Energy Markets and Innovation

COURSE SYLLABUS

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Course Details: Course Number: SUMA K4155
Other Details TBD

A. COURSE OVERVIEW

Existing energy sources and the infrastructures that deliver them to users around the world are undergoing a period of rapid change. Limits to growth, rapidly fluctuating raw material prices, and the emergence of new technology options all contribute to heightened risk and opportunity in the energy sector. The purpose of this course is to establish a core energy skill set for energy students and prepare them for more advanced energy courses by providing a basic language and toolset for understanding energy issues.

Using theoretical and practical understanding of the process by which energy technologies are developed, financed, and deployed, this course seeks to highlight the root drivers for change in the energy industry, the technologies that are emerging, and the factors that will determine success in their commercialization. Understanding these market dynamics also informs good policy design and implementation to meet a broad range of social welfare goals.

Upon completing the course, students should not only understand the nature of conventional and emerging energy generation and delivery, but also the tools for determining potential winners and losers and the innovative pathways to drive their further deployment.

B. COURSE PROCEDURES

This course is designed to be inter-disciplinary, integrating skills from finance, marketing, technology, regulation and policy, and entrepreneurship. However, no prior knowledge is required to excel in this course. It is intended to establish a foundation of knowledge and framework for further study.

Methodologically, there are some basic skills for measuring, costing, and valuing energy and electricity that must be understood, which are particular to the energy industry. Therefore, non-trivial mathematical and spreadsheet work will be required to show the necessary competence in these skills. Students should be reasonably comfortable with spreadsheet modeling for computation and financial projection before beginning the course, or choose a good partner for completing problem sets.

The hardest part of any work in emerging technologies (particularly in the fast changing energy sector) is to integrate vast amounts of information into useful and actionable information. It is vital to cut through the haze of data and uncertainty to identify key drivers for success and then present the qualitative and quantitative information necessary to determine the likelihood of and best pathway to success for a given solution. Such analysis will be messy and complex and will likely necessitate substantial supplemental research, but in the end will derive great practical benefit in the skills of analysis and presentation that will be useful in nearly all future careers.

C. COURSE MATERIAL

REQUIRED

1) ***Thinking in Systems***, Donella Meadows, Chelsea Green, 2008
   (if not available in bookstore, order online, fastest may be Amazon Kindle, or PC e-book app.)
2) Readings from the syllabus below and posted for students

OPTIONAL

1) ***Solar Revolution: The Transformation of the Global Energy Industry***, Travis Bradford, MIT Press, 2006

D. GRADING

Grading will be based on class participation, six problem sets, and either a final exam or final project. Students cannot take this course pass/fail.

1. Class participation (10%)

Class participation will count for 10% of the final grade. Thoughtful comments and focused questions that contribute to the learning environment are encouraged. Reading the material required before class will be necessary to make meaningful contributions, while tying the reading to the course concepts is considered most useful. Grades will be based on attendance and quality (not quantity) of contributions.

2. Six (6) Short Problem Sets (40%)

Six problem sets will be done individually or in pairs and will account for 40% of the final grade. These problem sets will reinforce concepts of measurement and metrics of energy, including generation and capacities, energy conversions, and calculation methodologies of cost and value of energy, electricity, and carbon. The calculations will be supplemented with qualitative assessments of the results.

3. Final Exam (50%)

The final will count for 50% of the final grade. The final exam will be given during the normal exam period for the class. It will both qualitatively and quantitatively test the fundamental concepts of class, the readings, lectures, and learnings from the problem sets. A list of the final concepts is provided below, but should not be considered exhaustive for the purposes of the exam.

E. GRADING POLICY

Late Problem Set assignments will be docked one half of a letter grade for each day they are turned in late. Any requests for grade review will require extraordinary circumstances and will subject all other work to simultaneous review, which could result in either upward or downward revision.

Problem Sets are to be completed individually or in pairs. Shared work beyond those pairs will be considered plagiarism, and treated accordingly.

Final Exams will only be given during the normal exam period.

