Climate Solutions Project: Losing 10,000 lbs (of CO_2 emissions) in 10 weeks or less

Use this handout as a resource for brainstorming a climate change solution project and developing your project system map.

This version of the handout includes a step-by-step example of a student-led project, Meatless Mondays, in green. Use the Meatless Mondays example to practice systems thinking and quantify your project's impact.

Guiding questions: What is your target?

Your goal is to reduce emissions of heat-trapping gases by 10,000 lbs CO_2-equivalents (CO_2-e) over a 10-week period by designing a project that can be implemented over the next few weeks or months in your school or community. There are many approaches to reducing CO_2-e emissions by 10,000 lbs and many scales or levels of organization you could target. For example, you could develop a project to:

- Change the behavior of students or other individuals (their parents? friends? a dorm?) to reduce emissions;
- Implement a new program or incentive at your school;
- Implement a new policy or incentive program in your community or city; or
- Expand the reach of currently available incentives or policies (e.g., does your state already have rebate programs for home energy efficiency that are under-utilized? Are there bike lanes in your community that few people use?)

The sectors and information available through Project Drawdown can be a great source of project ideas. Drawdown sectors include:

- Buildings and Cities
- Energy
- Food
- Land Use
- Materials
- Transportation
- Women and Girls

Keep in mind that Project Drawdown describes solutions at a global scale. For your project, you will need to focus on actions you can take at your school or in your community. Together, local actions around the world can generate the global action needed to address the climate challenge. You can find resources for local, state, and national climate solutions here: https://climatechangeinitiative.org/engage/students-get-involved/. Let's look at the criteria you should keep in mind as you brainstorm ideas.

Project Guidelines and Criteria

Once you have brainstormed and decided on a project theme (i.e., the Drawdown solution you would like to act on locally), ensure your project theme can be developed further to speak to the criteria below.

Competency	How Competency is Demonstrated in Final Project
Understanding Systems and applying the Habits of a Systems Thinker	Display Evidence of how the Habits of a Systems Thinker were applied to the research
Empathetic Understanding of World Climate Issues	Discuss your connection to the climate system and to others within the system.
Climate and Carbon Cycle System Literacy	Explain how your solution addresses the causes and impacts of climate change.
Introductory Stella Competency	Create a simulation model that demonstrates how your project would reduce 10,000 lbs. of CO_2-e in 10 weeks
Knowledge of Drawdown Solutions at the Global and Local Levels and how relates to Green Work and Lifestyle	Refer to Drawdown and your research into Green Work to make connections between global impacts and action in your community.
Demonstrated Preparation and Communication of a Solutions-Based Project	Articulate next steps to be taken, demonstrating how multiple perspectives were considered in the communication of the problem and benefits of action

Developing a System Map

A key step of the process is to determine the scale or level of activity that will be required to meet or exceed the 10,000 lbs CO_2-e emissions reductions goal. A bonus would be if the project has the potential to further reduce emissions in the future. Considering that the scale of action you choose has an impact on the other elements of your project, begin by modeling your proposal with your team to quantify the potential emissions reduced. See how your initial plan might have to evolve to meet the 10,000 lbs challenge!

Note that you can convert 10,000 lbs CO_2/10 weeks to the more commonly used units of metric tons/year using the following formula:

$$\frac{10{,}000\ lb\ CO_2}{10\ weeks} \times \frac{1\ ton\ CO_2}{2204.6\ lb\ CO_2} \times \frac{52\ weeks}{1\ year} = \frac{24\ ton\ CO_2}{year}$$

The term 'CO_2-e' refers to 'CO_2 equivalents,' or a way to express the emissions of any heat-trapping gas in terms of the amount of CO_2 emissions that would cause the same level of warming. For example, nitrous oxide (N_2O) is a heat-trapping gas that is 298 times more powerful than CO2 per unit mass. So, in order to convert 1 metric ton N_2O/year emissions to CO2 equivalents, you use the following formula:

$$\frac{1\ ton\ N_2O}{year} \times \frac{298\ ton\ CO_2e}{1\ ton\ N_2O} = \frac{298\ ton\ CO_2e}{year}$$

