Coal, China and International Climate Agreements

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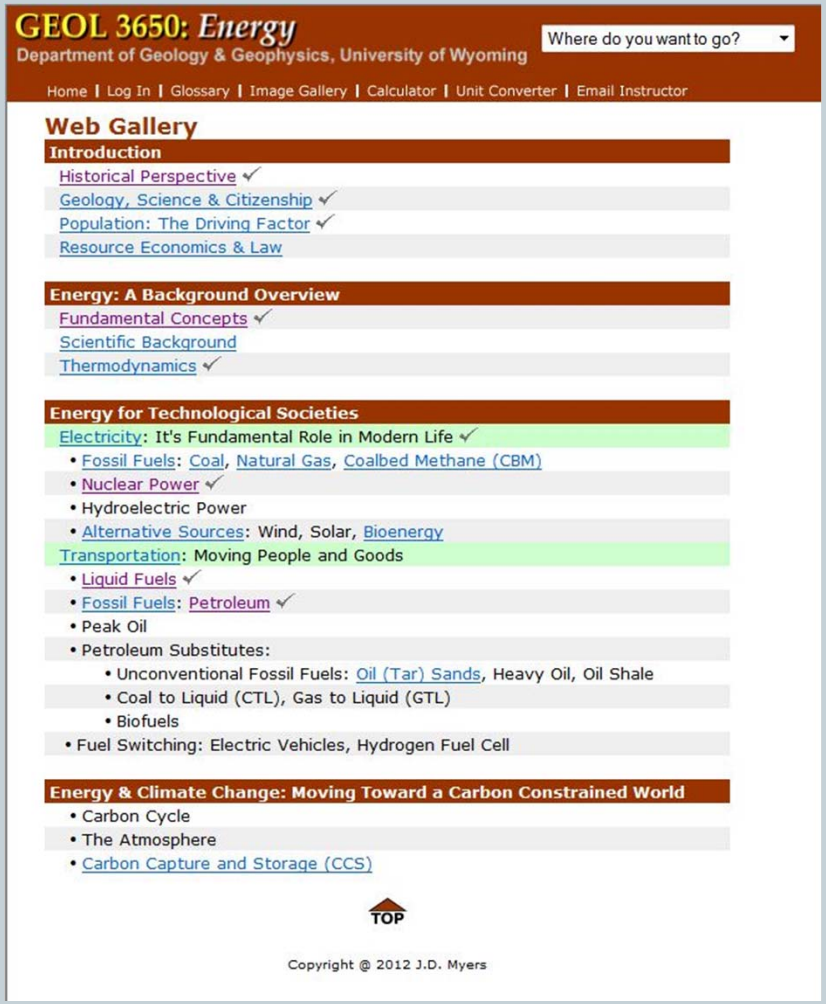
GEOL3650: Energy: A Geological Perspective

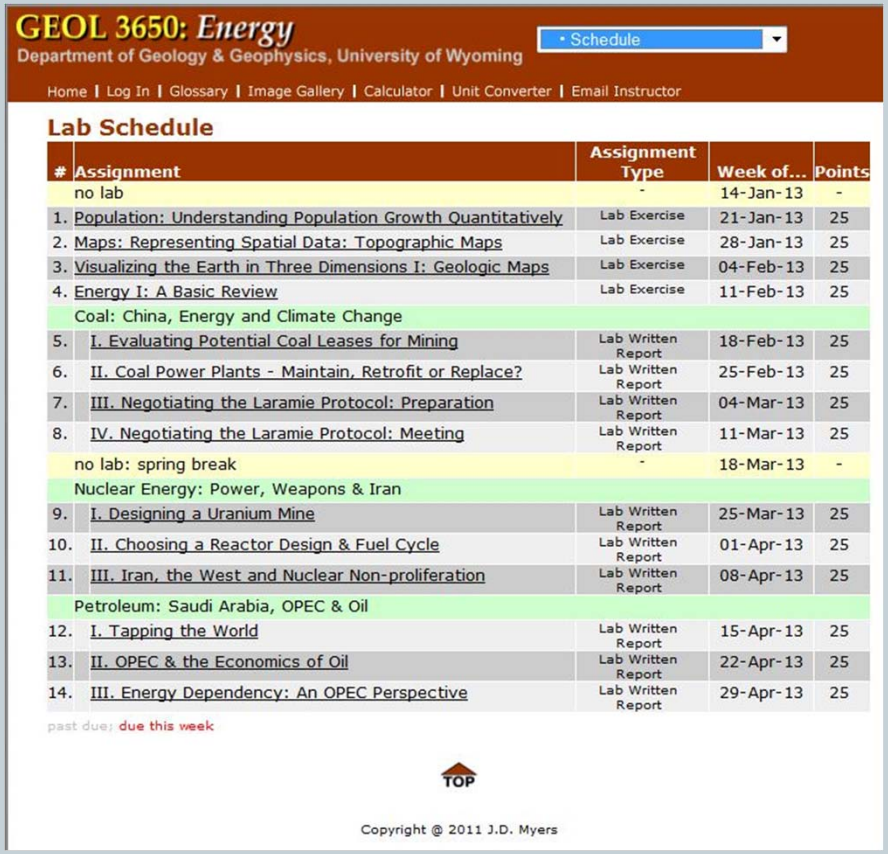
- primary use:
  - upper division class
  - non-majors & majors (50:50)
  - enrollment: 40-60
  - 4 credit: 3 hour lectures (1 hr) and 1 lab (2 hr)
- secondary use:
  - Global Sustainability: Managing the Earth's Resources



http://www.gg.uwyo.edu/geol3650

GEOL3650: Energy – Lab Component

- case study in lab
- others include:
  - nuclear power, weapons & Iran
  - oil, OPEC & Saudi Arabia (poster in Share Fair)



GEOL 3650: *Energy*

Department of Geology & Geophysics, University of Wyoming

• Schedule

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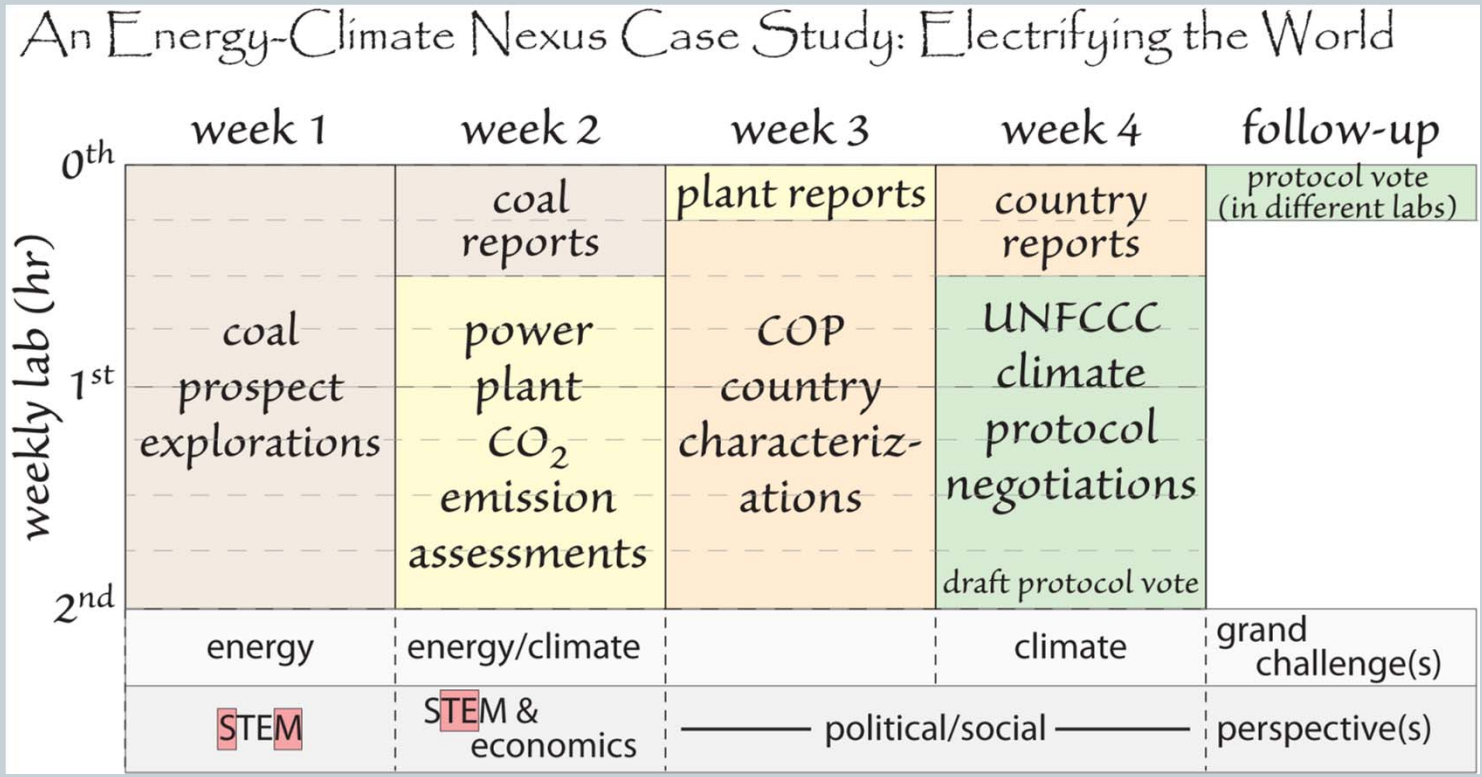
Lab Schedule

#	Assignment	Assignment Type	Week of...	Points
	no lab	-	14-Jan-13	-
1.	Population: Understanding Population Growth Quantitatively	Lab Exercise	21-Jan-13	25
2.	Maps: Representing Spatial Data: Topographic Maps	Lab Exercise	28-Jan-13	25
3.	Visualizing the Earth in Three Dimensions I: Geologic Maps	Lab Exercise	04-Feb-13	25
4.	Energy I: A Basic Review	Lab Exercise	11-Feb-13	25
	Coal: China, Energy and Climate Change			
5.	I. Evaluating Potential Coal Leases for Mining	Lab Written Report	18-Feb-13	25
6.	II. Coal Power Plants - Maintain, Retrofit or Replace?	Lab Written Report	25-Feb-13	25
7.	III. Negotiating the Laramie Protocol: Preparation	Lab Written Report	04-Mar-13	25
8.	IV. Negotiating the Laramie Protocol: Meeting	Lab Written Report	11-Mar-13	25
	no lab: spring break	-	18-Mar-13	-
	Nuclear Energy: Power, Weapons & Iran			
9.	I. Designing a Uranium Mine	Lab Written Report	25-Mar-13	25
10.	II. Choosing a Reactor Design & Fuel Cycle	Lab Written Report	01-Apr-13	25
11.	III. Iran, the West and Nuclear Non-proliferation	Lab Written Report	08-Apr-13	25
	Petroleum: Saudi Arabia, OPEC & Oil			
12.	I. Tapping the World	Lab Written Report	15-Apr-13	25
13.	II. OPEC & the Economics of Oil	Lab Written Report	22-Apr-13	25
14.	III. Energy Dependency: An OPEC Perspective	Lab Written Report	29-Apr-13	25

