Educational Goal: To provide an understanding of the Environmental Impact Factor (E-Factor) and how it is used in chemical processes and how it can be applied to everyday life.

Student Objectives: Students will...
- Understand principle 1 of green chemistry
- Perform an exercise which has them practice calculating the E-Factor
- Relate the exercise to chemical processes

Materials (for a class of 32):
- One large bag of M&Ms
- Digital scale
- Package of individually wrapped potato chip portions
- Optional: plastic gloves

Time Required: 45–60 minute class period

Standards Met: S1, S2, S5, S6, S7

Green Chemistry Principles Addressed: 2

Prep:
- Prepare five baggies of M&Ms as shown below.

<table>
<thead>
<tr>
<th>E-factor</th>
<th>M&amp;M model</th>
<th>Industry segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Petrochemicals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A chemical derived from Petroleum or natural gas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: Solvents detergents, adhesives</td>
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<tr>
<td>1</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Bulk Chemicals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>plastics and polymers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Example: plastic bottles, grocery bags</td>
</tr>
<tr>
<td>10</td>
<td><img src="image3.png" alt="Image" /></td>
<td></td>
</tr>
</tbody>
</table>

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**Procedure:**

- **Project slide #1**
  
  \[ \text{E-factor} = \frac{\text{mass of waste}}{\text{mass of product}} \]

- Ask the students for 4 volunteers who are ready for a snack.
- Ask the volunteers to come to the front of the class.
- Tell students that the goal of this experiment is to satisfy your need for a quick snack and to test out our equation using these individually packaged potato chips.
- Ask the students to unpack the potato chips and make a pile of chips and a pile of waste. You may want to have students use gloves at this stage so that they can eat the chips after.
- Ask the students to find the mass of the chips and then the mass of the packaging and record the totals on the board.
- Explain to the students that we are not finished yet as we haven’t used a key component in green chemistry principle #4 and tested to see if this product retains its efficacy. Therefore the volunteers will need to eat the chips and tell us if they satisfy their craving for a snack.
- While they eat, have another student come up and solve the E-factor equation for the potato chips.
- Debrief with students as to how well the product performed in regards to its e-factor. Make sure you include a discussion of why there was all that packaging and how that is what the person designing the product decided you needed in order to deliver the product you wanted.
- Ask students how the e-factor of this product might be improved.
- Ask students to get into groups of two or three.
- Tell the students that actually this formula is used by green chemists to evaluate chemical processes so at this point we would like to give you all a bag of chemicals.
- Hand out a small bag of M&Ms to each group of students.
- Explain that this bag of M&Ms is very special but that unfortunately the only ones that you can use are the green ones.
- Ask students to separate the green M&Ms from the other colors and make two piles. It turns out that green M&Ms have been discovered to be a key example of...
component in a revolutionary technology that helps to make hologram images come out of cell phones so that people can see each other when they chat.

- The green part is actually the chemical that you need.
- Ask students to calculate the e-factor for the bag of M&Ms
- Ask the students to tell you whether they are OK with having all this waste in order for them to have hologram images of their friends come out of their cell phones.
- Tell the students that you are going to give them another equation to help them be creative.
- Put the following equation on the board.
  - E-factor = (mass of inputs - mass of outputs) ÷ mass of product
- Ask students to creatively come up with ways that they could reduce the e-factor.
- Discuss with students their possibilities, real or imagined.
- Show students the pre-prepared bags of M&Ms and explain how these bags represent chemical processes.
- Now tell the students that you know, they know that isn’t real but that these techniques are really being used in industry.