EtF is:

a flexible, adaptable, affordable, modular full-year ninth grade technology/engineering standards-based constructivist curriculum for all students (not just those aiming at technical careers), which employs a series of engineering design challenges, each of which pose inquiry-based problem scenarios to be resolved via need-to-know discovery learning by student teams applying mathematics and science through sequential tasks comprising four distinct, engaging, term-length projects.

National Center for Technological Literacy®

Museum of Science, Boston

Key Curriculum Press

Engineering the Green Future

Science, Technology, and the Design Process

High School Curriculum Initiative

Lee Pulis, Professional Development Educator

CAPSULE July 27, 2011

EtGF:

Greening the curriculum means ensuring that students are capable of taking on the 21st century challenges of:

- global warming and climate change,
- social inequities,
- unsustainable lifestyles, and
- the urgent need to switch to a renewable energy-based economy.

What Is Engineering?

What is technology?

Technologies are the products and processes created by engineers. Engineers create the designed world, using

The Engineering Design Process

What Is Green Technology?

“Americans can prosper by outgreening everyone else”

Tom Friedman

Hot, Flat & Crowded

What Green Jobs are Needed?

- To meet regulations?
- For green marketing?
- To decrease global warming?
- To produce greener products?
- To decrease resource use and costs?

- Other needs…
-
-
-
-
-
-

Most any job can Go Green

More green job categories

- Education delivery (online)
- Utilities - energy, heat, light, and water (production, use, efficiencies, savings)
- Transporting people and goods (hybrid, electric, biodiesel, & conversions)
- Building construction, operation, and maintenance (interior air quality, daylight harvesting, passive solar, green roofs, nontoxic cleaning and hygiene)

And more…

- Food selection, production, purchasing, packaging, and distribution
- Grounds design, irrigation, precipitation runoff, and pest control
- Waste minimization
- Reuse and recycling
- Purchasing and use of supplies

Why go Green?

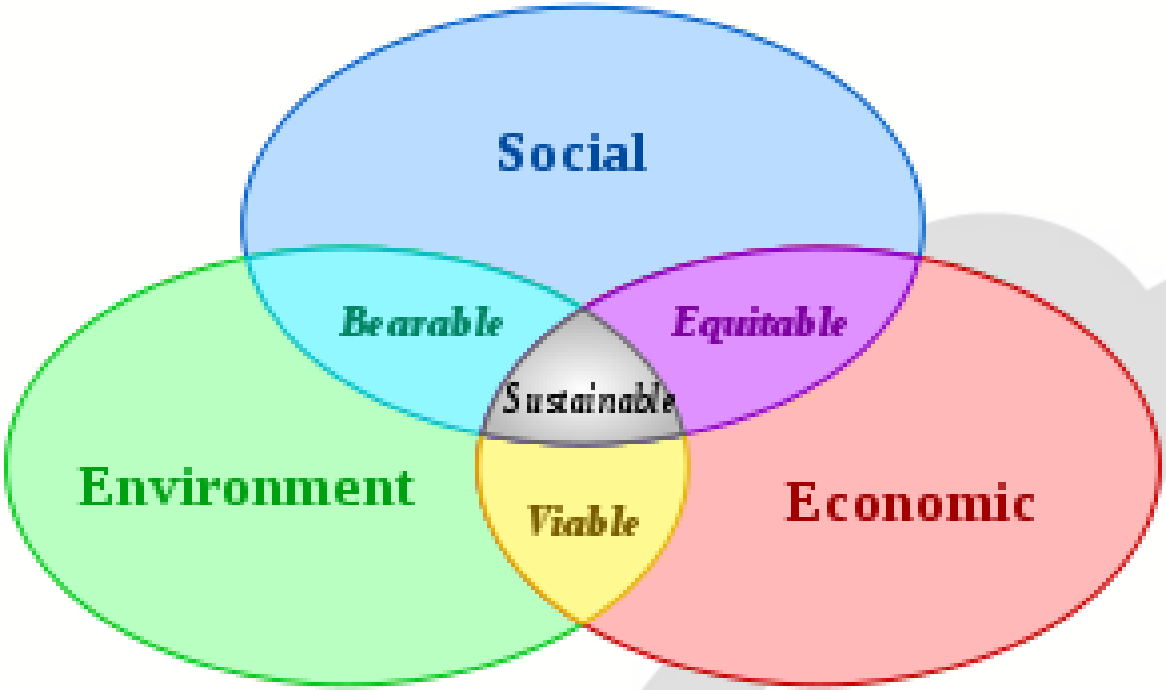
- **"green energy** is experiencing a social, political and economic surge that rivals any major movement of the last century.