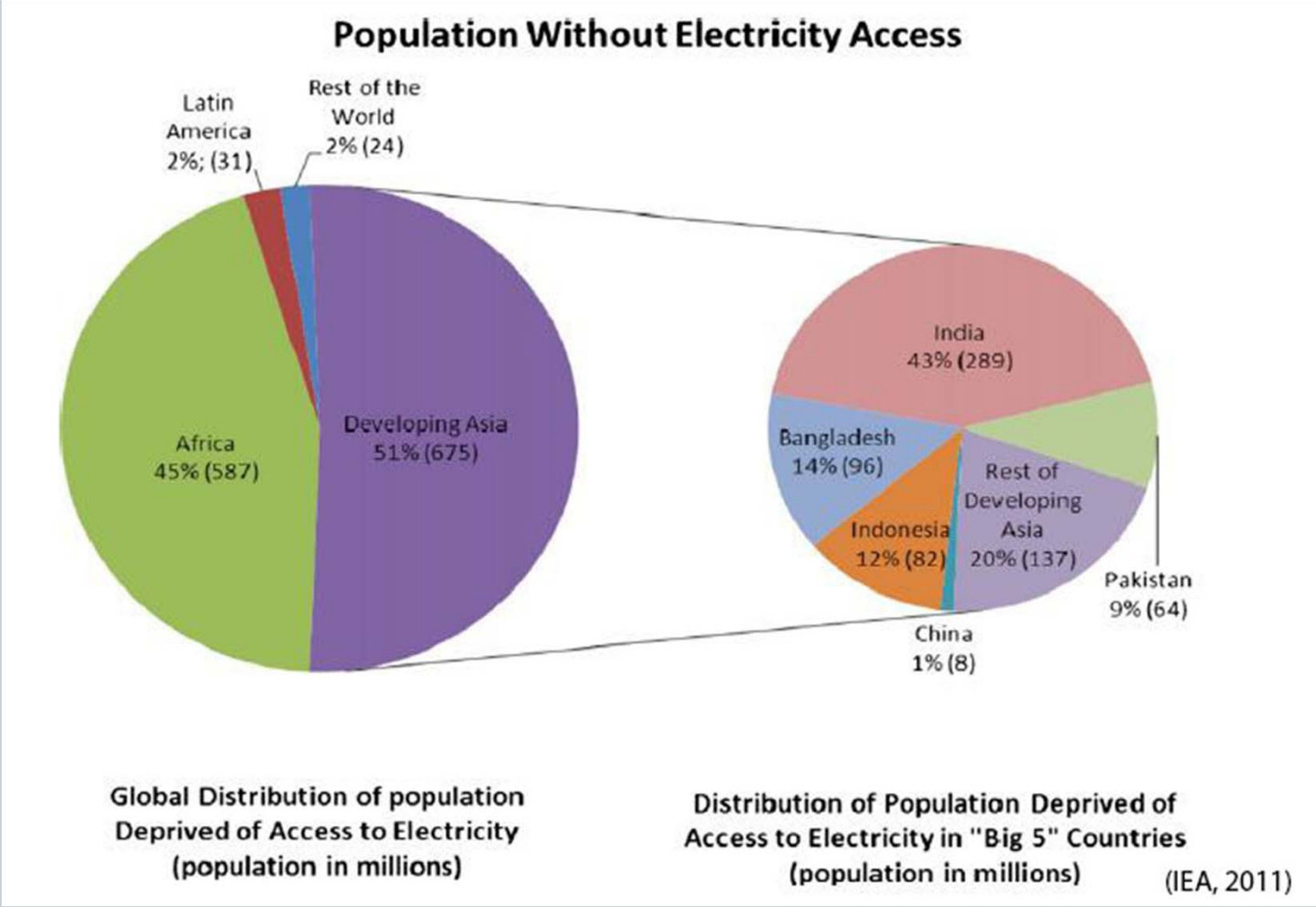
past due; due this week

TOP

Coal, China & International Agreements: Case



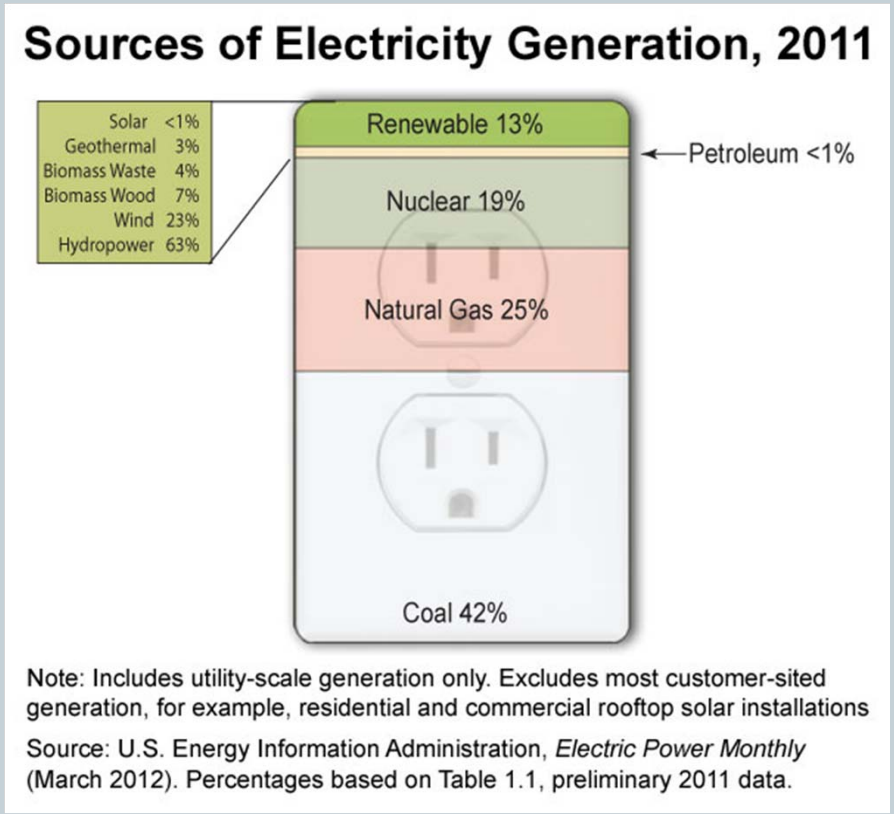
Grand Challenge: Energy



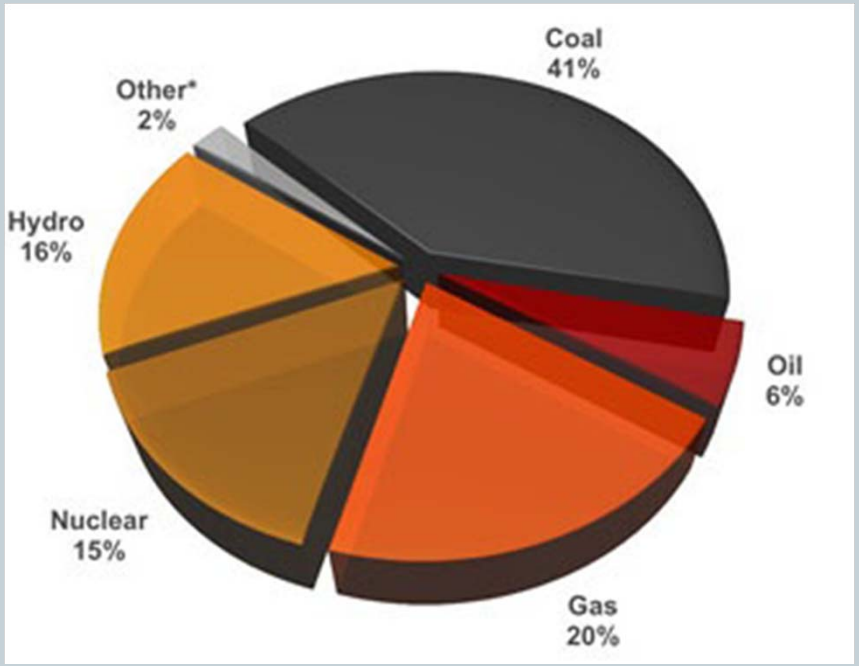
Grand Challenge: Energy

Grand Challenge: Energy & Climate

Grand Challenge: Energy & Climate



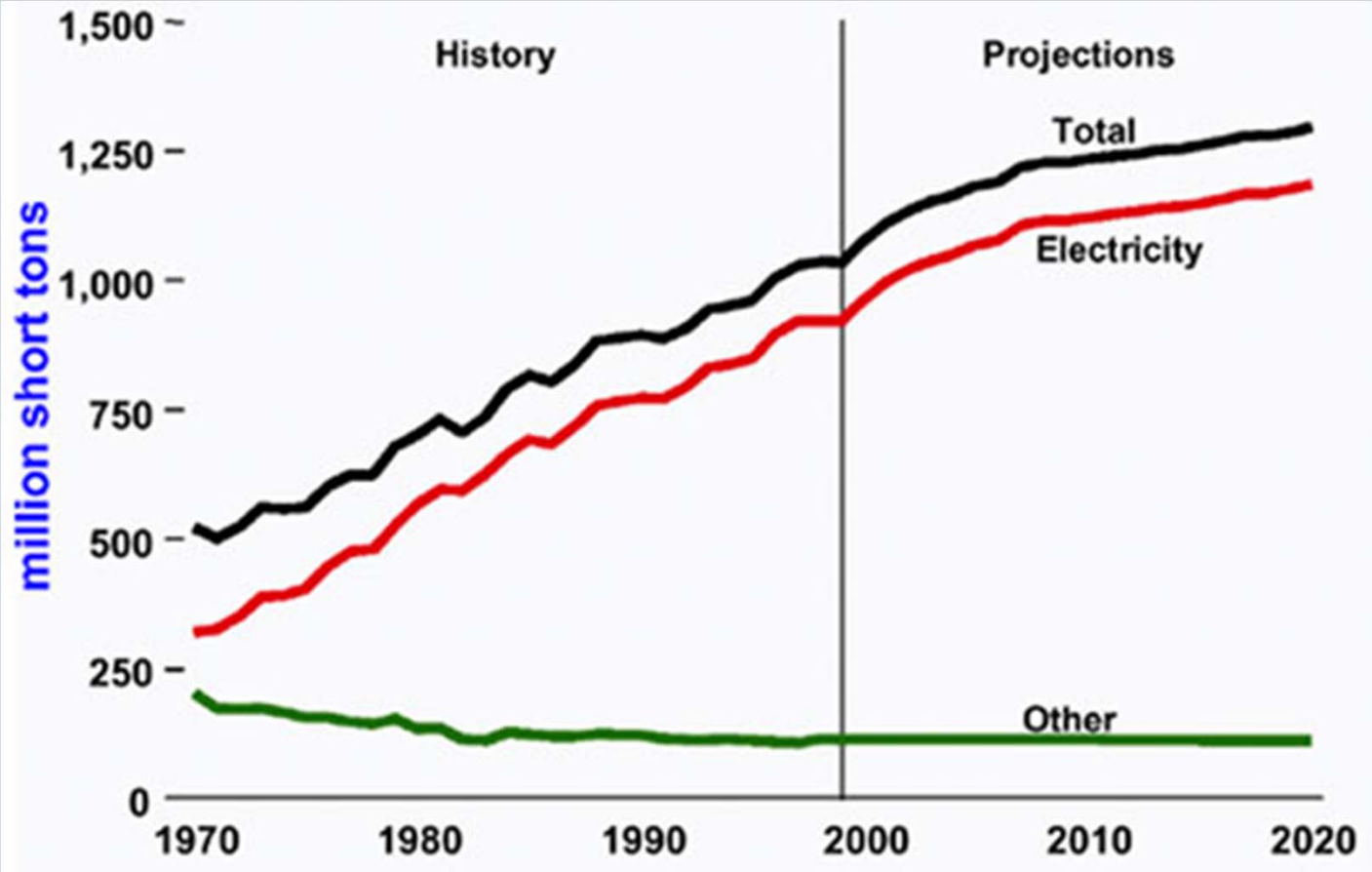
Electricity by source, 2006



(IEA, 2008)

Grand Challenge: Energy-Climate

Coal Use:



(EIA, 2010)

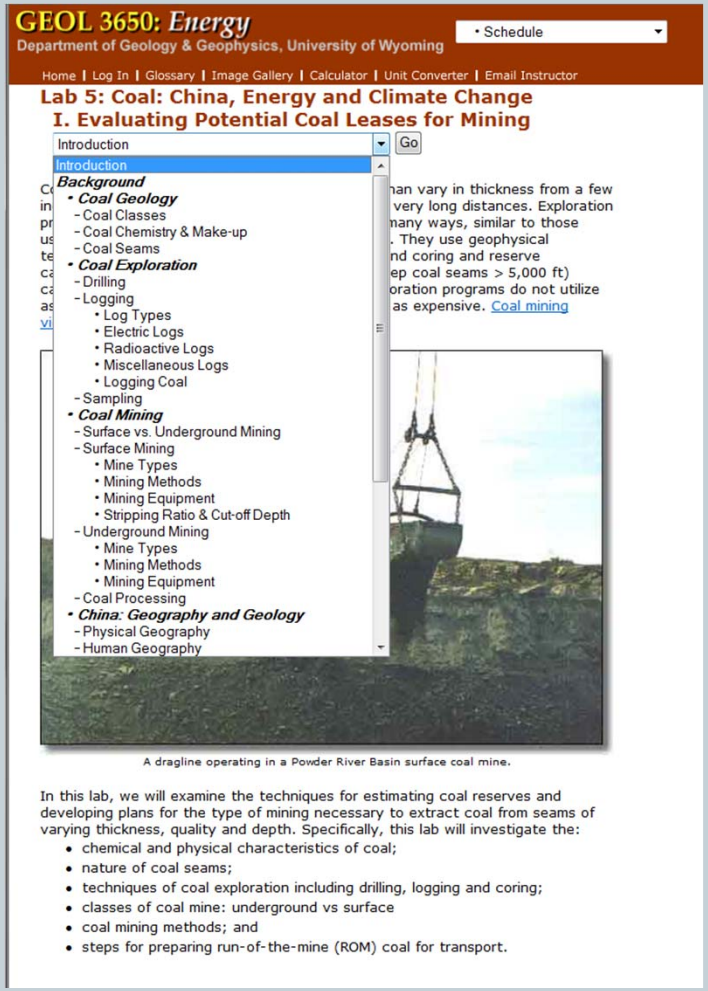
Module 1

Coal Exploration

Task

- investigates problem of ensuring coal supplies
  - exploration
  - evaluation
  - assessment
- done in groups
- done in one lab period
  - short follow-up next week for oral presentation
- assignments
  - oral presentation
  - written report