Use your STELLA modeling experience to frame your problem

Your goal for this activity is to develop a visual representation of your team's shared understanding of the system and the impact of your project on that system. You will develop both a Stock and Flow Diagram (SFD) and Causal Loop Diagram (CLD) that illustrate the key stock(s), flows, important variables that they interact with, and any feedback loops that can affect change. Your team will use these diagrams to develop a shared understanding of your system and to communicate about your project with others.

Project worksheet

1. **Project title**

Give your project a simple, easy-to-remember name that captures the key idea.

Go Meatless!

2. **Your project goal: clearly explain your team's goal in one sentence.**

The first step in any project is to clearly define your goal. What will your project accomplish (in addition to reducing emissions by 10,000 lbs)? How? Why? What will occur if your project is successful? A clear project goal will guide your team's work and is also critical for explaining your project to others.

Our project will demonstrate how implementing a Meatless Mondays program at our school reduces CO_2-e emissions by more than 10,000 lbs in 10 weeks while saving money and encouraging students to go meatless more often.

3. **What are the key variables in your project system? What factors are likely to affect your project outcomes?**

Working individually, spend **two minutes** brainstorming variables that are important in your project system. Each team member should write down variables in a shared document or space so everyone can see them. Work together to narrow down the variables that are important in your project system, clearly name each one and list their units of measure. Note that you should avoid qualifiers that indicate direction of change or whether something is positive or negative (e.g., use 'number of cyclists' instead of 'increasing cyclists'). You can edit variables later – the purpose of making this list is to help you consider the different components of the system that you might want to include in your model later. For each variable you include, make sure to also include units of measure.

Variable name	Unit of measure
Number of people who eat at school	***People***
Number of meals per week	***Meals/week***
Number of meals with meat	***Meals***
Number of meatless meals	***Meals***
Effectiveness of outreach program	***Dimensionless***

4. **Which variables are the key stocks in your system?**
Stocks are variables that accumulate or decline over time. They are often called 'state variables' because they describe the state of the system at any given time. Work as a group to decide which stock is the most important indicator of your system's state. Note that you should include a key stock **other than cumulative CO2e emissions reduced**. Which stock indicates the level of progress towards your project goal?

Number of meatless meals ***is a key stock in our system because as the number of meatless meals grows, so does the amount of CO_2 emissions that are reduced. If we are successful in growing the number of meatless meals rapidly, the program may become more popular over time and lead to even more emissions reductions.***

5. **Sketch a graph showing how you expect the key stock(s) in your system to behave over time.**

Draw a horizontal axis representing time and a vertical axis indicating the level of the key stock at a given time. The time axis should begin at some time in the past, reach the current time, and then extend to a future time when your project goal will be reached. Your time range should extend far enough into the past to establish the current behavior of the stock. Draw your estimate of the stock's past behavior over time on the graph. When drawing your graph, consider the following questions:

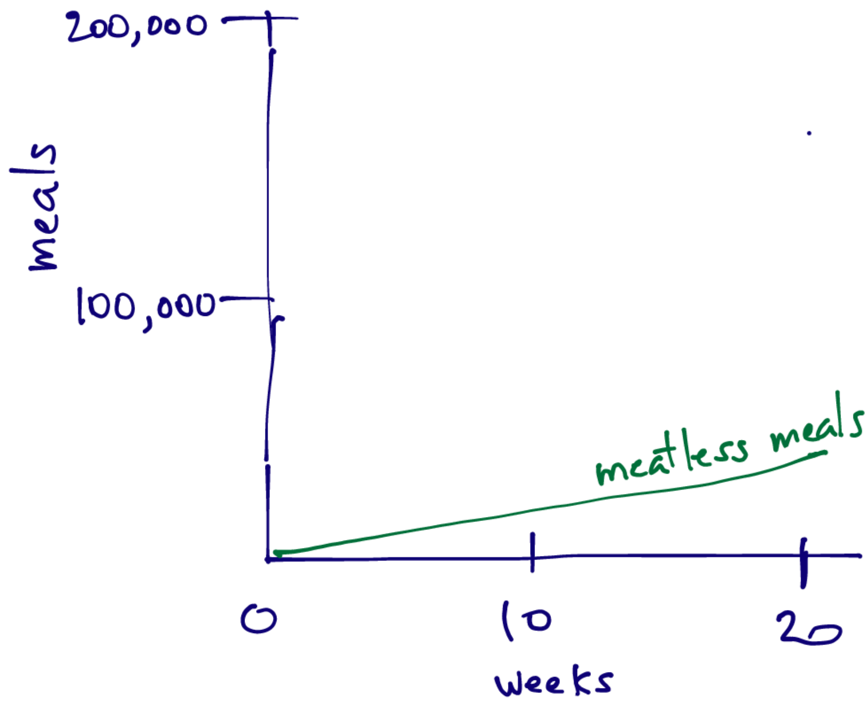
- **At what level was this stock at the beginning of the time represented on this graph? Why?** What is the pattern of its behavior from the past to the present – i.e., does it grow exponentially? Decline exponentially? Oscillate?
- **At what level is the stock today? Why?** For now, rough estimates of these levels are sufficient.
- **If your project is not implemented, how do you think the stock will change in the future?** Draw a line representing this expected behavior over time.
- **Next, consider how you would expect the level of the stock to change over time if your project is implemented**. Will it grow exponentially? Decay exponentially? Follow a logistic growth pattern? Sketch a line representing stock behavior under project implementation.

Make sure you are able to use your graph to tell the story of your project's impact.

Our school has about 2,000 students and we assume that all of the students eat lunch at school, 5 days per week. While our goal is to reduce emissions by 10,000 lbs CO_2-e over 10 weeks, we are extending our graph to 20 weeks so that we can think about the impact of the project over a longer time. If all of the students eat meat, then without our project, we would expect the total number of meals they eat in 20 weeks to be:

2,000 students x (1 meal/day per student) x (5 days/week) x 20 weeks = 200,000 meals in 20 weeks

If we implement a Meatless Monday program, every student will eat 1 meatless meal/week, or 2,000 students x 1 meal/week x 20 weeks = 40,000 meatless meals over 20 weeks.

