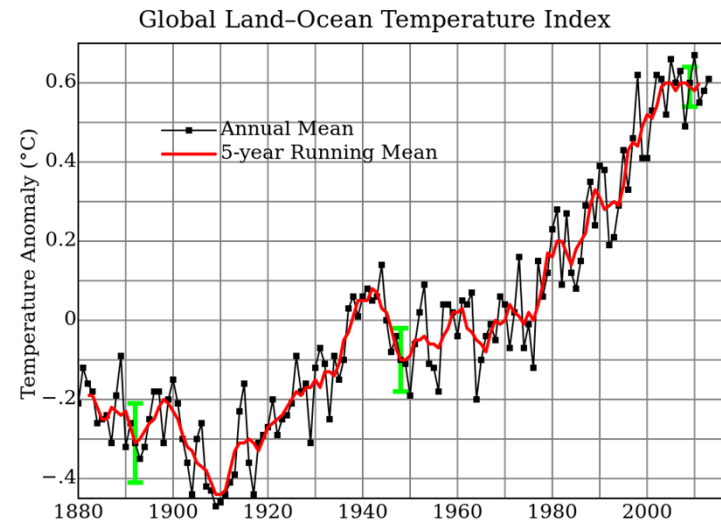


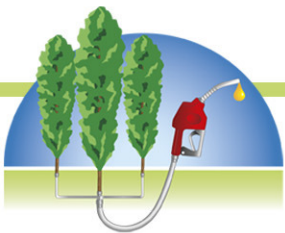
# Why Bioenergy in K12?



Source: [www.wikipedia.org](http://www.wikipedia.org)



Source: [www.dreamstime.com](http://www.dreamstime.com)



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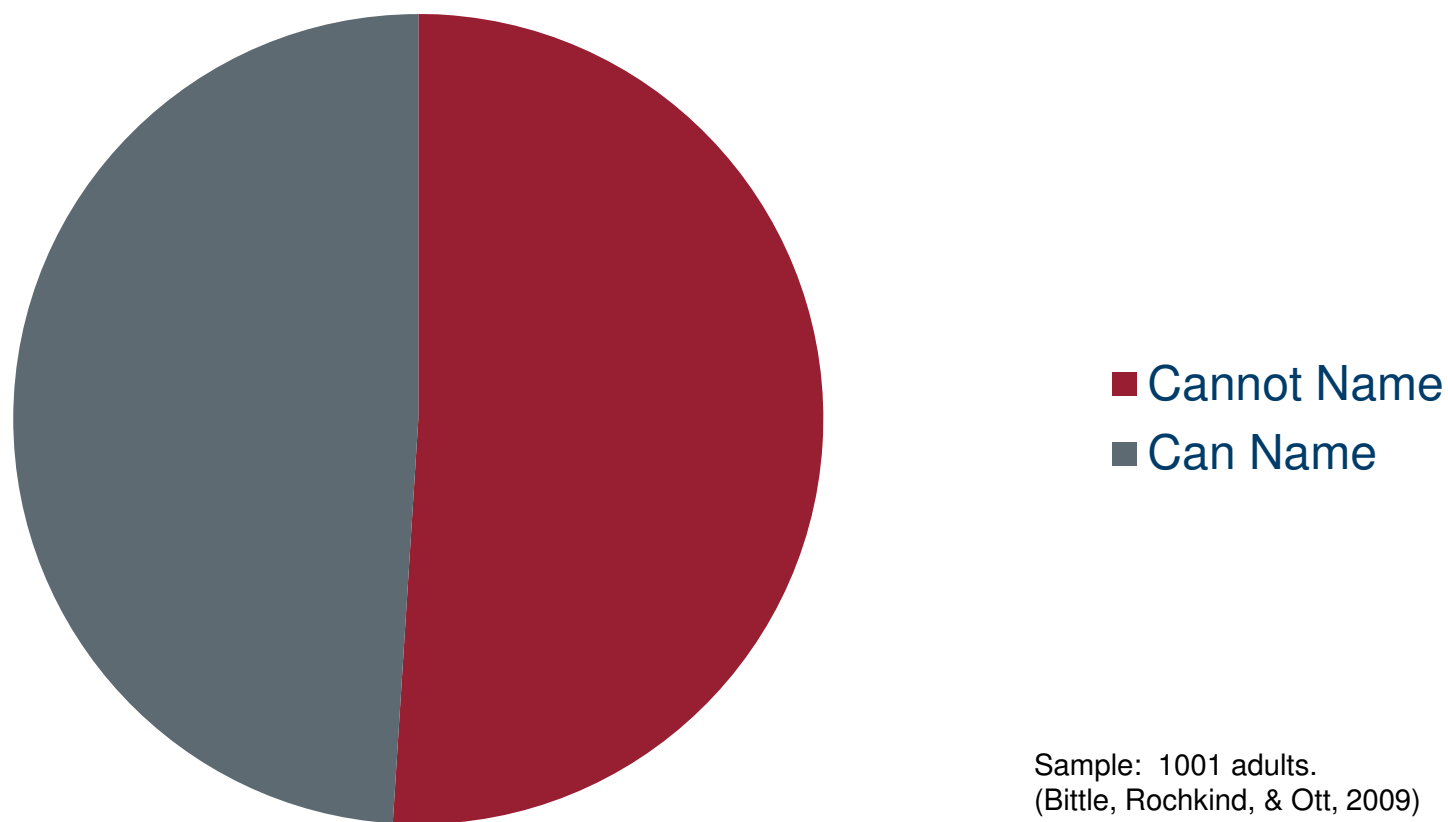