Background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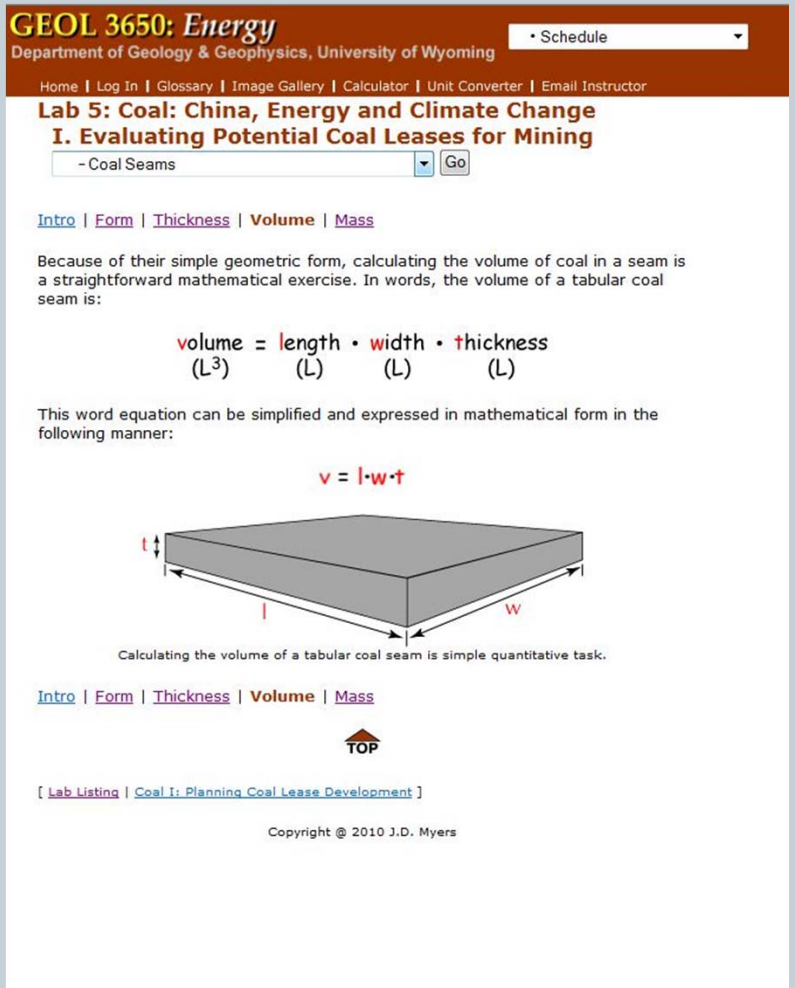
Lab 5: Coal: China, Energy and Climate Change
I. Evaluating Potential Coal Leases for Mining
Introduction
Go
Introduction
Background
• Coal Geology
- Coal Classes
- Coal Chemistry & Make-up
- Coal Seams
• Coal Exploration
- Drilling
- Logging
• Log Types
• Electric Logs
• Radioactive Logs
• Miscellaneous Logs
• Logging Coal
- Sampling
• Coal Mining
- Surface vs. Underground Mining
- Surface Mining
• Mine Types
• Mining Methods
• Mining Equipment
• Stripping Ratio & Cut-off Depth
- Underground Mining
• Mine Types
• Mining Methods
• Mining Equipment
- Coal Processing
• China: Geography and Geology
- Physical Geography
- Human Geography
A dragline operating in a Powder River Basin surface coal mine.
In this lab, we will examine the techniques for estimating coal reserves and developing plans for the type of mining necessary to extract coal from seams of varying thickness, quality and depth. Specifically, this lab will investigate the:
• chemical and physical characteristics of coal;
• nature of coal seams;
• techniques of coal exploration including drilling, logging and coring;
• classes of coal mine: underground vs surface
• coal mining methods; and
• steps for preparing run-of-the-mine (ROM) coal for transport.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Home | Log In | Glossary | Image Gallery | Calculator | Unit Converter | Email Instructor
Lab 5: Coal: China, Energy and Climate Change
I. Evaluating Potential Coal Leases for Mining
- Coal Seams
Go
Intro | Form | Thickness | Volume | Mass
Because of their simple geometric form, calculating the volume of coal in a seam is a straightforward mathematical exercise. In words, the volume of a tabular coal seam is:
volume = length • width • thickness
(L3) (L) (L) (L)
This word equation can be simplified and expressed in mathematical form in the following manner:
v = l•w•t
t
l
w
Calculating the volume of a tabular coal seam is simple quantitative task.
Intro | Form | Thickness | Volume | Mass
TOP
[Lab Listing | Coal I: Planning Coal Lease Development]
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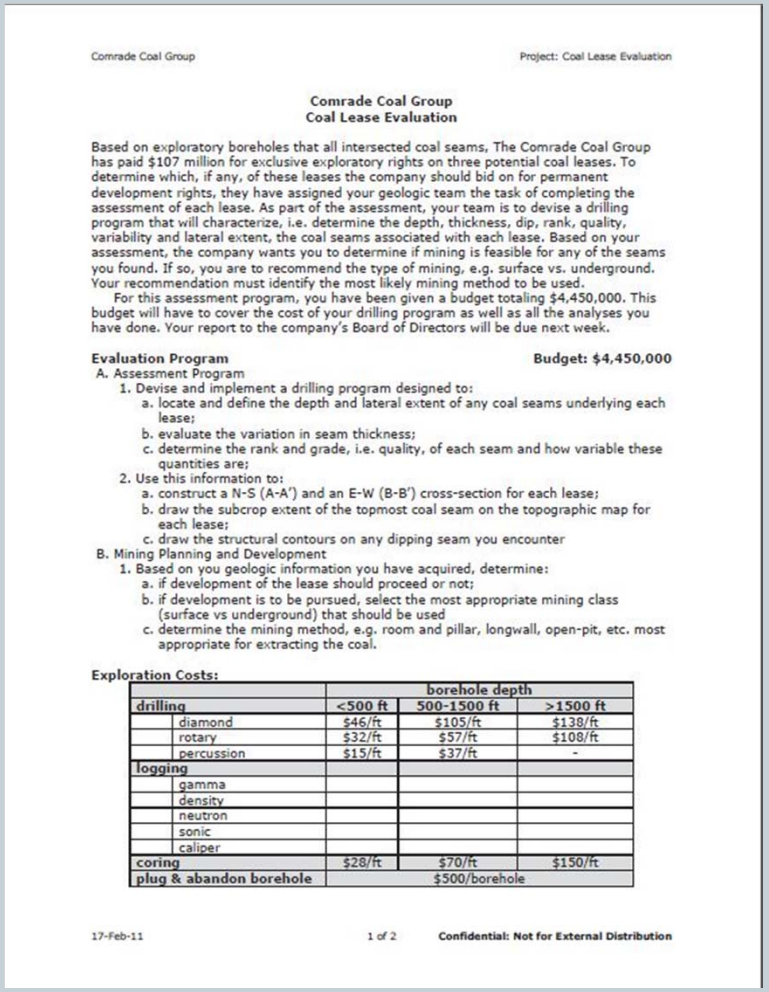
Drilling Program

- conduct drilling program to find coal seam(s)
- construct mental 3-D model by:
  - drawing cross-sections
  - defining lateral extent
  - drawing structural contour maps
- determine rank, quality, etc.
- recommend mine (y/n) and method



Comrade Coal Group
Coal Lease Evaluation

Based on exploratory boreholes that all intersected coal seams, The Comrade Coal Group has paid $107 million for exclusive exploratory rights on three potential coal leases. To determine which, if any, of these leases the company should bid on for permanent development rights, they have assigned your geologic team the task of completing the assessment of each lease. As part of the assessment, your team is to devise a drilling program that will characterize, i.e. determine the depth, thickness, dip, rank, quality, variability and lateral extent, the coal seams associated with each lease. Based on your assessment, the company wants you to determine if mining is feasible for any of the seams you found. If so, you are to recommend the type of mining, e.g. surface vs. underground. Your recommendation must identify the most likely mining method to be used.

For this assessment program, you have been given a budget totaling $4,450,000. This budget will have to cover the cost of your drilling program as well as all the analyses you have done. Your report to the company's Board of Directors will be due next week.

Evaluation Program **Budget: $4,450,000**

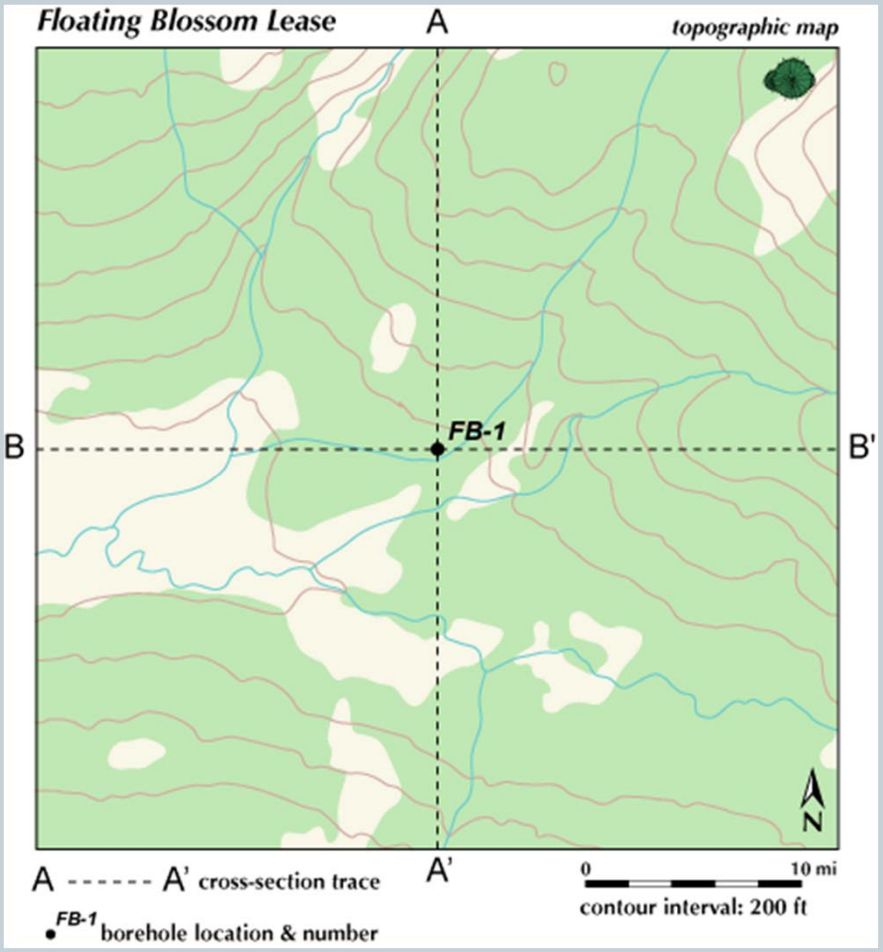
A. Assessment Program
1. Devise and implement a drilling program designed to:
   a. locate and define the depth and lateral extent of any coal seams underlying each lease;
   b. evaluate the variation in seam thickness;
   c. determine the rank and grade, i.e. quality, of each seam and how variable these quantities are;
2. Use this information to:
   a. construct a N-S (A-A') and an E-W (B-B') cross-section for each lease;
   b. draw the subcrop extent of the topmost coal seam on the topographic map for each lease;
   c. draw the structural contours on any dipping seam you encounter

