Ideas for Innovation in Energy and Climate

Prof. Mike Mauel and students

Applied Physics Lunch-Time Seminar

Fall 2015

Current Events (10/20/2015)

- (10/10) Naomi Oreskes, professor of the history of science at Harvard, writes about Exxon's Climate Concealment (http://www.nytimes.com/2015/10/10/opinion/exxons-climate-concealment.html)

- (10/20) Procter & Gamble will Run Its Factories With Wind Power built by EDF Renewable Energy in Texas that it says will power all of its North American plants that manufacture home care and fabric products. (http://www.nytimes.com/2015/10/20/business/energy-environment/procter-gamble-to-run-its-factories-with-wind-power.html)

- (10/20) Google announced it will contribute 12.5% of Africa's largest wind farm in Kenya, which will provide 310 MW when complete. (365 wind turbines, each with a capacity of 850 kW) See http://www.ltwp.co.ke/ and http://googlegreenblog.blogspot.com/2015/10/investing-in-africas-largest-wind.html

- (10/20) Duke, Piedmont Natural Gas and Dominion Energy filed paperwork for the $5 billion Atlantic Coast Pipeline, which would bring natural gas produced by hydraulic fracturing in Pennsylvania and West Virginia to power plants in Virginia and North Carolina. (http://www.wral.com/duke-energy-controversial-gas-pipeline-will-lower-nc-power-bills/14991152/#hTkjqSxlrbHYwko0.99)

Current Events (10/20/2015)

- (10/19) U.S. Secretary of Energy Ernest J. Moniz and Israeli Minister of National Infrastructures, Energy, and Water Resources Yuval Steinitz launched the 2015 U.S.-Israel Energy Dialogue. (http://www.energy.gov/articles/joint-statement-united-states-israel-energy-dialogue)
- (10/20) Presidential contender John Kasich last week proposed an "all of the above" approach to energy production that includes renewables and conservation measures along with stepped-up fossil fuel production.
- (http://www.toledoblade.com/Energy/2015/10/20/Kasich-All-the-above-energy-approach.html#aWVj61baFFtYuee5.99)
- (10/20) Richard Kauffman, chairman of energy and finance for Gov. Andrew M. Cuomo, said New York State is poised to spend an enormous $30 billion on its power grid in the coming decade, up sharply from $17 billion spent in the last decade, see "Reforming the Energy Vision" (REV) http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument

Task for Next Two Week

- Discuss your ideas with your (New) Team members.

  Try to reach consensus on at least one near-term objective and one long-term goal.
  (Be bold! But also be objective, technically sound, and realistic.)

- **Everyone**:
  - Find three references, of any type or source, that provides background or technical aspects of your idea
  - Write at least one key issue, having a quantitative answer, that must be resolved in order to assess whether or not your idea or plan is worthy of further consideration

Send by email to maueI@columbia.edu
before C.O.B. next Tuesday

Idea Summary

- Infrastructure, public transportation
- Helping communities with solar power choices
- Distributed energy generation and storage for all sorts of mechanical systems

- Nuclear Fusion
- Advanced Fission

- Public outreach/accurate Info

- Carbon Capture and Storage
- Methane capture and use

- “Light Traps” to improve solar power effectiveness
- Artificial Clouds
- Nano-tech to improve cooling efficiency

Innovation Teams

Clever NanoTech	Smart Infrastructure	Good Data-Info	Advanced Nuclear	CCS
Seth Olsen	**Omar Mahmood**	**Joshua Cohen**	**Sean Ballinger**	**Richard Cresswell**
Jonathan Fletcher	Tyler Cowan	**Lucas Zeppetello**	Farrah Simpson	**Aton Baleato-Lizancos**
Kevin Murphy	Drew Feldman	**Jason Williams**	Michael Wang	Lauren Riddiford
Chen Zhang	Derek Tropf		Ben Israeli	James Page
Alex Battery	Yumou Wei			
	Edwin Vargas			

Smart Infrastructure: Key Issues

- What are the economic and environmental criteria that need to be met for an infrastructural (e.g. rail) project **to be feasible**? To what extent can people be expected to migrate to areas with rail connections? Data science is not an issue to be resolved, but rather can give us the answers to some of these questions.

- **The key issue cost.** While many believe our current technology is sufficient enough to create these idealized smart cities, the hurdle of funding these endeavors will prove to be problematic.

