Eco-Dorm Retrofit

Nadim Atalla, Emilia Chojkiewicz, Chris Jernigan, Nick Kardous, Brigitte von Oppenfeld, Cassie Yuan

Mission Statement:

Reduce energy waste in Duke dormitories

Approach

Fenestration Analysis

$$\dot{Q}_{net} = UA\Delta T + c_p \dot{m} \Delta T - IA\tau$$

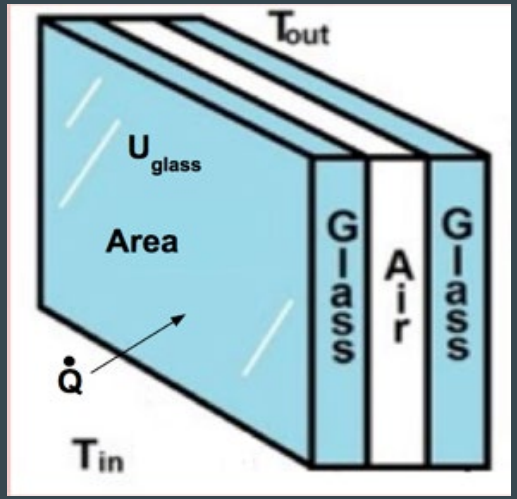
Heat Conduction

Air Leakage

Solar Heat Gain

Heat Conduction

$$\dot{Q}_{conduction} = UA\Delta T$$



Assumptions:

Double-paned, regular emissivity windows with air between panes

U_{glass} (provided by manufacturer) accounts for both conductance and radiation

Air Leakage

$$\dot{Q}_{leakage} = c_p \dot{m} \Delta T$$

Assumptions:

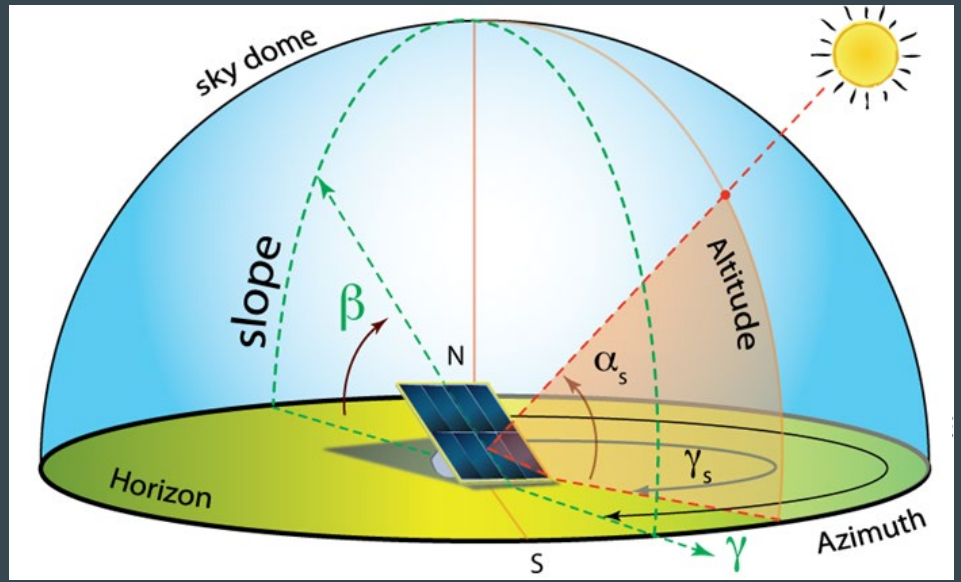
Steady, incompressible flow of air

Frictional losses are negligible

Weather tape reduces energy losses by 20%

Solar Heat Gain

$$\dot{Q}_{gain} = IA\tau$$



Assumptions:

Extrapolated weather data is accurate

No losses due to shading

Only August insolation considered

Solar Analysis

Monthly solar electricity generated calculated by:

- NREL's System Advisor Model (SAM)
- RDU weather data

Heat gained by thermal:

