

# Energy Security Curriculum

## United States Naval Academy

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United States Naval Academy  
Annapolis, MD

*Defense Energy Seminar*  
*26 October 2018*



# Mission Statement

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Create an interdisciplinary energy program at the United States Naval Academy that will develop leaders who understand and support the energy mission of the United States (with special attention given to the energy missions of the U.S. Navy and U.S. Marine Corps) and to foster geopolitical awareness of the relationship between energy and national security.



# Components

- Interdisciplinary Energy Security Elective
- Energy related electives
  - Environmental Economics
  - Environmental Policy
  - Wind and Tidal Energy
  - Solar Engineering
  - Waste-to-Energy Conversion
  - Fundamentals of Nuclear Energy
- Energy related midshipmen internships (OPNAV N45)
- Energy related midshipmen capstone projects
- Energy related midshipmen research projects



# Interdisciplinary Elective

## Energy Analysis, Policy, and Security

An Interdisciplinary Course of the U. S. Naval Academy

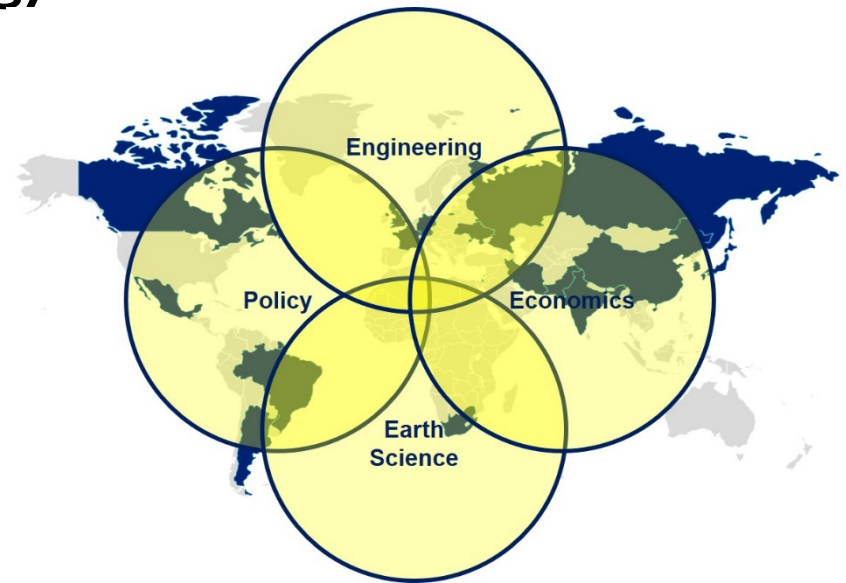


*A Joint Project of the Economics, Mechanical Engineering,  
Oceanography, and Political Science Departments*



# Overarching Themes

- The basics of energy science
- Energy scarcity and national security
- Energy as a strategic factor in military operations
- The determinants of energy conservation behavior
- The economics of energy
- Energy technologies
- Energy policy agreements
- Environmental impact



# Learning Objectives

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- Work independently and as part of a multi-disciplinary team to analyze complex issues related to the energy mission of the U.S. Navy, national and international energy policy, and the role of energy in national security.
- Demonstrate mastery of key discipline specific energy concepts and analytical tools.
- Understand the strategic importance of energy for the mission of the U.S. military
- Effectively present research findings orally and in written form
- Apply current energy issues to U.S. national security and geopolitics



# Course Organization

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- 4<sup>th</sup> time offered
- Four instructors
- All students (~60-70) get major elective credit
  - EM485, FP385, FE385, SO485
- Meet 50% of the time as a large group
  - Overview lectures
  - Guest speakers
- Meet 50% of the time in discipline specific sections
- Grouped into country themed interdisciplinary teams
- 30% or grade based on team deliverables
- 70% on discipline specific assessment





# Modules - Overview and Introduction

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- An interdisciplinary discussion of fracking (All)
- How much do we use and where does it come from? (Engr)
- Introduction to energy security and competing worldviews that drive environmental conflict (PolySci)
- How are energy sources distributed around the world and why does it matter (Ocean)
- The economics of energy (Econ)
- Introduction to environmental policy: solving market failures through collective action (PolySci)





