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This curriculum is provided as an example use of the Buildings, Industrial, Transportation, and Electricity Scenarios (BITES) tool, which is available at https://bites.nrel.gov/scenarios.php. For up-to-date educational materials and to provide feedback, visit https://bites.nrel.gov/education.php.

BITES Workshop Student Guide

Table of Contents

Goals 3
Introduction 3
Getting Started 5
Part I: Review the Baseline 6
Sector-specific Questions 7
Energy Portfolio Questions 7
Part 2: Sector Exploration 8
BUILDINGS Sector Exploration 9
INDUSTRY Sector Exploration 10
TRANSPORTATION Sector Exploration 11
ELECTRICITY GENERATION Sector Exploration 12
Part 3: Cross-Sector Exercise 13
Part 4: Scenario Readout and Discussion 15
Putting It Together 15
Appendix: Benchmarking Scenarios 16
The table below provides background reading for each sector as well as input references. 16

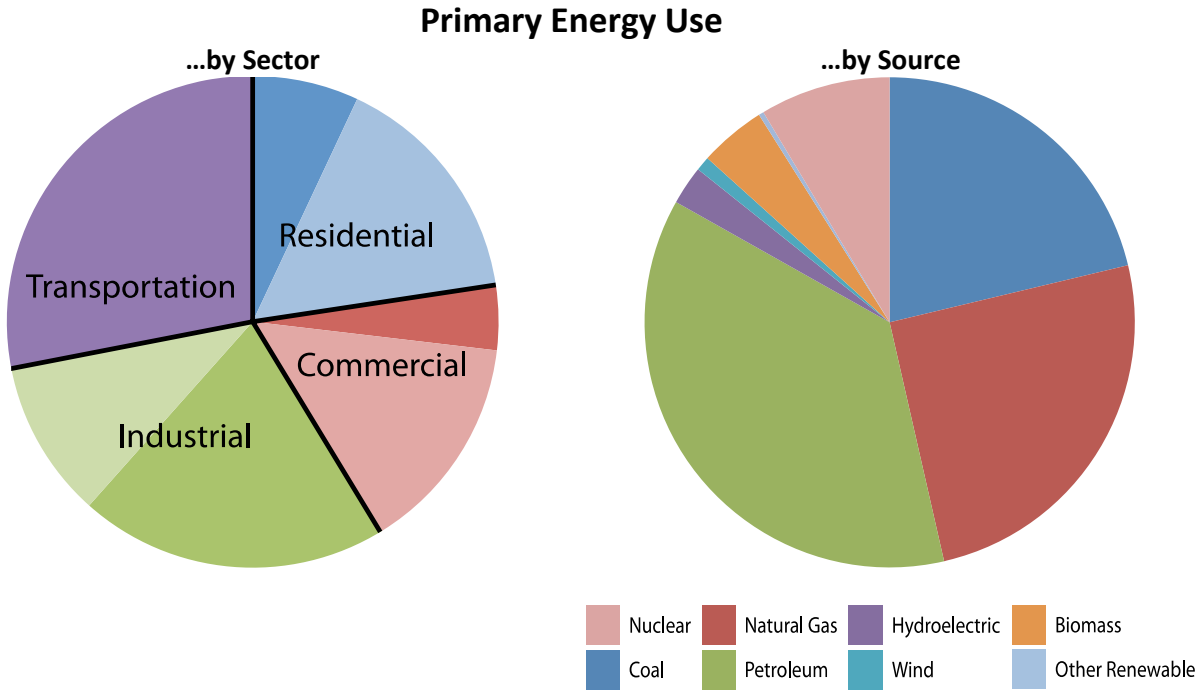
Goals

- Develop an understanding of where we get energy and how we use it today
- Visualize the energy consumption and production track we are on without making changes to the energy system
- Experiment with options for changing these tracks in each of the four sectors: building, industry, transportation, and electricity
- Explore the trade-offs between sectors and individual technologies
- Generate a realistic cross-sector scenario that approaches or meets chosen energy and carbon emissions targets
- Discuss, compare, and justify scenarios chosen to help define challenges and opportunities
- Achieve consensus on a class scenario (stretch goal)

Introduction

This is a workshop using the Buildings, Industrial, Transportation, and Electricity Scenarios – or BITES – tool to explore the potential future of the U.S. energy system. The mix of domestic energy generation and use has implications for the global climate environment—along with U.S. national security and prosperity.

Today, most U.S. energy comes from fossil fuels, and most U.S. GHG emissions come from this use.



There are many ways changes could impact U.S. energy use and CO_2 emissions. We divide these into four sectors:

Buildings

- Appliance Efficiency
- Building Codes
- Retrofits

Industry

- Industrial Efficiency
- Fuel Switching

Transportation

- Light-duty Vehicle Efficiency
- Heavy-duty Vehicle Efficiency
- Renewable Fuels
- Demand (Miles Driven)

Electricity

- Natural Gas
- Renewables
- Nuclear
- Carbon Capture and Sequestration

The energy system is very complex, so comparing the impact of various options can be challenging. BITES provides a way to see some of the impacts of various changes—with immediate feedback.

The engine behind BITES was originally developed to help the U.S. Department of Energy (DOE) explore how investments in clean energy technologies can contribute to national energy goals. Now, users of varying expertise can create scenarios to explore the energy use and carbon emission implications of altering the current U.S. energy profile.

The "business as usual" case in BITES is a baseline scenario based on a version of the Energy Information Administration's (EIA) Annual Energy Outlook (AEO 2011) extrapolated to 2050.[1] This baseline was chosen because it is a widely used reference case. BITES allows users to modify inputs as percentage changes to this baseline. These inputs are divided into four sectors – buildings, industry, transportation, and electricity – to enable exploration of alternative futures.