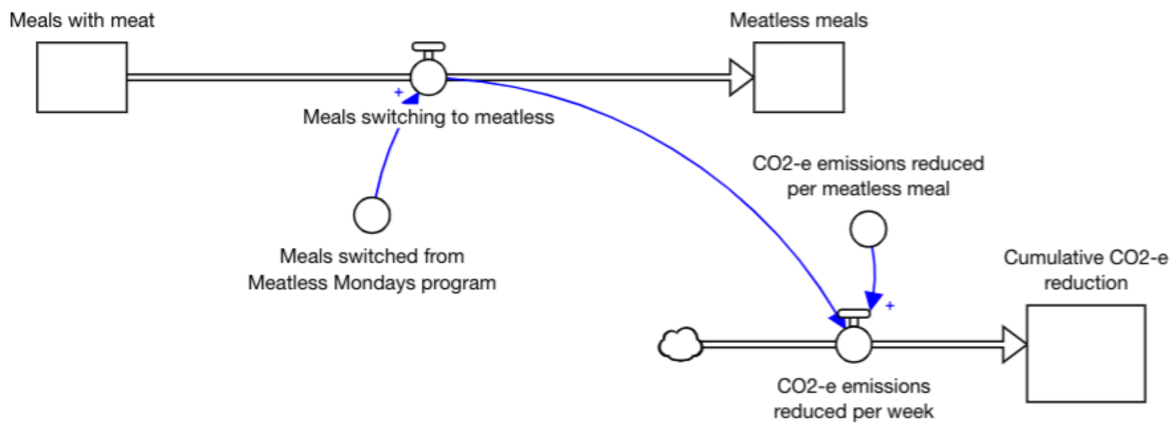


6. **Build your stock and flow diagram**

Your next step will be to build a map of the system structure in the form of a stock and flow diagram. Through an iterative process, you will use that map to identify, illustrate, and improve your planned intervention. First, draw your diagram on paper. You can then create a version in STELLA that will enable you to enter formulas and simulate a model.

- Start with the **key stock you identified in the section** above**. What are the flows into and out of that stock?** Working in a shared space with your team, sketch the stock and its flows.
- Be sure to make note your start and stop time and time units, as well as the units you will use for each element of your model.
- Make sure you use your documentation space to explain what variables mean
- Add **CO_2-e emissions reduced per week** as an inflow into the stock, **cumulative CO_2-e reductions.** What is the equation for **CO_2-e emissions reduced per week?**

If you are building your first draft in STELLA, are you able to simulate the model yet? If yes, look at the graphs for your main stock and the Cumulative Emissions Reduced stock. If no, check where you may have equation or unit errors.



Since our key stock is Number of meatless meals (meals), switching meals (meals/week) *is the inflow. Our unit of measure for time is weeks and our start and stop time are 1 and 20 weeks, respectively. To quantify* the Cumulative CO_2-e Emissions Reduced (lbs of CO_2-e), *we need to first determine CO_2-e emissions reduced per meatless meal (lbs CO_2-e /meal).*

According to the "Meatless Modays: Do They Really Help?" website (https://www.meatlessmonday.com/benefits/), eating meat emits 36 lbs CO_2-e/day while *eating vegetarian emits 14 lbs CO_2-e /day. If we assume that on an average school day students eat 1/3 of their daily food intake at school, emissions saved per day for going meatless are determined by the amount of CO_2-e emitted per day eating meat minus the amount of CO_2-e emitted day eating meatless divided by 3 meals per day, or:*

(36 lbs CO_2-e/day - 14 lbs CO_2-e/day)/(3 meals/day) = 7.33 lbs CO_2-e /meal.

So, for the converter, CO_2-e emissions reduced per meatless meal*, we enter the value 7.33 with units of* lbs CO_2-e /meal*. The equation for* CO_2-e emissions reduced per week *(lbs CO_2-e /week) is the product of* Switching Meal Type *and* CO_2-e emissions reduced per meatless meal*:*

CO_2-e emissions reduced per week = Switching Meal Type x CO_2-e emissions reduced per meatless meal

If the program is implemented, then Meals switched from Meatless Mondays Program *is 2,000 students x 1 meal/week per student = 2,000 meals/week.*

7. **Consider other parts of the system: what else influences your key stock(s)? Are there any feedback loops that you should consider?**

Note: you do not have to build and simulate this feedback loop into your STELLA model, but it should relate to your central stock. Before you identify an existing or potential loop in your model review what you know about feedback loops.

In a feedback loop, there is a closed chain of causal connections from a stock, through a set of decisions or processes that are dependent on the level of the stock, then back through a flow to change the stock.

