Energy Modeling and Net Zero Energy Buildings

Together
we engineer
success.

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MEP Engineering | Project Management

Net Zero Design and Living Building Challenge Philosophy

Design Team, Owner/Developer, Contractor Buy-In

New Construction vs Renovation/Adaptive Re-use

Optimization of Site Resources, building orientation, site permeability, heat island, natural ventilation

Integrated Project Milestones/Design Phase Approach, Engagement of energy providers, funding, etc.

Iterative Building Energy Modeling to inform design

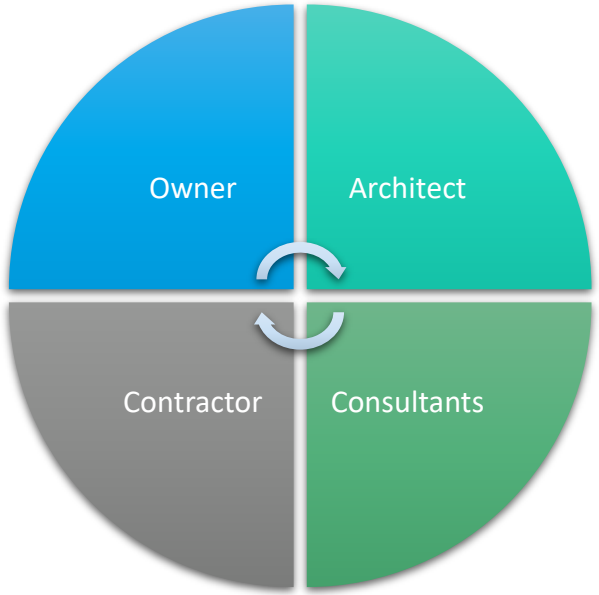
High Performing Building Envelope , Solar Tubular skylights, Green and biodiverse roofing, BIPV

Energy Efficient MEP Systems

Advanced Building Control, Management, Monitoring and Reporting

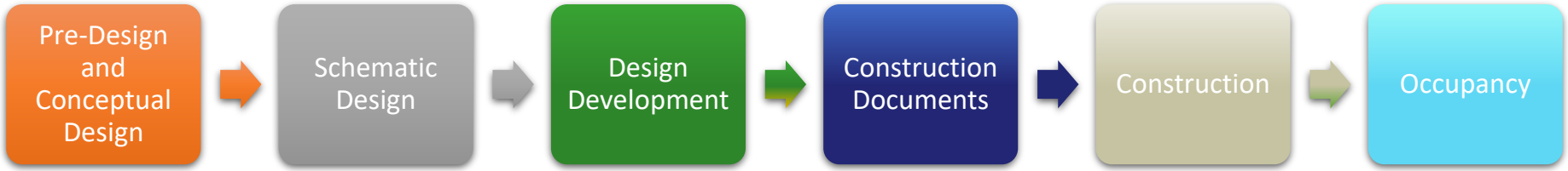
Decarbonization

End User/Operator and Occupant Satisfaction, Comfort, and Health



Integrated Project Milestones/Design Phase Approach

- Engagement of contracting team, owner, estimators, commissioning agent(s), subconsultants critical during early programming/conceptual design.
- Integrated Design Charrette
- All parties shall contribute to formalization of conceptual/schematic design.
- Development of Owner's Project Requirements (OPR) and/or project Basis of Design (BOD) documentation.
- Iterative energy modeling throughout each project design/construction phase.
- Engagement of energy providers, funding sources, and local authority early in project.



Description

Explanation of DC Clean Energy Act, DC Green Code, and design/operational strategies for impending Net-Zero Energy requirement.

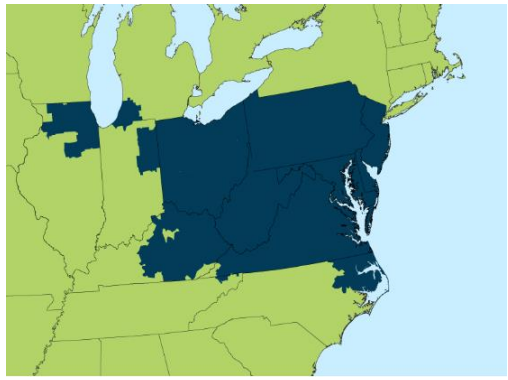
Objectives

- Applicable Codes, Standards, Compliance Requirements
- Net-Zero Design Philosophy
- Project Stage Milestones/Objectives
- Architectural Net-Zero Design Techniques
- MEP Net-Zero Design Techniques
- Decarbonization
- Net-Zero vs Occupant Health/Comfort
- Future Considerations
- Financing Options

https://www.gresb.com/nl-en/the-path-to-net-zero/

Clean Energy DC Omnibus Act of 2018

- Goal of running Washington D.C. on 100% renewable electricity by 2032.
- Goal of carbon reduction by 50% in 2032.
- Renewable Energy Credits (RECs) to be sourced only from PJM interconnecting region.
- Established DC's "Green Energy Bank" finance authority
- Established the Building Energy Performance Standard (BEPS) for existing privately-owned and District-owned buildings.
- 10% of Renewable Energy must be generated by solar PV within District by 2032.



DC GREEN BANK

Climate Commitment Act of 2021

- Focus on carbon reduction and carbon neutrality.
- Goal of carbon reduction by 45% in 2025 compared to 2006 emissions.
- Goal of carbon reduction by 60% in 2030 compared to 2006 emissions.
- Goal of carbon neutrality by 2045.
- Prohibition of natural gas fired furnaces or water heaters in 2025
- Commitment to Racial Equity
  - Monitoring of harmful particulate matter, carbon monoxide, nitrogen dioxide, etc,
  - Limit exposure to heat islands
  - Redress of past environmental and public health inequities

Clean Energy DC Building Code Amendment Act of 2022

- Beginning in **2026**, all new buildings and substantial renovations to existing building shall required to be net-zero construction.
- Compliance with the 2017 District of Columbia Energy Conservation Code – Appendix Z – Net-Zero Energy Compliance Path
- On site fuel combustion cannot be used as a provision for building thermal energy (space conditioning, water heating, refrigeration, etc.)
- Renewable Energy Credits (RECs) may not be procured by unbundled means but are available through offsite resources.

2017 DC Energy Conservation Code – Appendix Z

- Offsite energy procurement from qualified electrical provider of Tier 1 renewable sources.
  - Solar Thermal
  - Geothermal Ground Source Heat
  - On-Land and Offshore Wind
  - Hydroelectric
  - Solar PV

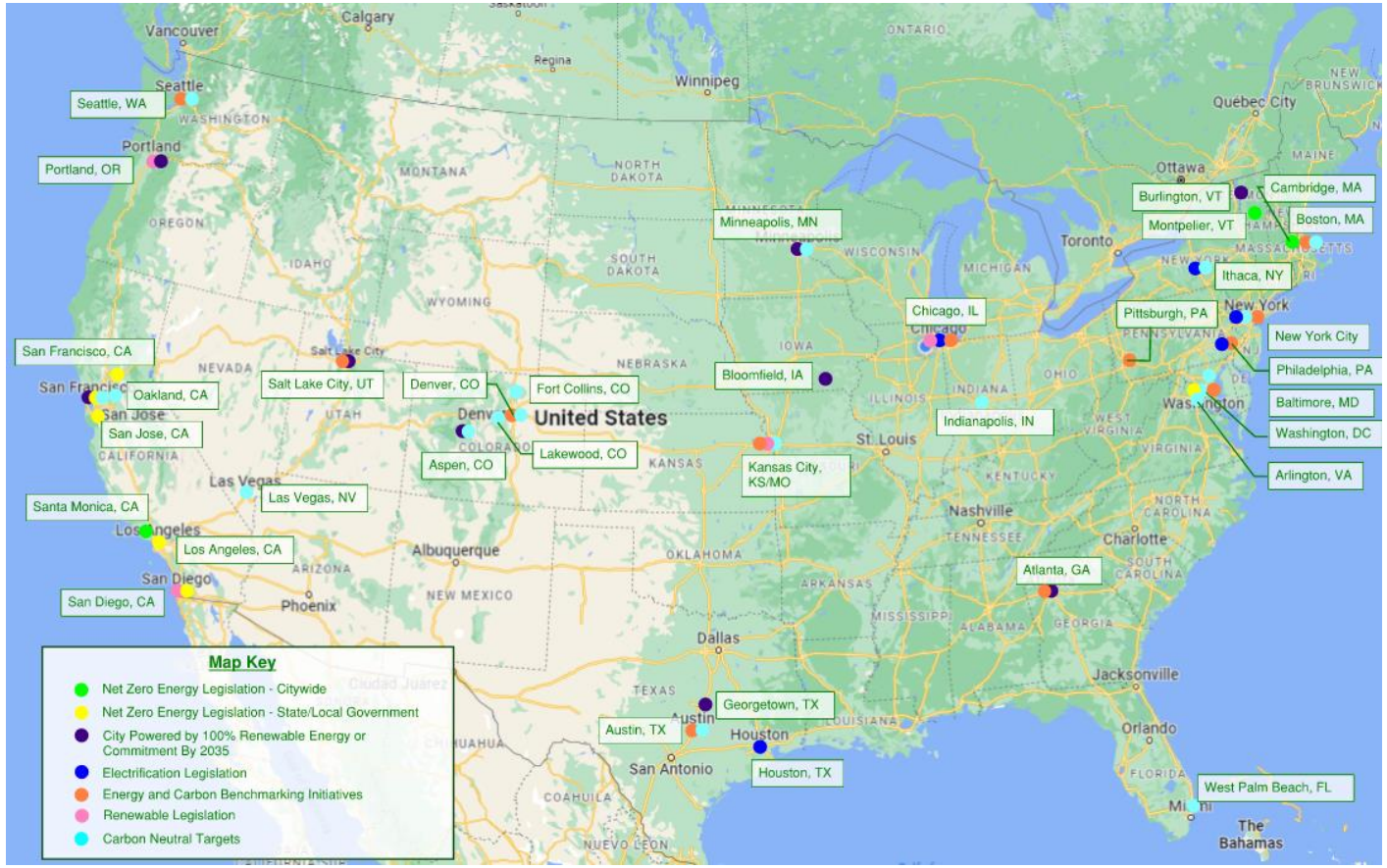
- Building Commissioning is required
  - Building Envelope
  - HVAC
  - Lighting, Daylighting, Lighting Control Systems
  - Domestic Hot Water Systems
  - Renewable Energy Systems

