# Analysis of the Average Olin Student's Environmental Impact

## And Techniques for Targeted Impact Reduction

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## Motivating Question

When working on any sustainability endeavor, it is important to know to what extent the remediative solutions pursued would actually reduce the environmental impact by. Without this knowledge, it is too easy to waste time pursuing behavior changes and impact reduction areas perceived as being significant, like convincing people to purchase fewer hardcopy books or to drink less coffee, while potentially missing larger impact areas like their daily 30-mile commute or unbridled use of space heating.

By learning more about where people's environmental impact comes from, we can direct sustainability efforts more effectively, to remediate larger environmental damages, with less effort.

This study attempts to answer the question of "in which category of our daily lives can we attain the largest reduction in environmental impact?", and is done in the context of a typical student at the Franklin W. Olin College of Engineering, a 350-person engineering school located in Needham, Massachusetts. The goal of the study is to inform and direct the sustainability efforts of the college's environmental organizations - in order to take action and reduce, as much as possible, the average Olin student's impact.

We collected information about student behavior through student surveys and correlated it against intuition and resource-usage data obtained from Olin College operations staff. This data was then used to perform a life cycle analysis (LCA) and to generate quantitative measures of Olin student impact. In analyzing this data, we identified three main areas of impact (travel, space heating, and 'stuff'), as well as specific areas/strategies within all six categories that could be targeted to easily reduce student impact.

## Background

A number of studies have been performed (Burkart, Griffith, Jones & Kammen) that have worked to analyze an individual's or a typical American household's environmental impact. Though the methods used in these works are sound and valid, it is difficult to apply existing literature like this to analyzing the impact of a college student in New England for a number of reasons: existing information is either too specific (as in Saul Griffith's case - who did a detailed analysis of his particular lifestyle), or too generalized (as in Jones & Kammen's and Burkart's cases, who performed analyses of average U.S. households). Furthermore, because the specific numbers and analyses sheets are not made publicly available, it is impossible to build off of the work done by these authors. Lastly, studies like Jones & Kammen's and Griffith's only take into account one measure of impact ($CO_2$) and not overall environmental impact, and as such are liable to misrepresent the environmental damage being done through resource depletion or ecotoxicity, or a number of other factors[1]. And, perhaps most importantly, they do not offer any sort of recommendations or analyses of what the the most potentially beneficial endeavors or specific areas of reduction might be - which is the core purpose of this study.

In our efforts, we have based many of our techniques and categories from the literature, but ultimately structured our study to be different in the following ways:

1. **Specific to the university setting**. We designed our study to be focused enough to get results that can be applied to Olin College students, and, with some minimal effort, expanded to other universities. We are not trying to build a blanket statement for all Americans or all university students - rather we are trying to analyze how an Olin student can most easily reduce their environmental impact.
2. **'Open-source' methods**. To enable this work to be scrutinized, continued, refined, and developed further, we have made our analyses and back-end tables available to the general public (Appendix I). This is done in the hopes that the work will be taken over by somebody else, and the field ultimately grown and expanded beyond our capabilities in this study.
3. **Impact analysis using ReCiPe points.** ReCiPe is a single-factor indicator that normalizes for a number of categories of environmental impact, thus providing a comprehensive measure of environmental impact[1]. Furthermore, ReCiPe points are collaboratively developed by a number of groups, and all information about them is made open source[2].
4. **Clear steps forward**. The goal of this study is to inform and direct sustainability efforts at Olin College - by giving insight into which areas of student lives should be targeted first. By being specific enough in our analysis, offering recommendations, and performing the study in a college setting, where there are many resources and groups already dedicated to the reduction of environmental impact, we hope to maximize potential for action after the study.

## Methods & Assumptions

Based off of common methods found during our literature search, we chose six primary areas of impact to study: space heating, water usage, electricity, travel, food, and 'stuff' (Burkart, Griffith, Jones & Kammen). Table 1 shows a breakdown of the categories and included sub-categories.

In our investigations, we only included sub-categories that students had the ability to control. This principle applies to some categories more than others (i.e. transport to/from college is a necessity and thus a fixed quantity - but the method is still variable), meanwhile others were completely excluded (physical infrastructure of college, common area lighting, operation of facilities equipment, etc.). It is a central decision in our analysis to study only factors that we believed could later be acted upon by students, as it makes no sense to hold students accountable for the environmental impact of things they have no control over.

