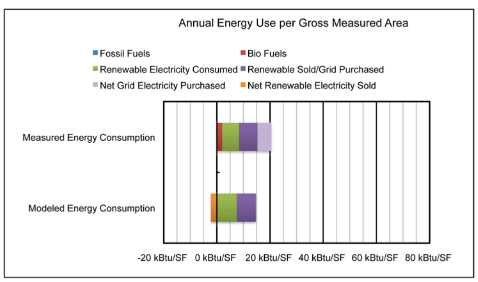
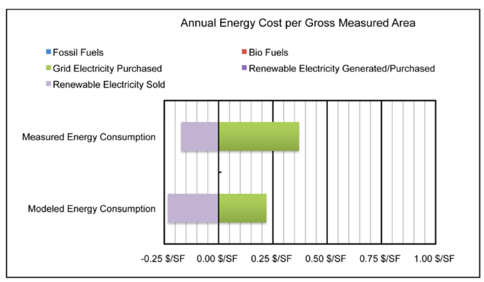
Carbon Neutral Design

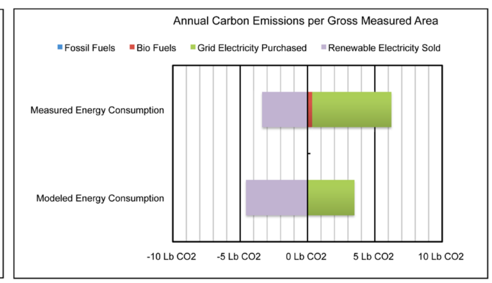
Building Case Study Spreadsheet

Michael Utzinger

December 1, 2010







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Purpose of the Carbon Neutral Design Building Case Study Spreadsheet

The AIA 2030 Challenge requires new buildings to consume 50% less energy than a similar building designed to codes in 2010 and be carbon neutral (no net carbon emissions) by 2030. To achieve these goals, architects and their consultants need to be able to measure the performance of the buildings they design. The Carbon Neutral Design (CND) Building Case Study Spreadsheet is designed to allow architects and consulting engineers to input building design information and energy and water consumption measurements. The spreadsheet calculates resource consumption and emission metrics and normalized building design and system variables. The spreadsheet is divided into two Levels.

Level 1 takes building project information (areas, cost, and occupancy data) and resource consumption data (fossil fuels, biofuels, grid electricity, renewable electricity and water) and produces a set of building resource consumption and carbon emissions metrics. The graphs illustrated on the title page are taken from the Level 1 Design Goals tab. There are a number of emissions calculators and spreadsheets currently available that produce resource consumption and emissions metrics. This spreadsheet has attempted to be broadly applicable by allowing the user to choose the appropriate building area for normalization, include or exclude parking garage area, normalize resource consumption and emissions to the occupant and output metrics in both imperial and standard international units.

The significant difference between this building case study spreadsheet and other emissions calculators is the inclusion of building and system design variables in Level 2. The building enclosure, lighting system, HVAC system, elevator/escalator system plug load demands and process load demands are inputs in Level 2. The CND Building Case Study Spreadsheet normalizes building shell and system variables to the building area definition chosen in Level 1. Most architects and engineers can suggest an appropriate normalized lighting power density (W/SF or W/m^2). Very few could suggest an appropriate normalized fan power density. Performance of buildings cannot be understood without measurement. By measuring resource consumption and carbon dioxide emissions and comparing them with normalized building and system design variables, architects and engineers should be able to understand their designs and produce better buildings in the future. Hopefully, the 2030 challenge can be met.

This document describes the inputs and outputs of the CND Building Case Study Spreadsheet.

Acknowledgements

Work on the building case study spreadsheet began in 2008 as part of the Carbon Neutral Design Curriculum Materials Project sponsored by the Society of Building Science Educators and the American Institute of Architects. After initial presentations to educators and professionals at a Carbon Neutral Design Conference in Milwaukee, Wisconsin in October, 2008 and a Carbon Neutral Design Workshop in Portland, Oregon in February 2010, additional funding support was provided to revise and complete the spreadsheet by the University of Wisconsin-Milwaukee, the University of Oregon, and BetterBricks.

A number of people provided helpful feedback which hopefully improved the usability of the final spreadsheet. James Wasley, Greg Thomson, Leyla Sanati, Steve Wollner and Mark Mommerts at the University of Wisconsin-Milwaukee; Alison Kwok, Karen Buse, Audrey Snyder and Cierra Mantz at the University of Oregon; Terri Boake at the University of Waterloo and John Quale at the University of Virginia all provided helpful feedback during the development. Architects and engineers participating in BetterBricks sponsored workshops in Portland, Oregon in February and September, 2010 and in Seattle, Washington in October, 2010 provided very helpful criticism of the spreadsheet tool. I thank all of you for your input into the final for of the spreadsheet.

Michael Utzinger
University of Wisconsin-Milwaukee
December 2010

The Carbon Neutral Design Building Case Study Spreadsheet

A completed case study of the Aldo Leopold Legacy Center will be used to introduce and explain inputs for and outputs of the Carbon Neutral Design Case Study Spreadsheet. The Aldo Leopold Legacy Center, designed by the Kubala Washatko Architects, is located outside Baraboo, Wisconsin near a pine forest planted in the 1930s by Aldo Leopold and his family. A campus of three small buildings, the Legacy Center was designed to be carbon neutral and net zero in its operation. As you will see later in this manual, the projected design performance can be compared to the actual resource use of your buildings. The three graphs on the cover of this manual are a comparison of the design and actual energy use, energy cost and carbon emissions of the Legacy Center.

The Legacy Center includes three buildings. The largest is conditioned and contains offices, exhibit space and a conference room. One of the smaller buildings is a seasonally occupied classroom. The other is a workshop and garage. The completed spreadsheet for the Aldo Leopold Legacy Center is used to introduce the spreadsheet tool on the following pages.

The photos at left, graciously provided by Mark Heffron, provide a view of the Legacy Center looking west with the 39.4 kW PV array and 100 SF solar thermal collectors located on the main office building roof and a view looking out to the northwest from inside the seasonal classroom. The following page illustrates the CND Case Study Spreadsheet Project tab with values entered for the Aldo Leopold Legacy Center.

Level 1 Case Study - Project Information

Aldo Leopold Legacy Center	
the Kubala Washatko Architects	***2007***
Baraboo	***Wisconsin***
Building Type	*Office Building*
No Housing	*0 Units*
Ownership Type	*Non-profit*

Design & Construction Cost		
Design Costs	***$***	***375,685***
Construction Costs	***$***	***4,042,140***
LEED Costs	***$***	***112,500***
Furnishing & Relocation	***$***	***134,500***
Total Costs	**$**	**4,664,825**

Building Floor Areas		**Distinct Building Areas**		
		Main Area	**SubArea 1**	**SubArea 2**
Area Name	**Total Building**	***Office***	***Classroom***	***Workshop/Garage***
			Unconnected, Unconditioned	*Unconnected, Unconditioned*
Gross Floor Area	**13,452 SF**	*10,398 SF*	*1,351 SF*	*1,703 SF*
Gross Measured Area	**12,322 SF**	*9,562 SF*	*1,209 SF*	*1,551 SF*
Major Vertical Penetrations	**105 SF**	*105 SF*	*0 SF*	*0 SF*
Building Common Area	**2,269 SF**	*2,269 SF*	*0 SF*	*0 SF*
Floor Common Area	**1,293 SF**	*1,293 SF*	*0 SF*	*0 SF*
Usable (Assignable) Area	**8,655 SF**	5,895 SF	1,209 SF	1,551 SF
Total Occupied Area	**12,217 SF**	9,457 SF	1,209 SF	1,551 SF
Mechanically Heated Area	**9,316 SF**	*9,316 SF*	*0 SF*	*0 SF*
Mechanically Cooled Area	**9,316 SF**	*9,316 SF*	*0 SF*	*0 SF*
Mechanically Ventilated Area	**9,316 SF**	*9,316 SF*	*0 SF*	*0 SF*
Parking Garage	**0 SF**	0 SF	0 SF	0 SF
Daylit Area	**10,760 SF**	*8,000 SF*	*1,209 SF*	*1,551 SF*
Metric Analysis Area	**12,322 SF**	**9,562 SF**	**1,209 SF**	**1,551 SF**

These Cells Calculated for Housing Only			

OCCUPANCY			
Staff	**Number of People**	**Time in Building**	**F.T.E**
Full Time Staff	*12*	*60%*	7.2 FTE
Part Time Staff	*3*	*10%*	0.3 FTE
Total Staff			**7.5 FTE**
Others	**Visits per Week**	**hours/visit**	**F.T.E**
Visitors	*140*	*2*	7.0 FTE
Student or Client	*0*	*0*	0.0 FTE
Total Others			**7.0 FTE**
Total Occupants			**14.5 FTE**

Building Area Used in Metrics Calculations	**Gross Measured Area**
Is Parking Garage included in Calculations?	**No**

Figure 1: CND Level 1 Project tab for Aldo Leopold Legacy Center

LEVEL 1 Case Study

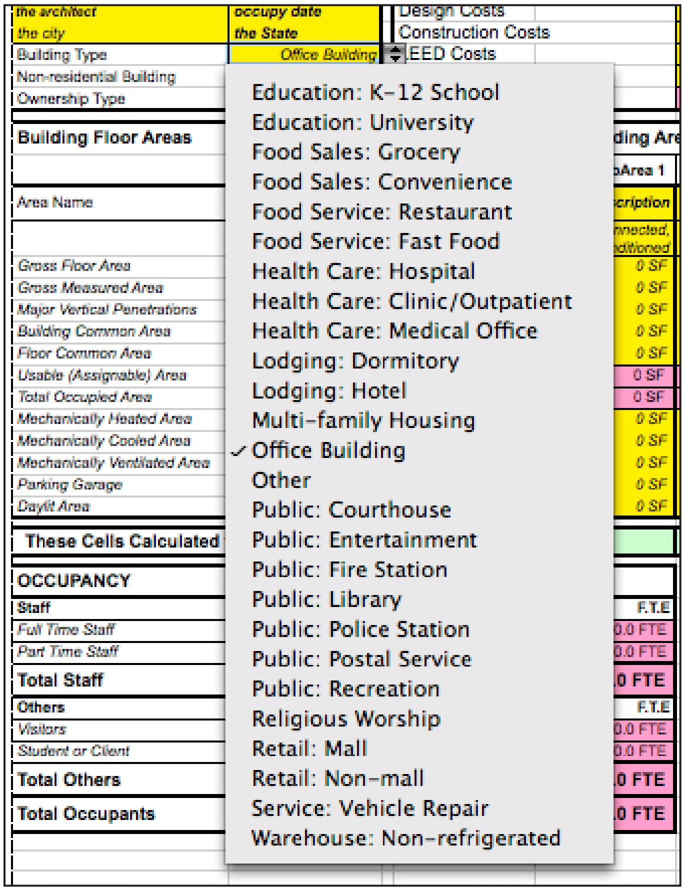

Figure 2: Building type drop-down menu

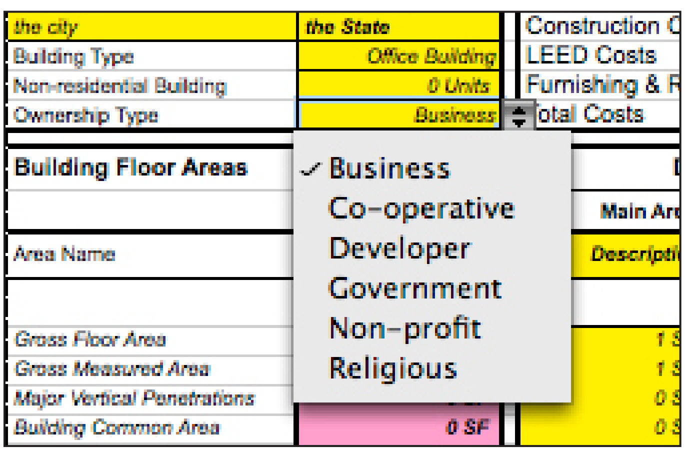

Figure 3: Ownership drop-down menu

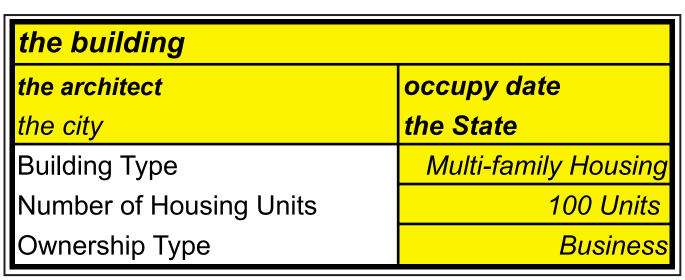

Figure 4: Building type Multi-family Housing

A Level 1 Building Case Study provides energy and water consumption as well as carbon dioxide emissions per unit building area and per occupant (if the building type is residential, consumption per residential unit or room is also computed). Information for the building project is input on the *Level 1 - Project* tab. Resource consumption for the building project is input on the *Level 1 - Resources* tab. Modeled (estimated) energy consumption is input on the *Level 1 - Design Goal* tab. Graphic comparison of estimated and actual energy use, energy cost and emissions data are found on the *Level 1 - Design Goal* tab. The *Level 1 - Metrics* tab provides energy consumption, carbon dioxide emissions, and water consumption use per unit area of the building, per full time equivalent occupant of the building and, if the building type is residential, per housing unit or per room. The user can chose whether to use gross building area, gross measured area or occupied area as the area for the energy us metrics calculations. If the building includes a parking garage, the user can also chose whether to include or exclude the parking garage area in the metric calculations.

For all tabs in the workbook, the yellow cells are the only cells for inputs. All other cells are protected. The worksheet/workbook protection does not include a password and can be unprotected (allowing modification of any of the equations and cell values) at any time by the user. The protection was placed to require the user to clearly decide to open up the case study spreadsheets for modification. Inputs and a description of each excel tab for a Level 1 Case Study follow.

Level 1 - Project

Project information includes general building data, construction cost, area and sub area data, and occupancy data. Figure 1 illustrates the completed Level 1 - Project tab for the Aldo Leopold Legacy Center. Discussion of each Project data input is provided below.

General Building Data

In the appropriate cells enter the building name, architect, year of occupancy, and location (city and state). The building type is chosen from a drop-down list (see Figure 2). Input the number of units only if building type is *Multi-family Housing*, *Lodging: Dormitory* or *Lodging: Hotel*.

Ownership Type is also chosen from a drop-down list (see Figure 3).

If the building type is residential, some of the cell values change to permit input of the number of housing units if the type is *Multi-family Housing* (Figure 4). If the building type is *Lodging: Dormitory* or *Lodging: Hotel*, the number of dorm or hotel rooms are entered. For these three residential building types, other cells in the workbook will change to permit building metrics per unit of housing or lodging room as will be described in the following pages.

Building Cost Data

Building Cost Data input is illustrated in Figure 1 for the Aldo Leopold Legacy Center. Only the total costs are used in the metrics calculations. The total costs will be the sum of all costs entered under each area. If different cost categories are desired, for example, site purchase costs, the user can unprotect the spread sheet and edit one of the cost categories.

Building Floor Areas		Distinct Building Areas		
		Main Area	SubArea 1	SubArea 2
Area Name	Total Building	*Office*	*Classroom*	*Workshop/Garage*
			Unconnected, Unconditioned	*Unconnected, Unconditioned*
Gross Floor Area	**13,452 SF**	*10,398 SF*	*1,351 SF*	*1,703 SF*
Gross Measured Area	**12,322 SF**	*9,562 SF*	*1,209 SF*	*1,551 SF*
Major Vertical Penetrations	**105 SF**	*105 SF*	*0 SF*	*0 SF*
Building Common Area	**2,269 SF**	*2,269 SF*	*0 SF*	*0 SF*
Floor Common Area	**1,293 SF**	*1,293 SF*	*0 SF*	*0 SF*
Usable (Assignable) Area	**8,655 SF**	5,895 SF	1,209 SF	1,551 SF
Total Occupied Area	**12,217 SF**	9,457 SF	1,209 SF	1,551 SF
Mechanically Heated Area	**9,316 SF**	*9,316 SF*	*0 SF*	*0 SF*
Mechanically Cooled Area	**9,316 SF**	*9,316 SF*	*0 SF*	*0 SF*
Mechanically Ventilated Area	**9,316 SF**	*9,316 SF*	*0 SF*	*0 SF*
Parking Garage	**0 SF**	0 SF	0 SF	0 SF
Daylit Area	**10,760 SF**	*8,000 SF*	*1,209 SF*	*1,551 SF*
Metric Analysis Area	**12,322 SF**	**9,562 SF**	**1,209 SF**	**1,551 SF**
These Cells Calculated for Housing Only				

Figure 5: CND Level 1 Project tab Building Area Section

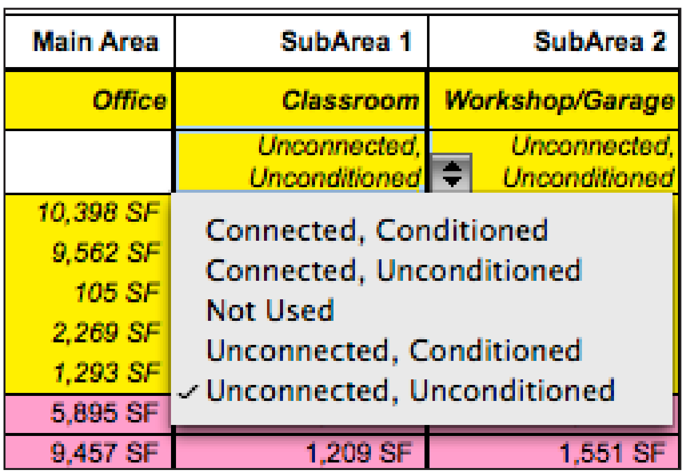

Figure 6: CND Level 1 Project tab SubArea drop-down menu.