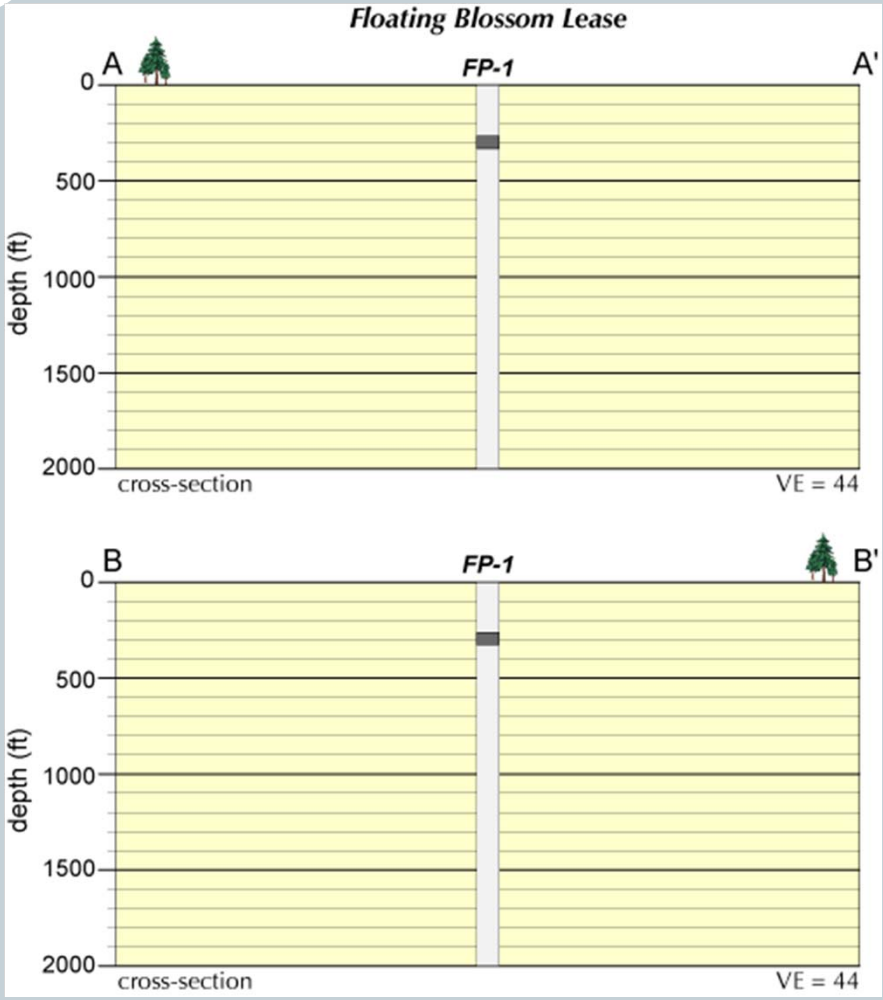
B. Mining Planning and Development
1. Based on you geologic information you have acquired, determine:
   a. if development of the lease should proceed or not;
   b. if development is to be pursued, select the most appropriate mining class (surface vs underground) that should be used
   c. determine the mining method, e.g. room and pillar, longwall, open-pit, etc. most appropriate for extracting the coal.

Exploration Costs:

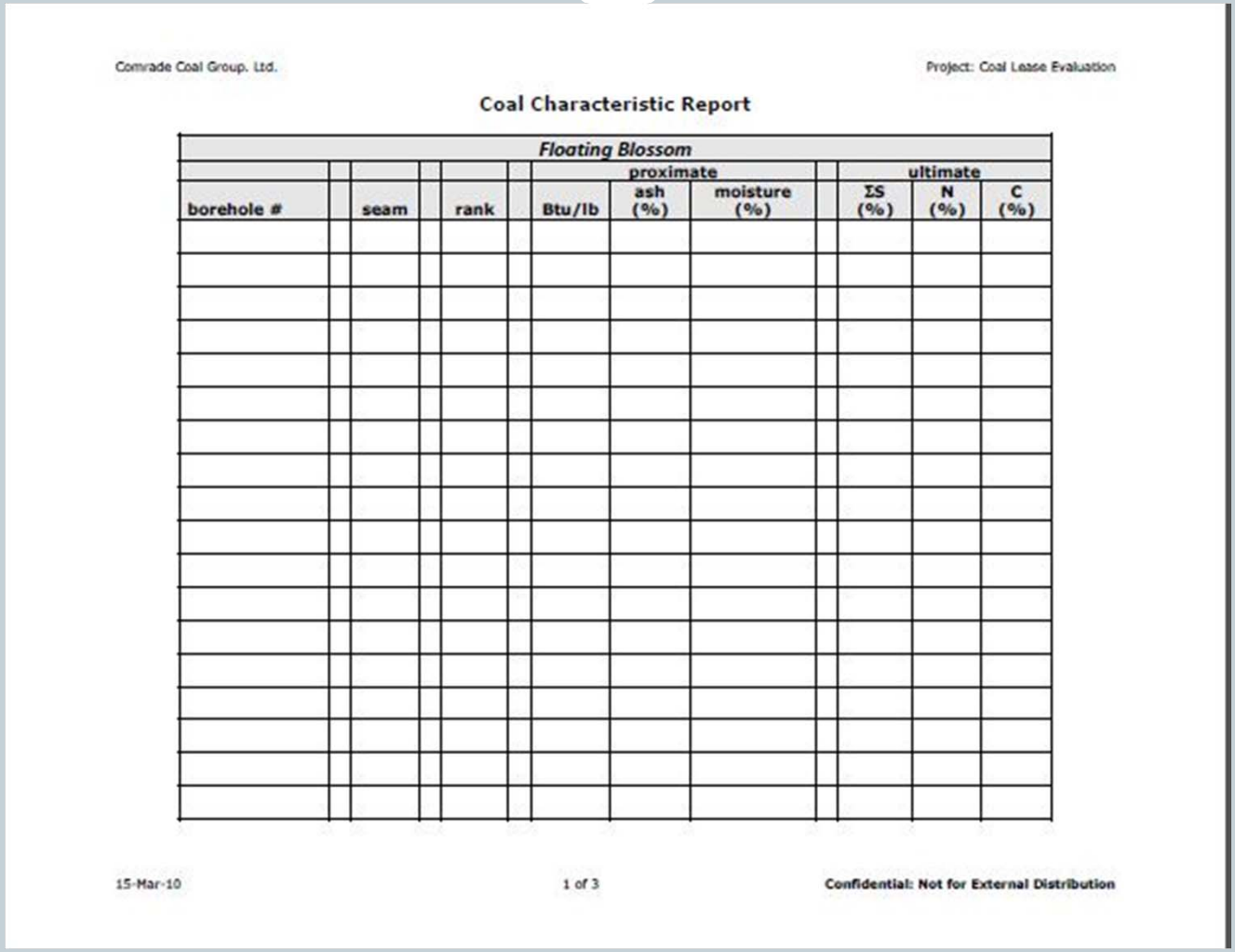
		borehole depth		
drilling		**<500 ft**	**500-1500 ft**	**>1500 ft**
	diamond	$46/ft	$105/ft	$138/ft
	rotary	$32/ft	$57/ft	$108/ft
	percussion	$15/ft	$37/ft	-
logging				
	gamma			
	density			
	neutron			
	sonic			
	caliper			
coring		$28/ft	$70/ft	$150/ft
plug & abandon borehole		$500/borehole		

3-D Mental Model





Evaluating Coal Value



Comrade Coal Group, Ltd.

Project: Coal Lease Evaluation

Coal Characteristic Report

Floating Blossom									
			proximate			ultimate			
borehole #	seam	rank	Btu/lb	ash (%)	moisture (%)	ΣS (%)	N (%)	C (%)

15-Mar-10

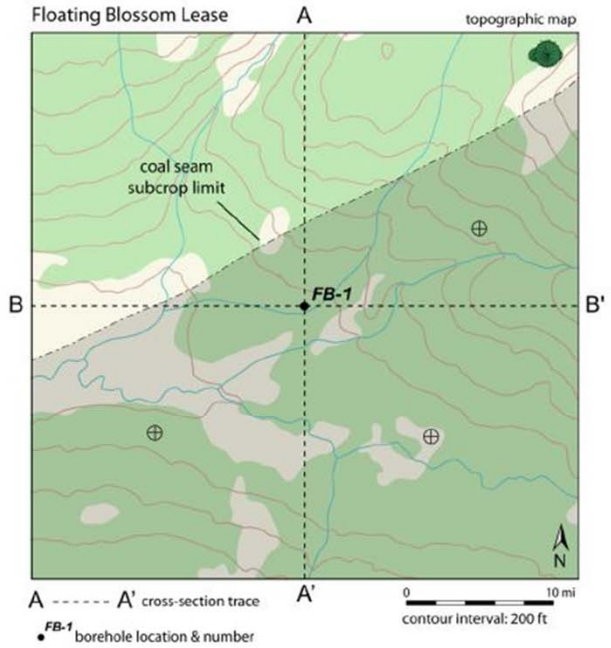
1 of 3

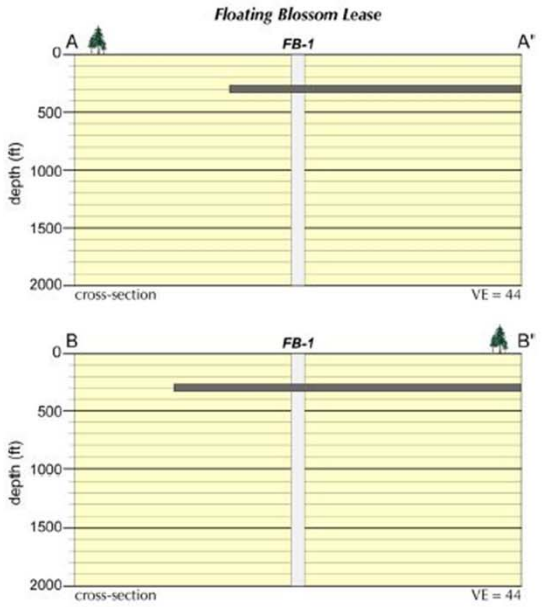
Confidential: Not for External Distribution

Instructor Feedback

Comrade Coal Group, Ltd.

Prospect: Coal Lease Evaluation: Geologic Maps, Cross-sections and Analyses





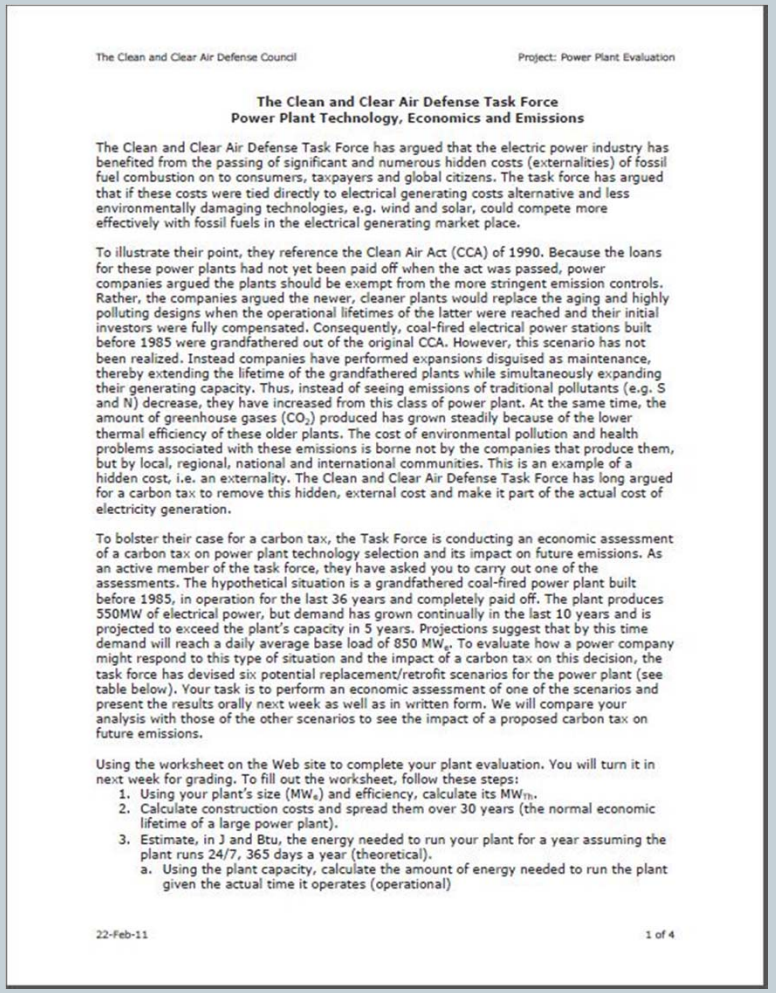
					proximate				ultimate		
lease		seam		rank	Btu/lb	ash (%)	moisture (%)		ΣS (%)	N (%)	C (%)
Floating Blossom				ant	13,950	1.0	6.5		3.2	1.5	93

Module 2

Generating Electricity

Tasks

- evaluate impact of carbon policy on power plant technology selection
  - business-as-usual (BAU)
  - $50/ton carbon tax
- technologies:
  - coal-fired: PC, SCPC, IGCC
  - natural gas combined cycle
  - nuclear (AP1000)
- energy, economics, policy



The Clean and Clear Air Defense Council — Project: Power Plant Evaluation

The Clean and Clear Air Defense Task Force
Power Plant Technology, Economics and Emissions

The Clean and Clear Air Defense Task Force has argued that the electric power industry has benefited from the passing of significant and numerous hidden costs (externalities) of fossil fuel combustion on to consumers, taxpayers and global citizens. The task force has argued that if these costs were tied directly to electrical generating costs alternative and less environmentally damaging technologies, e.g. wind and solar, could compete more effectively with fossil fuels in the electrical generating market place.