Syllabus Date: January 16, 2013

THE 10 LEARNING OBJECTIVES

10 things you should practically understand at the end of this course (and will be tested on):

The list below sets out the objectives for the course and provides the basis for questions for the final exam. You should note, however, that I will not treat these topics in the sequence and structure in which they are presented here. Rather, I expect you to use this list as a roadmap to navigate the class. It is your own responsibility to map the contents of the class to these ten objectives and ensure that, by the end of the class, you are capable of answering questions related to these objectives using tools acquired in the course. In the end, meeting these objectives is also the list I hope you will use to evaluate the course.

1. Understand the energy system status quo: industrial architecture, supply chain, incumbent dominant technologies, uses and users, pricing mechanisms, regulation
2. Understand the energy industry conceptually as a constrained system - including scarcity, negative externalities, limitations & repercussions, sunk costs
3. Be familiar with the entire palate of emerging energy alternatives, including specifically how and where they will need to compete to in the existing market
4. Know and be able to apply economic tools used for analyzing energy market failures - myopia, pollution, informational asymmetries
5. Know how to derive practical supply and demand curves for a specific market
6. Be able to define unique and fungible goods in the energy industry (and beyond)
7. Be able to convert physical energy and power flows and use the various units of measurements across the whole energy industry
8. Be able to calculate Levelized Cost of Energy (LCOE) and forecast its constituent elements, as well as be able to make appropriate comparisons using LCOE
9. Recognize the fundamental tension between evolutionary changes and disruptive changes in industrial architectures and describe the key drivers of each for a given application
10. Describe how policy structure, policy changes, and the prospect of policy changes impact decisions in the energy sector

COURSE READINGS AND ASSIGNMENTS

- Topic 1-2 (General Principles) has a fairly large amount of industry and background reading – the course text "Thinking in Systems" is introduced along with some more academic papers about obstacles to change, policy design and impacts, tragedy of the commons, externalities, etc. You should flip through and understand the data sources within the World Energy Assessment, BP Energy Assessment, IEO, IPCC Reports, etc.

- Topic 3-4 (Market Structures and Pricing) begins as an understanding of the existing electricity market and uses that market to demonstrate how physical transformations are made and then valued in one of the largest formal markets in the world. Understanding the pressures facing this market allow for examination of various solutions including efficiency and demand response.

- Topic 5-8 (Electricity Generation Options) assesses all of the utility- and distributed-scale generation options available today using a framework for determining competitiveness, including fungibility and values. A number of practical, economic, and forecasting competences will be developed throughout this section, including LCOE methodology and the role of storage.

- Topic 9-11 (Transportation) begins by looking at the constraints imposed by access to petroleum resources and the infrastructure to deploy those where transportation energy is required. It then looks at where and how capital can be deployed profitably to change this infrastructure and what those changes will look like. Finally, examining how transportation re-integrates with electricity architecture gives us an opportunity to examine the nature of disruptive technologies.

- Topic 12-14 (Opportunities in Energy) will integrate a wide range of situations and technology options into an examination of comprehensive systems. The role of natural gas, carbon pricing, and new methods of delivering vital energy to the world's poorest combine to help us spot emerging business opportunities now and in the future.

- *Links are Hot – You should be able to click through.*

BLOGS AND NEWS SITES TO FOLLOW

Here are a few sites/ rss feeds you may want to stay up on for current events on the energy and renewable energy industries:

- Prometheus Institute http://prometheus.org/
- Greentech Media: http://www.greentechmedia.com/
- Renewable Energy News: http://www.renewableenergyworld.com/rea/news
- World of Renewables: http://www.worldofrenewables.com/
- CleanEdge: http://www.cleanedge.com/news/
- Next Billion: http://nextbillion.net/

Course Outline (Topic, Title, Assignments, Topics and Tools)

