Math Model Demonstrating Costs and Benefits of Canton Central School District Cooperating with Local Farms with Anaerobic Digesters

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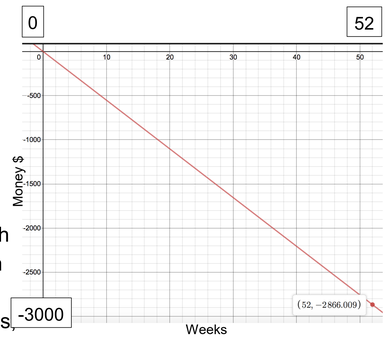
Background

- *Clarkson Food To Energy Project*
  - Cooperation between Canton Central School, Cornell Cooperative Extension, and Clarkson University
- *Goals*
  - Teach Canton students about Anaerobic Digestion (AD)
  - Take care of food waste in an environmentally and economically sustainable way
  - Field trips to see anaerobic digesters
- *Projects*
  - Food waste collection in school cafeteria
  - Developing activities and experiments for students
  - Teaching Canton students in the classroom
- *This Project*
  - Food waste is transported to local farms with anaerobic digesters
  - Then converted into biogas, fertilizer, and bedding
  - Gas can be used for things like heating and cooking or electricity
- *Model Created*
  - This economic model created to represent the loss or gain of money due to the program
  - The software used to make this was Desmos, and it is a free online graphing tool
    - The link to this specific graph is: https://www.desmos.com/calculator/dpl7asddg

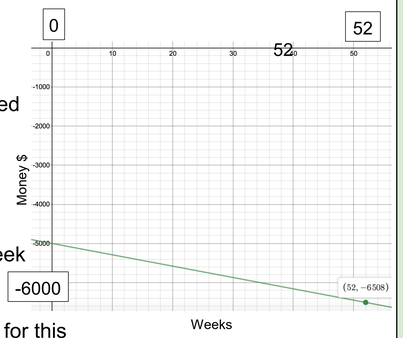
Food Waste to Landfill

- This model is a representation of how much money the school loses from throwing food waste away
  - Food waste, in this case, is valued just for the cost of throwing it away
- The Equation used for this graph is:
  - $N(x) = -((\mathbf{T}/907.185) \cdot \mathbf{F} \cdot \mathbf{x})$
- **x** is the number of weeks
  - Time
- **F** is the amount of food waste being collected
  - Currently 200 kg of food waste is being collected per week
- **T** is the tipping fee for one ton of trash
  - It costs $250 to dispose of one ton of trash
  - Because food waste is in kilograms, the conversion of tons to kilograms is 907.185 kg a ton



Composting at School

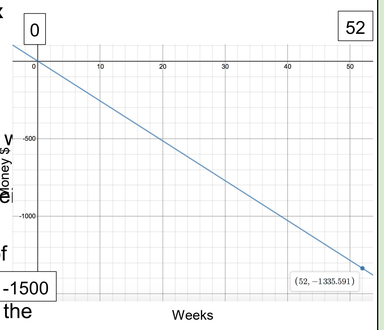
- This plan represents how much money it would cost the school to implement and maintain a composting system on campus
- The equation for this model is:
  - $P(x) = \mathbf{-C} - (\mathbf{H} \cdot \mathbf{W})\mathbf{x} + \mathbf{AF}\mathbf{x}$
- **x** is the number of weeks
  - Time
- **F** is the amount of food waste collected per week
  - Currently 200 kg of food waste is being collected per week
- **C** is the cost of a composting system
  - The estimated price is $5000
- **H** is the hours of work needed per week
  - Currently estimated at 5 hours
- **W** is the wages paid per hour
  - $15 an hour is the wage assumed for this
- **A** is the selling price of a kilogram of compost
  - 1 kg of compost is worth $0.23
    - This value was derived from the cost of compost locally at the Potsdam Agway



AD School's Perspective

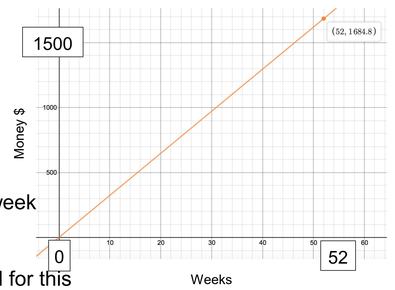
- This plan represents how much money it would cost the school to transport the food waste to a local anaerobic digester
- The equation for this graph is:

  $S(x) = -((\mathbf{DM}) + \mathbf{WH}))\mathbf{x} + (\mathbf{T}/907.185)\mathbf{Fx}$
- **x** is the number of weeks
  - Time
- **F** is the amount of food waste being collected per v
  - Currently 200 kg of food waste is be
- **T** is the tipping fee for one ton of trash
  - It costs $250 to dispose of one ton of t
  - Because food waste is in kilograms, the conversion of tons to kilograms is 907.185 kg a ton
- **D** is the driving cost per mile
  - $0.58 per mile paid
- **M** is how many miles driven to the farm and back
  - 10 miles are driven for the trip
- **H** is the hours of work needed per week
  - Currently 5 hours of work are needed
- **W** = Wages paid per hour ($/Hour)
  - $15 an hour is the wage assumed for this



AD Farmer's Perspective

- This plan represents the money the farmer would lose from taking in more food waste as well as the money they would gain
  - More time has to be put in to supervise the arrival of food waste
  - More biogas and effluent created due to increased food waste intake
- The equation for this model is:
  - $V(x) = (\mathbf{-HW} + (\mathbf{KFB}) + (\mathbf{EFG}) + \mathbf{IF})\mathbf{x}$
- **x** is the number of weeks
  - Time
- **F** is the amount of food waste being collected
  - Currently 200 kg of food waste is being collected per week
- **H** is the hours of work needed per week
  - Currently estimated at 5 hours
- **W** is the wages paid per hour
  - $15 an hour is the wage assumed for this
- **K** is the ratio of bedding to food waste
  - 0.025 kg of bedding is produced per kg of food waste
- **B** is the cost of bedding
  - $0.06 per kg of bedding
- **E** is the electricity produced per kg of food waste
  - 0.555 kWh of electricity is produced per kg of food waste
- **G** is the cost of electricity
  - It costs $0.10 per kWh of electricity
- **I** is the cost of fertilizer
  - $0.38 per kg of fertilizer



Comparing All

- The farmer gains the most resources from AD, which is why the relationship is a positive slope
- Composting is the worst option for Canton School due to high capital cost.
  - But, if donated, more viable
- Doing nothing, while not as bad as composting, is not the best option
- Transporting the food waste is the best option for the school economically, as without the tipping fees it is much cheaper in the long run to transport the food waste. This is ideal due to the fact that there is a nearby farm with an anaerobic digester that meets our current assumptions
- Showing that this is a sustainable and viable option opens new doors for other schools and programs to collect and donate food waste, instead of sending it to the landfill.

x (weeks)	No Plan ($)	Composting Plan ($)	School Plan ($)	Farm Plan ($)
1	-55.12	-5029	-48.88	188.40
2	-110.23	-5058	-97.78	376.80
3	-165.35	-5087	-146.65	565.20
4	-220.46	-5116	-195.54	753.60
8	-440.92	-5232	-391.08	1507.20
26	-1433	-5754	-1271	4898.40
52	-2866.01	-6508	-2541.99	9796.80