- What incentives will need to be put in place to make the modernization of transportation **financially attractive for a city**?

- The resounding question is: **at what point does the investment** in building these types of ("smart") roads pay off. We must consider a variety of parameters, including expected use of electric cars, the capacity of these cars to be charged through wireless methods, the efficiency of such charging, the costs associated with building and maintaining these roads, possible risks, etc.

- **It may be extremely costl**y to fit subways with a mechanical energy storage system. Subways don't travel fast (only 17 mph on average) are also more massive than such cars. Therefore, subway breaking energy capture systems will have to be made with innovative technologies. How might this be accomplished?

- **The main technical problem is the control algorithm** used to track and optimize traffic flow. The data must be dynamic (real time), and these data might only be accessible within the private companies.

Clever Nano-Tech

- After background reading, I learned that we already have technology producing nanostructure clothing and managing our body temperature. **A key outstanding issue is the structure of "nano-hair"**. But, this is worthy of further consideration since "personal" thermal controlling technology may be a good way to save energy in both summer and winter.

- Regarding artificial clouds, some key issues are **whether we can both predict where the clouds are going to go and how the altered flux of energy into the earth will affect the climate of the earth**. I believe this study should focus on the paths of these particles when they are introduced in the atmosphere above the ice caps, A way to test this would be to suspend particles in the atmosphere that can be easily tracked (such as a radioactive isotope).

- Luminescent solar concentrators (LSCs) consist of materials which absorb solar light and emit it into a waveguide so that the light can be collected by photovoltaics at the perimeter of the area covered by the LSCs. This idea began in the 1970s, but the potential for innovation seems great. **Issues are: optimizing the design, involving resonance overlap, resonance width, extinction coefficient, substrate thickness, and emission angle.** A quantitative question to be addressed is: what is the ratio of the research and development cost to the projected savings at reasonable estimates of the resulting increase in solar cell efficiency? If this ratio is less than 1, then we should move forward with the research!

- The key issues to be **resolved in choosing advanced battery technology are**: (a) offers the highest effective specific energy (J/kg), energy density (J/L), charge/discharge rates (W), economic feasibility ($/J) and safety; (b) is at least as effective (in terms of the criteria from (a)) as petroleum-based fuels currently used in transportation including automobiles, ships and aircraft; and (c) is effectively scalable and mass-producible so as to realistically be able to replace the vast majority of petroleum-burning engines.

CCS

- **Can we prove that the sequestered carbon will remain underground?** How can we test in the short term the long term safety of sequestration? Another question is whether we can improve the energy efficiency of the sequestration process. With current technology, it typically accounts for 10-40% of the energy produced by a power plant, making this option unreasonable.

- Should we capture and use? or capture and store methane produced by livestock (specifically cows)? **Cows contribute to 25% of global methane emissions.** How much carbon is emitted during methane combustion? What is the benefit of not releasing methane? And, would using the methane prevent us from getting energy in other, potentially more environmentally harmful, ways?

- How can a company could serve as **a middle-man between sites that produce methane** (agriculture, landfills, oil digging), **and natural gas companies.** If a company could efficiently capture methane and sell it back to natural gas companies (also getting the government subsidies of a natural gas company), it could help reduce greenhouse gases and break even. **The biggest issue is the startup cost.** Currently, projects similar to this (looking specifically at landfills for these calculations) are being funded for around $15 million. Projections indicate you could capture around 10,000 gallons of liquid natural gas per day, which comes out to ~70,000 MMBtu. The current price for methane is around $2.50 per MMBtu, so we'd be making a revenue of approx. $175,000 per operational day.

Good Data of Sustainable Energy

- In recent years, platforms for data gathering in the fields of environmental science have become available due to the proliferation of autonomous vehicles deployed in a scientific capacity. From drones to sea gliders, these platforms could be generalized and adapted to be less mobile and attached to commercial vehicles that traverse the globe. In this way, enormous datasets could be generated without explicitly designed field campaigns.

  Devising a systems of incentives by which companies are encouraged to participate in these data gathering initiatives would be a way to proliferate a mobile testing station to record data for academic research.

Advanced Nuclear

- An inherent technical issue with the Liquid Fluoride Thorium Reactors (LFTR) concept is the loss of delayed neutrons due to the perpetual flow of fuel. The neutron flux in the core is largely dependent on the delayed emission of neutrons by unstable fusion products. As these products perpetually flow out of the reactor core, a large fraction of emission may occur outside the core, depending upon device geometry and flow rate. Therefore control and maintenance of a stable reaction in the core is sensitive to and may have unpredictable reactions to changes in flow through the system. This complicates startup, shutdown, and modulation of the system.

