



Wedge Game

Multiple Disciplines

Goal: The Wedge Game is an activity of the Carbon Mitigation Initiative (CMI) of the Princeton Environmental Institute. Permission to use the activity is granted with the caveat that data be shared with CMI. The goal and purpose of the activity as stated by CMI is:

- “To provide hands-on experience with the challenges involved in cutting emissions, CMI developed the “Stabilization Wedge Game” in 2004. It was first used for CMI’s annual meeting, where it was played by 50 players from industry, academia, and the non-profit sector. Subsequent games have been carried out with players from a variety of backgrounds, and the game is adaptable for use with different audiences.”
- “The goal of the game is to build a plausible and politically acceptable portfolio of strategies to keep global carbon emissions flat for the next 50 years. Teams can choose to use each strategy more than once, but must consider the potential physical and economic limitations of each strategy.”

Note: *The activity can be used as it is written by CMI or as it has been modified below.*

Objectives: Students will...

- Develop an understanding of each strategy and their impact
- Problem-solve to find the most sustainable choice for their triangle

Materials (for a class of 30):

- Refer to the CMI activity for a list of materials
- OR for the modified version, you will need:
- Wedge Game-PowerPoint
- 30 copies of Wedge Game-Student Sheets
- 30 copies of Wedge Game-Stabilization Triangle Template
- Wedge Game-Teacher Sheet

Time Required: Two, 45-60 minute class periods

Standards Met: S1, S6, LA4, LA5, C4, C5, E1, G1, G5, WH9

Procedure:

- Review the document, [Wedges_Concept_Game_Materials_2005.pdf](http://www.princeton.edu/~cmi), to implement this activity in the classroom OR visit this website to access the activity: <http://www.princeton.edu/~cmi>

If you are implementing the modified version:

- Review the guidelines for the game on the Wedge Game-Teacher sheet.
- Divide students into groups of 3 (country groups).
- Present the idea of the Stabilization Triangle using the Wedge Game-PowerPoint.
- After showing the PowerPoint, provide students with this scenario:

- The chairperson of the Global Nations International Climate Summit (GNISC) invites and challenges each country to create the Stabilization Triangle using different strategies known as Strategy Wedges.

Note: This exercise is designed to address climate change using a global perspective and may provide some additional alternatives when each country seeks to find solutions that affect them directly.

- Review the guidelines and concepts on the Wedge Game-Teacher Sheet.
- Hand out the Wedge Game-Student Sheets to each group and let them begin making their Strategy Wedge choices.
- After students have made their Stabilization Triangles, ask them to bring them to the Global Nations International Climate Summit (GNISC) representative (you or a volunteer). Post triangles around the room.
- Give students the Wedge Game-Decision Grid & Sustainability Ratings. They will use the ratings to determine the overall sustainability of their Stabilization Triangle.
- Briefly review each triangle and its sustainability ratings.

Debrief:

- Discuss what it means to use a strategy wedge more than once. For example, if the Efficiency-Transportation strategy wedge is used more than once that means all cars would need to go from 30 mph to 90 mph OR from 30mph to 60 mph and drive ½ as much. These are social, political and economic factors that should be considered.
- Discuss the idea that there is no single method to mitigate increases in CO₂ emissions. For example, it is impossible to stabilize emissions using only wind or solar power.

Assessment:

- Participation in the activity
- Completed Wedge Game-Student Sheet
- Completed Wedge Game-Stabilization Triangle



Wedge Game-Teacher Sheet

Below are the guidelines for playing the modified version of the Wedge Game. To play the CMI version, refer to the pdf file listed in the materials list. You may also want to refer to both the PowerPoint and CMI version to learn more about the Stabilization Triangle concept.

- The Stabilization Triangle is made of 7 total Strategy Wedges. Students will choose their Strategy Wedges from a list of 15 on their Wedge Game-Student Sheet.
- Teams are allowed to use Strategy Wedges more than once.
- There are 4 sectors of Strategy Wedges: Energy, Heat, Transportation and Other; students can also create one wedge that may not be in the list.
- Teams **MUST** choose Strategy Wedges from at least **TWO** sectors.