To illustrate their point, they reference the Clean Air Act (CCA) of 1990. Because the loans for these power plants had not yet been paid off when the act was passed, power companies argued the plants should be exempt from the more stringent emission controls. Rather, the companies argued the newer, cleaner plants would replace the aging and highly polluting designs when the operational lifetimes of the latter were reached and their initial investors were fully compensated. Consequently, coal-fired electrical power stations built before 1985 were grandfathered out of the original CCA. However, this scenario has not been realized. Instead companies have performed expansions disguised as maintenance, thereby extending the lifetime of the grandfathered plants while simultaneously expanding their generating capacity. Thus, instead of seeing emissions of traditional pollutants (e.g. S and N) decrease, they have increased from this class of power plant. At the same time, the amount of greenhouse gases (CO_2) produced has grown steadily because of the lower thermal efficiency of these older plants. The cost of environmental pollution and health problems associated with these emissions is borne not by the companies that produce them, but by local, regional, national and international communities. This is an example of a hidden cost, i.e. an externality. The Clean and Clear Air Defense Task Force has long argued for a carbon tax to remove this hidden, external cost and make it part of the actual cost of electricity generation.

To bolster their case for a carbon tax, the Task Force is conducting an economic assessment of a carbon tax on power plant technology selection and its impact on future emissions. As an active member of the task force, they have asked you to carry out one of the assessments. The hypothetical situation is a grandfathered coal-fired power plant built before 1985, in operation for the last 36 years and completely paid off. The plant produces 550MW of electrical power, but demand has grown continually in the last 10 years and is projected to exceed the plant's capacity in 5 years. Projections suggest that by this time demand will reach a daily average base load of 850 MW_e. To evaluate how a power company might respond to this type of situation and the impact of a carbon tax on this decision, the task force has devised six potential replacement/retrofit scenarios for the power plant (see table below). Your task is to perform an economic assessment of one of the scenarios and present the results orally next week as well as in written form. We will compare your analysis with those of the other scenarios to see the impact of a proposed carbon tax on future emissions.

Using the worksheet on the Web site to complete your plant evaluation. You will turn it in next week for grading. To fill out the worksheet, follow these steps:

1. Using your plant's size (MW_e) and efficiency, calculate its MW_{th}.
2. Calculate construction costs and spread them over 30 years (the normal economic lifetime of a large power plant).
3. Estimate, in J and Btu, the energy needed to run your plant for a year assuming the plant runs 24/7, 365 days a year (theoretical).
   a. Using the plant capacity, calculate the amount of energy needed to run the plant given the actual time it operates (operational)

22-Feb-11 — 1 of 4

Background

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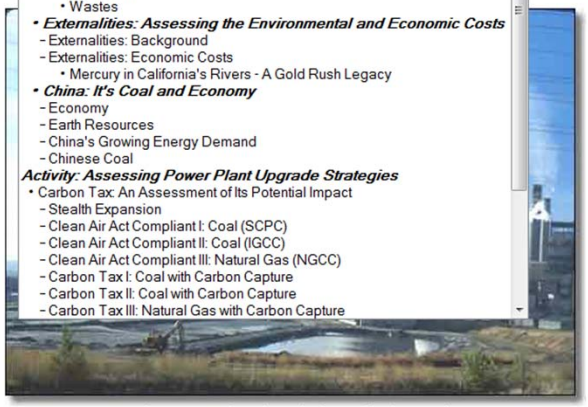
Coal: China, Energy and Climate Change
II. Coal Power Plants - Maintain, Retrofit or Replace?

Introduction | Go

Introduction
Background
- ***Electricity: The Energy of Modern Societies***
  - ***Generation***
    - Electricty Overview
    - Electicity Generation
    - Thermal Power Plant Designs
    - Other Power Plant Designs
  - ***Thermal Power Plant Inputs and Outputs***
    - Fuel Needs
    - Emissions
    - Wastes
- ***Externalities: Assessing the Environmental and Economic Costs***
  - Externalities: Background
  - Externalities: Economic Costs
    - Mercury in California's Rivers - A Gold Rush Legacy
- ***China: It's Coal and Economy***
  - Economy
  - Earth Resources
  - China's Growing Energy Demand
  - Chinese Coal

Activity: Assessing Power Plant Upgrade Strategies
- Carbon Tax: An Assessment of Its Potential Impact
  - Stealth Expansion
  - Clean Air Act Compliant I: Coal (SCPC)
  - Clean Air Act Compliant II: Coal (IGCC)
  - Clean Air Act Compliant III: Natural Gas (NGCC)
  - Carbon Tax I: Coal with Carbon Capture
  - Carbon Tax II: Coal with Carbon Capture
  - Carbon Tax III: Natural Gas with Carbon Capture



Cooling towers and smokestack of a coal-fired power plant.

This lab investigates the economic and environmental aspects of different types of coal-fired power plants and compares them to a nuclear plant. In particular, you will:

- examine the difference between MW_e and MW_{th};
- calculate the energy needed to power a plant for a year;
- determine the annual fuel needs of a variety of plant designs;
- access the annual fuel costs;
- evaluate the carbon dioxide and sulfur emissions of the different plants; and
- assess the impact of a carbon tax on power plant design.

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Coal: China, Energy and Climate Change
II. Coal Power Plants - Maintain, Retrofit or Replace?

• Electicity Generation | Go

Intro | Overview | Prime Mover | Turbine | Generator | Energy Conversions

In slightly over a century, electricity has transformed life in the United States as well as around the world and become a fundamental requirement for modern life. Lighting, refrigeration, electric motors, medical technologies, computers and mass communication are all dependent upon the availability of abundant electricity. It is a versatile and controllable form of energy that can perform many tasks efficiently. A kilowatt-hour of electricity can light a 100-watt light bulb for 100 hours, lift a ton of material a thousand feet, smelt enough aluminum for a six pack of soda or heat water for a few minutes' shower. In addition, electricity is one of the few forms of energy that can be generated in one place and used thousands of miles away.

Steam turbines and generators in a coal-fired power plant.

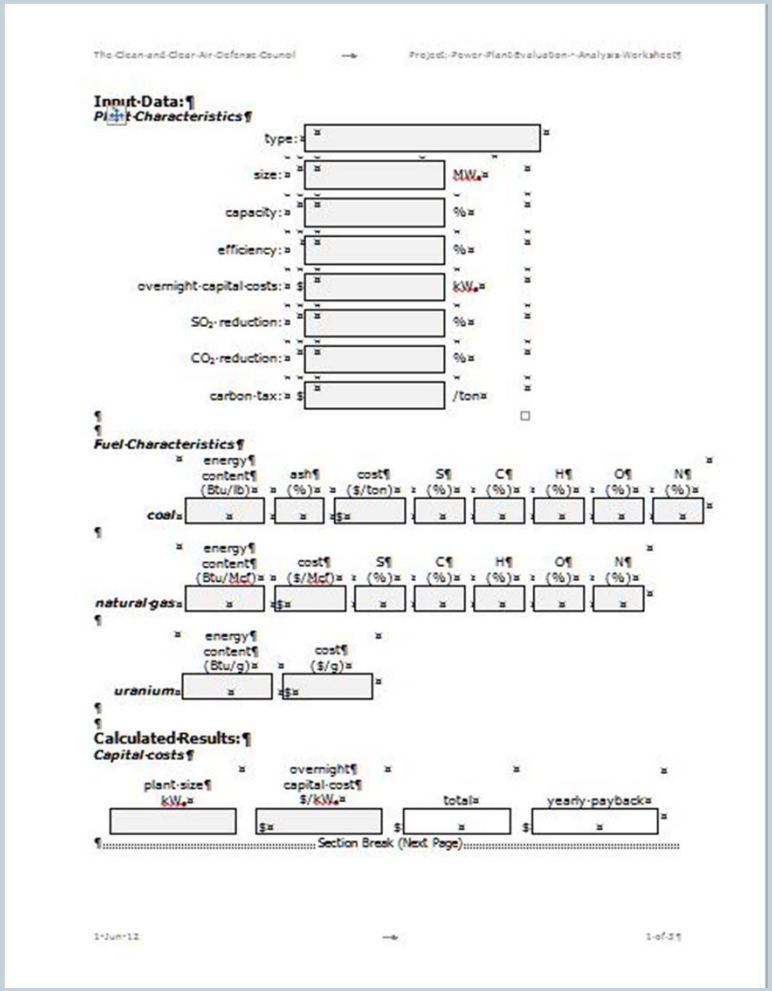
The importance of electricity in American life is reflected in the fact that it is a $170 billion a year business. Yet, providing for our ever increasing electrical needs is a formidable task. A large (1 gigawatt) power plant costs more than $1 billion to build and requires many years of planning to obtain regulatory and environmental permits. Clearly, an understanding of how electricity is generated and its impact on Earth resources is important.

Intro | Overview | Prime Mover | Turbine | Generator | Energy Conversions

TOP

Quantities Calculated

- fossil fuel options evaluated with and without carbon capture
- calculate:
  - overnight costs
  - MW_e – MW_{Th}
  - energy needs
  - fuel needs & costs
  - SO_2 and CO_2 emissions
- compare results from all technologies



Results

Plant Costs

	size (MW_e)	efficiency (%)	size (MW_{Th})	construction cost	payback ($/yr)
Stealth	300	36	833	$330,000,000	$11,000,000
SCPC					
w/o CC	850				
w/ CC	850				
IGCC					
w/o CC	850				
w/ CC	850				
NGCC					
w/o CC	850				
w/ CC	850				
AP1000	850				

CO_2

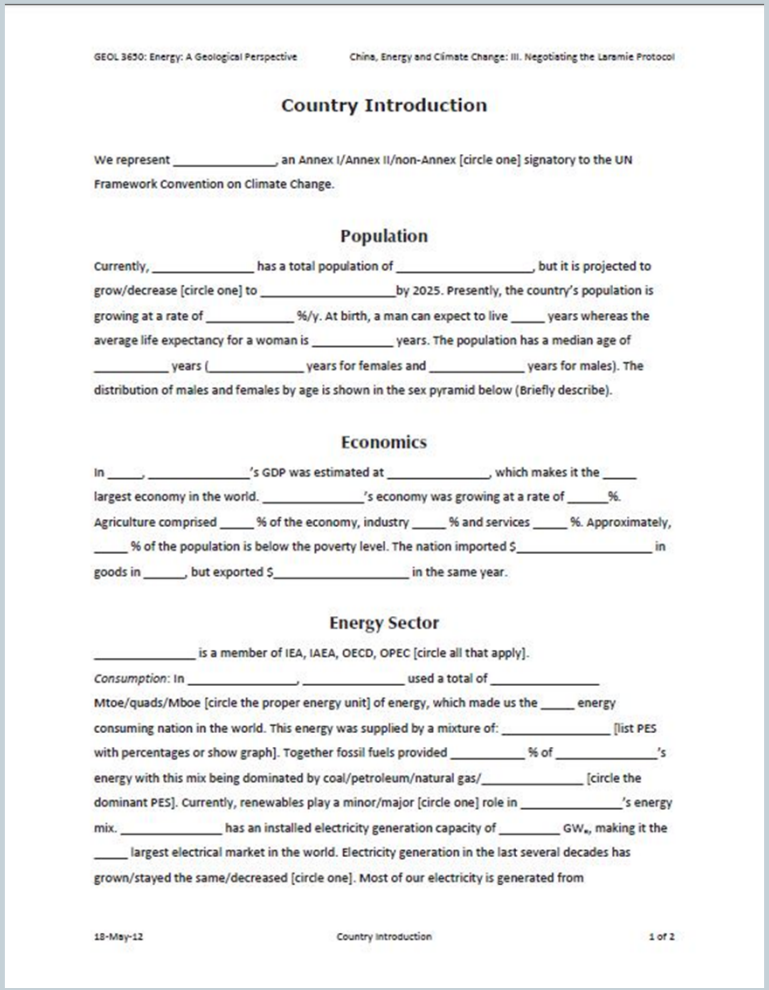
	produced		emitted		
	year (ton)	lifetime (ton)	year (ton)	lifetime (ton)	carbon tax (y^{-1})
Stealth	10,338,000	310,150,000	10,338,000	310,150,000	-
SCPC					
w/o CC	8,753,500	262,610,000	8,753,500	262,610,000	-
w/ CC	11,502,000	345,060,000	1,150,200	34,506,000	57,510,401
IGCC					
w/o CC	7,801,200	234,040,000	7,801,200	234,040,000	-
w/ CC	9,628,900	288,870,000	962,890	2,888,700	48,144,421
NGCC					
w/o CC	630,650	18,919,510	630,650	18,919,510	-
w/ CC	837,019	25,110,563	83,702	2,511,056	$4,185,094
AP1000	-	-	-	-	-

Module 3

Preparation for COP Meeting

Purpose

- introduce students to UNFCCC and its protocols
- countries:
  - Brazil
  - China
  - Indonesia
  - Norway
  - Saudi Arabia
  - United States
- prepares students for role in COP



GEOL 3650: Energy: A Geological Perspective China, Energy and Climate Change: III. Negotiating the Laramie Protocol

Country Introduction

We represent _____, an Annex I/Annex II/non-Annex [circle one] signatory to the UN Framework Convention on Climate Change.