Users can modify over 300 inputs to assess their implications on projected energy use and CO_2 emission outcomes. They can also explore and modify the calculator assumptions. A limited number of important input variables can be modified through the *Basic Mode*. This workshop will primarily focus on these *Basic Mode* inputs. Some discussion of model assumptions and other inputs accessible in *Advanced Mode* is also included.

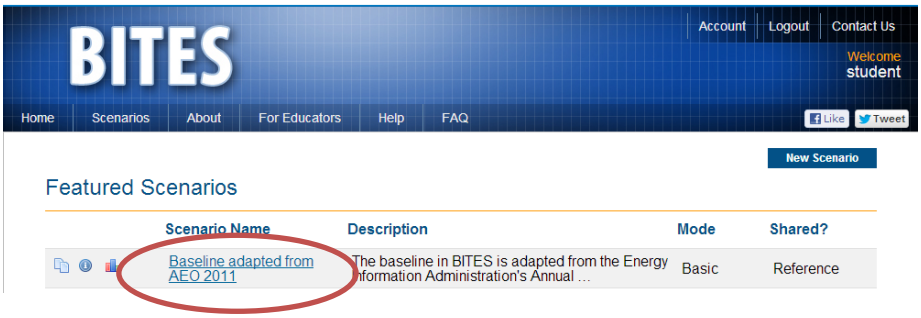
The summary outputs, including electricity demand, primary and delivered energy, oil and biomass consumption, and CO_2 emissions, are broken down by sector and compared to the AEO baseline in the *Benchmarking* section. Additional sector-specific outputs include projections for fuel use, electricity generation by source, building retrofits, and delivered energy by industrial sub-sector.

[1] More information on the AEO 2011 can be found at: http://www.eia.gov/forecasts/archive/aeo11/index.cfm.

Getting Started

First, we recommend watching the BITES introduction video in the bottom right portion on the home page. Be sure to register with BITES by clicking 'register' at the top right of the page so that you are able to save your work and create new scenarios.

Next, visualize energy use today and the baseline projection. Becoming familiar with the baseline scenario will help you familiarize yourself with the tool and get a sense for the current pathway. From the BITES home page, click on *Scenarios* or *Get Started,* then select *Baseline adapted from AEO 2011*.



Part I: Review the Baseline

Learning objective: Develop an understanding of where we use energy today, what we use it for, and what the United States can expect in the future if we continue on the "business as usual" path.

After completing this exercise, you should be able to answer the following types of questions:

- How does projected overall energy use change from 2010 to 2030 to 2050?
- What fuel types contribute the most to the total emissions in the transportation sector?
- Which appliances and HVAC equipment currently use the most energy in the residential sector?

Select *Scenarios* from the home page. Choose the *Baseline adapted from AEO 2011* in Basic Mode from the Featured Scenarios list. Review the default inputs for the four sectors before selecting *View Outputs* (bottom of page). The default inputs are based on projections for the energy system, with no significant changes, but continued population and economic growth.

Compare the resulting annual *Total Emissions by Sector* to the national carbon emission reduction goals of 17% by 2020 (4987 $MMTCO_2$), 42% by 2030 (3485 $MMTCO_2$), and 83% (1021 $MMTCO_2$) by 2050. Use the *View Data Table* button to see the numbers instead of the chart.

CO_2 Emissions (MMT CO_2)	**2020**	**2030**	**2050**
Buildings			
Electric			
Industry			
Transportation			
Total			
Goals	*4987*	*3485*	*1021*

Which sectors are the current and projected primary consumers of each fuel?

	2010	**2030**	
Oil			(*Oil Consumption* output view)
Biomass			(*Biomass Consumption* output view)
Electricity			(*Electric Demand* output view)

Sector-specific Questions

Use the *Outputs* screen to answer the following questions.

Buildings:

Does lighting or air conditioning use more energy in homes?
Go to *"Buildings" > "Residential Energy Use"*. Click on the legend to remove or add series.

Industry:

Which industrial subsector (e.g. refining, aluminum, glass) accounts for the most delivered energy?
Go to *"Industry" > "Delivered Energy by Subsector" > "View Data Table".*

Transportation:

Which type of transportation mode do we expect to emit more CO_2 in 2050—trucks or aircrafts?
Go to *"Transportation" > "Direct Emissions by Vehicle" > "View Data Table".*

Electricity:

Today, what percentage of electric sector CO_2 emissions come from coal?
Go to *"Electricity" > "Emissions" > "View Data Table".*

Energy Portfolio Questions

1) How much energy-related CO_2 is the United States projected to emit by 2050? What percentage increase is this compared to the 2010 levels?

2) What is the percentage savings from baseline 2050 levels we need to achieve in order to reach the goal of 1,021 MMT CO_2 by 2050 (if the goal is relative to 2010 levels)?

3) What are the top three energy uses in commercial buildings?

4) In the industrial sector, what three subsectors are currently responsible for the most emissions? [Hint: It might be easier to click *View Data Table* at the bottom of the graph to see the underlying *Industry Emissions by Subsector* data.]

5) What is the projected percentage of light-duty vehicle energy consumption attributed to oil in 2050? How does this change from 2010?

6) What is the projected total capacity for solar photovoltaics (PV) in 2050?

7) In 2010, what percentage of renewable generation was from onshore wind? [Hint: Look at the *Electricity Generation* graph and click on the non-renewable legend titles to exclude them from the graph.]

Part 2: Sector Exploration

Learning objective: Explore energy use in one specific sector, examine the relative impact of changes, and generate a scenario for the sector for presentation to the other workshop participants.

