Education at the Speed of Research: Integrating Research and Education for BioEnergy Literacy

Dr. R. Justin Hougham, University of Wisconsin-Extension
Upham Woods Outdoor Learning Center
Alex Nussbaum – Lead Research Naturalist
Taylor Riedl – Research Naturalist
Marc Nutter – Research Naturalist
Sarah Burgess – Research Naturalist
Northwest Advanced Renewables Alliance- Education and Outreach
W O O D T O W I N G

Measuring the environmental impact of converting forest residuals into bio-jet fuel and other co-products.

Converting forest residuals into chemical products such as a bio-jet fuel is anticipated to provide numerous benefits to society. As biofuels displace fossil fuels, U.S. energy independence is strengthened and net carbon emissions are reduced. A novel use for forest residuals can stimulate rural economic development and reduce fuel loads in the forest.

NARA funds research to determine how using forest residuals affects forest ecosystems, water and air quality so that regional stakeholders and society can make informed decisions.

W I L D L I F E

NARA researchers are studying the potential impact of forest residual removal on vertebrate abundance.
http://goo.gl/lbJQRe

A I R Q U A L I T Y

NARA is completing a "Life Cycle Assessment" that compares petroleum-based jet-fuel to forest residual-based blended jet-fuel for greenhouse gas emissions, ozone depletion, and smog emissions.

W A T E R Q U A L I T Y

Models to predict water quality, quantity, and the effects on stream channels under various residual harvest scenarios are being developed.
http://goo.gl/4GuwmU

M I C R O F A U N A

NARA researchers are collecting and examining microbial communities at test spots to understand the effects of forest residual removal and harvesting on microfauna.
http://goo.gl/4lipro

S O I L N U T R I E N T S

NARA is funding research to ensure that soil nutrient pools remain sustainable in working forests when limited forest residuals are removed.
http://goo.gl/90aQmY  http://goo.gl/1m4QC
NARA Feedstock --- Wood Waste

Forest Residues

Treetops and branches remaining on the ground after forest operations or accumulated as a result of natural disturbances such as storm, fire, insects and diseases.

Forest Residues - 2008
Pacific Northwest - 10.2 million BDT/yr

WASHINGTON 3.88 million BDT
OREGON 4.5 million BDT
MONTANA 0.92 million BDT
IDaho 0.92 million BDT

Construction & Demolition (C&D)

Nonhazardous painted, treated, and coated wood and wood products resulting from construction, remodeling, repair, or demolition of utilities, structures, and roads.

NARA Regional Waste Characterization Study

NARA is led by Washington State University and supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

1 http://www.epa.state.il.us/small-business/construction-debris/
<table>
<thead>
<tr>
<th>Grade School (GS)</th>
<th>Middle School (MS)</th>
<th>High School (HS)</th>
<th>Undergraduate (UG)</th>
<th>Graduate (GR)</th>
<th>Professional (PR)</th>
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<tbody>
<tr>
<td>MOSS</td>
<td>Facing the Future</td>
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<td>Imagine Tomorrow</td>
<td>with BioFuels</td>
<td>Salish Kootenai</td>
<td>Western</td>
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<td>College</td>
<td>Washington</td>
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**BIOENERGY IN EDUCATION**

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<tr>
<td>A NW regional nonprofit developing inquiry based curricula for grades 6-12 on biofuel development.</td>
<td>Promotes biofuel literacy to K-12 students, Grad students, and teaching professionals.</td>
<td>Summer research experience for undergraduates aimed at giving them hands on skills in biofuels and bio-products research.</td>
<td>A year long course for UI and WSU students providing supply chain analysis for an emerging wood products to biofuels industry.</td>
</tr>
<tr>
<td><a href="http://www.facingthefuture.org">www.facingthefuture.org</a></td>
<td><a href="http://uidaho.edu/cnr/moss">uidaho.edu/cnr/moss</a></td>
<td><a href="http://nararenewables.org/ed">nararenewables.org/ed</a></td>
<td><a href="http://idexstudio.org">idexstudio.org</a></td>
</tr>
</tbody>
</table>

