

ME 4805: FALL 2018



Drivers for Clean Energy Development

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What is driving the push for alternative energy technologies?

- Energy Independence/Availability
- CO₂ emissions are troublesome



Dealing with these issues will require an energy revolution that is just beginning!



Experts agree that human-caused global climate change is a serious problem

- **Our National Academy of Science has studied the science of climate change and found that it is a serious problem**
- **ASME has identified the necessary shift to green energy as one of the “Grand Challenges of Engineering”**
- **Carbon dioxide emissions are now being regulated around the world.**

What can engineers do to help solve these problems?



- Improve efficiency of energy generation and energy use (e.g. automobiles)
- Develop alternative energy systems





Understanding carbon dioxide emission trends (IEA Report*)

- Largest emitters:
 - China **8.0 Gigatonnes (up 251% since 1990)**
 - US 5.3 Gigatonnes (up 9% from 1990)
- Per capita emissions
 - China 5.9 tCO₂/person (up 199% from 1990)
 - US **16.9 tCO₂/person (down 13%)**
 - UK 7.1 tCO₂/person (down 26%)
 - Nepal 0.1 tCO₂/person (up 188%)
- Emissions per GDP
 - China 1.9 kg/US\$ (down 56% from 1990)
 - US 0.40 kg/US\$ (down 35% from 1990)
 - UK 0.19 kg/US\$ (down 49% from 1990)
 - Sweden **0.11 kg/US\$ (down 46% from 1990)**

In US industry is leading the way



- **World Business Council for Sustainable Development**
 - 180 leading companies
 - Total market capitalization= \$5.4 Trillion
 - Includes: Alcoa, Caterpillar, Coca-Cola, ConocoPhillips, Ford, Dow Chemical, GE, GM, IBM, *Johnson Controls*, S.C. Johnson & Son
- **U.S. Climate Action Partnership**
 - Alcoa, Dow, Shell, GE, etc. partner with NRDC and others to lobby lawmakers for federal carbon regulation.