You will be assigned to one of the following groups: *Buildings, Industry, Transportation*, or *Electricity Generation*. Each group will modify input variables for its assigned sector.
Note: In order to make the most informed choices, please read the sector-specific report section in the *Appendix*.

1) Log in to create and name your own scenario.
2) Explore the baseline outputs for your assigned sector.
   How does projected energy use change from 2010 to 2030 to 2050?
   What fuel contributes the most to the total emissions for this particular sector?
3) Review the baseline inputs, including their units of measurement, and identify potential ranges for each (based on the group members' knowledge). Document your work in the sector-specific worksheet (included in this file) for your group.
4) Modify these inputs for the sector to determine the overall impact of modifying a single sector. Record these input modifications on the sector-specific worksheet.
   You may use either an ambitious or moderate approach, but should consider justifying either in the broader renewable energy/energy efficiency space.
5) Compare the outputs associated with each input change to the sector goals and then to the overall energy system goals set.
6) Re-convene with the other groups to describe and discuss each sector-specific input, and whether goals were achievable through changes to one sector alone.
7) As other groups present different sector scenarios, use the sector worksheet to take notes for later review and reference.
8) **(Optional) Scenario Benchmarking** – For a deeper sector-specific analysis, adjust the Inputs according to the listed studies. See *Appendix* for the values. Record your findings in the table on your worksheet.
   - What input values are required to meet the projected data from each study?
   - Note variation in the projection dates among these studies.
   - Compare your inputs with the executive summaries of these reports. Are they in agreement?

   Note different reports use different business-as-usual baselines, so the last comparison should not be in exact agreement.

BUILDINGS Sector Exploration

Create and name your scenario with *Basic Mode* input and AEO 2011 Base Data. Note: you must be logged in to create your own scenario. Explore the baseline outputs for your assigned sector.

Questions:

How does projected energy use change from 2010 to 2030 to 2050? What fuel contributes the most to the total emissions for that sector?
Which appliances and HVAC equipment currently use the most energy in the residential sector?

Exercise:
Enter 50% building retrofits by 2050 with 15% efficiency improvements. What is the effect on buildings emissions and electricity demand? (Go to *Benchmarking* > *Total Emissions* and *Electric Demand.*).Compare these results to implementing aggressive Heating, Cooling and Appliance Efficiency Improvements in 2050.
What has a bigger effect on energy consumption in the buildings sector--building retrofits or fuel switching? (*Compare 100% fuel switching with 100% of existing buildings improving their efficiency by 43%.)*

Building improvements in 2030

30%	to	75%

Slider Value

Appliance efficiency in 2050

0%	to	52%

Slider Value

% Residential building retrofits in 2050

0%	to	100%

Slider Value

Fuel switching in 2050

0%	to	91%

Slider Value

% Improvement retrofits in 2050

0%	to	36%

Slider Value

% Energy Savings	% Carbon Savings

(Optional) Scenario Benchmarking – Adjust inputs according to each scenario and record values in table below. Scenarios defined in Appendix.

	Input	Slider Values	Output Comparison Notes
AEF 2009			
McKinsey 2009a			
McKinsey 2009b			
McKinsey 2009c			
APS 2008			

INDUSTRY Sector Exploration

Create and name your scenario with *Basic Mode* input and AEO 2011 Base Data. Note: you must be logged in to create your own scenario. Explore the baseline outputs for your assigned sector.

Questions:

Is biomass expected to represent a larger share of delivered energy consumption in 2050 versus 2010?
Decide on a motivating (non-binding) goal for reduction in consumption, CO_2 emissions, and/or energy use from action in the industry sector.

Exercise:

How does the impact of 40% overall industrial efficiency compare to a 60% low carbon fuel mix by 2050 for industrial emissions? (*Generate Outputs* for each change and record the *Industry* > *Emissions by Subsector* total.)
What are the implications for petroleum consumption of substituting petrochemical feedstocks with biofuel feedstocks in the chemical sector in 2050? (Select a 50% conversion and *Generate Outputs*.)
Petroleum Consumption can be found under *Benchmarking*.)

EE Industry Input

0%	to	43%

Slider Value

Low Carbon Fuel Mix Input

30%	to	70%

Slider Value

Biomass Feedstock Percent in 2050

0%	to	50%

Slider Value

% Energy Savings	% Carbon Savings

(Optional) Scenario Benchmarking – Adjust inputs according to each scenario and record values in table below. Scenarios defined in Appendix.

	Inputs	Slider Values	Output Comparison Notes
AEF 2009			
ACEEE 2011			

TRANSPORTATION Sector Exploration

Create and name your scenario with *Basic Mode* input and AEO 2011 Base Data. Note: you must be logged in to create to create your own scenario. Explore the baseline outputs for your assigned sector.

Questions:

Compare the resulting energy consumption from achieving 70 miles per gallon in 2050 with 10,000 vehicle miles in 2050. What is the impact of the introduction of electric vehicles into the light-duty stock mix?
Do electric vehicles represent more than 10% of vehicles by 2050?

Exercise:

What projected effect does maximizing biofuels (80 billion gallons) in 2050 have on oil consumption in the transportation sector? (*Generate Outputs* and select *Benchmarking* to compare).

Miles per Gallon in 2050

36	to	108

Slider Value

Non-LDV Efficiency in 2050

0%	to	60%

Slider Value

Biofuels 2050 (billion gallons)

34	to	80

Slider Value

VMT/LDV Adjustment in 2050

15,000	to	9,600

Slider Value

% Energy Savings	% Carbon Savings

(Optional) Scenario Benchmarking – Adjust inputs according to each scenario and record values in table below. Scenarios defined in Appendix.