**NARA**
Wood to Wing
Forest Residuals to Biofuel Supply Chains in the Pacific Northwest

Applying research-based findings, NARA and regional stakeholders identify conversion and depot sites in the Pacific Northwest. These site locations provide the best opportunity for economic, social and environmental success to develop a forest residuals to biofuel and co-products industry.
**NARA**

**SUPPLY CHAIN**

**FOREST RESIDUES PREPARATION**
Primary feedstock targets include forest residues from logging and trimming operations. We are also considering mill residues and discarded woody material from construction and demolition, in regions where these materials are under-utilized.

**TRANSPORTATION**
Feedstocks are transported from the collection site to a conversion facility. Chipping can take place at the loading or in a preprocessing facility.

**PRE-TREATMENT**
Wood chips are treated to make the sugar polymers (polysaccharides) accessible to degrading enzymes. These processes allow the lignin to be available for separation.

**ENZYMATIC HYDROLYSIS**
Specific enzymes are added to hydrolyze (breakdown) the polysaccharides and generate simple sugars (monosaccharides).

**FERMENTATION**
Specialized yeast convert the monosaccharides into isobutanol.

**BIOJET & CO-PRODUCTS**
Aviation fuels can be generated from the platform molecules derived from wood sugars. Lignin can be used to generate co-products such as epoxies, structural materials, and bio-based plastics. As an alternative, lignin can be burned to produce renewable energy.

ONE  BONE DRY  TON  WOODY  BIOMASS  +  DIESEL  +  HEAT, WATER, & CHEMICALS  =  ~600 POUNDS  LIGNIN  AND  ~59 GALLONS  ISOBUTANOL  OR  ~42 GALLONS  BIOJET
Flow for Education and Outreach of NARA research

- Life Cycle Analysis
- Community Partnerships
- Capital Framework

SUPPLY CHAIN

NARA Northwest Advanced Renewables Alliance

Forest Residues Preparation
Transportation
Pretreatment
Conversion
Biofuel and co-products

Feed Stock

- Heat, Water, & Chemicals

- ~600 Pounds Lignin
- ~59 Gallons Isobutanol
- ~42 Gallons Biojet

Biojet Products

BCP

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Flow for Education and Outreach of NARA research

- Life Cycle Analysis
- Community Partnerships
- Capitals Framework

Feed Stock → Transportation → Pretreatment → Conversion → Biofuel and co-products
Flow for Education and Outreach of NARA research

Research Data, Print Media, Digital Media, Social Media, Academic Publishing

- Life Cycle Analysis
- Community Partnerships
- Capitals Framework

Feed Stock → Transportation → Pretreatment → Conversion → Biofuel and co-products
Flow for Education and Outreach of NARA research

Education and Outreach Products & User Groups

Research Data, Print Media, Digital Media, Social Media, Academic Publishing

-Life Cycle Analysis
-Community Partnerships
-Capitals Framework

Feed Stock -> Transportation -> Pretreatment -> Conversion -> Biofuel and co-products
Flow for Education and Outreach of NARA research

- Life Cycle Analysis
- Community Partnerships
- Capitals Framework

K-12

Education and Outreach Products & User Groups

Research Data, Print Media, Digital Media, Social Media, Academic Publishing

Feed Stock → Transportation → Pretreatment → Conversion → Biofuel and co-products
Flow for Education and Outreach of NARA research

- Life Cycle Analysis
- Community Partnerships
- Capitals Framework

K-12
MOSS

Education and Outreach Products & User Groups

Research Data, Print Media, Digital Media, Social Media, Academic Publishing

Feed Stock
Transportation
Pretreatment
Conversion
Biofuel and co-products

NARARENEWABLES.ORG CC BY-NC-SA
Flow for Education and Outreach of NARA research

- Life Cycle Analysis
- Community Partnerships
- Capitals Framework

- K-12
- MOSS
- Web

Research Data, Print Media, Digital Media, Social Media, Academic Publishing

Education and Outreach Products & User Groups

- Feed Stock
- Transportation
- Pretreatment
- Conversion
- Biofuel and co-products

