# Fourth Annual Conference on Carbon Capture & Sequestration

*Developing Potential Paths Forward Based on the Knowledge, Science and Experience to Date*

*Public Outreach and Education*

## The Stabilization Wedge Game: A Tool for Communicating the Scale of the Greenhouse Gas Problem

Roberta Hotinski

May 2-5, 2005, Hilton Alexandria Mark Center, Alexandria Virginia

# The Stabilization Wedge Game:

## A Tool for Communicating the Scale of the Greenhouse Gas Problem

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# Background

- Based on concept originally devised by CMI Co-Directors Rob Socolow & Steve Pacala

  "Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies," *Science*, Vol 305, Issue 5686, 968-972 , 13 August 2004.

- Created as an interactive exercise for 2004 annual meeting

- Currently under development as an outreach tool, freely available for use by others

- More information at http://www.princeton.edu/~cmi

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# The Concept of the Game

- Distill debate around projected energy demand, stabilization targets, $CO_2$ concentration and emissions trajectories into a single target:

  **Reduce future emissions by 7 gigatons carbon per year by 2050**

- Teams must agree on a portfolio of seven strategies that meets their target

- Strategies are presented in terms and scale to which participants can relate and with some reality checks (constraints)

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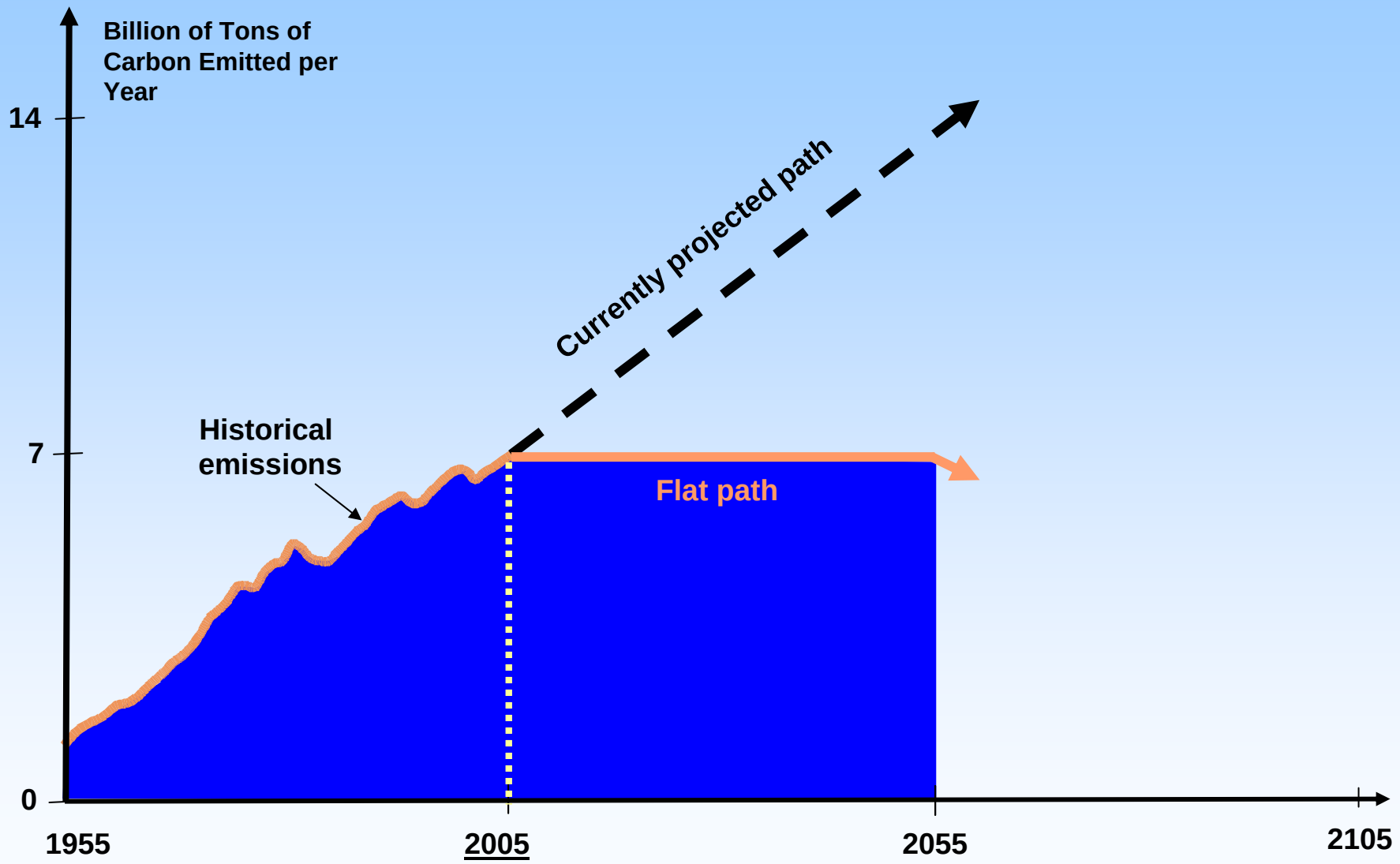
# The Stabilization Wedges – Two Scenarios