Date	Title	Due	Topics covered (tools in BOLD)
General Principles (2 weeks)			
1.	**Basic Energy Terms and Conversions**	Bio Sheet	Introduction, Course Outline and Objectives, **Energy vs. Power**, **Conversion**, Laws of Thermodynamics, **Stocks and Flows**, Costs vs. Price
2.	**Energy as an Economic System and Dealing with Market Failures**	PS #1 – Metrics & Conversion	Energy Systems, **System Dynamics**, Delivery Architectures, **Scenarios** for the Future, Resource Limitations, **Life Cycle Analysis (LCA)**, Environmental Impacts, Climate Change, Mitigation
3.	**Understanding Organized Electricity Markets and Efficiency** - *The Grid* - *Energy Efficiency*		Grid Purpose, Generation, Transmission, Distribution, Deregulation, **Supply Curves**, Load, **Wholesale Market Structure and Function**, Dispatchability, Interconnection
4.	**Supply and Demand I - Contracting Price** - *Demand Response*	PS #2 – Electricity Concepts	**Bus Bar Costs**, **LCOE**, Price of Electricity, Multiple Value Streams of Electricity, **Financing Electricity Projects**
5.	**Utility-Scale Generation Options** - *Nuclear Power* - *Utility-scale Renewables*		Project Development, IPPs, Regulated Utilities, Net Metering, **Cost of Capital (WACC)**, IRR, Fully-loaded costs, **Discounting**, Risk-weighting, COGS
6.	**Experience Curves and Disruptions** - *Distributed Generation*	PS #3 – LCOE	**Experience Curves**, Learning, Technology, **Market Disruptions,** Distributed Generation
7.	**Special Topic: Solar Energy** - *Solar Electricity*		PV, Crystalline Silicon, Thin Film, BoS and Soft Costs, Supply and Demand Reconciliation, **Forecasting Competing Costs**
8.	**Energy Storage Options** - *Electricity Storage*		Storage, Energy Density, Power Density, Chemistries, Fuel Cells, **LCOS**
9.	**Oil and Transportation Markets** - *Petroleum* - *Supply Chain Analysis*	PS #4 - Forecasting Oil Prices	**Resource** measurements, **Reserves**, Quality, Delivery Systems, Passenger vs. Cargo, Modes of Freight, Inter-modal, Energy Security
10.	**Alternate Fuel Sources** - *Biofuels*		Unintended consequences, Biofuels, Cellulosic, Algae, Drop-in Fuels, **Feedstock/ Fuel Linkages**
11.	**Electricity in Transportation Markets**	PS #5 - Cost/ Mile	Grid Reliability, Stand-by Power, V2G, Spinning Reserves, **Cost per Mile**
12.	**Natural Gas Markets** - *Natural Gas*		Natural Gas, Stranded Gas, Fracking & Shale Gas, CNG, LNG, Liquefaction, **Forecasting Prices**
13.	**Climate Change & the Impact of Energy Systems** - *Coal and CCS*	PS #6 - Carbon Abatement	Greenhouse gas effect, International Climate Government, ETS Trading System, Carbon Pricing, CCS, **Abatement Curves**
14.	**Global Energy Poverty and Access**		Energy Enterprise Development, Microfinance, Leapfrogging, Energy Access, Alleviating Energy Poverty, Micro-grids, Impact Investing

Lecture Readings, Assignments, and Questions

General Principles (2 Weeks)

1. BASIC ENERGY TERMS AND CONVERSIONS [WEEK 1]

Topics Covered:

Introduction, Course Outline and Objectives, Energy vs. Power, Conversion, Laws of Thermodynamics, Stocks and Flows, Costs vs. Price

Readings:

- Hafele and Sassin, "The Global Energy System" 1977.
- Holdren, J., "The Energy Innovation Imperative," Spring 2006.
- Energy Metrics Article

[Optional] Active Reading Strategy:

- The McGraw Center, Princeton. "Active Reading Strategies," 2008.

2. ENERGY AS AN ECONOMIC SYSTEM AND DEALING WITH MARKET FAILURES [WEEK 2]

Topics Covered:

Energy Systems, Delivery Architectures, Electricity - Generation, Transmission, Distribution, System Losses, Scenarios for Future, Resource Limitations, Life Cycle Analysis (LCA), Environmental Impacts, Climate Change, Mitigation

Reading:

- ***Thinking in Systems*** ***[Through the end of Section 1]***
- "energy [r]evolution: A Sustainable Global Energy Outlook " Greenpeace International and EREC, 2012 ***[Read Introduction, Executive Summary, Chapters 2 and 3, and SKIM Pages 54-87]***
- "Report on the First Quadrennial Technology Review", U.S. Department of Energy, September 2011. ***[Through page 33 only]***
- UNEP/ SEFI/ BNEF, "Global Trends in Sustainable Renewable Energy Investment 2012" ***[Executive Summary and Chapter 1 only]***

[Flip through only…] Background Data – Appendix

[Optional] Reference:

- Hardin, G. "Tragedy of the Commons", *Science* 162(3859) Dec. 1968, 1243-1248.
- "Deploying Renewables: Best and Future Policy Practice", Exec Summary, IEA, 2011.
- "Deploying Renewables: Best and Future Policy Practice", IEA, 2008.

