

## **Three Essentials of the Electric Grid: Business Essentials**

**Vermont Law and Graduate School**

**Summer Session 2023, Term 1**

**June 5, 2023- June 8, 2023**

**9:00 AM to 12:00 PM**

**Instructor: James C. Cater**

### **Syllabus and Course Information**

1. Course Overview: This course will explore business aspects of the electric grid by focusing on the application of conventional economic and financial concepts and methods to the evaluation of renewable energy projects with particular emphasis on solar electricity generation projects. Through this course, students will gain an understanding of how to assess the comparative economics of resources that make up the electric grid, especially renewable energy projects, and become familiar with benefit-cost analysis and the development and use of project pro forma financial analysis for business and public policy decision making.
2. Required Materials: Various videos, readings and reference materials are listed for each class session. Students should view the videos and engage the readings before each class session. The reference materials will support in class presentations. Most required materials can be accessed through the links provided in this syllabus. In some cases, the indicated materials will be posted on TWEN. Required materials include an Excel spreadsheet, developed by the instructor, that students must upload and be prepared to use and discuss during class sessions.
3. Note that many of the topics listed under the four class sessions are interrelated and best understood when considered together as opposed to separate segments. Depending on class dynamics, discussion topics might overlap class sessions or be addressed in slightly different order. Thus, students are encouraged to review as much material as possible, as early as possible, so they have some familiarity whenever particular topics are presented in class.
4. Examination: Open book, take home, due on Sunday June 11, 2023, at 4:00 PM. Further instructions will be provided during the course.
5. Instructor Contact Information:
  - a. Phone: 802-558-6630
  - b. E-mail: [jcater@vermontlaw.edu](mailto:jcater@vermontlaw.edu) or [james.c.cater@gmail.com](mailto:james.c.cater@gmail.com)
  - c. Office Hours: Virtual or in-person meetings can be scheduled during non-class hours June 5, 2023 – June 8, 2023

6. Course Requirements:

- a. Class Attendance: Vermont Law School (VLS) requires that you attend class and attendance will be recorded.
- b. Preparation: So that we can have a meaningful discussion of the issues, you are expected to come to class fully prepared by reading all the required materials in advance. You will be held responsible for the contents of all non-optional reading materials on the final exam.
- c. Final Exam: There will be a written final examination. This examination will be take-home, open book. Performance on the exam will be the predominant determinant of your grade for the course.
- d. Conduct/Honor Code: You are expected to conduct yourself in a professional manner throughout all aspects of the course. You are expected to abide fully by the VLS Honor Code.

7. Grading: Grades will be based primarily on the final examination, but earnest class participation is encouraged and will have a favorable impact on final grades.

8. Class Schedule and Required Materials

**CLASS 1**

**Monday, June 5, 2023**

**Electricity Sector Fundamentals**

Topics:

- Brief course overview
- Fundamentals of US Electric Grid
- Production, Transmission and Distribution
- Distributed Energy Resources
- Smart Grid
- RTOs, ISOs
- Micro Grid
- Measuring Electricity Costs
  - Focus on Production
  - Internal and External Costs
  - Energy, Capacity, Capacity Factor and All-In Cost
  - Avoided Cost

## Topics:

- Electric Utility Rate Making
  - Revenue Requirement
  - Tariffs
- Discounted Cash Flows
  - Present value and future value
  - Time value of money
  - Net present value of cash flows
- Levelized Cash Flows
- Levelized Cost of Electricity
- Levelized Avoided Cost of Electricity

## Videos

- <https://www.youtube.com/watch?v=nbPmsBmo03Y> (Grid 101)
- [https://www.youtube.com/watch?time\\_continue=149&v=JwRTpWZReJk&feature=emb\\_title](https://www.youtube.com/watch?time_continue=149&v=JwRTpWZReJk&feature=emb_title) (Video – Smart Grid)
- <https://www.vermontpublic.org/local-news/2023-04-11/watch-can-you-take-an-entire-town-off-the-grid-a-vermont-utility-thinks-you-can> (VPR Microgrid)
- [https://www.youtube.com/watch?v=7FsGpi\\_W9XI](https://www.youtube.com/watch?v=7FsGpi_W9XI) \*\*\* (NPV and Discounting)