	Input	Slider Values	Output Comparison Notes
UC Davis 2009			
Kerry 2010-Scenario A			
Kerry 2010-Scenario B			
DOT 2010			
EERE 2013			

ELECTRICITY GENERATION Sector Exploration

Create and name your scenario with *Basic Mode* input and AEO 2011 Base Data. Note: you must be logged in to create to create your own scenario. Explore the baseline outputs for your assigned sector.

Questions:
What are the top three sources of electric generation in 2010?
What are the top three sources of renewable lectricity in 2010?

Exercise:
What is the effect of increasing the percentage of renewables generation to 80% by 2050 (with 2% natural gas and 18% nuclear) on electric secor CO_2 emissions? (*Generate Outputs* and select *Electricity Emissions* under *Benchmarking.*)
Compare increasing the percentage of coal generation with carbon capture and storage (CCS) to 50% against doubling the percentage of renewables (to 28%) at the expense of coal generation (to 34%) in 2050. Use the electricity emissions benchmarking as a basis of comparison.

Generation Mix in 2050

Coal

0%	to	68%

Slider Value

Renewables

14%	to	80%

Slider Value

Natural Gas

2%	to	100%

Slider Value

% of Fossil CCS in 2050

0%	to	100%

Slider Value

Nuclear

16%	to	84%

Slider Value

% Energy Savings	% Carbon Savings

(Optional) Scenario Benchmarking – Adjust inputs according to each scenario and record values in table below. Scenarios defined in Appendix.

	Inputs	Slider Values	Output Comparison Notes
EIA 2009a			
EIA 2009b			
Google 2011			
RE Future			
Synapse 2011			

Part 3: Cross-Sector Exercise

In this exercise, organize students into cross-sector groups to explore a mixed portfolio of energy system changes that could lead progress toward national energy and carbon reduction goals.
Each group should include at least one representative from each of the former Buildings, Industry, Transportation, and Electricity Generation groups.

1) Agree on a goal or target for this exercise. This can be the goals from Part 1, or other goals at the group's discretion.
2) Divide members of the new group into sector-specific teams to discuss input variables. Use a balanced approach to determine slider values. Note: while ramping up all values will meet and exceed goals easily, these portfolios may be unrealistic. The objective of this exercise is to collaboratively consider technical and policy perspectives in a mixed portfolio.
3) Re-convene the entire group and enter the values in a new scenario. Each team must justify their input variables to the group and discuss where potential compromises in inputs may exist. Consider cost, time to implement, and market barriers.
4) Record total capacity, total generation, and total energy demand by sector for the new scenario and the baseline. How do these vary between the two scenarios?

National Goals

- Reduce emissions by 17% from 2005 levels by 2020 [Copenhagen, 2009]
- Reduce oil imports by 1/3 by 2025 (~22% decrease in oil consumption from 2011) [Speech given March 2011]

Your Goals

% Energy Savings	% Carbon Savings

Transportation

Miles Per Gallon in 2050	36 to 108	Slider Value
Non-LDV Efficiency in 2050	0% to 60%	Slider Value
Biofuels 2050 (billion gallons)	34 to 80	Slider Value
VMT/LDV Adjustments in 2050	15,000 to 9,600	Slider Value

% Energy Savings	% Carbon Savings

Industry

EE Industry Input	0% to 43%	Slider Value
Low Carbon Fuel Mix Input	30% to 70%	Slider Value
Biomass Feedstock Percent in 2050	0% to 50%	Slider Value

% Energy Savings	% Carbon Savings

Electricity Generation | Generation Mix in 2050

Coal	0 to 68%	Slider Value
Natural Gas	2% to 100%	Slider Value
Nuclear	16% to 84%	Slider Value
Renewables	14% to 80%	Slider Value
% of Fossil CCS in 2050	0 to 100%	Slider Value

% Energy Savings	% Carbon Savings

Buildings

Building Improvements in 2030	30% to 75%	Slider Value
% Residential Building Retrofits in 2050	0% to 100%	Slider Value
% Improvement Retrofits in 2050	0% to 36%	Slider Value
Appliance Efficiency in 2050	0% to 52%	Slider Value
Fuel Switching in 2050	0% to 91%	Slider Value

Overall Percentage Oil Savings	**Overall Percentage CO_2 Savings**	**Overall Percentage Energy Savings**
Electric Sector Profile Total Capacity Total Generation	*Base Case Demand by Sector* Buildings Industry Transportation	*New Scenario Demand by Sector* Buildings Industry Transportation

Part 4: Scenario Readout and Discussion

For the final presentation and group discussion, select and answer 3–5 questions from the *Energy Portfolio Questions* on page 6 for your group's scenario . You are also welcome to create your own questions.

After presenting to the other groups, the instructor and other groups will ask questions about your scenario. Continue until every group has presented and taken questions.

Following the presentations, as a class:

- Determine a level fo*r each input.*
- Vote to *accept* or *not accept* the scenario as representative of its consensus perspective.

The "for" and "against" cases may give a very brief synopsis of the strategy and sources for inputs to explain and support their perspective. Representatives of the "in favor of the class scenario" and "not in favor" voting blocs may give a very brief synopsis of the strategy and sources for inputs to explain and support their perspective.

Putting It Together

As a class, discuss the following questions to help synthesize your understanding:

- Based on the scenario exercises, how achievable are the Administration's goals?
- How would the U.S. energy system need to change to enable this future? How would your energy consumption patterns need to change to enable this future?
- What existing national or state energy policies are you aware of that would enable these changes?
- What gaps or barriers may make such a transition challenging?