PART ONE:

- Teams create their Stabilization Triangles with information on the Wedge Game-Student Sheet.

PART TWO:

- When teams have completed the Stabilization Triangle and handed it in, give them the Wedge Game-Decision Grid & Sustainability Ratings sheet.
- Ask teams to correlate their 7 strategy wedge choices with the sustainability ratings.
- They will then average all of their sustainability ratings to complete a decision grid for their team's Stabilization Triangle.
- When each team has completed their decision grid, post it next to their Stabilization Triangle.
- Discuss any differences they might make based on their decision grid results.
- Sustainability ratings were based on the list of criteria shown on the Wedge Game-Student Sheet. If time allows, consider listing detailed facts regarding each criteria as it relates to the strategy wedge.



Wedge Game-Wedge Descriptions

Below are tables for each sector.

ENERGY SECTOR

Strategy Wedge	Description	Action	Challenges
Coal to Natural Gas-Electricity	Replace coal-burning electric power plants with natural gas plants	1 Strategy Wedge will require an amount of natural gas to be used equal to that used for all purposes today	Natural Gas Geopolitics !
Coal to Wind-Electricity	Wind displaces coal at 50 times current capacity	1 Strategy Wedge will require area equal to ~3% of U.S. land area; ~6% of U.S. land area is suitable for wind development	Regional Climate Change, NIMBY !
Coal to Solar-Electricity	Solar PV displaces coal at 700 times current capacity	1 Strategy Wedge requires the equivalent of a 100x200km panel; An area 7% Colorado or greater than the total land area of New Jersey would supply enough energy for an entire wedge	Solar Cell materials !
Carbon Capture and Storage (CCS)-Electricity	CO ₂ from fossil fuel power plants stored and captured	1 Strategy Wedge will require injecting a volume of CO ₂ every year equal to the volume of all oil extracted	CO ₂ leakage !
Nuclear Electricity	Displace coal-burning electric plants with nuclear plants at 2 times current capacity	1 Strategy Wedge is ~3 times the effort France put into nuclear expansion in a typical year in the 1980's, (the government built 56 reactors in 15 years) sustained for 50 years	Proliferation, nuclear waste, NIMBY !!!

HEAT SECTOR

Strategy Wedge	Description	Action	Challenges
Coal to Natural Gas-Heat	Substitute natural gas for domestic heating or industrial processes	A wedge may be available from displacement of coal in all home heating or all industrial processes	Natural Gas geopolitics !
Efficiency-Heat	Increase insulation, furnace efficiency	1 wedge could be achieved by using best available technology in all new and existing buildings	House size !

TRANSPORTATION SECTOR

Strategy Wedge	Description	Action	Challenges
Produce Hydrogen through CCS	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 !!
Produce Hydrogen using Nuclear Energy	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 1980s, sustained for 50 years	proliferation, nuclear waste, NIMBY !!!
Produce Hydrogen using Wind Energy	Produce hydrogen with wind electricity	1 wedge would require that half the world's cars predicted for 2050 be powered by H ₂	Regional Climate Change, NIMBY !
Efficiency-Transportation	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 (or cutting miles driven in half)	Car size & power, Urban design !
Biofuels-Transportation	Biomass fuels from plantations replace petroleum fuels	1 wedge requires 2 billion cars onethand, using 1/6 of world cropland	Biodiversity, competing land use !

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OTHER SECTOR

Strategy Wedge	Description	Action	Challenges
Agricultural Practices	Storage in soils	1 wedge would expand conservation tillage to 100% of all cropland. Less than 5% of global cropland is currently no-till.	Certain crops do not do as well competing with other species! !
Natural Sinks	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! !

Make your own			
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Wedge Game-Student Sheet

Name: _____ Date: _____

Directions: Review the guidelines below to complete your Stabilization Triangle.