Building Floor Areas

Many projects include differing functions with differing HVAC systems. The CND Case Study spreadsheet allows subdivision of the building into three distinct areas: a Main Area and two SubAreas. If the building case study is not broken down into sub areas, all area values are input in the Main Area column. Figure 5 illustrates the building area inputs for the Aldo Leopold Legacy Center. The building includes a main building, which is thermally conditioned, a seasonally occupied classroom building and a workshop and garage. The thermal conditions and relationship of the sub area to the main building area are set using a drop-down menu illustrated in Figure 6. The sub area can be connected to the main area or not and can be conditioned or not. If sub areas are not used, select not used. The Classroom and Workshop/Garage of the Aldo Leopold Legacy Center are both unconnected and unconditioned.

There are a number of differing area definitions for buildings. The CND Case Study spreadsheet uses the BOMA (Building Owners and Managers Association) definitions of building areas. Building Resource Metrics and Building Unit Design Variables are computed as functions of specific building floor areas. The most common floor area measure used in metrics is the Gross Floor Area. The Total Occupied Area is also useful in computing resource metrics. This building performance analysis method uses the BOMA (Building Owners and Managers Association) area definitions along with additional floor area definitions. Each area is defined as follows:

- Gross Floor Area (GSF): The total constructed area of the building measured to the outside surface of the walls. This definition is from BOMA.
- Gross Measured Area (GMA): The total area of the building enclosed by the inside wall surface. This definition is from BOMA. NREL (National Renewable Energy Laboratory) calls this area the Gross Interior Floor Area and suggests that this is the appropriate building area for energy metrics calculations. (*Standard Definitions of Building Geometry for Energy Evaluation*, NREL/TP-550-38600, October 2005.)
- Major Vertical Penetrations (MVP): The stairs, elevator shafts, flues, pipe shafts, vertical ducts and the like, and their enclosing walls, which serve more than one floor of a building. Space considered either unsafe or not functional is classified as unusable and is included in the MVP calculations. This definition is from BOMA.
- Building Common Area (BCA): The area of the building that provides services to all building tenants. This area includes main and auxiliary lobbies, fire control rooms, mechanical rooms, etc. This definition is from BOMA.

- Floor Common Area (FCA): The areas on a floor, such as washrooms, janitorial closets, electrical rooms, elevator lobbies, public and shared corridors which are available primarily for the use of tenants on that floor. This definition is from BOMA.
- Usable Area (UA): The actual area of a floor that a building tenant is assigned. (Note: Space considered unsafe or not functional is classified as unusable and is included in the MVP calculations.) When a building has a single tenant, the sum of the Usable Area, Floor Common Area, Building Common Area and Major Vertial Penetrations should equal the Gross Measured Area.

$$UA_{\text{all tenants}} + FCA_{\text{all floors}} + BCA + MVP = GMA$$ This definition is from BOMA.

- Total Occupied Area (TOA): The sum of the Building Common Area, all Floor Common Areas and all Usable Areas. This definition is unique to the building case study method presented in this document, although based on BOMA area definitions. Using BOMA definitions, the TOA is defined as follows:

$$TOA = GMA - MVP$$

- Mechanically Heated Area (MHA): That portion of the Building Common Area, all Floor Common Areas all Usable Areas and Measured Vertical Penetrations served by a mechanical heating system. This definition is unique to the building case study method presented in this document.
- Mechanically Cooled Area (MCA): That portion of the Building Common Area, all Floor Common Areas all Usable Areas and Measured Vertical Penetrations served by an air-conditioning system. This definition is unique to the building case study method presented in this document.
- Mechanically Ventilated Area (MVA): That portion of the Building Common Area, all Floor Common Areas all Usable Areas and Measured Vertical Penetrations served by a mechanical ventilation system. This definition is unique to the building case study method presented in this document.
- Daylit Area (DA): That portion of the Building Common Area, all Floor Common Areas and all Usable Areas which is substantially illuminated by daylighting. The method of computing daylit areas is from LEED NB 3.0. This definition is unique to the building case study method presented in this document.

There are two unique building area types: Residential and Parking Garage. If the Building Type is either *Multi-family Housing*, *Lodging: Dormitory* or *Lodging: Hotel,* then energy matrics per residential unit or room can be computed. This is done by inserting the number of units or rooms in cell B5 and naming the *Main Area*, *SubArea 1* or *SubArea2* "Residential". The average assignable area per residential unit or room will be automatically calculated. In urban areas, parking garages are often included in building projects. Parking garages are often not conditioned and may or may not be mechanically ventilated. If a parking garage is a part of the building project, it should be input as a sub area of the building. NREL recommends that parking garages not be included in building energy evaluations. For the CND Case Study spreadsheet, inclusion or exclusion of parking garages in energy evaluations is a choice as described later. Figure 7 below provides an example of area inputs and calculations for a multifamily residential building with a parking garage, the parking garage area is chosen to be not included.

Note that the only Area Names for the Distinct Building Areas resulting in additional calculations are "Residential" and Parking Garage".

Building Floor Areas		**Distinct Building Areas**		
		Main Area	**SubArea 1**	**SubArea 2**
Area Name	**Total Building**	***Residential***	***Commercial***	***Parking Garage***
			Unconnected, Conditioned	*Unconnected, Unconditioned*
Gross Floor Area	**55,290 SF**	*35,088 SF*	*4,317 SF*	*15,885 SF*
Gross Measured Area	**52,961 SF**	*33,543 SF*	*4,078 SF*	*15,340 SF*
Major Vertical Penetrations	**2,834 SF**	*1,975 SF*	*301 SF*	*558 SF*
Building Common Area	**2,525 SF**	*1,589 SF*	*198 SF*	*738 SF*
Floor Common Area	**2,914 SF**	*2,914 SF*	*0 SF*	*0 SF*
Usable (Assignable) Area	**44,688 SF**	27,065 SF	3,579 SF	14,044 SF
Total Occupied Area	**50,127 SF**	31,568 SF	3,777 SF	14,782 SF
Mechanically Heated Area	**30,644 SF**	*27,065 SF*	*3,579 SF*	*0 SF*
Mechanically Cooled Area	**0 SF**	*0 SF*	*0 SF*	*0 SF*
Mechanically Ventilated Area	**45,426 SF**	*27,065 SF*	*3,579 SF*	*14,782 SF*
Parking Garage	**14,044 SF**	0 SF	0 SF	14,044 SF
Daylit Area	**15,660 SF**	*12,740 SF*	*2,920 SF*	*0 SF*
Metric Analysis Area	**38,917 SF**	**33,543 SF**	**4,078 SF**	**1,296 SF**
	Area per Housing Unit	**541 SF**		

Figure 7: CND Level 1 Project tab Sampe area inputs and calculations for a multifamily residential building with parking garage.

Occupancy

The CND Case Study spreadsheet estimates resource metrics per building occupant. One full time occupant (FTE) occupies the building 40 hours per week, 50 weeks per year. The occupants for the Aldo Leopold Legacy Center are illustrated in Figure 8. Full Time and Part Time Staff are estimated by the number of staff and their average percentage of weekly time in the building. Visitors, Students and/or Clients are estimated as the product of the number per week and the hours per visit. If the building type is either *Multi-family Housing*, *Lodging: Dormitory* or *Lodging: Hotel,* then the Visitors, Students or Clients are replaced with the number of Residents. One Resident equals one FTE. A sample Occupancy input for a multifamily housing project is illustrated in Figure 9.

OCCUPANCY			
Staff	**Number of People**	**Time in Building**	**F.T.E**
Full Time Staff	*12*	*60%*	7.2 FTE
Part Time Staff	*3*	*10%*	0.3 FTE
Total Staff			**7.5 FTE**
Others	**Visits per Week**	**hours/visit**	**F.T.E**
Visitors	*140*	*2*	7.0 FTE
Student or Client	*0*	*0*	0.0 FTE
Total Others			**7.0 FTE**
Total Occupants			**14.5 FTE**

Figure 8: CND Level 1 Project tab Occupancy data for Aldo Leopold Legacy Center.

OCCUPANCY			
Staff	**Number of People**	**Time in Building**	**F.T.E**
Full Time Staff	*1*	*100%*	1.0 FTE
Part Time Staff	*2*	*25%*	0.5 FTE
Total Staff			**1.5 FTE**
Residents	**Number**		**F.T.E**
Residents	*120*	*24*	120.0 FTE
	0	*0*	0.0 FTE
			120.0 FTE
Total Occupants	**Residents**	**120 People**	**121.5 FTE**

Figure 9: CND Level 1 Project tab Occupancy data for Multifamily Housing Project.

Areas Used in Metrics Calculations

Different building areas have been proposed for resource use metrics calculations. The CND Building Case Study spreadsheet allows the choice for four possible building areas for metrics calculations: the *Gross Floor Area*, *Gross Measured Area*, *Total Occupied Area*, and *Usable (Net Assignable) Area*. A drop-down menu allows the user to choose the building area to be used in all metrics calculations (Figure 10). NREL recommends the Gross Measured Area (defined as Gross Interior Floor Area in their publications) as the appropriate building area for resource metrics calculations. If the building includes a parking garage, it can be included or excluded from the metrics calculations by choosing yes (to include) or no (to exclude) from metrics calculations. NREL recommends excluding parking garage areas from the building area used in energy evaluations (*Standard Definitions of Building Geometry for Energy Evaluation*, NREL/TP-550-38600, October 2005).

Building Area Used in Metrics Calculations	**Gross Measured Area**	**12,322 SF**
Is Parking Garage included in Calculations?	**No**	

Figure 10: CND Level 1 Project tab Area Selection for Building Resource Metrics Calculations.

Level 1 Case Study - Measured Resource Consumption

Aldo Leopold Legacy Center			Solar PV Capacity	39.40 kW DC peak
the Kubala Washatko Architects			Solar Thermal Area	100 SF
Baraboo	Wisconsin		Wind System Capacity	0.00 kW DC peak

Scope 1 Energy & Emissions: Site Combustion				
Fossil Fuels	Natural Gas			
Comments	Date	Days	Fuel Purchased	Cost of Fuel
Natural Gas Consumption	1-Jan-09			
	1-Feb-09	31	0 Therm	$ -
	1-Mar-09	28	0 Therm	$ -
	1-Apr-09	31	0 Therm	$ -
	1-May-09	30	0 Therm	$ -
	1-Jun-09	31	0 Therm	$ -
	1-Jul-09	30	0 Therm	$ -
	1-Aug-09	31	0 Therm	$ -
	1-Sep-09	31	0 Therm	$ -
	1-Oct-09	30	0 Therm	$ -
	1-Nov-09	31	0 Therm	$ -
	1-Dec-09	30	0 Therm	$ -
	1-Jan-10	31	0 Therm	$ -
Annual Total		365	0 Therm	$ -
Natural Gas in kBtu & CO2 Emissions			0 kBtu	0.00 Ton CO2
Fossil Fuels	LPG (Propane)			
Comments	Date	Days	Fuel Purchased	Cost of Fuel
Propane Consumption	1-Jan-09			
	1-Feb-09	31	0 gal	$ -
	1-Mar-09	28	0 gal	$ -
	1-Apr-09	31	0 gal	$ -
	1-May-09	30	0 gal	$ -
	1-Jun-09	31	0 gal	$ -
	1-Jul-09	30	0 gal	$ -
	1-Aug-09	31	0 gal	$ -
	1-Sep-09	31	0 gal	$ -
	1-Oct-09	30	0 gal	$ -
	1-Nov-09	31	0 gal	$ -
	1-Dec-09	30	0 gal	$ -
	1-Jan-10	31	0 gal	$ -
Annual Total		365	0 gal	$ -
Propane in kBtu & CO2 Emissions			0 kBtu	0.00 Ton CO2

CND Case Study | Resource Data | 12/2/10 Page 1

Figure 11: CND Level 1 Resources tab Page 1 ~ Natural Gas & LPG.

Level 1 Case Study - Measured Resource Consumption

Fossil Fuels	Heating Oil			
Comments	Date	Days	Fuel Purchased	Cost of Fuel
Heating Oil Consumption	1-Jan-09			
	1-Feb-09	31	0 gal	$ -
	1-Mar-09	28	0 gal	$ -
	1-Apr-09	31	0 gal	$ -
	1-May-09	30	0 gal	$ -
	1-Jun-09	31	0 gal	$ -
	1-Jul-09	30	0 gal	$ -
	1-Aug-09	31	0 gal	$ -
	1-Sep-09	31	0 gal	$ -
	1-Oct-09	30	0 gal	$ -
	1-Nov-09	31	0 gal	$ -
	1-Dec-09	30	0 gal	$ -
	1-Jan-10	31	0 gal	$ -
Annual Total		365	0 gal	$ -
Heating Oil in kBtu & CO2 Emissions			0 kBtu	0.00 Ton CO2
Fossil Fuel Summary	Energy		CO2	Cost of Fuel
	0 kBtu		0.00 Ton CO2	$ -
Biofuels	Wood		Wood Species	Oak - White
Comments	Fuel	Quantity	Energy Equivelent	Cost of Biofuel
		0.85 Cords	24,735 kBtu	$ -
			0 kBtu	$ -
			0 kBtu	$ -
			0 kBtu	$ -
Annual Total			24,735 kBtu	$ -
			Biofuels CO2 Emissions	2.15 Ton CO2

CND Case Study | Resource Data | 12/2/10 Page 2

Figure 12: CND Level 1 Resources tab Page 2 ~ Heating Oil & Biofuels.

Level 1 - Resources

Actual building resource consumption (energy and water) is entered on the *Level 1 - Resources* tab. In addition, renewable energy resource systems are identified at the top of the tab (see Figure 11). Site solar photovoltaic systems are identified by their peak DC capacity in kW. Site solar thermal systems are identified by their collector area. Site wind electric systems are identified by their peak DC capacity in kW.

Scope 1 Energy Resources ~ Fossil Fuel & Biofuel Combustion

The World Resources Institute structure for carbon dioxide emissions accounting is used to organize energy consumption into Scope 1: On Site Combustion and Scope 2: Electricity Consumption and Generation. For Scope 1, on site combustion use is divided into fossil fuel use (natural gas, propane and fuel oil) and biofuel use. Fossil fuel use can be input from utility or fuel bills. Input dates for the beginning and end of each billing cycle, the energy consumed in that billing cycle, and the cost of supplying the energy during the billing cycle. The spreadsheet automatically computes the number of days in the billing cycle. For each fuel type, the annual energy consumption is prorated to 365 days (actual annual billing cycle may be slightly more or less than 365 days). The prorating calculation provides estimates of annual fuel consumption when partial year consumption is available. Click on Cell D21 to examine the prorating equation for natural gas consumption. Biofuels are limited at this time to wood energy measured in cords. The species of wood combusted is chosen from a drop-down menu located in cell E60 (see Figure 12, the cell containing *Oak - White*).

Carbon Dioxide emissions due to energy consumption are automatically estimated using conversion constants given in *Source Energy and Emission Factors for Energy Use in Buildings* (M. Deru & P. Torcellini, NREL/TP-550-3867). Separate calculations of fossil fuel and biofuel carbon dioxide emissions are calculated (see Figure 12).

Scope 2 Energy Resources ~ Electricity

Electricity purchased from the power grid and electricity produced from wind or solar energy on site are entered as Scope 2 Energy and Emissions quantities. Billing cycle start and end dates, energy quantities and energy costs are entered in the same manner as fossil fuel consumption (see Figure 13). Note that the electricity produced from solar PV panels is entered as a single annual value (see Figure 13). While actual measurements of energy consumption and production are desired, there were problems with the site measurements and an estimate based on the energy simulation, 48,000 kWh, was used. The solar generated electricity sold to the electric utility was metered by the utility and it is entered in the area for solar electricity sold to the grid (see Figure 14). Wind electricity generated on site and wind electricity sold to the grid are treated similar to solar electric (Figures 14 and 15). The Aldo Leopold Legacy Center did not include wind electric systems.