Population

Currently, _____ has a total population of _____, but it is projected to grow/decrease [circle one] to _____by 2025. Presently, the country's population is growing at a rate of _____ %/y. At birth, a man can expect to live _____ years whereas the average life expectancy for a woman is _____ years. The population has a median age of _____ years (_____ years for females and _____ years for males). The distribution of males and females by age is shown in the sex pyramid below (Briefly describe).

Economics

In _____, _____'s GDP was estimated at _____, which makes it the _____ largest economy in the world. _____'s economy was growing at a rate of _____%. Agriculture comprised _____ % of the economy, industry _____ % and services _____ %. Approximately, _____ % of the population is below the poverty level. The nation imported $_____ in goods in _____, but exported $_____ in the same year.

Energy Sector

_____ is a member of IEA, IAEA, OECD, OPEC [circle all that apply].

Consumption: In _____, _____ used a total of _____ Mtoe/quads/Mboe [circle the proper energy unit] of energy, which made us the _____ energy consuming nation in the world. This energy was supplied by a mixture of: _____ [list PES with percentages or show graph]. Together fossil fuels provided _____ % of _____'s energy with this mix being dominated by coal/petroleum/natural gas/_____ [circle the dominant PES]. Currently, renewables play a minor/major [circle one] role in _____'s energy mix. _____ has an installed electricity generation capacity of _____ GW_e, making it the _____ largest electrical market in the world. Electricity generation in the last several decades has grown/stayed the same/decreased [circle one]. Most of our electricity is generated from

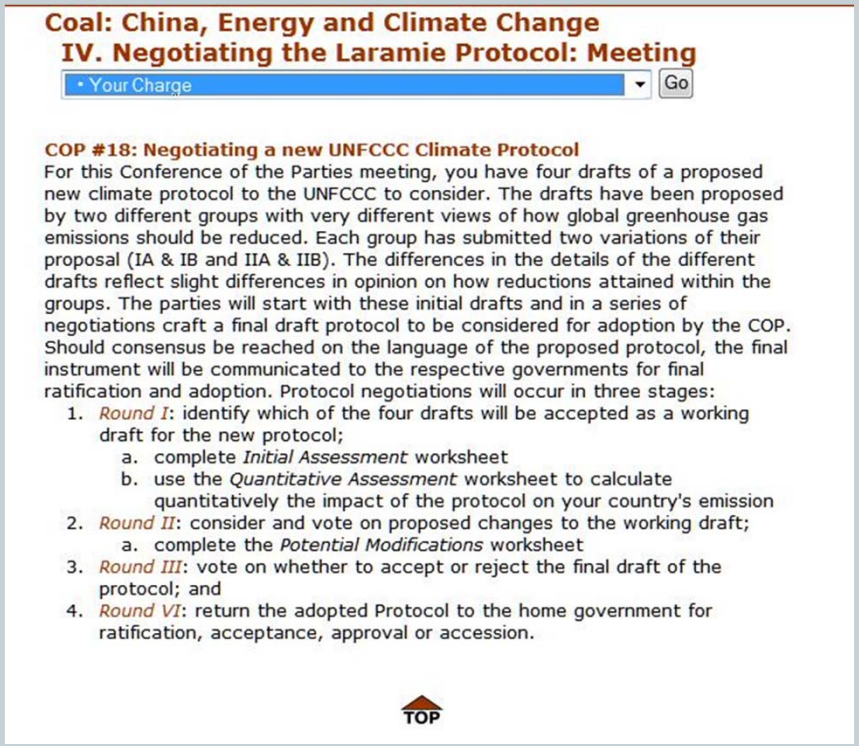
18-May-12 Country Introduction 1 of 2

Module 4

Negotiating a New UNFCCC Climate Protocol

Module 4: Laramie Protocol

- focus:
  - UNFCCC
  - UNFCCC protocols
  - Kyoto
  - IPCC
- *Conference of the Parties*
- simulates the negotiation process
  - several rounds
  - debate
  - vote
  - ratification



Coal: China, Energy and Climate Change
IV. Negotiating the Laramie Protocol: Meeting

• Your Charge Go

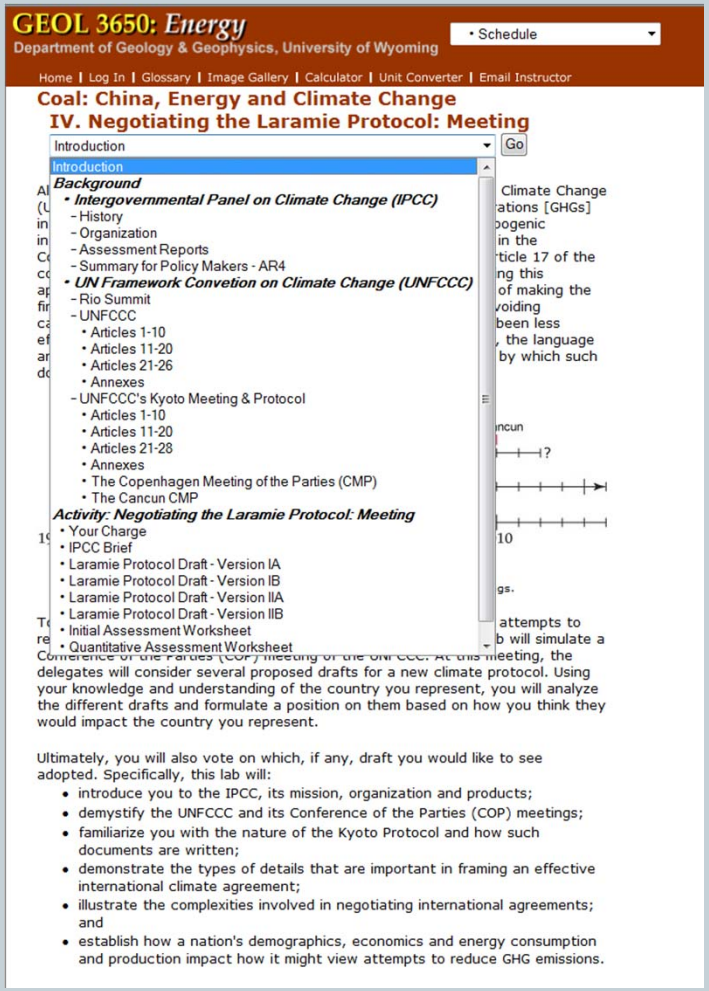
COP #18: Negotiating a new UNFCCC Climate Protocol

For this Conference of the Parties meeting, you have four drafts of a proposed new climate protocol to the UNFCCC to consider. The drafts have been proposed by two different groups with very different views of how global greenhouse gas emissions should be reduced. Each group has submitted two variations of their proposal (IA & IB and IIA & IIB). The differences in the details of the different drafts reflect slight differences in opinion on how reductions attained within the groups. The parties will start with these initial drafts and in a series of negotiations craft a final draft protocol to be considered for adoption by the COP. Should consensus be reached on the language of the proposed protocol, the final instrument will be communicated to the respective governments for final ratification and adoption. Protocol negotiations will occur in three stages:

1. *Round I*: identify which of the four drafts will be accepted as a working draft for the new protocol;
   a. complete *Initial Assessment* worksheet
   b. use the *Quantitative Assessment* worksheet to calculate quantitatively the impact of the protocol on your country's emission
2. *Round II*: consider and vote on proposed changes to the working draft;
   a. complete the *Potential Modifications* worksheet
3. *Round III*: vote on whether to accept or reject the final draft of the protocol; and
4. *Round VI*: return the adopted Protocol to the home government for ratification, acceptance, approval or accession.