2017 DC Energy Conservation Code – Appendix Z

1) **Zero Energy Performance Index, zEPI shall be 30 or lower. (zEPI = 50.4 x (EUIp/EUI), EUIp is modeled EUI of proposed building, and EUI modeled EUI as per ASHRAE 90.1 2016 Appendix G baseline model)**
2) **Maximum annual heating demand of 4.2 kBtu/sqft/yr**
3) **Maximum annual cooling demand of 6.4 kBtu/sqft/yr**
4) **Commissioning of:**
    a. Building Envelope
    b. HVAC systems and controls, active and passive systems
    c. Lighting, daylighting, and lighting control systems
    d. Domestic Hot water systems
    e. Renewable Energy Systems
5) **Building shall be provided with renewable energy equal to the EUIp on an annual basis**
6) **Onsite combustion of fossil fuels shall not be permitted for the provision of thermal energy**
7) **Acceptable sources of on-site renewable energy**
    a. PV
    b. Solar Thermal
    c. PVT (Solar thermal and PV combo)
    d. Wind turbines
    e. Biogas
8) **Energy Metering, monitoring, and reporting is required.**

The average incremental cost for NZEB is about 10-15% more than minimum code compliant building. However, the average Life cycle cost is about 7-10% lower than minimum code compliant building. The case studies are for office buildings, over a 30-year period. The studies were conducted by NIST (National Institute of Standards and Technology) and the Rocky Mountain Institute.

2017 DC Energy Conservation Code – Appendix Z



13. RENEWABLE ENERGY

13.1 Prescriptive Renewable Path

13.1.1 *On-Site Renewable Energy Systems. Building projects* shall comply with either the Standard Renewables Approach in Section 13.1.1.1 or the Alternate Renewables Approach in Section 13.1.1.2 where any of the following conditions are met:

1. New construction of 10,000 sf (929 m^2) or greater, not including first time tenant fit-outs within a newly constructed core and shell building/space.
2. Additions of 10,000 sf (929 m^2) or greater.
3. *Alteration* area of 10,000 sf (929 m^2) or greater in Level 3 *alteration*.
4. Combined Level 3 *alteration* and addition area of 10,000 sf (929 m^2) or greater.

Exceptions: Buildings that demonstrate compliance with both of the following conditions are not required to contain *on-site renewable energy systems*:

1. An annual daily average incident solar radiation available to a flat plate collector oriented due south at an angle from horizontal equal to the latitude of the collector location less than 4.0 kWh/m^2·day (1.2 kBtu/ft^2/day), accounting for existing buildings, permanent infrastructure that is not part of the *building project*, topography, and trees.
2. A commitment to purchase renewable electricity products complying with the Green-e Energy National Standard for Renewable Electricity Products of at least 7 kWh/ft^2 (75 kWh/m^2) of *conditioned space* each year until the cumulative purchase totals 70 kWh/ft^2 (750 kWh/m^2) of *conditioned space*.

13.1.1.1 Standard Renewables Approach: Baseline *On-Site Renewable Energy Systems*. *Building projects* shall contain *on-site renewable energy systems* that provide the annual energy production equivalent of not less than 6.0 kBtu/ft^2 (20 kWh/m^2) multiplied by the *gross roof area* in ft^2 (m^2) for single-story buildings, and not less than 10.0 kBtu/ft^2 (32 kWh/m^2) multiplied by the *gross roof area* in ft^2 (m^2) for all other buildings. The annual energy production shall be the combined sum of all *on-site renewable energy systems*.

13.1.1.2 Alternate Renewables Approach: Reduced *On-Site Renewable Energy Systems* and Higher-Efficiency Equipment. *Building projects* complying with this approach shall comply with the applicable equipment efficiency requirements in Normative Appendix B of ASHRAE 189.1 (Prescriptive Equipment Efficiency Tables for the Alternate Reduced Renewables and Increased Equipment Efficiency Approach in Section 7.4.1.1.2), the water-heating efficiency requirements in Section 7.4.4.1 of ASHRAE 189.1, equipment efficiency requirements in Section 10.6 of ASHRAE 189.1, and the applicable ENERGY STAR® requirements in Section 10.11.2 of 189.1, and shall contain *on-site renewable energy systems* that provide the annual energy production equivalent of not less than 4.0 kBtu/ft^2 (13 kWh/m^2) multiplied by the *gross roof area* in ft^2 (m^2) for single-story buildings, and not less than 7.0 kBtu/ft^2 (22 kWh/m^2) multiplied by the *gross roof area* in ft^2 (m^2) for all other buildings. The annual energy production shall be the combined sum of all *on-site renewable energy systems*. For equipment listed in Section 10.11.2 of ASHRAE 189.1 that is also contained in Normative Appendix B of ASHRAE 189.1, the installed equipment shall comply by meeting or exceeding both requirements.

Exception: If *building project* includes less than 75% of build-out of net-occupiable floor area, then the project team cannot use Alternate Renewables Approach in Section 13.1.1.2, and shall use the Standard Renewables Approach in Section 13.1.1.1.

13.2 Adoption of ASHRAE 189.1 Normative Appendices

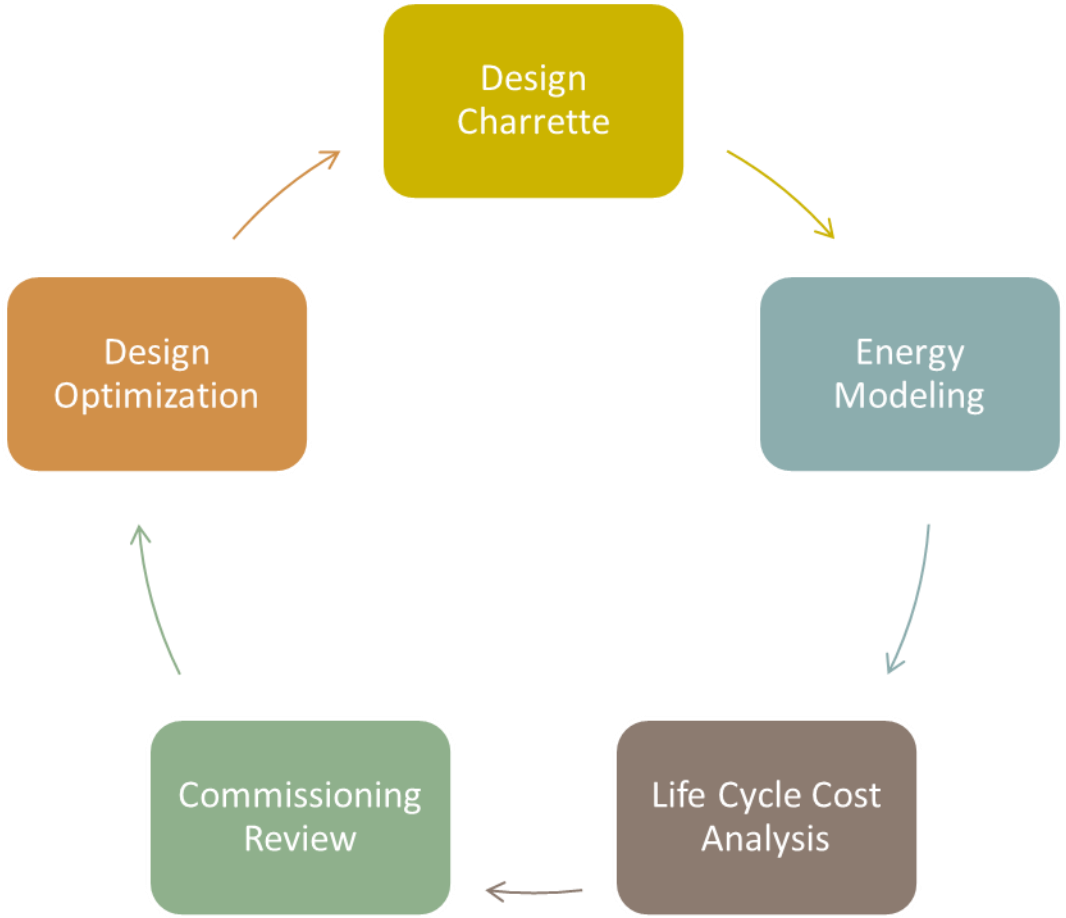
The following Normative Appendices of ANSI/ASHRAE/USGBC/IES Standard 189.1—2014, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*, are hereby adopted, in whole or in part, in the District of Columbia and incorporated by reference into the *Energy Conservation Code—Commercial Provisions* as provided below.

1. Normative Appendix B, *Prescriptive Equipment Efficiency Tables for the Alternate Reduced Renewables* and Increased Equipment Efficiency Approach in Section 7.4.1.1.2;
2. Normative Appendix A, Table A-2, Minimum Duct Installation R-Value Heating and Cooling-Only Supply Ducts and Return Ducts (I-P), and Table A-3, Minimum Duct Installation R-Value Combined Heating and Cooling Supply Ducts and Return Ducts (I-P).

NORMATIVE APPENDICES

Normative Appendix A in ASHRAE 90.1, *RATED R-VALUE OF INSULATION AND ASSEMBLY U-FACTOR, C-FACTOR, AND F-FACTOR DETERMINATIONS*, is adopted in the District of Columbia as Normative Appendix A in the *Energy Conservation Code—Commercial Provisions*.

