Physics 333 – BPP 2

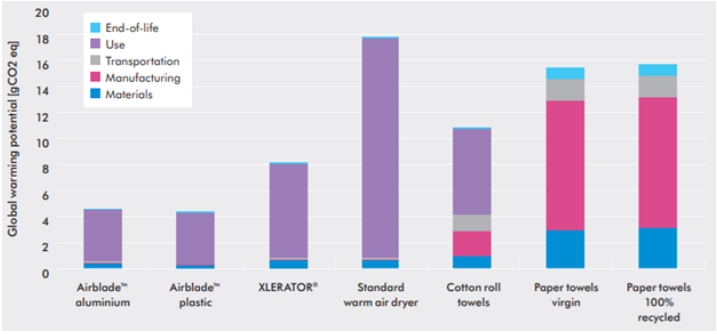
I want that we compare ***two ways of drying hands: (1) using an electric hand dryer, and (2) using paper towels. Which of them has a smaller CO2 footprint?*** Assume that we are talking about British Columbia. If you wish, you can comment on broader perspective of this question, and add other part of Canada, or other countries.

Overview

In this paper I will address the BPP of whether the method of using an electric hand dryer or using paper towels will contribute to a smaller CO2 footprint in British Columbia. To answer this question, I will be making broad assumptions due to the limitations of data available, and use it to achieve an approximation. The methods of hand drying in focus are Dyson's Airblade and Kruger Products paper towels with non-electric hands-free dispensers. I made these choices because throughout the past few years, I have noticed that UBC are predominately using these specific products. I chose the mechanical dispensers because it is still the majority that I've been seeing at UBC and outside of campus (in restaurants and small businesses), whereas electric dispensers are seen in low volumes. The calculations will be based on UBC's spending habits, with the assumption of 1,000,000 hand washings per week. The timescale of the calculation will be the lifespan of a single Dyson Airblade, which I will make the assumption of 10 years. The lifespan is determined by the process starting from manufacturing, transport, usage, and then disposal.

Assumptions:

i. There will be 1,000,000 hand washing per week. 2 paper towels per wash; or 10 seconds hand of drying time per wash. Lifespan of a Dyson Airblade is 10 years.
ii. A typical commercial paper towel is 8" x 950' and 25 lbs with 950 sheets per roll.
iii. I will use UBC as the specific geographic location to estimate the values: electricity production and transportation. We will be using the UBC location for our estimates.
iv. All the electronic hand dryers at UBC are Dyson Airblade, and all the paper towels are made by Kruger Products with non-electronic dispensers.
v. Dyson Airblade's CO2e from manufacturing, transportation, materials, and end-of-life disposal are negligible based of the *Cumulative energy demand* and *Global warming potential* table from MIT's paper "Life Cycle Assessment of Hand Drying Systems." Only the usage is accounted for because it contributes to just over 90% CO2e potentials.



vi. Non-electrical paper towel dispensers have less materials and is less complicated to produce than a Dyson Airblade, so we will make the same assumption that its manufacturing, transportation, materials, and end-of-life disposal are negligible.
vii. UBC uses Kruger Products for paper towels 100% recycled material and they have a manufacturing plant here in British Columbia in New Westminster responsible for converting and papermaking. This location isn't far from UBC and is considered local, so that makes transportation a negligible factor for paper towels.
viii. Maintenance for Dyson Airblade is regularly done by a UBC technician and paper towels gets replaced by a janitor. Transportation cost for maintenance will not be accounted for.

Calculation Outline:

Dyson Airblade's GHG emission over the lifespan of a Dyson Airblade (10 years).

1. Amount of power consumption throughout its lifespan.
2. Total power consumption translation to CO2 emission.

Paper towel's GHG emission over a 10-year time period.

3. Amount of paper towel consumption over a 10-year time period.
4. Required CO2 emission to manufacture the paper towel demands of 10 years.
5. Amount of methane produced for paper towel disposal.

Step 1: Amount of GHG emission over the lifespan of a Dyson Airblade (10 years).

From the Dyson Airblade V specification document we found that the standby power consumption is: 0.5W in idleness, and has a rated power of 1400W.

- There are about 70 classroom buildings on UBC Vancouver campus.
- Let's assume for each building there are 6 gendered washrooms (3 men; 3 women) and 2 wheelchair accessible washrooms.
- Each gendered washrooms have 2 hand dryers, and each wheelchair accessible washrooms have 1 hand dryer.
- Each building have:
  (6 gendered washrooms x 2 hand dryers each) + (2 wheelchair accessible washrooms x 1 hand dryer each) = 14 hand dryers.
- UBC classroom buildings have an estimated total of
  (70 buildings x 14 hand dryers) = 980 hand dryers.
- We'll say there are 20 extra Dyson Hand dryers for private access buildings,
  so UBC campus have an estimated total of 1000 Dyson Airblade Hand dryers.
- (1,000,000 hand washing per week / 1000 hand dryers)
  gives an average of 1,000 hand drying usage per Dyson Airblade.