Appendix: Benchmarking Scenarios

The table below provides background reading for each sector as well as input references.

Benchmarking Scenarios			
Sector	Source	Data	Basic Mode Input
Buildings	**AEF 2009** "Real Prospects for Energy Efficiency in the United States," America's Energy Future, 2009 (pp.79-80)	2030 Residential Electricity Savings: 30% 2030 Residential Natural Gas Savings: 28% 2030 Commercial Electricity Savings: 34% 2030 Commercial Natural Gas Savings: 35%	Appliance Efficiency input in 2050
Buildings	**McKinsey 2009a** "Unlocking Energy Efficiency in the U.S. Economy," McKinsey 2009 (p.29,46, 51, 55, 68)	Residential 2020 Residential Savings due to EE: 28% 2020 Electrical Devices & Small Appliances Savings: 27% 2020 Lighting & Major Appliances Savings: 10% Commercial 2020 Commercial Savings due to EE: 29% 2020 Office and Non-commercial Devices Savings: 29%	Appliance Efficiency input in 2050
Buildings	**McKinsey 2009b** "Unlocking Energy Efficiency in the U.S. Economy," McKinsey 2009 (p.34, 39, 58, 61)	Residential 2020 Existing Non-low income Home Retrofits: 39% 2020 Existing Low-income Home Retrofits: 40% Commercial 2020 Existing Private Buildings Retrofits: 28% 2020 Government Buildings Retrofits: 31%	% Improvement Retrofits in 2050
Buildings	**McKinsey 2009c** "Unlocking Energy Efficiency in the U.S. Economy," McKinsey 2009 (p.41, 64)	Residential 2020 New Homes Savings due to EE: 33% Commercial 2020 New Private Buildings Savings: 25%	% New Building Improvements in 2030
Buildings	**APS 2008** "Energy Future, Think Efficiency: How America can look within to achieve energy security and reduce global warming," American Physical Society, 2008 (p.76)	Residential 2030 Energy Savings Potential due to EE: 30%	Appliance Efficiency input in 2050

Benchmarking Scenarios			
Sector	Source	Data	Basic Mode Input
Industry	**AEF 2009** "Real Prospects for Energy Efficiency in the United States," America's Energy Future, 2009 (pp.197-198)	Energy Efficiency Savings 2020 Industry Overall: 14-22% 2020 Paper: 6% 2020 Iron & Steel: 15% 2020 Cement: 19%	Energy Efficiency Savings Industry in 2050
Industry	**ACEEE 2011** DOE Industrial Technology Program Bandwidth Studies - Summarized in ACEEE Paper - "Industry Energy Futures - Challenges and Opportunities for the U.S. Industrial Sector in a Carbon Constrained Future," 2011 (pp.7-8)	Energy Efficiency Savings by Subsector 2050 Chemicals: 66% 2050 Pulp & Paper: 33% 2050 Refining: 53% 2050 Iron & Steel: 40% 2050 Aluminum: 63% 2050 Glass: 46% 2050 Cement: 38% 2050 Food: 19% 2050 Durables: 19% 2050 Other Mfg: 19% 2050 Non-Mfg: 19%	Energy Efficiency Savings Industry in 2050 (Overall, these bandwidth savings translate to 43%, the maximum value that can be entered in Basic Mode)
Transportation	**UC Davis 2009** "Achieving deep reductions in US Transport greenhouse gas emissions: Scenario Analysis and Policy Implications," UC Davis, 2009 (p.5586, 5588)	2050 Electric-drive 50in50 Scenario LDV Fleet Vehicle Shares: Battery-Electric Vehicles: 20% Hydrogen Fuel Cell Vehicles: 60% Plug-In Hybrid Electric Vehicles: 20% Fleet Average On-road LDV Fuel Economy: 80 mpg Transport Greenhouse Gas emissions: 954 $MMTCO_2$	LDV Miles Per Gallon in 2050
Transportation	**Kerry Request 2010** "EPA Analysis of the Transportation Sector: Greenhouse Gas and Oil Reduction Scenarios," Senator John Kerry Request for additional information re: HR 2454, 2010 (p.12, 15, 52)	2030 Moderately Aggressive ("Scenario A") Biofuels Consumption: 25 billion gallons LDV Fuel Economy: 70 MPG Transportation Sector Oil Reduction: 26% 2030 Very Aggressive Scenario ("Scenario B") Biofuels Consumption: 25 billion gallons LDV Fuel Economy: 90 MPG Transportion Sector Oil Reduction: 42%	Biofuels Consumption in 2050 (billion gallons) LDV Miles Per Gallon in 2050

