Climate Management 101:
Complex problems with no known solutions

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Link to PDF of this presentation

Rood contact information

- University of Michigan Web Page (Addresses, etc.)
- Class Website // Lectures --- Climate Change: The Move to Action

- Rood Blogs at wunderground.com
- Organized subsets of wunderground.com blogs

- climatepolicy.org blogs
- Organized subsets of climatepolicy.org blogs

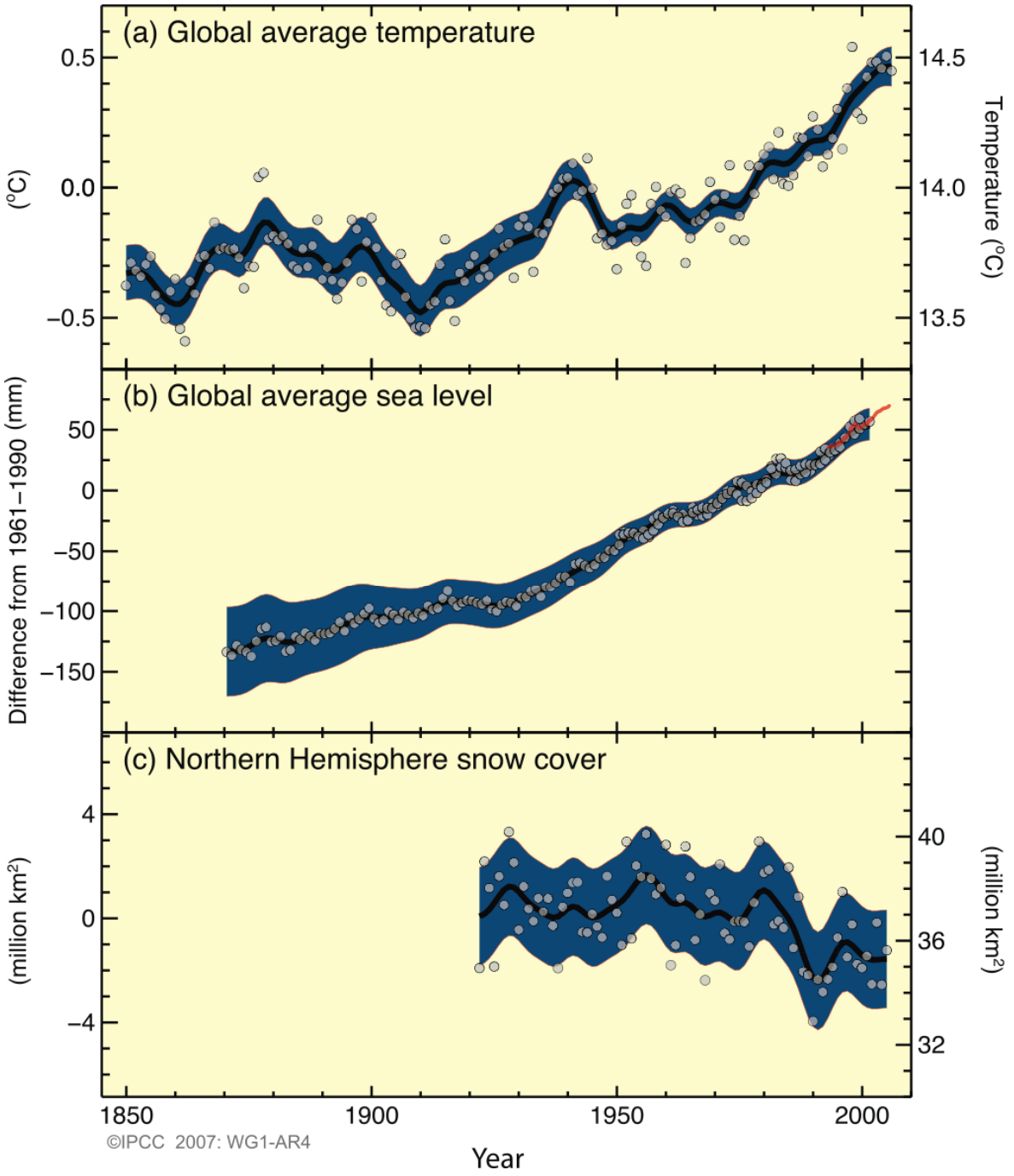
Outline

- The results of scientific investigation
- Mitigation and adaptation
- Unique opportunity and responsibility
- The pursuit of policy
- The need to do something soon
- Climate change and energy
- Human resistance to change
- The role of uncertainty in development of policy
- Relationship of climate change to consumption and population
- The need for climate management
- Things that are clear: Conclusions