- GA weather data

System Sizing

○ Specify desired array size

Desired array size: 4 kWdc

DC to AC ratio: 1.20

◉ Specify modules and inverters

Modules per string: 8

Strings in parallel: 3

Number of inverters: 1

Configuration at Reference Conditions

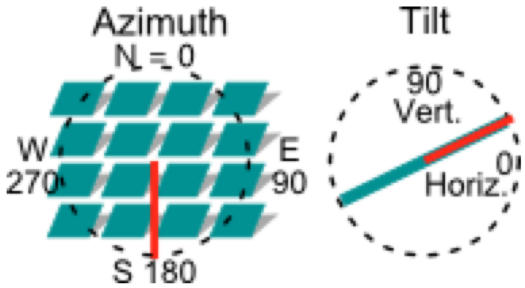
Modules			Inverters		
Nameplate capacity	4.681	kWdc	Total capacity	3.800	kWac
Number of modules	24		Total capacity	3.928	kWdc
Modules per string	8		Number of inverters	1	
Strings in parallel	3		Maximum DC voltage	600.0	Vdc
Total module area	30.6	m²	Minimum MPPT voltage	250.0	Vdc
String Voc	363.5	V	Maximum MPPT voltage	480.0	Vdc
String Vmp	295.5	V	Battery maximum power	0.000	kWdc

Sizing messages (see Help for details):

Actual DC to AC ratio is 1.23.

Voltage and capacity ratings are at module reference conditions shown on the Module page.

Orientation



Array type: Fixed roof mount

Tilt: 26 degrees

Azimuth: 160 degrees

Ground coverage ratio: 0.4

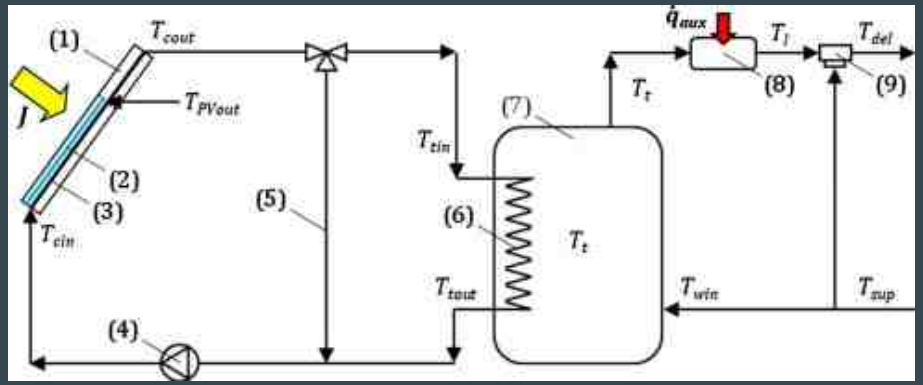
Solar Analysis

Efficiencies

- 15% efficiency of PV
- 35% efficiency of thermal
- 0.5% electrical output loss per 1°C