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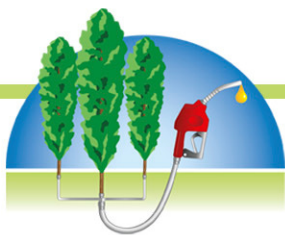
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# Adults Don't Know Energy

Adults Able to Name One Alternative Energy Source



Sample: 1001 adults.  
(Bittle, Rochkind, & Ott, 2009)



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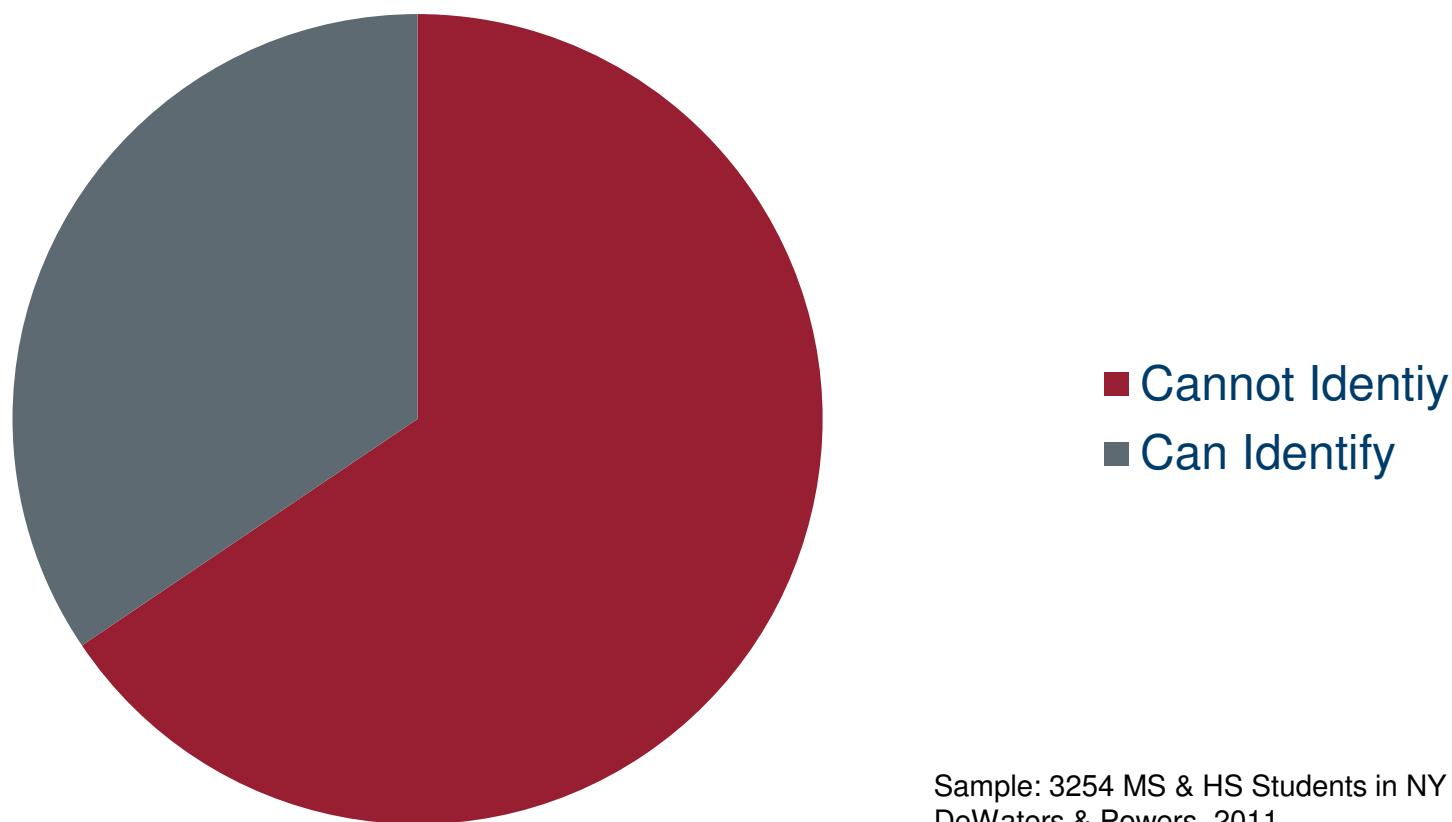


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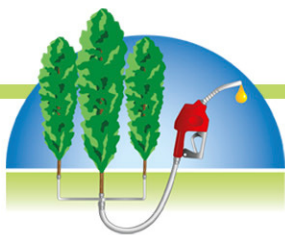
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# Children Don't Know Energy

Middle School Students Able to Identify a Biofuel in List



Sample: 3254 MS & HS Students in NY  
DeWaters & Powers, 2011



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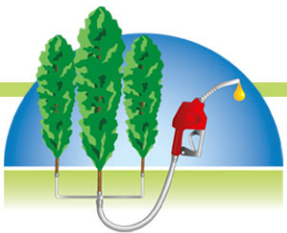
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# What is Essential to Teach?