“Green is good for business.”—GE Chairman

Triple Bottom Line → financial, social, and environmental

MSOE is a part of this movement



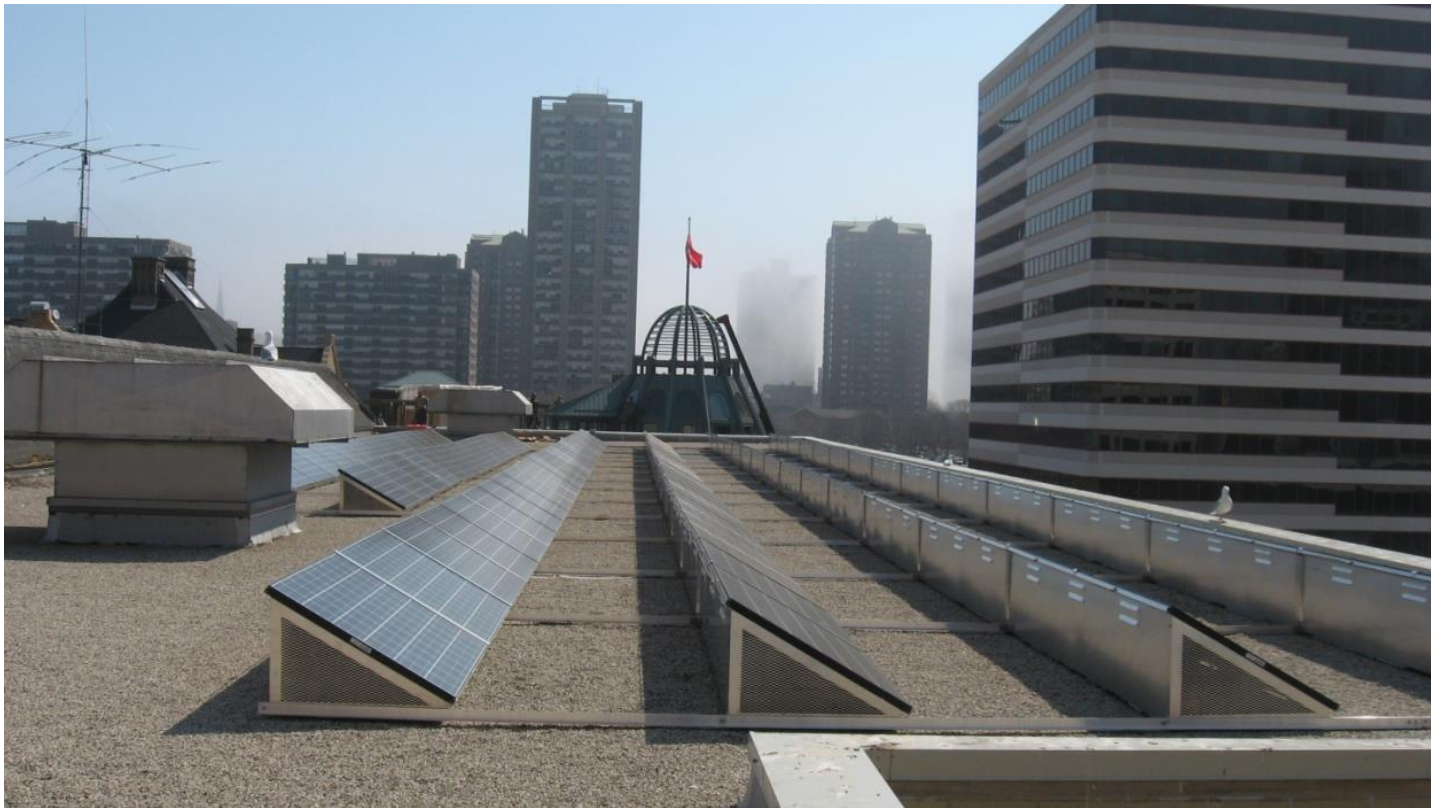
- 30 kW Solar Photovoltaic System
- Solar Thermal system provides hot water to MLH dormitory
- Renewable Energy Systems Laboratory
- Advanced Energy Technologies Laboratory
- Supermileage Vehicle team
- Formula-Hybrid team



MSOE's Solar Power Plant



- Installed August 2008, 30 kW system (peak DC)
- 144 solar photovoltaic (PV) panels on campus center building (~2500 ft² collection area)
- Output is about 32,000 kWh/year (25 tons of avoided carbon dioxide per year)



MSOE's Solar Thermal System



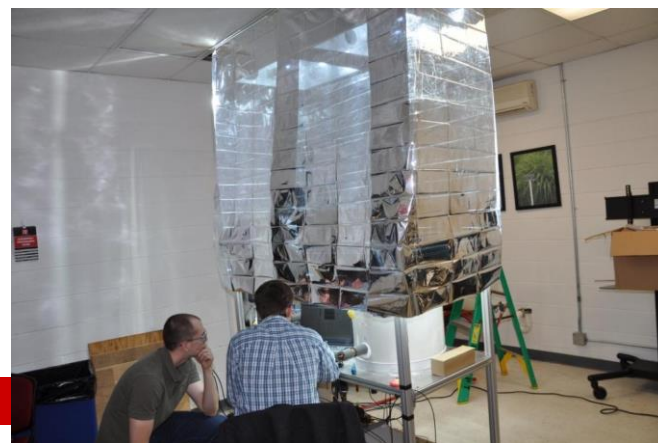
- **Installed Aug. 2011**
- **System size: 14 panels,
520 ft² of collectors**
- **Output is about 1100 therms/yr
(10-20% of domestic hot water
needs of dorm)**
- **6 tons of avoided CO₂
emissions/year**





Renewable energy systems laboratory

- Portable solar energy systems with in-lab solar simulator
- Commercial size solar PV and Solar Thermal systems





Advanced energy technologies laboratory

- Focus is on technologies that allow for highly efficient energy conversion: e.g. cogeneration systems and fuel cells