- the Internet is fueling a massive community of **green**…savvy bloggers and activists from every street corner, office, coffee shop and grandmother's basement."

(squidoo.com/green-energy)

What does “Greening” include?

Three elements of the Green Economy



Triple Bottom Line of Sustainability

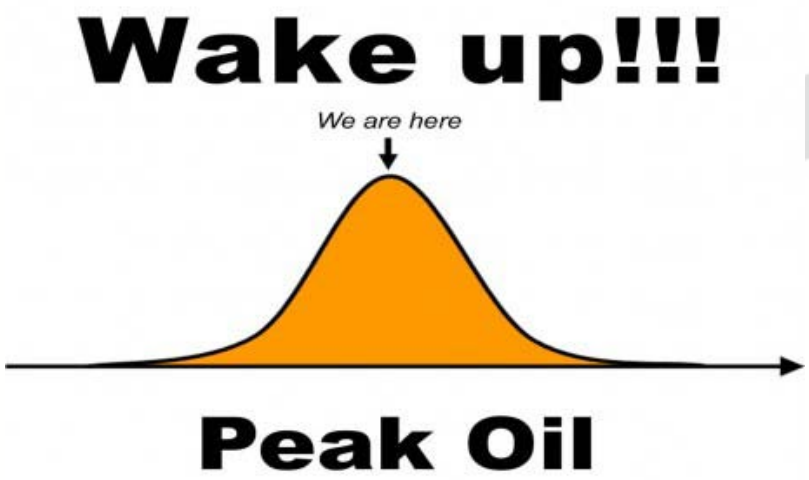
Social reasons to Go Green

Poverty & equity

Legacy for future generations

Environmental reasons to Go Green

Accelerated species extinction



Resource depletion

Economics of Greening

Use less -- lower costs

- Energy
- Water
- Raw material
- Nonrenewables

Go renewable for sustainability

Conduct Life Cycle Analysis

Reduce carbon/energy/ecological footprint

Waste less – increase profits

- Reduce, Reuse, Recycle
- Decrease emissions
- Remanufacture defects

Green Engineering Activities Encourage Students to

- Invent • Create
- Innovate • Redesign
- Iterate • Optimize
- Work in teams
- Value diversity
- Integrate disciplinary learning
- Assess Cradle to Grave product impacts

Green Engineering Activities

would aim to instill knowledge, understanding, skills, experiences and attitudes needed to create a generation of graduates . . .