# Modules - Overview and Introduction

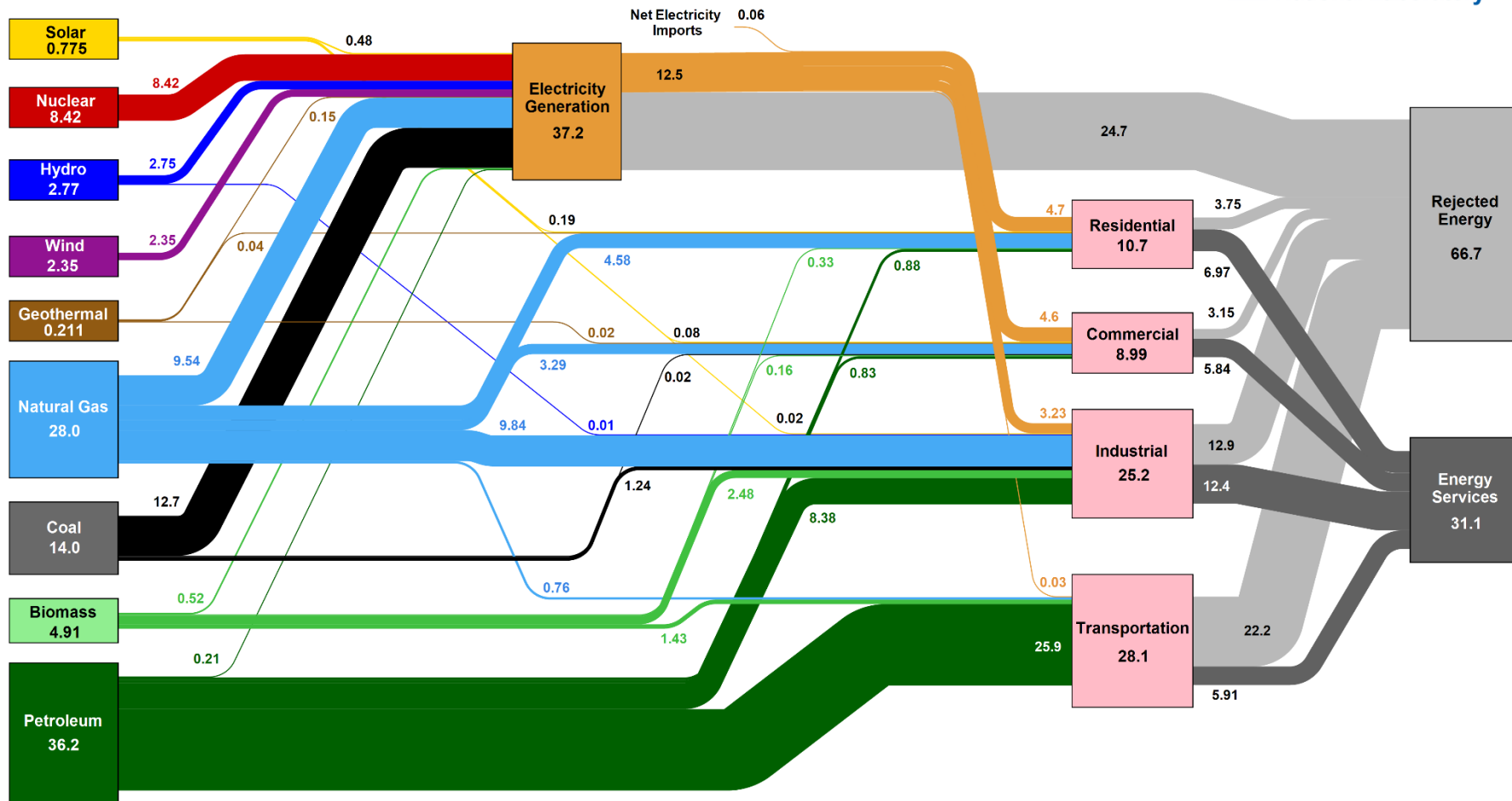
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# How much do we use and where does it come from?

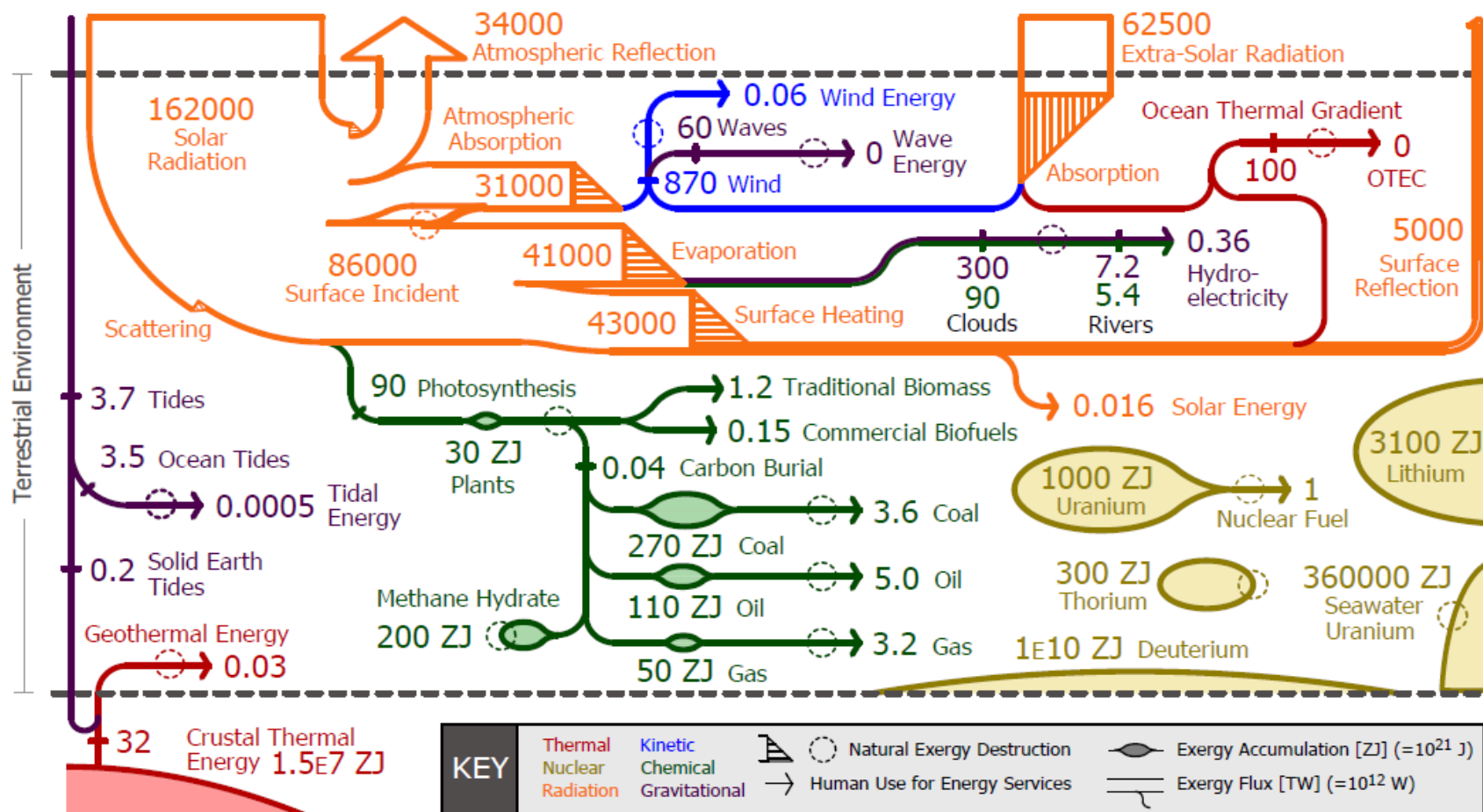
Estimated U.S. Energy Consumption in 2017: 97.7 Quads



