AIM: A HOME-OWNER USABLE ENERGY CALCULATOR FOR EXISTING RESIDENTIAL HOMES

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ABSTRACT

An energy efficiency metric for residential homes was developed to provide home-owners, realtors and builders a method to rate the energy efficiency of an existing house. To accomplish this, a web-based calculator was developed, which is based on DOE2 simulations and a simplified systems model. To simplify the use of the calculator, parameters, like window U-factor, roof / wall insulation, which are normally required for simulations in existing homes are filled using statistical tables. This allows the home-owner to use the calculator with information commonly available during a real estate transaction.

WEB FRONT-END

This application is built in two main components: the front-end that runs on the user's browser and a server which serves the application and handles requests for simulations. The web front-end is split into several panels that the homeowner navigates to calculate their home energy use and obtain a score.

HOME

The Home panel is the first screen seen by the user of the application. The homeowner simply goes through each question and fills out the appropriate response. Currently, the calculator is designed to handle all the counties that are in Texas.

FLOORPLAN

In the Floorplan and More Floorplan panels, the homeowner describes the general geometry of the home. Also, the bedrooms and bathroom are given which are used to calculate the internal load of the home used in the yearly energy loads calculation.

ROOF & ATTIC

In the Roof & Attic panel, we ask for what type of roof is on the house, its color and some questions about the insulation in the attic. During the design of AIM, it was important to balance the tradeoffs between what homeowners can easily measure and what effect it had on the energy usage of the home.

WINDOWS

In the windows panel, the glazing for the building is determined. For each side of the building, we ask how many windows are on each side. In the simulation model, we assume that the windows are 3'x5' so that we don't require homeowners to measure their windows.

A/C

This simply asks what type of A/C is in the home. We also allow them to get credit for having a newer A/C that assumedly has a higher SEER. These assumptions are discussed further on p.3 in House Characteristics by Age.

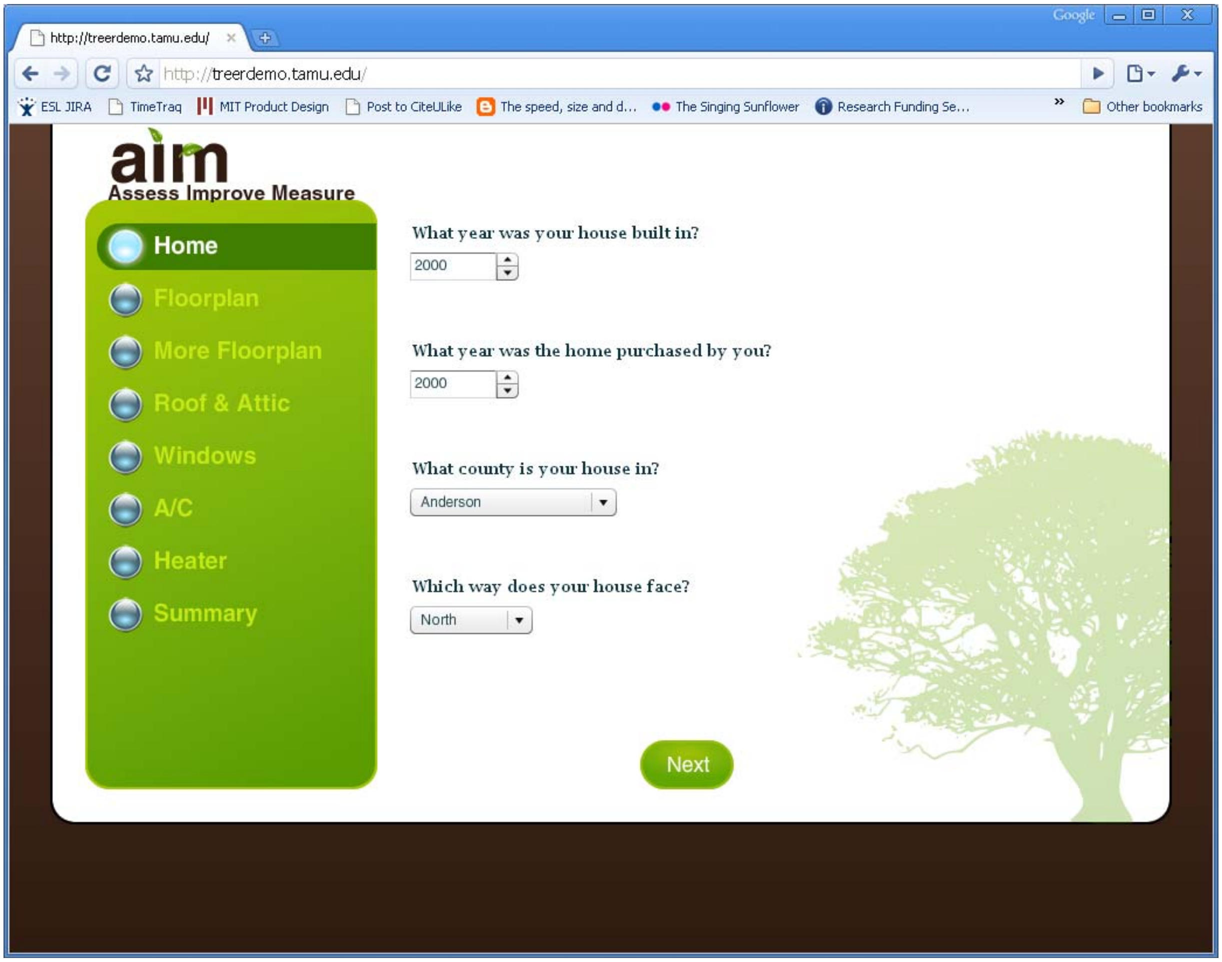

Figure 1. The home panel

HEATER

On this panel, we ask similar questions for the heater and the water heater. Similar assumptions are made as in the A/C section.