Benchmarking Scenarios			
Sector	Source	Data	Basic Mode Input
Transportation	**DOT 2010** "Transportation's Role in Reducing U.S. Greenhouse Gas Emissions, Volume 1: Synthesis Report," Report to Congress by US DOT, 2010 (p. 3-33, 3-34)	2030 Vehicle Fuel Efficiency Strategy Efficiency Improvements for non-LDV: Rail System Modifications: 5-57% Train Efficiency Improvements: 4-10% individually Marine Improvements to Design: 4-15% Aircraft Engine Technology: 1.4-2.3%	Non-LDV Efficiency in 2050
Transportation	**EERE 2013** Transportation Energy Futures, EERE, 2013 http://www1.eere.energy.gov/analysis/transportationenergyfutures/index.html	Inputs Available in BITES https://bites.nrel.gov/inputs.php?id=1146	
Electricity Generation	**Google 2011** "The Impact of Clean Energy Innovation," Google, Examining the Impact of Clean Energy Innovation on the United States Energy System and Economy, June 2011 (p.15)	2030 Electricity Generation Mix - Clean Policy Scenario Coal: 36% Renewables: 27% Nuclear: 22% Natural Gas: 15% 2030 Electricity Generation Mix - All Tech Breakthrough Coal: 40% Renewables: 28% Nuclear: 20% Natural Gas: 12%	Generation Mix in 2050
Electricity Generation	**Synapse 2011** Toward a Sustainable Future for the U.S. Power Sector: Beyond Business as Usual 2011," Synapse Energy Economics, Inc., 2011 (p.54)	2050 Electricity Generation Mix Coal: 0% Nuclear: 19% Natural Gas: 34% Renewables: 47%	Generation Mix in 2050
Electricity Generation	**EIA 2009** "Energy Market and Economic Impacts of HR 2454, the American Clean Energy and Security Act of 2009 (Waxman-Markey)," EIA, August 2009 (p.22)	2030 Electricity Generation Mix Coal: 18% Coal w/CCS: 11% Nuclear: 34% Natural Gas: 14% Renewables: 22%	Generation Mix in 2050 % of Fossil CCS in 2050
Electricity Generation	**RE Futures** Renewable Electricity Futures, NREL 2012 http://www.nrel.gov/analysis/re_futures/	Inputs available in BITES https://bites.nrel.gov/inputs.php?id=1287	

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BITES Workshop Instructor Guide

June 2013

This instructor guide is intended to complement the BITES student workshop.

Outline

- Suggested Timeline
- Goals
- Suggested Preparation
- Workshop and Instructor Notes
- FAQ
- Other Materials
- Appendix – Background Reading
- Appendix – "Answer Key"

Suggested Timeline (approximately 3 class hours)

- Pre-lesson readings (optional but recommended, 45 minutes – 1 hour; see Appendix for suggested pages and links)
- Introduction (30 minutes)
- BITES Demo (10 minutes)
- Sector Exercises (45 minutes)
- Break (10 minutes)
- Group Exercises (45 minutes)
- Presentation, Discussion of Scenarios, and Class Consensus Scenario (40 minutes)

Goals

- Improve students' understanding of the U.S. energy system – energy consumption and production – both current and projected through 2050, and the implications for CO_2 emissions.
- Help students gain familiarity with BITES as a means of quickly identifying the implications of altering the U.S. energy profile.
- Explore the possible tradeoffs between sectors and individual technologies and generate a realistic cross-sector scenario that meets national or class-chosen energy and carbon emissions targets.
- Compare and evaluate scenarios and deepen understanding of presented concepts.

Suggested Preparation

- Follow the student guide for each of the four sectors.

- Familiarize yourself with the sources suggested below.
- Consider any specifics or conditions within your class or group that might require changes to the workshop plan.

Instructor Notes for Each Workshop Section

The following is a short list of suggested points to cover in discussion. If you have other suggestions, please suggest them to the project team at bites@nrel.gov for inclusion in future versions of this guide.

Part 2: Sector Exploration

A key insight goal for this section is to convey that no amount of change in any single sector can entirely achieve national goals. Often, energy discussion centers around one sector, but students who use BITES often conclude that cross-sector partnership is more effective.

Encourage students in each group to think of themselves as the resident experts for their particular sectors. They will be sharing the knowledge they gain here with classmates in Part 3.

Part 3: Cross-Sector Exercise

A key insight goal for this section is to communicate the balance between optimism (we can do any of these options) and practical realities (many will be challenging). Encourage the students to think through the monetary and social costs, as well as the benefits, of action in each sector.

Part 4: Scenario Readout and Discussion

Each group will briefly present their inputs for each sector as well as a synopsis of the strategy and sources for the inputs. This discussion should allow them to voice their reasoning behind the choices made in their group.

Example critical questions for each group to consider include:

1) Which inputs in your sector have the greatest effect on primary/ delivered energy or carbon dioxide emissions?
2) What limits or constraints did you select for your scenario? What anticipated costs are attached to your scenario?
3) The U.S. Energy Information Administration's (EIA) Annual Energy Outlook (AEO), used in the baseline, assumes today's policies are held constant and technologies only improve incrementally. What technology breakthroughs or policy changes could make your scenario more achievable?
4) What other benefits, aside from those associated with climate and energy, might be possible because of elements of the scenario?

Additional discussion questions are included in the student guide.

If the class seems to have a good chance of deciding on a consensus scenario, the class may identify a level to use for each input through discussion or voting. In larger workshops, representatives from each group may be more effective for determining a proposed consensus. After determining each input, the class will vote to either accept or not accept the scenario as representative of its perspective. The "for" and "against" cases can give a very brief statement to explain and support their perspectives. Although

we usually encourage the class to try to achieve a consensus scenario, encourage students to voice their disagreements politely and constructively. Not achieving a consensus is not necessarily a negative. Energy is a subject with many perspectives.

Possible Follow-up Activities

Group review in advanced mode. Groups may reconvene to develop additional scenarios, this time in *Advanced Mode*, which offers more than 300 inputs.

Assumption review. Many default input values are held constant over the 2010-2050 timeframe in the *Basic Mode*. These instances can be identified by comparing the AEO 2011 (baseline) scenario in both modes, along with additional "Assumptions" in *Advanced Mode*. Compare these modes in individual groups and review the assumptions.

Calculator overview. Collect participant feedback on the BITES tool inputs, outputs, and features. User feedback is taken directly into account when planning future versions, so the class can have a direct impact on improving the tool.