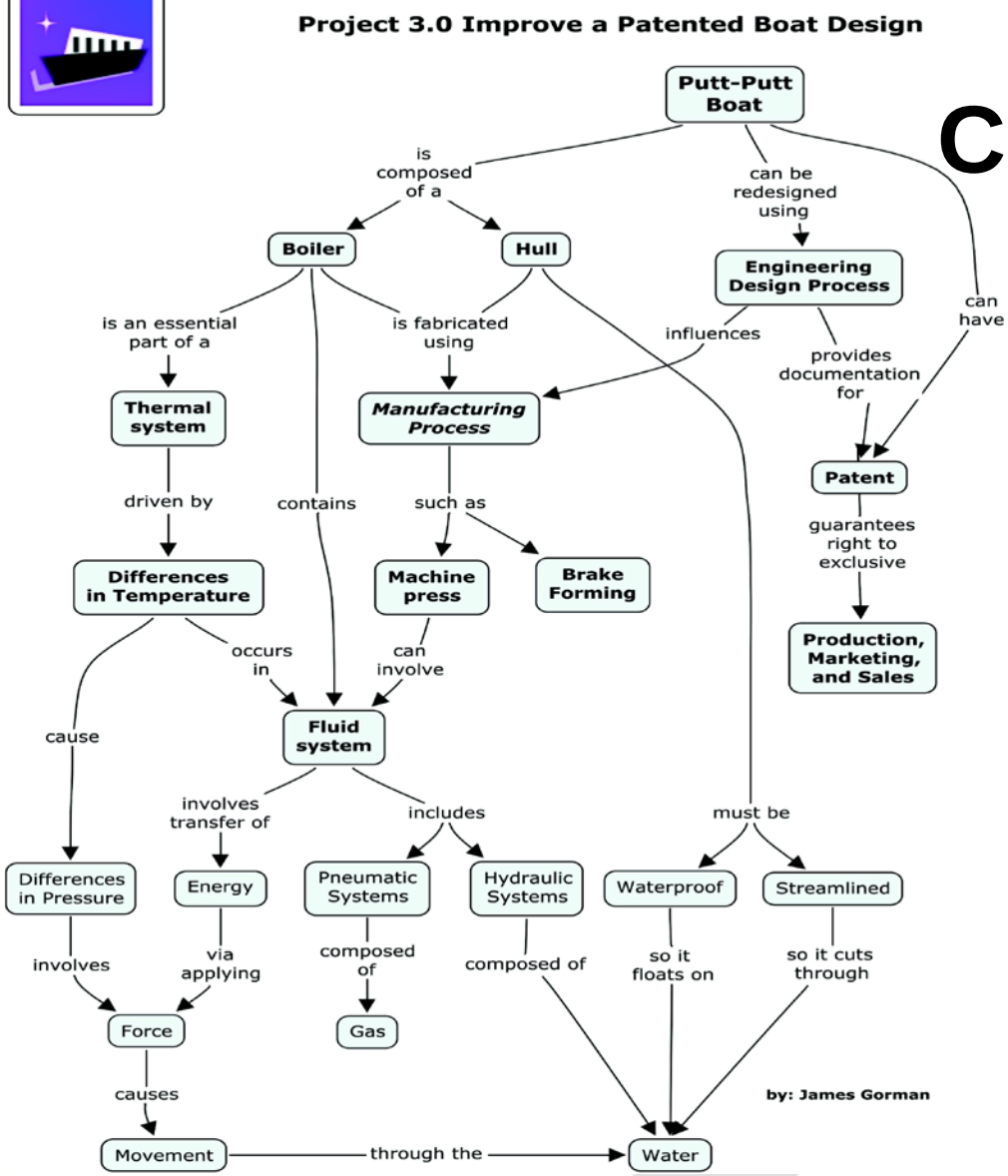
- who have a grounding in **compassion and ethics** (the impacts of climate change are hitting poorer nations first)
- who grasp **the science of global warming and** the current and impending **impacts of climate change**
- who have a clear understanding of **how their health and ecosystem health are interrelated**
- who know they are a **part of Nature**
- who understand the **ecological principles underlying how life works on Earth**