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[1] ReCiPe points normalize for climate change, ozone depletion, human toxicity, photochemical oxidant formation, particulate matter formation, ionising radiation, terrestrial acidification, freshwater eutrophication, marine eutrophication, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity, agricultural land occupation, urban land occupation, natural land transformation, water depletion, metal depletion, and fossil depletion.

[2] ReCiPe points information: http://www.lcia-recipe.net/. Factor normalization: https://sites.google.com/site/lciarecipe/file-cabinet/ReCiPe105.xls?attredirects=0

1 **Space Heating**
2 **Water**
   - Showering
   - Hand-Washing
   - Shaving, Washing Face, Etc.
   - Toilet Use
   - Washing Clothes

3 **Electricity**
   - Personal Electronics (sound system, phone charger, etc.)
   - Personal Computing (laptop, desktop, etc.)
   - Amenities (water boiler, microwave, etc.)
   - Room Lighting
   - Refrigeration

4 **Travel**
   - Driving to train station (16km)
   - Driving into nearby city (Boston - 28km)
   - Going Home for Holidays/Vacation (Flying, Driving)

5 **'Stuff'**
   - Electronics
     - Low-Intensity Consumer Electronics (speakers, water boilers, lamps, hair irons, etc.)
     - Medium-Intensity Consumer Electronics (electric shavers, sound systems, desktops, etc.)
     - High-Intensity Consumer Electronics (cameras, cell phones, etc.)
   - Clothes & Shoes
   - Books, Papers, Binders, Office Supplies
   - Soaps, detergents, and other consumable chemicals

6 **Food**

*Table 1: A listing of the categories and subcategories included in the analysis*

In each of these six categories, we gathered data from 10% of Olin's population through student surveys, experimental measurements, and personal interviews. We then correlated this data against quantitative resource consumption data obtained from the college (BTUs for space heating, BTUs for water heating, and electricity usage) and analytical calculations (heat loss through window, power consumption estimates). This triangulation of data helped us gain more accurate usage data and obtain more accurate analyses.

In order to make the results more accessible to outside audiences, we translated our final ReCiPe impact numbers into a "coffee cups" equivalent, which indicates how many hot cups of coffee it would take to equal the environmental impact of that category. This was done in order to make it easier for external readers to get a feel for how much environmental impact an activity is - as ReCiPe points, though accurate, are ultimately an arbitrary measurement, while number of cups of coffee is something people can more readily relate to.

Since we are ultimately measuring "daily impact", for all of our calculations, the functional unit is ReCiPe points/day.

Because of the sheer scale of the study undertaken, it is impractical to enumerate every assumption and system boundary here. Rather, this information, as well as the raw survey results and analysis are embedded in the spreadsheets that contain our analyses - which can be viewed in Appendix I.

## Results

Figure 1 shows the impact breakdown of the typical Olin student. The bulk of the environmental impact comes from two categories: heating and food. 'Stuff' and travel are a close second tier of importance, and electricity and water usage are at the lowest rung. Each category is broken up into its subcategories and their relative impacts displayed alongside the entry.