NARA

nararenewables.org [CC BY-NC-SA]
Flow for Education and Outreach of NARA research

- Life Cycle Analysis
- Community Partnerships
- Capitals Framework

Education and Outreach Products & User Groups

Research Data, Print Media, Digital Media, Social Media, Academic Publishing

K-12, MOSS, Web, IT

Feed Stock, Transportation, Pretreatment, Conversion, Biofuel and co-products
Flow for Education and Outreach of NARA research

- K-12
- MOSS
- Web
- IT
- FtF

Education and Outreach Products & User Groups

Research Data, Print Media, Digital Media, Social Media, Academic Publishing

Life Cycle Analysis
Community Partnerships
Capitals Framework

Feed Stock → Transportation → Pretreatment → Conversion → Biofuel and co-products
Flow for Education and Outreach of NARA research

- Life Cycle Analysis
- Community Partnerships
- Capitals Framework

Education and Outreach Products & User Groups

Research Data, Print Media, Digital Media, Social Media, Academic Publishing

- K-12
- MOSS
- Web
- IT
- FtF
- Grad

- Feed Stock
- Transportation
- Pretreatment
- Conversion
- Biofuel and co-products
Education and Outreach Connections

NARA Supply Chain
1) Forest Residues Preparation
2) Transportation
3) Pretreatment
4) Enzymatic Hydrolysis
5) Fermentation
6) Biojet + Co-products
Long Term Soil Productivity

LCA
Sustainability
and
Context
Stakeholder Outreach Efforts
Stakeholder Outreach Efforts
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Stakeholder Outreach Efforts
Education and Outreach Connections

1. NARA Supply Chain
   1) Forest Residues Preparation
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   5) Fermentation
   6) Biojet + Co-products

2. Research Products
   1) Research Data
   2) Academic Publishing
   3) Social Media
   4) Print Media
   5) Digital Media
Outdoor Science Schools

MOSS Graduates Field testing curriculum
Students using curriculum
Field testing curriculum

Explore:
Complete the following steps.
1. Determine the height of your tree.

Distance from base of tree out on meter tape so you can see the top of the tree (b): _______ m
Angle on clinometer from ground to top of tree (A): _______ degrees
Distance from ground to observer’s eyes (z): _______ m
Height of tree = H = ((tan A x b) + z)

2. Measure the circumference of the tree.
Circumference of tree: _______ cm

3. Determine the amount of Carbon in the tree.
Using the “How Much Carbon Is in a Tree?” chart

NARA
Northwest Advanced Renewables Alliance

McCall Outdoor Science School

jet fuel calculations

Height of tree

Circumference of tree

Carbon in the tree

“How Much Carbon Is in a Tree?” Chart

Jet fuel miles tree contains

“How Far Can I Fly?” Chart

Jet fuel miles tree contains

miles using whole tree

miles actually used

\[ \text{Height of tree} \times \frac{1}{2} = \text{Jet fuel} \]
In this issue:

- Aligning your science curriculum with Generation Science Standards can be a time-consuming task. Before you look for new ideas, check out the articles in this issue on how other middle school science teachers made the transition from the National Standards to NGSS.

Featured Articles:

- Free - Cross-Disciplinary Writing: Bioscience, the Common Core, and the Global Model
- Free - Editor's Roundtable: Start Your Year Off Right, Take the NSP, and Win a Year Free

The Value of a Tree

What is the value of a tree? Of a forest? How do we manage our forests to ensure that we minimize our impact on the environment while creating the products we use and need? The need to power our energy-rich lives? As Earth Day approaches, wise and efficient use of energy is on our minds—it is an important and timely topic for students, consumers, policy makers, scientists, and educators. With an increasing world population and decreasing supply of fossil fuels, finding a reliable, abundant, and sustainable source of energy is a high priority. One current research effort being led by the U.S. Department of Agriculture's Forest Service Advanced Renewables Alliance (NARA), which combines research efforts from industry and education institutions to build a renewable supply chain for aviation biofuel.