# How much do we use and where does it come from?



## Global Exergy Flux, Reservoirs, and Destruction



Prepared by Wes Hermann and A.J. Simon  
Global Climate and Energy Project at Stanford University (<http://gcep.stanford.edu>)

Ver. 1.1 © GCEP 2005, 2007



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# Environmental Worldview Survey

	Strongly Disagree			Strongly Agree	
1) Animals are generally governed by instincts (not reason, emotions, or social ties) .	-2	-1	0	1	2
2) Animals exist to serve human needs.	-2	-1	0	1	2
3) Animals are capable of forming meaningful friendships with humans.	-2	-1	0	1	2
4) Some pets feel genuine sadness when separated from their owners.	-2	-1	0	1	2
5) Man and animals are tied in a web of mutually dependent connections.	-2	-1	0	1	2
6) Environmentalists give too much attention to animal rights.	-2	-1	0	1	2
7) Humans should protect endangered species, even if doing so harms the economy .	-2	-1	0	1	2
8) Horse meat should be available in grocery stores.	-2	-1	0	1	2



# Environmental Worldview Survey

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Sum your scores for odd questions (3, 4, 5, & 7)

Invert scores for even questions (1, 2, 6, & 8):

- -2 becomes 2
- -1 becomes 1
- 0 remains 0
- 1 becomes -1
- 2 becomes -2

Total your score (range between -16 and 16)



# Environmental Worldview Survey

Dark Green Predictions	Low Score Predictions
I think it is important that people join environmental groups	I have not seriously considered joining an environmental group
I would sign a petition for tougher environmental laws	I would be reluctant to sign an environmental petition
I recycle whenever possible	I recycle when it is easily available
Fuel economy played a large role in my car selection	Fuel economy did not play a major role in my car purchase
Human caused climate change is a major concern for you	I do not think much about climate change
Our government has a responsibility to protect our air and water from pollution	Environmental regulations limit my personal freedoms
Public schools should place greater emphasis on environmental education	Parents, not schools, should teach children about environmental responsibility
Technology tends to cause as many environmental problems as it solves	Technology, not the government, should be relied on to solve our current environmental problems.
Environmental conditions are likely to get worse in the future	Environmental conditions are relatively stable and in some cases improving
Social/Political Predictions	
You do not attend religious services regularly	You attend religious services regularly.
Your parents are democrats	Your parents are republicans.
Welfare is a necessary step up for people during times of need	Welfare is an incentive for people not to work.
Oppose capital punishment	Some people need a good killing.





# Fossil Fuels: oil, gas, and coal

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- Deriving energy from fossil fuels (Engr)
- Fossil fuels: nonrenewable resource economics experiment (exhaustibility, rate of consumption, free v. regulated markets) (Econ)
- Fossil fuels, CO<sub>2</sub>, climate change, and national security (Ocean)
- Climate change: The promise and problems associated with geoengineering solutions (Ocean)



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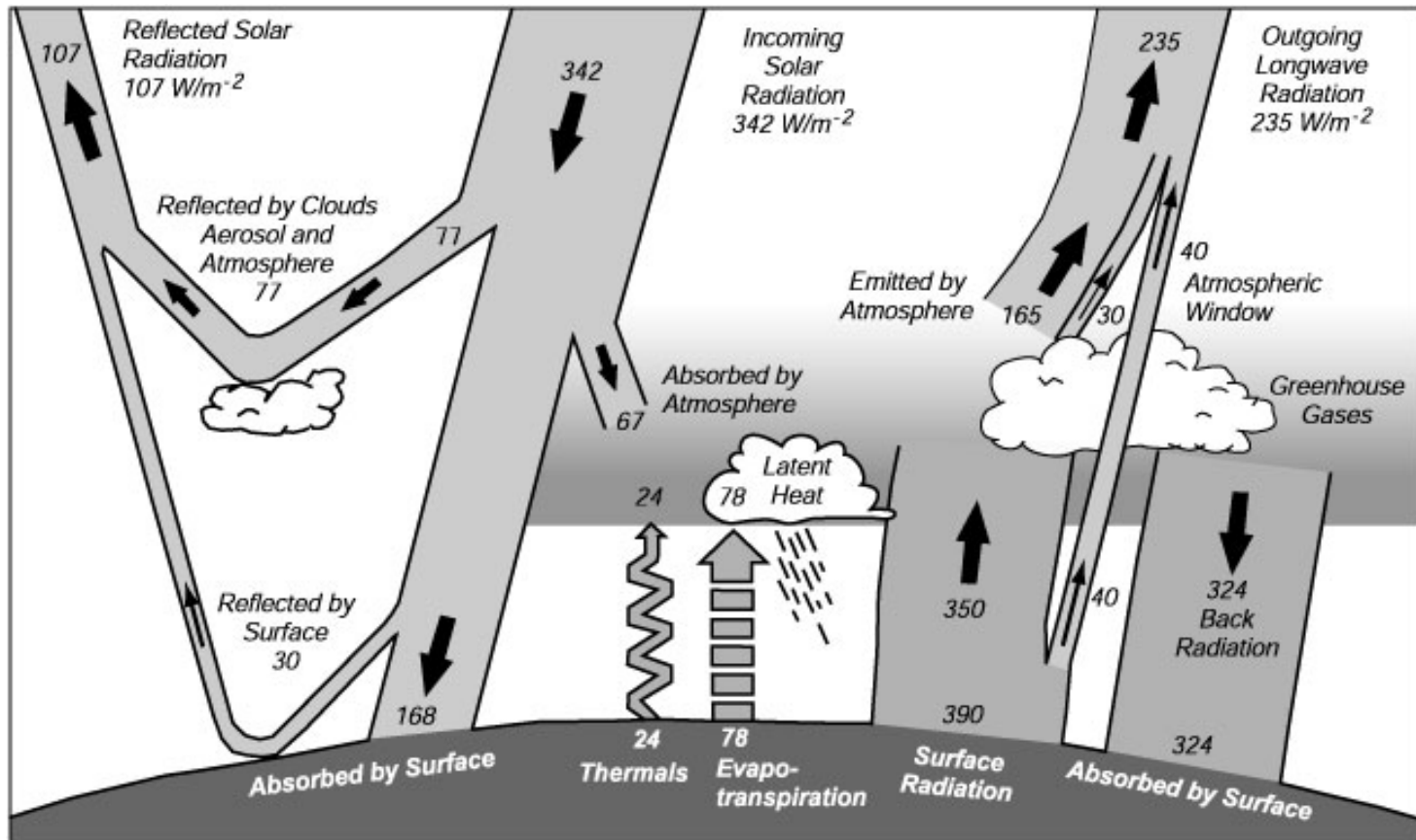