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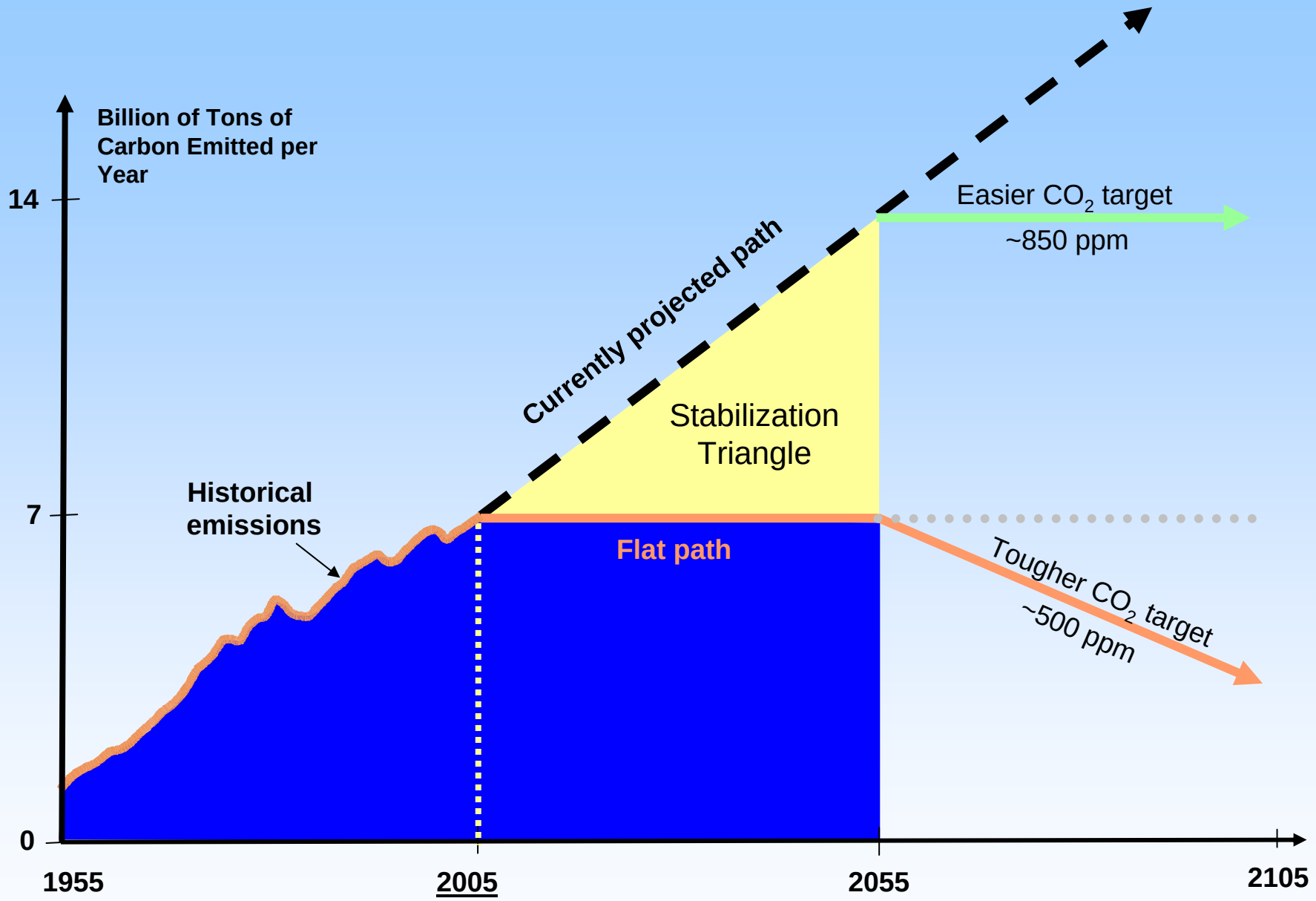


