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ADVANCED ENERGY MODELING FOR LEED
ONLINE TRAINING COURSE

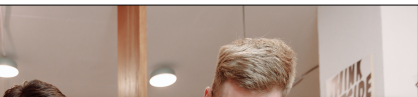
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ENERGY SPECIALIST CURRICULUM





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OUTPUT-INPUT CONSISTENCY
QUALITY CONTROL CHECKLIST
FOR ENERGY PROFESSIONALS

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WHAT SHOULD YOU LEARN



Output-Input Consistency
Quality Control Checklist



OUTPUT QUALITY CONTROL CHECKLIST

The next step is to determine whether the outputs comply with the referenced standard's requirements and LEED requirements, such as unmet load hours, process energy use, and exceptional calculations. Table 3.2 presents a checklist to help teams and reviewers confirm that the requirements have been met and the output values reported in the LEED credit form are consistent with the simulation output reports. The checklist applies to projects using ASHRAE 90.1-2016+ and California Title 24-2005, Part 6.

Output-Input Consistency Checklist

The last step for verifying the accuracy of the energy savings is to check for consistency between outputs and inputs. Table 3.3 is a checklist for reviewing the consistency of energy modeling outputs and inputs and provides calculation methods and rules of thumb to predict rough order-of-magnitude results. It can assist with quality assurance on projects using ASHRAE 90.1-2016+ and California Title 24.



Table 3.3. Output-Input Consistency Quality Control Checklist		
End-use level energy demand, consumption, and savings		
TOPIC	CHECK	COMMENTS
Interior and exterior lighting power	Calculate lighting demand for both cases with average lighting power densities reported in EAp2 Section 1.4 table. Verify consistency with lighting power demand and consistency of exterior lighting demand reported in Table EAp2-5.	Calculate lighting demand based on building floor area provided in Table 1.2 and lighting power density input in EAp2 Section 1.4 table. $\text{Lighting Demand} = \text{Average Lighting Power Density} \times \text{Building Floor Area}$
	Determine whether any differences can be justified based on lighting control credits.	Lighting schedule differences and daylighting, occupancy sensors, and other controls can account for differences in lighting power.
Interior and exterior lighting consumption	Verify that equivalent full-load hours (EFLHs) of both cases are based on lighting energy use and demand reported in Table EAp2-5.	Calculate interior lighting EFLHs of proposed design: $\text{EFLHs} = \text{Lighting Energy Used} / \text{Lighting Power}$
	Determine whether any differences in EFLHs can be justified based on lighting control credits.	Proposed case EFLHs can be reduced by lighting controls, such as daylighting controls, and reduced lighting schedules.
	If project references California Title 24-2005, verify that exterior lighting and unconditioned space lighting have been added to results reported in Tables EAp2-4 and EAp2-5.	Include exterior and unconditioned lighting energy use for both baseline and proposed cases.
	Check Form OLTG-2-C for exterior lighting input and Form LTG-5-C for unconditioned space lighting input. Verify that energy use is calculated correctly.	Multiply installed wattages by average annual operating hours, then divide by 1,000 to obtain annual energy consumption. Multiply average annual energy consumption by average electricity cost to obtain annual energy cost.

Table 3.3. Output-Input Consistency Quality Control Checklist		
End-use level energy demand, consumption, and savings +		
TOPIC	CHECK	COMMENTS
Cooling equipment efficiency	Confirm whether average efficiency of cooling equipment correlates (within reasonable margin) with Integrated Part Load Value IPLV reported in EAp2 Section 1.4 table.	Use output of total ton-hours (or million Btu) of cooling and total kWh of cooling energy use to calculate cooling equipment average efficiency. $\text{Average Efficiency (kW/ton)} = \text{Input kWh} / \text{Output Ton-Hours}$
	Identify any parameters that may cause variance.	Chillers operating mostly at full load show different IPLV from those operating mostly at part load (for DOE-2 models, see PS-C report, Equipment Load and Energy Use, for number of hours within each part-load range).
Fan and pump power	Verify that fan and pump demand reported in Tables EAp2-4 and EAp2-5 is consistent with fan and pump power reported in EAp2 Section 1.4 table.	Demand reported in Table EAp2-4 and EAp2-5 should not be greater than total power reported in EAp2 Section 1.4 table. $\text{Input kW} = \text{Output Hp} \times 0.746 / \text{Efficiency}$
	Verify that differences in fan and pump energy consumption versus demand between baseline and proposed cases can be justified.	Variable speed fans instead of constant-speed fans may justify variance in fan energy consumption versus demand. Variable-speed fans can lead to large consumption savings even when peak demand is similar.