Carbon Dioxide emissions due to electric generation are estimated using conversion constants given in *Source Energy and Emission Factors for Energy Use in Buildings* (M. Deru & P. Torcellini, NREL/TP-550-3867). The user must select the appropriate electric generation region from a drop-down menu in cell C165 (Figure 15). The *Eastern* electric region is chosen for the Legacy Center. If sub-metering is provided in the building project, the spreadsheet permits input of submetered electric consumption based either on sub areas of the building or on sub-metered uses. For the Aldo Leopold Legacy Center, each building was sub-metered as were the lights and the plug loads (see Figure 15).

Finally, water consumption can be entered (Figure 16). None is entered for the Legacy Center as water from the site well was not metered.

Level 1 Case Study - Measured Resource Consumption

Scope 2 Energy & Emissions: Electricity

Grid Electricity	Purchases				
Comments	Date	Days	Electricity Purchased		Cost of Service
	1-May-08			$	-
	1-Jun-08	31	1,160 kWh	$	130.90
	1-Jul-08	30	1,320 kWh	$	163.56
	1-Aug-08	31	2,640 kWh	$	321.91
	1-Sep-08	31	1,680 kWh	$	182.89
	1-Oct-08	30	1,400 kWh	$	161.45
	1-Nov-08	31	2,720 kWh	$	285.88
	1-Dec-08	30	4,840 kWh	$	490.65
	1-Jan-09	31	6,960 kWh	$	668.28
	1-Feb-09	31	8,640 kWh	$	811.28
	1-Mar-09	28	5,400 kWh	$	566.55
	1-Apr-09	31	5,040 kWh	$	539.12
	1-May-09	30	2,360 kWh	$	248.89
Annual Total		365	44,160 kWh	$	4,571.36
Electricity in Heat Units			150,718 kBtu		

Solar Electricity	Total Solar Electricity Generated or Purchased				
Comments	Date	Days	Electricity Produced		
	1-May-08				
	1-Jun-08	31	0 kWh		
	1-Jul-08	30	0 kWh		
	1-Aug-08	31	0 kWh		
	1-Sep-08	31	0 kWh		
	1-Oct-08	30	0 kWh		
	1-Nov-08	31	0 kWh		
	1-Dec-08	30	0 kWh		
	1-Jan-09	31	0 kWh		
	1-Feb-09	31	0 kWh		
	1-Mar-09	28	0 kWh		
	1-Apr-09	31	0 kWh		
	1-May-09	30	48,000 kWh		
Annual Total		365	48,000 kWh	$	-
Electricity in Heat Units			163,824 kBtu		

CND Case Study Resource Data 12/2/10 Page 3

Figure 13: CND Level 1 Resources tab Page 3 ~ Grid & Solar Electricity.

Level 1 Case Study - Measured Resource Consumption

Solar Electricity	Solar Electricity Sold to Grid				
Comments	Date	Days	Electricity sold		Value of Electricity
Enter solar PV electricity	1-May-08				
sold to grid here here.	1-Jun-08	31	3,720 kWh	$	312.48
	1-Jul-08	30	3,240 kWh	$	272.16
	1-Aug-08	31	2,520 kWh	$	211.68
	1-Sep-08	31	3,480 kWh	$	292.32
	1-Oct-08	30	3,160 kWh	$	265.44
	1-Nov-08	31	1,880 kWh	$	157.92
	1-Dec-08	30	880 kWh	$	73.92
	1-Jan-09	31	40 kWh	$	3.36
	1-Feb-09	31	120 kWh	$	10.08
	1-Mar-09	28	1,080 kWh	$	90.72
	1-Apr-09	31	2,000 kWh	$	168.00
	1-May-09	30	3,200 kWh	$	268.80
Annual Total		365	25,320 kWh	$	2,126.88
Electricity in Heat Units			86,417 kBtu		

Wind Electricity	Total Wind Electricity Generated or Purchased				
Comments	Date	Days	Electricity Produced		vlaue of sales
Enter Wind electricity	1-Jan-09				
produced here.	1-Feb-09	31	0 kWh		
	1-Mar-09	28	0 kWh		
	1-Apr-09	31	0 kWh		
	1-May-09	30	0 kWh		
	1-Jun-09	31	0 kWh		
	1-Jul-09	30	0 kWh		
	1-Aug-09	31	0 kWh		
	1-Sep-09	31	0 kWh		
	1-Oct-09	30	0 kWh		
	1-Nov-09	31	0 kWh		
	1-Dec-09	30	0 kWh		
	1-Jan-10	31	0 kWh		
Annual Total		365	0 kWh	$	-
Electricity in Heat Units			0 kBtu		

CND Case Study Resource Data 12/2/10 Page 4

Figure 14: CND Level 1 Resources tab Page 4 ~ Solar & Wind Electricity.

Level 1 Case Study - Measured Resource Consumption

Wind Electricity	Wind Electricity Sold to Grid				
Comments	Date	Days	Electricity sold		
Enter Wind electricity	1-Jan-09				
sold to grid here here.	1-Feb-09	31	0 kWh	$	-
	1-Mar-09	28	0 kWh	$	-
	1-Apr-09	31	0 kWh	$	-
	1-May-09	30	0 kWh	$	-
	1-Jun-09	31	0 kWh	$	-
	1-Jul-09	30	0 kWh	$	-
	1-Aug-09	31	0 kWh	$	-
	1-Sep-09	31	0 kWh	$	-
	1-Oct-09	30	0 kWh	$	-
	1-Nov-09	31	0 kWh	$	-
	1-Dec-09	30	0 kWh	$	-
	1-Jan-10	31	0 kWh	$	-
Annual Total		365	0 kWh	$	-
Electricity in Heat Units			0 kBtu		

Electricity Use Summary			
Electricity Consumed in Building	228,125 kBtu		
Net Grid Electricity Purchased and Cost	64,301 kBtu	$	2,444.48
Net Solar & Wind Electricity Sold and Value	0 kBtu	$	-

Scope 2 Carbon Dioxide Emissions due to Electricity Consumption & Sales			
Electricity Region & Grid Emissions	Eastern	0.481 Lb CO2/kBtu	36.21 Ton CO2
Solar & Wind Electricity Sold			-20.76 Ton CO2
Net Carbon Dioxide Emissions			15.45 Ton CO2

Building Energy Use Summary	
Annual Fuel Cost	$ 2,444
Building Consumption	252,860 kBtu
Net Fuel Imports	64,301 kBtu
Renewable Energy Fraction	75%

Building Submetered Energy Use	Main Area	Subarea 1	Subarea 2
	Office	Classroom	Workshop/Garage
Annual Electricity Use by Area	211,265 kBtu	5,546 kBtu	11,314 kBtu
Renewable Electricity	151,716 kBtu	3,983 kBtu	8,125 kBtu
Grid Purchased Electricity	59,549 kBtu	1,563 kBtu	3,189 kBtu
Annual Fossil Fuel Use by Area	Office	Classroom	Workshop/Garage
Natural Gas	0 kBtu	0 kBtu	0 kBtu
Fuel Oil	0 kBtu	0 kBtu	0 kBtu
Propane	0 kBtu	0 kBtu	0 kBtu
Annual Biofuel Use by Area	Office	Classroom	Workshop/Garage
	19,293 kBtu	5,442 kBtu	0 kBtu
Annual Electricity Use by Function	Office	Classroom	Workshop/Garage
Lighting	23,983 kBtu		
Plug Loads	57,403 kBtu		
Pumps			
Fans			
Heating			
Cooling			

CND Case Study Resource Data 12/2/10 Page 5

Figure 15: CND Level 1 Resources tab Page 5 ~ Electricity Summary.

Level 1 Case Study - Measured Resource Consumption

Water Consumption					
Comments	Date	Days	Water Purchased		Cost of Service
	1-Jan-09				
	1-Feb-09	31	0 ccf	$	-
	1-Mar-09	28			
	1-Apr-09	31			
	1-May-09	30			
	1-Jun-09	31			
	1-Jul-09	30			
	1-Aug-09	31			
	1-Sep-09	31			
	1-Oct-09	30			
	1-Nov-09	31			
	1-Dec-09	30			
	1-Jan-10	31			
Annual Water Total		365	0 ccf	$	-

Water Recycling & Harvest				
Comments	Date	Days	Water Recycled	Rain Harvested
	1-Jan-09			
	1-Feb-09	31	0 ccf	0 ccf
	1-Mar-09	28		
	1-Apr-09	31		
	1-May-09	30		
	1-Jun-09	31		
	1-Jul-09	30		
	1-Aug-09	31		
	1-Sep-09	31		
	1-Oct-09	30		
	1-Nov-09	31		
	1-Dec-09	30		
	1-Jan-10	31		
Annual Water Total		365	0 ccf	0 ccf

Water Consumption by Sub-category	Mains Water	Recycled Water	Harvested Rain Water	Total for End Use
Hot Water				0 gal
Water for Toilets & Urinals				0 gal

Water Consumption by Sub-area	Mains Water	Recycled Water	Harvested Rain Water	Total Water
Office				0 gal
Classroom				0 gal
Workshop/Garage				0 gal

CND Case Study Resource Data 12/2/10 Page 6

Figure 16: CND Level 1 Resources tab Page 6 ~ Water.

Level 1 Case Study - Design and Performance Comparison

Aldo Leopold Legacy Center		Basis of Analysis	Gross Measured Area
the Kubala Washatko Architects		Parking Garage Included in Analysis?	No
Baraboo	Wisconsin		

Fuel	Modeled Energy Consumption			
	Energy	Energy/GMA	Cost/GMA	CO2/GMA
Fossil Fuels	0 kBtu	0 kBtu/SF	0.00 $/SF	0 Lb CO2
Bio Fuels	0 kBtu	0 kBtu/SF	0.00 $/SF	0 Lb CO2
Grid Electricity Purchased	89,352 kBtu	7 kBtu/SF	0.22 $/SF	3 Lb CO2
Renewable Electricity Generated/Purchased	209,108 kBtu	17 kBtu/SF	0.00 $/SF	-8 Lb CO2
Renewable Electricity Sold	117,206 kBtu	10 kBtu/SF	-0.23 $/SF	-5 Lb CO2
Renewable Sold/Grid Purchased		7 kBtu/SF		
Net Grid Electricity Purchased	0 kBtu	0 kBtu/SF	0.00 $/SF	0 Lb CO2
Net Renewable Electricity Sold	27,854 kBtu	-2 kBtu/SF	0.06 $/SF	-1 Lb CO2
Renewable Electricity Consumed	91,902 kBtu	7 kBtu/SF		

Fuel	Measured Energy Consumption			
	Energy	Energy/GMA	Cost/GMA	CO2/GMA
Fossil Fuels	0 kBtu	0 kBtu/SF	0.00 $/SF	0 Lb CO2
Bio Fuels	24,735 kBtu	2 kBtu/SF	0.00 $/SF	0 Lb CO2
Grid Electricity Purchased	150,718 kBtu	12 kBtu/SF	0.37 $/SF	6 Lb CO2
Renewable Electricity Generated/Purchased	163,824 kBtu	13 kBtu/SF	0.00 $/SF	-6 Lb CO2
Renewable Electricity Sold	86,417 kBtu	7 kBtu/SF	-0.17 $/SF	-3 Lb CO2
Renewable Sold/Grid Purchased		7 kBtu/SF		
Net Grid Electricity Purchased	64,301 kBtu	5 kBtu/SF		3 Lb CO2
Net Renewable Electricity Sold	0 kBtu	0 kBtu/SF		0 Lb CO2
Renewable Electricity Consumed	77,407 kBtu	6 kBtu/SF		

CND Case Study 12/2/10 Page 1

Figure 17: CND Level 1 Design Goals tab Page 1 ~ Modeled Energy Use.

Level 1 - Design Goals

With the input of estimated energy consumption of the building deign, actual resource use can be compared to design projections. Estimated energy consumption of the building is input on the *Level 1 - Design Goals* tab (one could also input actual energy consumption fo a building before rennovation). Energy estimates typically are provided in a LEED submission. Values for fossil fuel, biofuel, electricity pruchases from the grid, site based renewable electricity sold to the grid, and the renewable energy generated or purchased for direct use in the building are entered on page one of the *Level 1 - Design Goals* tab (see Figure 17). Three graphs are produced to compare actual and estimated (modeled) energy use and emissions.

Comparison of actual and modeled building energy use (EUI) is given in the top graph of Figure 18. The building EUI in kBtu/SF per year is the total length of the bar, mad up of different energy consumption components. There are no fossil fuels consumed in the Legacy Center. Actual biofuel consumption (wood burning stoves) is included, but it was not modeled during design. The dark purple indicates an equal portion of renewable electricity sold to the grid and electricity purchased from the grid. The simulation model indicated more renewable energy sold to the grid (the negative portion of the modeled energy consumption). The actual building consumed more electricty from the grid than was sold (light purple area in the Measured energy consumption bar). The lower graph indicates electricity purchases (green) and renewable electricity sales (purple) in dolars per SF per year.

The carbon emissions graph is illustrated in Figure 19. Renewable energy is indicated as negative, or avoided, carbon dioxide emissions.

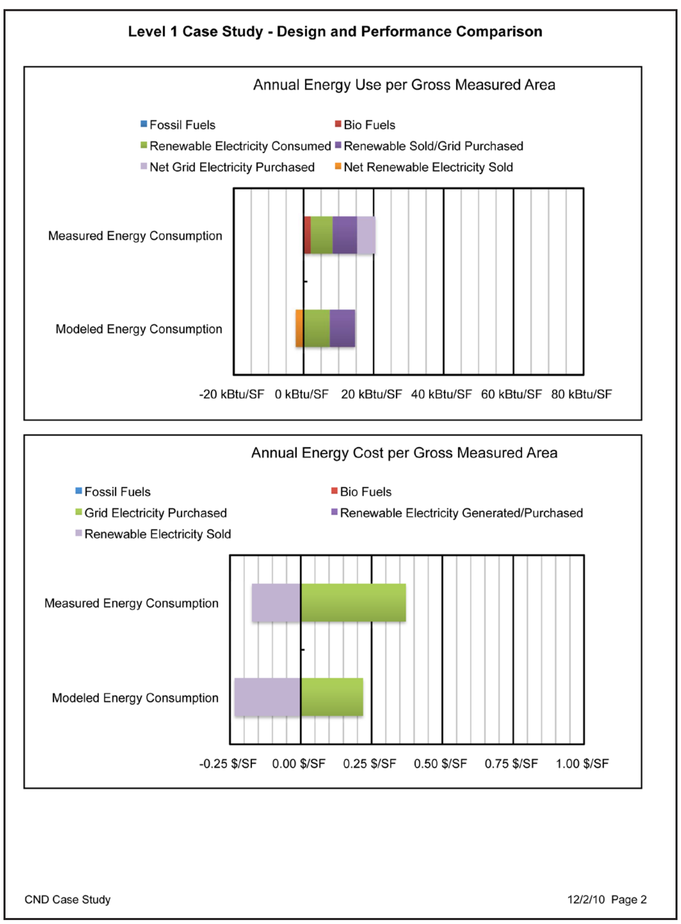

Figure 18: CND Level 1 Design Goals tab Page 2 ~ Energy & Cost Graphs.

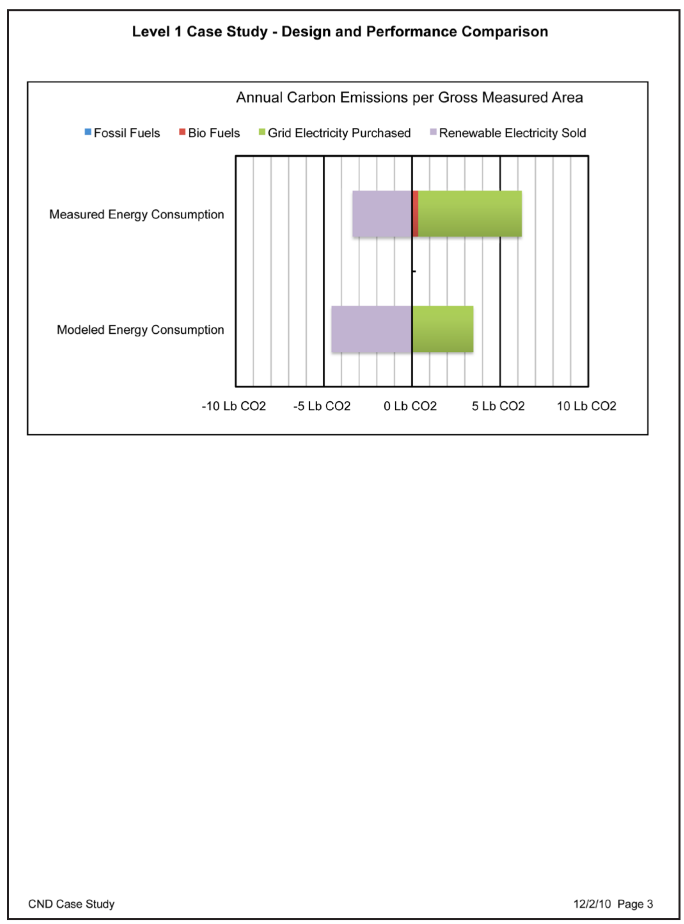

Figure 19: CND Level 1 Design Goals tab Page 3 ~ CO_2 Emissions.