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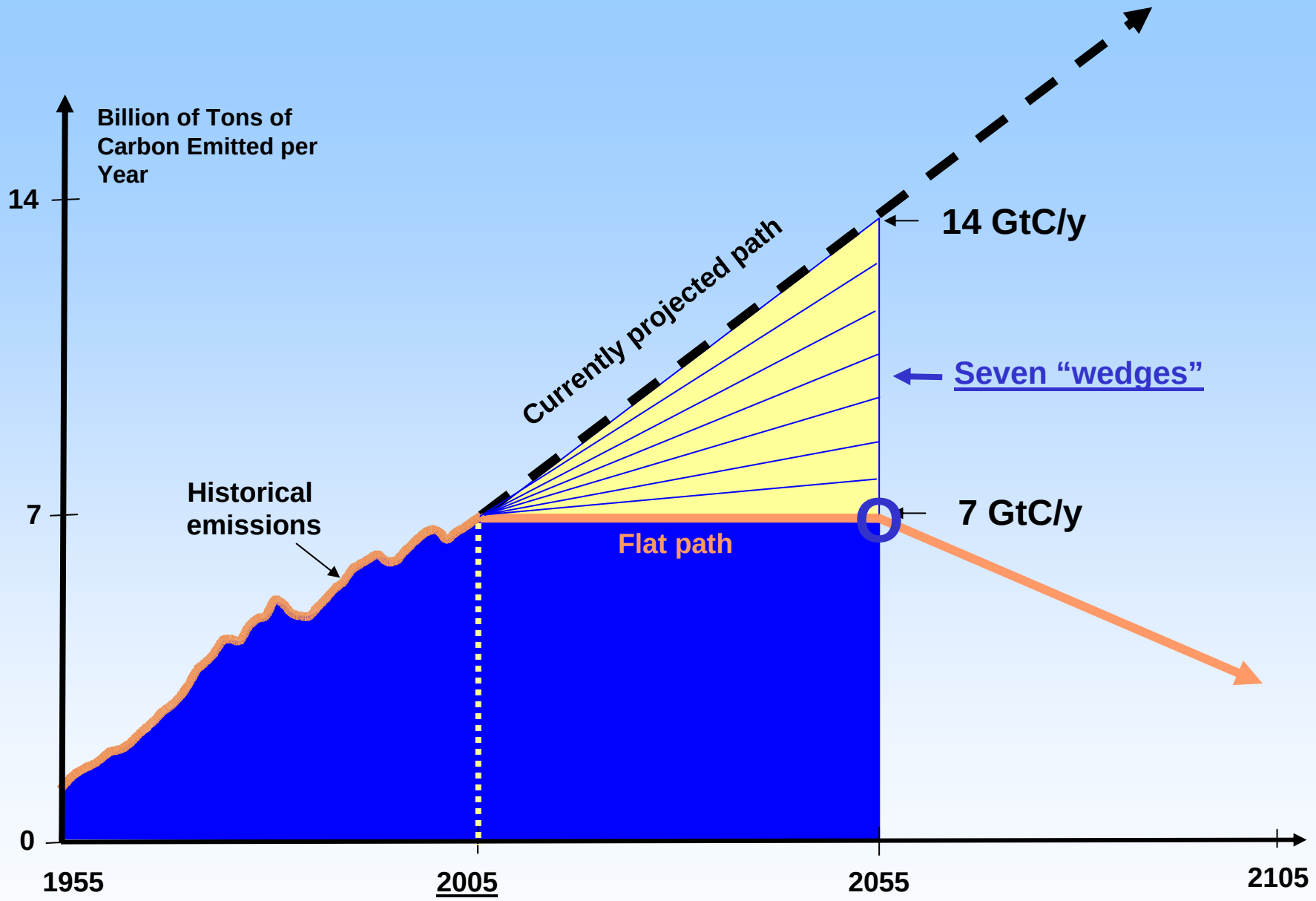


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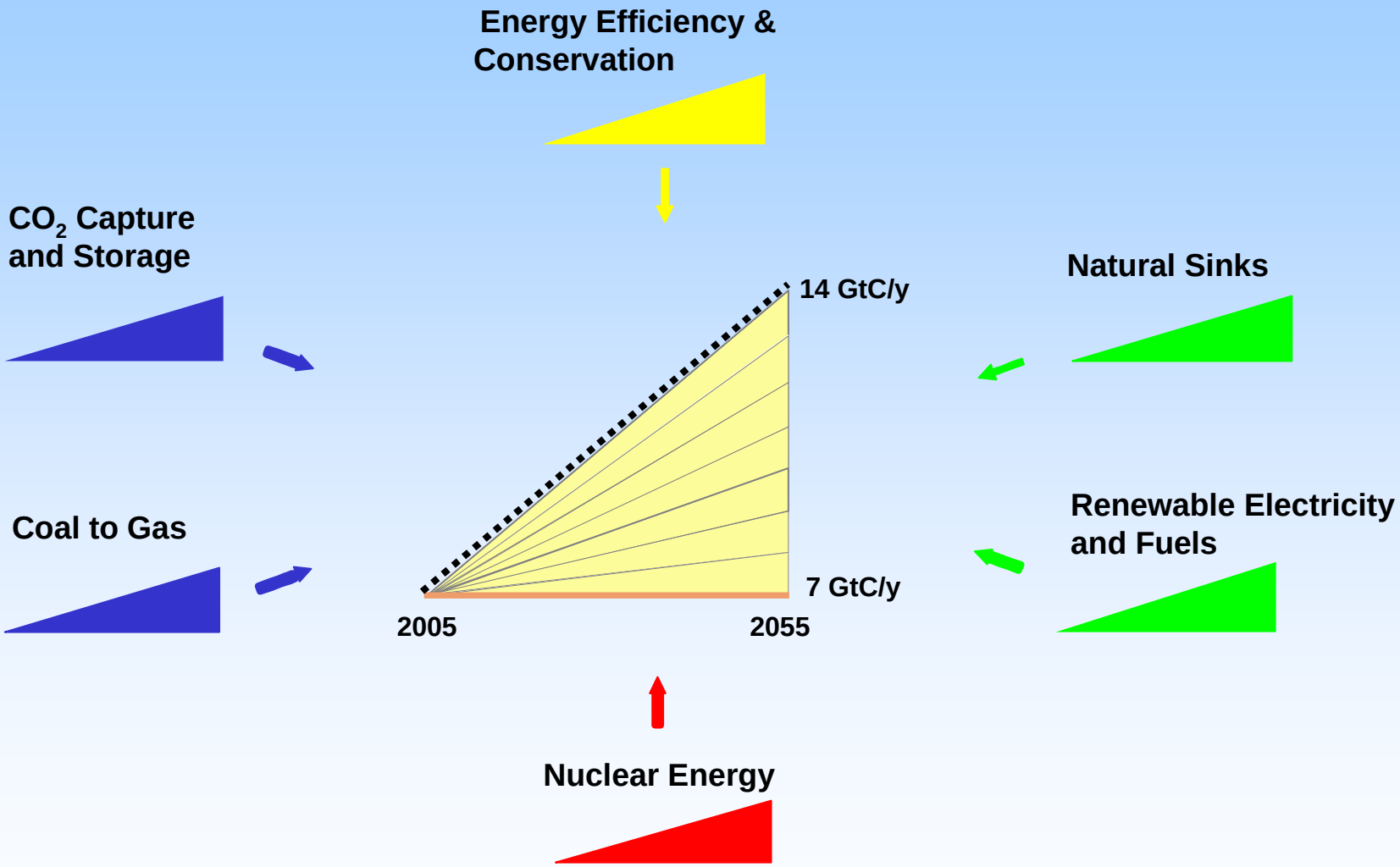
# Challenge: Cut emissions with currently available technologies