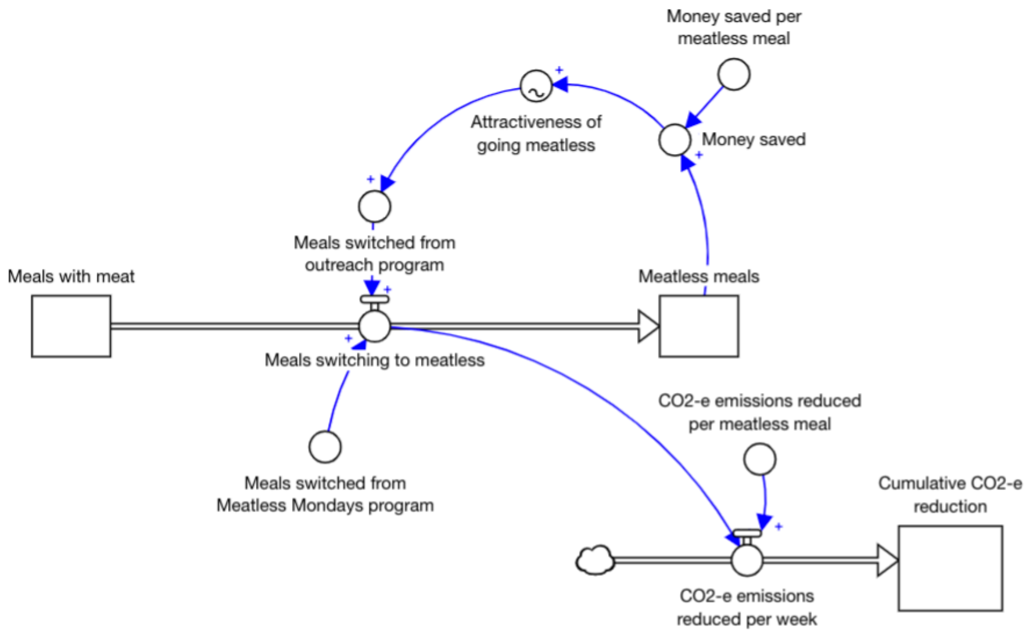
- Reinforcing feedback loops lead to accelerating change: E.g., vicious or virtuous cycles; downward spiral; snowball effects. They have an even number (or no) negative links and generate exponential growth or decline.
- Balancing feedback loops generate goal-seeking or oscillating behavior. They have an odd number of '-' links (note that an outflow can also be represented as a causal link from the outflow to the stock with a '-' polarity; i.e., all else equal, increasing the rate of an outflow causes a greater decline in its stock).
- In your own system diagram, label the type of loops ('B' for balancing and 'R' for reinforcing), and name the loops.

We learned that eating meals without meat saves money – for example, if a family of four switches one meal from meat lasagna to vegetarian lasagna, they save about $10/meal, or $2.50/person per meal. If the money saved from meatless meals was accounted for and combined with an outreach program that shared the benefits of saving money with students, we think that going meatless could become more attractive, causing more meals to be switched to meatless.

We added variables to our system to represent the benefits of an outreach program, including:

- **Money saved per meatless meal ($2.50/meal);**
- **Money saved (Meatless meals x Money saved per meatless meal; $);**
- **Attractiveness of going meatless (dimensionless; *a measure of how attractive going meatless becomes as more money is saved and those savings are shared with students);***
- **Meals switched from outreach program (meals/week).**

As the number of meatless meals grows over time, so does the amount of money saved and the attractiveness of going meatless, leading to a reinforcing feedback loop.


Money saved per meatless meal
Attractiveness of going meatless
Money saved
Meals switched from outreach program
Meals with meat
Meatless meals
Meals switching to meatless
CO2-e emissions reduced per meatless meal
Meals switched from Meatless Mondays program
Cumulative CO2-e reduction
CO2-e emissions reduced per week

Appendix. Research Resources

If you are interested in reducing emissions through behavior change at the individual level, you will likely find it helpful to calculate your own carbon footprint (or a friend's or family member's) in order to better understand key activities that generate GHG emissions and opportunities for reducing those emissions. There are many carbon footprint calculators. Two calculators that do not require you to collect detailed information beforehand are:

- https://coolclimate.berkeley.edu/calculator (note that this website also has a calculator for businesses)
- https://www.carbonfootprint.com/calculator1.html (also has a business level calculator)