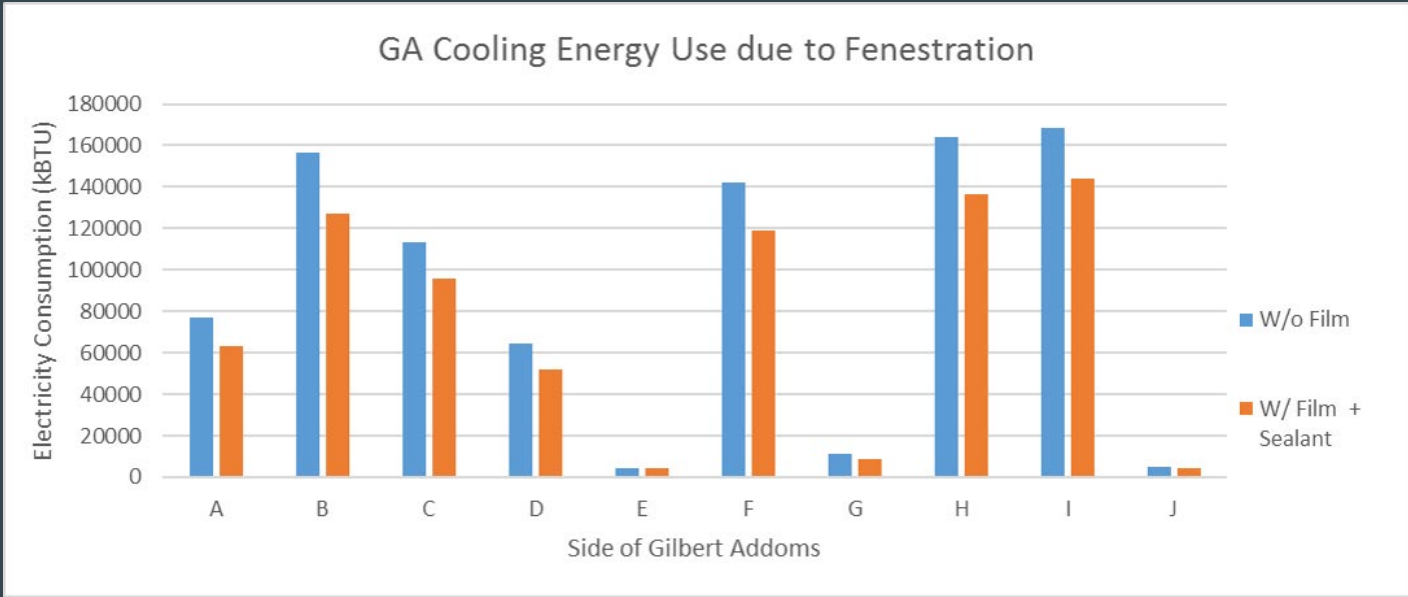
Assumptions

- 100% efficiency in electricity transformation
- 100% efficiency of heat transfer through piping



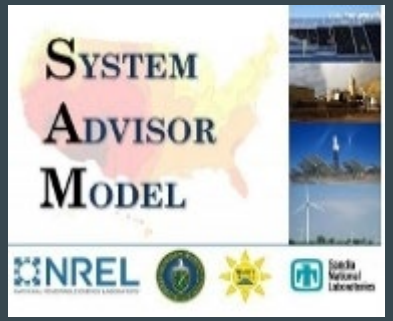
Results

Fenestration Results



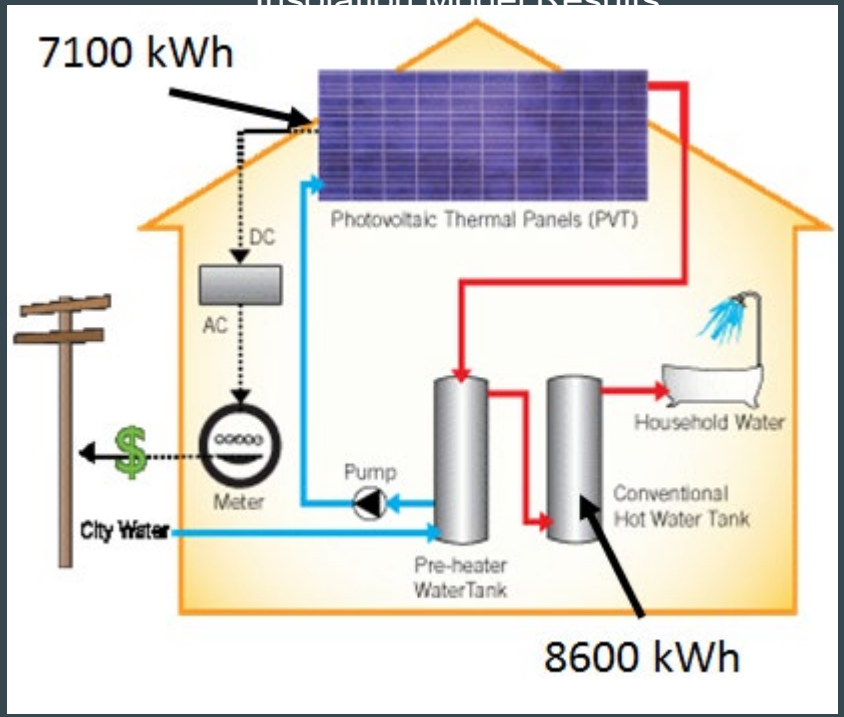
Annual energy saved from fenestration retrofit:	**45,000 kWh**