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| Strategy | Use<br>Electricity (E), Transport. (T), or Heat ( H) | Description | Size of a Wedge | Cost | Challenges |
|---|---|---|---|---|---|
| **Coal to Gas Electicity** | **E** | Replacing coal-burning electric plants with natural gas plants (1400 1 GW coal plants) | **1 wedge will require an amount of natural gas equal to that used for all purposes today** | **$ (max 1)** | Natural gas, geopolitics **!** |
| **Coal to Gas Heat** | **H** | Substitute natural gas for domestic heating or industrial processes | **A wedge may be available from displacement of coal in all home heating (DW) or all industrial processes** | **$ (max 1)** | Natural gas, geopolitics **!** |
| **CCS Electricity** (Coal or NG-) | **E** | CO2 from fossil fuel power plants stored and captured (700 GW of coal or 1400 GW of gas plants) | **1 wedge will require injecting a volume of $CO_2$ every year equal to the volume of oil extracted** | **$$** | $CO_2$ leakage **!** |
| **CCS $H_2$** | **H,T** | Hydrogen automotive fuel from fossil sources with CCS (displaces 1 billion 30mpg cars) | **1 wedge would require $H_2$ production at 10 times the current rate** | **$$$** | Infrastructure; $H_2$ safety **! !** |
| **Nuclear Electricity** | **E** | Displace coal-burning electric plants with nuclear plants (2 x current capacity) | **1 wedge is ~3 times the effort France put into nuclear expansion in a typical year in the 1980's, sustained for 50 years** | **$$** | proliferation, nuclear waste, NIMBY **! ! !** |
| **Nuclear $H_2$** | **H,T** | Produce hydrogen with nuclear energy to replace petroleum fuels | **1 wedge is ~5 times the effort France put into nuclear expansion in a typical year in the 1980's, sustained for 50 years** | **$$$** | proliferation, nuclear waste, NIMBY **! ! !** |

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| Strategy | Use<br>Electricity (E), Transport. (T), or Heat ( H) | Description | Size of a Wedge | Cost | Challenges |
|---|---|---|---|---|---|
| **Efficiency – Transport** | **T** | Increase automobile fuel efficiency (2 billion cars projected in 2050) | **1 wedge would require doubling the efficiency of the all world's cars from 30 to 60 mpg** | **$* (max 3)** | Car size & power, Urban design **! *** |
| **Efficiency Electricity** | **E** | Increase efficiency of lighting, motors, power generation | **1/4 wedge would require replacing ~500 million incandescent bulbs with compact fluorescents annually** | **$* (max 4)** | Tropical A.C **! *** |
| **Efficiency Heat** | **H** | Increase insulation, furnace efficiency | **1 wedge could be achieved by using best available technology in all new and existing buildings** | **$* (max 4)** | House size **! *** |
| **Wind Electricity** | **E** | Wind displaces coal (50 x current capacity) | **1 wedge will require area equal to ~3% of U.S. land area** | **$$** | Regional climate change, NIMBY **!** |
| **Solar Electricity** | **E** | Solar PV displaces coal (700 x current capacity) | **1 wedge will requires the equivalent of a 100 x 200 km PV array** | **$$$** | PV cell materials **!** |
| **Biofuels** | **T,H** | Biomass fuels from plantations replace petroleum fuels | **1 wedge requires scaling up world ethanol production by a factor of 50** | **$$** | Biodiversity, competing land use **! *** |
| **Natural Sinks** | **n/a** | Storage in new forest, soils | **1 wedge would be achieved by halting deforestation in 50 years and doubling the rate of new plantation creation** | **$*** | Biodiversity, competing land use **! *** |