Level 1 - Metrics

Once project and resumption data is entered, the Carbon Neutral Design Building Case Study Spreadsheet produces two pages of resource consumption and emissions metrics (Figures 20 and 21 at left). Metrics are computed based on the metric area chosen on the Project tab. In the case of the Aldo Leopold Legacy Center, Gross Measured Area (which NREL calls the Gross Interior Floor Area) is the metric area. The chosen metric area is automatically indicated in the spreadsheet for each consumption metric. Normalized consumption is given in both imperial (IP) and standard international (Metric) units.

The first set of metrics relate to costs. Construction, annual energy, and annual water costs are provided per SF and m^2.

Energy Use is given in heat and electrical energy units for total building energy consumption, renewable energy generation and net imported enery consumption.

Carbon dioxide emissions are given by Scope for the total building and as net emissions per chosen floor area measure.

Water usage is given as total consumption, fraction recycled, and fraction harvested from rain. Water usage was not measured at the Aldo Leopold Legacy Center.

Energy and water use as well as emissions are given per occupant FTE in both heat (kBtu) and electrical energy (kWh) units.

Daylit area of the building is provided as a percentage of the chosen floor area. Often this percentage is calculated for the LEED submission.

Floor area efficiencies are given as percentages of the gross floor area.

The second page of the tab (Figure 21) provides resource metrics based on sub areas.

Energy use and carbon emissions are given as a functions of the sub area of the chosen floor area metric, in the case of the Legacy Center illustrated, the metrics are based on the gross measured area of each sub area. The blank cells would be visible of the building type were multifamily housing or lodging with measrements given per housing unit or lodging room.

Level 1 Case Study - Building Resource Use Metrics

Aldo Leopold Legacy Center		Building Type and Ownership		
the Kubala Washatko Architects		Building Type	Office Building	Year Completed
Baraboo	Wisconsin	Ownership Type	Non-profit	2007

Costs per Gross Measured Area	IP Units	Metric Units
Unit Construction Cost	378.58 $/sf	4074.97 $/m^2
Unit Energy Cost per year	0.20 $/sf-yr	2.14 $/m^2-yr
Unit Water Costs per year	0.00 $/sf-yr	0.00 $/m^2-yr

Energy Use per Gross Measured Area	IP Heat Units	IP Electrical Units	Metric Electrical Unit
Energy Utilization Intensity	20.5 kBtu/SF-yr	6.0 kWh/SF-yr	64.7 kWh/m^2-yr
Site Renewable Energy Generation Intensity	15.3 kBtu/SF-yr	4.5 kWh/SF-yr	48.3 kWh/m^2-yr
Net Imported Energy Intensity	5.2 kBtu/SF-yr	1.5 kWh/SF-yr	16.5 kWh/m^2-yr

Carbon Dioxide Emissions	IP Units	Metric Units
Scope 1 - Fossil Fuels	0.00 Ton CO2	0.00 metric T CO2
Scope 1 - Biofuels	2.15 Ton CO2	1.95 metric T CO2
Scope 2 - Grid Electricity	36.21 Ton CO2	32.88 metric T CO2
Scope 2 - Solar PV Electricity	-20.76 Ton CO2	-18.85 metric T CO2
Total Emissions	**17.60 Ton CO2**	**15.98 metric T CO2**
Net Fossil Fuel Emissions	**15.45 Ton CO2**	**14.03 metric T CO2**
CO2 Emissions per Gross Measured Area	**2.51 Lb CO2/SF-yr**	**12.3 kg CO2/m^2-yr**

Water Usage	IP Units	Metric Units
Water Usage per Gross Measured Area	0.0 gal/sf-yr	0.0 l/m^2-yr
Site Recycled Water	0%	
Site Rainfall Harvested	0%	

Resource Use per Occupant	IP Units	Metric Units
Occupant Utilization Intensity	850 sf/FTE	79 m^2/FTE
Occupant Energy Intensity	17,439 kBtu/FTE-yr	5,109 kWh/FTE-yr
Occupant Imported Energy Intensity	4,435 kBtu/FTE-yr	1,299 kWh/FTE-yr
Occupant Net CO2 Emissions Intensity	1.07 T CO2/FTE-yr	0.97 mT CO2/FTE-yr
Occupant Water Intensity	0 ccf/FTE-yr	0 l/FTE-yr

Daylighting	per Gross Measured Area
Percent Daylit Spaces	87.3%

Floor Area Efficiencies	per Gross Area
Measured Area/Gross Area Ratio	91.6%
Usable (Assignable) Area/Gross Area Ratio	64.3%
Occupied Area/Gross Area Ratio	90.8%
Mechanically Heated to Occupied Area Ratio	76.3%
Mechanically Cooled to Occupied Area Ratio	76.3%
Mechanically Ventilated to Occupied Area Ra	76.3%

CND Case Study Level 1 - Metrics 12/2/10 Page 1

Figure 20: CND Level 1 Design Goals tab Page 1 ~ Modeled Energy Use.

Level 1 Case Study - Building Resource Use Metrics

BUILDING RESOURCE USE METRICS BASED ON SUB-AREAS

Energy Use per Gross Measured Area	Office	Classroom	Workshop/Garage
Energy Utilization Intensity	**24.1 kBtu/SF-yr**	**9.1 kBtu/SF-yr**	**7.3 kBtu/SF-yr**
	7.1 kWh/SF-yr	**2.7 kWh/SF-yr**	**2.1 kWh/SF-yr**
	76.0 kWh/m^2-yr	**28.7 kWh/m^2-yr**	**23.0 kWh/m^2-yr**
Site Renewable Energy Generation	**17.9 kBtu/SF-yr**	**7.8 kBtu/SF-yr**	**5.2 kBtu/SF-yr**
	5.2 kWh/SF-yr	**2.3 kWh/SF-yr**	**1.5 kWh/SF-yr**
	56.4 kWh/m^2-yr	**24.6 kWh/m^2-yr**	**16.5 kWh/m^2-yr**
Net Imported Energy Intensity	**6.2 kBtu/SF-yr**	**1.3 kBtu/SF-yr**	**2.1 kBtu/SF-yr**
	1.5 kWh/SF-yr	**0.7 kWh/SF-yr**	**0.4 kWh/SF-yr**
	16.5 kWh/m^2-yr	**7.2 kWh/m^2-yr**	**4.8 kWh/m^2-yr**

Carbon Dioxide Emissions per Sub Area	Office	Classroom	Workshop/Garage
Scope 1 - Fossil Fuels	0.00 Ton CO2	0.00 Ton CO2	0.00 Ton CO2
	0.00 metric T CO2	0.00 metric T CO2	0.00 metric T CO2
Scope 1 - Biofuels	1.68 Ton CO2	0.47 Ton CO2	0.00 Ton CO2
	1.52 metric T CO2	0.43 metric T CO2	0.00 metric T CO2
Scope 2 - Grid Electricity	14.31 Ton CO2	0.38 Ton CO2	0.77 Ton CO2
	12.99 metric T CO2	0.34 metric T CO2	0.70 metric T CO2
Scope 2 - Solar PV Electricity	0.00 Ton CO2	0.00 Ton CO2	0.00 Ton CO2
	0.00 metric T CO2	0.00 metric T CO2	0.00 metric T CO2
Total Emissions	15.98 Ton CO2	0.85 Ton CO2	0.77 Ton CO2
	14.51 metric T CO2	0.77 metric T CO2	0.70 metric T CO2
Net Fossil Fuel Emissions	14.31 Ton CO2	0.38 Ton CO2	0.77 Ton CO2
	12.99 metric T CO2	0.34 metric T CO2	0.70 metric T CO2
Fossil CO2 Emissions Intensity	**2.99 Lb CO2/SF-yr**	**0.62 Lb CO2/SF-yr**	**0.99 Lb CO2/SF-yr**
per Gross Measured Area	**14.6 kg CO2/m^2-yr**	**3.0 kg CO2/m^2-yr**	**4.8 kg CO2/m^2-yr**

CND Case Study Level 1 - Metrics 12/2/10 Page 2

Figure 21: CND Level 1 Design Goals tab Page 2 ~ Energy & Cost Graphs.

LEVEL 2 Case Study

A Level 2 Building Case Study allows input of building shell and systems data. The measures output are building enclosure and system design variables normalized to the chosen building metric area. Think of how installed lighting power density is understood as a system variable. Is 2 Watt per square foot energy efficient for a general office? Of course not. Under 1 Watt per square foot would be considered approaching an efficient design. We know this because light power density has been a measure of building lighting design for over a decade. Now, what installed fan power density for HVAC system fans would be appropriate? We don't know what an appropriate installed HVAC fan system power density (W/SF or W/m2) is because we haven't, as a profession, been consistently measuring this value. The Level 2 analysis has been structured to provide a number of building shell and building system variables normalized to the chosen building floor area metric to provide architects and engineers with data to compare energy metrics as a function of design over the portfolio of there energy efficient buildings. There are four input tabs in the spreadsheet for building and system information: *Enclosure, Lights, HVAC,* and *Plug_Process*. Two output tabs are included: *Level 2 - Metrics* and *Graphs*. Each input and output tab is described on the following pages.

NOTE: The input tabs may not provide enough rows for variable inputs, for example, your building may have more unique building enclosure surfaces or system supply air fans. The process of expanding input tables is the same for any of the input tabs.

- Unprotect the sheet.
- Select a row in the middle of the table.
- Insert as many additional rows as you need.
- In the row just above the newly inserted rows, select all of the cells contained in the table in that row.
- Copy those table cells into the blank cells of your inserted rows (this copies all appropriate equations of the table into your new rows).
- Select the yellow input cells in the inserted rows.
- From the excel menu command **Format:Cells:Protection** uncheck the **Locked** box.
- Protect the sheet.

This procedure will allow the expansion of any building enclosure or system variable table to the number of inputs needed for the building case study.

Level 2 - Enclosure

Enclosure information for the main building area and two sub areas is input on this tab. Heat loss rate to the ground, heat loss rate through enclosure surfaces (opaque, windows and doors), and heat loss rate through infiltration are calculated for the main area and each sub area. In addition, if a sub area is connected to the main area (walls and/or floors separating the main area and sub area), the description of the surfaces separating the two areas are input in the sub area section. The tab provides project information and calculated heat transfer rates for the main area and each sub area the top of the sheet (Figure 22, upper right). The total enclosure heat transfer rate, UA, for the main building area is given as:

$$UA_{mainarea} = UA_{perimeter} + UA_{walls} + UA_{windows} + UA_{doors} + UA_{infiltration}$$

The UA value for the sub areas is calculated similar to the UA for the main area.

The total building heat transfer rate calculation depends on whether the sub areas are conditioned and, if unconditioned, whether the sub area is connected to the main area (with walls and or floors separating the areas). If the sub area is conditioned, its UA value is added to the main building to calculate the total building UA, whether the sub area is connected to the main building area or not. If the sub area is unconditioned, its UA value only affects the total building UA value when it is connected to the main building area. Then the total building UA calculation is given as:

$$UA_{building} = UA_{mainarea} + 1 / (1 / UA_{subArea} + 1 / UA_{common})$$

Where UA_{common} is the heat transfer rate of the walls and floors separating the main area and adjacent sub area. For the Aldo Leopold Legacy Center, both sub areas, the classroom and the workshop/garage, are unconditioned and unconnected. The total building UA is equal to the main area (offices) UA as the offices are the only conditioned space.

The main area identifying name, building area used as metric area and main metric area are provided above the input cells for the main area enclosure (Figure 22).

Level 2 Case Study - Building Enclosure Heat Transfer

Aldo Leopold Legacy Center	
the Kubala Washatko Architects	
Baraboo	Wisconsin

Building Enclosure Heat Transfer Rate		
Office	UA	**1,699 Btu/hr-F**
Classroom	UA	**1,652 Btu/hr-F**
Workshop/Garage	UA	**1,680 Btu/hr-F**
Building	UA Building	**1,699 Btu/hr-F**

Main Building Area Exterior Enclosure Surface Takeoffs, Infiltration Rates and Heat Transfer Calculations

Area Name:	**Office**	**Gross Measured Area**	**9,562 SF**

Main Area ENCLOSURE HEAT LOSS RATE TROUGH THE GROUND PER UNIT LENGTH OF PERIMETER

Condition		Length	Transfer Rate	UA_perimeter
1	*Slab-on-Grade w/ext. Slab*	*207.7 Ft*	*0.35 Btu/hr-ft-F*	73 Btu/hr-F
2	*Slab-on-Grade*	*218.8 Ft*	*0.45 Btu/hr-ft-F*	98 Btu/hr-F
3	*Basement*	*61.8 Ft*	*0.70 Btu/hr-ft-F*	43 Btu/hr-F
4	*Crawl Space*	*0.0 Ft*	*0.10 Btu/hr-ft-F*	0 Btu/hr-F
Total		**488.2 Ft**		**214 Btu/hr-F**

CONDITIONED ENCLOSURE SURFACES (Walls & Roof) **Opaque Enclosure Calculations**

Figure 22: CND Level 2 Enclosure tab Page 1 ~ UA outputs and ground heat loss rate.

Enclosure Heat Loss Rate through the Ground

Building heat transfer to the ground is estimated by a heat transfer rate per hour per °F temperature difference between building and environment per hour per foot of perimeter wall. The rate of heat loss will depend on whether the foundation is a slab on grade, a crawl space or a full basement and what the insulation conditions of the foundation are. Both the *ASHRAE Handbook of Fundamentals* and *Mechanical and Electrical Equipment for Buildings* provide values of heat transfer rates through the ground to ambient per unit length of building perimeter for different foundation conditions. For the Aldo Leopold Legacy Center main building area illustrated in Figure 22, there are four distinct building foundation conditions. Each is described with the associated perimeter length and heat transfer rate. The spreadsheet calculates the UA value for each perimeter ground heat loss condition. The total perimeter length of the main area and the total heat loss rate through the ground ($UA_{perimeter}$) are summed.

Total					488.2 Ft		214 Btu/hr-F	
CONDITIONED ENCLOSURE SURFACES (Walls & Roof)					**Opaque Enclosure Calculations**			**Do**
Orientation	**Gross Surface Area**	**Window Area**	**Percent Operable Windows**	**Door Area**	**Net Enclosure Surface Area**	**Enclosure Surface R Value**	**UA enclosure Surface**	**Door R**
South	*452 SF*	*48 SF*	*0%*	*25 SF*	379 SF	*32.13 hr-SF-F/Btu*	12 Btu/hr-F	*2.00 hr*
South	*1,186 SF*	*393 SF*	*50%*	*74 SF*	719 SF	*25.38 hr-SF-F/Btu*	28 Btu/hr-F	*2.00 hr*
South	*70 SF*	*27 SF*	*16%*	*0 SF*	43 SF	*32.13 hr-SF-F/Btu*	1 Btu/hr-F	*2.00 hr*
South	*420 SF*	*110 SF*	*40%*	*25 SF*	285 SF	*32.13 hr-SF-F/Btu*	9 Btu/hr-F	*2.00 hr*
East	*477 SF*	*40 SF*	*17%*	*0 SF*	437 SF	*32.13 hr-SF-F/Btu*	14 Btu/hr-F	*2.00 hr*
East	*304 SF*	*50 SF*	*0%*	*27 SF*	227 SF	*12.00 hr-SF-F/Btu*	19 Btu/hr-F	*2.00 hr*
East	*473 SF*	*146 SF*	*50%*	*51 SF*	276 SF	*32.13 hr-SF-F/Btu*	9 Btu/hr-F	*2.00 hr*
East	*165 SF*	*55 SF*	*50%*	*0 SF*	110 SF	*25.38 hr-SF-F/Btu*	4 Btu/hr-F	*2.00 hr*
West	*357 SF*	*0 SF*	*0%*	*26 SF*	331 SF	*29.00 hr-SF-F/Btu*	11 Btu/hr-F	*2.00 hr*
West	*348 SF*	*110 SF*	*43%*	*0 SF*	238 SF	*32.13 hr-SF-F/Btu*	7 Btu/hr-F	*2.00 hr*
West	*200 SF*	*55 SF*	*50%*	*25 SF*	120 SF	*25.38 hr-SF-F/Btu*	5 Btu/hr-F	*2.00 hr*
West	*473 SF*	*126 SF*	*50%*	*0 SF*	347 SF	*32.13 hr-SF-F/Btu*	11 Btu/hr-F	*2.00 hr*
North	*555 SF*	*34 SF*	*40%*	*0 SF*	521 SF	*29.00 hr-SF-F/Btu*	18 Btu/hr-F	*2.00 hr*
North	*250 SF*	*92 SF*	*27%*	*0 SF*	158 SF	*32.13 hr-SF-F/Btu*	5 Btu/hr-F	*2.00 hr*
North	*275 SF*	*0 SF*	*0%*	*48 SF*	227 SF	*6.75 hr-SF-F/Btu*	34 Btu/hr-F	*4.00 hr*
North	*690 SF*	*230 SF*	*47%*	*0 SF*	460 SF	*29.00 hr-SF-F/Btu*	16 Btu/hr-F	*2.00 hr*
North	*677 SF*	*167 SF*	*15%*	*0 SF*	510 SF	*32.13 hr-SF-F/Btu*	16 Btu/hr-F	*2.00 hr*
North	*420 SF*	*30 SF*	*50%*	*0 SF*	390 SF	*32.13 hr-SF-F/Btu*	12 Btu/hr-F	*2.00 hr*
Horizontal	*9,501 SF*	*0 SF*	*0%*	*0 SF*	9,501 SF	*45.00 hr-SF-F/Btu*	211 Btu/hr-F	*2.00 hr*
Horizontal	*295 SF*	*0 SF*	*0%*	*0 SF*	295 SF	*28.00 hr-SF-F/Btu*	11 Btu/hr-F	*2.00 hr*
Horizontal	*1,523 SF*	*0 SF*	*0%*	*0 SF*	1,523 SF	*39.38 hr-SF-F/Btu*	39 Btu/hr-F	*2.00 hr*
TOTAL	**19,111 SF**	**1,713 SF**		**301 SF**	**17,097 SF**		**491 Btu/hr-F**	

Figure 23: CND Level 2 Enclosure tab Page 1 ~ Main Building Area enclosure area takeoffs and UA calculations.