Other Materials (available at https://bites.nrel.gov/education.php)

- Student Workbook (Word document/PDF)
- BITES feedback survey
- BITES tutorials (coming soon)

Appendix: Background reading for each sector, and input references

- See this short description of the Annual Energy Review from the EIA

- Complete Scenarios
  - Reinventing Fire (http://www.rmi.org/ReinventingFire) by the Rocky Mountain Institute
  - Energy Technology Perspectives (http://www.iea.org/etp/) by the International Energy Agency

Buildings

- "Unlocking Energy Efficiency in the U.S. Economy," McKinsey (2009)
  - Read p. 29-33, "Residential" and p. 55-57, "Commercial"
  - Complete sector inputs, p. 29–68
- "Energy Future, Think Efficiency: How America can look within to achieve energy security and reduce global warming," American Physical Society (2008)
  - Read p. 52-56, "Buildings: Residential, Commercial, Primary Energy"
  - Complete sector inputs, p. 76.
- "Real Prospects for Energy Efficiency in the United States," America's Energy Future (2009)
  - Read p. 61-67, "Approaches to Understanding Energy Efficiency Potential"
  - Complete sector inputs, p. 79-80.

Industry

- "Real Prospects for Energy Efficiency in the United States," America's Energy Future (2009)
  - Read p. 185-187, "Energy Efficiency in Industry"; p.192-198 "Potential for Energy Savings"; and p. 200, "State Assessments"
  - Complete sector inputs, p. 197-198 (from Clean Energy Futures and McKinsey studies)
- "Industry Energy Futures - Challenges and Opportunities for the U.S. Industrial Sector in a Carbon Constrained Future," ACEEE (2011)
  - Read about the study: http://www.aceee.org/files/proceedings/2011/data/papers/0085-000066.pdf
  - Complete sector inputs, p. 7-8.

Transportation

- "Achieving Deep Reductions in U.S. Transport Greenhouse Gas Emissions: Scenario Analysis and Policy Implications," UC-Davis (2009)
  - Read Abstract
  - Complete sector inputs, p. 5586 and 5588
- "EPA Analysis of the Transportation Sector: Greenhouse Gas and Oil Reduction Scenarios," Senator John Kerry Request for additional information re: HR 2454 (2010)
  - Read p. 4-10, "Scenario Overview and Caveats"
  - Sector inputs, p. 12, 15, 52
- "Transportation's Role in Reducing U.S. Greenhouse Gas Emissions, Volume 1: Synthesis Report," Report to Congress by US DOT, 2010
  - Read ES-1 Introduction; p. 3-8 to 3-12, "Strategy: Increase Vehicle Fuel Efficiency"
  - Sector inputs, p. 3-33 and 3-34.

Electricity Generation

- "The Impact of Clean Energy Innovation," Google, *Examining the Impact of Clean Energy Innovation on the United States Energy System and Economy*, June (2011)
  - Read p. 1-6, "Summary, Introduction and Methods"; p. 19, "Clean Policy" and "All Tech Breakthrough" descriptions
  - Complete sector inputs, p. 15, Figure 13
- "Toward a Sustainable Future for the U.S. Power Sector: Beyond Business as Usual 2011," Synapse Energy Economics, Inc. (2011)
  - Read p. 1-5
  - Complete sector inputs, p. 54
- "Energy Market and Economic Impacts of HR 2454, the American Clean Energy and Security Act of 2009 (Waxman-Markey)," EIA (2009)
  - Read p. v – viii, "Executive Summary"

        - Complete sector inputs, p. 22
    - Renewable Electricity Futures Study (http://www.nrel.gov/analysis/re_futures/).

FAQ

Q: What if there is something I want to do but cannot with the available inputs?
A: Encourage the students to think through how this factor might affect the outputs in BITES. If it is a quantitative suggestion, students may search for resources suggesting what the impact would be in units used in BITES such as Terawatt-hours, quadrillion BTU, or MMT CO_2. Suggest it to the project team at BITES@NREL.gov.

Q: What is the expected background of the participants in a BITES workshop?
A: This example curriculum was written with the assumption that participating students have some familiarity with the energy system. Instructors should 'tune' the workshop based on the experience and interests of their students. For example, students with limited knowledge of energy can use the tool in basic mode, with about a dozen inputs that are mostly intuitive. More advanced students might experiment with the detailed inputs available in advanced mode.

Q: What are some other ways to use BITES in the classroom?
A: Instructors and students are encouraged to experiment with uses of BITES beyond the specific workshop described here. For example, the tool could be used in basic mode at the beginning of a course to experiment with simple options, and then revisited in advanced mode after exploration of more detailed sector content throughout the course.

Appendix – "Answer Key" (Background reading for each sector and input references)

Benchmarking Scenarios			
Sector	Source	Data	Basic Mode Input
Buildings	**AEF 2009** "Real Prospects for Energy Efficiency in the United States," America's Energy Future, 2009 (pp.79-80)	2030 Residential Electricity Savings: 30% 2030 Residential Natural Gas Savings: 28% 2030 Commercial Electricity Savings: 34% 2030 Commercial Natural Gas Savings: 35%	Appliance Efficiency input in 2050
Buildings	**McKinsey 2009a** "Unlocking Energy Efficiency in the U.S. Economy," McKinsey 2009 (p.29,46, 51, 55, 68)	Residential 2020 Residential Savings due to EE: 28% 2020 Electrical Devices & Small Appliances Savings: 27% 2020 Lighting & Major Appliances Savings: 10% Commercial 2020 Commercial Savings due to EE: 29% 2020 Office and Non-commercial Devices Savings: 29%	Appliance Efficiency input in 2050
Buildings	**McKinsey 2009b** "Unlocking Energy Efficiency in the U.S. Economy," McKinsey 2009 (p.34, 39, 58, 61)	Residential 2020 Existing Non-low income Home Retrofits: 39% 2020 Existing Low-income Home Retrofits: 40% Commercial 2020 Existing Private Buildings Retrofits: 28% 2020 Government Buildings Retrofits: 31%	% Improvement Retrofits in 2050
Buildings	**McKinsey 2009c** "Unlocking Energy Efficiency in the U.S. Economy," McKinsey 2009 (p.41, 64)	Residential 2020 New Homes Savings due to EE: 33% Commercial 2020 New Private Buildings Savings: 25%	% New Building Improvements in 2030
Buildings	**APS 2008** "Energy Future, Think Efficiency: How America can look within to achieve energy security and reduce global warming," American Physical Society, 2008 (p.76)	Residential 2030 Energy Savings Potential due to EE: 30%	Appliance Efficiency input in 2050