- A Comprehensive High-Performance Building (HPB) Program assists Owners & Project Team in:
  - Establishing goals
  - Researching alternatives
  - Staying on track
  - Providing exceptional customer service
- The Components of an HPB Program:
  - High Performance Building Plan
  - Energy Modeling
  - Life Cycle Cost Analysis
  - Commissioning
  - Design Optimization



New Haven School Construction
High Performance Schools Design Requirements

Project Name
Schematic Design Initial Plan: 00/00/0000

3.0 BUILDING ENERGY USE: GOALS AND PROCESS

Goals	Corresponding LEED Credit & Description	N/A	Comply: Pre SD	SD	DD	Final	No	Poss. Pts	Strategy	Initial Performance Plan Conceptual Design Project Approach	Action By	% Comp	Due Date	Comments
TOTALS		0	0	0	0	0	0	52						
3.1 Energy Goals														
3.1.1 Design to Energy Star Targets & Max. Energy Performance	EA Pre. 2: Minimum Energy Performance							1	**A. Earn a numerical score above 75** when measured against the Energy Star Target Finder system for electric power & fossil fuels.					
								1	1. Above 80					
								1	2. Above 90					
								1	**B. Architect and Engineer of Record are Energy Star Partners.**					
								1	1. Apply for Designed for Energy Star Award @ 100% CD.					
	EA 01: Optimize Energy Performance							1	**C. Design to exceed the minimum building energy efficiency** and performance required by ASHRAE/IESNA 90.1-2001					
								1	1. Project kBtu/SF/Year Goal is established as:					
3.1.2 Achieve Optimized Energy Performance								1	**A. Reduce design energy cost** of regulated components in accordance with the requirements of Energy Cost Budget Method, described in Section 11 of the Standard.					
	EA 01: Optimize Energy Performance								**B. Design the building envelope and systems with:**					
								1	1. Computer simulation model					
								1	2. Cost effective energy measures					
								1	3. Energy performance compared to the baseline building					
3.1.3 Utilize renewable energy systems	EA 02: Renewable Energy							1	**A. Supply a min. of 2.5% on-site renewable energy of the building's total energy.**					
								1	1. 7.5%					
								1	2. 12.5%					
								1	3. Self-supply or net metering					
									B. Assess the project for renewable energy potential					
								1	1. Solar PV/DHW					
								1	2. Wind					
								1	3. Geothermal					
								1	4. Low-impact hydro					
								1	5. Biomass					
								1	6. Bio-gas					
3.1.4 Purchase Green Power	EA 06: Green Power								**A. Utilize Green Power**					
								1	1. Renewable energy technologies					
								1	2. Net zero pollution					
	EA 01: Optimize Energy Performance							1	**B. Consider the potential for use of combined heat and power systems** (cogeneration)					
								1	1. Micro-turbines					
								1	2. Other innovative technologies					
3.1.5 Rebates									**A. Apply for rebates for energy savings**					
								1	1. UI					
								1	2. CT Clean Energy Fund					
								1	3. Other					
Subtotal 3.1		0	0	0	0	0	0	29						

LEED v4 for New Construction and Major Renovations — **317 K Street**
Preliminary — **100% Design Development Documents**

Y	?	N	d/c	Credit	Title	Points	Responsible	Notes
45	6	65			**Total** — Possible Points:	110		
					Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110			**Notes**
0		1	d	Credit 1	Integrative Process	1	Civil	Preliminary Energy Modeling, Integrated Design charrettes
11	0	5			**Location and Transportation** — Possible Points:	16		
Y	?	N	d/c					Notes:
			c	Credit 0	LEED for Neighborhood Development Location	16	Civil/GC	
		1	d	Credit 1	Sensitve Land Protection	1	Civil	Locate the development on land that has been previously developed
		2	d	Credit 2	High Priority Site	2	Owner	Locate the project on an infill location in a historic district, Brownfield remediation site
3		2	d	Credit 3	Surrounding Density and Diverse Uses	5	Owner	Site whose surrounding existing density within 1/4 mile radius, 12 DU/acre for 35,000 of buildable land(res), 0.8 FAR for non res
5		0	d	Credit 4	Access to Quality Transit	5	Civil	Locate any functional entry of project within 1/4 mile walking distance of existing or planned bus, streetcar or rideshare stops. Or within 1/2 mile of existing or planned bus rapid transit, light rail or heavy rail, 360 weekday trips, 216 weekend trips
1		0	d	Credit 5	Bicycle Facilities	1	Arch	Locate the project such that a functional entry or bicycle storage is within 200 yards walking density from bicycle network, provide short term bicycle storage for at least 2.5% of all peak visitors, long term storage for 5% of all regular building occupants
1		0	d	Credit 6	Reduced Parking Footprint	1	Arch	20% reduction from local minimum local code requirements for parking capacity
1		0	d	Credit 7	Green Vehicles	1	Civil	Install EV stations in 2% of all parking spaces used by the project
3	0	7			**Sustainable Sites** — Possible Points:	10		
Y	?	N	d/c					Notes:
Y			c	Prereq 1	Construction Activity Pollution Prevention		Civil/GC	ESC Plan required by GC (Prevention of soil loss, sedimentation, pollution of air with dust and particulate). Describe actions to effectively implement ESC. Licensed Professional Exemption to Registered Civil in lieu of ESC
		1	d	Credit 1	Site Assessment	1	Civil	Site survey to include topography, hydrology, climate, vegetation, soils, Human use, Human health
		2	d	Credit 2	Site Development-Protect or Restore Habitat	2	Owner	Preserve and protect from all development and construction activity 40% of the greenfield area on the site
1		0	d	Credit 3	Open Space	1	Owner	Provide outdoor space greater than or equal to 30% of the total site area including building footprint. A minimum of 25% of outdoor space has to be vegetated
		3	d	Credit 4	Rainwater Management	3	Civil	manage on site the run off from the developed site for the 95th percentile of regional or local rainfall events using low impact development
2		0	d	Credit 5	Heat Island Reduction	2	Arch	Use high reflective roof greter than 82 SRI, 3 year aged SRI of 64, or install a vegetated roof
		1	d	Credit 6	Light Pollution Reduction	1	Arch	Meet uplight and light trespass requirements using either the Backlight Uplight glare method or the calculation method
5	0	6			**Water Efficiency** — Possible Points:	11		
Y	?	N						Notes:
Y			d	Prereq 1	Outdoor Water Use Reduction—30% Reduction		MEP	No irrigation or reduce the projects landscape water requirement by at least 30% from the calculated baseline for the sites peak watering month
Y			d	Prereq 2	Indoor Water Use Reduction—20% Reduction		MEP	Reduce aggregate water consumption by 20% from the baseline
Y			d	Prereq 3	Building Level Water Metering		MEP	Install permanent water meters
2		0	d	Credit 1	Outdoor Water Use Reduction	2	Landsc	Demonstrate that landscape does not require a permanent irrigation system beyond a max. 2 year establishment period
3		3	d	Credit 2	Indoor Water Use Reduction	6	na	35% water use reduction
		2	d	Credit 3	Cooling Tower Water Use	2	na	
		1	d	Credit 3	Water Metering	1	MEP	
14	0	19			**Energy and Atmosphere** — Possible Points:	33		
Y	?	N						Notes:
Y			c	Prereq 1	Fundamental Commissioning and Verification		CxA	OPR & BOD; CxA Plan completed (Owner/Arch/MEP/CxA). Name of CxA, info for 2 similar projects, CX plan, functional checklist
Y			d	Prereq 2	Minimum Energy Performance		MEP	Targeting 24% Energy Cost Savings
Y			d	Prereq 3	Building Level Energy Metering		MEP	Install new meters or sub meters
Y			d	Prereq 4	Fundamental Refrigerant Management		MEP	Do not use CFC based refrigerants
3		3	d	Credit 1	Enhanced Commissioning	6	MEP	Enhanced Cx for all MEP systems
10		8	d	Credit 2	Optimize Energy Performance	18	na	Targeting 24% Energy Cost Savings
		1	c	Credit 3	Advanced Energy Metering	1	CxA	
		2	d	Credit 4	Demand Response	2	MEP	
		3	c	Credit 5	Renewable Energy Production	3	MEP	
1			c	Credit 6	Enhanced Refrigerant Management	1	Owner	Low Impact Refrigerants, low ODP
		2	c	Credit 7	Green Power and Carbon Offsets	2	Owner	
2	0	11			**Materials and Resources** — Possible Points:	13		
Y	?	N						Notes:
Y			d	Prereq 1	Storage and Collection of Recyclables		Arch	Need narrative describing size of storage area, accessibility, expected volume, collection frequency. Floor plans showing recycling storage areas
Y			d	Prereq 2	Construction and Demolition Waste Management Planning		Arch	
		5	c	Credit 1	Building Life Cycle Impact Reduction	5	Arch	
		2	c	Credit 2	Building Product Disclosure and Optimization - Environmental Product	2	Arch	
		2	c	Credit 3	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2	GC	
		2	c	Credit 4	Building Product Disclosure and Optimization - Material Ingredients	2	Arch	
2		0	c	Credit 5	Construction and Demolition Waste Management	2	GC	Divert 75% and 4 material streams
9	1	7			**Indoor Environmental Quality** — Possible Points:	16		
Y			d	Prereq 1	Minimum Indoor Air Quality Performance		MEP	62MZ Calculator uploads
Y			d	Prereq 2	Environmental Tobacco Smoke (ETS) Control		Owner	No Smoking Building, Need drawing with no smoking signage details or photos. No smoking at least 25' from all entries
2		0	d	Credit 1	Enhanced Indoor Air Quality Strategies	2	MEP	Will need permanent mats at primary entrances. Roll out mats acceptable but have to be maintained on weekly basis. Upload mechanical drawings showing MERV 13 filters, and increased ventilation by 30%
3		0	d	Credit 2	Low-Emitting Materials	3	MEP	Included in spec. Need Product manufacturer, product name/model, VOC content, source of VOC data
1		0	c	Credit 3	Construction Indoor Air Quality Management Plan	1	GC	IAQ plan required for upload, narrative describing how absorptive materials are protected from moisture damage during construction
		2	c	Credit 4	Indoor Air Quality Assessment	2	GC	
1		0	c	Credit 5	Thermal Comfort	1	GC	ASHRAE 55 2010
2		0	c	Credit 6	Interior Lighting	2	GC	Lighting controls for atleast 90% of occupants, adhere to lighting quality criteria, CRI 80, L70 of atleast 24,000 hrs, direct overhead lighting for 25% of spaces
		3	c	Credit 7	Daylight	3	GC	
	1	1	c	Credit 8	Quality Views	1	GC	Line of sight to ourdoors via vision glazing for 75% of all regularly occupied floor area
		1	d	Credit 9	Acoustic Performance	1	Arc/M	
1	5	5			**Innovation and Design Process** — Possible Points:	6		
	1	1	d/c	Credit 11	Innovation in Design: Green Education	1	Owner	Public Education program in 2 forms; active & passive
	1	1	d/c	Credit 12	Innovation in Design: Low-emitting wall, ceiling and Insulation	1		
	1	1	d/c	Credit 13	Innovation in Design: Purchase 100% Green Power	1	Owner	
	1	1	d/c	Credit 14	Innovation in Design: Exemplary Performance	1	Owner	Maximize open space credit SSc 5.2, greater than 40% of open space is vegetated
	1	1	d/c	Credit 15	Innovation in Design: Reduced Mercury Lighting	1	Owner	
1			d/c	Credit 2	LEED Accredited Professional	1		Architect
0	0	4			**Regional Priority Credits** — Possible Points:	4		
		1	d/c	Credit 11	Regional Priority: MRc2 Construction Waste Management	1		
		1	d/c	Credit 12	Regional Priority: Specific Credit	1		
		1	d/c	Credit 13	Regional Priority: Specific Credit	1		
		1	d/c	Credit 14	Regional Priority: Specific Credit	1		