[Optional] Reference:

- ***[For Reference – look at, but no need to read]*** "A Manual for Economic Evaluation of EE and RE Technologies", Short et. al., NREL, March 1995

Market Structures and Pricing (2 Weeks)

3. UNDERSTANDING ORGANIZED ELECTRICITY MARKETS AND EFFICIENCY [WEEK 3]

Topics Covered:

Generation, Transmission, Distribution, Deregulation, Load types, Dispatchability, Interconnection, Monopsony

Readings:

- MRS Bulletin, "The Electric Power Grid: Today and Tomorrow", August 2008.
- Borenstein and Bushnell, "Electricity Restructuring", February 2000.
- "2007 Long-Term Reliability Assessment", North American Electric Reliability Corporation, October 2007. ***[Pages 6-21 only]***
- ACEEE, "The Long-term Energy Efficiency Potential", 2012. ***[Through page 14 only]***
- Accenture/ WEF, "Accelerating Smart Grid Investments", 2009.

[Optional] Assessing and Financing EE:

- DB and Rockefeller Foundation, "US Building EE Retrofits," March 2012

4. Supply and Demand I – Contracting Price [Week 4]

Topics Covered:

Bus Bar Costs, Price of Electricity, Multiple Value Streams of Electricity, Financing Electricity Projects, Venture Capital and Growth

Readings:

- ***Thinking in Systems*** ***[Section 2]***
- Kammen, D., and S. Pacca. "Assessing the Costs of Electricity", *Annual Review of Environment & Resources* 29(1), Nov. 2004, 301-C-3.
- Enernoc, "Demand Response: A Multi-Purpose Resource for Utilities and Grid Operators", 2010

Electricity Generation Options (4 weeks)

5. Utility-Scale Generation Options [Week 5]

Topics Covered:

Project Finance, IPPs, Regulated Utilities, Net Metering, Cost of Capital, IRR, Fully-loaded costs, Discounting, Risk-weighting, COGS, LCOE, WACC

Readings:

- Jefferies & Company, Clean Technologies Primer, "Project Finance Primer" [Class Site]
- "Program on Technology Innovation: Integrated Generation Technology Options", EPRI, June 2011 ***[YES, the entire thing – use active reading techniques]***

[Optional] Discounting :

- Awerbuch, S. "Determining the real cost: Why renewable power is more cost-competitive than previously believed", *Renewable Energy World*, March-April 2003
- "The Drivers of LCOE", Sunpower Corporation, August 2008

6. EXPERIENCE CURVES AND DISRUPTIONS [WEEK 6]

Topics Covered:

Experience Curves, Learning, Technology, Disruptive Technologies, Distributed Generation

Readings:

- Bower and Christensen, "Disruptive Technologies: Catching the Wave" [on Class Site]
- "Experience Curves for Energy Technology Policy", OECD/IEA, 2000 ***[Chaps. 1 and 4]***

7. SPECIAL TOPIC: SOLAR ENERGY [WEEK 7]

[Optional] Background:

- "Solar Primer" Jefferies & Company, Clean Technologies Primer [on Class Site]
- Solar Revolution, Chapters 1, 6, 7, and 10
- Solar Forecasting Methodology [on Class Site]

8. ELECTRICITY STORAGE OPTIONS [WEEK 8]

Topics Covered:

Storage, Energy Density, Power Density, Chemistries, Fuel Cells

Readings:

- "Electricity Energy Storage Technology Options," EPRI, December 2010 ***[Executive Summary ONLY]***

Transportation Sector (3 Weeks)

9. OIL AND TRANSPORTATION MARKETS [WEEK 9]

Topics Covered:

Resource measurements, Reserves, Quality, Delivery Systems, Passenger vs. Cargo, Modes of Freight, Inter-modal, Energy Security

Readings:

- "Understanding Today's Crude Oil and Products Markets". American Petroleum Institute, 2011
- Whitney, et. al., "US Fossil Resources: Terminology, Reporting, and Summary" Congressional Research Service, March 2011
- Owen, et al., "The status of conventional world oil reserves – Hype or cause for concern?" Energy Policy, 2010
- "The Oil Crunch: Securing the UK's Energy Future" UK Industry Taskforce on Peak Oil & Energy Security (ITPOES), February 2010 ***[Through the end of Section 2 – page 14]***

[OPTIONAL] BACKGROUND:

- "Repowering Transport", World Economic Forum, February 2011
- Gordon, "Understanding Unconventional Oil" Carnegie Insititute,
- Portney, et al. "The Economics of Fuel Economy Standards", *Journal of Economic Perspectives* 17(4), Autumn 2003, 203-217

10. ALTERNATE FUEL SOURCES [WEEK 10]

Topics Covered:

Unintended consequences, Biofuels, Cellulosic, Algae, Drop-in Fuels

Readings:

- "Biofuels Issues and Trends", EIA, October 2012 ***[Through page 20]***
- "Technology Roadmap: Biofuels for Transport", IEA, 2011 ***[Through page 40]***

[Optional] Background:

- "Betting on Science: Disruptive Technologies in Transport Fuels", Accenture, 2009

11. ELECTRICITY IN TRANSPORTATION MARKETS [WEEK 11]

Topics Covered:

Grid Reliability, Stand-by Power, V2G, Spinning Reserves

Readings:

- "Transportation Electrification: A Technology Overview," Electric Power Research Institute, July 2011 ***[Through the end of chapter 3 Only]***
- "EV and PHEV Technology Roadmap" IEA, June 2011

Other Energy Markets (3 Weeks)

12. NATURAL GAS MARKETS [WEEK 12]

Topics Covered:

Natural Gas, Stranded Gas, Fracking & Shale Gas, CNG, LNG, Liquefaction

Readings:

- "Natural Gas – From Wellhead to Burner Tip", NaturalGas.org, 2012
- "Natural Gas Business Overview", NaturalGas.org, 2012
- Jacoby et. al., "The Influence of Shale Gas on U.S. Energy and Environmental Policy", Economics of Energy & Environmental Policy, 2012.

13. Climate Change and the Impact of Energy Systems [Week 13]

Topics Covered:

Greenhouse gas effect, International Climate Government, ETS Trading System, Carbon Pricing, CCS, Abatement Curves

Readings:

- ***Thinking in Systems*** ***[Section 3]***
- "A Cost Curve for Greenhouse Gas Reduction" McKinsey Quarterly, February 2007. ***[Registration is required.]***
- "The Future of Coal: options for a carbon-constrained world", MIT, 2007. ***[Chapters 2 to 4 ONLY – Pages 5-59]***

14. Global Energy Poverty and Access [Week 14]

Topics Covered:

Energy Enterprise Development, Microfinance, Leapfrogging, Energy Access, Alleviating Energy Poverty, Micro–grids, Impact Investing

Readings:

- Flavin, C., and M. Aeck. "Energy for Development - The Potential Role of Renewable Energy in Meeting the Millennium Development Goals", Ren21, Renewable Energy Policy Network, Worldwatch Institute, 2005.
- "Resource Revolution", McKinsey Global Institute, November 2011 ***[Exec. Summary only]***

[Optional] Reference:

- "World Energy Outlook, 2010: Energy Poverty Summary" IEA, September 2010

Appendix: Reference Documents for Background Information

Energy System Statistics

- "IEA Key World Energy Statistics 2012", International Energy Agency
- "BP Statistical Review of World Energy 2012" BP, 2012.