The best examples of renewable (liquid) biofuels for transportation applications are biodiesel and ethanol blends—in both cases, they are used for automobiles (see Biofuels Sidebar for more information). Standards that increase efficiency and decrease emissions are being rolled out in all energy sectors and will affect cars, municipal power, electronics, and mass transportation. Recently there is an increasing focus on aviation fuel, as well. The United States Department of Agriculture and many other governmental and private industry groups are working to create biofuels from forest, mill, and construction waste to be refined into
Facing the Future

Fueling Our Future: Exploring Sustainable Energy Use
An Interdisciplinary Curriculum Recommended for Grades 9–12

Scenario: Sustainable Flight in the Pacific Northwest

The federal government has mandated that an increasing amount of biofuel be mixed into jet fuel over the next few years in order to reduce the amount of crude oil used in the nation. The federal government has established regional councils to help identify the most sustainable biofuel feedstock(s) for different regions in the nation. You have been selected to be a part of the Pacific Northwest Regional Biofuel Council. This region includes Washington, Idaho, Montana, and Oregon. Over the next few days, you will:

- identify and understand the reasons for developing aviation biofuels,
- conduct research on different kinds of biofuels and consider their impacts on the environment,
- represent a specific stakeholder at a negotiation, identify other stakeholders’ perspectives, and create a policy that identifies a sustainable fuel mix for the Pacific Northwest region,

so that you can answer the following question:

What are the most sustainable biofuels that can be produced in the Pacific Northwest for aviation?
Education and Outreach Connections

1. NARA Supply Chain
   1) Forest Residues Preparation
   2) Transportation
   3) Pretreatment
   4) Enzymatic Hydrolysis
   5) Fermentation
   6) Biojet + Co-products

2. Research Products
   1) Research Data
   2) Academic Publishing
   3) Social Media
   4) Print Media
   5) Digital Media

3. Education and Outreach Products & User Groups
   1) K-12
   2) Outdoor Science Ed.
   3) Webinars and Workshop
   4) Collegiate Course Work
EnergyLiteracyPrinciples.org
Energy Literacy Framework

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

What is Energy Literacy?
Energy Literacy is an understanding of the nature and role of energy in the world and daily lives accompanied by the ability to apply this understanding to answer questions and solve problems.

An energy-literate person:
- Can trace energy flows and think in terms of energy systems.
- Knows how much energy they use, for what purpose, and where the energy comes from.
- Can assess the credibility of information about energy.
- Can communicate about energy and energy use in meaningful ways.
- Is able to make informed energy use decisions based on an understanding of impacts and consequences.

What is the Energy Literacy Framework?
Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education is an interdisciplinary approach to teaching and learning about energy. The framework identifies seven Essential Principles and a set of Fundamental Concepts to support each principle. The guide does not seek to identify all areas of energy understanding, but rather to focus on those that are essential for all citizens K-Gray. It presents energy concepts that, if understood and applied, will help individuals and communities make informed energy decisions.

Who led the development of the Energy Literacy document?
The Energy Literacy document is the culmination of public listening sessions and thousands of experts from diverse fields of study contributing to a dialogue about what an energy literate person should know and understand. This included over 20 recognized educational partners and 13 federal agencies that comprise the U.S. Global Change Research Program Partner agencies.

How should we approach energy literacy?
Energy Literacy looks at energy through the lens of natural science as well as social science. Energy issues require an understanding of civics, history, economics, sociology, psychology, and politics in addition to science, technology, engineering and mathematics. A comprehensive study of energy and curriculum designed using Energy Literacy should be interdisciplinary and use a
Educational Resources

The NARA Energy Literacy Principles Matrix is a collection of educational resources related to biofuel solutions that are economically viable, socially acceptable, and meet the high environmental standards of the Pacific Northwest. You can use the Matrix to find teaching materials such as lesson plans, datasets, videos, images, activities, software, and modules. All of the resources align to the energy principles and concepts as outlined in the Department of Energy's peer-reviewed Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education framework. Please take a look at an overview for how to use this site here.