Project Concept Maps

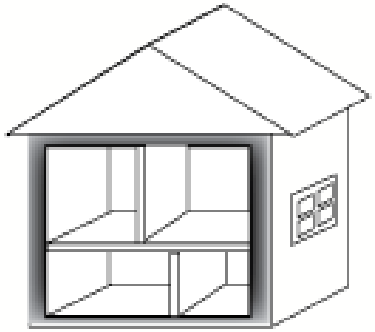
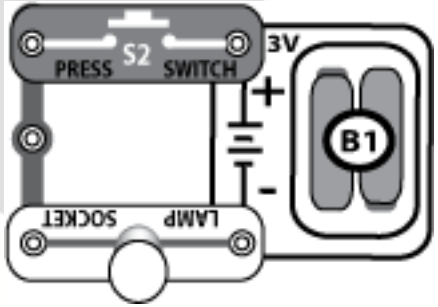
Teacher Guide

Page 344

Add Green Concept Connections



Unifying Concepts for Energy Flow

Thermal Energy Flow Rate	Fluid Volume Flow Rate	Electric Charge Flow Rate
$I_Q = \Delta T / R$ 	$I_F = \Delta P / R$ 	$I_E = \Delta V / R$ 

Unit 1: Creators of the Designed World

Engineering Design Process and Manufacturing

Students read about:

Amy Smith, MIT engineering professor, introduces a screenless hammer mill as an *appropriate technology* in Haiti

Students design:

An organizer and consider how to manufacture their product for a mass market *with minimal waste*

Introduction to:

Engineering Design, Manufacturing Systems

1.2 Design a Cell Phone Holder

- Using a manila folder and tape, build a mock-up (model) of a new kind of cell phone holder. Think about new features or improve some old ones.

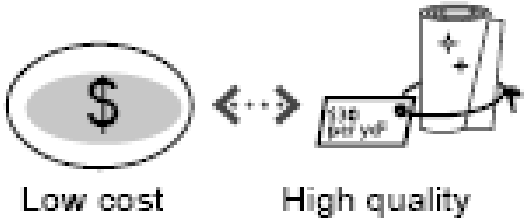
- Criteria: teamwork, folder & tape
- Constraint: time
- Green relevance: Life Cycle Assessment

Costs of Manufacturing

- Costs (p. 12-16)
  - ***Material cost*** - choice of material
  - Layout of design to reduce waste (Area)
  - ***Labor cost*** – Employee wages, hours, items produced per hour/week/year
  - ***Overhead cost*** - Cost to rent the factory, pay the utility bills, other business maintenance
  - ***Total Production cost*** = Material cost + Labor cost + Overhead cost
  - Manufacturer's markup (cost recovery + profit)
  - ***Wholesale cost***
  - Packing Material – Volume/cost of material for packaging
  - ***Store cost***
  - ***Retail Price*** – including store cost markup

- Trade-offs (p. 17)