Building Main Area Conditioned Enclosure Surfaces

Enclosure surface area take-offs input is illustrated in Figure 23 for the Aldo Leopold Legacy Center. Each surface has an orientation, gross area, window area, percentage of window area that can be opened, door area and the thermal resistance or R-values of the wall, window and door. The orientation of each surface is chosen from a drop-down menu with choices of North, South, East, West and Horizontal. Assume any surface sloped less than 45° to be horizontal. All other surfaces are assumed to be vertical with one of the four general compass coordinates. Assume any vertical surface with an orientation between southeast and southwest to be facing south. The other three orientations are treated similarly. The spreadsheet calculates the net wall enclosure surface area and the UA product for each enclosure surface.

Figure 24 provides a continuation of the enclosure surface input and calculations for the main building area. The spreadsheet calculates the door and window UA products for each surface, the operable window area for each surface and the window area for each orientation. Sums of wall, door window and operable window surfaces are calculated as well as the total wall, door and window UA products and the total window area for each of the five general orientations.

	Door Calculations		**Window Calculations**			**Window Area for Each Orientation**				
ure ce	**Door R Value**	**UA Door**	**Window R Value**	**UA Window**	**Operable Window Area**	**South**	**West**	**North**	**East**	**Horizontal**
F	*2.00 hr-SF-F/Btu*	13 Btu/hr-F	*2.98 hr-SF-F/Btu*	16 Btu/hr-F	0 SF	48 SF	0 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	37 Btu/hr-F	*2.98 hr-SF-F/Btu*	132 Btu/hr-F	197 SF	393 SF	0 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	9 Btu/hr-F	4 SF	27 SF	0 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	13 Btu/hr-F	*2.98 hr-SF-F/Btu*	37 Btu/hr-F	44 SF	110 SF	0 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	13 Btu/hr-F	7 SF	0 SF	0 SF	0 SF	40 SF	0 SF
F	*2.00 hr-SF-F/Btu*	14 Btu/hr-F	*2.98 hr-SF-F/Btu*	17 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	50 SF	0 SF
F	*2.00 hr-SF-F/Btu*	26 Btu/hr-F	*2.98 hr-SF-F/Btu*	49 Btu/hr-F	73 SF	0 SF	0 SF	0 SF	146 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	18 Btu/hr-F	28 SF	0 SF	0 SF	0 SF	55 SF	0 SF
F	*2.00 hr-SF-F/Btu*	13 Btu/hr-F	*2.98 hr-SF-F/Btu*	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	37 Btu/hr-F	47 SF	0 SF	110 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	13 Btu/hr-F	*2.98 hr-SF-F/Btu*	18 Btu/hr-F	28 SF	0 SF	55 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	42 Btu/hr-F	63 SF	0 SF	126 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	11 Btu/hr-F	14 SF	0 SF	0 SF	34 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	31 Btu/hr-F	25 SF	0 SF	0 SF	92 SF	0 SF	0 SF
F	*4.00 hr-SF-F/Btu*	12 Btu/hr-F	*2.98 hr-SF-F/Btu*	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	77 Btu/hr-F	108 SF	0 SF	0 SF	230 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	56 Btu/hr-F	25 SF	0 SF	0 SF	167 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.98 hr-SF-F/Btu*	10 Btu/hr-F	15 SF	0 SF	0 SF	30 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	*2.00 hr-SF-F/Btu*	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
F		**139 Btu/hr-F**		**575 Btu/hr-F**	**677 SF**	**578 SF**	**291 SF**	**553 SF**	**291 SF**	**0 SF**

Figure 24: CND Level 2 Enclosure tab Page 1 ~ Main Building Area enclosure area takeoffs and UA calculations

Building Main Area Infiltration

Infiltration rate is estimated as the product of the enclosure main area air volume and the infiltration rate in air changes per hour (A.C.H.). The input area for the main building area infiltration is indicated in Figure 25. The average floor-to-ceiling height and the infiltration air change rates are input. The total occupied area of the main building area is multiplied by the height to estimate the main building area air volume. Without actual measured infiltration rates from blower door tests, the heat loss rate due to infiltration estimate has a high degree of inaccuracy. Infiltration rate is inversely proportional to building volume. The ASHRAE Handbook of Fundamentals provides direction and methods for estimating the building infiltration rate.

MAIN AREA AIR VOLUME & INFILTRATION	
Average Ceiling Height	11.0 ft
Conditioned Air Volume	104,027 CF
Infiltration Rate	0.15 A.C.H
UA_infiltration	280.9 Btu/hr-F

Figure 25: CND Level 2 Enclosure tab Main Building Area Infiltration

SubArea 1	Relation to Main Area		Classroom	UA_subArea_1	1,652 Btu/hr-F
	Unconnected, Unconditioned	Floor Area	1,209 SF	UA_Common_1	0 Btu/hr-F

SubArea 1 HEAT LOSS RATE TO THE GROUND PER UNIT LENGTH OF PERIMETER				
Condition		Length	Transfer Rate	UA_perimeter
1	Slab-on-Grade w/ext. Slab	47.6 Ft	0.85 Btu/hr-ft-F	40 Btu/hr-F
2	Retaining Wall	101.7 Ft	0.91 Btu/hr-ft-F	93 Btu/hr-F
Total		149.3 Ft		133 Btu/hr-F

SubArea 1 ENCLOSURE HEAT TRANSFER RATE					Opaque Enclosure Calculations			Door Calculations		Window Calculations			Window Area for Each Orientation				
Orientation	Gross Surface Area	Window Area	Percent Operable Windows	Door Area	Net Enclosure Surface Area	Enclosure Surface R Value	UA enclosure Surface	Door R Value	UA Door	Window R Value	UA Window	Operable Window Area	South	West	North	East	Horizontal
South	675 SF	128 SF	25%	0 SF	547 SF	1.60 hr-SF-F/Btu	342 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	64 Btu/hr-F	32 SF	128 SF	0 SF	0 SF	0 SF	0 SF
West	335 SF	168 SF	3%	0 SF	167 SF	1.60 hr-SF-F/Btu	104 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	84 Btu/hr-F	5 SF	0 SF	168 SF	0 SF	0 SF	0 SF
North	507 SF	338 SF	12%	48 SF	121 SF	1.60 hr-SF-F/Btu	76 Btu/hr-F	2.00 hr-SF-F/Btu	24 Btu/hr-F	2.00 hr-SF-F/Btu	169 Btu/hr-F	41 SF	0 SF	0 SF	338 SF	0 SF	0 SF
East	335 SF	168 SF	3%	0 SF	167 SF	1.60 hr-SF-F/Btu	104 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	84 Btu/hr-F	5 SF	0 SF	0 SF	0 SF	168 SF	0 SF
Horizontal	1,400 SF	0 SF		0 SF	1,400 SF	4.00 hr-SF-F/Btu	350 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
TOTAL	3,252 SF	802 SF		48 SF	2,402 SF		976 Btu/hr-F		24 Btu/hr-F		401 Btu/hr-F	83 SF	128 SF	168 SF	338 SF	168 SF	0 SF

COMMON WALL BETWEEN SubArea 1 & Main Area								Door Calculations		Window Calculations			Window Area for Each Orientation				
Orientation	Gross Surface Area	Window Area	Percent Operable Windows	Door Area	Net Enclosure Surface Area	Enclosure Surface R Value	UA enclosure Surface	Door R Value	UA Door	Window R Value	UA Window	Operable Window Area	South	West	North	East	Horizontal
South	0 SF	0 SF	50%	0 SF	0 SF	1.00 hr-SF-F/Btu	0 Btu/hr-F	4.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
West	0 SF	0 SF	0%	0 SF	0 SF	1.00 hr-SF-F/Btu	0 Btu/hr-F	4.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
North	0 SF	0 SF	0%	0 SF	0 SF	1.00 hr-SF-F/Btu	0 Btu/hr-F	4.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
TOTAL	0 SF	0 SF		0 SF	0 SF		0 Btu/hr-F		0 Btu/hr-F		0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF

SUB AREA 1 INFILTRATION	
Average Ceiling Height	12.0 ft
Unconditioned Air Volume	14,508 CF
Infiltration Rate	0.45 A.C.H
UA_infiltration	118 Btu/hr-F

Figure 26: CND Level 2 Enclosure tab - SubArea 1 Enclosure Inputs and Calculations.

SubArea 1	Relation to Main Area		Classroom	UA_subArea_1	1,652 Btu/hr-F
	Unconnected, Unconditioned	Floor Area	1,209 SF	UA_Common_1	0 Btu/hr-F

SubArea 1 HEAT LOSS RATE TO THE GROUND PER UNIT LENGTH OF PERIMETER				
Condition		Length	Transfer Rate	UA_perimeter
1	Slab-on-Grade w/ext. Slab	47.6 Ft	0.85 Btu/hr-ft-F	40 Btu/hr-F
2	Retaining Wall	101.7 Ft	0.91 Btu/hr-ft-F	93 Btu/hr-F
Total		149.3 Ft		133 Btu/hr-F

SubArea 1 ENCLOSURE HEAT TRANSFER RATE					Opaque Enclosure Calculations			Door Calculations		Window Calculations			Window Area for Each Orientation				
Orientation	Gross Surface Area	Window Area	Percent Operable Windows	Door Area	Net Enclosure Surface Area	Enclosure Surface R Value	UA enclosure Surface	Door R Value	UA Door	Window R Value	UA Window	Operable Window Area	South	West	North	East	Horizontal
South	675 SF	128 SF	25%	0 SF	547 SF	1.60 hr-SF-F/Btu	342 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	64 Btu/hr-F	32 SF	128 SF	0 SF	0 SF	0 SF	0 SF
West	335 SF	168 SF	3%	0 SF	167 SF	1.60 hr-SF-F/Btu	104 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	84 Btu/hr-F	5 SF	0 SF	168 SF	0 SF	0 SF	0 SF
North	507 SF	338 SF	12%	48 SF	121 SF	1.60 hr-SF-F/Btu	76 Btu/hr-F	2.00 hr-SF-F/Btu	24 Btu/hr-F	2.00 hr-SF-F/Btu	169 Btu/hr-F	41 SF	0 SF	0 SF	338 SF	0 SF	0 SF
East	335 SF	168 SF	3%	0 SF	167 SF	1.60 hr-SF-F/Btu	104 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	84 Btu/hr-F	5 SF	0 SF	0 SF	0 SF	168 SF	0 SF
Horizontal	1,400 SF	0 SF		0 SF	1,400 SF	4.00 hr-SF-F/Btu	350 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
TOTAL	3,252 SF	802 SF		48 SF	2,402 SF		976 Btu/hr-F		24 Btu/hr-F		401 Btu/hr-F	83 SF	128 SF	168 SF	338 SF	168 SF	0 SF

COMMON WALL BETWEEN SubArea 1 & Main Area								Door Calculations		Window Calculations			Window Area for Each Orientation				
Orientation	Gross Surface Area	Window Area	Percent Operable Windows	Door Area	Net Enclosure Surface Area	Enclosure Surface R Value	UA enclosure Surface	Door R Value	UA Door	Window R Value	UA Window	Operable Window Area	South	West	North	East	Horizontal
South	0 SF	0 SF	50%	0 SF	0 SF	1.00 hr-SF-F/Btu	0 Btu/hr-F	4.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
West	0 SF	0 SF	0%	0 SF	0 SF	1.00 hr-SF-F/Btu	0 Btu/hr-F	4.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
North	0 SF	0 SF	0%	0 SF	0 SF	1.00 hr-SF-F/Btu	0 Btu/hr-F	4.00 hr-SF-F/Btu	0 Btu/hr-F	2.00 hr-SF-F/Btu	0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF
TOTAL	0 SF	0 SF		0 SF	0 SF		0 Btu/hr-F		0 Btu/hr-F		0 Btu/hr-F	0 SF	0 SF	0 SF	0 SF	0 SF	0 SF

SUB AREA 1 INFILTRATION	
Average Ceiling Height	12.0 ft
Unconditioned Air Volume	14,508 CF
Infiltration Rate	0.45 A.C.H
UA_infiltration	118 Btu/hr-F

Figure 27: CND Level 2 Enclosure tab - SubArea 1 Enclosure Inputs and Calculations.

Building Sub Area Enclosure Calculations

Enclosure tab inputs and calculations for SubArea1 and SubArea2 are illustrated in Figures 26 and 27 respectively. Input and calculation for ground heat transfer rate, wall, door and window heat transfer rate and infiltration heat transfer rate are identical to the inputs and calculations for the main building area. The only difference is the calculation of heat transfer rates for common enclosure surfaces separating the sub area and the main building area. Inputs for the common surface areas are similar to the enclosure surface area inputs (wall, door, and window surfaces).

Level 2 - Lights

The Level 2 Lights tab page 1 and page 2 are illustrated in Figures 28 and 29 respectively. For the all input categories, input an identifier for each unique luminaire, the power per lamp, lamps per luminaire number of luminaires and type of luminaire control (manual, occupant sensor or daylight). The installed power for each luminaire is the product of the power, number of lamps and number of luminaires. Lights are entered for each sub area as well as exterior lights attached to the building and site lights. The values for lights in Figures 28 and 29 are for the Aldo Leopold Legacy Center.

Aldo Leopold Legacy Center	
the Kubala Washatko Architects	
Baraboo	Wisconsin

INSTALLED LIGHTING Main Building Area			**Office**		
Luminaire	**Power per Lamp**	**Lamp/Luminaire**	**# Luminaires**	**Installed Power**	**Control**
A	*32 W*	*1*	*16*	512 W	*Manual*
B	*32 W*	*1*	*9*	288 W	*Occupant Sensor*
B1	*18 W*	*1*	*2*	36 W	*Manual*
C	*54 W*	*4*	*11*	2,376 W	*Daylight*
C1	*132 W*	*2*	*3*	792 W	*Daylight*
C2	*54 W*	*1*	*10*	540 W	*Daylight*
D	*32 W*	*2*	*9*	576 W	*Occupant Sensor*
F	*24 W*	*1*	*2*	48 W	*Occupant Sensor*
G	*32 W*	*2*	*13*	832 W	*Manual*
H	*32 W*	*1*	*9*	288 W	*Manual*
H1	*32 W*	*1*	*6*	192 W	*Manual*
N	*32 W*	*1*	*14*	448 W	*Manual*
P	*50 W*	*1*	*2*	100 W	*Manual*
P1	*35 W*	*1*	*2*	70 W	*Manual*
R	*50 W*	*1*	*19*	950 W	*Manual*
S	*32 W*	*1*	*9*	288 W	*Manual*
T	*35 W*	*4*	*2*	280 W	*Manual*
T1	*35 W*	*1*	*2*	70 W	*Manual*
T2a	*25 W*	*1*	*8*	200 W	*Manual*
T2b	*25 W*	*2*	*7*	350 W	*Manual*
T2c	*25 W*	*2*	*8*	400 W	*Manual*
T3	*60 W*	*1*	*5*	300 W	*Manual*
T4	*25 W*	*3*	*2*	150 W	*Manual*
U	*54 W*	*1*	*5*	270 W	*Manual*
U1	*54 W*	*2*	*1*	108 W	*Manual*
U2	*54 W*	*4*	*2*	432 W	*Manual*
V	*32 W*	*2*	*1*	64 W	*Occupant Sensor*
X	*10 W*	*1*	*15*	150 W	*Exit always on*
Total Installed Lights, Main Area				**11,110 W**	
INSTALLED LIGHTING SubArea 1			**Classroom**		
Luminaire	**Power per Lamp**	**Lamp/Luminaire**	**# Luminaires**	**Installed Power**	**Control**
H1	*32 W*	*1*	*17*	544 W	*Manual*
S	*25 W*	*1*	*1*	25 W	*Manual*
L	*18 W*	*1*	*3*	54 W	*Manual*
Total - Lights in Sub Area 1				**623 W**	

Figure 28: CND Level 2 Lights tab - Page 1.