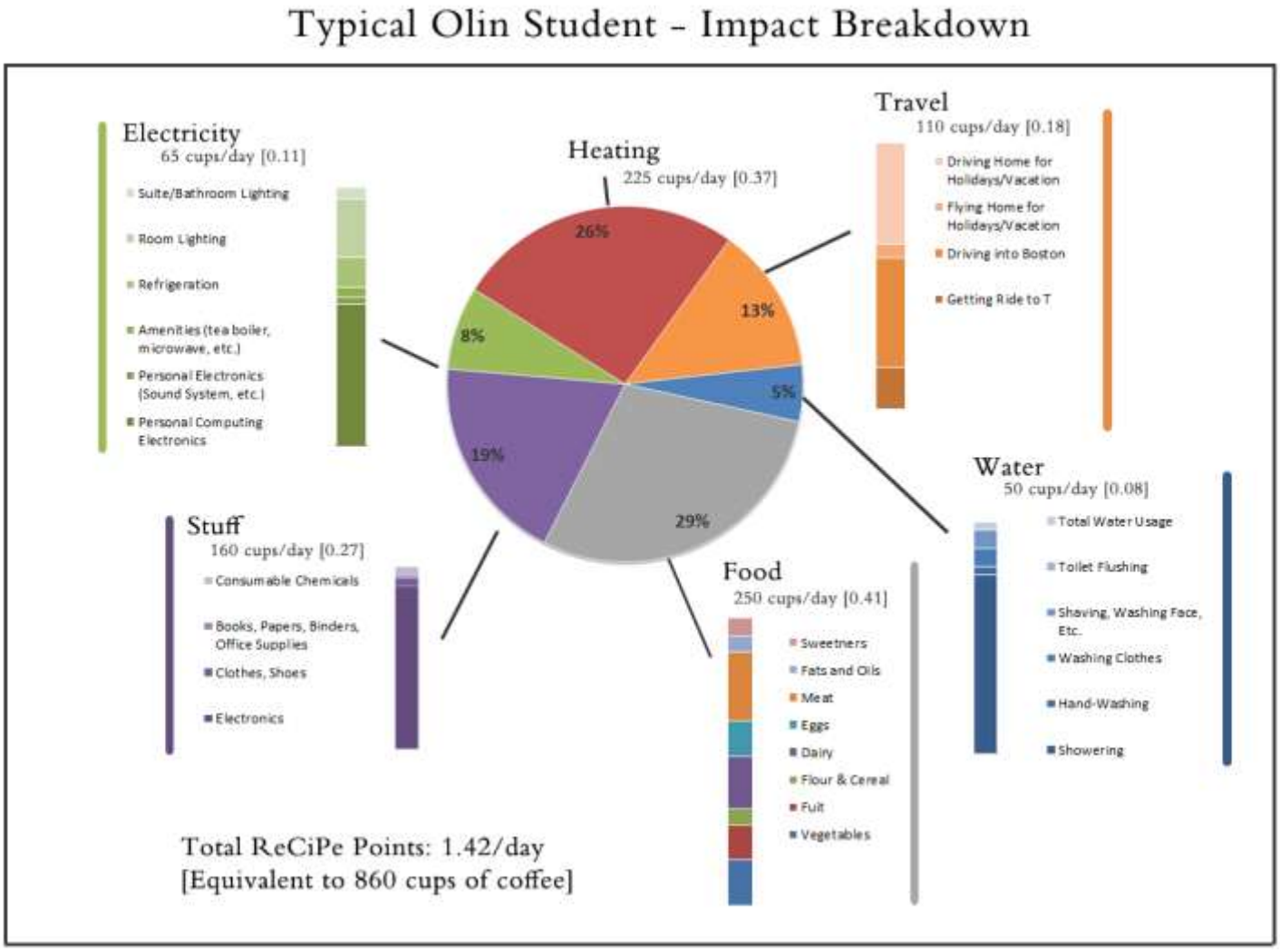


*Fig. 1: The breakdown of typical Olin student's impact, over the course of one day. The numbers are shown in ReCiPe points, and the equivalent # of coffee cups, given that environmental impact.*

Analyzing this data, we can see a clear domineering area in each subcategory: [**electricity**] personal computing electronics and room lighting, [**travel**] driving into Boston and driving home, [**water**] showering, [**stuff**] electronic equipment, and [**food**] meat, eggs, and dairy.

Any category that outweighs the others is a good target for directing environmental efforts, as minimal reductions in such a category would have significant overall reductions in impact. Identifying these 'dominating' categories and subcategories is critical to our study, and shows us the areas in which we should focus our analyses and direct environmental efforts toward.

For each category of impact, we also calculated the 15$^{th}$ and 85$^{th}$ percentile behaviors, which allowed us to generate statistics about the different capacities to which students behave in each of these categories. We then used these numbers to generate two 'personas' to compare the average/typical impact values to: an "environmentally conscious" student and "ultra low impact" student.

We define an 'environmentally conscious' student as one who is aware of most environmental issues, and, within reason, acts to minimize their impact - but not at the risk of their comfort. They try to bike when they can, eat as little meat as possible, and cut down their shower time. An "ultra low impact" student goes even

farther and recognizes sustainability as a pursuit of utmost importance. They adopt a number of lifestyle measures to minimize their impact - being vegan, travelling exclusively by biking, not owning many electronics, insulating their windows, flying/travelling by train, etc.