Table 3.3. Output-Input Consistency Quality Control Checklist		
End-use level energy demand, consumption, and savings +		
TOPIC	CHECK	COMMENTS
System demand	Verify that system demand reported in Tables EAp2-4 and EAp2-5 is consistent with demand calculated with system capacities and efficiencies reported in EAp2 Section 1.4 table of Tableable, particularly for cooling system.	<ul style="list-style-type: none">❑ If cooling is provided only by chillers, project's cooling demand can be calculated with following equation: $\text{Cooling Demand (ton-hours)} = \text{Chiller Capacity (tons)} \times \text{Chiller Efficiency (kW/ton)}$❑ Large baseline and use consumption may result from inappropriate autotizing for cooling and heating capacities, fan supply volume, and pump flow. Autotizing ratio cannot be double-counted (applied at both system and plant levels).
Energy consumption by end use	Verify that energy consumption by end use is reasonable for project's climate zone based on inputs provided	Develop energy efficiency measures Compare existing building's measured or estimated load demand, verify consistency of variation in heating and cooling loads between and proposed cases versus energy efficiency measures, such as increased insulation, high-performance fenestration or shading, thermal mass, cool roof, and optimized building operation. Exhaust air heat recovery A natural energy recovery is noted as efficiency measure, check that proposed case accounts for additional fan power associated with energy recovery. EHR savings are often exaggerated when fan power increases are not included in model. Ground source heat pumps If no supplemental fossil fuel boiler, expect to see significant heating energy savings in cold climates associated with electric resistance heating. Expect to see increased pump power in most cases. Verify that modeled efficiency gains and loop temperatures are consistent with actual design. Variable refrigerant volume systems Expect limited savings in climates where there is little simultaneous heating and cooling in thermal zones, unless heat recovery is implemented for water heating or other uses. Highest savings (about 30%) occur in climates where heating and cooling of thermal zones is often, but not simultaneous (e.g., heating in north-facing zones while cooling in south-facing zones).
Energy end-use savings	Identify efficiency measures from input summary table and verify that heating, cooling, fan, and pump savings are justified based on combined efficiency measures. Confirm that top two end uses with highest energy savings (absolute savings) are reasonable based on energy efficiency measures implemented.	

Table 3.3. Output-Input Consistency Quality Control Checklist		
End-use level energy demand, consumption, and savings +		
TOPIC	CHECK	COMMENTS
		Variable-speed drives If constant-volume fan control is modeled in baseline and VAV is proposed, expect to see 30%-40% savings from full-load value. Higher values should be questioned. For chilled water, condenser water, and hot water pumps, significant savings can be achieved from variable primary configuration versus constant primary or variable secondary configuration. Variable-speed chillers Decreasing on control methods, these chillers can save 50%-60% of cooling energy. Limit of savings requires control strategy that usually requires changes at 50%-60% load and is typically associated with variable flow and condenser water reset controls. Reduced domestic hot water flow Calculations reflecting realistic flow should not affect energy use calculations; energy savings equal to flow reduction are unlikely. Consistencies reflecting energy should account for percentage of hot water versus cold water flow to fixtures. Domestic hot water • Delta-T and entering water temperatures are critical parameters. Large heating savings should not be expected unless current strategies generally limit entering water temperature to 130°F or below. The heating curve should be carefully scrutinized to verify that average fuel utilization efficiency (AFUE) is consistent with average efficiency reported for baseline case. Increased Chw delta-T • Expected results for elevated chilled water differential temperatures include lower pumping energy due to reduced flow, improved performance of variable speed chillers at low flow conditions, and increased fan power unless measures are taken to lower fan static pressure.

Table 3.3. Output-Input Consistency Quality Control Checklist		
End-use level energy demand, consumption, and savings +		
TOPIC	CHECK	COMMENTS
Consistency between end uses	Identify reasons for cooling capacities that vary substantially from 400 sf/in, and for supply air flows that vary substantially from 1 cfm/sf. Verify cooling versus heat rejection energy savings.	NA
	Calculate approximate expected proposed design fan energy savings of VAV systems and verify consistency with percentage savings reported in Table EAp2-5.	<ul style="list-style-type: none">❑ Cooling and heat rejection should reflect similar savings. Exception: If control strategies for heat rejection vary between baseline and proposed case, differences may be justified (e.g., difference may occur if wet bulb temperature is reset to 65°F versus 70°F or design temperature is 75°F versus 85°F, or water-side economizer is used).❑ After normalizing fan power, VAV system fan energy savings should align with cooling (and to lesser extent heating) energy savings. $\text{Approximate Expected Proposed Design Fan Energy Savings} = 1 - [100\% - \text{Percentage of Proposed Design Fan Demand Savings}] \times [100\% - \text{Percentage of Proposed Design Cooling Energy Savings}]$ Exception: Cooling equipment efficiency measures that improve cooling performance at part load would not be reflected in fan savings.
	Verify cooling energy savings or heating energy increase versus lighting or process power density reduction.	<ul style="list-style-type: none">❑ Cooling savings should occur with lighting or process power density reductions. Exception: Projects with economizer controls will not reflect maximum savings associated with loads reductions.❑ Heating energy increase should occur with lighting or process power density reductions.

Table 3.3. Output-Input Consistency Quality Control Checklist		
Building-level energy consumption and cost		
TOPIC	CHECK	COMMENTS
Benchmark comparison	Verify that total energy consumption, EUI, and energy cost per unit floor area relative to benchmark data are reasonable for both baseline and proposed cases for building type and climate. Verify that statistically significant differences are justified based on building-specific parameters.	<div>Commercial Buildings Energy Consumption Survey (CBECS) consumption and expenditures tables, available at http://www.eia.doe.gov/menus/cbeec/cbeec2003/tables_tables_2003_tables_2003.html.</div> <div>Check Commercial End-Use Survey (CEUS) data, available at http://www.energy.ca.gov/ceus/.</div>
Virtual energy rates	Determine whether differences in virtual energy rates are justified based on utility rate information provided.	<div>Calculate virtual energy rates for each type of fuel by dividing total cost by total use.</div> <div>Higher virtual rates are seen when peak demand charges are high and demand by end use is high.</div> <div>Lower virtual rates are seen when peak demand rates are high and energy efficiency measures, such as thermal energy storage or daylight harvesting controls, curb peak demand.</div> <div>Gas rate is calculated based on virtual rate comprising mostly monthly meter fees.</div>
EAp2 = Energy and Atmosphere Prerequisite 2 CBECS = Commercial Buildings Energy Consumption Survey CEUS = Commercial End-Use Survey EFLH = equivalent full-load hours EUI = energy use intensity VAV = variable air volume		



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