Learn More
Search the NARA Matrix's vast collection of educational resources related to biofuel research. You can use the Matrix to find teaching materials such as lesson plans, datasets, videos, images, activities, software and modules.

THREE EASY WAYS TO SEARCH

**BASIC SEARCH**
Quickly find results through a basic keyword search.

› Search Now

**ADVANCED SEARCH**
Use the advanced search feature to narrow results to specific areas of the matrix, topic, or resource type.

› Search Now

**MATRIX BROWSER**
Browse the matrix by drilling down by topic, sub-topic and resource.

› Search Now
Search

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> Search Now
Basic Search

Quickly find results through a basic key word search. Enter the key word in the search box below. If you want narrow results to specific areas of the matrix, topic, or resource types please use the advanced search feature.

Search

About NARA

Scientists from public universities, government laboratories and private industry from throughout the Northwest and beyond, are joining together to focus on developing ways to turn one of the region's most plentiful commodities—wood and wood waste—into jet fuel.
Search the NARA Matrix's vast collection of educational resources related to biofuel research. You can use the Matrix to find teaching materials such as lesson plans, datasets, videos, images, activities, software and modules.

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Search

Filter By Topic:

Filter By Sub-Topic:

Filter By Type:

Filter By Grade Level:

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<th>Topic</th>
<th>Sub-Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy is a physical quantity that follows precise natural laws.</td>
<td>Sub-Topic 1.1 Energy is a quantity that is transferred from system to system.</td>
</tr>
<tr>
<td>Physical processes on Earth are the result of energy flow through the Earth system.</td>
<td>Sub-Topic 1.2 The energy of a system or object that results in temperature is called thermal energy.</td>
</tr>
<tr>
<td>Biological processes depend on energy flow through the Earth system.</td>
<td>Sub-Topic 1.3 Energy is neither created nor destroyed.</td>
</tr>
<tr>
<td>Various sources of energy are used to power human activities.</td>
<td>Sub-Topic 1.4 Energy available to do useful work decreases as it is transferred from organism to organism.</td>
</tr>
<tr>
<td>Energy decisions are influenced by economic, political, environmental, and social factors.</td>
<td>Sub-Topic 2.1 Sunlight, gravitational potential, decay of radioactive isotopes, and rotation of the Earth.</td>
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<tr>
<td>The amount of energy used by human society depends on many factors.</td>
<td>Sub-Topic 2.2 Food is a biofuel used by organisms to sustain energy for internal living processes.</td>
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<td>The quality of life of individuals and societies is affected by energy choices.</td>
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<td>Wood-based biofuels are one form of energy that is renewable.</td>
<td>Sub-Topic 2.4 Energy available to do useful work decreases as it is transferred from organism to organism.</td>
</tr>
<tr>
<td>Conservation of energy has two very different meanings.</td>
<td>Sub-Topic 3.1 The Sun is the major source of energy for organisms and the ecosystems of which they are a part.</td>
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<td>Economic security is impacted by energy choices.</td>
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<td>Sources of cellulose fuel are found in forest operations and in industry processes.</td>
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<td>One way to manage energy resources is through conservation.</td>
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<td>National security is impacted by energy choices.</td>
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<td>Transportation and logistics considerations shape cost and feasibility within the supply chain.</td>
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<td>1.4 Water plays a role in energy transfer.</td>
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<td>2. Physical processes on Earth are the result of energy flow through the Earth system.</td>
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<td>2.1 Earth constantly changes as energy flows through the system.</td>
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<td>2.2 Sunlight, gravitational potential, decay of radioactive isotopes, and rotation of the Earth are energy sources.</td>
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<td>2.3 Earth's weather and climate are mostly driven by energy from the Sun.</td>
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<td>2.4 Energy moves through food webs in one direction.</td>
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<td>4. Various sources of energy are used to power human activities.</td>
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<td>4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.</td>
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<td>4.2 Humans use energy to sustain and constraints.</td>
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<td>4.3 Forest and biofuels are organic matter that contains energy captured from sunlight.</td>
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<td>4.4 Humans transport energy from place to place.</td>
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<td>4.5 Energy decisions can be made using a systems-based approach.</td>
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<td>4.6 Energy decisions are influenced by economic, political, environmental, and social factors.</td>
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<td>4.7.1 Economic security is impacted by energy choices.</td>
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<tr>
<td>4.8 Energy infrastructure is an economy.</td>
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<td>4.9 National security is impacted by energy choices.</td>
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<td>5. Energy decisions are influenced by economic, political, environmental, and social factors.</td>
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<td>5.1 Decisions concerning the use of energy resources are made at many levels.</td>
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<td>7. The quality of life of individuals and societies is affected by energy choices.</td>
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<td>8.3 Pretreatment processes make sugars more available.</td>
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</table>