Guidelines:

PART ONE

1. Each strategy wedge represents a reduction of 25 billion tonnes of carbon emissions over 50 years.
2. Choose a total of 7 strategy wedges to comprise your Stabilization Triangle.
3. Review the strategy wedge descriptions on the Wedge Game-Wedge Descriptions sheet.
4. You **MUST** choose strategy wedges from more than one sector. Sectors include: Energy, Heat, Transportation and Other.
5. You can use strategy wedges more than once.
6. You can only create **ONE** additional strategy wedge.
7. Write in your strategy wedge choices in Table 1.
8. Write the name of your strategy wedge choices in each wedge of the Stabilization Triangle. Use the colored pencils to shade each wedge according to the Key.
9. Present your Stabilization Triangle to the Global Nations International Climate Summit (GNISC) Representative.
10. Get the Wedge Game-Decision Grid & Sustainability Ratings from your teacher.

PART TWO

1. Complete the Wedge Game-Decision Grid & Sustainability Ratings sheet.
2. Submit your final decision grid to a Global Nations International Climate Summit (GNISC) Representative.

See the Table 1 on the next page.

TABLE 1:
Complete the table below when you've chosen your strategy wedges.

Strategy Wedge #	Strategy Wedge Description	Sector (E, H, T or O)	Sustainability Rating	Challenges (!)
1			Env: SE: Econ:	
2			Env: SE: Econ:	
3			Env: SE: Econ:	
4			Env: SE: Econ:	
5			Env: SE: Econ:	
6			Env: SE: Econ:	
7			Env: SE: Econ:	
TOTALS		E= H= T= O=	Env: SE: Econ:	(Add all ! and put # here)



Wedge Game Decision Grid & Sustainability Ratings

Use the information below to fill in the Sustainability Ratings column in Table 1.