Green Rating Systems Admin and Energy Master Plans

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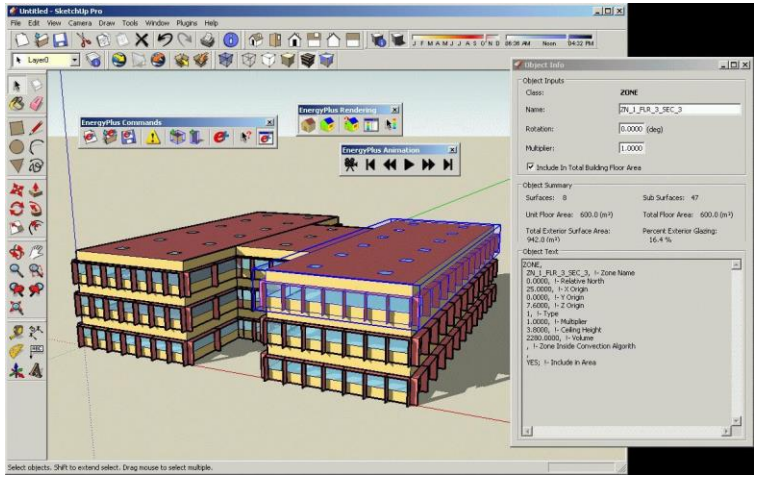
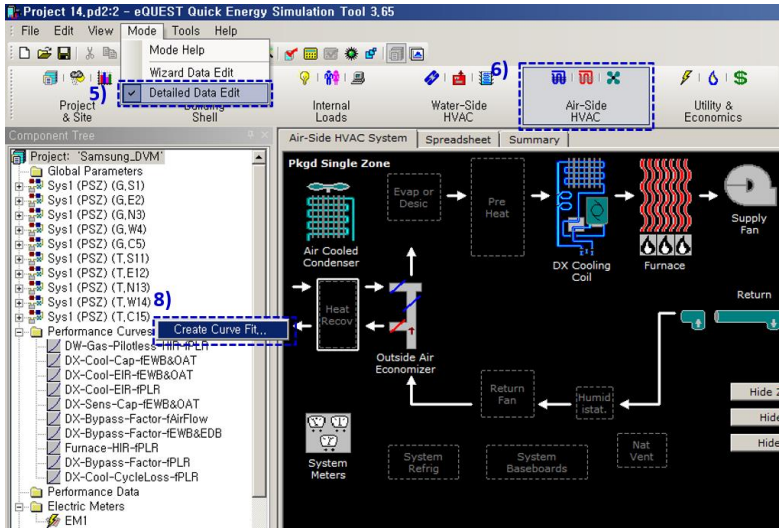
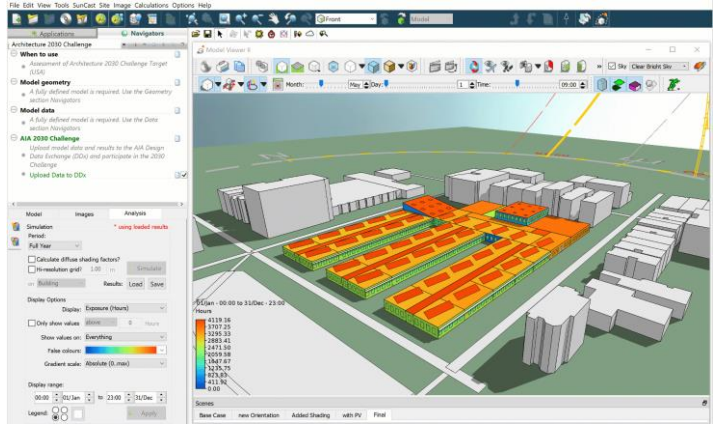
- In 2018, the residential and commercial sectors accounted for about 40% (or about 40 quadrillion British thermal units) of total U.S. energy consumption [EIA, May 2019]
- Opportunity exists for project teams to utilize energy modeling software to help evaluate design decisions in terms of life-cycle cost impacts in order to maximize building performance
- Building energy performance is a function of numerous, interdependent internal and external factors, such as material selection, mechanical and electrical systems, solar orientation, climate, and occupant usage
- Modification of various design components can produce complex interactions that are difficult to analyze in isolation
- Building energy simulation softwares provide tools for evaluating energy impacts across dynamic interrelated systems

Why Do we need Energy Modeling

- Determines utility cost and consumption
- Compares the effect of an ECM on the utility consumption (ergo, costs
- Suggest ECMs
- Simulate building operations with various ECMs
- Program to simulate annual Energy consumption, also used to perform Heating and Cooling load calculations
- Calibrated Energy Model
- Life Cycle Cost Analysis
- Software Platforms
  - TRACE 3D
  - HAP
  - IESVE
  - eQUEST
  - EnergyPlus
  - OpenStudio with EnergyPlus







Energy Modeling

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- These are the overall steps followed to create an energy model

Step 1

- Collects data at the site enough to fully define the building and energy consuming features
  - Inputs that are unknown should be highlighted and used as calibration parameters
  - List of data required to build an energy model
    - Drawings, as-built
    - Utility bills
    - Equipment schedules
    - Lighting drawings
    - Square footage
    - Occupancy (24/7, intermittent, conference rooms, etc.)
    - Schedule – mechanical and occupancy
    - Building function, purpose, usage

Step 2

- Fills out the model and run the simulation
  - Copies the monthly output tables to an excel spreadsheet and calibrates the model to within 5-10% of the monthly/annual utility bills

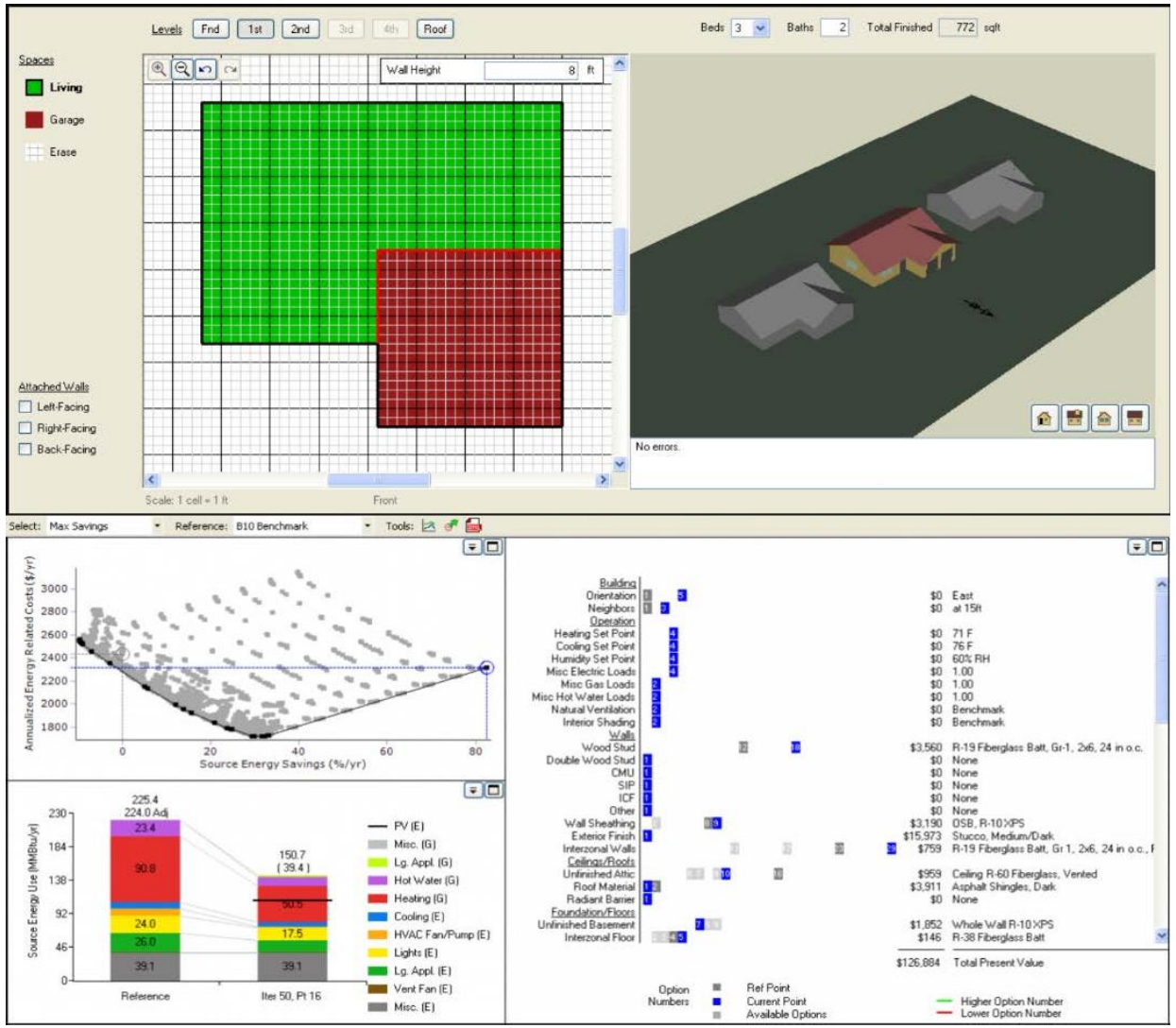
Step 3

- Uses the model to run various “what if” scenarios to calculate energy savings associated with identified energy conservation measures