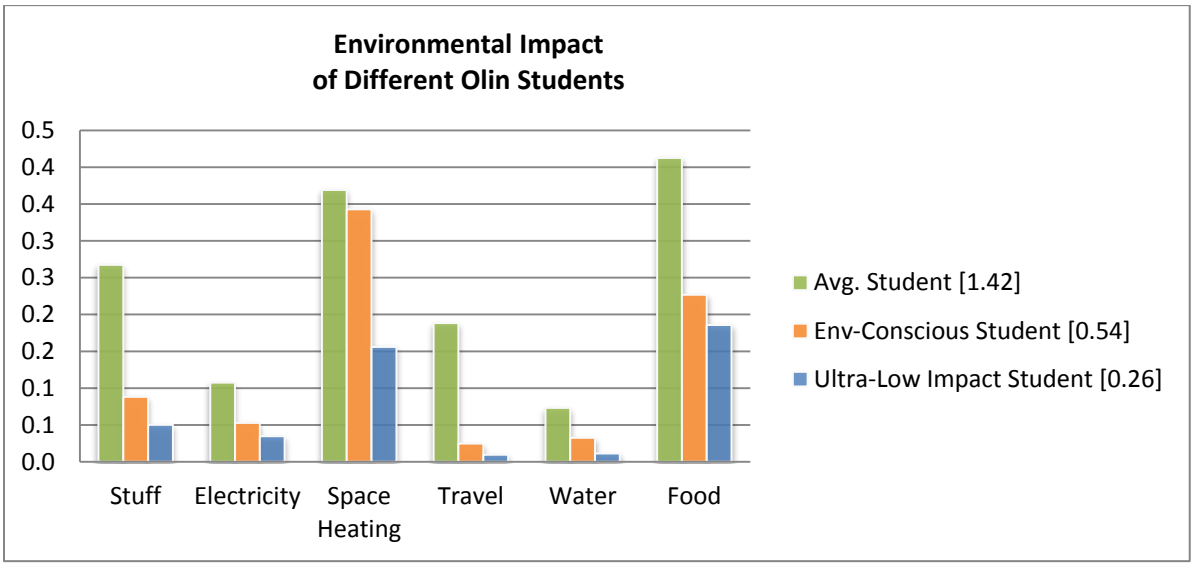


*Fig. 2: A comparison of the environmental impact (in ReCiPe points/day) of the average Olin student, compared to an 'environmentally-conscious' student and an 'ultra-low impact' student.*

| Category | ReCiPe Impact of Typical Olin Student | ReCiPe Impact of Env-Conscious Student | ReCiPe Impact of Ultra-Low Impact Student | X-Factor Avg-Env. Reduction | X-Factor Env.-Ultra-Lo Reduction | Total X-Factor Impact Reduction Potential |
|---|---|---|---|---|---|---|
| Stuff | 0.27 | 0.09 | 0.05 | 3.03 | 1.76 | 5.32 |
| Electricity | 0.11 | 0.05 | 0.03 | 2.03 | 1.52 | 3.09 |
| Space Heating | 0.37 | 0.34 | 0.16 | 1.08 | 2.20 | 2.36 |
| Travel | 0.19 | 0.02 | 0.01 | 7.62 | 2.59 | 19.70 |
| Water | 0.07 | 0.03 | 0.01 | 2.25 | 2.89 | 6.49 |
| Food | 0.41 | 0.23 | 0.19 | 1.82 | 1.22 | 2.22 |
| Total | 1.42 | 0.54 | 0.26 | 2.62 | 2.07 | 5.41 |

*Table 2: The quantitative numbers behind the daily impact analysis. A typical Olin student has an impact of 1.42 ReCiPe points/day, an environmentally-conscious student has 0.54, and an ultra-low impact student has 0.26. The red x-factor column shows the relative impact reduction possible by transitioning from a typical student to an environmentally-minded, and the green x-factor column shows the further reduction possible by adopting an ultra-low impact lifestyle.*

Comparing the 'environmentally conscious' and 'ultra low impact' personas against the impact of a typical Olin student gives us the results seen in Table 2 (visually represented in Figure 2). Table 2 shows us that it is possible to reduce, without being terribly unreasonable, one's environmental impact by **2.6X** (the environmentally-conscious persona), and, if more dramatic actions are taken, by **5.4X** (the ultra-low impact persona).