SUMMARY

Once the summary panel is reached by the homeowner, a request is made to the server with all the information given in the prior forms. The server transforms these inputs into a DOE-2 input file and runs a yearly simulation with the proper weather based on the county given.

Once the yearly annual energy loads are calculated, the A/C, heater, and water heater energy usage are calculated based upon their assumed efficiencies which are in turn dependent upon the age given by the homeowner.

The score is then calculated based upon the annual energy usage of the A/C, heater, and water heater.

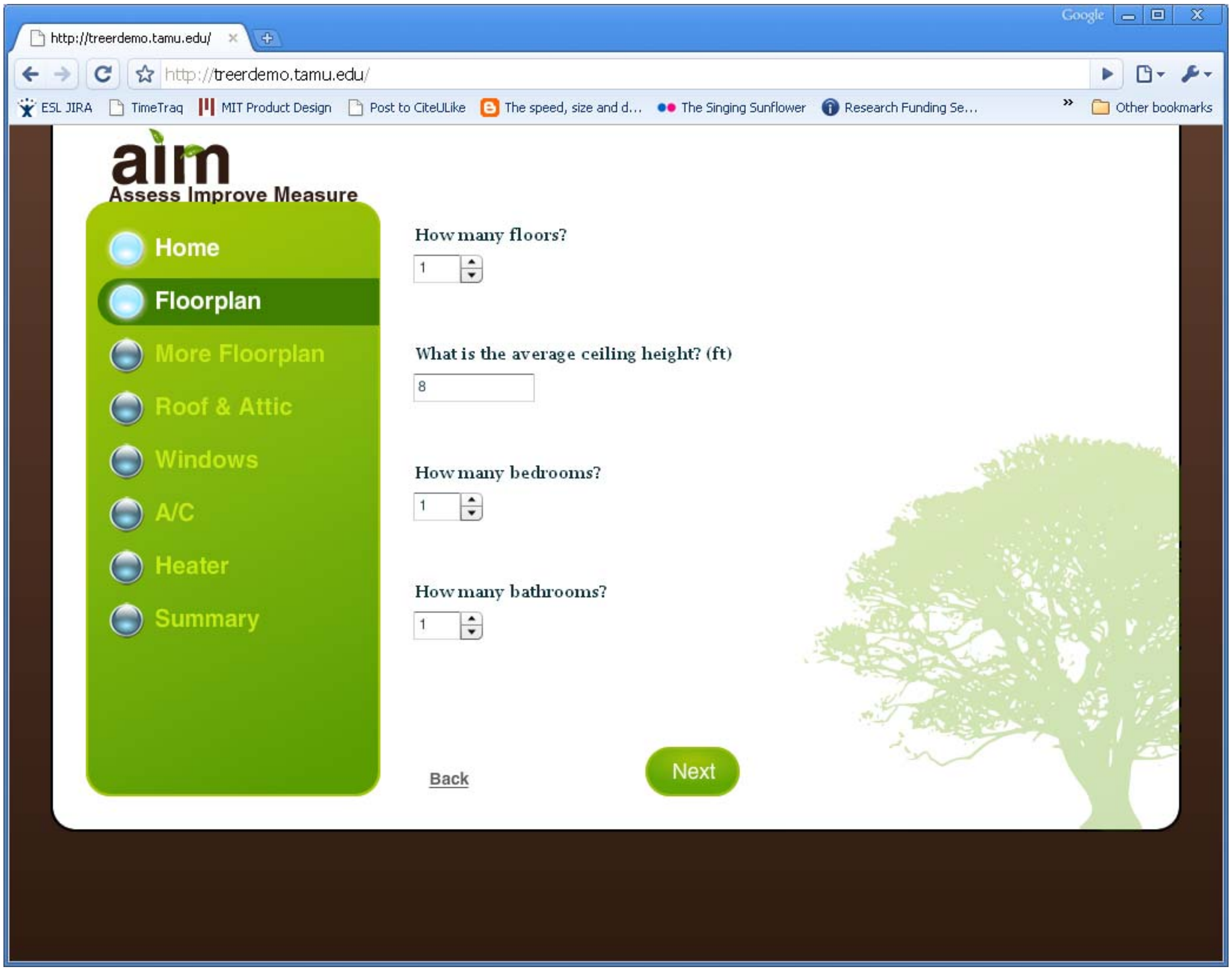

Figure 2. The floorplan panel

HOUSE CHARACTERISTICS BY AGE OF THE HOUSE

The characteristics of a residential house by the year of construction were culled from the following sources:

- 2000/2001 IECC, 2006 IECC: for building energy code values during 2001-2005 and 2006 onwards, respectively
- NAHB Housing Survey Data (1997-2004): provided wall and ceiling insulation and window type during 1997-2004 for East TX and West TX. These values are extrapolated for years prior and after 1997-2004.
- ASHRAE Fundamentals: provided generic U-value and SHGC of windows for window types obtained from NAHB data
- Home Energy Saver: for HVAC and DHW system efficiencies
- FSEC publications for air infiltration

REFERENCES

Chan, W., Price, P., Sohn, M., and Gadgil, A., “Analysis of US Residential Air Leakage Database”. Lawrence Berkeley National Laboratory Report No. 53367.

