All ECE systems require electric power
  • Energy needs to come from somewhere

Energy one of the dominating domestic and international issues

Today’s lecture: generating electric power from other energy sources
  • Focus on solar cells

Next week’s lecture: distribution of electric power
  • Power grid
Energy vs. Power

- Definition of energy
  - Amount of work that can be performed by a physical system

- Definition of power
  - Rate at which work is performed or energy is converted

Activity

- What are sources of energy?
Sources of Energy

- **Mechanical**
  - Compressed spring, elevated mass, thrown ball, vibrations

- **Thermal**
  - Water steam, molten lava

- **Chemical**
  - Fossil fuels, explosives

- **Nuclear**
  - Nuclear material for fission or fusion

- **Electromagnetic radiation**
  - Light, microwaves

- **Note:** *anything* has energy associated with it
  - In practice it matters if we can extract that energy

Energy Conversion

- Energy can be converted from one type to another
  - Conversion typically not 100% efficient (i.e., energy loss)

- Example devices/processes for energy conversion:
  - (from wikipedia.com)

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<tr>
<th>from \ to</th>
<th>mechanical</th>
<th>thermal</th>
<th>electric</th>
<th>electromagnetic radiation</th>
<th>chemical</th>
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Mechanical to Electric

- Hydroelectric turbine
Chemical to Electric

- **Fuel cell**
  - Chemical reaction directly generates current

Proton exchange membrane fuel cell

- Hydrogen fuel is channeled through field flow plates to the anode on one side of the fuel cell, while oxidant oxygen is sent to be channeled to the cathode on the other side of the cell.
- At the anode, a platinum catalyst causes the hydrogen to split into positive hydrogen ions (protons) and negatively charged electrons.
- The polymer electrolyte membrane (PEM) allows only the positively charged ions to pass through the cathode. The negatively charged electrons must travel along an external circuit to the cathode, creating an electrical current.
- At the cathode, the electrons and positively charged hydrogen ions combine with oxygen to form water, which flows out of the cell.

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Thermal to Electric

- **Thermocouple**
  - Thermoelectric effect used to generate voltage

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**Nuclear to Electric**

- Betavoltaic cell
  - Beta-particles from radioactive decay induce current
  - Very long lifetime (tens of years)

**Electromagnetic Radiation to Electric**

- Solar cell (photovoltaic cell, PV cell)
  - Photons knock loose electrons in silicon
  - Combination of n-p layer induces drift current
Demo

- Measurement of current and voltage of real solar cell
  - Potentiometer to "move along characteristic cure"

[Graph showing a voltage-current characteristic curve for a solar cell]
Solar Cell: Voltage and Current

- “Characteristic curve” of solar cell
  - Relationship between current and voltage
  - Curve depends on light intensity, temperature, etc.

System Optimization

- How to get maximum power out of the solar cell?
System Optimization

- How to get maximum power out of the solar cell?
  - Power is $P=I\cdot V$
  - Maximize “P area” under curve

How to get maximum power out of the solar cell?

- Problem: optimal operation point changes with conditions
  - “Maximum power point tracker”
    - DC-to-DC converter
    - DC voltage on solar cell side: voltage of optimal operation
    - DC voltage for battery charging

Typical installation:
Solar Installation

- Example installations:

- Amount of solar exposure determines effectiveness of system
  - How to find best location?

Meet a UMass EE Alumnus

- Willard MacDonald (EE’94)
  - President and CEO of Solmetric
- Product: SunEye
  - Embedded device to measure and compute solar exposure
    - Camera captures sky view
    - Location determines sun’s path
Courses in ECE Curriculum

- ECE 211 – Circuit Analysis I
- ECE 212 – Circuit Analysis II
- ECE 323 – Electronics I
- ECE 324 – Electronics II
- ECE 597D – Power Systems

Upcoming...

- Next Wednesday: power grid
  - Power distribution
- Moodle quiz