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# Wedge Worksheet

**Choose strategies to reduce total fossil fuel emissions by 7 wedges by 2054**
(1 "wedge" = 1 billion tons carbon per year)

- **You may use a strategy more than once**
- **Use only whole numbers of slices**
- **You may only use**
  - 5 "E" slices (Electricity)
  - 4 "T" slices (Transportation)
  - 5 "H" slices (Heat)

| Slice # | Strategy | E, T, or H | Cost ( $ ) | Challenges ( ! ) |
|---|---|---|---|---|
| 1 | Efficiency | E | $ | ! |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| | **TOTALS** | E=____ (5 max)<br>T=____ (4 max)<br>H=____ (5 max) | | |

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# Possible ways to look at game:

- Assumptions, technical data
- <u>Effectiveness as a communication tool</u>
- Detailed analysis of results

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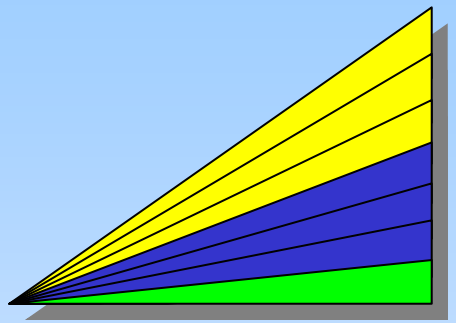
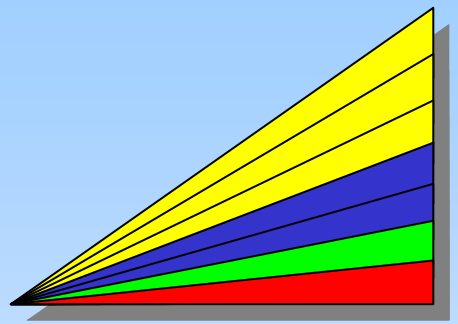
# Princeton Results

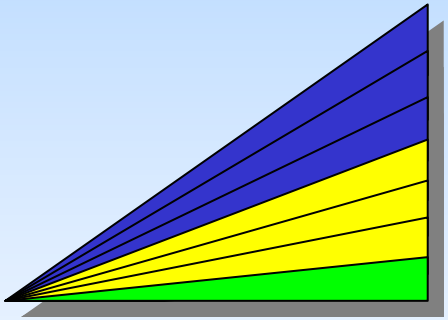
~60 participants: mixed industry, academic, NGO



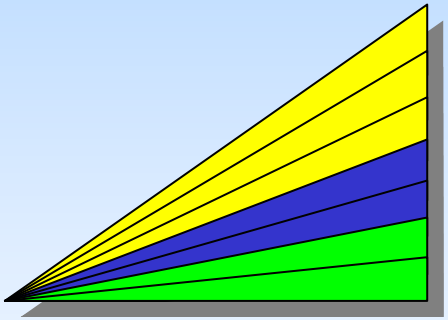
Eff (H)
Eff (E)
Eff (T)
Coal to gas (E)
CCS (E)
Coal to Gas (E)
Solar/Wind (E)



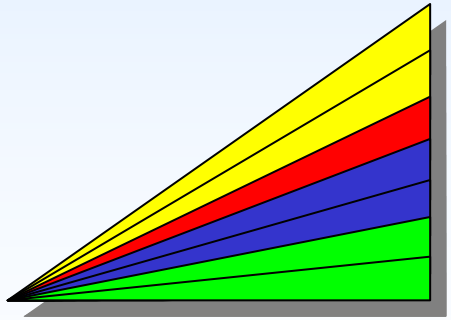
Eff (H)
Eff (T)
Eff (E)
Coal to Gas (E)
CCS (E)
Other (solar/wind/biofuels/sinks)
Nuclear (E)



Coal to Gas (H)
CCS (E)
CCS H2
Eff (E)
Eff (T)
Eff (H)
Wind (E)

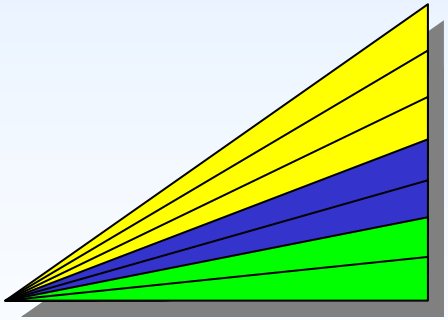


Eff (H)
Eff (T)
Eff (E)
Coal to Gas (H)
CCS (E)
Other – (Geothermal, biofuels, tides, hydro, etc.)
Solar (E)



1&2: Eff (E,T,H)