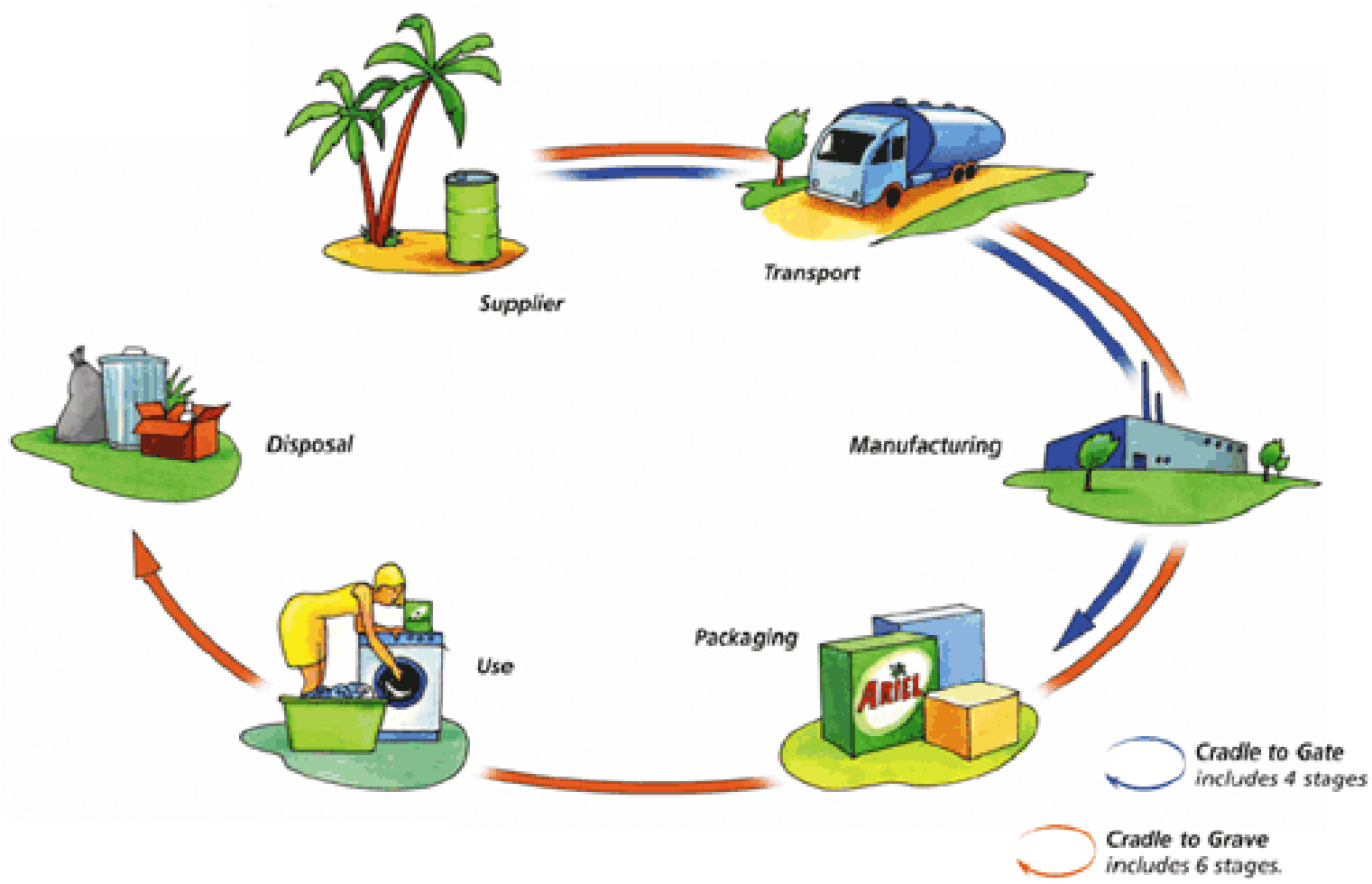
  Niche vs Mass marketing, cost vs quality…



Life Cycle Assessment (LCA)

- Environmental impact of a product or service
  - Raw Material Production
  - Transportation
  - Manufacture
  - Packaging
  - Use
  - Disposal

Life Cycle Assessment



Project 1: Design a Green Organizer

or-gan-iz-er (noun): anything designed to keep smaller things so they stay together and are easy to find and retrieve when needed.

Organizers store, protect, and separate stuff, and provide easy access…generally making our lives more orderly.

Green Relevance: Recycling bins

Unit 2: Sustainable Cities

Construction Technology and Thermal Systems

<u>Students read about:</u>

Lauren Stencil, a U Mass participant in the National Solar Decathlon, outlines simple and innovative ways to build an energy efficient home

<u>Students design:</u>

A plan and model for a building of the future that includes energy efficiency features

<u>Introduction to:</u>

New urbanism, fundamentals of *energy* and *energy transfer*

Sustainability

"meet present needs without compromising the ability of future generations to meet their needs"

United Nations Conference

1987

Project 2: Design a Green Building of the Future

Construction Technologies & Thermal Systems

- New Urbanism, Urban Sprawl
- Sustainable Development, Mixed Use Zoning
- Multi-Use Buildings, Building Codes
- Construction Materials Properties
- Failure Analysis, Safety Factors
- Live and Dead Loads, Stress, Strain, Strength
- Green Building, Energy Efficient Design
- Passive and Active Solar, Thermal Systems
- Scale Drawing, 3-D Models

Project 2: Design a Green Building of the Future

Construction Technologies & Thermal Systems

Greening the challenge:

Design and **scale model** a building of the future (or a green remodel/remediation) incorporating energy efficiency, green materials, and sensitive site development for minimum energy/carbon/ecological footprint. Justify your proposed budget with reference to future operating costs.