Modeling Inputs For Existing Buildings

The BEopt™ (Building Energy Optimization Tool) software provides capabilities to evaluate residential building designs and identify cost-optimal efficiency packages at various levels of whole-house energy savings along the path to zero net energy

BEopt ™ provides detailed simulation-based analysis based on specific house characteristics, such as size, architecture, occupancy, vintage, location, and utility rates. Discrete envelope and equipment options, reflecting realistic construction materials and practices, are evaluated



Building Energy Modeling Tools
Beopt (Residential)

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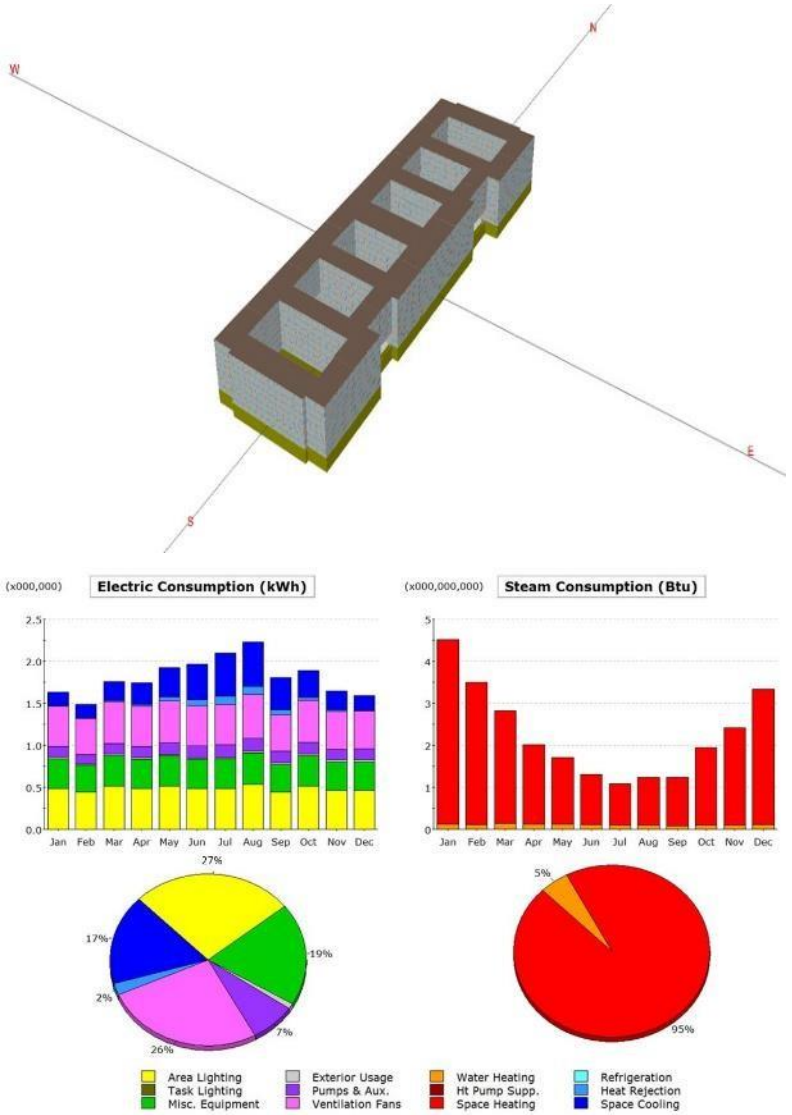
- The Quick Energy Simulation Tool, or eQUEST is a DOE-2 interface which allows users to develop 3-dimensional simulation models of a particular building design

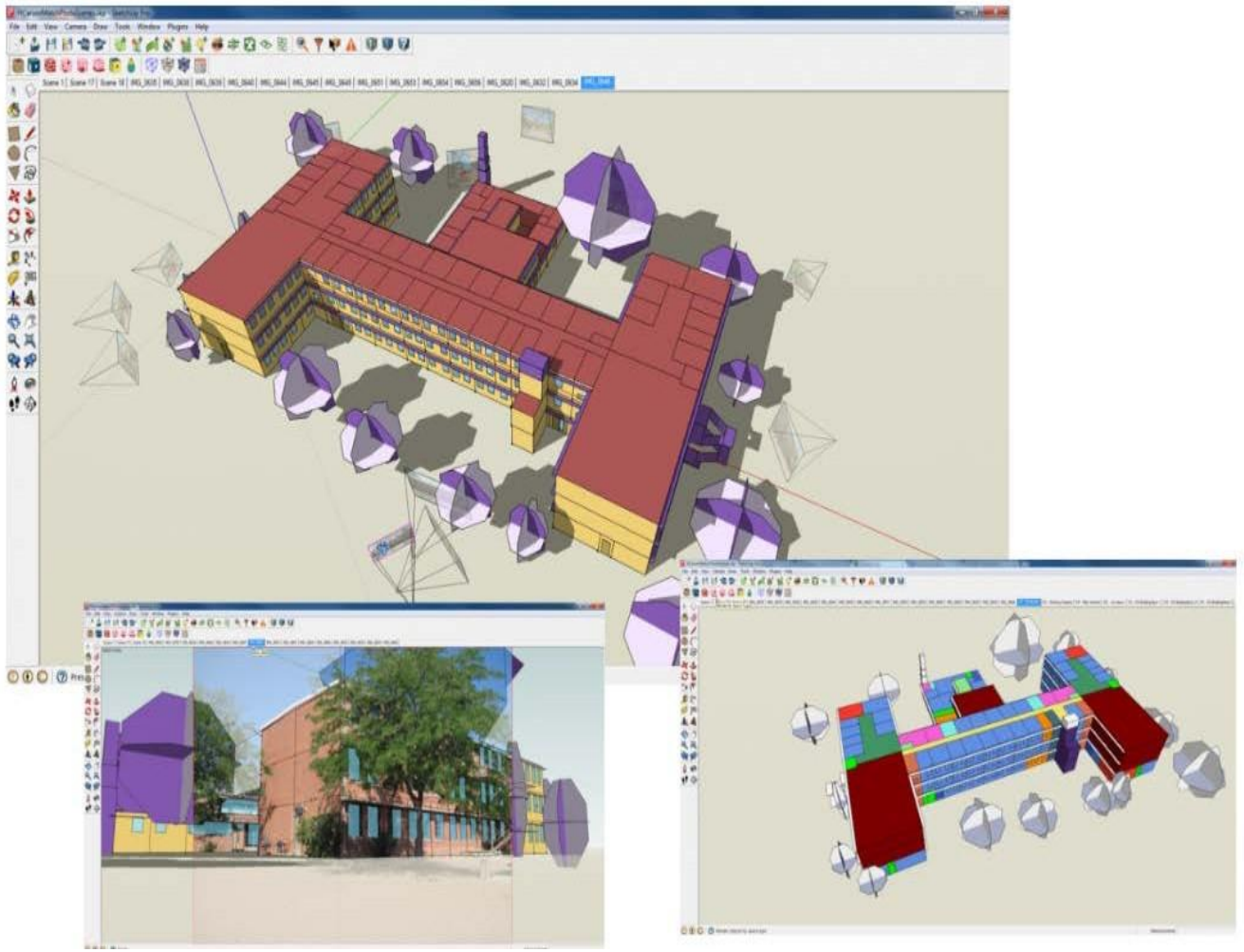
- These simulations incorporate building location, orientation, wall/roof construction, window properties, as well as HVAC systems, day-lighting and various control strategies, along with the ability to evaluate design options for any single or combination of energy conservation measure(s)



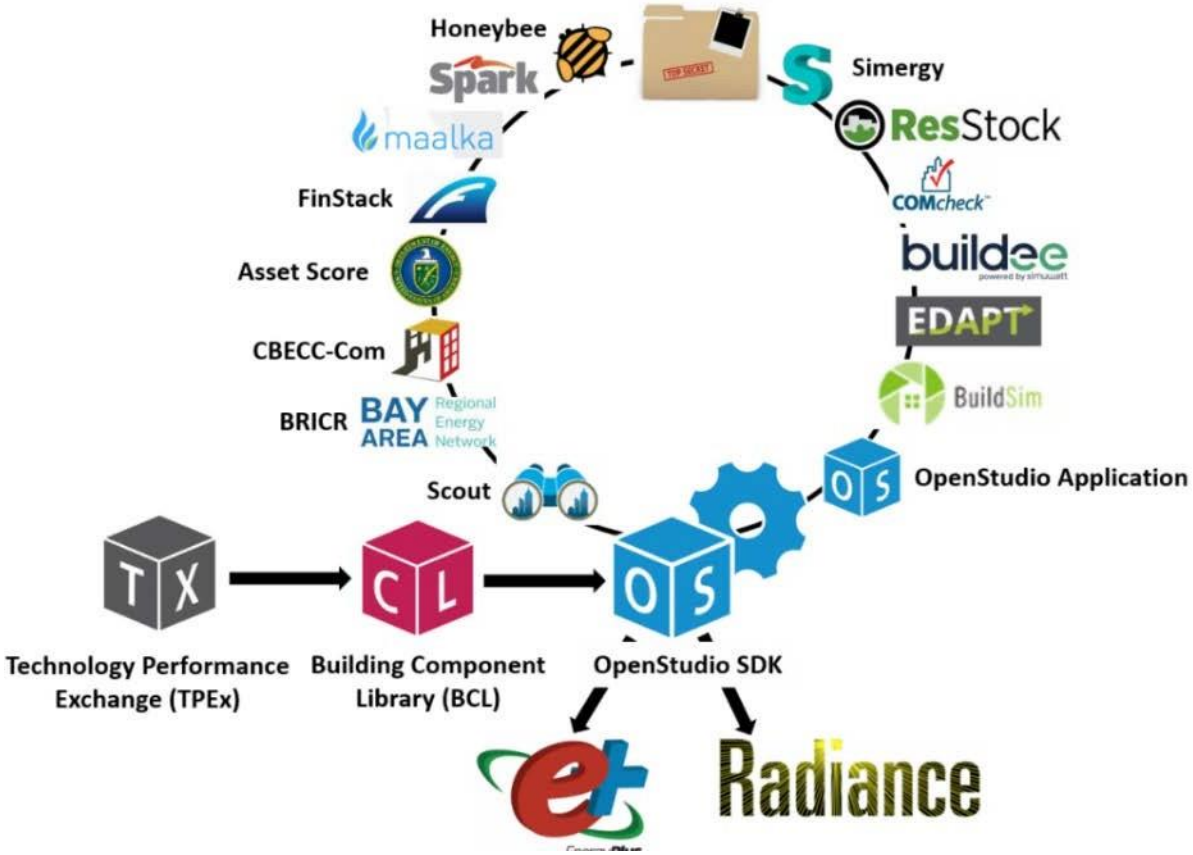
Building Energy Modeling Tools
eQuest (Commercial)