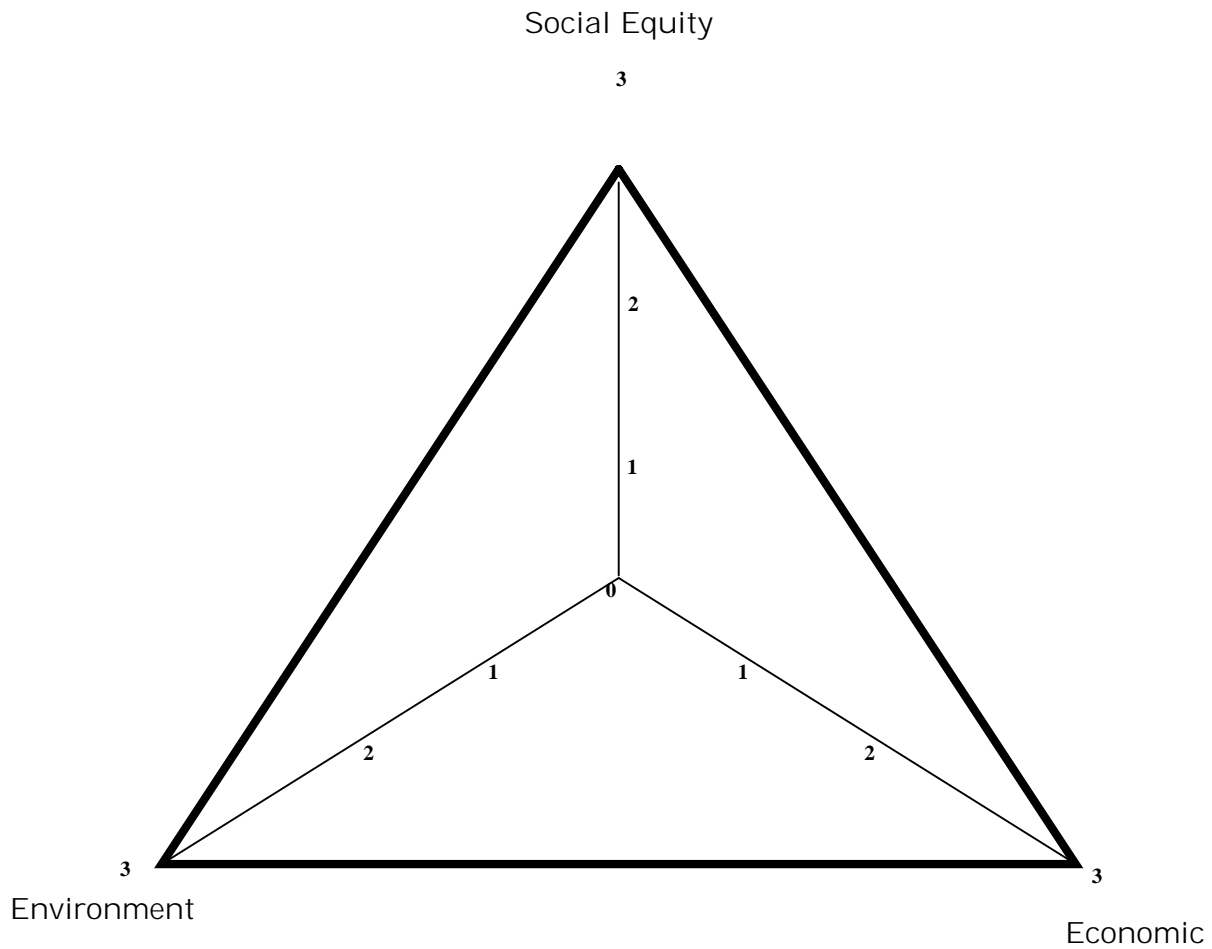
Energy Sector		Heat Sector		Transportation Sector		Other Sector	
Strategy Wedge	Sustainability Rating	Strategy Wedge	Sustainability Rating	Strategy Wedge	Sustainability Rating	Strategy Wedge	Sustainability Rating
Coal to Natural Gas Electricity	Env. 2 SE 3 Econ 3	Coal to Natural Gas Heat	Env. 2 SE 3 Econ 3	Produce Hydrogen through CCS	Env. 2 SE 2 Econ 1	Agricultural Practices	Env. 3 SE 2 Econ 2
Coal to Wind Electricity	Env. 2 SE 1 Econ 2	Efficiency-Heat	Env. 2 SE 3 Econ 2	Produce Hydrogen using Nuclear Energy	Env. 2 SE 1 Econ 1	Natural Sirks	Env. 1 SE 2 Econ 1
Coal to Solar-Electricity	Env. 2 SE 2 Econ 1			Produce Hydrogen using Wind Energy	Env. 2 SE 1: Econ 2	Other: Make your own!	
Carbon Capture and Storage (CCS)-Electricity	Env. 2 SE 2 Econ 1			Efficiency-Transportation	Env. 3 SE 2 Econ 2		
Nuclear Electricity	Env. 3 SE 1 Econ 1			Biofuels-Transportation	Env. 2 SE 2 Econ 2		

Complete the following:

1. Find the average of each E for sustainability ratings.
Example: Add up all of your ratings for Environment and divide by 7. List your averages in the space below.

Environment: _____
Social Equity: _____
Economics: _____

2. Graph your averages for sustainability in the grid below. This shows the overall sustainability of your Stabilization Triangle.



Criteria for Sustainability Ratings:

Economics

- Promote diversification of the local, national, and global economy
- Improve opportunities for new and existing businesses
- Sound from a financial and human resource perspective
- Prevent net economic returns from negatively impacting the health and well being of society or environment
- Promote transfer of skills or technologies, which protect the environment, add value to human endeavor, and improve the region's economic viability

Environment

- Take into consideration the carrying capacity, keeping levels of pollution, consumption, and populations size within the environment's ability to handle them
- Maintain or enhances ecosystem functions
- Reduce resource consumption
- Focus on preventing wastes and pollution
- Promote use-reduction, renewable energy, and greater efficiency in the use of energy resources