# Fossil fuels, CO<sub>2</sub>, climate change, and national security

@ Steady-State,  $\Delta Q_{NET} = 0$ ;  $SW_{NET\downarrow} = LW_{NET\uparrow}$

Shortwave Solar Radiation Flux

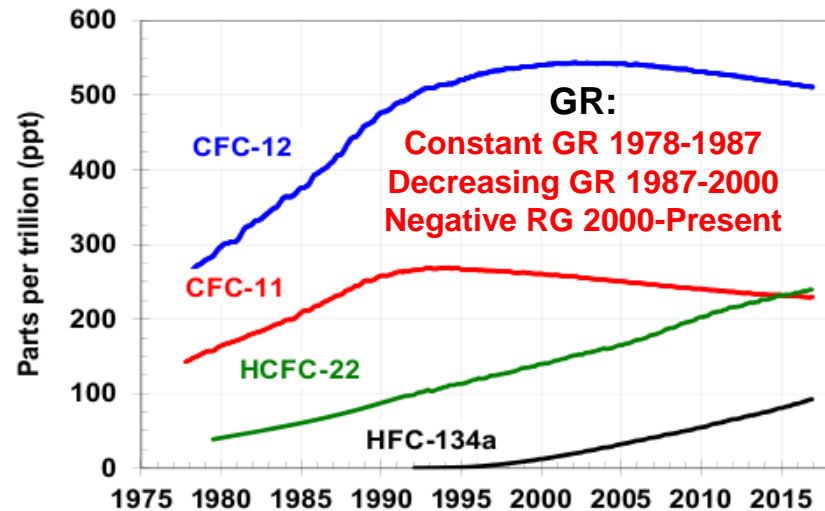
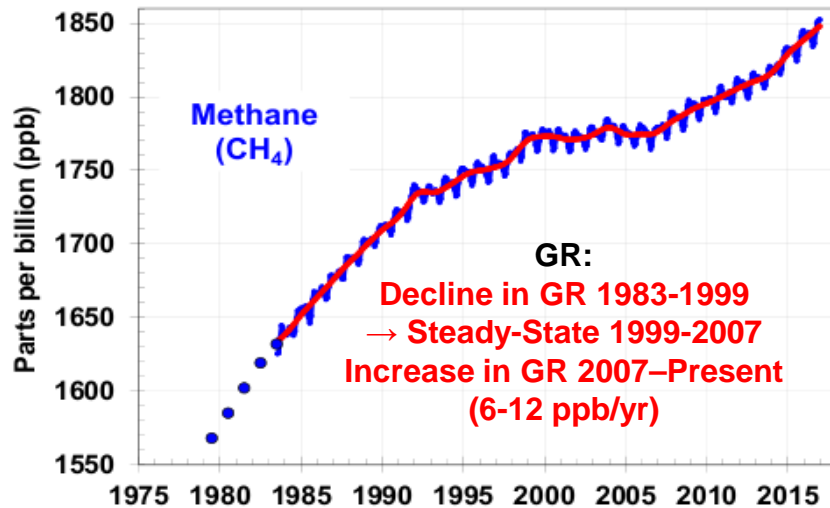
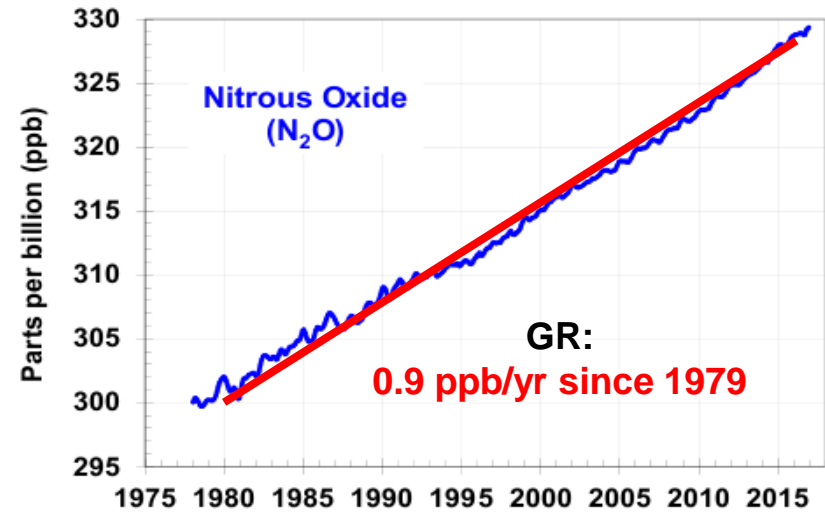
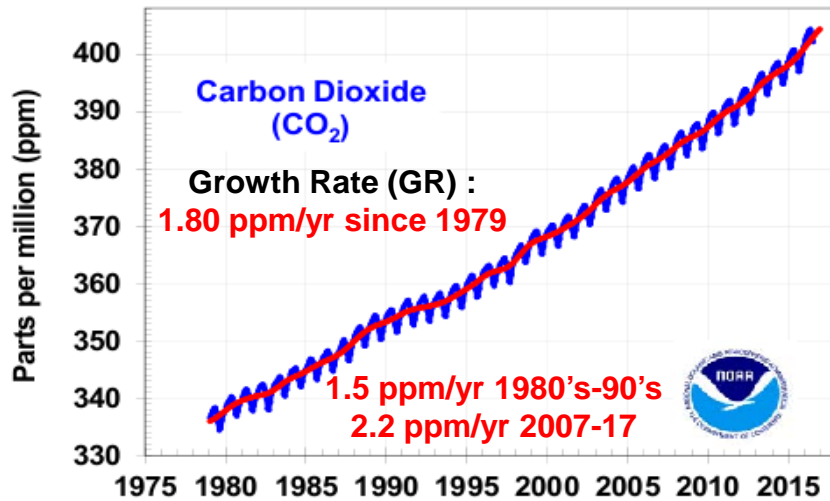
Longwave Radiation Flux from the Earth