Nuclear (E)
Coal to Gas (H)
CCS (E)
Wind (E)
Biofuels



3xEff (E,H,T)

CCS (E)
CCS H2
Wind (E)
Biofuels

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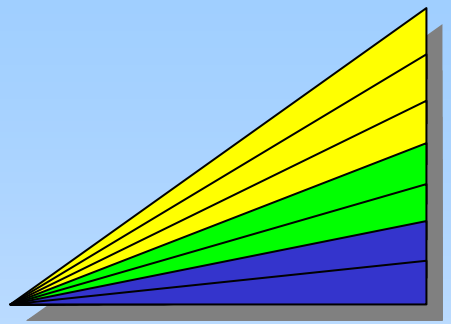
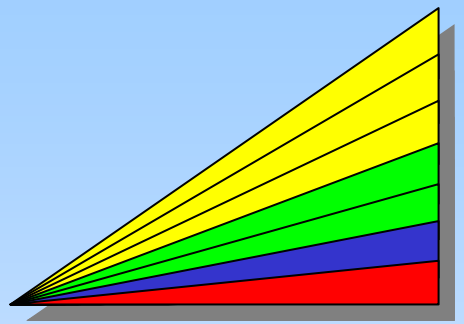
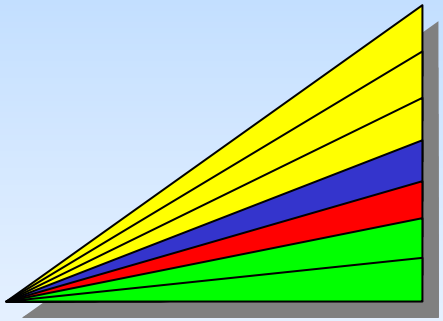
# WRI Results ~30 participants: NGO's, Industry, Consumers Groups, Energy Co's



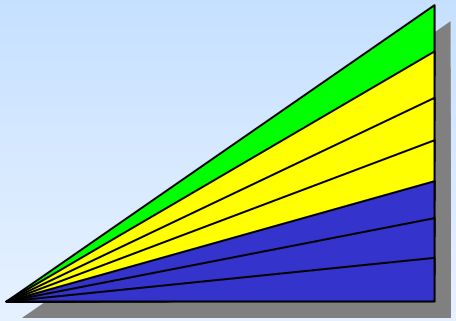
Eff (H)
Eff (E)
Eff (T)
Wind (E)
Biofuels
CCS (E)
Coal to Gas (E)



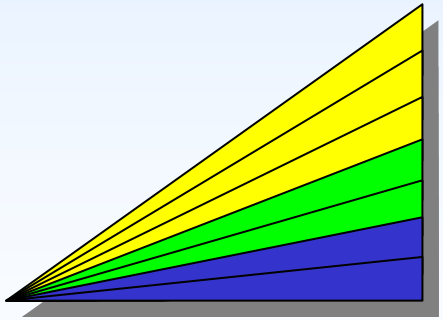
Eff (T)
Eff (H)
Eff (E)
Biofuels
Natural Sinks
CCS (E)
Nuclear (E)



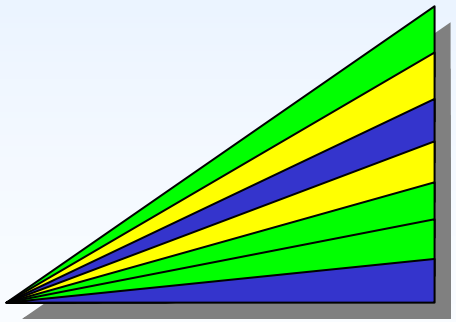
Eff (T)
Eff(H)
Eff (E)
CCS (E)
Nuclear (E)
Solar/Wind (E)
Biofuels



Wind
Eff (H)
Eff (T)
Eff (E)
Coal to Gas (E)
CCS (E)
Coal to Gas (H)



Eff(T)
Eff(H)
Eff(E)
Solar/Wind (E)
Natural Sinks
CCS(E)
Coal to Gas (E)



Biofuels
Eff (E)
CCS (E)
Eff (T)
Wind (E)
Natural Sinks
CCS (E)

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# Climate Group Conference – April 6, 2005

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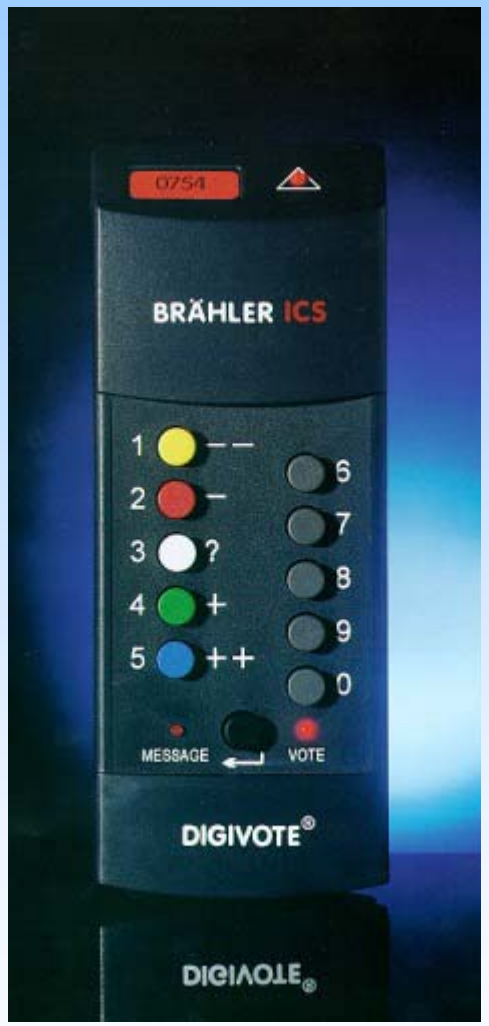