Benchmarking Scenarios			
Sector	Source	Data	Basic Mode Input
Industry	**AEF 2009** "Real Prospects for Energy Efficiency in the United States," America's Energy Future, 2009 (pp.197-198)	Energy Efficiency Savings 2020 Industry Overall: 14-22% 2020 Paper: 6% 2020 Iron & Steel: 15% 2020 Cement: 19%	Energy Efficiency Savings Industry in 2050
Industry	**ACEEE 2011** DOE Industrial Technology Program Bandwidth Studies - Summarized in ACEEE Paper - "Industry Energy Futures - Challenges and Opportunities for the U.S. Industrial Sector in a Carbon Constrained Future," 2011 (pp.7-8)	Energy Efficiency Savings by Subsector 2050 Chemicals: 66% 2050 Pulp & Paper: 33% 2050 Refining: 53% 2050 Iron & Steel: 40% 2050 Aluminum: 63% 2050 Glass: 46% 2050 Cement: 38% 2050 Food: 19% 2050 Durables: 19% 2050 Other Mfg: 19% 2050 Non-Mfg: 19%	Energy Efficiency Savings Industry in 2050 (Overall, these bandwidth savings translate to 43%, the maximum value that can be entered in Basic Mode)
Transportation	**UC Davis 2009** "Achieving deep reductions in US Transport greenhouse gas emissions: Scenario Analysis and Policy Implications," UC Davis, 2009 (p.5586, 5588)	2050 Electric-drive 50in50 Scenario LDV Fleet Vehicle Shares: Battery-Electric Vehicles: 20% Hydrogen Fuel Cell Vehicles: 60% Plug-In Hybrid Electric Vehicles: 20% Fleet Average On-road LDV Fuel Economy: 80 mpg Transport Greenhouse Gas emissions: 954 $MMTCO_2$	LDV Miles Per Gallon in 2050
Transportation	**Kerry Request 2010** "EPA Analysis of the Transportation Sector: Greenhouse Gas and Oil Reduction Scenarios," Senator John Kerry Request for additional information re: HR 2454, 2010 (p.12, 15, 52)	2030 Moderately Aggressive ("Scenario A") Biofuels Consumption: 25 billion gallons LDV Fuel Economy: 70 MPG Transportation Sector Oil Reduction: 26% 2030 Very Aggressive Scenario ("Scenario B") Biofuels Consumption: 25 billion gallons LDV Fuel Economy: 90 MPG Transportion Sector Oil Reduction: 42%	Biofuels Consumption in 2050 (billion gallons) LDV Miles Per Gallon in 2050

Benchmarking Scenarios			
Sector	Source	Data	Basic Mode Input
Transportation	**DOT 2010** "Transportation's Role in Reducing U.S. Greenhouse Gas Emissions, Volume 1: Synthesis Report," Report to Congress by US DOT, 2010 (p. 3-33, 3-34)	2030 Vehicle Fuel Efficiency Strategy Efficiency Improvements for non-LDV: Rail System Modifications: 5-57% Train Efficiency Improvements: 4-10% individually Marine Improvements to Design: 4-15% Aircraft Engine Technology: 1.4-2.3%	Non-LDV Efficiency in 2050
Transportation	**EERE 2013** Transportation Energy Futures, EERE, 2013 http://www1.eere.energy.gov/analysis/transportationenergyfutures/index.html	Inputs Available in BITES https://bites.nrel.gov/inputs.php?id=1146	
Electricity Generation	**Google 2011** "The Impact of Clean Energy Innovation," Google, Examining the Impact of Clean Energy Innovation on the United States Energy System and Economy, June 2011 (p.15)	2030 Electricity Generation Mix - Clean Policy Scenario Coal: 36% Renewables: 27% Nuclear: 22% Natural Gas: 15% 2030 Electricity Generation Mix - All Tech Breakthrough Coal: 40% Renewables: 28% Nuclear: 20% Natural Gas: 12%	Generation Mix in 2050
Electricity Generation	**Synapse 2011** Toward a Sustainable Future for the U.S. Power Sector: Beyond Business as Usual 2011," Synapse Energy Economics, Inc., 2011 (p.54)	2050 Electricity Generation Mix Coal: 0% Nuclear: 19% Natural Gas: 34% Renewables: 47%	Generation Mix in 2050
Electricity Generation	**EIA 2009** "Energy Market and Economic Impacts of HR 2454, the American Clean Energy and Security Act of 2009 (Waxman-Markey)," EIA, August 2009 (p.22)	2030 Electricity Generation Mix Coal: 18% Coal w/CCS: 11% Nuclear: 34% Natural Gas: 14% Renewables: 22%	Generation Mix in 2050 % of Fossil CCS in 2050
Electricity Generation	**RE Futures** Renewable Electricity Futures, NREL 2012 http://www.nrel.gov/analysis/re_futures/	Inputs available in BITES https://bites.nrel.gov/inputs.php?id=1287	