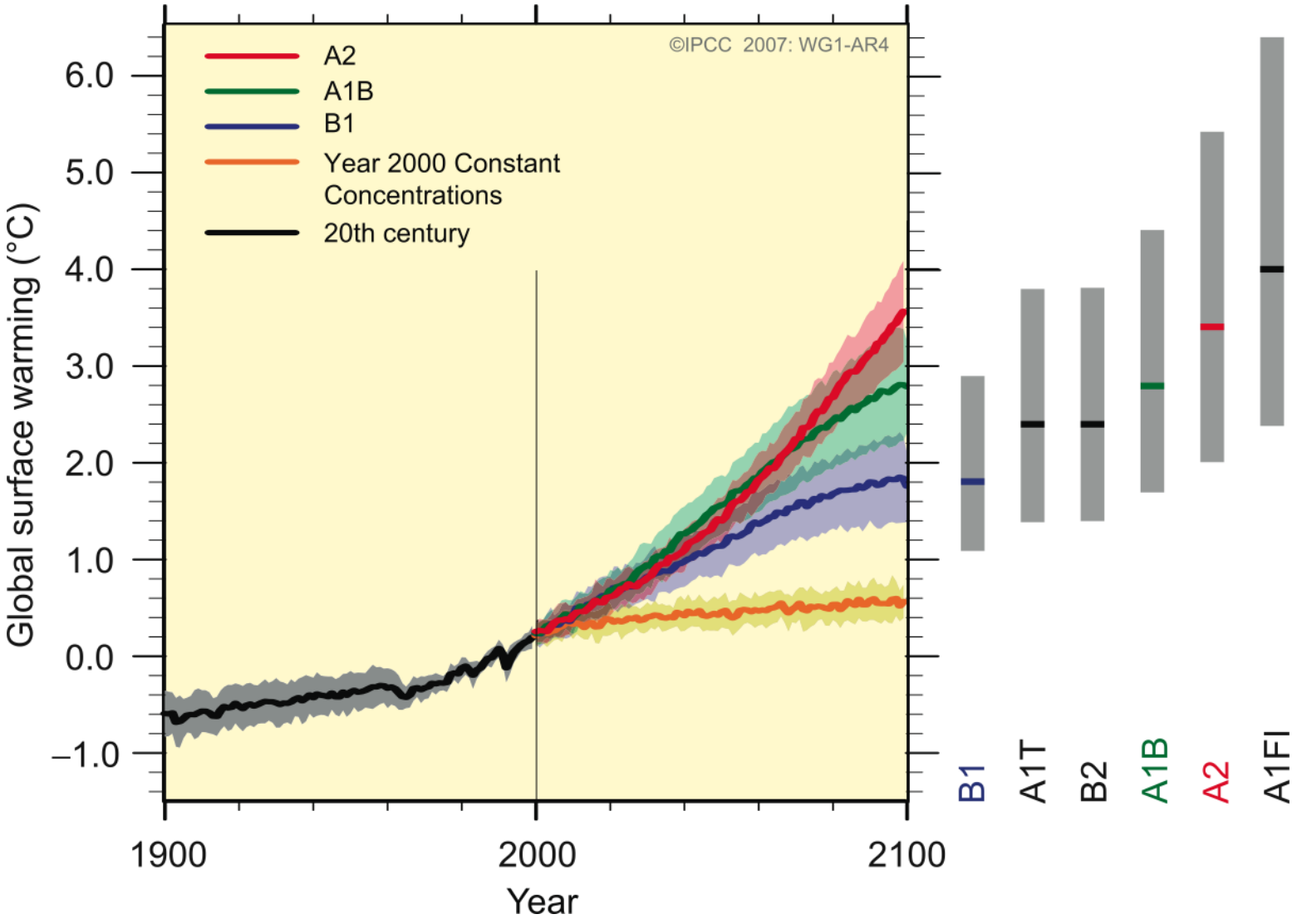
Scientific Investigation

- Scientific investigation has demonstrated that:
  - The surface Earth is warming
  - A primary cause of the Earth warming is due to the activities of humans
    - Combustion of oil, natural gas, and coal release greenhouse gases into the atmosphere
      - Holds heat close to the surface like a blanket
    - Other greenhouse gases
    - Changes in the characteristics of the Earth's surface
  - The Earth will
    - warm more in the coming decades and century
    - the warming will be rapid

IPCC: The last ~100 years



IPCC projections for the next 100 years.



Scientific Investigation

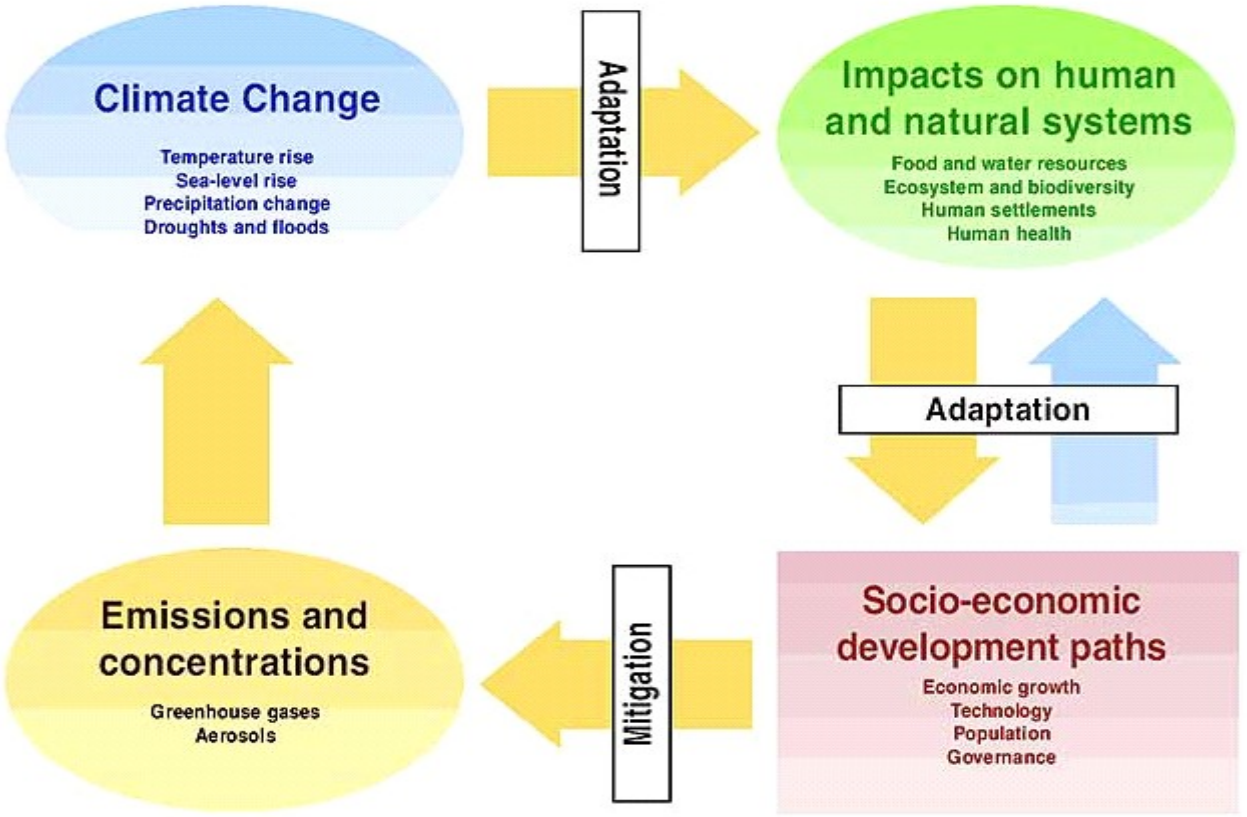
- With significant certainty we can say
  - The Earth will get warmer
  - Sea level will rise
  - The weather will change
    - The distribution and storage of water will change

The mitigation-adaptation framework

Science, Mitigation, Adaptation Framework

Adaptation is responding to changes that might occur from added CO_2

It's not an either / or argument.



Mitigation is controlling the amount of CO_2 we put in the atmosphere.

Some definitions

- Mitigation: The notion of limiting or controlling emissions of greenhouse gases so that the total accumulation is limited.
- Adaptation: The notion of making changes in the way we do things to adapt to changes in climate.
- Resilience: The ability to adapt.
- Geo-engineering: The notion that we can manage the balance of total energy of the atmosphere, ocean, ice, and land to yield a stable climate in the presence of changing greenhouse gases.

A point or two

- Mitigation and adaptation have different characteristics.
  - A major one is the amount of time for them to be effective.
    - The very long time scales of the climate change problem mean that any advantages of controlling the increase of CO_2 are perceived many years after the action to control the increase.
      - Cause and effect are difficult to evaluate
      - Cost and benefit are difficult to evaluate
    - Adaptation is far easier to evaluate.