## Readings

- [https://en.wikipedia.org/wiki/Regional\\_transmission\\_organization\\_\(North\\_America\)](https://en.wikipedia.org/wiki/Regional_transmission_organization_(North_America)) (RTO and ISO Defined)
- <http://www.mresearch.com/pdfs/docket4185/NG11/doc5.pdf> (Avoided Cost)
- <https://www.nytimes.com/2023/02/23/climate/renewable-energy-us-electrical-grid.html> (NYT Grid Constraints)
- <https://www.profitwell.com/blog/discount-rate-formula> (Discounting and Net Present Value)
- [https://www.eia.gov/outlooks/aeo/pdf/electricity\\_generation.pdf](https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf) (pages 1-10) LCOE and LACE

## Reference Materials

- [Instructor Provided Spreadsheet \(Posted on TWEN\)](#)
- <https://www.eia.gov/electricity/generatorcosts/> (Reference Material on Construction Costs of Electricity Generation Resources)
- [https://www.eia.gov/outlooks/aeo/assumptions/pdf/table\\_8.2.pdf](https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf) (Reference Material on Total Costs of Electricity Generation Resources)
- <http://euanmearns.com/solar-pv-capacity-factors-in-the-us-the-eia-data/>

**CLASS 2**  
**Tuesday, June 6, 2023**

**Project Analysis**

Topics:

- Basic Project Financing
  - Debt, Equity and D/E Ratio
  - Weighted Cost of Capital
- Discount Rate Measurement
  - Opportunity Cost (WACC)
  - Private versus Social
- Basic Benefit-Cost Analysis
- Benefit-Cost Metrics
- Comparative Resource Analytics
- Benefit-Cost Analysis in Long-Term Societal Context
  - Value of Statistical Life
  - Current Economy Versus Future Quality of Life
  - Effects of Discounting

Videos:

- <https://www.youtube.com/watch?v=7tdKkeNCIPE> (Introduction to B/C Analysis)

Readings:

- <https://www.nrel.gov/docs/fy12osti/52197.pdf> pages 6-11 (Investment Decision Metrics)
- <https://www.nrel.gov/docs/legosti/old/5173.pdf>, pages 9-14 (Cost of Capital and Cash Flow Discounting)
- [https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701\\_cea\\_discounting\\_issue\\_brief.pdf](https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf) (Development Private and Social Discount Rate)
- <https://yaleclimateconnections.org/2021/10/is-cost-benefit-analysis-the-right-tool-for-federal-climate-policy/>
- <https://www.epa.gov/environmental-economics/mortality-risk-valuation - means>

Reference Materials:

- [https://www3.epa.gov/ttnecas1/docs/ria/utilities\\_ria\\_final-clean-power-plan-existing-units\\_2015-08.pdf](https://www3.epa.gov/ttnecas1/docs/ria/utilities_ria_final-clean-power-plan-existing-units_2015-08.pdf) pages ES-10.ES-14 (EPA Analysis of Clean Power Plan)
- [https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument\\_SocialCostofCarbonMethaneNitrousOxide.pdf](https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf)
- <https://www.youtube.com/watch?v=uE5CtT-dOJg> (VSL)
- <https://www.forbes.com/sites/theapothecary/2020/03/27/how-economists-calculate-the-costs-and-benefits-of-covid-19-lockdowns/-a814e4c6f630> (Valuing Human Life)

**CLASS 3**  
**Wednesday, June 7, 2023**

**Financial Analysis of Renewable Energy Resources**

Topics:

- Basic Analytics of Renewable Resources
- Current Renewable Mix
- Key Cash Flows
  - Revenue
  - Avoided Cost
  - Investment Cost
  - Operating Costs
  - Taxes
    - Investment Tax Credit (ITC)
    - Production Tx Credit (PTC)
    - Modified Accelerated Cost-Recovery System (MACRS)
- Incentives
- Externalities
- Renewable Energy Certificates (“RECs”)
- Proforma Cash Flow Analysis

Readings:

- <https://www.eia.gov/outlooks/steo/report/electricity.php> Renewable Mix
- APPA Value of Solar Primer, 2016 American Public Power Association [www.PublicPower.org](http://www.PublicPower.org) (Available on TWEN)
- [https://rmi.org/wp-content/uploads/2017/05/RMI\\_Document\\_Repository\\_Public-Rep\\_rts\\_eLab-DER-Benefit-Cost-Deck\\_2nd\\_Edition131015.pdf](https://rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Rep_rts_eLab-DER-Benefit-Cost-Deck_2nd_Edition131015.pdf) (pages 7-17)
- <https://www.seia.org/initiatives/solar-investment-tax-credit-itc> (SEIS ITC)
- <https://www.seia.org/initiatives/depreciation-solar-energy-property-macrs> (MACRS)
- <https://www.epa.gov/green-power-markets/renewable-energy-certificates-recs> (RECs)
- <https://www.nrdc.org/resources/regional-greenhouse-gas-initiative-model-nation> (RGGI)

Reference Materials:

- Instructor Provided Spreadsheet (Posted on TWEN)
- <https://www.nrel.gov/docs/fy14osti/62447.pdf>
- <https://www.nrel.gov/docs/fy19osti/72399.pdf>
- <https://www.youtube.com/watch?v=qBpiXcyB7wU&t=1182s>
- <https://programs.dsireusa.org/system/program/detail/1235> (DESIRE MACRS)
- <https://programs.dsireusa.org/system/program/detail/1235> (DESIRE Residential Credit)
- <https://programs.dsireusa.org/system/program/detail/658> (DESIRE Business ITC)
- <https://programs.dsireusa.org/system/program/detail/734> (DESIRE PTC)
- [https://www.epa.gov/sites/default/files/2018-03/documents/gpp\\_guide\\_rec\\_offset.pdf](https://www.epa.gov/sites/default/files/2018-03/documents/gpp_guide_rec_offset.pdf)

**CLASS 4**  
**Thursday, June 8, 2023**

**Alternate Perspectives on Resource Economics and C/B outcomes**

Topics:

- Electric Utility Cross Customer Subsidization
  - Fixed versus variable cost
- Stakeholder Perspectives
  - Developer
  - Solar Customer
  - Utility
  - Society
- Stakeholder Perspective and Cost-Benefit Metrics
- Grid Expansion and Modernization
  - In many cases will be necessary to accommodate renewable generation
  - Could be costly
  - NIMBY issues
  - Will it pass B/C test
  - Does B/C analysis work in the context of long-term climate change
  - Cost effectiveness analysis as a possible alternative to B/C

Readings:

- APPA Paper – Solar Photovoltaic Power: Assessing the Cost and Benefits (Posted on TWEN)
- [https://rmi.org/wp-content/uploads/2017/05/RMI\\_Document\\_Repository\\_Public-Reprrts\\_eLab-DER-Benefit-Cost-Deck\\_2nd\\_Edition131015.pdf](https://rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprrts_eLab-DER-Benefit-Cost-Deck_2nd_Edition131015.pdf) (pages 12-19)
- <https://www.nytimes.com/2023/02/23/climate/renewable-energy-us-electrical-grid.html>
- <https://www.greentechmedia.com/articles/read/renewable-us-grid-for-4-5-trillion>
- <https://yaleclimateconnections.org/2021/10/is-cost-benefit-analysis-the-right-tool-for-federal-climate-policy/>

Reference Materials:

- Instructor Provided Spreadsheet (Posted on TWEN)
- <https://energy.mit.edu/wp-content/uploads/2012/03/MITEI-RP-2011-001.pdf>  
Integrating Intermittent Resources
- <https://www.energy.gov/eere/articles/nrel-study-identifies-opportunities-and-challenges-achieving-us-transformational-goal>
- <https://www.americanactionforum.org/research/the-cost-of-upgrading-electricity-transmission/>
- <https://www.reuters.com/investigates/special-report/usa-renewables-electric-grid/>
- <https://www.cnbc.com/video/2021/01/27/what-it-will-take-for-the-us-to-build-a-100percent-renewable-electric-grid.html>
- [https://www.youtube.com/watch?v=s3ScJ\\_FwaZk](https://www.youtube.com/watch?v=s3ScJ_FwaZk)
- <https://www.youtube.com/watch?v=e0yWi9p9RGg>