- "Monthly Energy Review" DOE Energy Information Agency (EIA)

ENERGY RESOURCE INDUSTRY REFERENCE DOCUMENTS

- **Petroleum and Transportation**
  - "Understanding Today's Crude Oil and Products Markets". American Petroleum Institute, 2011
  - "On the Road in 2035", MIT, 2008
- **Natural Gas**
  - "Natural Gas – From Wellhead to Burner Tip", NaturalGas.org, 2012
  - "Natural Gas Business Overview", NaturalGas.org, 2012
  - "The Future of Natural Gas", MIT, 2011
- **Electric Grid**
  - "The Future of the Electric Grid" MIT, 2011
- **Coal**
  - "Coal Explained", EIA, 2012
  - "Global Coal Risk Assessment", World Resources Institute, November 2012
- **Hydropower**
  - "Hydropower Explained", EIA, 2012
  - "Hydropower Roadmap" IEA, 2012
- **Nuclear Power**
  - "The Future of Nuclear Power", MIT, 2003.
  - "2009 Update to the Future of Nuclear Power", MIT, 2009
- **Biomass and Biogas Electricity**
  - "CPUC GHG Modeling – Biomass" CPUC, August 2007
- **Wind Electricity**
  - "Global Wind Energy Outlook", GWEC, 2012
  - EPRI – Wind Innovation
  - EPRI – Wind Integration
- **Concentrating Solar Electricity**
  - "Solar Task Force Report", Western Governors' Assoc., January 2006
- **Ocean-based power: Tidal and Wave Electricity**
  - "Accelerating Marine Energy", Carbon Trust (UK), 2011
- **Geothermal Electricity**
  - "The Future of Geothermal Energy", MIT, 2006
- **Distributed PV**
  - "Reducing the Cost of PV", Rocky Mountain Institute, 2012

Energy System Fundamentals – Technical Video Links

Title	Video Link

Energy Revolution Series	**Energy Revolution (Sponsored by Shell, 44 min. each)** [Part 1] http://www.youtube.com/watch?v=Q9lZYcmeKNg [Part 2] http://www.youtube.com/watch?v=WsqrRWn_QDk [Part 3] http://www.youtube.com/watch?v=35LYymY9H3w [Part 4] http://www.youtube.com/watch?v=HIE0kE2k1qw
Understanding Organized Electricity Markets and Efficiency - *The Grid* - *Energy Efficiency*	**Electricity Generation 101 (5 min.)** http://www.youtube.com/watch?v=20Vb6hlLQSg&feature=related **Overview of the Electricity Grid (4 min.)** http://www.youtube.com/watch?v=38EEmWHI0C8 **Smart Grid (Institute of Electrical and Electronics Engineers, 9 min.)** http://www.youtube.com/watch?v=YrcqA_cqRD8&feature=related **A day in the life of the grid, July 21, 2011 (MISO, 33 min.) –** *Well worth the investment* http://www.youtube.com/watch?v=HTvsgeOxb00&hd=1 **[Optional] - Anatomy of a Transmission System (AEP, 4 min.)** http://www.youtube.com/watch?v=WTIQ_xcp0sU&feature=related **[Optional] - Anatomy of a Distribution System (AEP, 10 min.)** http://www.youtube.com/watch?v=YcBgxVfD70Q&feature=relmfu
Utility-Scale Generation Options - *Coal Thermal Power Plant* - *Gas Fired Combined Cycle* - *Co-Gen Plant* - *Utility-scale Renewables*	**Coal Power Plant (MidAmerican Energy, 6 min.)** http://www.youtube.com/watch?v=j0e772Vo73k **Combined Cycle Natural Gas (Duke Energy, 7 min.)** http://www.youtube.com/watch?v=iNspo_s-1jY **Co-generation Plant at NYU (3 min.)** http://www.youtube.com/watch?v=9m9SgsTTgiA&feature=related **Biomass Co-Generation Plant at Nagda site (4 min.)** http://www.youtube.com/watch?v=tARuhig03To **Hydro Power (2 min.)** http://www.youtube.com/watch?v=cEL7yc8R42k&feature=related **Nuclear Power – How it works (7 min.)** http://www.youtube.com/watch?v=LTnfXLws40Q **Wind Turbines (UVSAR, 10 min.)** http://www.youtube.com/watch?v=LNXTm7aHvWc&feature=related **Utility Scale Solar PV (ABB, 2 min.)** http://www.youtube.com/watch?v=edYNj_TrTXY&hd=1 **Concentrating Solar Thermal (Allstrom, 3 min.)** http://www.youtube.com/watch?v=qoOtqUPH8T4&hd=1 **Geothermal (Chevron, 3 min.)** http://www.youtube.com/watch?v=oVDpwwmNJV0 **Tidal and Wave Power (5 min.)** http://www.youtube.com/watch?v=tSBACzRE3Gw&feature=related
Energy Storage Options - *Electricity Storage*	**Columbia Social Enterprise Forum – Energy Storage and Battery Technology (56 min.)** http://www.youtube.com/watch?v=661-GIswZco&hd=1 **Pumped Hydro Storage – in German with translation (2 min.)** http://www.youtube.com/watch?v=GJ7ltJlMY9E **Grid Storage – A123 Batteries (DoE, 9 min.)** http://www.youtube.com/watch?v=6C8Ji05UJaw
Oil and Transportation Markets - *Petroleum* - *Supply Chain Analysis*	**Full Oil Value Chain (Chevron, 6 min.)** http://www.youtube.com/watch?v=KpxctsUJ3hw **Oil and Gas Drilling (7 min.)** http://www.youtube.com/watch?v=F9prX-HRAdg **Dirty Jobs – Oil Drill (6 mins)**