This is unique opportunity

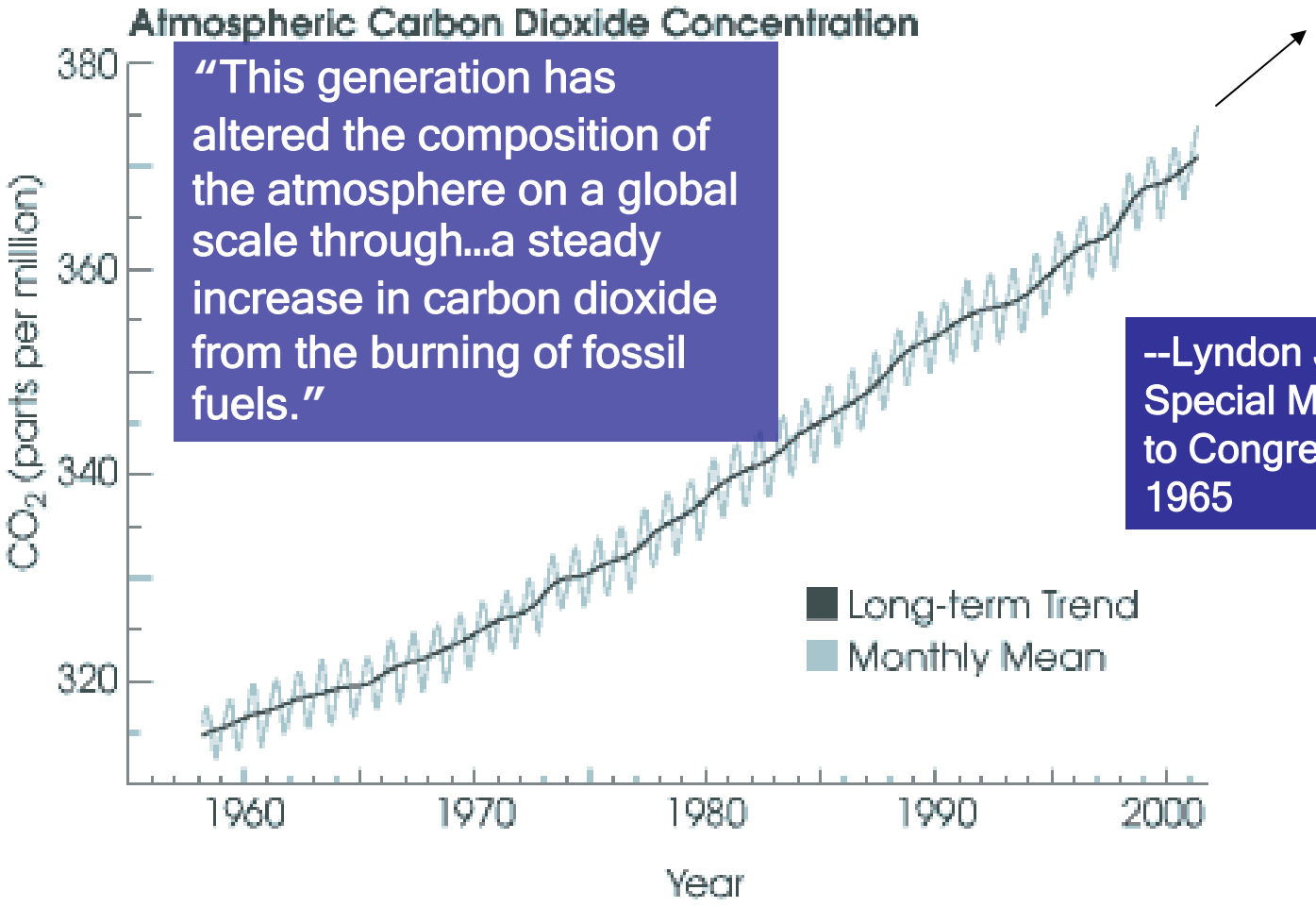
- We have credible and verifiable predictions of how the climate will change.
- We know that changes in the climate impact people
  - There is benefit
  - There is damage
- We also have the ability to do something
- We have responsibility to do something

The responsibility to do something?

- We have knowledge that there will be
  - Benefit
    - What are the consequences of exploiting this opportunity?
  - Damage
    - How do we reduce the impact of this damage?
- We are, in fact, engineering the climate of the Earth
  - Without conscious intent
  - With our waste
- Is it responsible to assume that our waste will serve to benefit our environment, our welfare, our sustainability?

We the people are changing the climate

Increase of CO_2 (Keeling et al., 1996)



"This generation has altered the composition of the atmosphere on a global scale through...a steady increase in carbon dioxide from the burning of fossil fuels."

--Lyndon Johnson Special Message to Congress, 1965

Naomi Oreskes, Why Global Warming Scientists are Not Wrong

Policy

- A natural response to the perceived risks of climate change is to propose a policy which will limit it in some way.

- Since CO_2 from combustion is the primary cause of the warming, then controlling CO_2 is sensible.

- Propose to keep temperature changes at some level that is considered tolerable.

Hence,

- Determine what is a tolerable ceiling for carbon dioxide.
  - Tolerable ceilings have been posed as between 450 and 550 ppm.
    - Ice sheet melting and sea level?
    - Oceanic circulation / The Gulf Stream?
    - Ocean acidification?
- Determine a tolerable measure of increased temperature
  - British policy → 2^{o} C

Framework Convention on Climate Change (US in part of this.)

- UN Framework Convention on Climate Change (1992, non-binding, voluntary, 190 signers)
  - Reduce CO_2 Emissions in 2000 to 1990 levels
  - Inventories of greenhouse gas emissions
  - Mitigate Climate Change

- Mid-1990's
  - No reduction in emissions
  - Evidence of warming and impacts

Framework Convention on Climate Change

- Ultimate Objective of the UNFCCC (Article 2)

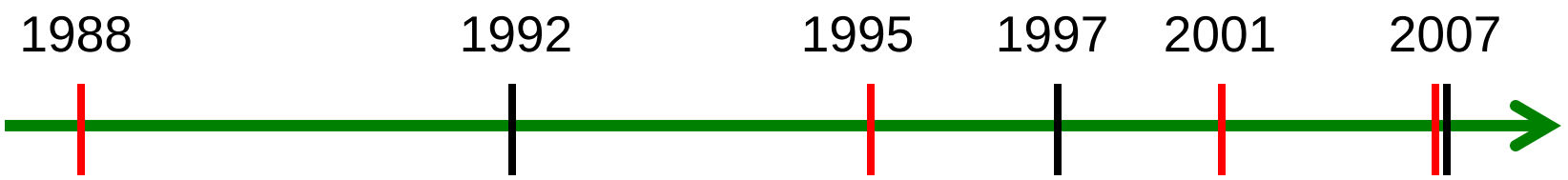
"...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to:

- allow ecosystems to adapt naturally to climate change;
- ensure that food production is not threatened; and
- enable economic development to proceed in a sustainable manner.