Allen + Shariff
MEP Engineering | Project Management

- OpenStudio® is a cross-platform (Windows, Mac, and Linux) collection of software tools to support whole building energy modeling using EnergyPlus and advanced daylight analysis using Radiance
- OpenStudio is the front-end of the EnergyPlus
- EnergyPlus is an energy analysis and thermal load simulation program
- EnergyPlus is not a user interface. It is intended to be the simulation engine around which a third-party interface can be wrapped



Building Energy Modeling Tools
OpenStudio (Commercial)



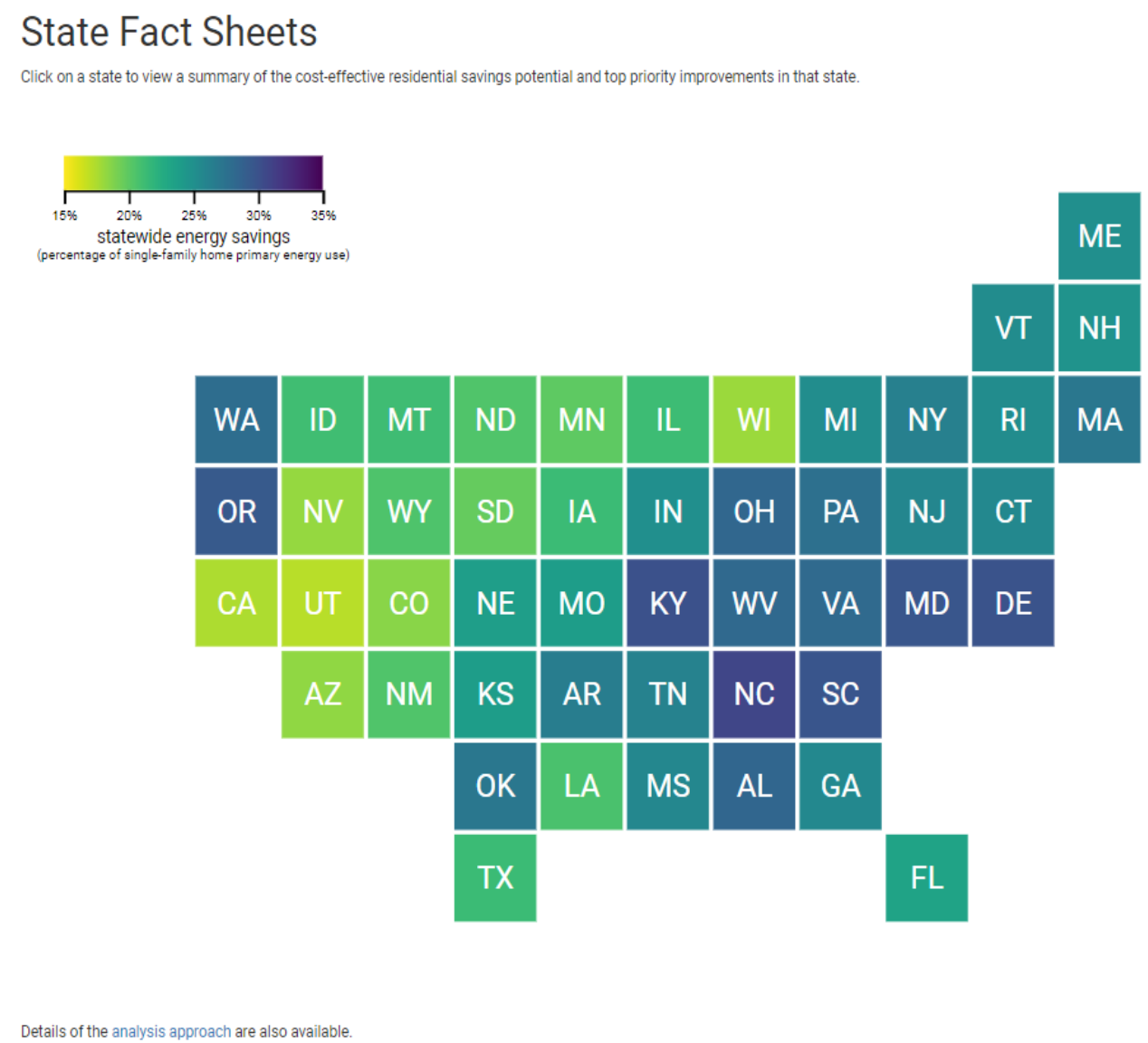
- EnergyPlus directly supports several public and private sector tools and services. It supports additional applications and services via the OpenStudio Platform

Building Energy Modeling Tools
OpenStudio and EnergyPlus Adoption

Allen + Shariff
MEP Engineering | Project Management

- The ResStock analysis tool is helping states, municipalities, utilities, and manufacturers identify which home improvements save the most energy and money

- The ResStock software is offered at no cost, leveraging the U.S. Department of Energy's (DOE's) open-source building energy modeling ecosystem of OpenStudio® and EnergyPlus™.



Building Energy Modeling Tools
ResStock (Residential)

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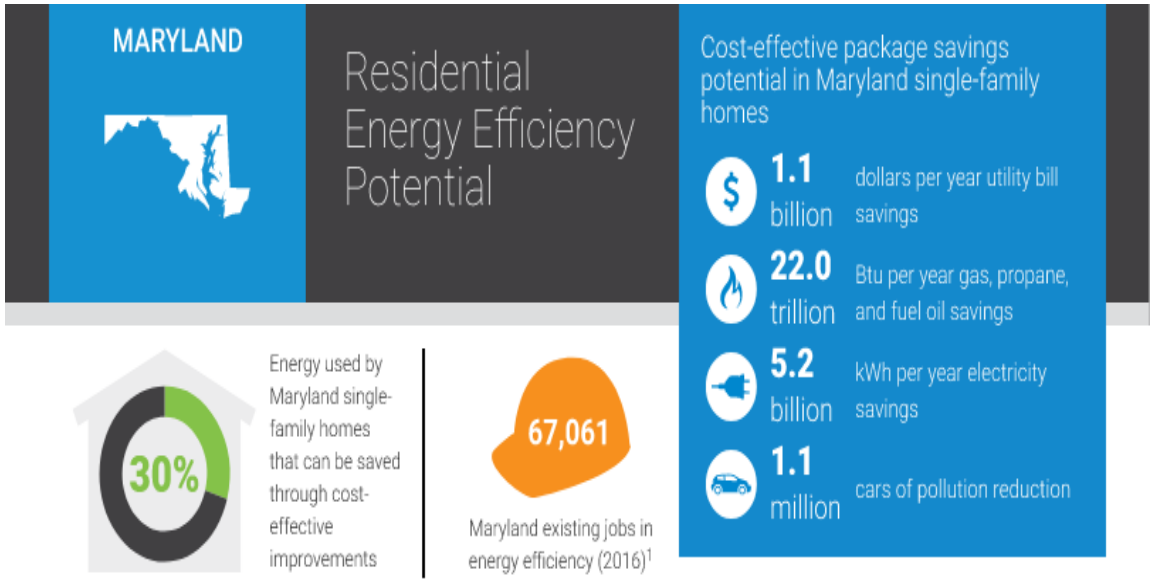

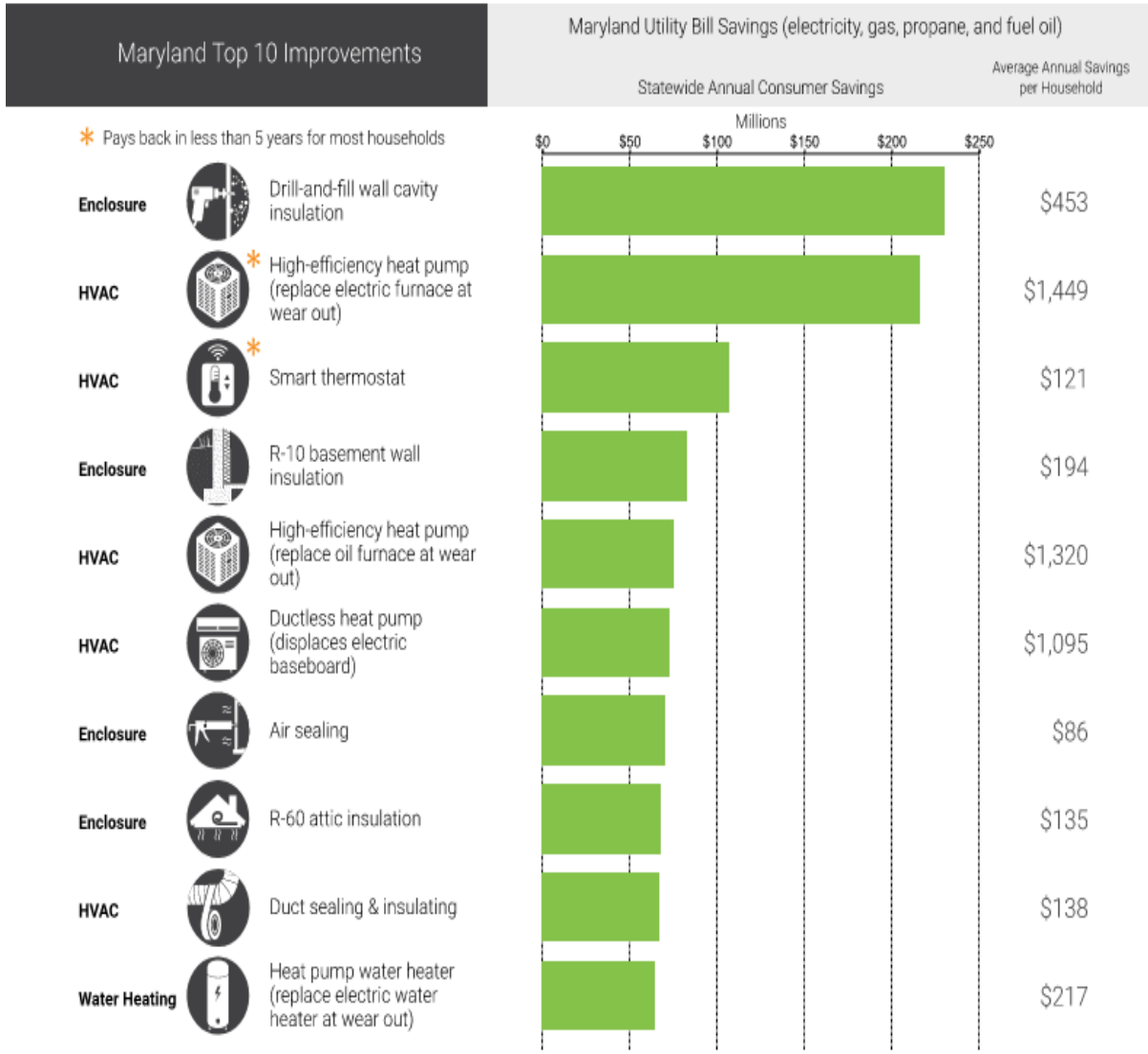

Building Energy Modeling Tools
ResStock (Residential)