INSTALLED LIGHTING SubArea2		**Workshop/Garage**			
Luminaire	**Power per Lamp**	**Lamp/Luminaire**	**# Luminaires**	**Installed Power**	**Control**
K	*32 W*	*2*	*10*	640 W	*Manual*
K1	*32 W*	*2*	*5*	320 W	*Occupant Sensor*
J	*26 W*	*1*	*5*	130 W	*Manual*
Total - Lights in Sub Area 2				**1,090 W**	

Exterior Lights (attached to Buildings)					
Luminaire	**Power per Lamp**	**Lamp/Luminaire**	**# Luminaires**	**Installed Power**	**Control**
OB	*35 W*	*1*	*12*	420 W	
				0 W	
				0 W	
Total - Exterior Lights attached to Building				**420 W**	

INSTALLED LIGHTING - SITE					
Luminaire	**Power per Lamp**	**Lamp/Luminaire**	**# Luminaires**	**Installed Power**	**Control**
				0 W	
				0 W	
				0 W	
Total - Site Lighting				**0 W**	

TOTAL INSTALLED LIGHTING POWER	
Total Installed Illumination Power	**13,243 W**

Figure 29: CND Level 2 Lights tab - Page 2.

Level 2 - HVAC Systems

HVAC systems are sub-divided into ventilation fans, pumps, heating equipment, heat pumps, cooling equipment, miscellaneous equipment and service hot water. Within each subdivision, equipment is entered by main and sub building areas. Equipment energy demand is totaled for each sub area and the total building.

Aldo Leopold Legacy Center	
the Kubala Washatko Architects	
Baraboo	Wisconsin

HVAC	Ventilation Fans				
Main Building Area			**Office**		
Supply Fans	**Function**	**Max. Air Flow**	**Constant Volume, Variable or VFD**	**Motor HP**	**Motor Watts**
AHU1	*Air supply for offices & exhibit*	*1,195 cfm*	*VFD*	*1.50 Hp*	1,119 W
ERV1 - Supply	*Meeting Room ERV Supply Fan*	*500 cfm*	*Variable Speed*	*0.33 Hp*	249 W
ERV2 - Supply	*Exhibit Space ERV Supply Fan*	*675 cfm*	*Variable Speed*	*0.33 Hp*	249 W
Total Installed Supply Fan CFM & Power		**2,370 cfm**		**2.17 Hp**	**1,616 W**
				Supply Fans Heat Transfer Efficiency	**1.6 Btu/hr-F-W**
				Supply Fans Volume Flow Efficiency	**1.5 cfm/W**
Exhaust Fans	**Function**	**Max. Air Flow**	**Control: Constant, Variable or VFD**	**Motor HP**	**Motor Watts**
ERV1 - Exhaus	*Meeting Room Energy Recovery Ventilator Exhaust*	*500 cfm*	*Variable Speed*	*0.33 Hp*	246 W
ERV2 - Exhaus	*Exhibit Space Energy Recovery Ventilator Exhaust F*	*675 cfm*	*Variable Speed*	*0.33 Hp*	246 W
EF-1	*Staff Area Cooling Season Exhasut Fan*	*400 cfm*	*Constant Volume*	*0.03 Hp*	19 W
EF-2	*Copy Room Exhaust Fan*	*50 cfm*	*Constant Volume*	*0.01 Hp*	7 W
EF-3	*Janitor's Closet Exhaust Fan*	*50 cfm*	*Constant Volume*	*0.07 Hp*	50 W
EF-4	*Server Room Exhaust Fan*	*295 cfm*	*Constant Volume*	*0.16 Hp*	120 W
EF-5	*Basement Shower Room*	*75 cfm*	*Constant Volume*	*0.07 Hp*	50 W
EF-6	*Men's Restroom Exhaust Fan*	*150 cfm*	*Constant Volume*	*0.02 Hp*	12 W
EF-7	*Women's Restroom Exhaust Fan*	*150 cfm*	*Constant Volume*	*0.02 Hp*	12 W
TF-1	*Staff Area Transfer Fan to South Corridor - Heating S*	*400 cfm*	*Constant Volume*	*0.04 Hp*	30 W
Total Installed Exhaust Fan CFM & Power		**2,745 cfm**		**1.06 Hp**	**793 W**
				Exhaust Fans Heat Transfer Efficiency	**3.7 Btu/hr-F-W**
				Exhaust Fans Volume Flow Efficiency	**3.5 cfm/W**
Main Area Installed Fan CFM & Power		**5,115 cfm**		**3.23 Hp**	**2,408 W**
				All Fans Heat Transfer Efficiency	**2.3 Btu/hr-F-W**
Main Area Outdoor Air Supply				**All Fans Volume Flow Efficiency**	**2.1 cfm/W**
	Outdoor Air Ventilation Rate	***2,370 cfm***			
	Fraction of Supply Air that is Outdoor Air	***100%***			

Figure 30: CND Level 2 HVAC tab - Ventilation Fans, main building area.

Fans

Ventilation fans are broken down into supply fans and exhaust fans. Space is provided for fan designation and for function. For each fan provide maximum design (or rated) cfm, fan type and motor horse power. Fan type is either constant volume, variable speed or VFD (Variable Frequency Drive) and is chosen by drop-down menu. Fan power input by horse power rating is converted to watts. If the fan power is provided in watts, there are cells in column I of the HVAC tab that provide conversion from Watts to Hp. Finally, the maximum outdoor air ventilation rate in cfm is enter. The spreadsheet calculates total supply and exhaust cfm, percentage of supply cfm that is outdoor air, total installed supply and exhaust fan power (in Hp and Watt) and fan thermal and flow efficiency.

Ceiling fans, while providing destratification and air flow for thermal comfort, do not move air into or out of the building zones. Ceiling fans should be accounted under miscellaneous HVAC equipment.

The main building area fan input for the Aldo Leopold Legacy Center is illustrated in Figure 30. The Legacy Center is designed with a 100% outdoor air displacement ventilation system. Air is exhausted directly from the space. Supply air for the displacement system is delivered via under floor ducts. For this design, the exhaust fans have half the power and twice the efficiency to move the same quantity of air.

Fan inputs for sub area 1 and sub area 1 are illustrated in Figures 31 and 32 on the following page. Data input is similar to the main building area fan input illustrated above. In addition, calculation of total building fan supply and exhaust cfm, fan power, outdoor air ventilation rate and fan efficiencies are illustrated in Figure 32.

FANS - SubArea 1		Classroom			
Supply Fans	Function	Max. Air Flow	Constant Volume, Variable or VFD	Motor HP	Motor Watts
		0 cfm	VFD	0.00 Hp	0 W
		0 cfm	Constant Volume	0.00 Hp	0 W
Total Installed Supply Fan CFM & Power		0 cfm		0.00 Hp	0 W
			Supply Fans Heat Transfer Efficiency		0.0 Btu/hr-F-W
			Supply Fans Volume Flow Efficiency		0.0 cfm/W
Exhaust Fans	Function	Max. Air Flow	Control: Constant, Variable or VFD	Motor HP	Motor Watts
		0 cfm	VFD	0.00 Hp	0 W
		0 cfm	Constant Volume	0.00 Hp	0 W
Total Installed Exhaust Fan CFM & Power		0 cfm		0.00 Hp	0 W
			Exhaust Fans Heat Transfer Efficiency		0.0 Btu/hr-F-W
			Exhaust Fans Volume Flow Efficiency		0.0 cfm/W
SubArea 1 Installed Fan CFM & Power		0 cfm		0.00 Hp	0 W
			All Fans Heat Transfer Efficiency		0.0 Btu/hr-F-W
SubArea 1 Outdoor Air Supply			All Fans Volume Flow Efficiency		0.0 cfm/W
	Outdoor Air Ventilation Rate	0 cfm			
	Fraction of Supply Air that is Outdoor Air	0%			

Figure 31: CND Level 2 HVAC tab - Ventilation Fans, sub area 1.

FANS - SubArea 2		Workshop/Garage			
Supply Fans	Function	Max. Air Flow	Constant Volume, Variable or VFD	Motor HP	Motor Watts
		0 cfm	VFD	0.00 Hp	0 W
		0 cfm	Constant Volume	0.00 Hp	0 W
Total Installed Supply Fan CFM & Power		0 cfm		0.00 Hp	0 W
			Supply Fans Heat Transfer Efficiency		0.0 Btu/hr-F-W
			Supply Fans Volume Flow Efficiency		0.0 cfm/W
Exhaust Fans	Function	Max. Air Flow	Constant Volume, Variable or VFD	Motor HP	Motor Watts
		0 cfm	VFD	0.00 Hp	0 W
		0 cfm	Constant Volume	0.00 Hp	0 W
Total Installed Exhaust Fan CFM & Power		0 cfm		0.00 Hp	0 W
			Exhaust Fans Heat Transfer Efficiency		0.0 Btu/hr-F-W
			Exhaust Fans Volume Flow Efficiency		0.0 cfm/W
SubArea 2 Installed Fan CFM & Power		0 cfm		0.00 Hp	0 W
			All Fans Heat Transfer Efficiency		0.0 Btu/hr-F-W
SubArea 2 Outdoor Air Supply			All Fans Volume Flow Efficiency		0.0 cfm/W
	Outdoor Air Ventilation Rate	0 cfm			
	Fraction of Supply Air that is Outdoor Air	0%			
FANS - Total Building					
	Supply Fans CFM	2,370 cfm	Supply Fans Power		1,616 W
			Supply Fans Heat Transfer Efficiency		1.6 Btu/hr-F-W
			Supply Fans Volume Flow Efficiency		1.5 cfm/W
	Exhaust Fans CFM	2,745 cfm	Exhaust Fans Power		793 W
			Supply Fans Heat Transfer Efficiency		3.7 Btu/hr-F-W
			Supply Fans Volume Flow Efficiency		3.5 cfm/W
Total Building Installed Fan CFM & Power		5,115 cfm			2,408 W
			All Fans Heat Transfer Efficiency		2.3 Btu/hr-F-W
Total Building Outdoor Air Supply			All Fans Volume Flow Efficiency		2.1 cfm/W
	Outdoor Air Ventilation Rate	2,370 cfm			
	Fraction of Supply Air that is Outdoor Air	100%			
Fan Characteristics			Flow Rate	Motor Watts	Flow Efficienncy
	Constant Volume Fans		1,570 cfm	300 W	5.2 cfm/W
	Variable Frequency Drive Fans		1,195 cfm	1,119 W	1.1 cfm/W
	Variable Speed Fans		2,350 cfm	989 W	2.4 cfm/W
	All Fans		5,115 cfm	2,408 W	2.1 cfm/W

Figure 32: CND Level 2 HVAC tab - Ventilation Fans, sub area 2 and total building.

Pumps

Spreadsheet input and calculations of HVAC pumps for the main building area, sub area 1, sub area 2 and the total building are illustrated in Figures 33 and 34 below. Inputs are similar to fan inputs except that flow is input in gpm of liquid instead of cfm of air and there is no differentiation for supply and return. Redundant pumps are treated separately. Redundant pumps often occur in lead/lag configuration and are counted separately if they are not controlled to operate at the same time as the line pumps.

HVAC	Pumps				
Main Building Area		**Office**			
Line Pumps	Function	Flow Rate	Control	Motor HP	Motor Watts
P-1	*Main Geothermal Loop - Small Load*	*6.6 gpm*	*Constant*	*0.08 Hp*	62 W
P-2	*Main Geothermal Loop - Lead*	*36.6 gpm*	*VFD*	*0.75 Hp*	559 W
P-4	*Radiant Floor- Small Load*	*5.0 gpm*	*Constant*	*0.04 Hp*	30 W
P-5	*Radiant Floor - Lead*	*21.4 gpm*	*VFD*	*0.33 Hp*	249 W
P-7	*AHU-1 - Main Coil*	*22.9 gpm*	*VFD*	*0.50 Hp*	373 W
P-8	*Heat Pump - 1 / Storage Tank Loop*	*7.0 gpm*	*Constant*	*0.04 Hp*	30 W
P-9	*Heat Pump - 2 / Storage Tank Loop*	*7.0 gpm*	*Constant*	*0.04 Hp*	30 W
P-10	*Heat Pump - 3 / Storage Tank Loop*	*7.0 gpm*	*Constant*	*0.04 Hp*	30 W
P-11	*Ground Loop / Heat Pump 4*	*6.6 gpm*	*Constant*	*0.08 Hp*	62 W
P-12	*Heat Pump 4 / Meeting Room Storage Tank*	*6.0 gpm*	*Constant*	*0.08 Hp*	62 W
P-13	*Meeting Room Storage Tank / Fin Tube Convectors*	*6.0 gpm*	*Constant*	*0.08 Hp*	62 W
P-14	*Meeting Room Storage Tank / ERV Cooling Coil*	*6.0 gpm*	*Constant*	*0.08 Hp*	62 W
P-15	*DHW Tank / Reheat Coil*	*6.0 gpm*	*Constant*	*0.08 Hp*	62 W
PP-1	*DHW tank / Storage Tank*	*3.6 gpm*	*Constant*	*0.04 Hp*	30 W
PP-2	*Solar Collectors / Solar Storage Tank*	*3.5 gpm*	*Constant*	*0.04 Hp*	30 W
Total Line Pumps		**151.2 gpm**		**2.32 Hp**	**1,733 W**
				Pump Heat Transfer Efficiency	**43.7 Btu/hr-F-W**
				Pump Volume Flow Efficiency	**0.09 gpm/W**
Redundant (lead/lag) Pumps					
P-3	*Main Geothermal Loop - Lag*	*36.6 gpm*	*VFD*	*0.75 Hp*	559 W
P-6	*Radiant Floor - Lag*	*21.4 gpm*	*VFD*	*0.33 Hp*	249 W
Total - Redundant Pumps		**58.0 gpm**		**1.08 Hp**	**808 W**
Total - Main Building Area Pumps		**209.3 gpm**		**3.41 Hp**	**2,540 W**

Figure 33: CND Level 2 HVAC tab - Pumps, main building area.

PUMPS - SubArea 1		**Classroom**			
Line Pumps	Function	Flow Rate	Control	Motor HP	Motor Watts
		0.0 gpm	*VFD*	*0.00 Hp*	0 W
		0.0 gpm	*VFD*	*0.00 Hp*	0 W
Total Line Pumps		**0.0 gpm**		**0.00 Hp**	**0 W**
				Pump Heat Transfer Efficiency	**0.0 Btu/hr-F-W**
				Pump Volume Flow Efficiency	**0.00 gpm/W**
Redundant (lead/lag) Pumps					
		0.0 gpm	*VFD*	*0.00 Hp*	0 W
		0.0 gpm	*VFD*	*0.00 Hp*	0 W
Total - Redundant Pumps		**0.0 gpm**		**0.00 Hp**	**0 W**
Total - SubArea1 Pumps		**0.0 gpm**		**0.00 Hp**	**0 W**
PUMPS - SubArea 2		**Workshop/Garage**			
Line Pumps	Function	Flow Rate	Control	Motor HP	Motor Watts
		0.0 gpm	*VFD*	*0.00 Hp*	0 W
		0.0 gpm	*VFD*	*0.00 Hp*	0 W
Total Line Pumps		**0.0 gpm**		**0.00 Hp**	**0 W**
				Pump Heat Transfer Efficiency	**0.0 Btu/hr-F-W**
				Pump Volume Flow Efficiency	**0.00 gpm/W**
Redundant (lead/lag) Pumps					
		0.0 gpm	*VFD*	*0.00 Hp*	0 W
		0.0 gpm	*VFD*	*0.00 Hp*	0 W
Total - Redundant Pumps		**0.0 gpm**		**0.00 Hp**	**0 W**
Total- SubArea2 Pumps		**0.0 gpm**		**0.00 Hp**	**0 W**

PUMPS - Total Building		**Flow Rate**	**Motor Watts**	**Flow Efficiency**
Line Pumps	**Constant Speed**	**70.3 gpm**	**552 W**	**0.13 gpm/W**
	Variable Frequency Drive	**80.9 gpm**	**1,181 W**	**0.07 gpm/W**
	Variable Speed	**0.0 gpm**	**0 W**	**0.00 gpm/W**
	Total - Line Pumps	**151.2 gpm**	**1,733 W**	**0.09 gpm/W**
Redundant Pumps		**58.0 gpm**	**808 W**	

Figure 34: CND Level 2 HVAC tab - Pumps, sub areas 1 & 2 and total building.

Heating Equipment

Heating equipment input for the main building area and each sub area is illustrated in Figures 35 and 36 below.