1992 Convention Commitments

- **All Parties agree to:**
  - **4.1.b. Mitigate emissions and enhance sinks**
  - **4.1.c. Promote technology development and transfer**
  - **4.1.e. Cooperate on research and observation**
- **Developed Countries' aim to return emissions to 1990 levels by the end of the century**

Development of International Climate Change Regime



IPCC established

Framework Convention (UNFCCC)

Kyoto Protocol

?????

Scientific assessment

Non-binding aim

Binding emissions target

Assessment

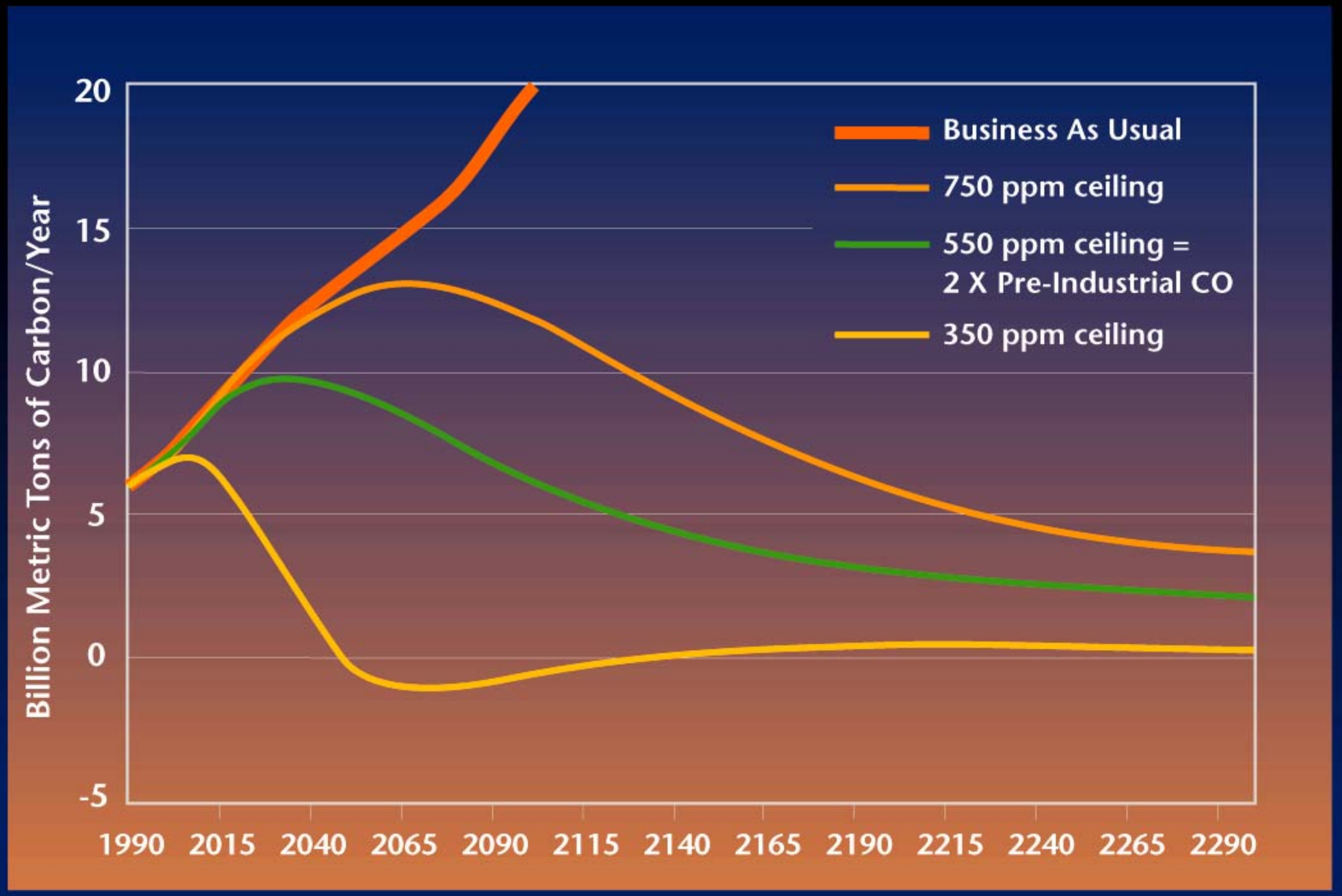
- Mid-1990's
  - No reduction in emissions
  - Evidence of warming and impacts
- 2001
  - No reduction in emissions
  - Evidence of warming and impacts
- 2007
  - No reduction in emissions
  - Evidence of warming and impacts

An observation

- Despite good intentions, development of some policies, a lot of discussion, debate, and controversy, we have not
  - reduced CO_2 emissions
  - shown any real ability to mitigate warming of the planet
- To do so is a formidable task.

Basic constraint on carbon stabilization

Atmospheric Stabilization Emissions Paths



Basic constraint on carbon stabilization

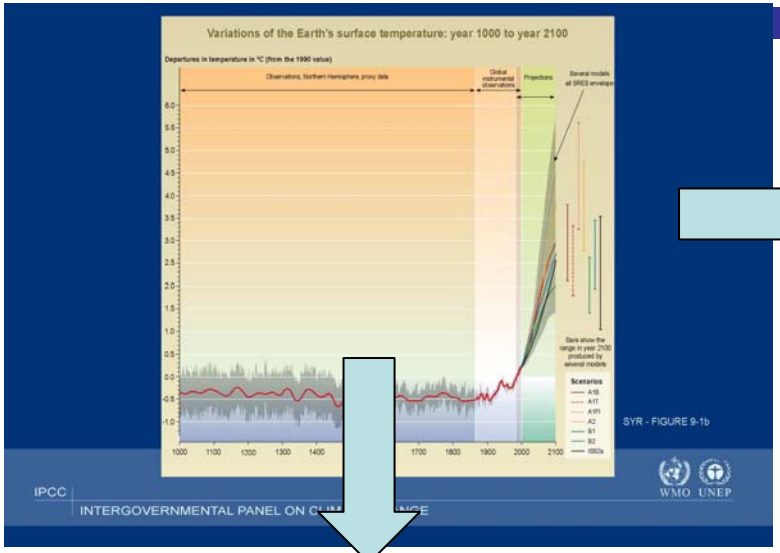
Stabilizing concentrations at 550 ppm Means Action Now …

Ceiling (ppmv)	350	450	550	650	750
Start Date	Too late	2007	2013	2018	2023
Max Emission	6.0	8.0	9.7	11.4	12.5
Max Year	2005	2011	2033	2049	2062

1950 – 1.8 tons // 1990 – 5.8 tons // 2000 – 6.5 tons

What stands in our way?