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Cummings, J. B., Tooley, J. J., Moyer, N. A. and Dunsmore, R., "Impacts of Duct Leakage on Infiltration Rates, Space Conditioning Energy Use, and Peak Electrical Demand in Florida Homes," Proceedings of the ACEEE 1990 Summer Study, Pacific Grove, CA, August 1990.

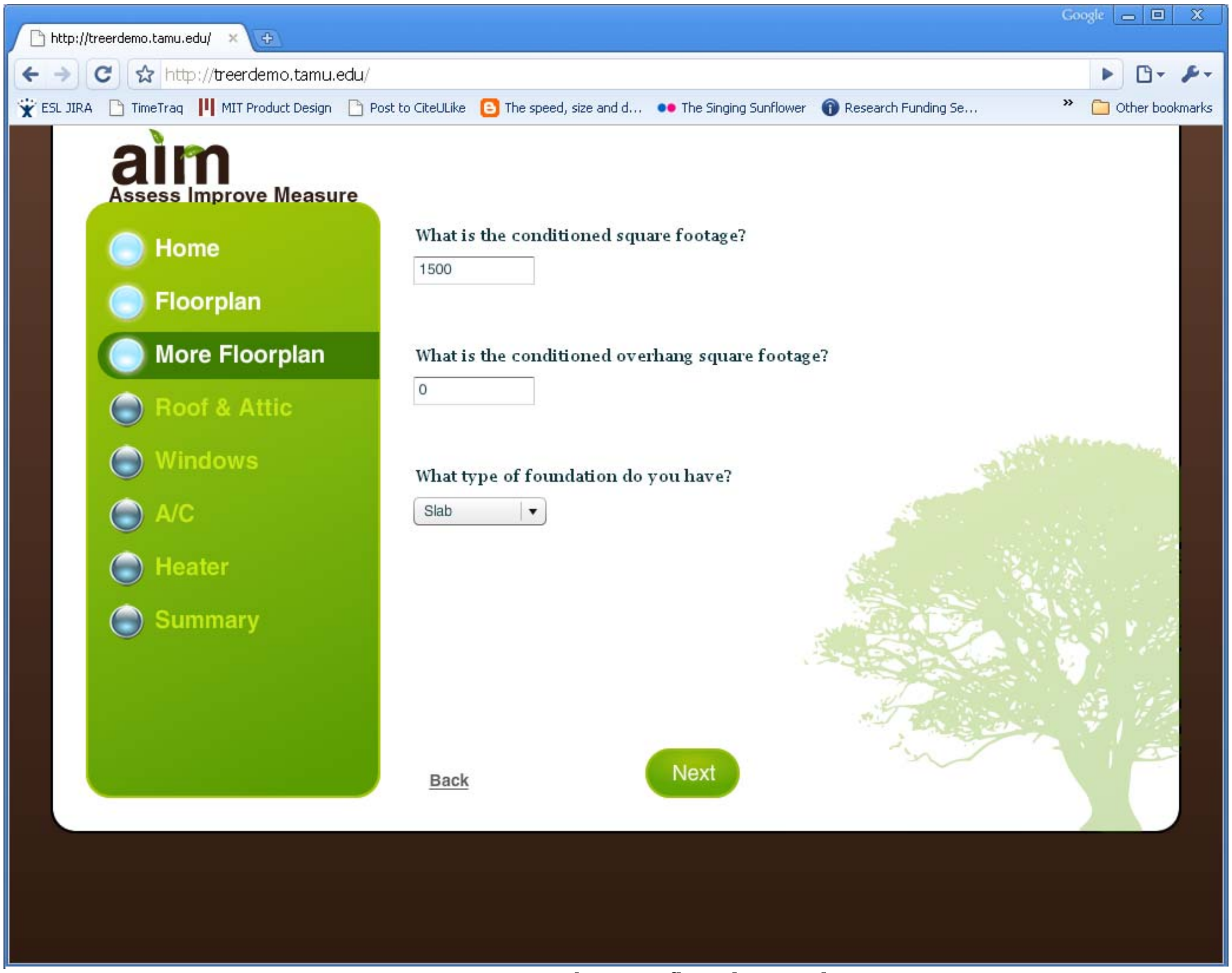

Figure 3. The more floorplan panel

Cummings, J.B., Tooley, J.Jr., Moyer N., "Investigation of Air Distribution System Leakage and Its Impacts in Central Florida Homes", Prepared for the Governor's Energy Office, FSEC-CR-397-91, January 31, 1991.

Mills, E.. et al. 2007. "Home Energy Saver: Documentation of Calculation Methodology, Input Data, and Infrastructure." Lawrence Berkeley National Laboratory Report No. 51938.