Project 2 “Greened Up” Tasks

- Principles of sustainable site development
- Soda can solar collector quick-build
- Investigate thermal resistance, structural loads, and properties of materials
- Perform an energy audit
- Calculate your carbon/energy/ecological footprint
- NAHB Green Home Building Guidelines
- LEED for New Construction Rating System
- Consideration of green structural materials; interior and exterior finishes; heating, lighting, and cooling systems; and appliances
- Present your proposed design as drawings and a scale model

Related Green Jobs

Home energy auditor

Industry life cycle analyst

Footprint calculations

Materials Testing

Concrete

Embodied energy is the energy consumed by all of the processes associated with production, from the acquisition of natural resources to product delivery. Cement production and aggregate quarrying make concrete's EE very high. :+(

Greening methods:

Fly ash, carbon fiber, post-consumer glass, recycled concrete & tires as aggregate, porous matrix, translucence, etc.

Unit 3: Going with the Flow

Thermal and Fluid Power Systems

Students read about:

Josh Tickell describes his bio-diesel van, doing his part in the reduction of fossil fuel use

Students re-design:

A heat engine for the putt-putt boat and write a patent application for their improvement(s)

Introduction to:

Thermodynamics, *energy sources*, *engines* and *efficiency*

Improve a Toy Boat Design

Thermal and Fluid Power

Challenge:

Build a Putt-Putt Boat that runs on a fluid-thermal system and write a patent for a Green design improvement.

Improve a Toy Boat Design

Green Transport/Sustainable Mobility

Greening the Challenge:

Investigate transport propulsion systems and develop a **mock-up** of one green alternative design improvement lessening today's reliance on fossil fuels for either car, boat, truck, train, cycle, or airplane.

(or renewable energy HVAC fluid-thermal system)

Activity: How <u>does</u> it work?

Interpret Drawings

5 E's

Engage>Explain>

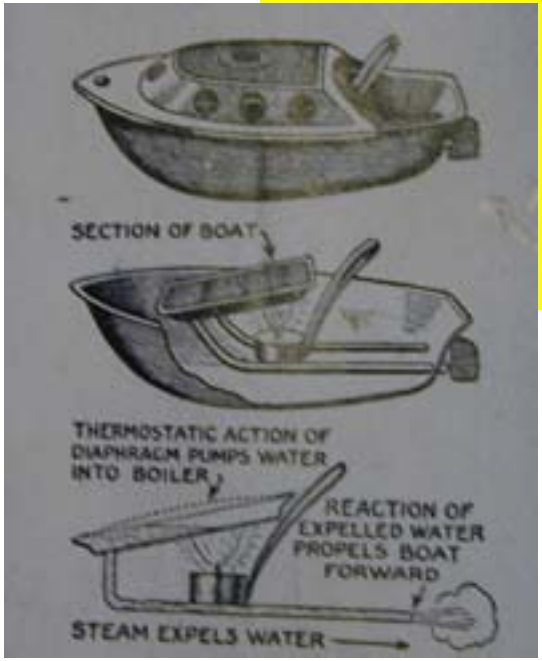
Explore>Elaborate>

Evaluate

Think

Pair

Share



Brainstorm

How does the Putt-Putt boat work?