Sub-TOPIC: 1.2 The energy of a system or object that results in its temperature is called thermal energy.
Search Results

2013 RENEWABLE ENERGY DATA BOOK

Department of Energy publication detailing the amount of energy used and produced in 2013 across all sectors.

Associated Grade Levels: 7-8, 9-10, 11-12, Public

A BLANKET AROUND THE EARTH

NASA site explaining the different greenhouse gasses and their effects on our planet. The explain that the IPCC stated humans within the last 250 years have above a 90% chance of causing some of the climate change.

Associated Grade Levels: 9-10, 11-12, Public
A Blanket Around the Earth

Description:
NASA site explaining the different greenhouse gasses and their effects on our planet. The explain that the IPCC stated humans within the last 250 years have above a 90% chance of causing some of the climate change.

Web Location:
http://climate.nasa.gov/causes/

Related Topics:
1. Energy is a physical quantity that follows precise natural laws.
2. Physical processes on Earth are the result of energy flow through the Earth system.
3. Biological processes depend on energy flow through the Earth system.

Associated Grade Levels:
9-10  11-12  Public
A blanket around the Earth

Sunlight passes through the atmosphere and warms the Earth’s surface. This heat is radiated back toward space.

Most of the outgoing heat is absorbed by greenhouse gas molecules and re-emitted in all directions, warming the surface of the Earth and the lower atmosphere.

We live in a greenhouse

Life on Earth depends on energy coming from the sun. About half the light reaching Earth’s atmosphere passes through the air and clouds to the surface, where it is absorbed and then radiated upward in the form of infrared heat. About 90 percent of this heat is then absorbed by the greenhouse gases and radiated back toward the surface, which is warmed to a life-supporting average of 59 degrees Fahrenheit (15 degrees Celsius).

Is the sun to blame?
Featured Topics

💡 A Guide to The Energy of the Earth
This brief Ted.Ed lesson details many exciting principles related to energy. This brief video details many... read more>

💡 Carbon Footprint Calculator
Use this resource to see how you compare to national and worldwide averages for carbon emissions. This... read more>
A Guide to The Energy of the Earth

Description:
This brief Ted.Ed lesson details many exciting principles related to energy. This brief video details many topics from electricity production to the carbon cycle.

Additional Topics:
No additional topics at this time.

RESOURCES
A Guide to The Energy of The Earth
A TED-Ed video lesson about the different sources of energy and how using these different resources can impact our daily lives.
Associated Grade Levels: 5-6, 7-8, 9-10, 11-12, Public
NARA Energy Literacy Assessment

This survey is designed to see what you know about energy and energy use.

Assessment Results
NARA Energy Literacy Assessment
Assessing energy literacy principles

Assessment Results

About NARA

Scientists from public universities, government laboratories and private industry from throughout the Northwest, and beyond, are joining together to focus on developing ways to turn one of the region's most plentiful commodities—wood and wood waste—into jet fuel.

Led by Washington State University, the Northwest Advanced Renewables Alliance (NARA) will take a holistic approach to building a supply chain for aviation biofuel with the goal of increasing efficiency in everything from forestry operations to conversion processes. Using a variety of feedstocks, including forest and mill residues, construction waste, as well as new energy crops, the project aims to create a sustainable industry to produce aviation biofuels and important co-products. The project includes a broad alliance. 