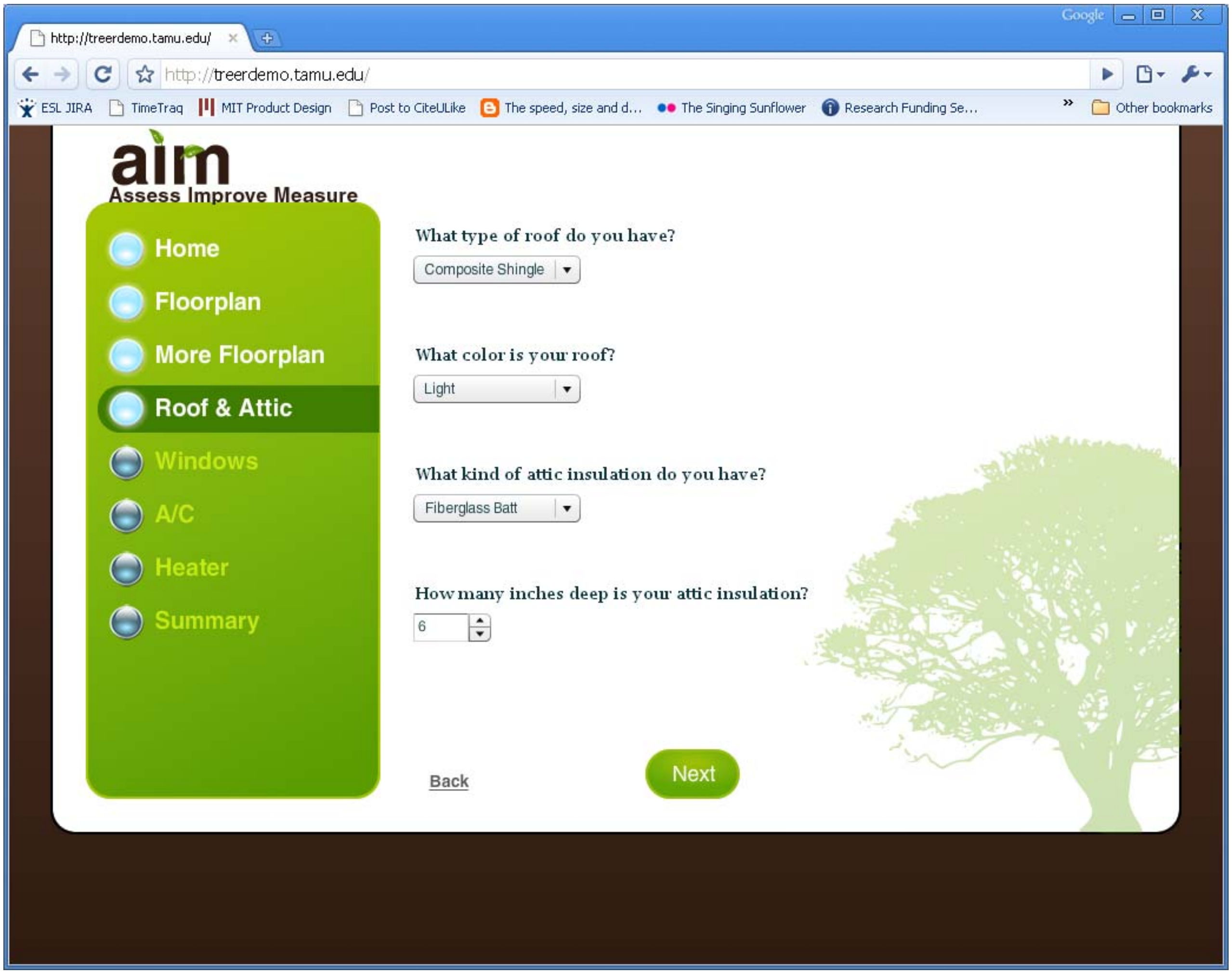

Figure 4. The roof and attic panel