Energy usage for hand drying over 10 years is
(10 sec. x 1,000 uses per week x 4 week/month x 12 months x 10 years)
= 4.8E6 seconds per hand dryer.

(1400W x 10 sec. x 1,000 uses per week x 4 week/month x 12 months x 10 years)
= 6.72E9 Watt seconds
= **1.867E6 Wh**

(3.1536E7 seconds in a year x 10 years)
= 3.1536E8 seconds in 10 years

Idleness is defined as when the hand dryer is not in usage:
(3.1536E8 sec. in 10 years) – (4.8E6 sec. of hand drying usage per 10 years)
= 3.1056E8 seconds of idleness

Energy usage in idleness per 10 years is
(3.1056E8 seconds of idleness) x (0.5W)
= 155E6 Watts seconds
= **43,100 Wh**

Total energy usage for one hand dryer over 10 years is
(1.867E6 Wh of active usage + 43,100 Wh of standby usage)
= 1.91 million Wh per hand dryer.

1,000 Dyson Airblades x 1.91 million Wh per hand dryer
= 1.91 billion Wh of total energy consumption over the 10 years usage.

Step 2: Total power consumption translation to CO2 emission.

First we need to figure out the main source of electricity used by UBC. We know that BC Hydro provides most of the electricity in British Columbia with 95% of BC's electricity generated from renewables. Electricity in UBC is supplied through the Integrated grid. B.C.'s Grid Electricity GHG Emission Intensity Factors for 2020 Integrated grid is 40.1 tCO2e/Gwh.

The total CO2e produced (by a Dyson Airblade) from the total energy consumption over 10 years.
1.91E9 Wh = 1.91 GWh
(1.91 GWh) x (40.1 tCO2e/Gwh)
= 76.19 tCO2e from electricity consumption over the 10 years usage at UBC.

Step 3: Amount of paper towel consumption over a 10-year time period.

Calculate how many sheets of paper towels are needed over a 10-year time period:
(1,000,000 hand washings per week) x (2 sheets per hand washing) x (4 week/month x 12 months x 10 years) = 9.6E8 sheets of paper towels.

- A typical commercial paper towel is 8" x 950' and 25 lbs with 950 sheets per roll.

Weight of paper towel consumption over a 10-year time period:
(9.6E8 sheets of paper towels) / (950 sheets per roll) = about 1,010,527 rolls of paper towel.
(25 lbs per roll) x (1,010,527 rolls of paper towel) = 25263175 lbs
= **11,459 metric ton of paper towel consumption over 10 years.**

Step 4: Required CO2 emission to manufacture the paper towel demands of 10 years.

- From Kruger Product's 2020 Sustainability Report, it is stated that their Greenhouse gas emission intensity from paper manufacturing is 580 kgCO2e/MDMT.
- MDMT is machine dried metric tons, but for calculations let's associate this value as the weight of paper towels.

Amount of CO2e:
(11,459 metric tons) x (580 kgCO2e/metric-tons)
= 6,646,000 kg = 6,646 metric tons.
6,646t of CO2e emission is produced to manufacture 10 years of paper towel demands.

Step 5: Amount of GHG produced for paper towel disposal.

- Environmental impact for compost and gasification of paper towels is 1.882kgCO2/kg as founded in "Comparison of End of Life Options for Waste Paper Towel at the University of British Columbia" (Deere, Yang, Bahrami – April 2013).

11,459 metric tons = 1.146E7 kg
Total carbon emission is (1.146E7 kg x 1.882kgCO2/kg) = 21565.84 kg = 21.57t
21.57t of CO2e from compost and gasification of paper towels.

Results

Calculate in terms on grams of CO2 emission per dry.
Dyson Airblade V:
(76.19 tonnes CO2e / 1,000,000 uses per week x 4 week/month x 12 months x 10 years)
= 0.159 gCO2e/dry
Kruger Product Paper towel:
(6,668 tonnes CO2e / 9.6E8 paper towel sheets) x 2 sheets per dry = 13.89 gCO2/dry

- Total Dyson Airblade CO2e is 76.19 tCO2e from electricity consumption over the 10 years usage at UBC. Or 0.159 gCO2e/dry.