Predictions motivate action



Is there some sort of tipping point or abrupt change which will be catastrophic?

Is there some range of warming which we can tolerate, adapt to, perhaps be beneficial?

Are there feedbacks in the system which will cool the Earth – counter the warming?

Should we perhaps just push forward, the problem is bigger than we are, it just costs too much, we don't know what we are doing anyway ...

How should we respond to the predictions?

Scientific Investigation

- Scientific investigation has demonstrated that:
  - ...
  - A primary cause of the Earth warming is due to the activities of humans
    - Combustion of oil, natural gas, and coal release greenhouse gases into the atmosphere
      - Holds heat close to the surface like a blanket
    - ...
    - ...
  - ...

Hence

- The climate problem is completely entwined with the production of energy.
- The production of energy is strongly correlated with societal success and standard of living.
- Hence to do something about climate change requires us to do something about society, us, the way we behave.
  - Requires change

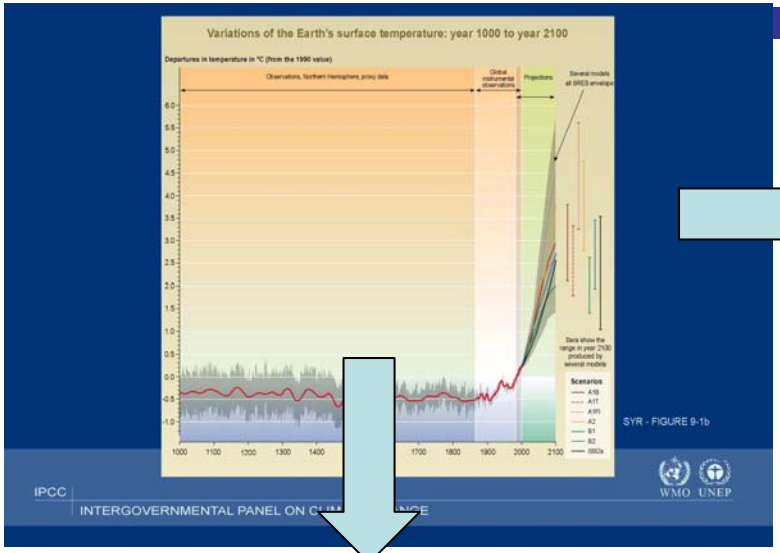
Human Change

- We resist change
  - It's natural to resist change. We learn how to behave, how to get along, and that's what we do.
  - To require change suggests that we are doing something wrong. We don't like to be wrong.
  - What we are doing now is, largely, viewed as successful. We are reluctant to give up that which is successful. We are afraid that we will suffer loss.

Let’s think about science investigation some more

- Science is the investigation of phenomena through observation and the development of testable hypotheses, theory, and prediction.
  - It is not the development of facts.
  - It is the development of knowledge.
  - Scientific investigation also provides an estimate of uncertainty.

Science: Knowledge and Uncertainty



Knowledge from Predictions

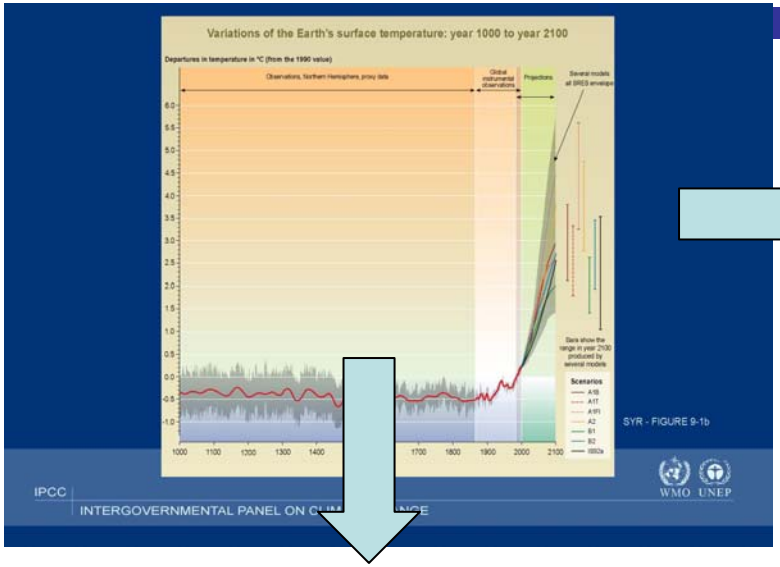
Motivates policy

Uncertainty of the Knowledge that is Predicted

Policy

1) Uncertainty always exists
2) New uncertainties will be revealed
3) Uncertainty can always be used to keep policy from converging

Science: Knowledge and Uncertainty



Knowledge from Predictions

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Policy

1) **Uncertainty always exists**
2) **New uncertainties will be revealed**
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What we are doing now is, largely, viewed as successful. We are reluctant to give up that which is successful. We are afraid that we will suffer loss.

Therefore

- Climate change problem cannot be solved in isolation.
- Requires integration with all elements of society.
  - Requires identification of reasons to motivate us to take action
    - Apparent benefit
    - Excess Risk

A Conclusion about Policy

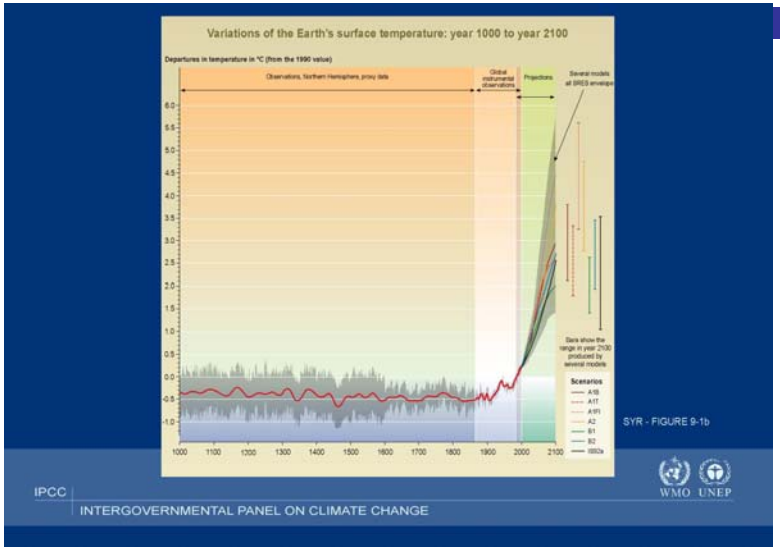
- Policy cannot stand alone as our response to climate change.
  - Every person and every group of people will be impacted by climate change, and therefore, by policy to address climate change.
    - In fact, some feel that they are more impacted by policy than by climate change.
- Policy has to not only be effective, but it has to include and balance the interests of all who have a stake.
- Policy represents our values – our societal belief system.
  - It sets the bounds on behavior to benefit society

Motivators for Policy

- More is needed than scientific knowledge to motivate the development of policy.
  - A policy accelerator or catalyst is needed to promote convergence on policy.
    - Apparent benefit
    - Excess risk
  - What are important sources of benefit and risk?