Social Equity

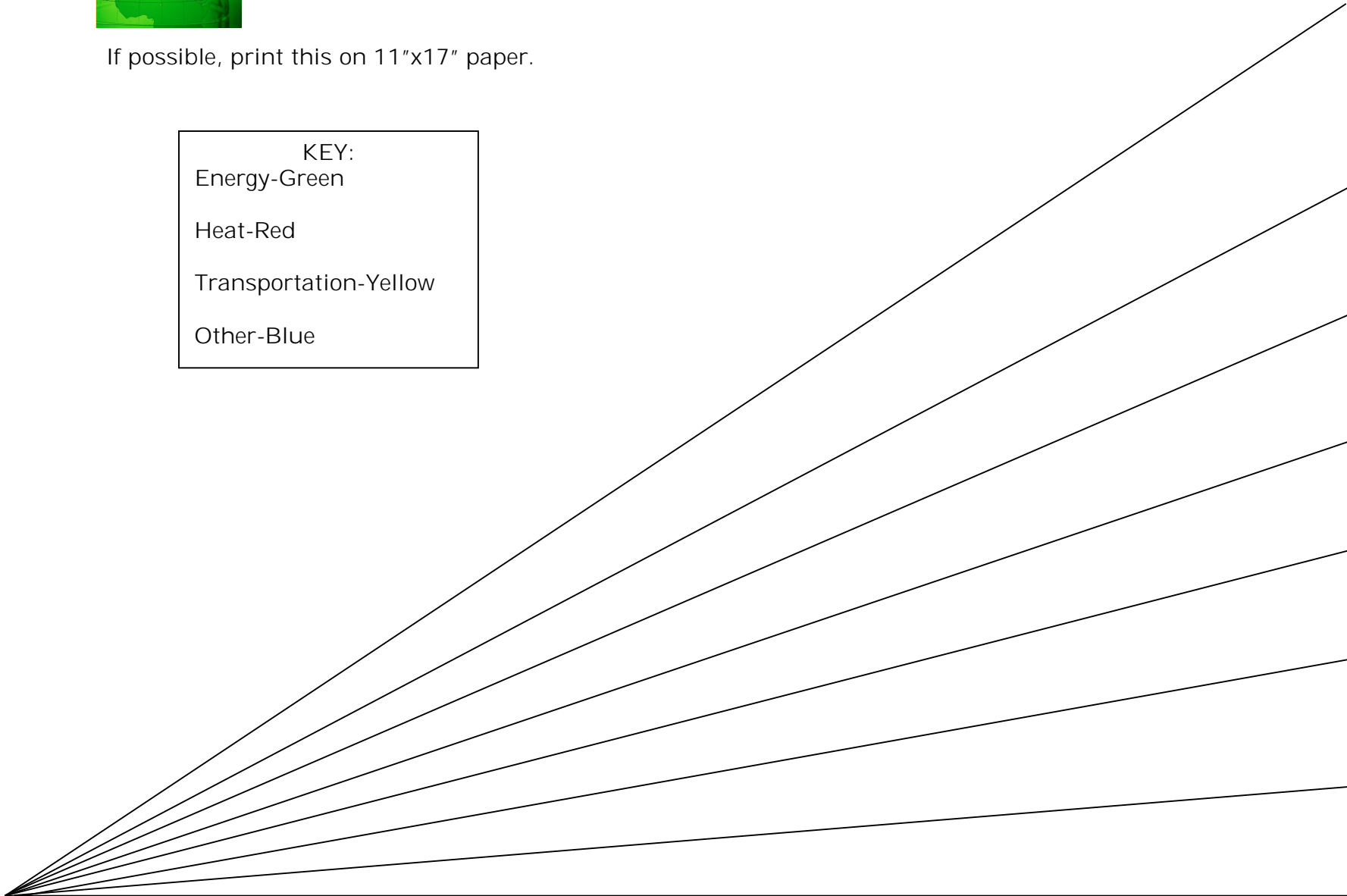
- Consider the health and well being of all stakeholders
- Represent the wishes of the majority of citizens
- Distribute benefits fairly to all stakeholders
- Consider the well being of all members who will inherit the impacts
- Improve the sense of safety and security



Wedge Game-Stabilization Triangle Template

If possible, print this on 11"x17" paper.

KEY:
Energy-Green
Heat-Red
Transportation-Yellow
Other-Blue





Wedge Game-Student Sheet

Name: _____ Date: _____

Directions: Review the guidelines below to complete your Stabilization Triangle.