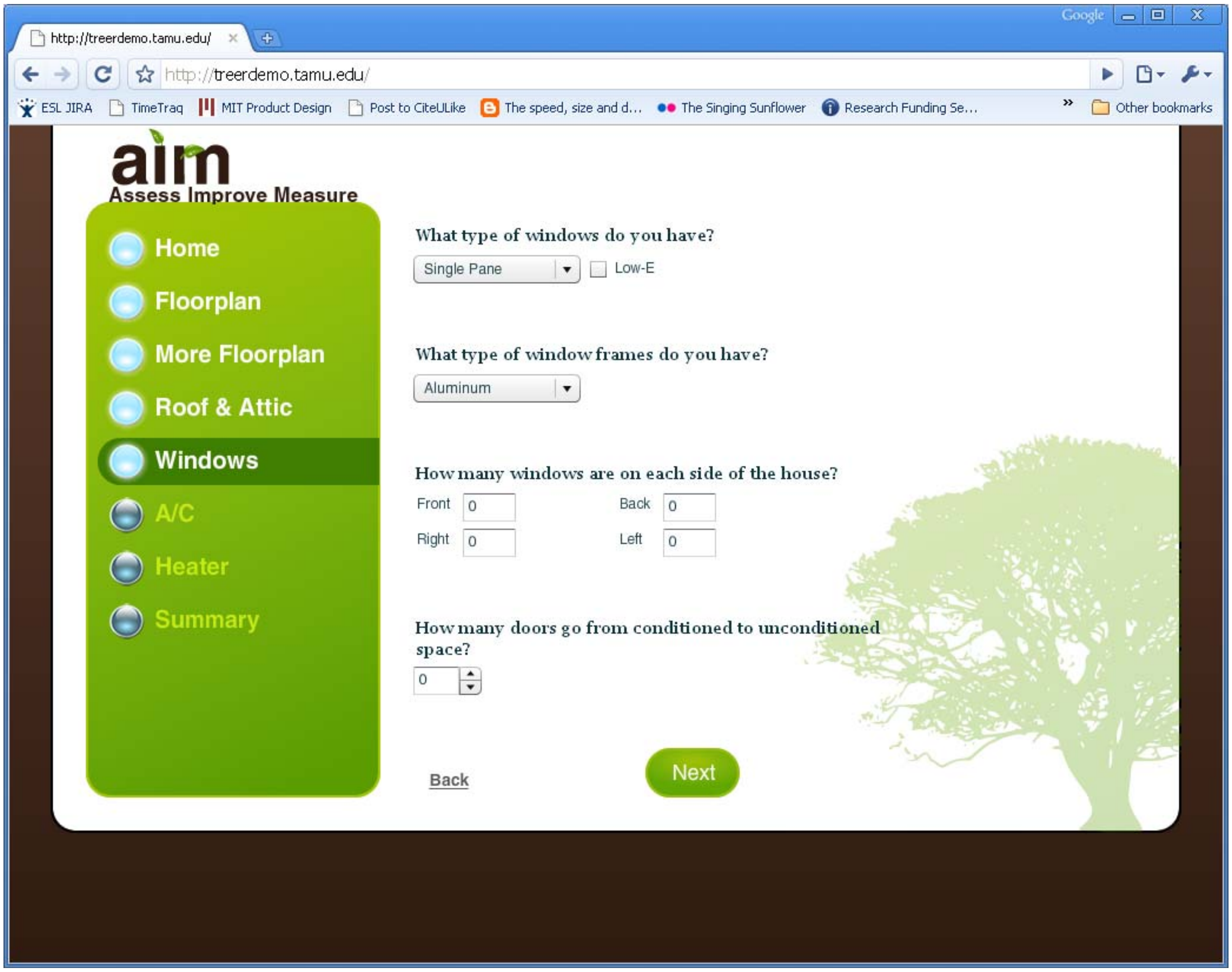

Figure 5. The windows panel

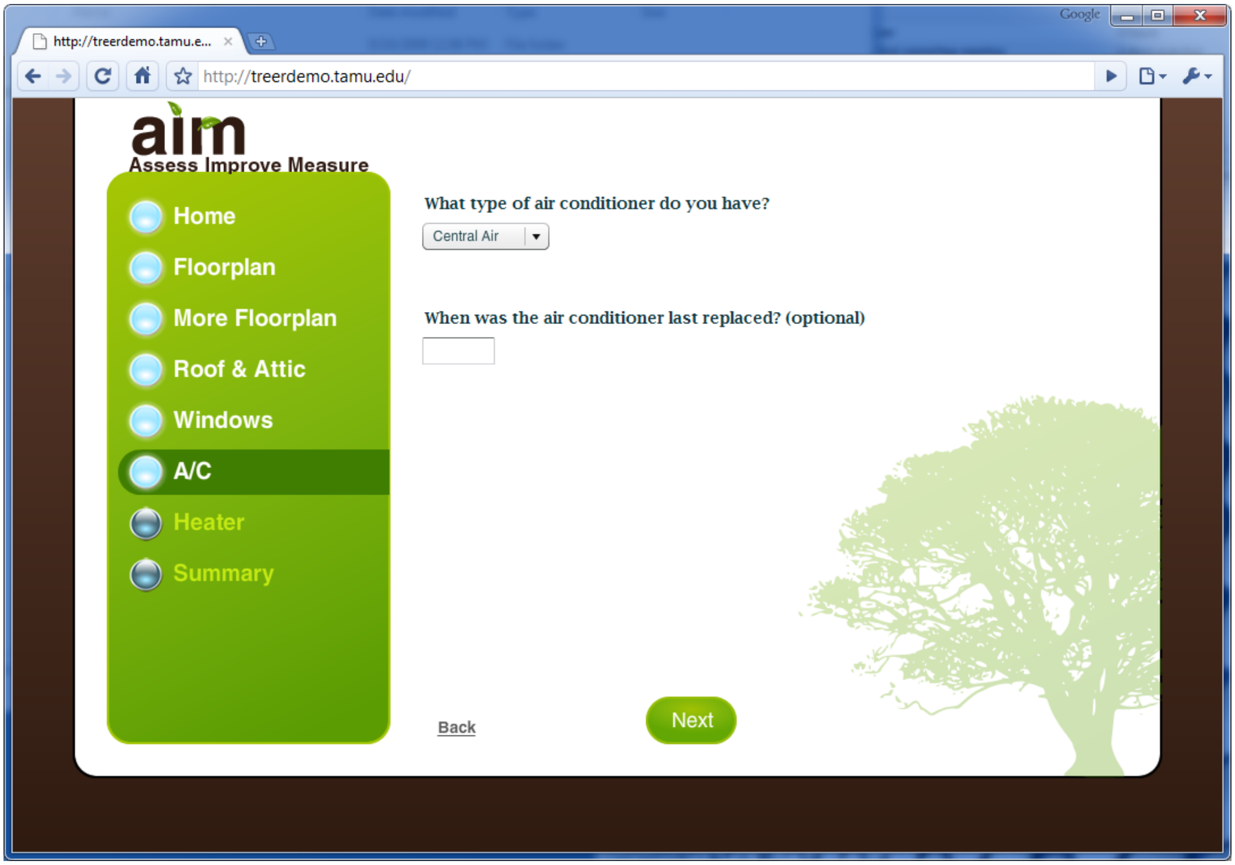