A blank page to take notes

Predictions motivate action

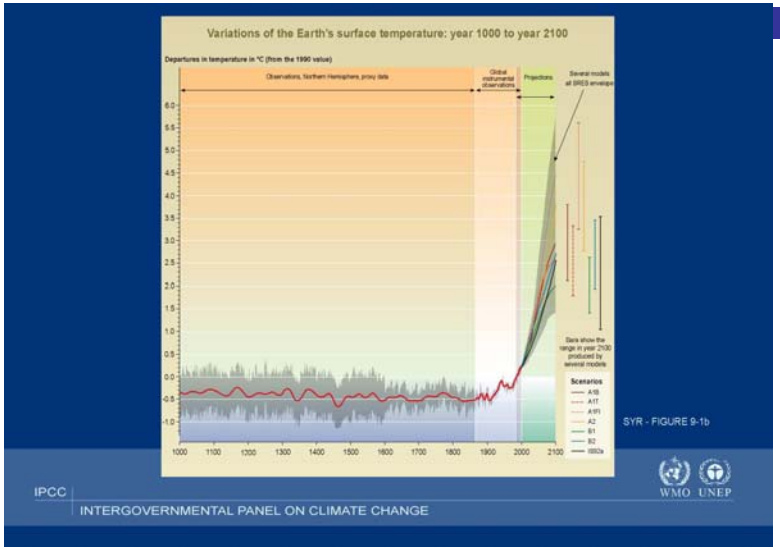


How should we respond to the predictions?

Must remember that the climate problem is currently entwined with energy sources, energy use.

Energy use touches every part of society.
Societal success.
Standard of living.

For example: At the individual level cheap energy might be the choice.



Impact on agriculture

Drought-flood
Moisture stress
More insects

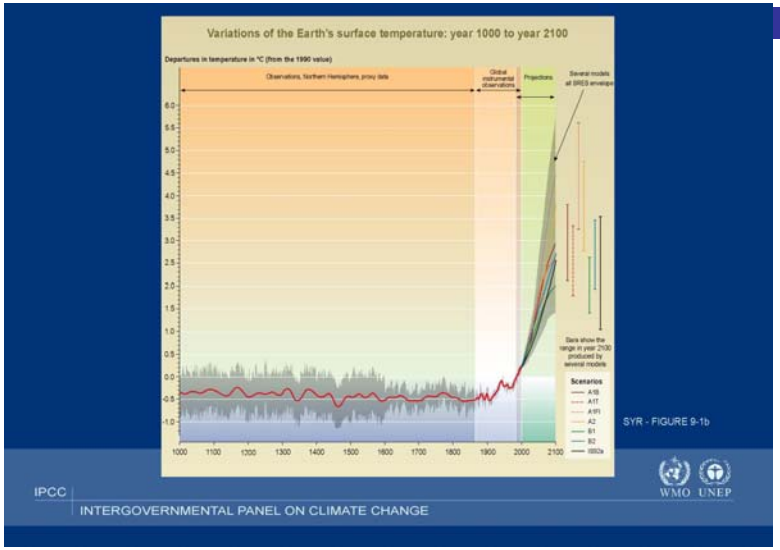
Longer growing season

COST OF ENERGY

DOUBLE CROP

COST OF WATER / INSECTICIDE

For example: Or whole sector might change its focus because there is money to be made in energy



Impact on agriculture

ENERGY PRODUCTION

FOOD PRODUCTION

FOOD SECURITY

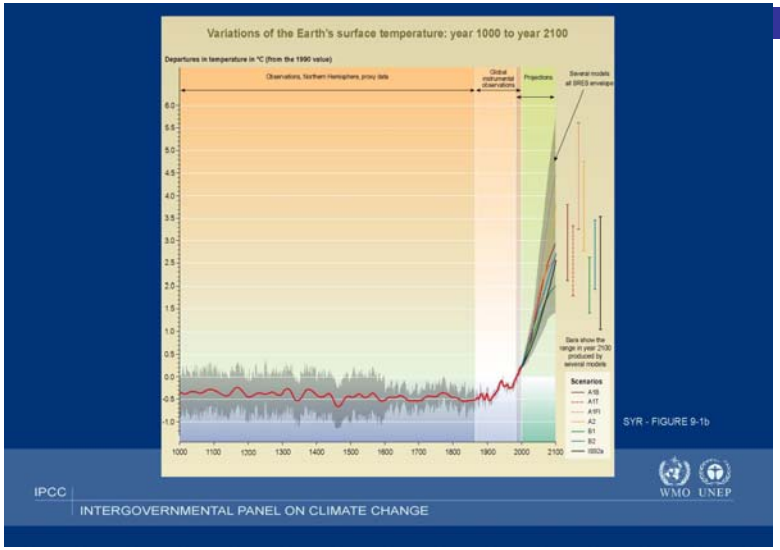
NATIONAL SECURITY

ENERGY SECURITY

NATIONAL SECURITY

GLOBAL TRADE

Predictions motivate action



How should we respond to the predictions?

How we respond depends very much on the current capabilities of the society or nation