Guidelines:

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1. Each strategy wedge represents a reduction of 25 billion tonnes of carbon emissions over 50 years.
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PART TWO

1. Complete the Wedge Game-Decision Grid & Sustainability Ratings sheet.
2. Submit your final decision grid to a Global Nations International Climate Summit (GNISC) Representative.

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Wedge Game Decision Grid & Sustainability Ratings

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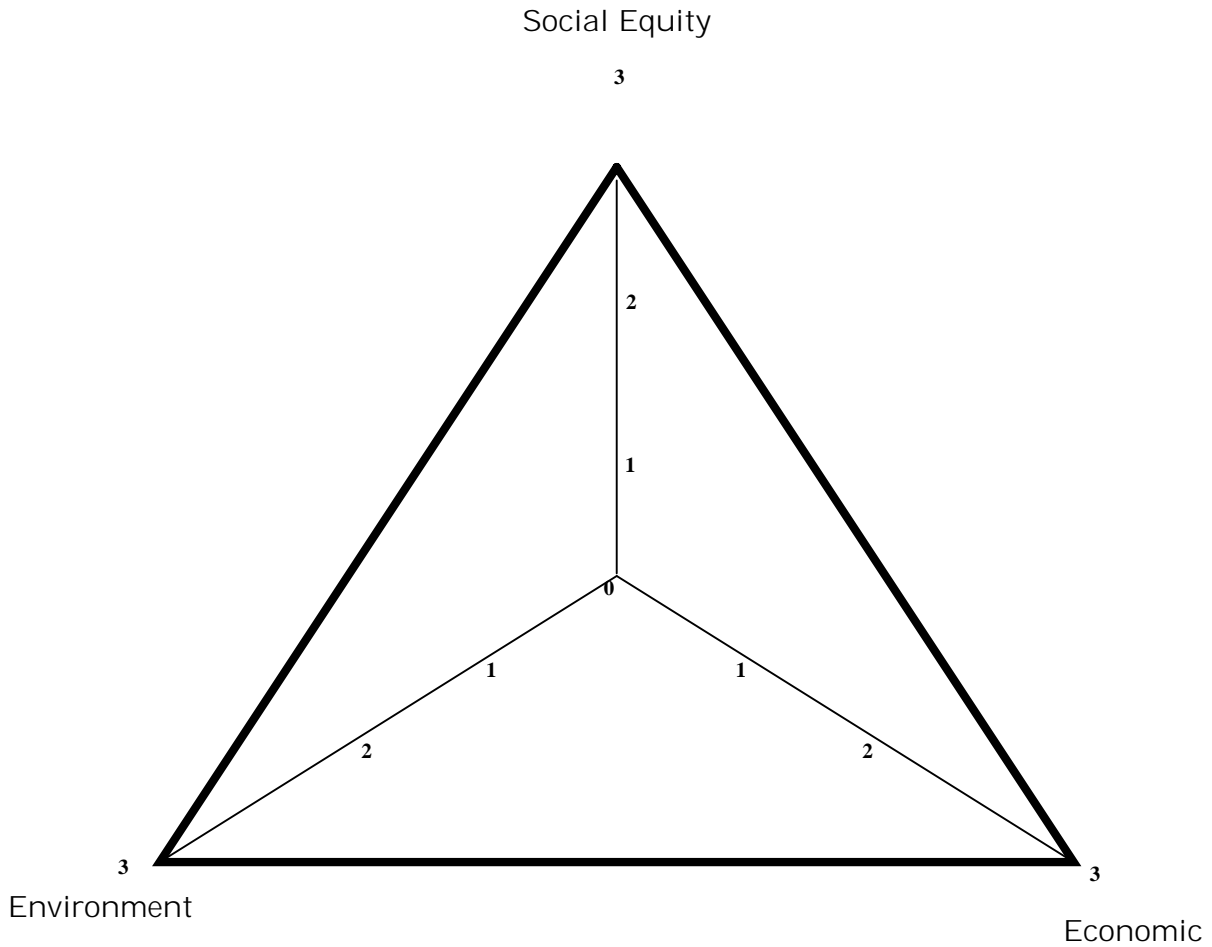
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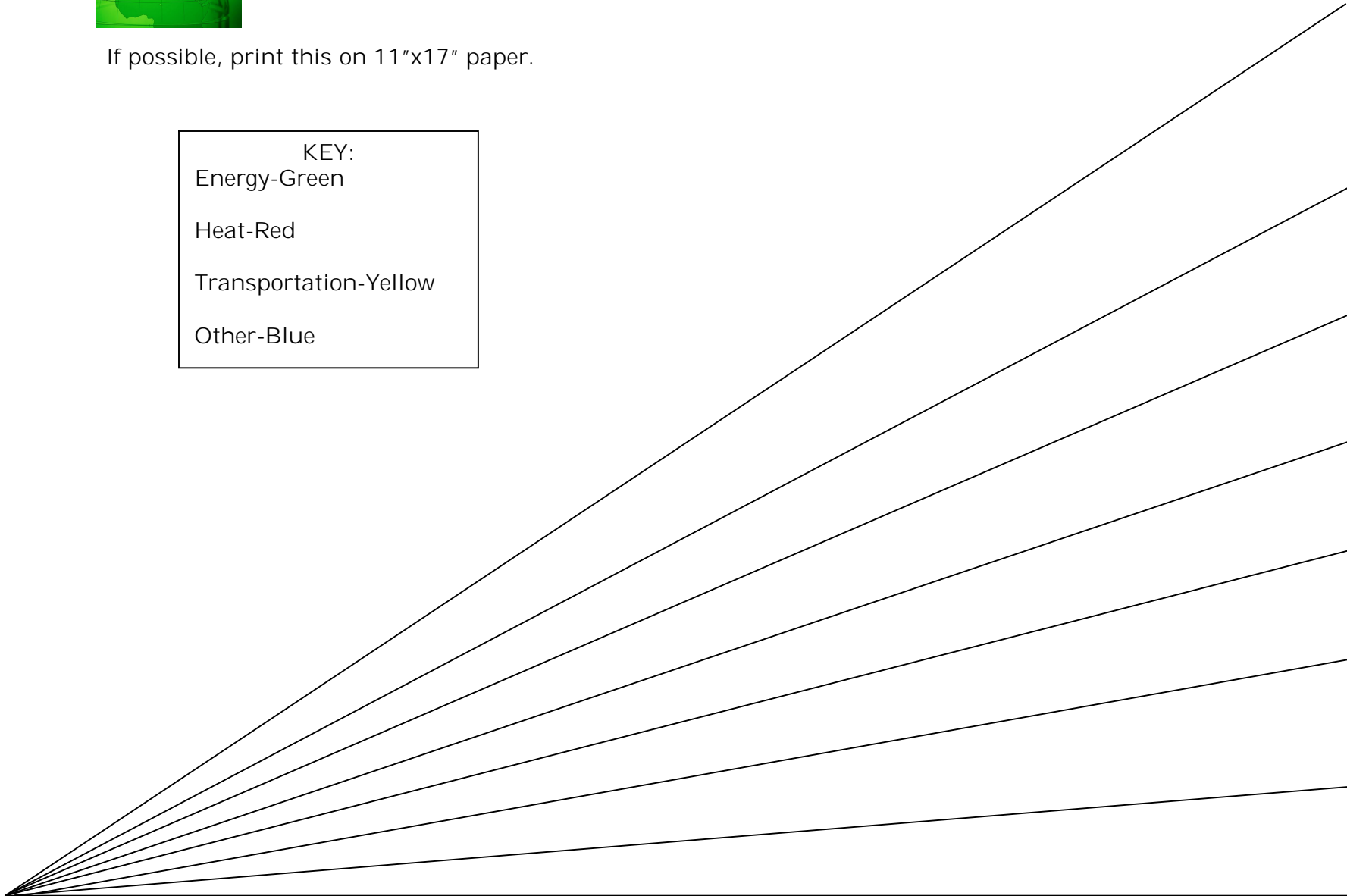
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CSI: Climate Status Investigations-High School
REPRODUCIBLE