Figure 6. The A/C panel

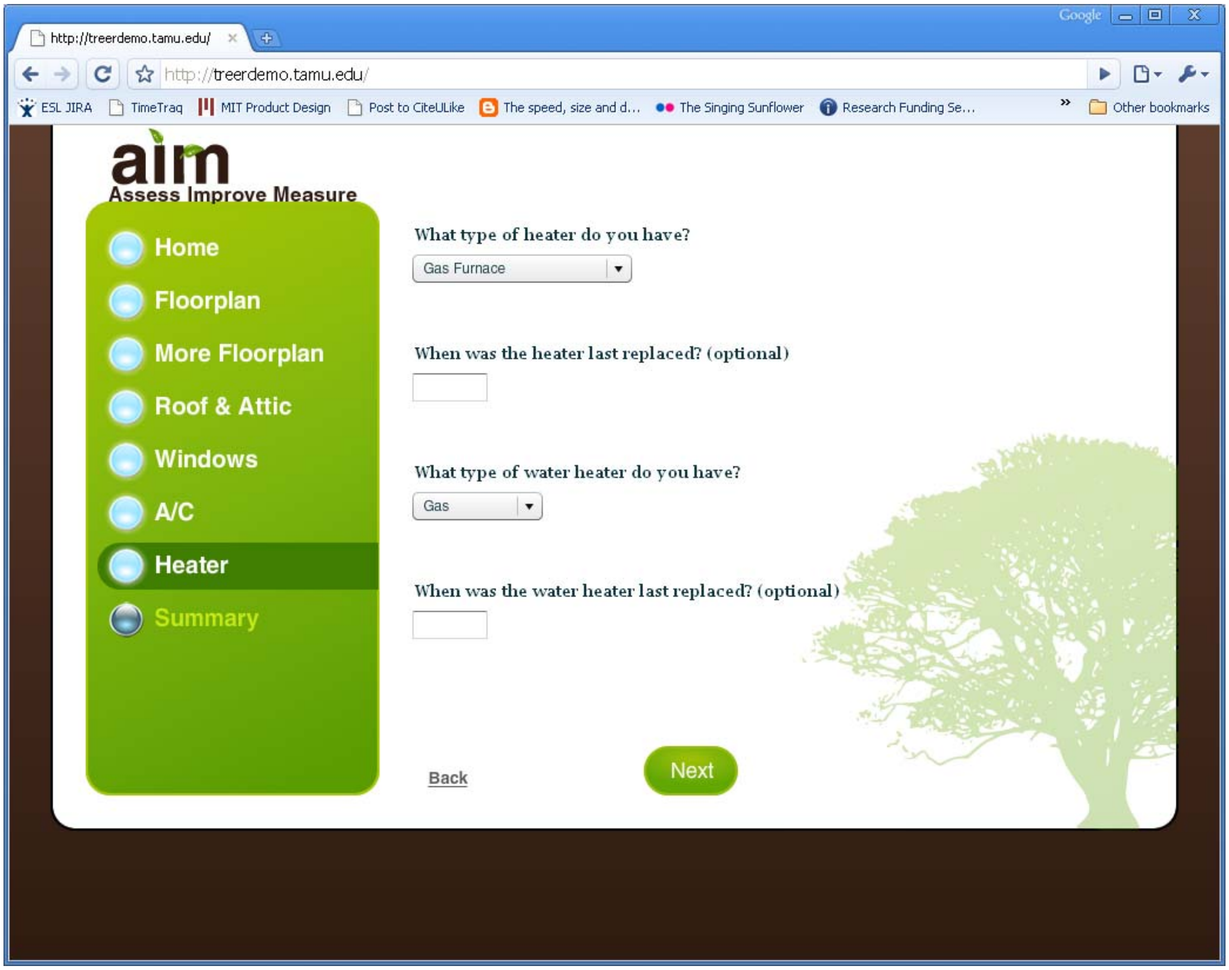

Figure 7. The heater panel.