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MEP Engineering | Project Management

Models renewable energy technologies and energy efficiency

- Energy efficiency
- Renewable energy:
  - Wind power
  - Geothermal power
  - Solar PV
  - Solar thermal
  - Ocean
  - Tidal
  - Wave
- Other technologies:
  - Fuel cells
  - Micro-turbines

Also models conventional combustion technologies

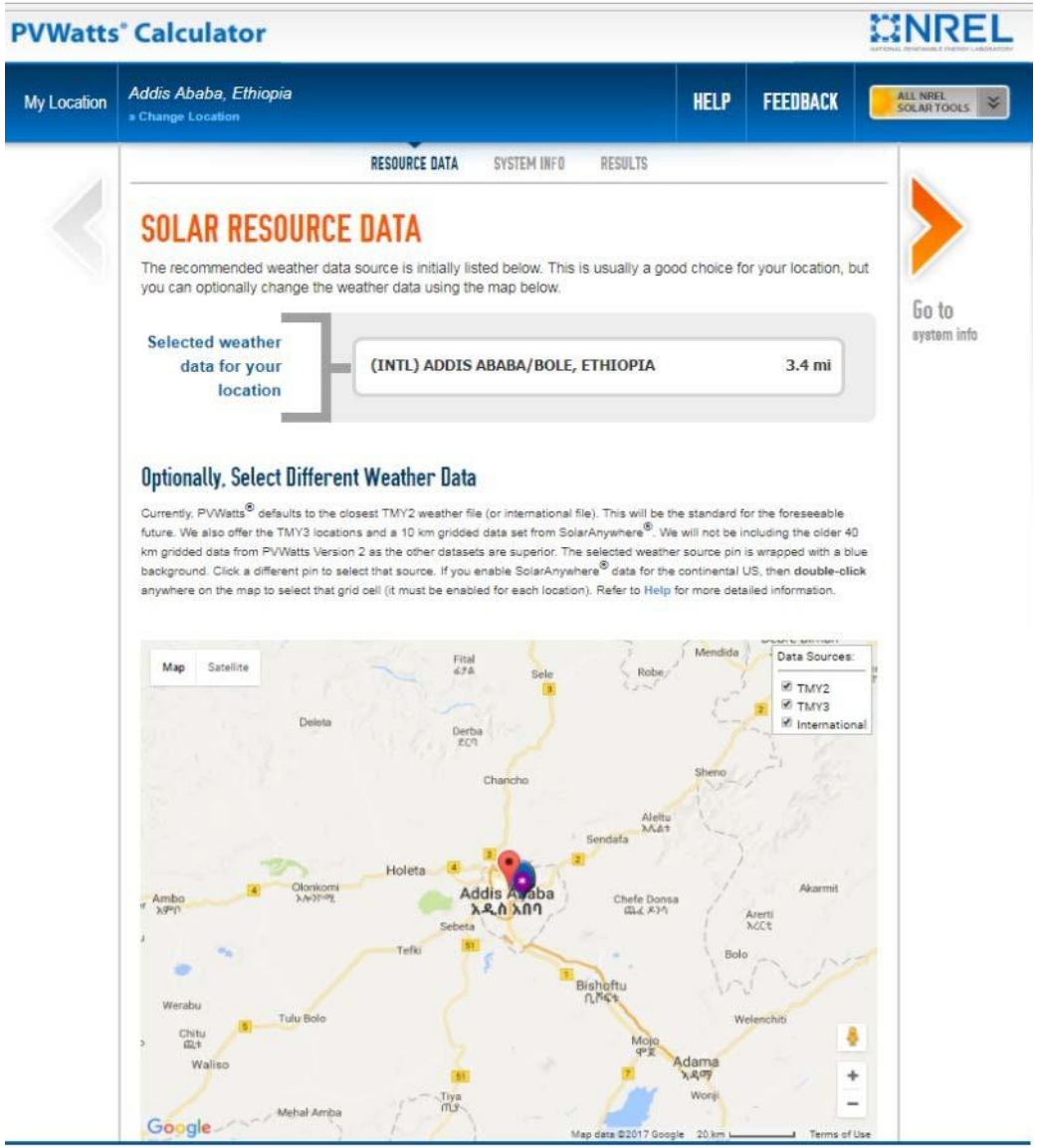
- Steam turbine
- Gas turbine
- Gas turbine – combined cycle
- Reciprocating engine

Building Energy Modeling Tools
RETScreen (renewable Energy Modeling)

Allen + Shariff
MEP Engineering | Project Management

- Estimates the energy production and cost of energy of grid-connected photovoltaic (PV) energy systems throughout the world

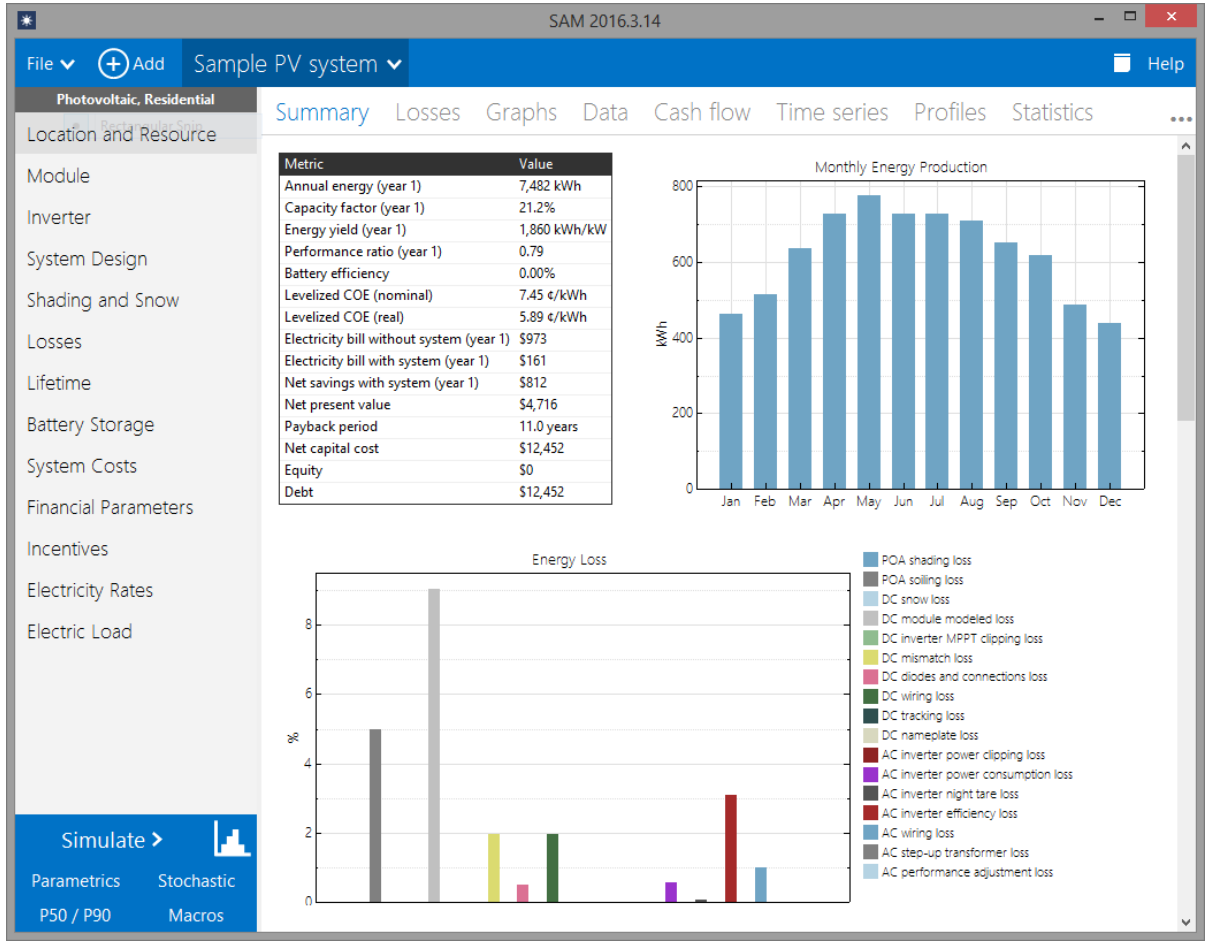
- It allows homeowners, small building owners, installers and manufacturers to easily develop estimates of the performance of potential PV installations



Related Non-Building Energy Modeling Tools-PVWatts Solar PV Modeling Tool

Allen + Shariff
MEP Engineering | Project Management

Free software that combines detailed performance and financial models to estimate the cost of energy for systems



Technologies

- Photovoltaics, detailed & PVWatts
- Battery storage
- Concentrating solar power
- Wind
- Geothermal
- Biomass
- Solar water heating