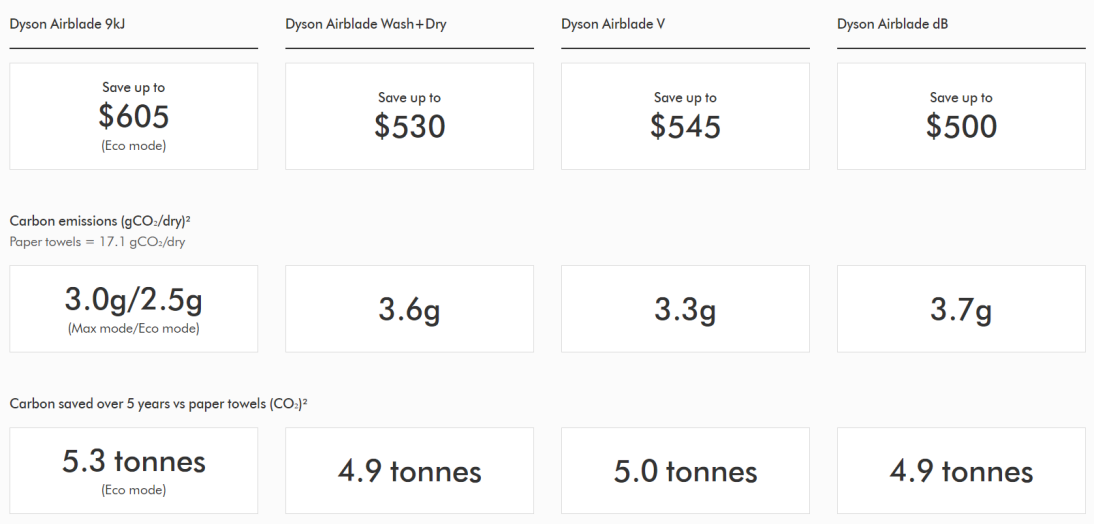
- Total paper towel CO2e is (6,646 tCO2e + 21.57 tCO2e = 6,667.57 tCO2e)
  About 6,668 tCO2e emission is produced to manufacture 10 years' worth of paper towel demands. Or 13.89 gCO2/dry.

In conclusion, using an electric hand dryer like Dyson Airblade V will contribute to less CO2 footprint when compared to using paper towels over the course of 10 years. To satisfy the hand drying demand over 10 years, Dyson Airblade will only produce 76.19 tCO2e (or 0.159 gCO2e/dry) whereas Kruger Product's paper towels produces 6,668 tCO2e (or 13.89 gCO2/dry).

Discussion

We want to see how our estimations stack up against an industry report with a company like Dyson Limited. I can found some data based on their research findings.

- Dyson's report is based on 200 uses per day (or 1400 uses per week) over 5 years with a drying time of 12 seconds.
  - Dyson Airblade V produces 3.3 gCO2/dry
  - Paper towels produces 17.1 gCO2/dry without specifying calculation variables.



Dyson Airblade 9kJ	Dyson Airblade Wash+Dry	Dyson Airblade V	Dyson Airblade dB
Save up to $605 (Eco mode)	Save up to $530	Save up to $545	Save up to $500
Carbon emissions (gCO_2/dry)[2] Paper towels = 17.1 gCO_2/dry			
3.0g/2.5g (Max mode/Eco mode)	3.6g	3.3g	3.7g
Carbon saved over 5 years vs paper towels (CO_2)[2]			
5.3 tonnes (Eco mode)	4.9 tonnes	5.0 tonnes	4.9 tonnes

At first glance we see that our calculated result for paper towel carbon emission is at 13.89 gCO2e/dry, which is very close to that of Dyson's report of 17.1 gCO2e/dry. The difference is only 3.21 gCO2e/dry.

Dyson did not specify the variables they have used to achieve their estimate. The difference is possibly due to our assumption that it takes 2 paper towel sheets to dry our hands, and that Dyron's report could have used something more 2 sheets. I also did not include materials because the assumption is that UBC uses 100% recycled paper towels, so the carbon emission from materials is negligible. The transportation is not accounted for because Kruger's papermaking manufacturing plant is located in Vancouver city, so the transport to UBC is negligible. These are the assumptions that could add up to the difference between my result and that of Dyson's report. One aspect I want to point about my value is that it could actually be lower than 13.89 gCO2e/dry because the number I'm using from Kruger's sustainability report of 580 kg CO2e/metric ton which is the average of all their plants in Canada. In B.C. we have a cleaner source of energy, so the plant in New Westminster could actually be less than 580 kg CO2e/metric ton.

However, looking at the result of Dyson Airblade V's carbon emission shows a big difference when comparing our at 0.159 gCO2e/dry with Dyson reporting at 3.3 gCO2e/dry. The difference is by 3.05 gCO2e/dry (20 times my calculated result!).

One possibility to justify our big difference lies at our assumptions for our calculation. Comparing to Dyson's variables, our hand drying duration is 17% shorter, usage is 29% less, and electricity from BC Hydro is at 40.1 tCO2e/GWh. Although Dyson did not specify where they are getting their energy source, we know that an "average electricity generation intensity of 160 to 200 tonnes per GWh for Canadian provinces and territories" (BC Hydro Climate leadership: Greenhouse Gasses). That is 4 to 5 times the GHG compared to British Columbia. I also did not account for the materials, manufacturing, transportation, and disposal of the Dyson Airblade V because those are negligible factors that adds up to only about 7.9% of the total carbon emission as stated in "The Dyson Airblade Hand Dryer Receives Industry First Carbon Reduction Label," an article by Dyson in 2010. After tweaking my variables to match that of Dyson's variables (of 200 uses per day over 5 years with a drying time of 12 seconds and other assumptions), it comes to be around 1.5 gCO2e/dry. The tweaked result is at about 50% of Dyson's reported value, with a difference of 1.55 gCO2e/dry. Since Dyson did not publish their specific calculations, it is difficult to observe where exactly are the discrepancies. My hypothesis is that the source of energy they use for their report is less green than that of BC Hydro. This is a possible area for further research.

References

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