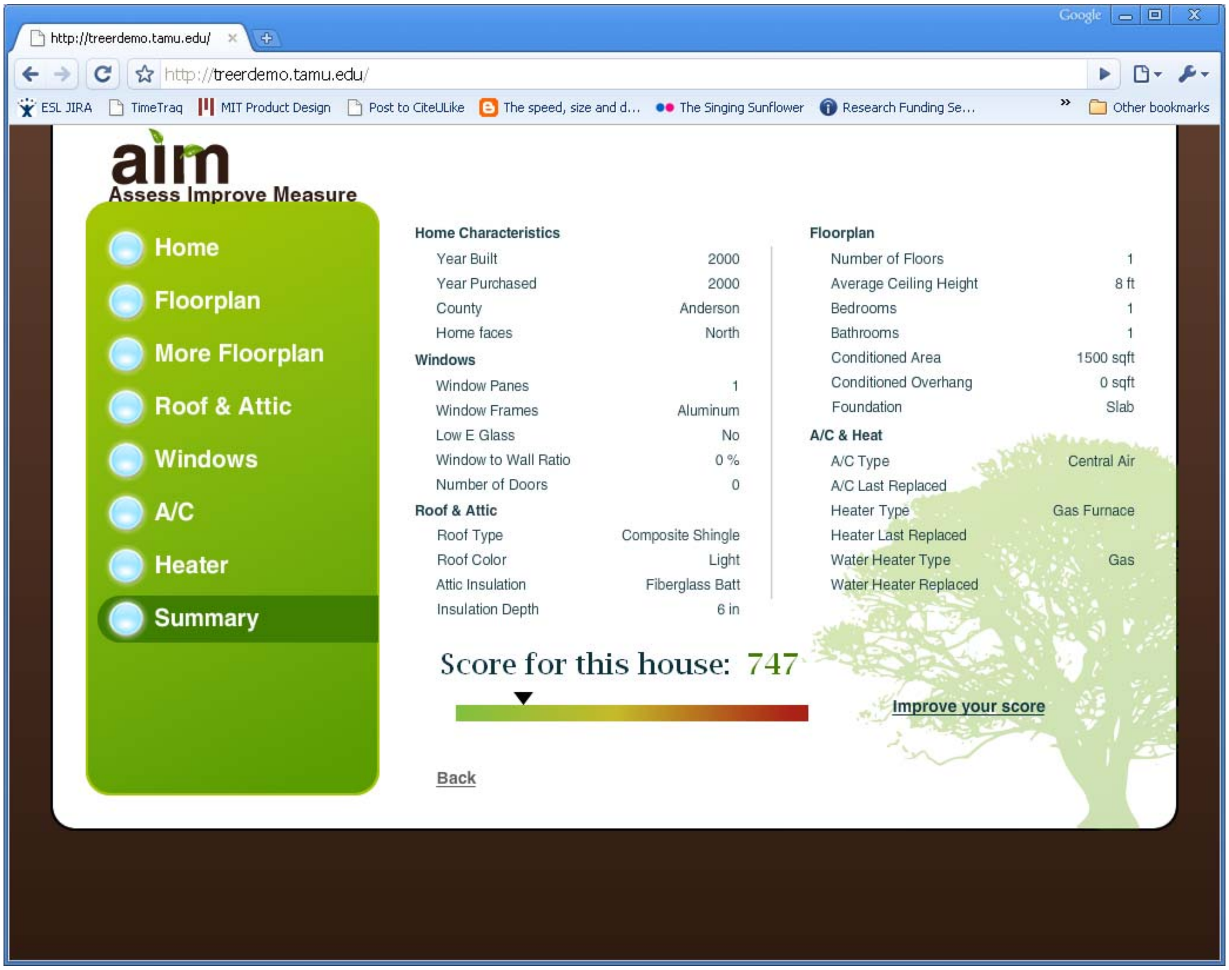

Figure 8. The summary panel

Table 1. House characteristics by age of the house[1 2]

Year of Const.	Heating System			Cooling System		DHW System [1]	
	Elec. Furn. (AFUE)	Elec. HP (HSPF)	Gas Furn. (AFUE)	Central AC (SEER)	Elec. HP (SEER)	Electric (EF)	NG (EF)
1970	98	3.74	60.00	6.50	5.50	79.8	47.4
1971	98	3.98	61.35	6.58	5.86	79.8	47.4
1972	98	4.22	62.70	6.66	6.21	79.8	47.4
1973	98	4.22	62.70	6.75	6.21	79.8	47.4
1974	98	4.22	62.70	6.85	6.21	79.8	47.4
1975	98	4.22	65.83	6.97	6.21	79.8	47.4
1976	98	4.67	66.12	7.03	6.87	79.9	47.5
1977	98	4.69	66.42	7.13	6.89	79.9	47.5
1978	98	4.92	66.71	7.34	7.24	80.0	47.6
1979	98	4.99	68.66	7.47	7.34	80.1	47.6
1980	98	5.11	70.60	7.55	7.51	80.2	47.7
1981	98	5.24	70.44	7.78	7.70	80.3	47.8
1982	98	5.30	70.28	8.31	7.79	80.4	47.9
1983	98	5.60	70.13	8.43	8.23	80.6	48.0
1984	98	5.75	72.62	8.66	8.45	80.9	48.1
1985	98	5.82	72.89	8.82	8.56	81.2	48.3
1986	98	5.92	73.73	8.87	8.70	81.5	48.4
1987	98	6.07	74.33	8.97	8.93	81.9	48.6
1988	98	6.21	74.86	9.11	9.13	82.3	48.8
1989	98	6.30	74.67	9.25	9.26	82.8	49.0
1990	98	6.43	76.70	9.31	9.46	83.2	49.2
1991	98	6.64	77.54	9.49	9.77	83.7	49.4
1992	98	7.21	82.08	10.46	10.60	84.2	49.6
1993	98	7.38	82.41	10.56	10.86	84.6	49.8
1994	98	7.44	82.43	10.61	10.94	85.0	49.9
1995	98	7.46	82.33	10.68	10.97	85.4	50.0
1996	98	7.48	82.66	10.68	11.00	85.7	50.1
1997	98	7.46	82.86	10.66	10.97	85.7	50.1
1998	98	7.68	82.62	10.92	11.29	85.7	50.1
1999	98	7.68	82.63	10.96	11.29	85.7	50.1
2000	98	7.62	82.62	10.95	11.21	85.7	50.1
2001	98	7.68	83.15	11.07	11.30	max[85.7, f1(V)]	max (50.1, f2(V))
2002	98	7.69	83.15	11.07	11.31	max[85.7, f1(V)]	max (50.1, f2(V))
2003	98	7.69	83.15	11.07	11.31	max[85.7, f1(V)]	max (50.1, f2(V))
2004	98	7.69	83.15	11.07	11.31	max[90, f1(V)]	max (55, f2(V))
2005	98	7.69	83.15	11.07	11.31	max[90, f1(V)]	max (55, f2(V))
2006	98	7.70	83.15	13.00	13.00	max[90, f1(V)]	max (55, f2(V))
2007	98	7.70	83.15	13.00	13.00	max[90, f1(V)]	max (55, f2(V))
2008	98	7.70	83.15	13.00	13.00	max[90, f1(V)]	max (55, f2(V))