Rich, technologically advanced

Resource rich, desiring richness

Poor, low technologically

Ethics // Equality // Liability

The importance of relationships

Climate Change Relationships

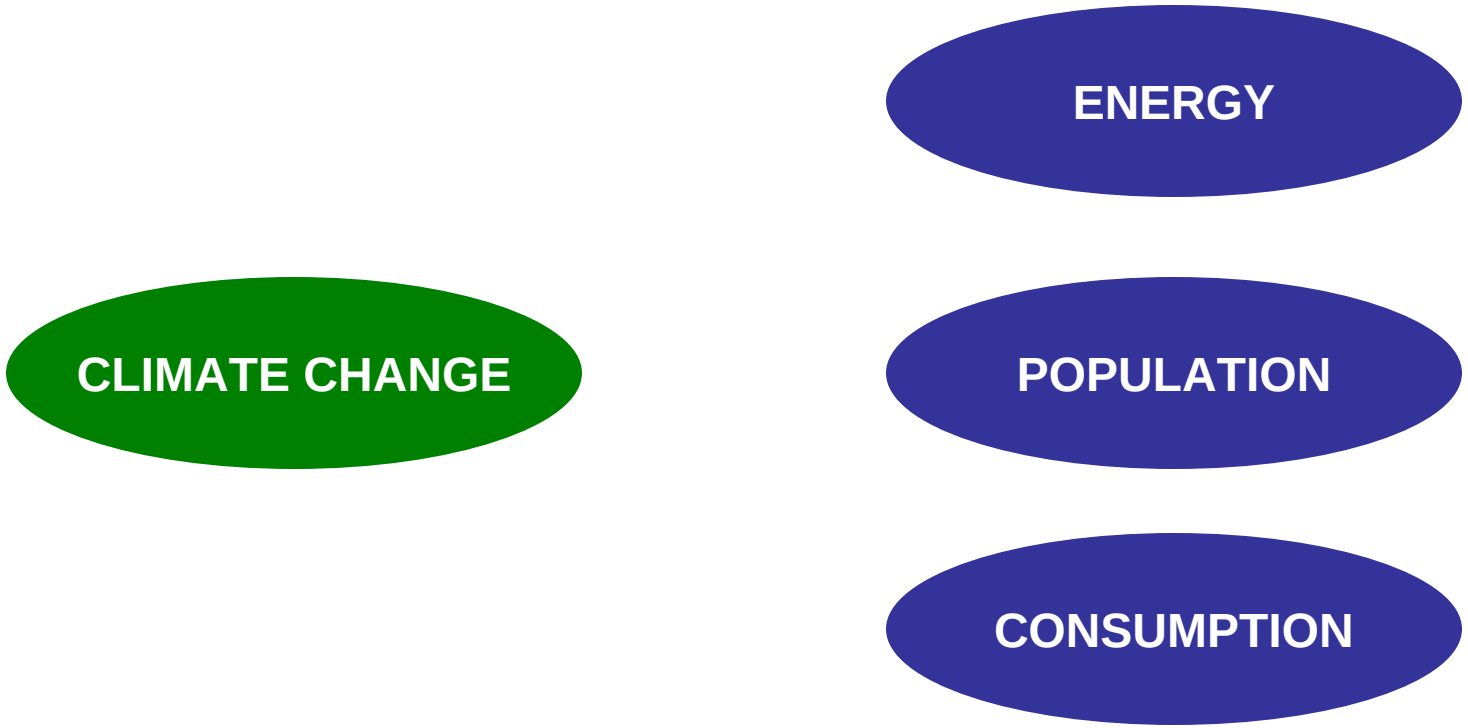
- We have a clear relationship between energy use and climate change.

CLIMATE CHANGE

ENERGY

Climate Change Relationships

- Energy, Population, and Consumption are all fundamentally related to climate change.



Climate Change Relationships

- Climate change is also linked to consumption.
  - A relatively small part of the world's population has consumed the energy that is responsible for the increasing CO_2.

- Population: If all of the population were to consume in the same way at the same level that the developed world has consumed, then ... There would be a LOT more CO_2 in the atmosphere and ocean.

Some conclusions

- Obviously, we need some sort of energy policy.
  - Energy demand
  - Energy security
- It is possible (likely?) that we will seek energy security that does not address the climate change problem.
  - Cost
  - Urgency

Some conclusions

- There needs to be some cost of consumption that controls or treats the waste that comes from consumption.

A thought

- It has been observed that economic development is often the most effective way to slow population growth.
- Therefore, if rather than working on the climate problem, we work on development, with the idea of controlling population, then addressing the climate problem will follow.
- However, we have the fact that, to date, the increase of CO_2 in the atmosphere is more a problem of consumption than a problem of population.

The need for climate management

Some Basic Management Tenets

WHERE WE ARE NOW

WHERE WE ARE GOING

WE WILL GET DESIRED RESULT AS A BENEFIT OF WHERE WE ARE GOING.

THIS APPROACH INCREASES RISK OF NOT GETTING THE DESIRED RESULT, BECAUSE THE "COST" OF DESIRED RESULT IS NEVER INTEGRATED INTO THE PROCESS

DESIRED RESULT

TRYING TO BE CLEAR

WHERE WE ARE NOW

ENERGY SECURITY

WE WILL GET REDUCED CARBON FROM QUEST FOR ENERGY SECURITY – ENERGY POLICY.

CARBON REDUCTION DOES <u>NOT</u> AUTOMATICALLY FOLLOW FROM SOLVING THE ENERGY PROBLEM. CARBON REDUCTION ALSO NEEDS TO BE A REQUIREMENT → <u>NEED CARBON POLICY</u>

CARBON REDUCTION

Basic Management

- If there is a goal which you must meet, then you need to manage towards than goal.
  - If the goal is critical to success,
  - If the goal must be met on some schedule,
  - then this raises the level of management that is needed.

NEED CARBON POLICY

- We need a carbon policy which is integrated with energy policy.
  - Some alternative energy sources don't do much for reducing carbon dioxide in atmosphere.
  - Coal is viewed as our easy energy security
    - Without sequestration (carbon removal), coal makes the problem worse.

- Concern: Quest for energy security-national security, demand for cheap energy will reduce priority we give to reduction of carbon dioxide in the atmosphere.

Some challenges

Challenge

- It is a challenge, therefore, to bring together all of the elements of society towards a solution.

- Is it possible?

The possibility of addressing the climate change challenge

- One strategy is to integrate into our thinking, our culture, our behavior the value of the climate and the consequences of our decisions, and in particular, what happens with our waste.

The possibility of addressing the climate change challenge

- What does bring us all together?
- How do we ascribe value and valuation?
  - Our beliefs and belief systems link us strongly.
    - And stand at the foundation of our disagreements.
  - Our economies link us strongly.

Economies, markets

- A leading policy mechanism is the carbon market. This would be a way to allow valuation of our climate and the treatment of our waste.
  - Markets are a way to provide an interface between all of the interested parties.
    - Requires participation in the market.
    - Requires a functioning market.
  - The most likely way to touch most elements of society.
  - How to develop a market?

Challenge

- How to develop a strategy for management of the climate.

Local, Regional, Federal, Global

- How to organize to manage the climate is not evident.
  - Personally, I think a centralized climate agency is a bad idea.
  - What is a good idea?

The problem of complexity

- One of the problems that challenges how we manage the climate problem is complexity.
  - Complexity of the physical climate
  - Complexity of the impact of climate change
  - Complexity of society

- What are the strategies for managing complexity.

A strategy for approaching complexity

- Break the complex problem into pieces based on their intrinsic time scales.
- What time scales are we dealing with?
  - Human lifetimes
  - Energy infrastructure lifetimes
  - Return on market investment
  - Mitigation cause and effect
  - Adaptation return on investment
  - Technology development
  - ...

Some things that are clear.