Sample Rubric

- Combustion
- Temperature difference
- Pressure difference
- Energy flow
- Conduction
- Vaporization/phase change
- Boiler expansion (Putt-)
- Boiler contraction (Putt)
- Mass expulsion (water)
- Velocity increase through pipes
- Action-reaction propulsion
- Boat motion
- Jet flow/sink flow
- Water intake/exhaust
- Cycle

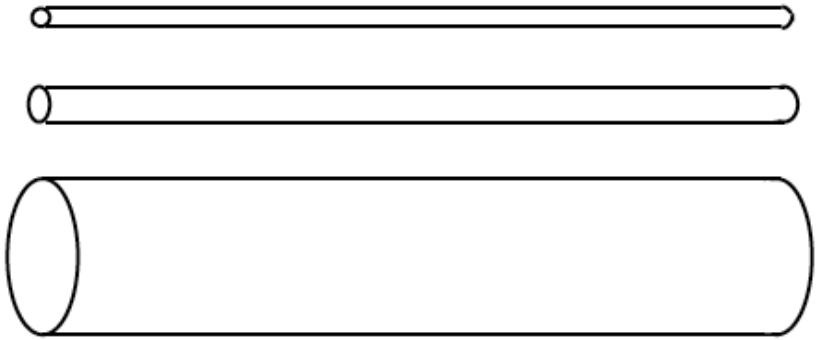
Students are prompted to refine their answers three times

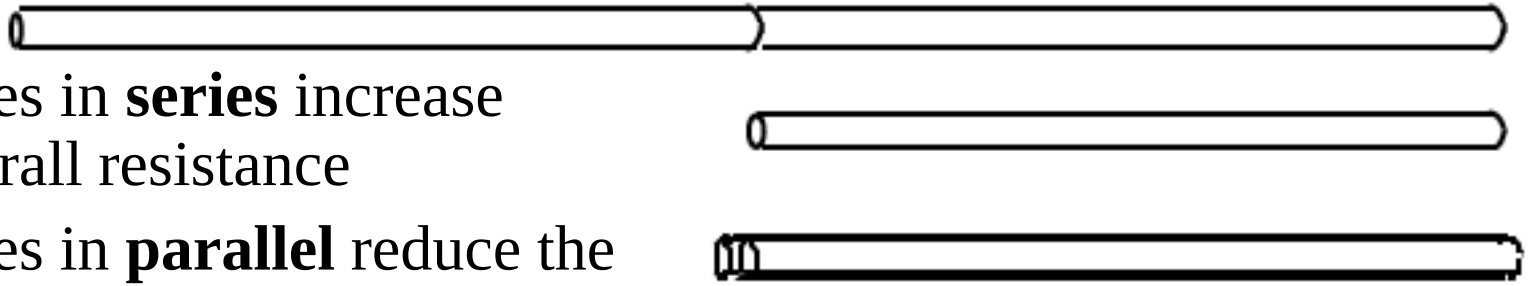
How to Improve Boat Design?

- Faster
- Louder/Quieter (stealth)
- Longer running
- Bigger/smaller
- Different Fuels
- Style/Attractiveness
- Different Materials
- Manufacturing Process
- Cost/Benefit Analysis
- More efficient
- Marketability
- Purpose/Utility
- Other

Investigate Resistance in Pipes

- Resistance is directly proportional to length
- Resistance is inversely proportional to area
- Bends and elbows increase resistance





- Pipes in **series** increase overall resistance
- Pipes in **parallel** reduce the overall resistance
- Resistance relates to energy efficiency

Project 3 Green Revision - Tasks

- Review patent documentation
- Reverse engineer a simple toy vehicle
- Investigate laws of motion, fluids, heat flow, pressure, hydraulics, pneumatics, resistance in pipes
- Explore diverse propulsion systems: heat engines, mass expulsion, solar electric, battery & hybrid, wind, animal/human powered - Example: Car of the Future design game: http://www.miniusa.com/ -/play/carOfTheFuture-m
- Compare technologies, efficiencies, and external costs of alternatives to fossil fuels: hydrogen, biodiesel, nuclear, solar, electric battery, hybrid, compressed air
- Build and label a mock-up of your proposed vehicle/transport system
- Write a patent application for your green design improvement