TOP

Background


GEOL 3650: Energy
Department of Geology & Geophysics, University of Wyoming
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Coal: China, Energy and Climate Change
IV. Negotiating the Laramie Protocol: Meeting
Introduction
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Introduction
Background
• Intergovernmental Panel on Climate Change (IPCC)
- History
- Organization
- Assessment Reports
- Summary for Policy Makers - AR4
• UN Framework Convetion on Climate Change (UNFCCC)
- Rio Summit
- UNFCCC
• Articles 1-10
• Articles 11-20
• Articles 21-26
• Annexes
- UNFCCC's Kyoto Meeting & Protocol
• Articles 1-10
• Articles 11-20
• Articles 21-28
• Annexes
• The Copenhagen Meeting of the Parties (CMP)
• The Cancun CMP
Activity: Negotiating the Laramie Protocol: Meeting
• Your Charge
• IPCC Brief
• Laramie Protocol Draft - Version IA
• Laramie Protocol Draft - Version IB
• Laramie Protocol Draft - Version IIA
• Laramie Protocol Draft - Version IIB
• Initial Assessment Worksheet
• Quantitative Assessment Worksheet
Climate Change
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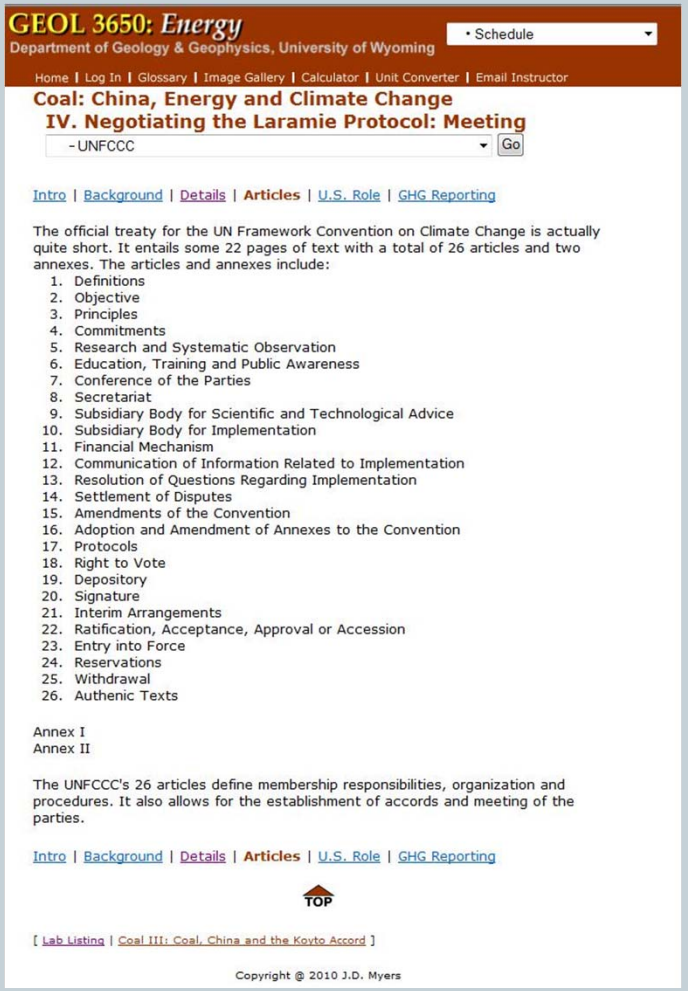
attempts to
b will simulate a
meeting, the
delegates will consider several proposed drafts for a new climate protocol. Using your knowledge and understanding of the country you represent, you will analyze the different drafts and formulate a position on them based on how you think they would impact the country you represent.
Ultimately, you will also vote on which, if any, draft you would like to see adopted. Specifically, this lab will:
• introduce you to the IPCC, its mission, organization and products;
• demystify the UNFCCC and its Conference of the Parties (COP) meetings;
• familiarize you with the nature of the Kyoto Protocol and how such documents are written;
• demonstrate the types of details that are important in framing an effective international climate agreement;
• illustrate the complexities involved in negotiating international agreements; and
• establish how a nation's demographics, economics and energy consumption and production impact how it might view attempts to reduce GHG emissions.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- UNFCCC
Go
Intro | Background | Details | Articles | U.S. Role | GHG Reporting
The official treaty for the UN Framework Convention on Climate Change is actually quite short. It entails some 22 pages of text with a total of 26 articles and two annexes. The articles and annexes include:
1. Definitions
2. Objective
3. Principles
4. Commitments
5. Research and Systematic Observation
6. Education, Training and Public Awareness
7. Conference of the Parties
8. Secretariat
9. Subsidiary Body for Scientific and Technological Advice
10. Subsidiary Body for Implementation
11. Financial Mechanism
12. Communication of Information Related to Implementation
13. Resolution of Questions Regarding Implementation
14. Settlement of Disputes
15. Amendments of the Convention
16. Adoption and Amendment of Annexes to the Convention
17. Protocols
18. Right to Vote
19. Depository
20. Signature
21. Interim Arrangements
22. Ratification, Acceptance, Approval or Accession
23. Entry into Force
24. Reservations
25. Withdrawal
26. Authenic Texts
Annex I
Annex II
The UNFCCC's 26 articles define membership responsibilities, organization and procedures. It also allows for the establishment of accords and meeting of the parties.
Intro | Background | Details | Articles | U.S. Role | GHG Reporting
TOP
[Lab Listing | Coal III: Coal, China and the Koyto Accord]
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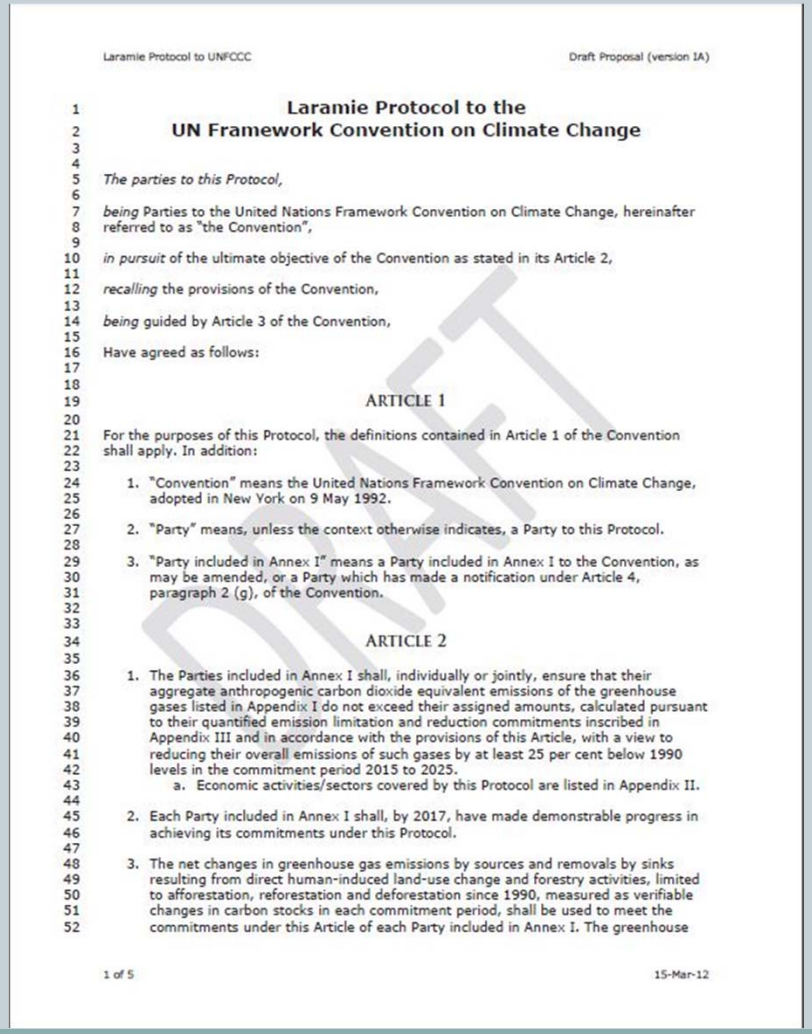
Module 4: Laramie Protocol



Laramie Protocol to UNFCCC Draft Proposal (version IA)

Laramie Protocol to the UN Framework Convention on Climate Change

The parties to this Protocol,

being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as "the Convention",

in pursuit of the ultimate objective of the Convention as stated in its Article 2,

recalling the provisions of the Convention,

being guided by Article 3 of the Convention,

Have agreed as follows:

ARTICLE 1

For the purposes of this Protocol, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. "Convention" means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.
2. "Party" means, unless the context otherwise indicates, a Party to this Protocol.
3. "Party included in Annex I" means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2 (g), of the Convention.

ARTICLE 2

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Appendix I do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Appendix III and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 25 per cent below 1990 levels in the commitment period 2015 to 2025.
    a. Economic activities/sectors covered by this Protocol are listed in Appendix II.
2. Each Party included in Annex I shall, by 2017, have made demonstrable progress in achieving its commitments under this Protocol.
3. The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse

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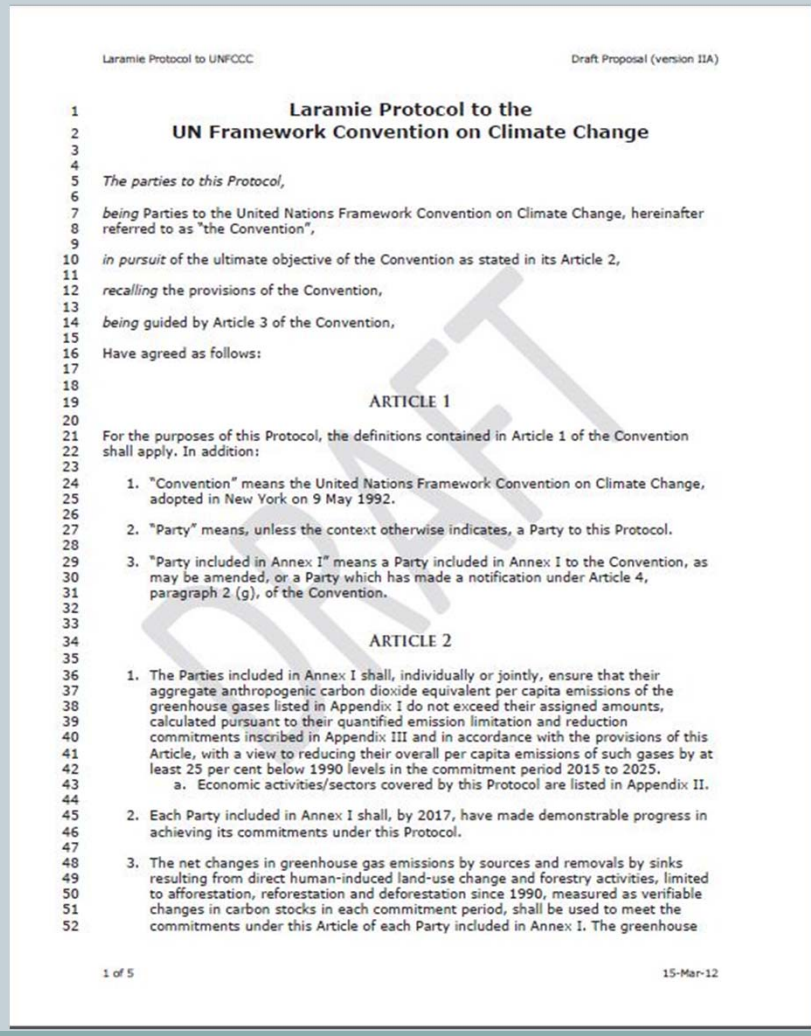

Laramie Protocol to UNFCCC Draft Proposal (version IIA)

Laramie Protocol to the UN Framework Convention on Climate Change

The parties to this Protocol,

being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as "the Convention",

in pursuit of the ultimate objective of the Convention as stated in its Article 2,

recalling the provisions of the Convention,

being guided by Article 3 of the Convention,

Have agreed as follows:

ARTICLE 1

For the purposes of this Protocol, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. "Convention" means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.
2. "Party" means, unless the context otherwise indicates, a Party to this Protocol.
3. "Party included in Annex I" means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2 (g), of the Convention.

ARTICLE 2

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent per capita emissions of the greenhouse gases listed in Appendix I do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Appendix III and in accordance with the provisions of this Article, with a view to reducing their overall per capita emissions of such gases by at least 25 per cent below 1990 levels in the commitment period 2015 to 2025.
    a. Economic activities/sectors covered by this Protocol are listed in Appendix II.
2. Each Party included in Annex I shall, by 2017, have made demonstrable progress in achieving its commitments under this Protocol.
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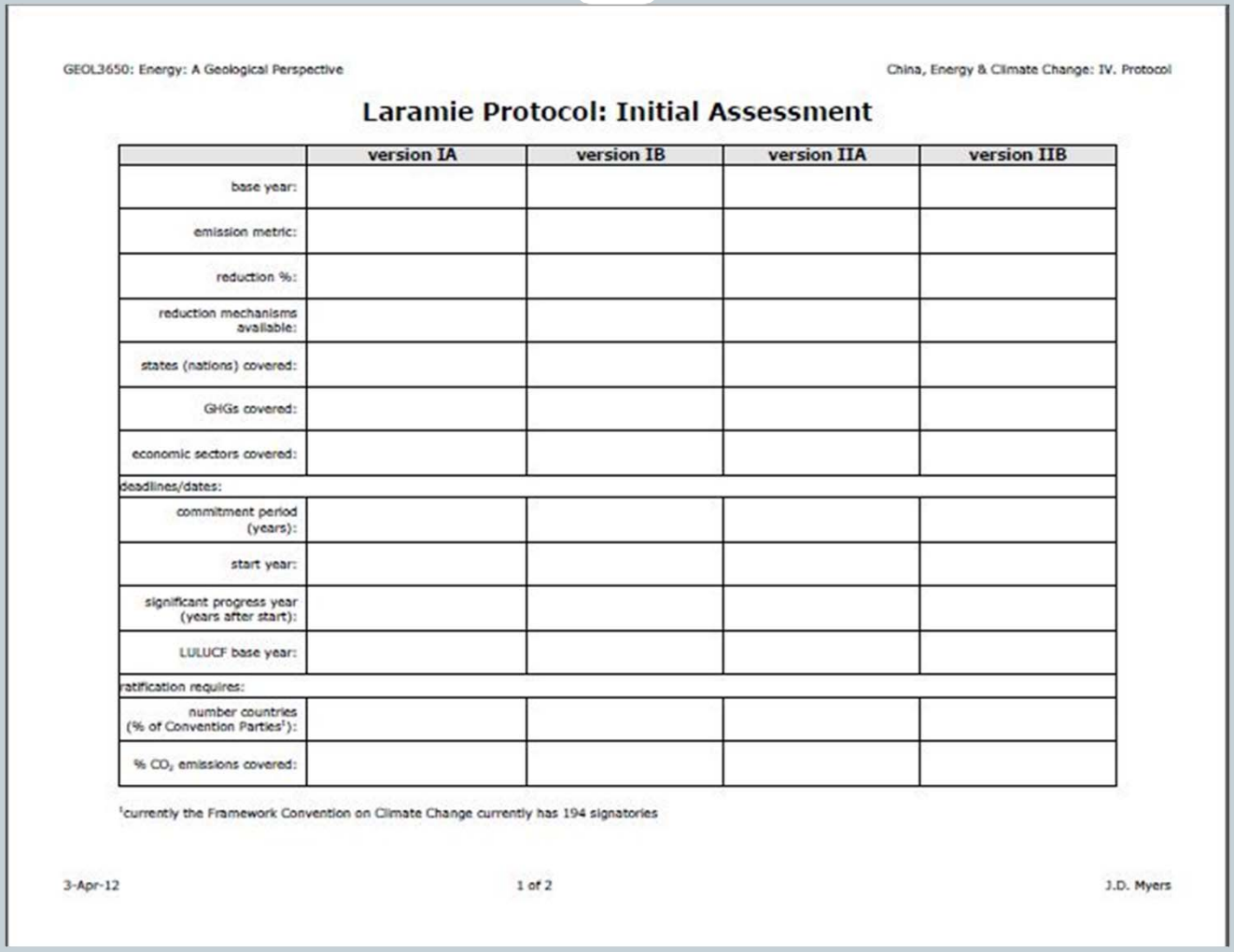
Module 4: Laramie Protocol



