Teaching Energy Conservation

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About Me

- Purdue Univ. MS Electrical Power Eng. & TA
- TCC Adjunct Inst. of Engineering & Eng. Tech
- Power & Interdisciplinary EE Experience
  - Utility
  - Renewable
  - Military: Space, Aviation, Land & Naval
- Ancestors Depression Era Farmers
- Hobby & Part Time Truck Farming

Technology Education Approach

- Teach Scientific Principles of Energy & Power
  - Active Problem Solving vs. Passive Lists & Definitns.
  - Relate to Other Science Studies
  - Minimal Outside Jargon
- Relate Scientific Principles to Non-Science
  - Policies, Laws and Regulations
  - Acronyms
  - Politics
  - Government Agencies
  - Non-Gvernment

Goals

- Review Basic Definitions
- What Are We Conserving?
- Energy Budget vs. Energy Costs
- The Grid and Agriculture
- Student Exercises

Forms of Energy

- Thermal
- Electrical
- Electromagnetic e.g. Light, Radio-Waves
- Chemical
- Mechanical
- Nuclear

Law of Conservation of Energy

- Energy is Neither Created of Destroyed
- Definition from Newtonian Physics
- Practical for Energy Conservation
- Corollary – Conservation of Mass

Work = Energy

- Mechanical Work = Mechanical Force x Distance
- Electrical Work =
  Electromagnetic Force x Distance

Energy vs. Power

Energy

- The Ability to Do Work
- Energy = Power x Time
- Example
  - Full Battery Charge
  - The Height of Water Falls

Power

- The Rate Work is Done
- Power = Energy/Time
- Example
  - Rate of Battery Charge
  - Flow Over Falls

Entropy – Energy "Quality"

- The Universe is Becoming More Disorganized
- Flow From High to Low Temp.
  - Heat Engine
  - Temperature Converted From Energy Source
- Temperature Difference Corresponds to Quality
- Electricity is High Quality
- Solar Thermal (not concentrated) is Low Quality
- Heat Death
  - Everything at the Same Temperature

Efficiency < 100%

- Definitions
- Return on Investment

Electrical vs. Other Sources

- Energy "Quality"
  - Entropy
  - Temperature Required
- Electricity
  - Not always a good intermediate step
  - Where is waste heat dumped?
  - What is the efficiency of the entire energy flow?
  - PV or Hot air for space heating
  - PV or Fluid for Domestic Hot Water

Time of Use

- Cost of Energy Varies With Time
  - Motivation for Smart Meters
  - Avoid Using Expensive Energy
- Power Available
  - Maximum Distribution
  - Maximum Power Generation

Logical Problem Solving

Troubleshooting

- What is Broken
- Test
- Measure
- Analyze
- Fix
- Iterate

Scientific Method

- Hypothesis
- Experiment
- Conclusion
- Iterate

Student Exercises

- Cell Phone
- Parasitic Loads
- Analysis of Electric Bill
- Yearly and Daily Energy Use
- ERCOT Graphics

Engage Students

- STEM
  - Renewable Energy
  - Robotics
  - Ag Technology Projects
- Energy Learning Objectives → Curricula
  - Definitions
  - Applications
  - Measurements
  - Problem Solving

Tools for Experiments

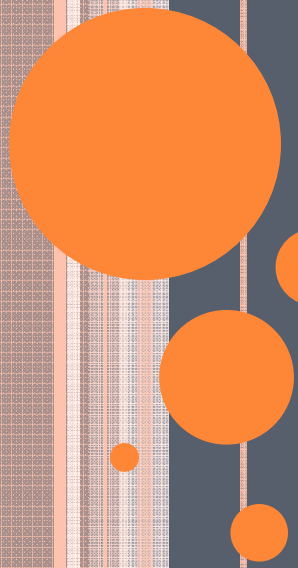
- Thermometer
- Airflow
- Tachometer
- Digital Multi-Meter & Conservation Meters
- Kilowatt-Hour Meter
- Instruments from Renewable Energy Kits
- USB Interfaces for Data Logging
- Embedded & Wireless Sensors

Devising a Lab Practical

- Devise Basic Learning Experiment
- Hands on Measurement and Resolution
- Relate to Practical Example
- Gather Typical Data
- Propose Solutions for Example

Traditional vs. Renewable

- Conservation of Traditional Energy Sources
- Conservation of Renewable Energy Sources
- Relate the Two
- Problem Solving vs. Checklists
- Energy Budget



Appendix

Student Exercises

Parasitic Loads

- "Wall Warts" Always Consume Power
- Simple Measure – How Hot is It?
- Unplug or Switch Off When Needed
- Supply Power Only While Charging Battery
- Use Switched Plug Strip

Energy Budget

- Money Flows Opposite Direction of Energy
- Energy Flows One Way
- Money Circulates
- Add Energy Used With Line Items

Measure "Parasitic" Loads

- Make Sure Someone is Measuring
- Smart Meter
- Load Meter
- DMM
- Does it Feel Hot?

Smart Meter Exercise

- Obtaining a Texas Smart Meter Account

Phase Change Loads

- Dry Wet Things Outside of Air Conditioning
- Open Containers in Refrigerator Kitchen
- Dry Clothes on the Line
- Exhaust Fans in Kitchen & Bathrooms
- Be Aware of Relative Humidity

AC Circuits

- Power Factor
  - Energy Delivered at Low Power Factor Costs More
  - PF = cos(phase angle between current & voltage)
- Three Phase Motors More Efficient
  - Constant Mechanical Torque
  - Less Copper and Magnetic Material Needed
- Renewable Energy Inverters
  - Choose 3 PH over 1 PH at lower
  - Weight

Using Smart Meter Data

- Use Typical or Actual Local Smart Meter Data
- Base Load
- Demand Charge

Texas Energy Production

- Energy Reliability Council of Texas
  - Resource Adequacy Reserve < 14%
- Utility Deregulation
  - No New Generating Plants
  - Some Renewable Energy
- Emissions Regulation
  - Limited Use of Local Engine Generators
  - High & Uncertain Costs to Build Plants

Smart Grid

- Technology Accomplishment of 21st Century
- Vulnerable to Cyber Attacks
- Student Data Exercise
- Grid Vulnerable to Physical Attacks

Appendix 2

Back-up Information

Bibliography

- Unpublished Class Notes

Too Much Information (TMI) Relate to Science in Separate Units

- LEED
- MW
- MVAR
- DOE
- NREL
- AWEA
- ERCOT

"Free Energy" and Other Scams

- Based on Circular or Poor Definitions
- Misunderstandings of Advanced Definitions
- Misquotes or Oversimplifications