- Game carried out by Bramshaw Conference Communications
- Approximately 170 participants
- Collected information on sector, age, opinions on climate change
- Allows immediate display of results
- Anonymous and rapid polling

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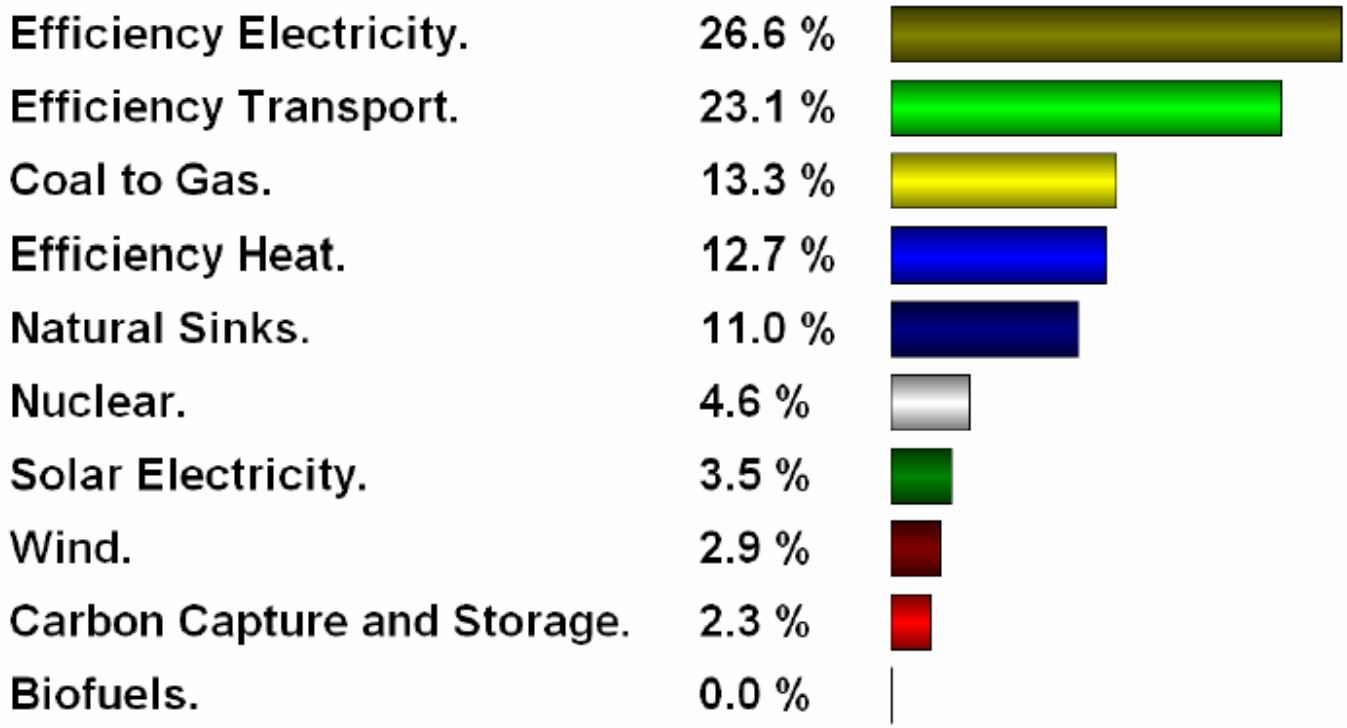
## Please enter the strategy number selected for Wedge 1 .