- A key issue to tackle: cost and availability of fuel from thorium. Unlike mined uranium, mined thorium does not have a fissile isotope. Thorium reactors breed fissile uranium-233 from thorium, but require U-233 for initial start up. This raises the problem of how to start the reactors; however, Transatomic claims it's possible to use low-enriched uranium or even spent nuclear fuel for start-up.

ENERGY.GOV

PUBLIC SERVICES | SCIENCE & INNOVATION | ENERGY SAVER | ABOUT ENERGY.GOV

Home » The Quadrennial Technology Review

THE QUADRENNIAL TECHNOLOGY REVIEW

QTR 2015 describes the nation's energy landscape and the dramatic changes that have taken place over the last four years. Specifically, it begins by building on the first QTR and identifying what has changed in the technologies reviewed within it since 2011. It then identifies the RDD&D activities, opportunities, and pathways forward to help address our national energy challenges. QTR 2015 approaches the analysis from a strong systems perspective to explore the integration of science and energy technology RDD&D with cross cutting technology RDD&D, and conducts an integrated analysis of RDD&D opportunities.


Independent Statistics & Analysis
eia
U.S. Energy Information Administration
Sources & Uses
Topics
Geography
Search eia.gov
TODAY IN ENERGY
HOME
BROWSE BY TAG
PRICES
ARCHIVE
ABOUT
GLOSSARY ›
Most Popular Tags
Liquid Fuels
States
International
Renewable
Exports
Electricity
Crude Oil
Consumption
Gasoline
Imports
Natural Gas
Production
Generation
Demand
Forecast
Oil/Petroleum
Prices
Coal
Weather
Capacity
View All Tags ›
View Tag Cloud ›
y significantly across vehicle types
NOVEMBER 14, 2013
2013 completions of large solar thermal power plants mark technology gains
FEBRUARY 26, 2013
Cellulosic biofuels begin to flow but in lower volumes than foreseen by statutory targets
YouTube
Add us to your site
Have a question, comment, or suggestion for a future article? Send your feedback to

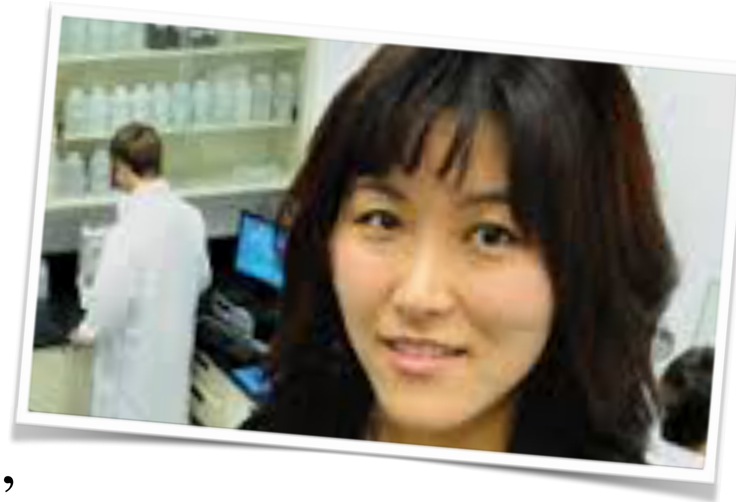
Task for Nov 23rd (5 Weeks)

- Team oral presentations begin
- **Team leaders (Seniors)**: Two slide summary
  - What technical goals/motivations drive your innovation?
  - Introduce/describe the element(s) of your tech/implementation
- **Everyone**: Three slide summary
  - Slide 1: Description; what are you discussing/describing
  - Slide 2: Present a technical summary of work/research to be done
  - Slide 3: Present at least one why your idea shows promise

Send by email to mauel@columbia.edu
before Friday, November 13

Next Week

Prof. Ah-Hyung "Alissa" Park, Interim Director of Lenfest Center for Sustainable Energy



Prof. Park is an expert in energy, environmental engineering and particle technology. Prof. Park's research interests are carbon capture, utilization, and storage (CCUS); sustainable energy conversion systems; synthesis of hydrogen and liquid fuels from alternative energy sources.