The mean annual radiant energy and heat balance of the Earth. From Fig 1.3, IPCC AR 2 WG 1, 1995; Houghton et al., 1996; Kiehl and Trenberth (1996).



# Fossil fuels, CO<sub>2</sub>, climate change, and national security

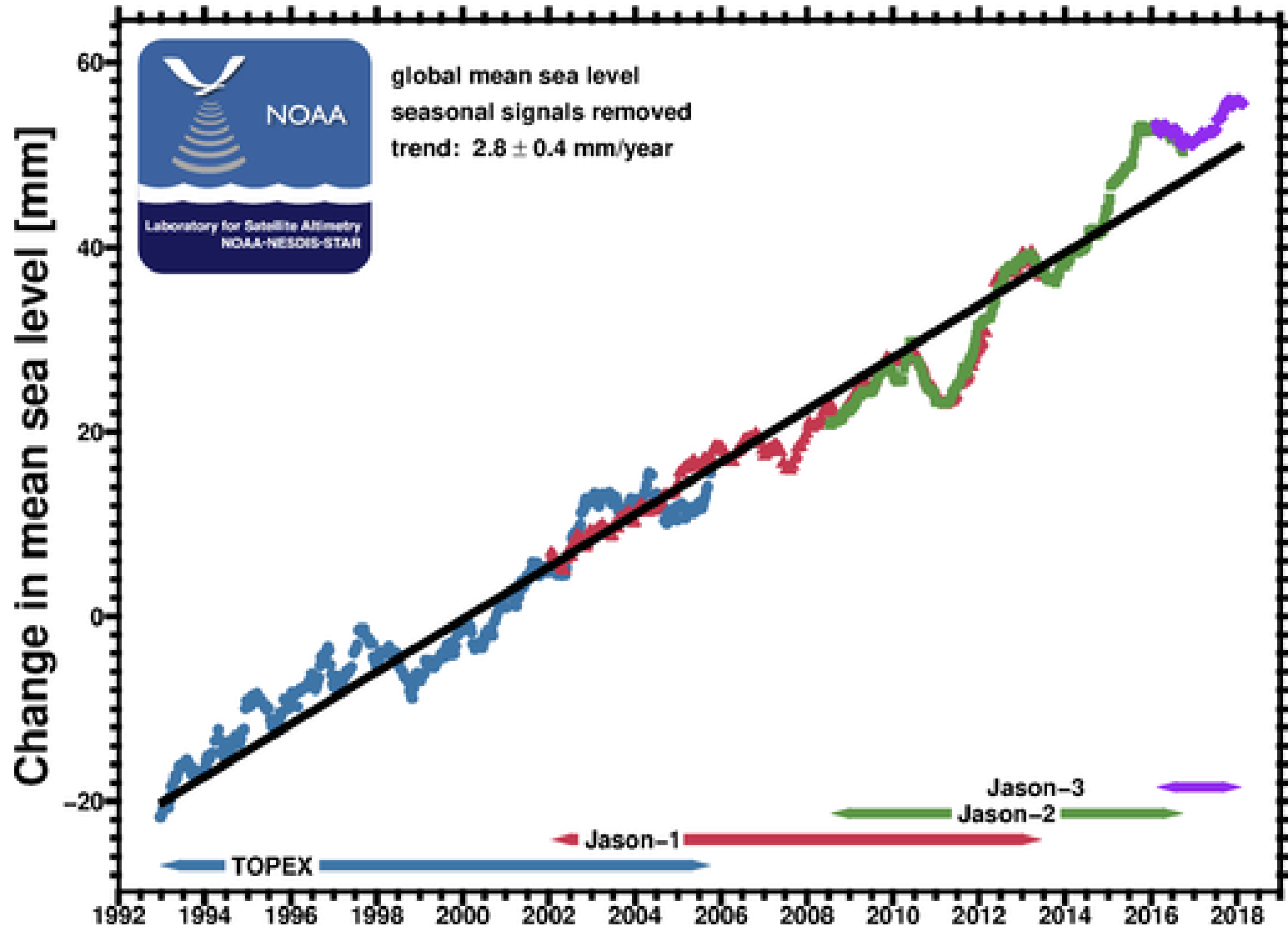


Global average abundances of the major, well-mixed, long-lived greenhouse gases [Etheridge et al., 1998], adjusted to the NOAA calibration scale [Dlugokencky et al., 2005].