Solar Results



7300 kWh

Insolation Model Results

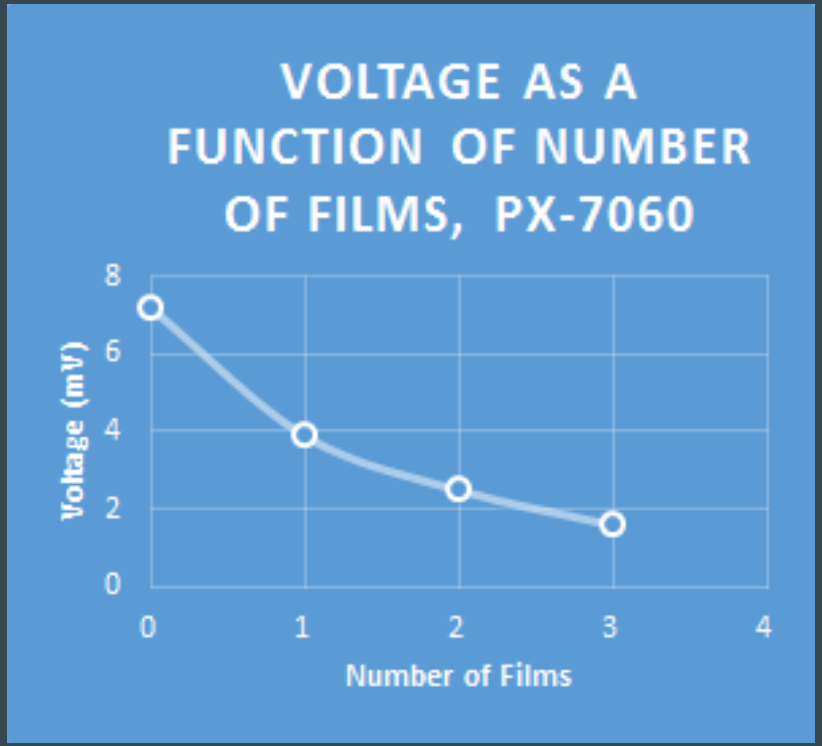


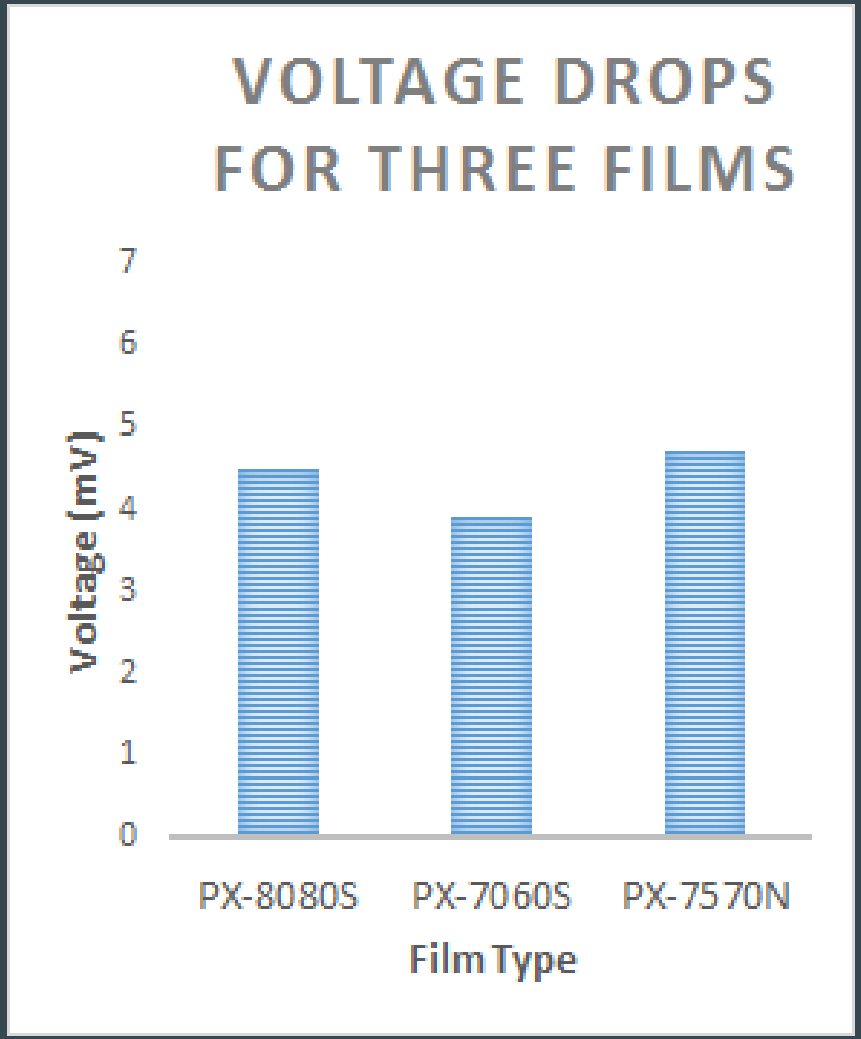
Viability Testing

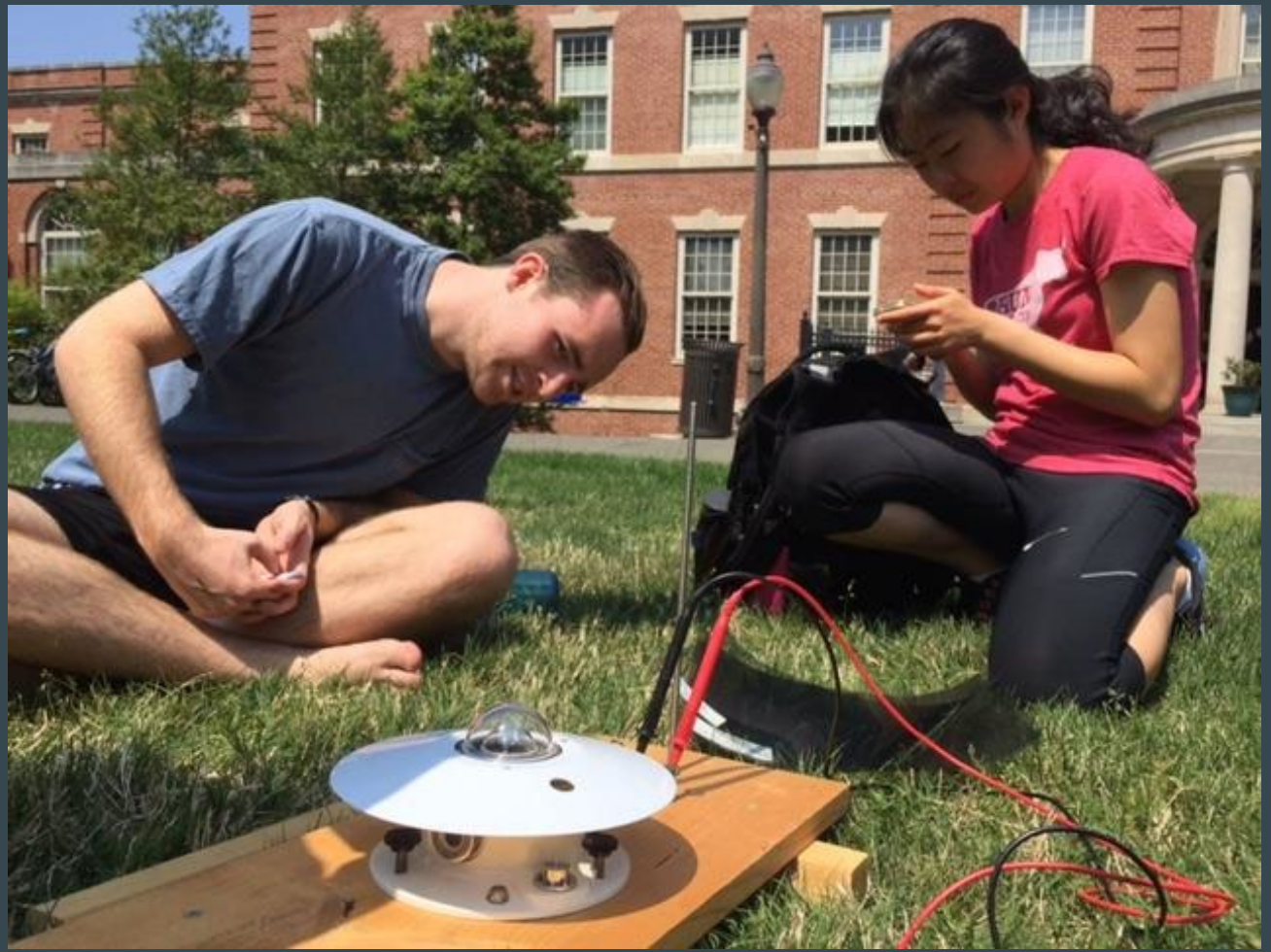
Fenestration Viability Testing

Actual energy use summer 2016 (kBtu)	**1,670,000**
% Energy loss due to fenestration	**54.4 %**
Energy saved from fenestration retrofit over the summer (kBtu)	**153,000**
Energy saved from fenestration retrofit over the summer (kWh)	**45,000**
% Energy saved	**16.9 %**