HVAC	**Providing Heat: Boilers, Furnaces, Radiant & Electric Heaters**				
Main Building Area		**Office**			
Boiler	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Boilers			0 kBtu/hr	0 kBtu/hr	
Furnace	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Furnaces			0 kBtu/hr	0 kBtu/hr	
Radiant Heater	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Radiant Heaters			0 kBtu/hr	0 kBtu/hr	
Electric Heater	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Electric Heaters			0 kBtu/hr	0 kBtu/hr	
Total - Main Building Area Heat Production			**0 kBtu/hr**	**0 kBtu/hr**	**0%**
SubArea 1		**Classroom**			
Boiler	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Boilers			0 kBtu/hr	0 kBtu/hr	
Furnace	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Furnaces			0 kBtu/hr	0 kBtu/hr	
Radiant Heater	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Radiant Heaters			0 kBtu/hr	0 kBtu/hr	
Electric Heater	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Electric Heaters			0 kBtu/hr	0 kBtu/hr	
Total - SubArea 1 Heat Production			**0 kBtu/hr**	**0 kBtu/hr**	**0%**

Figure 35: CND Level 2 HVAC tab - Heating Equipment, main building area and sub area 1.

SubArea 2		**Workshop/Garage**			
Boiler	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Boilers			0 kBtu/hr	0 kBtu/hr	
Furnace	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Furnaces			0 kBtu/hr	0 kBtu/hr	
Radiant Heater	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Radiant Heaters			0 kBtu/hr	0 kBtu/hr	
Electric Heater	Function	Fuel	Rated Output	Input	Efficiency
			0 kBtu/hr	*0 kBtu/hr*	*0%*
					0%
Total Electric Heaters			0 kBtu/hr	0 kBtu/hr	
Total - SubArea 2 Heat Production			**0 kBtu/hr**	**0 kBtu/hr**	**0%**
Total Building Heat Production			Rated Output	Input	Efficiency
		Boilers	**0 kBtu/hr**	**0 kBtu/hr**	**0%**
		Furnaces	**0 kBtu/hr**	**0 kBtu/hr**	**0%**
		Radiant Heaters	**0 kBtu/hr**	**0 kBtu/hr**	**0%**
		Electric Heaters	**0 kBtu/hr**	**0 kBtu/hr**	**0%**
		Total	**0 kBtu/hr**	**0 kBtu/hr**	**0%**

Figure 36: CND Level 2 HVAC tab - Heating Equipment, sub area 2 and total building.

Heat Pumps

Heat pump system input for the main building area and each sub area of the building is illustrated in Figure 37 below. Inputs include equipment reference and description, refrigerant, rated input (compressor) power, design heating capacity and design cooling capacity. Calculated values include total rated power, maximum heating hapacity and maximum cooling capacity for each sub area of the building and the total building. Figure 37 illustrates the water-water ground source heat pumps for the Aldo Leopold Legacy Center. The heat pumps maintain a hot water tank in the heating season and a chilled water tank in the cooling season. Water is pumped from the tank to the air handling unit coil and to the radiant slabs to heat or cool the building.

HVAC	**Heat Pump Systems: Air-Air, Water-Air & Water-water**				
Main Building Area		**Office**			
Heat Pump	Heating or Cooling Function	Refrigerant	Rated Input Power	Heat Capacity	Cool Capacity
WHP-1	*Heating or Chilling Storage Tank*	*R-410A*	*5,241 W*	*49 kBtu/hr*	*51 kBtu/hr*
WHP-2	*Heating or Chilling Storage Tank*	*R-410A*	*5,241 W*	*49 kBtu/hr*	*51 kBtu/hr*
WHP-3	*Heating or Chilling Storage Tank*	*R-410A*	*5,241 W*	*49 kBtu/hr*	*51 kBtu/hr*
WHP-4	*Heating or Chilling Storage Tank*	*R-410A*	*5,241 W*	*24 kBtu/hr*	*31 kBtu/hr*
Total - Main Area Heat Pump Systems			**20,964 W**	**172 kBtu/hr**	**185 kBtu/hr**
SubArea 1		**Classroom**			
Heat Pump	Heating or Cooling Function	Refrigerant	Rated Input Power	Heat Capacity	Cool Capacity
			0 W	*0 kBtu/hr*	*0 kBtu/hr*
Total - SubArea 1 Heat Pump Systems			**0 W**	**0 kBtu/hr**	**0 kBtu/hr**
SubArea 2		**Workshop/Garage**			
Heat Pump	Heating or Cooling Function	Refrigerant	Rated Input Power	Heat Capacity	Cool Capacity
			0 W	*0 kBtu/hr*	*0 kBtu/hr*
Total - SubArea 2 Heat Pump Systems			**0 W**	**0 kBtu/hr**	**0 kBtu/hr**
Total Building Heat Pumps			Rated Input Power	Heat Capacity	Cool Capacity
		Total Building	**20,964 W**	**172 kBtu/hr**	**185 kBtu/hr**

Figure 37: CND Level 2 HVAC tab - Heat Pumps.

Cooling Equipment

Cooling equipment descriptions and capacities for the main building area and sub areas is illustrated in Figure 38 below and Figure 39 on the following page. Equipment is entered for the main building area and each sub area. For each piece of cooling equipment, enter an equipment identifying number and description. For chillers and DX units enter the refrigerant, rated input (compressor) power and SEER (seasonal energy efficiency ratio) and cooling capacity. For absorption chillers, enter the absorber fluid, rated heat input (in watts) SEER and cooling capacity. For evaporative coolers and cooling towers enter the fan power and the rated cooling capacity. For each sub area and the total building, the spreadsheet calculates total input power and total cooling capacity.

HVAC	Producing Cooling: Chillers, DX Coolers, Evaporative Coolers and Cooling Towers				
Main Building Area		**Office**			
Chillers		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Chillers - Main Area			**0 W**		0 kBtu/hr
DX Air-Conditioning		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total DX Air-Conditioning - Main Area			**0 W**		0 kBtu/hr
Absorption Air-Conditioning		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Absorption Air-Conditioning - Main Area			**0 W**		0 kBtu/hr
Evaporative Coolers			Fan Power		Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Evaporative Coolers - Main Area			**0 W**		0 kBtu/hr
Cooling Towers used for direct cooling			Fan Power		Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Cooling Towers - Main Area			**0 W**		0 kBtu/hr
Total - Cooling Capacity - Main Area			**0 W**		**0 kBtu/hr**
SubArea 1		**Classroom**			
Chillers		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Chillers - SubArea 1			**0 W**		0 kBtu/hr
DX AC		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total DX Air-Conditioning - SubArea 1			**0 W**		0 kBtu/hr
Absorption Air-Conditioning		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Absorption Air-Conditioning - SubArea 1			**0 W**		0 kBtu/hr
Evaporative Coolers			Fan Power		Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Evaporative Coolers - SubArea 1			**0 W**		0 kBtu/hr

Figure 38: CND Level 2 HVAC tab - Cooling Equipment, main building area and sub area 1.

Cooling Towers used for direct cooling			Fan Power		Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Cooling Towers - SubArea 1			**0 W**		0 kBtu/hr
Total - Cooling Capacity - SubArea 1			**0 W**		**0 kBtu/hr**
SubArea 2		**Workshop/Garage**			
Chillers		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Chillers - SubArea 2			**0 W**		0 kBtu/hr
DX AC		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total DX Air-Conditioning - SubArea 2			**0 W**		0 kBtu/hr
Absorption Air-Conditioning		Refrigerant	Rated Input Power	SEER	Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Absorption Air-Conditioning - SubArea 2			**0 W**		0 kBtu/hr
Evaporative Coolers			Fan Power		Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Evaporative Coolers - SubArea 2			**0 W**		0 kBtu/hr
Cooling Towers used for direct cooling			Fan Power		Cool Capacity
	Notes		*0 W*		*0 kBtu/hr*
Total Cooling Towers - SubArea 2			**0 W**		0 kBtu/hr
Total - Cooling Capacity - SubArea 2			**0 W**		**0 kBtu/hr**
Total Building Cooling Production			Rated Input		Cooling Capacity
			0 W		**0 kBtu/hr**
HVAC	**Installed Heating and Cooling Capacity**		**Peak Capacity**		
	Heating Systems		**172 kBtu/hr**		
	Cooling Systems		**185 kBtu/hr**		

Figure 39: CND Level 2 HVAC tab - Cooling Equipment, sub area 2 and total building

Miscellaneous HVAC Equipment

Miscellaneous HVAC and equipment includes all equipment not covered under ventilation fans, pumps, heating equipment, heat pumps and cooling equipment. Items such as wood burning stoves and ceiling fans are included here. Spreadsheet inputs and calculations for miscellaneous equipment are illustrated in Figure 40 below. For each piece of equipment, inter the rated maximum input power, heating capacity and/or cooling capacity as appropriate.

HVAC	**Other Systems (eg. wood burning stoves; ceiling fans; district system heat exchangers, etc.**			
Device	Function	Power Rating	Heating Capacity	Cooling Capacity
Fireplace	*Located in lobby, Rumsford design, used rarely*	*0 W*	*0 kBtu/hr*	*0 kBtu/hr*
Wood Stove	*Located in staff kitchen, used on chilly mornings*			
Wood Stove	*Located in Meeting Room, used during occupancy in winter*			
Wood Stove	*Located in Seed Hall, used on cool spring and fall days*			
Total - Other Systems		**0 W**	**0 kBtu/hr**	**0 kBtu/hr**

Figure 40: CND Level 2 HVAC tab - Miscellaneous HVAC Equipment

Service Hot Water Equipment

Service Hot Water Equipment inputs include equipment reference, description, refrigerant (if used), heater input rating and heating capacity. Spreadsheet inputs and calculated values are illustrated in Figure 41 below.

Level 2 Case Study - HVAC and Service Hot Water Systems

Service Hot Water System				
Device	Function	Fuel/Refrigerant	Input Rating	Heating Capacity
WHP-5	DHW Back-up Heat Pump	R-410A	*10,300 W*	*24 kBtu/hr*
				0 kBtu/hr
Total - Service Hot Water			**10,300 W**	**24 kBtu/hr**

Figure 41: CND Level 2 HVAC tab - Service Hot Water.

Level 2 - Plug, Process, Elevators and Escalators

The Level 2 Plug, Process, Elevator and Escalator loads cover all other installed power and combustion equipment. Elevators and escalators include all people moving equipment. Process equipment includes electrical and combustion equipment used as part of the building occupancy function, for example, industrial equipment, kitchen equipment in a restaurant, refrigeration equipment for coolers and freezers in a supermarket, etc. Plug equipment is equipment such as computers, copiers and appliances that are connected to electrical outlets in the building.

Aldo Leopold Legacy Center	
the Kubala Washatko Architects	
Baraboo	Wisconsin

Plug Loads		**Main Building Area**		**Office**
Device	**Function**	**Num. of Units**	**Watts/Unit**	**Installed Watts**
Computer Worstation		14	*225 W*	3.2 kW
Servers		2	*180 W*	0.4 kW
Copier		1	*750 W*	0.8 kW
LCD Screens		2	*250 W*	0.5 kW
Refrigerator		1	*800 W*	0.8 kW
Stove		1	*1,800 W*	1.8 kW
Microwave		1	*1,200 W*	1.2 kW
Coffee Maker		1	*150 W*	0.2 kW
		0	*0 W*	0.0 kW
Total Installed Plug Load Devices (kW) in Main Building Area				**8.7 kW**
Plug Loads		**SubArea 1**		**Classroom**
Device	**Function**	**Num. of Units**	**Watts/Unit**	**Installed Watts**
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
Total Installed Plug Load Devices (kW) in subArea 1				**0.0 kW**
Plug Loads		**SubArea2**		**Workshop/Garage**
Device	**Function**	**Num. of Units**	**Watts/Unit**	**Installed Watts**
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
Total Installed Plug Load Devices (kW) in subArea 2				**0.0 kW**
Plug Loads		**Total Building**		
Total Installed Plug Load Devices (kW) in Building				**8.7 kW**

Figure 42: CND Level 2 Plug_Process tab - Plug Loads.

Plug

Plug loads includes all appliances and equipment connected by electrical outlet to the grid: computers, copiers, printers, etc. Plug loads inputs and calculations are illustrated in Figure 42 above.

Elevators and Escalators		Main Building Area		Office
Device	Function	Num. of Units	Watts/Unit	Installed Watts
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
Total Elevators and Escalators (kW) in Main Building Area				**0.0 kW**
Elevators and Escalators		**SubArea 1**		**Classroom**
Device	Function	Num. of Units	Watts/Unit	Installed Watts
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
Total Elevators and Escalators (kW) in subArea 1				**0.0 kW**
Elevators and Escalators		**SubArea2**		**Workshop/Garage**
Device	Function	Num. of Units	Watts/Unit	Installed Watts
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
Total Elevators and Escalators (kW) in subArea 2				**0.0 kW**
Elevators and Escalators		**Total Building**		
Total Elevators and Escalators (kW) in Building				**0.0 kW**

Figure 43: CND Level 2 Plug_Process tab - Elevator and Escalator Equipment.

Elevators and Escalators

Elevator and escalator inputs and outputs for the main building area and sub areas are illustrated in Figure 43 above. Inputs include an equipment identifier, description, number of units and rated maximum power. The spreadsheet calculates installed kW for each sub area and for the total building.

Process Loads		Main Building Area		Office
Device	Function	Num. of Units	Watts/Unit	Installed Watts
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
Total Installed Process Loads (kW) in Main Building Area				**0 kW**

Process Loads		SubArea 1		Classroom
Device	Function	Num. of Units	Watts/Unit	Installed Watts
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
Total Installed Process Loads (kW) in subArea 1				**0.0 kW**

Process Loads		SubArea 2		Workshop/Garage
Device	Function	Num. of Units	Watts/Unit	Installed Watts
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
		0	*0 W*	0.0 kW
Total Installed Process Loads (kW) in subArea 2				**0.0 kW**

Figure 44: CND Level 2 Plug_Process tab - Process Loads.

Process Loads

Process load inputs and outputs for building main and sub areas are illustrated in Figure 44 above. Inputs include equipment identifier, description, number of units, rated power of the unit in watts (combustion equipment will need to have rated power converted from heat units to electrical units). The spreadsheet calculates installed kW for each sub area and for the total building.

Level 2 Case Study - Building Design Variables

Aldo Leopold Legacy Center	**Basis of Analysis**	**Gross Measured Area**
the Kubala Washatko Architects	Parking Garage Included in Analysis?	**No**
Baraboo **Wisconsin**		

Renewable Resource Variables per Gross Measured Area		**IP Units**	**Metric Units**
Solar PV Density		3.20 Wpeak/SF	34.4 Wpeak/m^2
Wind Electric Density		0.00 Wpeak/SF	0.0 Wpeak/m^2
Solar Thermal Density		0.008 SF/SF	0.008 m^2/m^2

Building Enclosure Variables per Gross Measured Area		**IP Units**	**Metric Units**
Enclosure Area per Gross Measured Area	**Total Building**	**2.15 SF/SF**	**2.15 m^2/m^2**
Main Area	Office	2.00 SF/SF	2.00 m^2/m^2
SubArea 1	Classroom	2.69 SF/SF	2.69 m^2/m^2
SubArea 2	Workshop/Garage	2.66 SF/SF	2.66 m^2/m^2
Heat Transfer Rate per Gross Measured Area	**Total Building**	**0.14 Btu/hr-sf-°F**	**0.78 W/m^2-°C**
Main Area	Office	0.18 Btu/hr-sf-°F	1.01 W/m^2-°C
SubArea 1	Classroom	1.37 Btu/hr-sf-°F	7.76 W/m^2-°C
SubArea 2	Workshop/Garage	1.37 Btu/hr-sf-°F	7.76 W/m^2-°C

Illumination Variables per Gross Measured Area		**IP Units**	**Metric Units**
Lighting Power Density	**Total**	**1.075 Watt/SF**	**11.57 Watt/m^2**
Main Area	Office	1.162 Watt/SF	12.51 Watt/m^2
SubArea 1	Classroom	0.515 Watt/SF	5.55 Watt/m^2
SubArea 2	Workshop/Garage	0.703 Watt/SF	7.56 Watt/m^2

Building Glazing per Gross Measured Area		Main Area	**Subarea 1**	**Subarea 2**
	Total Building	**Office**	**Classroom**	**Workshop/Garage**
South	5.7%	6.0%	10.6%	0.0%
East	3.7%	3.0%	13.9%	0.0%
North	7.3%	5.8%	28.0%	0.7%
West	4.2%	3.0%	13.9%	3.9%
Horizontal	0.0%	0.0%	0.0%	0.0%
Total Glazing	**21.0%**	**17.9%**	**66.3%**	**4.6%**

Ventilation Variables per Gross Measured Area		**IP Units**	**Metric Units**
Operable Window Area	**Total**	**6.3%**	**6.3%**
Main Area	Office	7.1%	7.1%
SubArea 1	Classroom	6.8%	6.8%
SubArea 2	Workshop/Garage	1.0%	1.0%
Outdoor Air Ventilation Rate	**Total**	**0.19 cfm/SF**	**0.98 l/s-m^2**
Main Area	Office	0.25 cfm/SF	1.26 l/s-m^2
SubArea 1	Classroom	0.00 cfm/SF	0.00 l/s-m^2
SubArea 2	Workshop/Garage	0.00 cfm/SF	0.00 l/s-m^2
Supply Air Ventilation Capacity	**Total**	**0.19 cfm/SF**	**0.98 l/s-m^2**
Main Area	Office	0.25 cfm/SF	1.26 l/s-m^2
SubArea 1	Classroom	0.00 cfm/SF	0.00 l/s-m^2
SubArea 2	Workshop/Garage	0.00 cfm/SF	0.00 l/s-m^2

Heating Capacities per Gross Measured Area		**IP Units**	**Metric Units**
Heating Capacity	**Total**	**4.08 Watt/SF**	**43.9 W/m^2**
Main Area	Office	5.26 Watt/SF	56.6 W/m^2
SubArea 1	Classroom	0.00 Watt/SF	0.0 W/m^2
SubArea 2	Workshop/Garage	0.00 Watt/SF	0.0 W/m^2
Heating Installed Power	**Total**	**1.70 Watt/SF**	**18.3 W/m^2**
Main Area	Office	2.19 Watt/SF	23.6 W/m^2
SubArea 1	Classroom	0.00 Watt/SF	0.0 W/m^2
SubArea 2	Workshop/Garage	0.00 Watt/SF	0.0 W/m^2

CND Case Study Level 2 Metrics 12/5/10 Page 1

Figure 45: CND Level 2 - Metrics tab - Page 1.

