Spring 2024 Syllabus for OLLI 452 –Energy and Climate Change
Wednesdays 1:45-3:15 PM
Study Group Leaders – Ron Edelstein and Albert Cheh

Overview:
We start with the dangers of climate change, current impacts of climate change, and why temperature rise should be limited to 1.5-2.0 °C. The current energy system, heavily based on fossil fuels, is the largest source of global warming/climate change emissions stemming from human activity. Meeting the climate change challenge calls for a complete overhaul of the global energy system. With energy being the lifeblood of modern economies, the quest for and control of energy sources is also a major factor in shaping today's global geopolitics.

We will examine the US energy system, starting with the makeup of the current largely fossil fuel and nuclear energy system and discuss how changes in energy sourcing and utilization can make the energy system more sustainable and resilient to environmental stresses. We will focus on how various sustainable energy sources (solar, wind, biomass, geothermal, some types of hydroelectric) operate and discuss their prospects for meeting increasing future energy demand. We will also examine measures for decreasing energy use and emissions (industrial, residential, commercial and in transportation), an equally important part of creating a sustainable energy system.

Week 1 – March 6 - Introduction – Climate change status and projections – Ron Edelstein
What is the greenhouse effect? Climate change status, information and projections from the IPCC and other sources; what has to be done to keep temperature rise under 1.5 or 2.0 °C and why. Correlation of CO_2 levels and increased global temperature and discussion of the consequences will be presented.

Week 2 – March 13 - Energy basics; current status; transitions and metrics – Albert Cheh
Basic energy units (metric and English). Limits imposed by the Laws of Thermodynamics and what is meant by high vs. low quality energy (which underlies the magic of heat pump efficiency). Energy vs. power. The current US energy system and carbon emissions; basic concepts of electricity, the electrical grid and electrical standards. What can drive an energy transition to renewable sources; what are the challenges posed by the cost, scale, land requirements and critical materials needed for such a transition; the importance of improving energy efficiency. Financial measures: simple payback periods for new energy production/efficiency methods. Energy return on investment (EROI)

Week 3 – March 20 - Reducing emissions from industrial processes. Energy efficiency basics, building materials and contents - Albert Cheh
Reducing emissions from industrial processes – fertilizer, steel, cement, petrochemicals, with zero emissions (green) and other types of hydrogen as a potential part of those reductions (more on hydrogen production in session 8). Efficiency: Energy intensity. Why building efficiency is the largest single focus for energy efficiency; life cycle assessment, including building materials and embodied energy. Building operations - heating, ventilation, air conditioning (HVAC) and appliance standards; building surface/volume ratios; LED lighting.

Week 4 – March 27 - Towards net zero buildings; transportation efficiency - Albert Cheh
Passive solar heating; hot water heating; minimizing cooling needs (white and green roofs); building orientation; window glass and overhangs. Introduction to the AU LEED Gold SIS

Building. Transportation efficiency: mode of travel; mass transit; private automobiles – why electric vehicles are more efficient and less carbon emitting overall (depending on how the electricity is produced), CAFE mileage standards; air travel efficiency improvements. Energy intensity for freight - pipelines vs. other transportation modes. Can container ships use sustainable fuels rather than heavy oil? Critical materials for electric motors and EV and storage batteries.

Week 5 – April 3 - Fossil fuel generation - Ron Edelstein
The history and current US status of oil, natural gas and coal – how horizontal drilling and hydraulic fracturing (fracking) technologies revolutionized oil and natural gas production and bankrupted coal; Bakken shale and Canadian tar/oil sands; dependence on pipelines, construction protests and pipeline geopolitics; methane emissions. Combined cycle electric power generators. Future prospects, including carbon capture and storage technologies. Is natural gas a bridge fuel, part of the solution or part of the challenge to global warming.

Week 6 – April 10 - Nuclear power and the electrical grid system - Ron Edelstein
Current nuclear power plants and license extensions. Nuclear futures: Gen 3 and 4; small modular reactors and novel concepts. How the US grid system developed, smart grids and long-distance transmission geography. Why is fusion always 50 years away? The grid: electric transmission bottlenecks to utility-scale renewable energy plants: How to expedite the approval process; need for integration of energy storage

Week 7 – April 17 - Distributed electrical generation, photovoltaics (PV) and wind - Albert Cheh
Solar resource geography; concentrated solar thermal electric power/concentrated solar power (CSP); solar photovoltaics (PV); single vs. multijunction cells. Intermittency: why we need energy storage with renewables. Wind turbine types, onshore and offshore wind, and wind resources; turbine operations and siting. Wind turbine problems. Installed capacity and capacity factor. How to integrate intermittent solar and wind generation with real-time electrical demand - demand side management

Week 8 –April 24– Storage; other renewable energy sources - Ron Edelstein and Albert Cheh
Albert Cheh: . Energy storage methods – batteries and other. Cost trends. Biofuels: lower net carbon emissions via recycling carbon dioxide(?). Biofuel types and production; is algal fuel the future? Renewable fuel standard and EROI. Is bioenergy with carbon capture and storage (BECCS) a promising method for *removing* carbon dioxide from the atmosphere (negative emissions later in this century)?
Ron Edelstein: Detailed discussion of pitfalls and promise of hydrogen production. Geothermal: geographical limitations for large centralized geothermal plants; are geothermal heat pumps a promising local application? Ocean technologies: ocean thermal energy (OTEC), tidal power, wave power. Geoengineering and direct air capture technologies for atmospheric carbon removal; energy system resilience.

Week 9 – May 1 - From now into the future - Ron Edelstein and Albert Cheh
Ron Edelstein: *Your choice*: use of En-ROADS interactive global warming model.
Albert Cheh: Listing of key areas of research, development and implementation for reducing emissions (climate mitigation)