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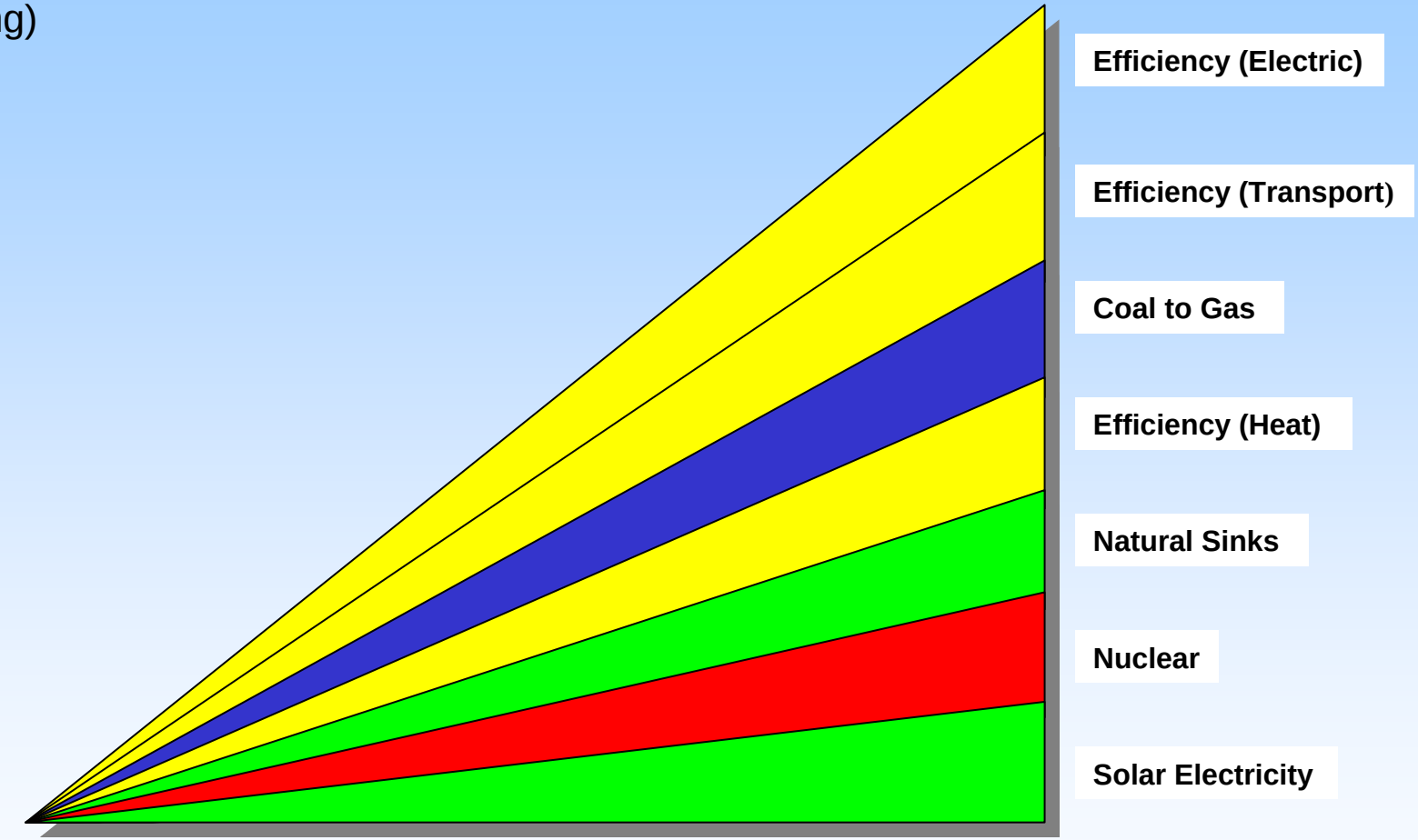
# Climate Conference Result

(~170 participants from government, industry, NGO's, education, law/consulting)

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## Comparison Among 3 Games

| | Princeton | WRI | Melbourne |
|---|---|---|---|
| CCS (E) | X | X | |
| Coal to gas (E) | | X* | X |
| Coal to gas (H) | X | | |
| Efficiency (E) | X | X | X |
| Efficiency (T) | X | X | X |
| Efficiency (H) | X | X | X |
| Nuclear (E) | | | X |
| Biofuels | X | X | |
| Wind (E) | X | X | |
| Natural Sinks | | X* | X |
| Solar (E) | | | X |
| CCS H2<br>Wind H2<br>Nuclear H2 | | | |

X* = two-way tie

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# Initial Findings & Insights

- This is a relatively fun way to convey the complicated issues of scale (of problem and potential solutions) to people with broad range of experience in climate change

- Disparate groups come to roughly similar conclusions: There is no Silver Bullet - it takes portfolio of technologies with a mix of **efficiency**, fossil fuels, and renewables (+/- nuclear) to build the "stabilization triangle."

- The game can be used successfully with groups of different sizes and participants from a wide variety of backgrounds

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# Initial Findings & Insights, cont'd

- The exercise allows participants with limited expertise to knowledgeably compare and contrast the impacts of various carbon mitigation strategies
- The wedge game fosters good discussion among people from different backgrounds by forcing participants to make tough choices
- Especially combined with electronic voting, provides interesting non-threatening interaction on a "hot-button" issue (& potentially lots of data)
- The impacts of different voting and judging techniques can be considerable

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# Potential Audiences

- Already shown successful with professionals with some climate/energy knowledge
- General public, communities with carbon mitigation
- Secondary schools
- Policymakers/negotiators
- Your organization?

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# What’s Next?

- Looking into possibility of computer version of the game
- Seeking input to improve the assumptions
- Exploring how this could be used in conjunction with other outreach and awareness raising efforts
- Continued and more detailed analysis of results

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