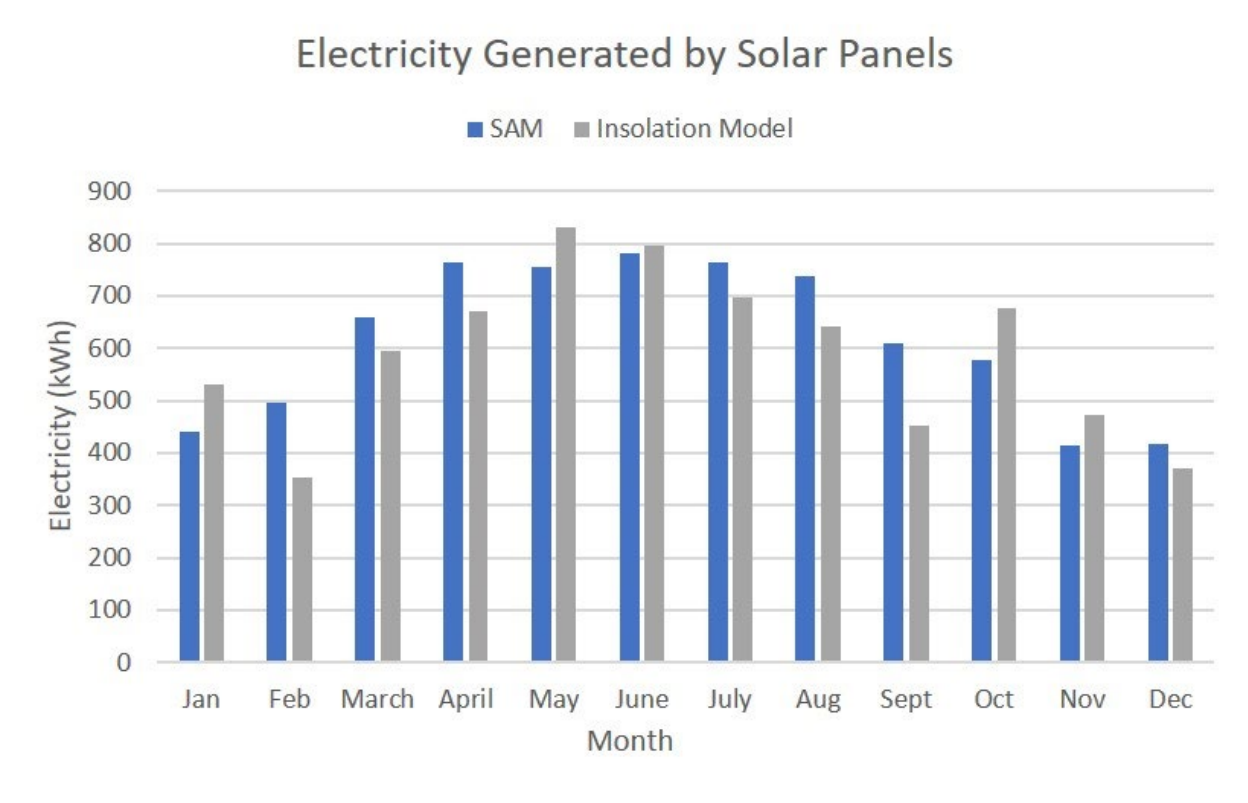
Film Testing







Solar Viability Testing



Total Energy Production

Insolation Model

7100 kWh

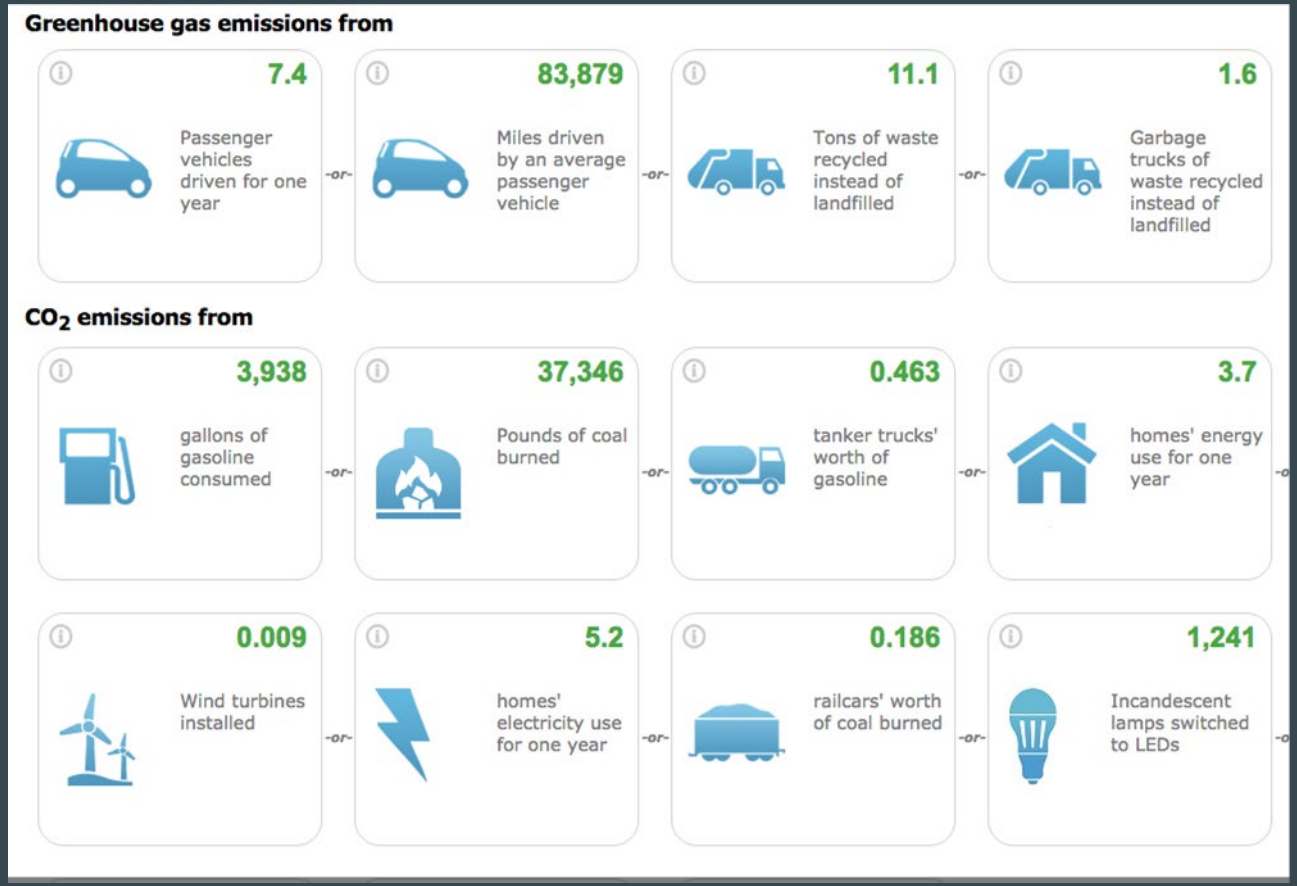
SAM

7300 kWh

Economic Impact

Annual energy saved from fenestration retrofit	45,000 kWh
Money Saved	$3,350
Total cost	$21,340
# of years to break even	6.4
Annual energy saved from solar retrofit	15,700 kWh
Money Saved	$1,200
Total cost	$33,700
# of years to break even	28.8

Environmental Impact



Conclusions

Next Steps

Recalculating results with regular PV panels instead of the overly sophisticated PV/T

Expand fenestration model to include winter for more accurate approximation of annual energy savings

Sharing findings with Facilities Management to assess implementation feasibility

Acknowledgements

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