GEOL3650: Energy: A Geological Perspective — China, Energy & Climate Change: IV. Protocol

Laramie Protocol: Initial Assessment

	version IA	version IB	version IIA	version IIB
base year:				
emission metric:				
reduction %:				
reduction mechanisms available:				
states (nations) covered:				
GHGs covered:				
economic sectors covered:				
deadlines/dates:				
commitment period (years):				
start year:				
significant progress year (years after start):				
LULUCF base year:				
ratification requires:				
number countries (% of Convention Parties[1]):				
% CO_2 emissions covered:				

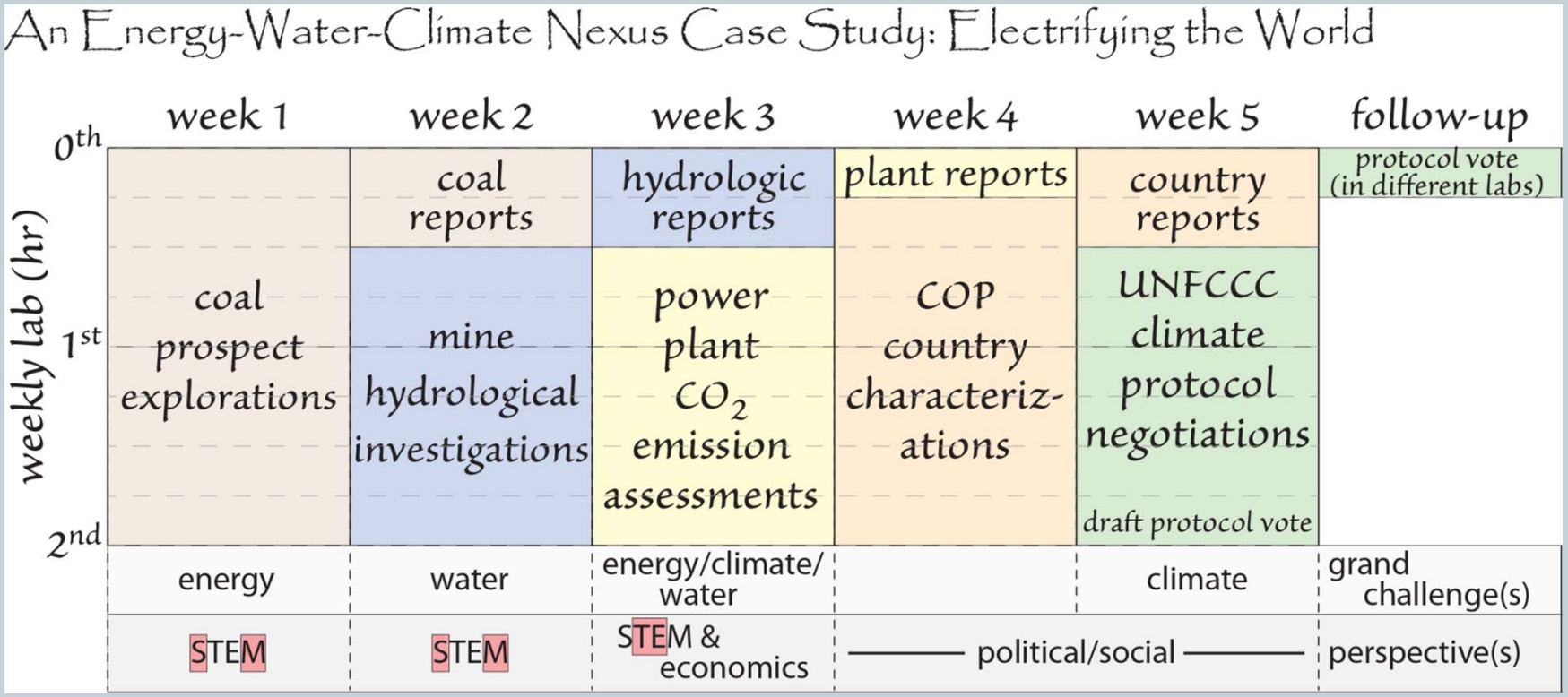
[1]currently the Framework Convention on Climate Change currently has 194 signatories

3-Apr-12 — 1 of 2 — J.D. Myers

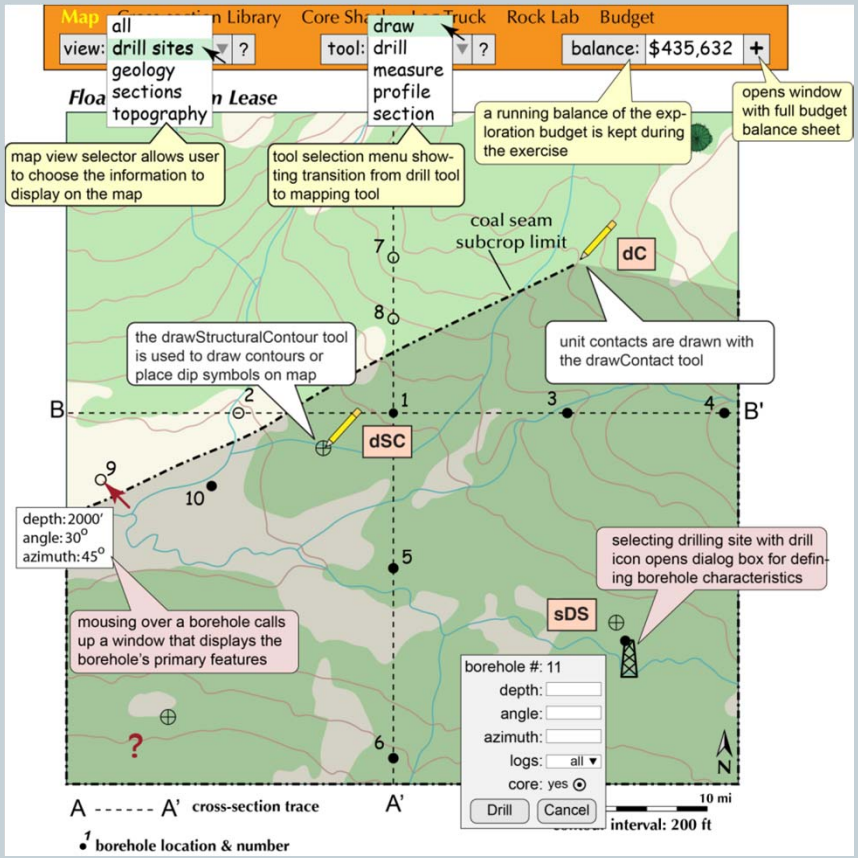
Next Steps

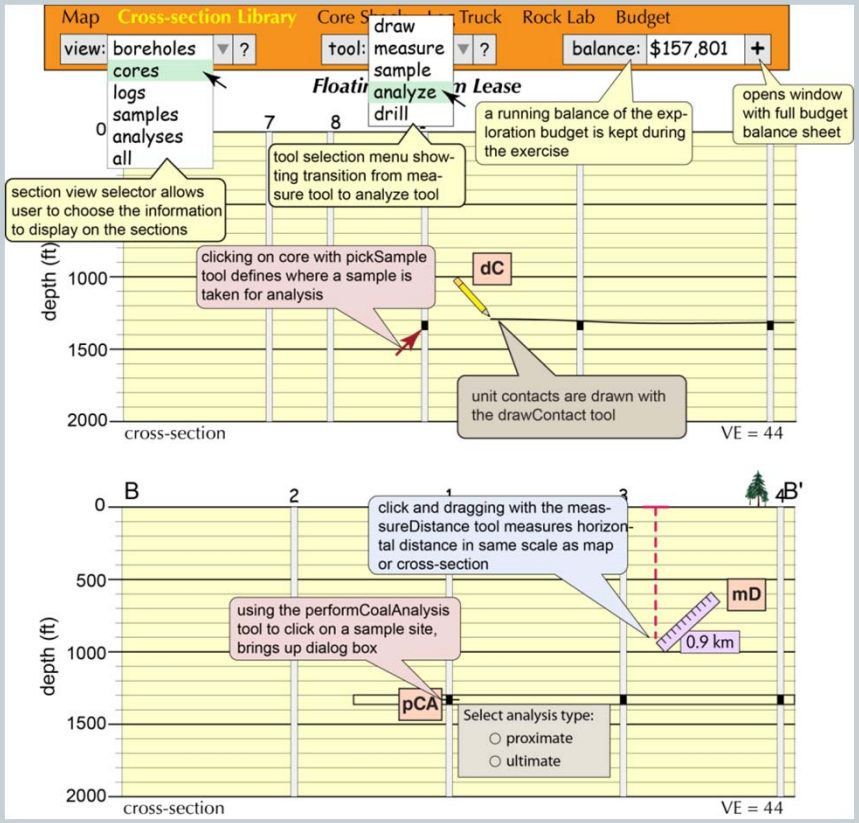
- addition of another module on water and mining
- conversion of coal and water to computer – dynamic digital case study
  - melding of visualization and simulation with inquiry learning of case studies
- modification power plant technology module to include water demand
- use of forms to collect data in real time for module 3 (new) and 4

Water Module



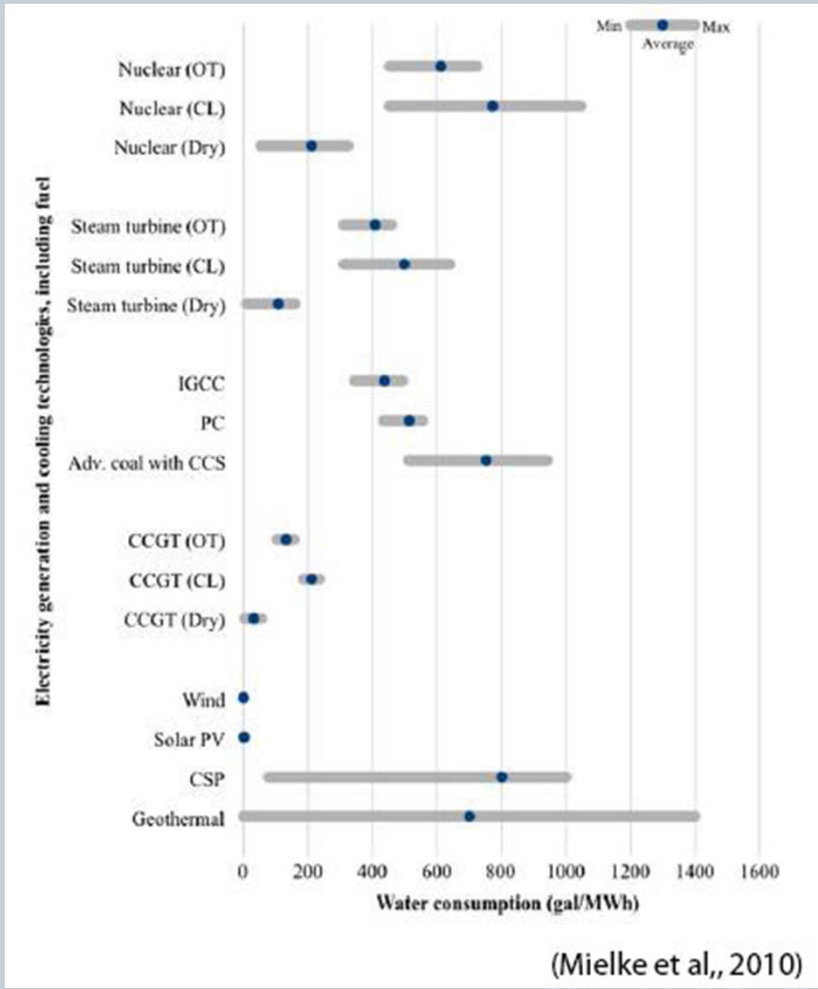
Dynamic Digital Case Studies (DDCS)





Water Demand

- electricity production is closely tied to water
- different demands for different technologies
  - nuclear power plants shut down because of drought or water too hot
- will look at how water demand can limit technological choices
  - must be balanced with all other variables



(Mielke et al,, 2010)

Automating Data Collection

- for modules 3 & 4, need to collect data students either calculate (3) or acquire (4)
  - used for whole lab discussion
- currently, done manually
  - students fill in overhead; or
  - complete sheet and read it
- both are time consuming and use valuable discussion time
- automate this collection so more time on discussion
  - Google forms
  - Acrobat X forms

Summary

- case study focused on grand challenges of:
  - energy
  - water
  - climate
- resource focus: coal
- perspectives: science, engineering, technology, mathematics, economics, policy, politics, international agreements
- done at UW as integrated sequence to emphasize interconnectedness
  - each module can be done as standalone case study
- url: http://www.gg.uwyo.edu/geol3650 (lab schedule)