<https://www.esrl.noaa.gov/gmd/aggi/aggi.html>



# Fossil fuels, CO<sub>2</sub>, climate change, and national security



[https://www.star.nesdis.noaa.gov/sod/lsa/SeaLevelRise/LSA\\_SLR\\_timeseries\\_global.php](https://www.star.nesdis.noaa.gov/sod/lsa/SeaLevelRise/LSA_SLR_timeseries_global.php)



# Non-Fossil Fuels: nuclear and renewables

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- Renewables: An earth science perspective (Ocean)
- Engineering renewables: Exploring the case of trash to energy (Engr)
- The cost of going green: Exploring the economics of renewable energy (Econ)
- Exploring community, state, and national policies that promote renewable energy (PolySci)
- Unleashing the power of the atom: The mechanics of nuclear energy (Engr)
- Fukushima, Chernobyl, and Three Mile Island: The environmental impact of nuclear accidents (Ocean)
- The nuclear option: Public opinion, markets, policy, and security questions concerning nuclear power (PolySci and Econ)



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# Exploring the economics of renewable energy

## Levelized Cost of Electricity (LCOE)

$$\text{LCOE} = \frac{\text{sum of costs over lifetime}}{\text{sum of electricity produced over lifetime}} = \frac{\sum_{t=1}^n \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^n \frac{E_t}{(1+r)^t}}$$