	http://www.youtube.com/watch?v=Wy1pv9J84F8&feature=related **Refinery (14 min.)** http://www.youtube.com/watch?v=9Py8-Xy9MKo **Transportation Fuels – GHG implications (5 min.)** http://www.youtube.com/watch?v=hq2uWWBqe4M **Offshore Oil Platforms (53 min.)** http://www.youtube.com/watch?v=X-s62EOLACo&feature=related *[Scarabeo 9 pics]* http://www.youtube.com/watch?v=GyQNuw6FyeE **Megastructures - Oil Sands (48 min.)** http://www.youtube.com/watch?v=Z4lxpZUw3bw&feature=related **Shale Oil (Energy Now, 28 min.)** http://www.youtube.com/watch?v=U_T-AwYOhp4&feature=related **History - Oil (1930s explanation) (9 min.)** http://www.youtube.com/watch?NR=1&feature=endscreen&v=h3XMlZHZqKQ **History - Pipeline to the Arctic (22 min.)** http://www.youtube.com/watch?v=TXVViPgF02U&hd=1
Biofuels - *Biofuels*	**Ethanol from Sugar Cane- Production Process (15 min.)** http://www.youtube.com/watch?v=kP1S2HGf5-E **Corn Ethanol on Modern Marvels (7 min.)** http://www.youtube.com/watch?v=poTGr8ONgl0 **How it is made – Biodiesel (4 min.)** http://www.youtube.com/watch?v=xLa83KIaEyw **Biofuels, Beyond Ethanol (10 min.)** http://www.youtube.com/watch?v=CkJJ-x7U5NI
Electricity in Transportation Markets - *Electric Vehicles* - *Fuel Cell Vehicles*	**The State of Electric Vehicles in America (29 min.)** http://www.youtube.com/watch?v=1ZGQgZPaQ6o&feature=relmfu **Hydrogen Vehicles and Fueling infrastructure (5 min.)** http://www.youtube.com/watch?v=fhoQAxLSuFw
Natural Gas Markets - *Natural Gas*	**Natural Gas Production and Marketing (Chesapeake Energy, 10 min.)** http://www.youtube.com/watch?v=ga7HibLmSd8 **Natural Gas Pipelines Operation (9 min.)** http://www.youtube.com/watch?v=aTTJeTaYDyc **Hydraulic Fracturing (Marathon Oil, 3 min.)** http://www.youtube.com/watch?v=iBMVMapwGSw&hd=1 **Natural Gas: The Energy to move Forward (Conoco Philips, 5 min.)** http://www.youtube.com/watch?v=BzLZnidztpI **LNG Value Chain (Chevron, 3 min.)** http://www.youtube.com/watch?v=5LplbGd8aXI&feature=relmfu **History – I am Natural Gas - 1959** http://www.youtube.com/watch?v=PKX0GeF9w-k **History – Natural Gas Pipeline Development - 1959** http://www.youtube.com/watch?v=Wodvxh6WEs4