Level 2 Case Study - Building Design Variables

Cooling Capacities per Gross Measured Area		**IP Units**	**Metric Units**
Cooling Capacity	**Total**	801 SF/Ton	21.2 m^2/kW
Main Area	Office	622 SF/Ton	16.4 m^2/kW
SubArea 1	Classroom	0 SF/Ton	0.0 m^2/kW
SubArea 2	Workshop/Garage	0 SF/Ton	0.0 m^2/kW
Installed Power	**Total**	1.70 Watt/SF	18.3 W/m^2
Main Area	Office	2.19 Watt/SF	23.6 W/m^2
SubArea 1	Classroom	0.00 Watt/SF	0.0 W/m^2
SubArea 2	Workshop/Garage	0.00 Watt/SF	0.0 W/m^2

Fan Efficiencies per Gross Measured Area		**IP Units**	**Metric Units**
Fan Power Density (supply & exhaust)	**Total**	0.20 Watt/SF	2.10 Watt/m^2
Main Area	Office	0.25 Watt/SF	2.71 Watt/m^2
SubArea 1	Classroom	0.00 Watt/SF	0.00 Watt/m^2
SubArea 2	Workshop/Garage	0.00 Watt/SF	0.00 Watt/m^2
Fan Volume Flow Efficiency	**Total**	2.1 cfm/W	1.00 Liter/s/W
Main Area	Office	2.1 cfm/W	1.00 Liter/s/W
SubArea 1	Classroom	0.0 cfm/W	0.00 Liter/s/W
SubArea 2	Workshop/Garage	0.0 cfm/W	0.00 Liter/s/W
Fan Thermal Transfer Efficiency	**Total**	2.3 Btu/hr-°F-W	4.36 kJ/hr-°C-W
Main Area	Office	2.3 Btu/hr-°F-W	4.36 kJ/hr-°C-W
SubArea 1	Classroom	0.0 Btu/hr-°F-W	0.00 kJ/hr-°C-W
SubArea 2	Workshop/Garage	0.0 Btu/hr-°F-W	0.00 kJ/hr-°C-W
Fan Characteristics	**Flow Rate**	**Motor Watts**	**Flow Efficienncy**
Constant Volume Fans	1,570 cfm	300 W	5.2 cfm/W
Variable Frequency Drive Fans	1,195 cfm	1,119 W	1.1 cfm/W
Variable Speed Fans	2,350 cfm	989 W	2.4 cfm/W

Pump Efficiencies per Gross Measured Area		**IP Units**	**Metric Units**
Pump Power Density	**Total**	0.14 Watt/SF	1.51 Watt/m^2
Main Area	Office	0.18 Watt/SF	1.95 Watt/m^2
SubArea 1	Classroom	0.00 Watt/SF	0.00 Watt/m^2
SubArea 2	Workshop/Garage	0.00 Watt/SF	0.00 Watt/m^2
Pump Volume Flow Efficiency	**Total**	0.09 gpm/W	0.01 Liter/s/W
Main Area	Office	0.09 gpm/W	0.01 Liter/s/W
SubArea 1	Classroom	0.00 gpm/W	0.00 Liter/s/W
SubArea 2	Workshop/Garage	0.00 gpm/W	0.00 Liter/s/W
Pump Thermal Transfer Efficiency	**Total**	43.7 Btu/hr-°F-W	82.95 kJ/hr-°C-W
Main Area	Office	43.7 Btu/hr-°F-W	82.95 kJ/hr-°C-W
SubArea 1	Classroom	0.0 Btu/hr-°F-W	0.00 kJ/hr-°C-W
SubArea 2	Workshop/Garage	0.0 Btu/hr-°F-W	0.00 kJ/hr-°C-W
Pump Characteristics	**Flow Rate**	**Motor Watts**	**Flow Efficienncy**
Constant FlowPumps	70.3 gpm	552 W	0.13 gpm/W
Variable Frequency Drive Pumps	80.9 gpm	1,181 W	0.07 gpm/W
Variable Speed Pumps	0.0 gpm	0 W	0.00 gpm/W

Figure 46: CND Level 2 - Level 2 Metrics tab - Page 2.

Level 2 - Metrics

The Level 2 Metrics for the building enclosure and systems are illustrated in Figures 45, 46 and 47. The values illustrated are for the Aldo Leopold Legacy Center. The metric area used as a basis of analysis and whether parking garage areas are included in the calculation of metrics are listed along with project data. In the case of the Legacy Center, the Gross Measured Area is the metric area of analysis.

Site renewable energy capacity per unit area is given for solar electric, wind electric and solar thermal systems.

Building Enclosure variables are given for the total building and each sub area. Enclosure variables include enclosure area per metric area and heat transfer rate per metric area. Note the difference in heat transfer rate per metric area for the Aldo Leopold Legacy Center main building and unconditioned classroom and garage.

Illumination variables include lighting power density and glazing area per metric area for total building and sub areas. For the Legacy Center, only the unconditioned classroom building has a glazing to metric area ratio larger than 20%.

Ventilation variables include operable window area per metric area, outdoor air ventilation rate per metric area and supply air ventilation capacity per metric area. Values presented are for the Legacy Center.

Heating capacity and installed power are presented for the total building and each sub area. As the main building area is the only conditioned area, the values presented illustrate the difference between considering the total building and only the main building area, which is the only sub area that is heated.

Cooling capacities include both the mazimum cooling capacity per unit metric area and the installed rated (compressor or absorption) power per unit metric area.

Fan variable metrics calculated include power density, volume flow efficiency, thermal transfer efficiency and breakdown by fan control type (constant volume, variable speed and variable frequency drive).

Pump variable metrics calculated include power density, volume flow efficiency, thermal transfer efficiency and breakdown by fan control type (constant volume, variable speed and variable frequency drive).

Finally, installed plug power density, elevator power density and process power density are given for each buildig subarea and the total building (Figure 47 on the following page).

Level 2 Case Study - Building Design Variables

Plug Load Power per Gross Measured Area		IP Units	Metric Units
	Total	0.71 Watt/SF	7.61 Watt/m^2
Main Area	Office	0.91 Watt/SF	9.80 Watt/m^2
SubArea 1	Classroom	0.00 Watt/SF	0.00 Watt/m^2
SubArea 2	Workshop/Garage	0.00 Watt/SF	0.00 Watt/m^2

Elevator & Escalator Power per Gross Measured Area		IP Units	Metric Units
	Total	0.00 Watt/SF	0.00 Watt/m^2
Main Area	Office	0.00 Watt/SF	0.00 Watt/m^2
SubArea 1	Classroom	0.00 Watt/SF	0.00 Watt/m^2
SubArea 2	Workshop/Garage	0.00 Watt/SF	0.00 Watt/m^2

Process Load Power per Gross Measured Area		IP Units	Metric Units
	Total	0.00 Watt/SF	0.00 Watt/m^2
Main Area	Office	0.00 Watt/SF	0.00 Watt/m^2
SubArea 1	Classroom	0.00 Watt/SF	0.00 Watt/m^2
SubArea 2	Workshop/Garage	0.00 Watt/SF	0.00 Watt/m^2

CND Case Study Level 2 Metrics 12/4/10 Page 3

Figure 47: CND Level 2 - Metrics tab - Page 3.

Level 2 - Graphs

The Level 2 Graphs for the building enclosure and systems are illustrated in Figures 48 and 49. Figure 48 presets the heat transfer rate for the total building and each building sub area in terms of each heat flow path. Figure 49 illustrates installed power for all flow paths.

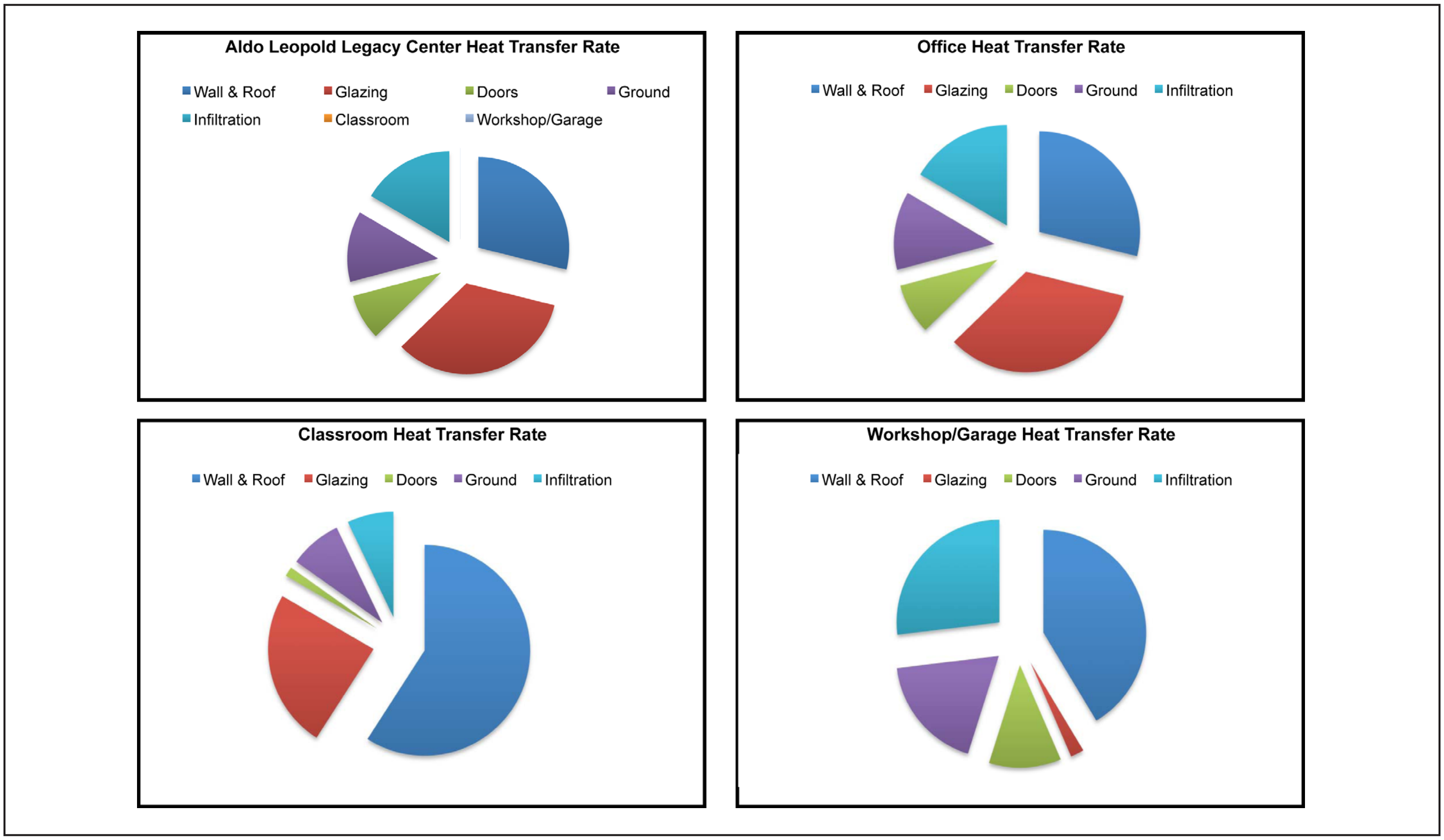

Figure 48: CND Level 2 - Graphs - Building and Sub Area Heat Transfer Rates by Flow Path.

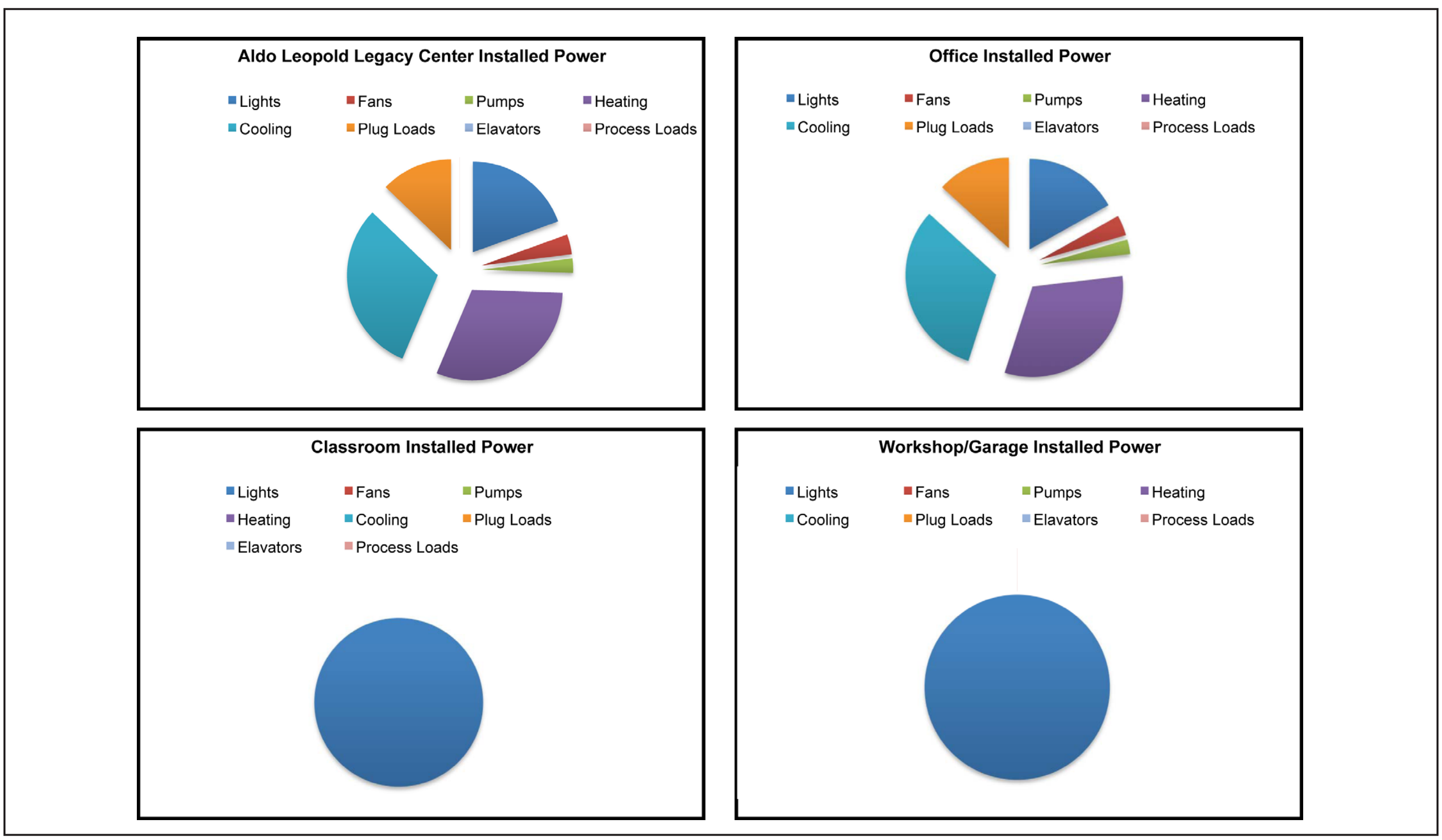

Figure 49: CND Level 2 - Graphs - Installed Power Capacities for the building and sub areas by system.