Scientific Investigation

- With significant certainty we can say
  - The Earth will get warmer
  - Sea level will rise
  - The weather will change
    - The distribution and storage of water will change

There will be impacts of climate change

- There will be both winners and losers in both absolute and relative senses.
- Minimally, climate change will be disruptive, likely occur on time scales faster than ecosystems evolve, and challenge water and food supply.
- We should expect that this will cause contention on the international level.

We will need to

- Need for more binding commitments.
- Need to mitigate the release of greenhouse gases to stabilize the concentration of greenhouse gases.
- Need to develop adaptation plans to adapt to the greenhouse gas increases that will inevitably occur.
- Need to consider the direct removal of greenhouse gases from the atmosphere and storing these gases some place. (Sequestration)
- Need to consider global environmental engineering strategies that might provide, at least temporary, relief from global warming.

Climate change and energy use

- We need to break the one-to-one relationship between climate change-energy-economy. This will allow the development of economically viable approaches to the climate change problem.
  - Alternative sources of energy is part of the solution
    - Biofuels seem to be the top of the food chain right now.
    - Ethanol is a bad idea
  - This requires perceived cost-benefit in the development of alternative sources of energy.

Efficiency is a good idea

- We need to focus on improved efficiency in our use of fossil fuel energy. This provides one of the biggest ways to reduce greenhouse gases.
  - #1s) Space heating, Cars, Industrial machines and electrolytic processes
  - #2s) Appliances, Light trucks, Steam generation

Efficiency and Conservation?

- The record in the U.S.: Increased efficiency leads to doing more, not reduced use of energy.
  - We need policy that assures conservation.
- We need to give value to efficiency.
- There needs to be some cost of consumption that controls or treats the waste that comes from consumption.

My final viewgraph

- We must take a multi-lateral approach to this problem. This is not a problem of science and policy; it is much more complex. Business is a key part of the solution. All elements of society have a stake.
- We required sustained management of the climate, which will require that the value of the climate and the dispensation of the waste products of our endeavors be integrated into our day-to-day lives.

Some more details and ideas

An important notion.

- The climate change problem is directly related to energy consumption and energy consumption is directly related to economic growth and development.

The role of business

- Since climate change is directly related to the economy, and since we are as a species committed to economic development and growth, it is impossible to consider, credibly, solutions to the climate change problem without the participation of the economic elements of society; that is, business.

Key elements

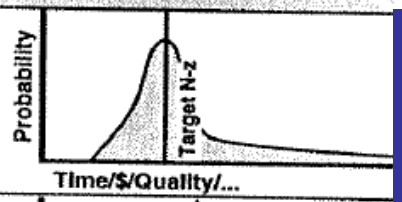
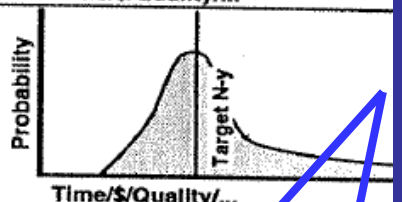
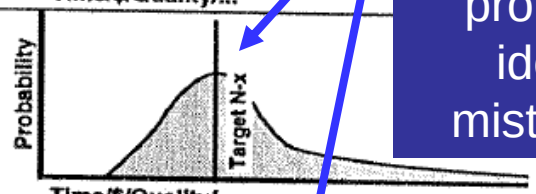
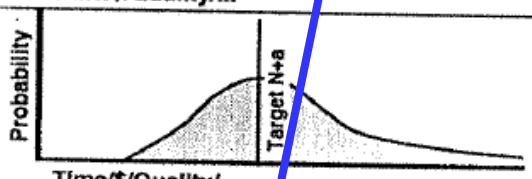
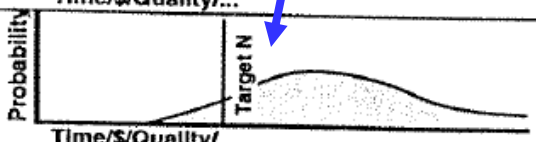
- Business, science and policy, therefore, emerge as three elements that must be considered when seeking a solution to the climate change problem.
  - What are other important elements, communities?

Therefore

- Climate change problem cannot be solved in isolation.
- Requires integration with all elements of society.
  - Requires identification of reasons to motivate us to take action
    - Apparent benefit
    - Excess Risk
- Climate change problem will not be solved as the consequence of address of some other problem.
  - We must take responsibility for managing the climate of the Earth.

Another Management Idea

Evolution of Process Capability

Level	Process Characteristics	Predicted Performance
5 Optimizing	Process improvement is institutionalized	
4 Managed	Product and process are quantitatively controlled	
3 Defined	Technical practices are integrated with management practices and institutionalized	
2 Repeatable	Project management practices are institutionalized	
1 Initial	Process is informal and ad hoc	

The first and largest improvements come from a plan, an approach to the problem, and identifying mistakes early

This axis is ability to target cost, quality, time

A personal conclusion

- If we are going to manage the climate change problem, as opposed to fixing it, we need to develop a stable, integrated managed approach.
  - This is a massive task.
  - Are there new paradigms for developing this?
    - Do we have to rely on ozone model?
    - Do we have to rely on sulfur model?

Some Mitigation-Adaptation Details

Thinking about ADAPTATION

- Adaptation: What people might do to reduce harm of climate change, or make themselves best able to take advantage of climate change.
  - Autonomous that people do by themselves
  - Can be encouraged by public policy
    - Command and control tell you to do it
    - Incentives
    - Subsidies
  - Can be anticipatory or reactive
- Adaptation is local; it is self help.
- Adaptation has short time constants - at least compared to mitigation → Hence people see the need to pay for it.
- Some amount of autonomous-reactive adaptation will take place.
  - Moving villages in Alaska

Thinking about MITIGATION

- Mitigation: Things we do to reduce greenhouse gases
  - Reduce emissions
  - Increase sinks
- Mitigation is for the global good
- Mitigation has slow time constants
- Mitigation is anticipatory policy
- This is the “second” environmental problem we have faced with a global flavor.
  - Ozone is the first one. Is this a good model?

Some Mitigation-Adaptation considerations

- Those who are rich and technologically advanced generally favor adaptation; they feel they can handle it
  - Plus, technology will continue to make fossil fuel cheap, but with great(er) release of CO_2
- Those who are poor and less technologically advanced generally advocate mitigation and sharing of adaptation technology
- Emission scenarios don't matter for the next 50 years.
- There are a lot of arguments, based on economics, that lead towards adaptation
  - Mitigation always looks expensive, perhaps economically risky, on the time scale of 50 years.
    - Adaptation looks easier because we will know more
    - This will remain true as long as the consequences seem incremental and modest
      - The Innovators Dilemma, evolution vs revolution?

Responses to the Climate Change Problem