$I_t$  : investment expenditures in the year  $t$

$M_t$  : operations and maintenance expenditures in the year  $t$

$F_t$  : fuel expenditures in the year  $t$

$E_t$  : electricity generation in the year  $t$

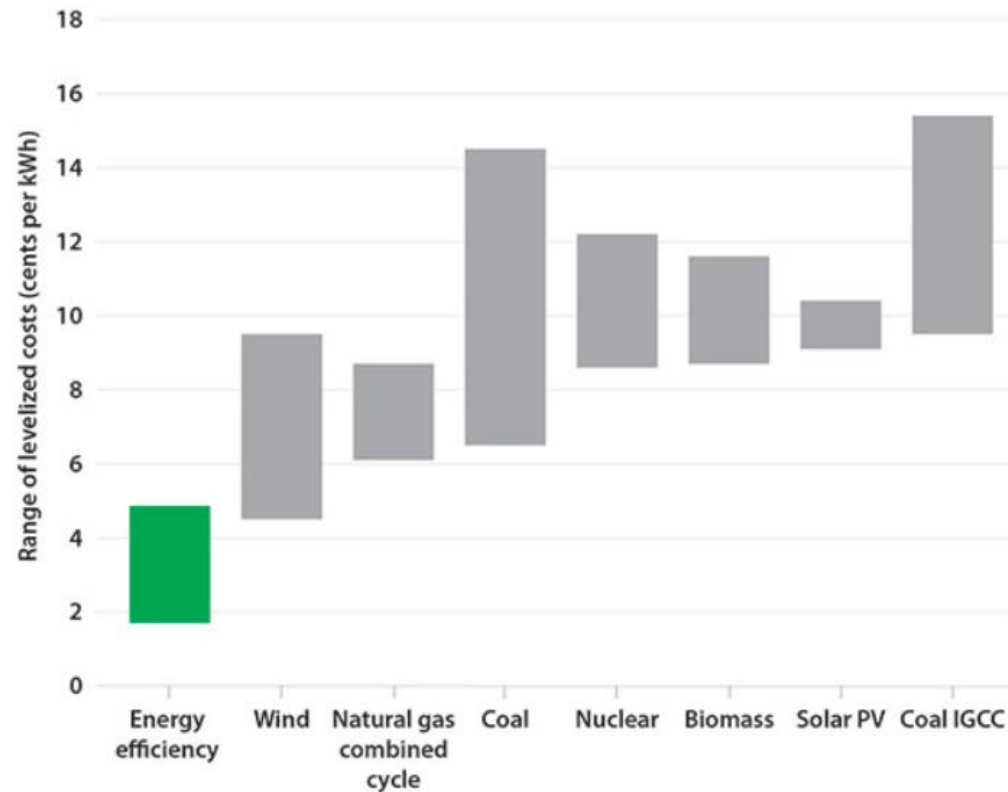
$r$  : discount rate

$n$  : expected lifetime of system or power station



# Exploring the economics of renewable energy

## New Report Finds Energy Efficiency is America's Cheapest Energy Resource

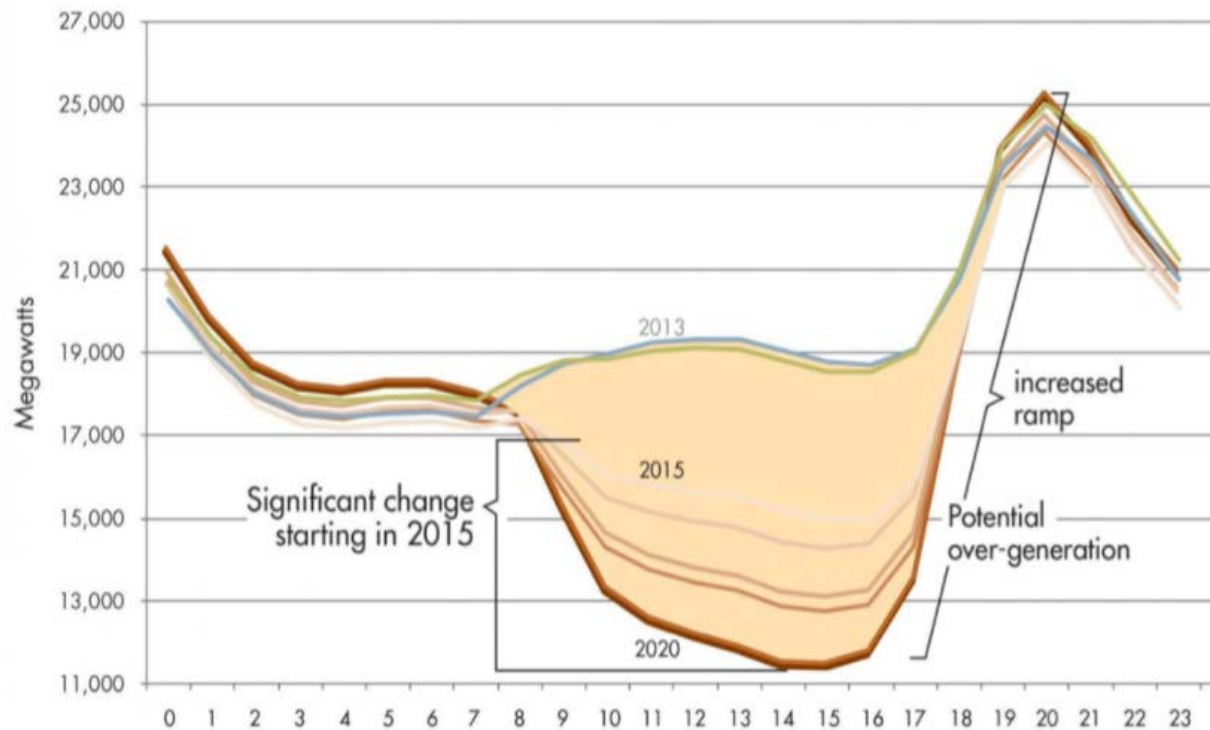


Source: American Council for an Energy-Efficient Economy. (2014). New Report Finds Energy Efficiency is America's Cheapest Energy Resource. Retrieved Oct 24, 2017, <http://aceee.org/press/2014/03/new-report-finds-energy-efficiency-a>



# Exploring the economics of renewable energy

## The Duck Curve



Source: Golden, M. 2016. How Energy Efficiency Can Help Manage the Duck Curve. Retrieved from <https://www.greentechmedia.com/articles/read/the-grid-has-changed-how-energy-efficiency-can-help-manage-the-duck#gs.VQvBeRY>



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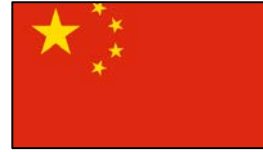
# Group Project Countries



Brazil



Canada



China



Egypt



France



Germany



India



Iran



Israel



Nigeria



Norway



Russia



Saudi Arabia



Turkey



United Kingdom



Venezuela



Vietnam

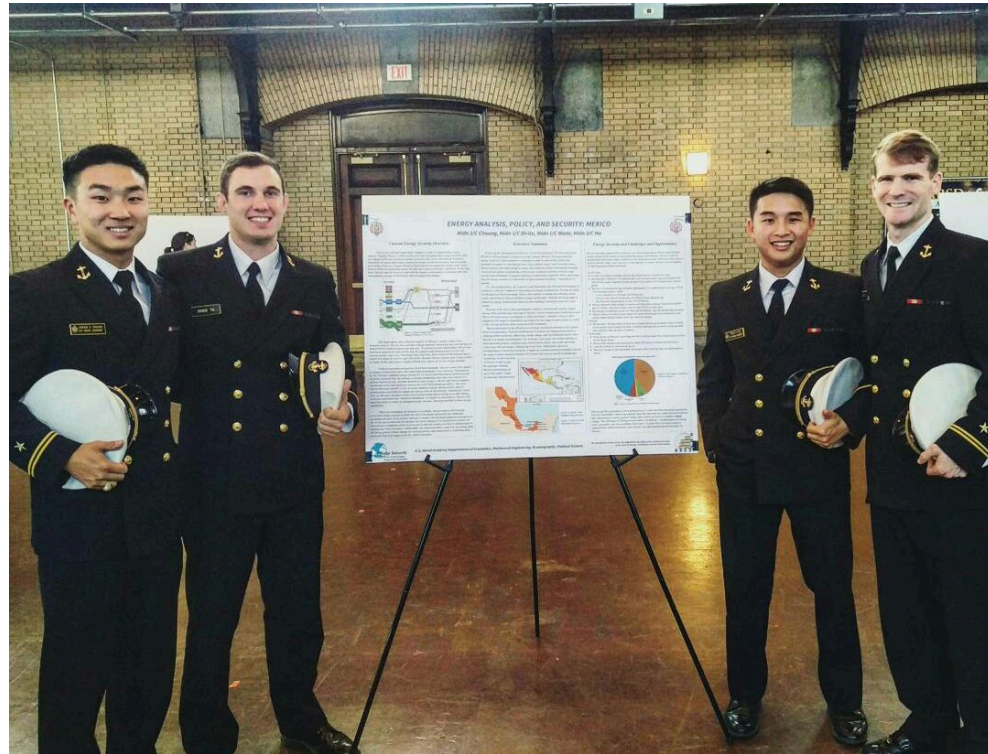


South Africa



# Group Projects: Country Specific Teams

- Nation Specific Energy Security Brief to the U.S. Secretary of State: 2000 word point paper to integrate:
  - natural resource availability
  - geopolitical vulnerabilities
  - economic considerations
  - political pressures
  - forecast country's energy circumstances in 2033





# State Department Field Trip





# State Department Field Trip

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Roundtable discussions with energy experts



# Group Projects: Technology

- USN or USMC Technology Initiative
  - Relate the technology to the Navy's stated energy security goals
  - Assess the technology in comparison to competing technologies
  - Assess the likely human impact of the technology
    - Will troops accept the new technology
    - Will Navy leaders see its value

kinetic knee energy harvester



# Group Projects: Behavior related

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- Energy Audit of Captains Row at USNA
  - Perform physical energy audit and compare to meter audit
  - Determine payback period for efficiency upgrades
  - Perform lifecycle analysis of the energy source
  - Suggest behavior modification interacting with systems
  - Incentivized with contest: Which residence could produce largest change?