Patenting Green Innovations

- Patent Application Guideline
  - Abstract of Disclosure
  - Declaration
    - Give Appropriate Credit
    - Oath of Originality
  - Specification
    - Describe Prior Work
    - Drawing and Explanation
    - Green Design Improvement Claims

Unit 4: Power to Communicate

Electricity and Communication Systems

Students read about:

Jim Gordon of Cape Wind describes some of the obstacles that alternative energy technology faces, trying to become mainstream

Students design:

Electrical circuits and consider the efficiency of different energy sources

Introduction to:

Electricity generation and *distribution*, *communication systems*

More Green Jobs

Solar panel installer

Wind turbine technician

Project 4: Electricity and Communication Systems

Electrical Systems and Communication Technologies

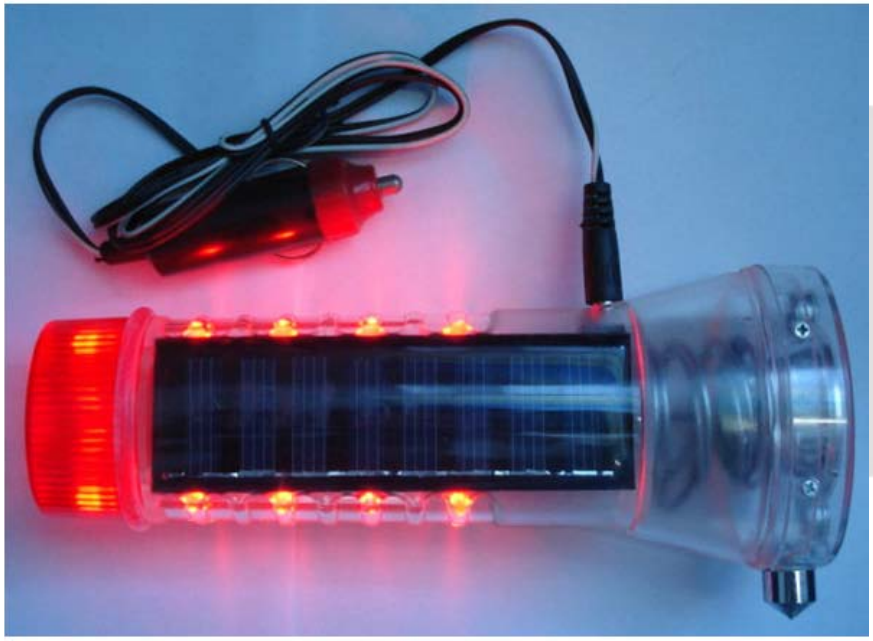
Greening the Challenge: Explore power production systems and energy utilization circuits, then propose and **describe, model or prototype** your idea for an alternative control, device, process, circuit or system designed to increase energy conservation or efficiency and reduce environmental impacts.

Project 4 Revised Green Tasks

- Analyze technology and circuitry for household lighting (incandescent and compact fluorescent)
- Explore features of proliferating LED personal lighting devices
- Compare life cycle analyses for current energy/power production and transmission technologies
- Review ecological carrying capacity, species extinction, human impacts, the case for global warming
- Brainstorm environmental mitigation/remediation measures including conservation, efficiency improvements, wastes as resources, localized production, internalizing external costs
- Propose, describe and model or protoype an idea for an alternative control, device, process, circuit or system designed to increase energy conservation or efficiency and reduce environmental impacts.

Consumer Device Circuit Analysis

Personal Multi-functional Solar LED Flashlight



How do we prepare?

- Online education
- Inservice Training
- Seated, hands-on PD

VS

.

- Create awareness

When & Where do we start?

THANK YOU

Key Curriculum Press

Contact Us!

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Video:

www.mos.org/nctl/etf_video