Energy  
LCA  
Thermodynamics  
Climate  
Photosynthesis  
Policy  
Conversion  
Economics  
Biomass

# How to Get an Expert Opinion When the Everyone Disagrees?

- Group Problems
- Delphi Technique
  - Experts at a distance
  - Anonymous
  - Multiple iterations
  - Statistical analysis
  - Develop consensus



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# The Process

- Experts: 180 → 42 → 21 & 20
- Question: What science and engineering concepts are essential in K12?
- Round 1 -- Brainstorming
- Round 2 – Shortening (Current status)
- Round 3 -- Prioritizing

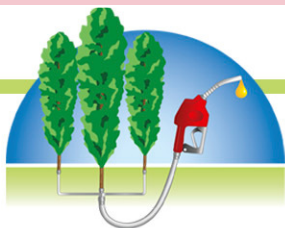


# Science Results (K12)

Concept	Rating	SD
<b>Climate Change:</b> Historical record and projected consequences	4.6	0.5
<b>Energy Fundamentals:</b> Work, energy, conversions	4.5	0.5
<b>Photosynthesis:</b> How light energy is stored in plants	4.4	0.9
<b>Chemical Cycles:</b> Water, carbon, nitrogen cycles	4.3	0.7
<b>Ecosystems:</b> Ecology and human impact	4.2	1.0
<b>Conversion Principles:</b> Types of conversions	4.2	0.8
<b>Lifecycle Assessment:</b> Environmental impacts from cradle to grave	4.2	0.9
<b>Economics:</b> How economics impacts biofuel use	3.9	1.1
<b>Biomass Sources:</b> How solar energy is stored	3.8	1.1
<b>Laws of Thermodynamics:</b> Conservation of energy	3.8	1.0
<b>Public Policy:</b> Impacts of politics on bioenergy production	3.3	1.4

# Engineering Results (K12)

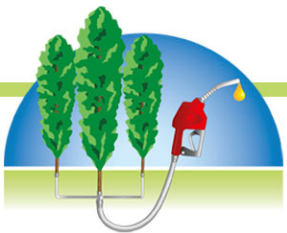
Concept	Rating	SD
<b>Energy Consumption:</b> Current and historical energy sources	4.8	0.7
<b>Energy Fundamentals:</b> Types and conversions of energy	4.2	1.0
<b>Energy Requirements:</b> Quantity and type of energy needed	4.2	1.1
<b>Nature of Engineering:</b> Role of engineering in bioenergy	4.2	1.1
<b>Conversion Technologies:</b> Types of conversions	3.9	1.2
<b>Bioenergy Products:</b> Types of biofuels	3.7	1.1
<b>Lifecycle Assessment:</b> Social, environmental, and economic impacts	3.7	1.1
<b>Process Economics:</b> Economic analysis of conversion processes	3.4	1.0
<b>Chemical Engineering Fundamentals:</b> Conservation mass/energy; heat/mass transfer	3.3	1.5





# Next Generation Science Standards

- Developed by states. National Academies, 2013.
- Depth vs. breadth
- Emphasis on both science and engineering practices
- Connections across disciplines



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# Bioenergy Framework & NGSS

- **Climate Change →**

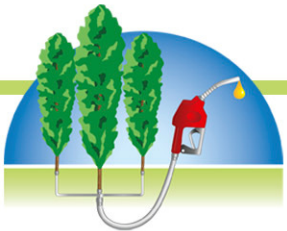
- MS-ESS3.D: Global Climate Change**

- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming).

- **Energy Fundamentals →**

- HS-PS3.A: Definitions of Energy**

- PS3.B: Conservation of Energy and Energy Transfer**

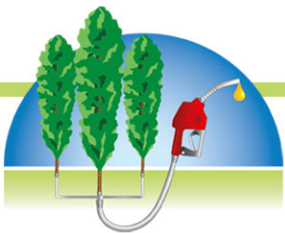


# Undergraduate Results (Kimi Grzyb)

Concept	Rating	SD
Energy Basics	4.73	0.47
Types of Bioenergy	4.64	0.67
Environmental impacts	4.45	0.52
Current technologies	4.27	0.47
Societal issues	4.27	0.47
Logistics	4.18	0.40
Policy	4.09	0.54
Biomass composition	4.00	1.0

# Discussion & Next Steps

- Consensus is developing (Complete Round 3)
- Results are compatible with NGSS
- Emphasis on core science concepts
- Guide development of additional curriculum
- Teachers: Grade-band concepts
- Links K12 to Undergraduate



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