# Guest Speakers

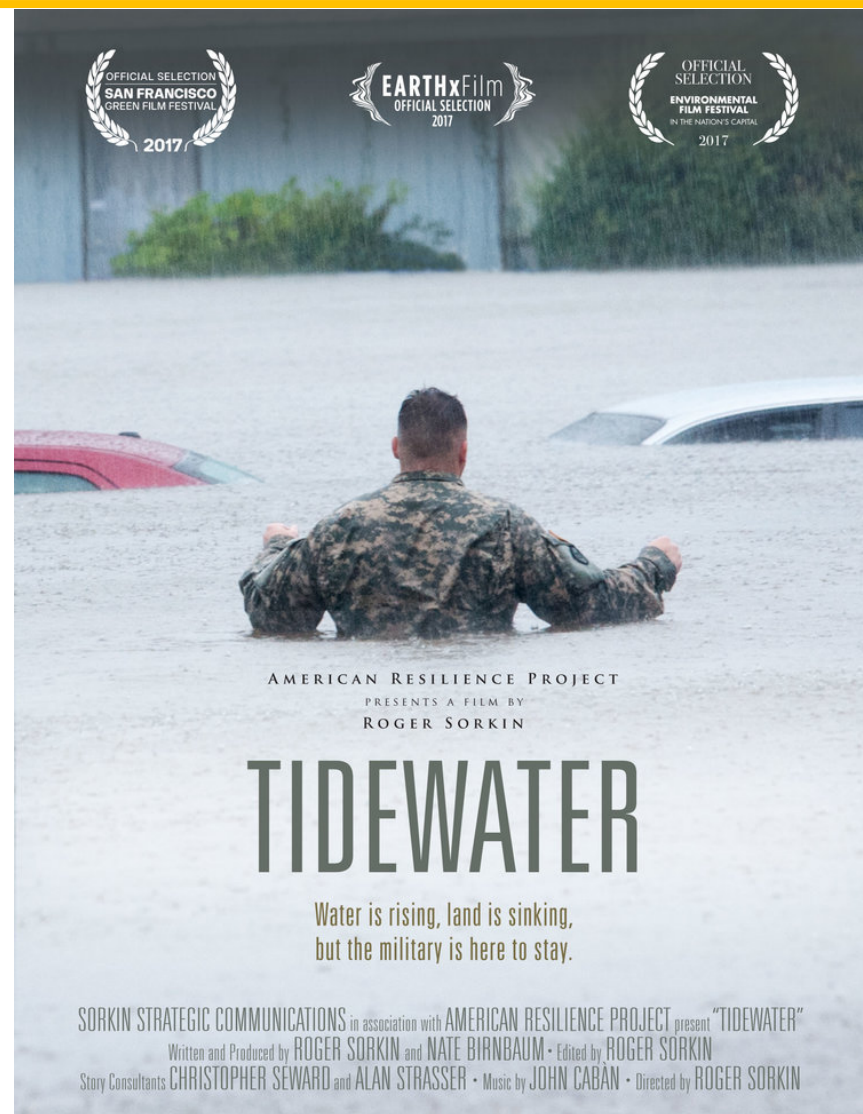
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- VADM (Ret) Dennis McGinn: ASN Energy, Environment and Installations
- COL James Caley: Marine Expeditionary Energy Office
- CAPT (Ret) William Ostendorff: Former U.S. Nuclear Regulatory Commissioner
- Dan McMahan: Hannon Armstrong, Financing renewables and efficiency upgrades
- Roger Sorkin: Documentary filmmaker





# Film Screenings: Roger Sorkin



# Evaluating Efficacy: pre and post-course survey

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- 1) How much do you personally worry about the environmental impact of energy?
- 2) How often do you reduce the energy you use for environmental reasons?
- 3) When it is impossible to find a reasonable compromise between economic development and energy conservation, which do you usually believe is more important?
- 4) Do you think environmental protection laws and regulations have gone too far, or not far enough, or have struck about the right balance?
- 5) Technology will find a way of solving energy problems.
- 6) Energy issues will play an increasingly important role in national security.
- 7) Government officials need to place more emphasis on energy conservation.
- 8) Energy conservation should be taught in public schools.



# Evaluating Efficacy: pre and post-course survey

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9) Next, you will read a statement that could be made by someone who wants to be a United States Senator or President of the United States. Here is the statement: “I believe that global warming has been happening for the past 100 years, mainly because we have been burning fossil fuels and putting out greenhouse gasses. Now is the time for us to be using new forms of energy that are made in America and will be renewable forever...” If a candidate says this, would this make you more likely to vote for this candidate, less likely to vote for this candidate, or would it not affect how likely you would be to vote for this candidate?  
\_\_ More \_\_ Less \_\_ Has no effect \_\_ Don't know/Refuse

10) Next, I will read you a statement that could be made by someone who wants to be a United States Senator or President of the United States. Here is the statement: “When people ask me if I believe global warming has been happening, I'm not qualified to debate the science over climate change, because I am not a scientist. When people ask me if I believe human activity causes global warming, I don't know...” If a candidate says this, would this make you more likely to vote for this candidate, less likely to vote for this candidate, or would it not affect how likely you would be to vote for this candidate?  
\_\_ More \_\_ Less \_\_ Has no effect \_\_ Don't know/Refuse



# Evaluating Efficacy: Results

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## Amping-Up Pedagogy through Interdisciplinary Instruction:

A Study of the Effects of Interdisciplinary Instruction on Undergraduate Attitudes and Values Related to Energy Issues at the U.S. Naval Academy

Patrick Caton, Howard Ernst, Karen Flack, Joseph P. Smith, and Kurtis Swope

### Abstract

This study makes use of a pre-test/post-test design (with a control group) to test the effect of an interdisciplinary energy course on student attitudes and values related to energy issues. The interdisciplinary energy course was co-taught by engineering, political science, economics, and oceanography professors at the United States Naval Academy during the fall of 2015. The study finds that students in the interdisciplinary energy course experienced significant changes in their energy attitudes on half the categories tested, while students in the control group did not experience similar changes. The changes were greatest among female students, politically moderate students, and engineering students. The findings suggest that interdisciplinary instruction can have a powerful impact on student values, but that the impact works through existing demographic and ideological factors.

**Key Words:** interdisciplinary, education, environment, attitudes, and values





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# Bottom Line Goals

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Equip future Navy and Marine Corps leaders  
with multi-disciplinary energy literacy

How do innovation, policy, technology, and economics of energy affect the ability of the U.S. military to successfully and efficiently succeed in its various missions?



# Acknowledgements

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- ASN Energy, Installations & Environment
- OPNAV N45, Energy & Environmental Readiness Division
- NAVFAC Engineering & Expeditionary Warfare Center
- NPS Energy Academic Group

Questions?