Natural gas-fired micro-combined heat and power

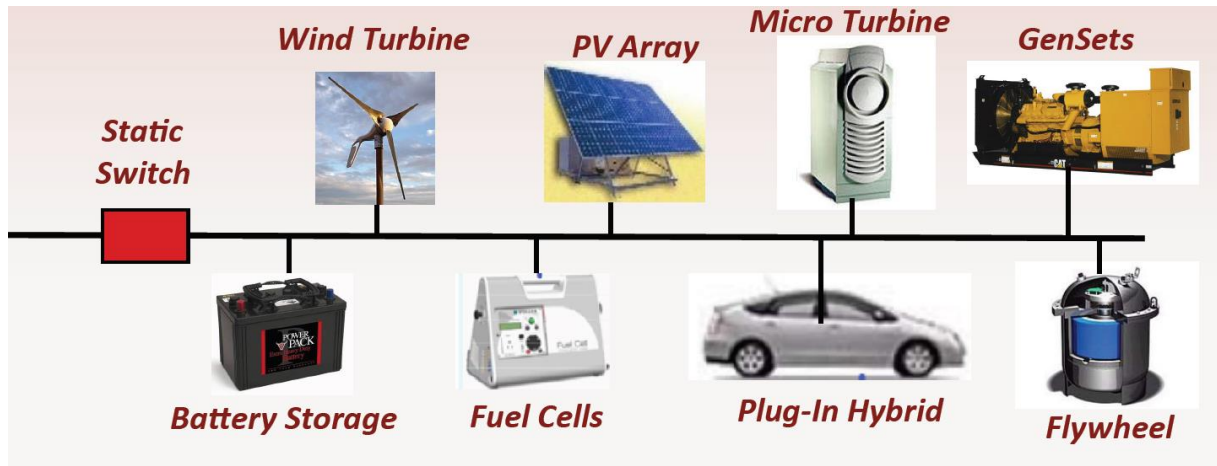
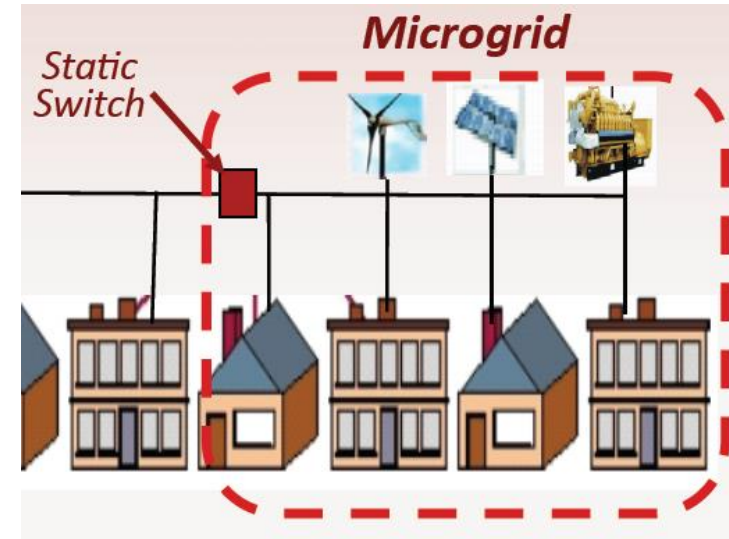


Hydrogen fuel cell

Promising Areas



- Distributed energy generation
 - Renewable energy
 - Combined heat and power
- Solar energy utilization
- Smart grid/Microgrids





Notable developments and key challenges for green energy deployment

- Solar PV costs (\$/kWh) have dropped 60% in the last 4 years reaching cost parity with fossil fuel generation in many markets.
- More solar capacity was installed in last 18 months than in the prior 30 yrs. combined!
- Wind is now the least expensive option for new electricity generation sources.
- Key remaining hurdles:
 - Wind and solar are intermittent sources → need cost effective storage.
 - Opposition from electric utilities.
 - Policy and regulatory challenges.
 - NIMBY-ism