[1] DHW System Energy Factor: f1(V) = 0.93 - 0.00132V (Electric); f2(V) = 0.62 - 0.0019V (Gas)

[2] Air Infiltration (ACH) = Normalized Leakage x Weather Factor (location dependent, from ASHRAE 136)

Table 2. House characteristics by age of the house (cont.)[3][4][5]

Year of Const.	Air Infil. [2]	Wall Cavity R-value [3,4]	Ceiling R-value [3,4]		Window U-value [3,4]		Window SHGC [4,5]	
	Normalized Leakage	East and West TX	East TX	West TX	East TX	West TX	East TX	West TX
1970	0.67	0	19	19	1.27	1.27	0.75	0.75
1971	0.67	0	19	19	1.27	1.27	0.75	0.75
1972	0.67	0	19	19	1.27	1.27	0.75	0.75
1973	0.67	0	19	19	1.27	1.27	0.75	0.75
1974	0.67	0	19	19	1.27	1.27	0.75	0.75
1975	0.67	0	19	19	1.27	1.27	0.75	0.75
1976	0.67	11	19	19	1.27	1.27	0.75	0.75
1977	0.67	11	19	19	1.27	1.27	0.75	0.75
1978	0.67	11	19	19	1.27	1.27	0.75	0.75
1979	0.67	11	19	19	1.27	1.27	0.75	0.75
1980	0.60	11	19	19	1.27	1.27	0.75	0.75
1981	0.60	11	19	19	1.27	1.27	0.75	0.75
1982	0.60	11	19	19	1.27	1.27	0.75	0.75
1983	0.60	11	19	19	1.27	1.27	0.75	0.75
1984	0.60	11	19	19	1.27	1.27	0.75	0.75
1985	0.60	11	19	19	1.27	1.27	0.75	0.75
1986	0.60	11	19	19	1.27	1.27	0.75	0.75
1987	0.60	11	19	19	1.27	1.27	0.75	0.75
1988	0.60	11	19	19	1.27	1.27	0.75	0.75
1989	0.60	11	19	19	1.27	1.27	0.75	0.75
1990	0.44	11	19	19	1.27	1.27	0.75	0.75
1991	0.44	11	19	19	1.27	1.27	0.75	0.75
1992	0.44	11	19	19	1.27	1.27	0.75	0.75
1993	0.44	11	19	19	1.27	1.27	0.75	0.75
1994	0.44	11	19	19	1.27	1.27	0.75	0.75
1995	0.44	11	19	19	1.27	1.27	0.75	0.75
1996	0.44	11	19	19	1.27	1.27	0.75	0.75
1997	0.44	13	19	30	1.27	0.87	0.75	0.66
1998	0.44	13	30	30	0.87	0.87	0.66	0.66
1999	0.44	13	30	30	1.27	0.87	0.75	0.66
2000	0.44	13	22	22	0.87	0.87	0.66	0.66
2001	0.44	max(13,Code)	max(30,Code)	max(30,Code)	min(0.87,Code)	min(0.87,Code)	min[0.66,f3(HDD)]	min[0.66,f3(HDD)]
2002	0.44	max(13,Code)	max(22,Code)	max(30,Code)	min(0.77,Code)	min(0.77,Code)	min[0.48,f3(HDD)]	min[0.48,f3(HDD)]
2003	0.44	max(13,Code)	max(30,Code)	max(30,Code)	min(0.77,Code)	min(0.77,Code)	min[0.48,f3(HDD)]	min[0.48,f3(HDD)]
2004	0.44	max(13,Code)	max(30,Code)	max(30,Code)	min(0.77,Code)	min(0.77,Code)	min[0.48,f3(HDD)]	min[0.48,f3(HDD)]
2005	0.44	max(13,Code)	max(30,Code)	max(30,Code)	min(0.77,Code)	min(0.77,Code)	min[0.48,f3(HDD)]	min[0.48,f3(HDD)]
2006	0.36	max(13,Code)	max(30,Code)	max(30,Code)	min(0.77,Code)	min(0.77,Code)	min(0.48,Code)	min(0.48,Code)
2007	0.36	max(13,Code)	max(30,Code)	max(30,Code)	min(0.77,Code)	min(0.77,Code)	min(0.48,Code)	min(0.48,Code)
2008	0.36	max(13,Code)	max(30,Code)	max(30,Code)	min(0.77,Code)	min(0.77,Code)	min(0.48,Code)	min(0.48,Code)

[3] Code-specified window U-values, and wall cavity and ceiling R-values (2001-2005) vary by WWR and HDD of the location (2000/2001 IECC, Chapter 5, Table 502.2.4)

[4] Code-specified window U-values and SHGC, and wall cavity and ceiling R-values (2006 onwards) vary by HDD of the location (2006 IECC, Chapter 4, Table 402.1.1)

[5] Code-specified window SHGC (2001-2005): f3(HDD) = 0.4 if HDD <3,500; f3(HDD) = 0.68 if HDD >= 3,500