demand response, distributed energy resources, electric vehicles
    e. Policy levers to help modernize the power grid
    f. Emerging business models and case studies: e.g., California's duck curve, Western grid integration, Puerto Rico, Engie (North America), Viridity, international examples
    g. In-depth HBS-style case study
    h. Visiting speaker slot

<u>Evolving role of traditional energy (~1-2 weeks)</u>

13. Alternative pathways to deep decarbonization, and implications for business models
    a. U.S. Deep Decarbonization Pathways Project
    b. Obama White House Mid-Century Strategy
    c. Shell's vision for a decarbonized planet
14. Decarbonizing other energy supply
    a. Potential for fuel decarbonization
    b. Policy levers for fuel decarbonization
    c. Case studies: e.g., actions by oil majors, power-to-gas (SoCalGas), biofuels
    d. Role of riskier technologies: nuclear, carbon capture and storage, biomass
15. Fossil fuels
    a. Brief overview of the coal market, future prospects
    b. Brief overview of the oil market, future prospects
        a. The international oil market

c. The natural gas market
    a. Future prospects
    b. Reducing methane emissions from the oil and gas industry
    c. Case studies: e.g., Southwestern
d. Policies related to fossil fuels
e. Emerging models to reduce dependence on fossil fuels
    a. Divestment initiatives
    b. Market instruments for clean energy investments
    c. Financing based on clean energy criteria
f. Visiting speaker slot

<u>Rounding it off (<1 week)</u>

16. Leading edge of the clean energy revolution
    a. Emerging business models and case studies: e.g., blockchain for energy, yieldcos, Internet of Things
17. The international climate context
    a. The Paris Agreement, international goals
    b. Actions of large economies: China, India, Germany
    c. Overview of international markets for clean energy
    d. Goals of the United States
18. Energy politics
19. Energy security

<u>Presentations (1 week)</u>

20. Project presentations

<u>Example group projects</u>

Thorough investigation of any new, emerging or established business model for ramping up:

- Energy efficiency (residential and commercial)
- Industrial energy efficiency
- Large scale renewables
- Distributed renewables
- Electric vehicles
- Sustainable transportation
- Decarbonization of buildings and end-uses
- Energy storage
- Demand side technologies
- Grid modernization
- Grid integration of clean energy resources
- Sustainable fuels
- Carbon capture and storage