For an environmentally-minded student, a surprisingly large number of categories (travel - **7.6X**, water - **2.2X**, stuff - **3X**, food - **1.8X**, and electricity - **2X**) have the potential for substantial impact reduction (which we define as greater than a 1.5X reduction) - with space heating being the only exception (**1.1X**). On top of these

reductions, an ultra-low impact student can gain significant drops in their space heating (**2.2X**), water consumption (**2.9X**), and travel habits (**2.6X**).

One interesting observation we can extract from these results is that some categories seem to have a ***lower bound*** to how much the impact can be reduced. For example, an ultra-low impact student can cut out wasteful light use, not own/use a large sound system, and replace their room lamps with small lamps, but ultimately they must still use their laptop for homework and use electric lighting at night. *These are categories where they cannot avoid having an impact.* Likewise, with food, vegetarianism and veganism offer substantial reductions in impact, but only to the point where a lower bound in caloric intake is reached. These observations serve to indicate that in some categories, impact reduction past a certain point will not be possible. This is important to know, for appropriately directing sustainability efforts and reducing student's impact.

Analyzing the results more, we can see that space heating is a particularly interesting category, because it is not one that most students would think they could control or have much effect over. And as our results show, this is mostly true - turning down the thermostat by a couple degrees (env.-conscious behavior) barely reduces the impact (Figure 2). However, by turning the thermostat significantly down and adding extra insulation over room windows, an ultra-low impact student can substantially reduce their impact due to heating - but ultimately will also hit a lower bound, due to imperfect insulation.

## Recommendations and Future Work

Our results ultimately show that it is possible to reduce one's impact without undue uncomfort or excessive effort, by a factor of **2.6X**. By adopting a number of significant lifestyle changes, that reduction can grow to **5.4X** for an ultra-low impact student. This leads us to offering the following behaviors as suggestions for students at Olin College (and other universities) to adopt:

*Environmentally-Conscious*

- Try eating as little meat as possible (esp. red meat). Cut back on dairy when possible
- Lower shower pressure to lowest setting
- Be cognizant of how much you drive; if you drive home for holidays, try flying instead (less impactful)
- Learn to turn off unnecessary lights in room; put desktop to idle when not using
- Purchase fewer electronics, or buy them used.
- Be wary of leaving window open on cold days

*Ultra-low Impact*

- Switch to a vegan diet; reduce amount of sweeteners and processed food consumed
- Turn down room thermostat and insulate windows with extra material at night
- Replace car travel with biking
- Replace central room lighting with small second-hand table lamps
- Eliminate as many high-intensity electronics as possible
- Purchase organic and natural soap products

As they stand now, our work and results provide a jumping-off platform for a number of future endeavors:

- Using the information about the biggest impact area reduction potentials and implementing programs at the university to either change student behavior, or change the systems behind their behaviors

- Analyze the quantitative reduction potential of each of these sustainable behaviors, in order to quantitatively assess which behavior changes can have the largest reduction in impact
- Perform a more rigorous persona-generation process, and include information about 'excessive' students
- Modularize and expand these results and analyses to be able to be implemented by other colleges
- Share and disseminate these results in an education campaign

The list goes on. Regardless, we believe our work provides a strong launching platform for knowing where to direct sustainability efforts at Olin, and will hopefully lead to many students working to reduce their environmental impact, and ultimately be expanded to other colleges and settings.

## References


Burkart, Karl. "Defining your 'total environmental impact'". *MNN.com*. http://www.mnn.com/green-tech/research-innovations/blogs/defining-your-total-environmental-impact

Griffith, Saul. "Living in the Future". *TEDxSydney*. http://www.youtube.com/watch?v=XwyQKqlXpNY

Jones & Kammen. "Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities". *Environmental Resources & Technology*.


## Appendix I

All calculations of impact, raw survey data, and methods are included as an attachment [OlinImpact_AppendixI.zip], or can be viewed online at http://bit.ly/OlinStudentImpact (older version)