NARA is primarily supported by an Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416, from the USDA National Institute of Food and Agriculture. © 2013 Nevada Information Presentation Software created by MagWiz LLC.
12. When sunlight is absorbed by a plant, it

Correct Answer: 2

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Bar</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>gets stored as electrical energy in the leaves</td>
<td></td>
<td>21</td>
<td>9%</td>
</tr>
<tr>
<td>2</td>
<td>powers photosynthetic reactions that produce sugars</td>
<td></td>
<td>202</td>
<td>82%</td>
</tr>
<tr>
<td>3</td>
<td>is conducted down to the root system where new energy is produced</td>
<td></td>
<td>23</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>246</td>
<td></td>
</tr>
</tbody>
</table>

13. Why is there less available energy at the top of the food chain as compared to the bottom of the food chain?

Correct Answer: 1

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Bar</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>most of the energy consumed by organisms is used to meet their own body’s needs</td>
<td></td>
<td>176</td>
<td>72%</td>
</tr>
<tr>
<td>2</td>
<td>organisms higher on the food chain consume less</td>
<td></td>
<td>35</td>
<td>14%</td>
</tr>
<tr>
<td>3</td>
<td>producers are less energy efficient than consumers</td>
<td></td>
<td>35</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>246</td>
<td></td>
</tr>
</tbody>
</table>

14. Which of the following answers best describes the greatest impact that humans have on the energy flow in earth’s ecosystem:
EnergyLiteracyPrinciples.org
Implications

Developing sustainable alternatives to conventional energy sources is key 21st century challenge, one that will require a future workforce prepared to succeed in the bioenergy sector.

Moving education forward at the speed of research will require a transformational shift in academic approaches, away from entrenched disciplinary specialization and towards pedagogies rooted in authentic, experiential learning and real-world issues (Hougham, et al 2012).

The overarching goal of the education component of this project is to recruit, motivate, and train students to become next-generation bioenergy professionals by transforming bioenergy-based education. We achieve this goal by introducing bioenergy literacy in many venues where students and stakeholders can engage with research in progress.

The potential outlined here for integrated and holistic educational approaches for multidisciplinary grant-funded work stretches beyond energy literacy, offering a framework that could be used in a variety of large-scale research programs.
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Sample Articles

Opinions
[Undergraduate Energy Education: The Interdisciplinary Imperative]
By Kenneth Kibrows, Wilkes University

Special Collection on BioEnergy Literacy from the Northwest Advanced Renewables Alliance
[Global Sustainability: An Authentic Context for Energy Education]
By Danica Hendrickson, Kimberly Corrigan, Alicia Koche, Danielle Shaw, Sheba Jacob, Laura Schult, Jennifer Schon, Karla Bradley Edel and Justin Hougham, Northwest Advanced Renewables Alliance

Reports and Case Studies
[Energy information sharing in social networks: The roles of objective knowledge and perceived understanding]
By Brian G. Southwell, Joseph J. Murphy, Jan E. DeWaters (Clarkson University), Patricia A. LeBann and Jessica Fitts Wilkoughby, RTI International

Scholarly Articles
[Put a Brick in the Toilet: Overcoming Student Perceptions of the Effectiveness of Native Environmental Solutions]
By Theodore J. Hogan, Northern Illinois University, and Paul Koller, North Dakota State University

MultiMedia
[There's no such thing as a free megawatt: Hydrofracking as a Gateway Drug to Energy Literacy]
By Don Duggan-Haas, Paleontological Research Institution Museum of the Earth

www.SustEd.org
Acknowledgement
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Education at the Speed of Research: Integrating Research and Education for BioEnergy Literacy

Dr. R. Justin Hougham, University of Wisconsin-Extension
Upham Woods Outdoor Learning Center
Alex Nussbaum – Lead Research Naturalist
Taylor Riedl – Research Naturalist
Marc Nutter – Research Naturalist
Sarah Burgess – Research Naturalist
Northwest Advanced Renewables Alliance- Education and Outreach