Financials

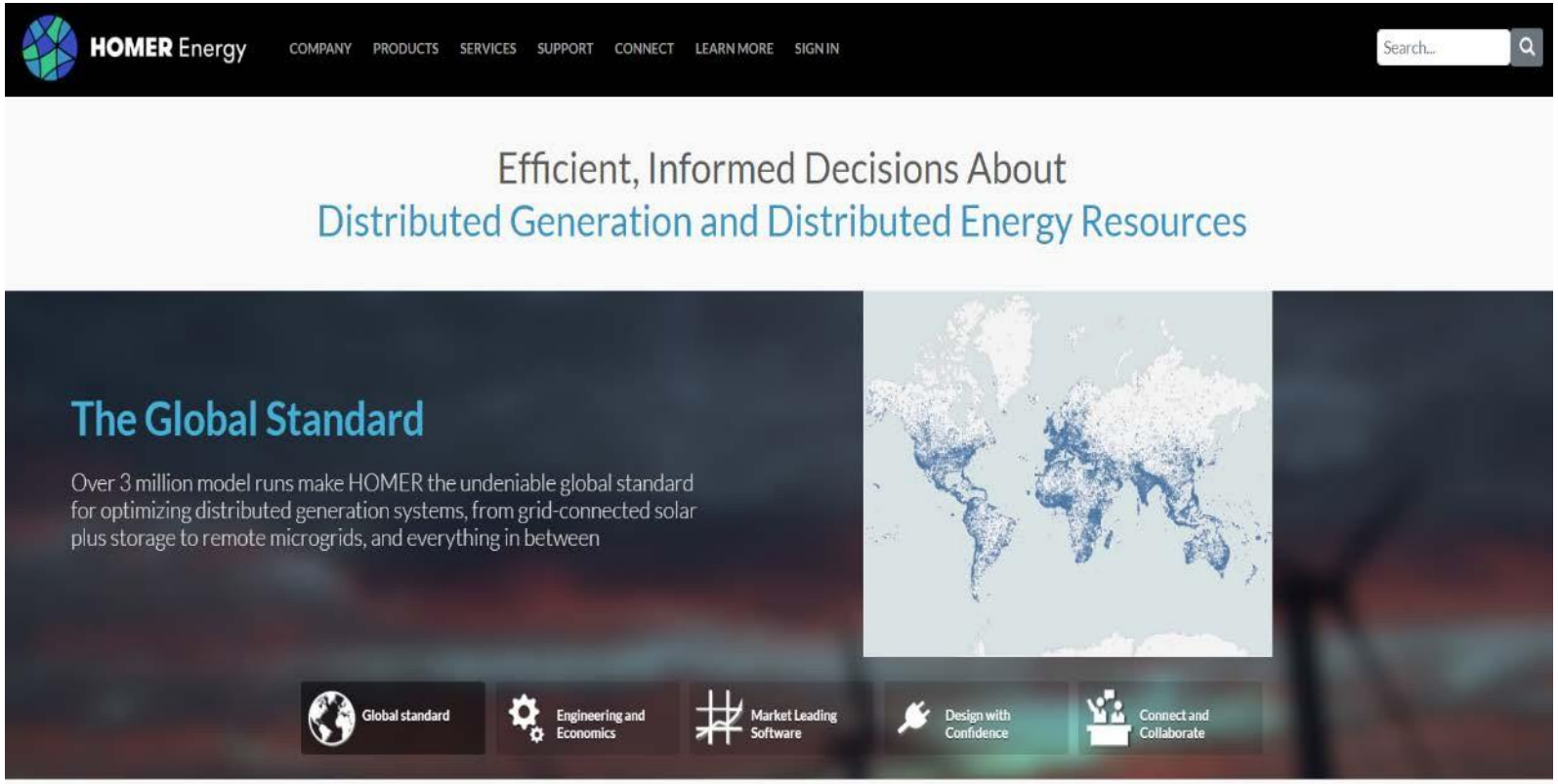
- Behind-the-meter
- residential
- commercial
- Power purchase agreements
- single owner
- equity flips
- sale-leaseback
- Simple LCOE calculator

Related Non-Building Energy Modeling System Advisor Model for Renewable Energy

Allen + Shariff
MEP Engineering | Project Management

- HOMER (Hybrid Optimization Model for Multiple Energy Resources) is used to model and optimize conventional electrical generation microgrids with a high penetration of renewable energy

- Free and pay versions available



Related Non-Building Energy Modeling
Homer Energy Microgrid Modeling

Allen + Shariff
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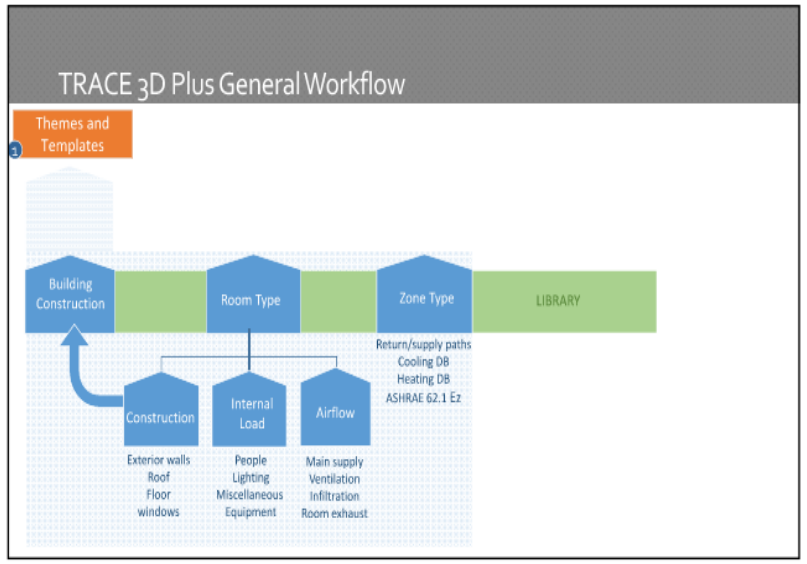
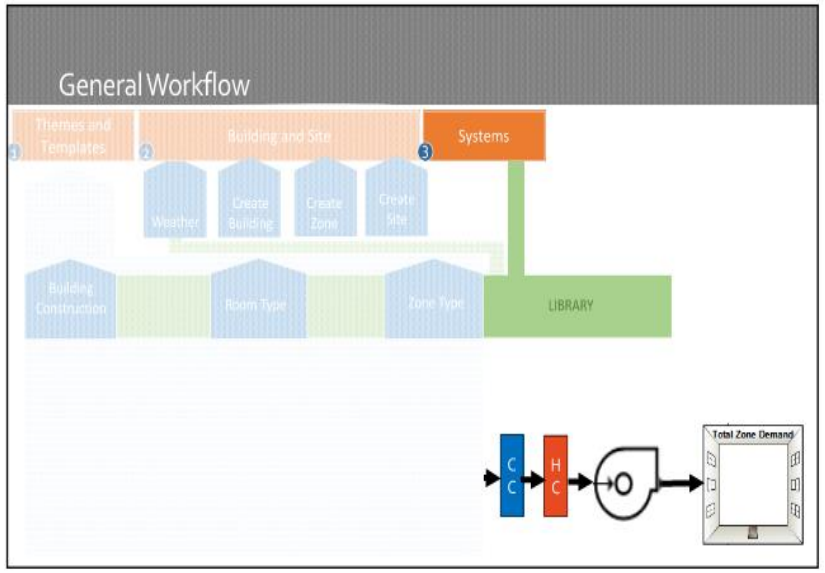
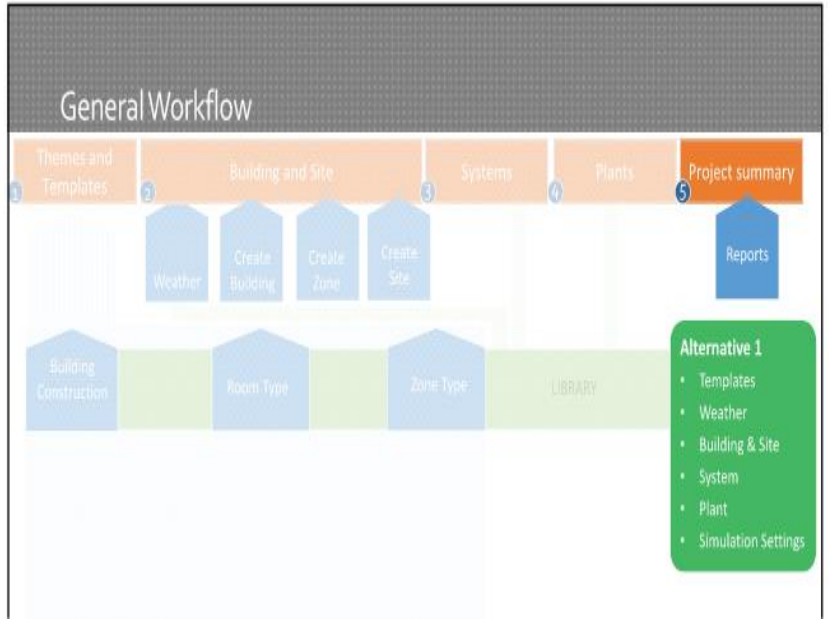
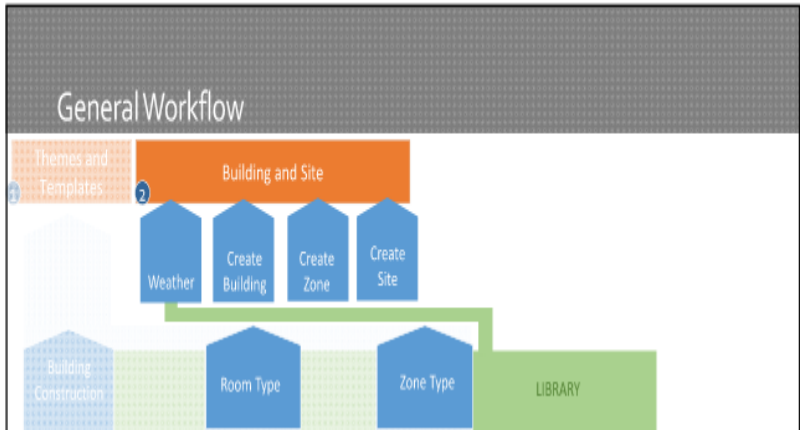
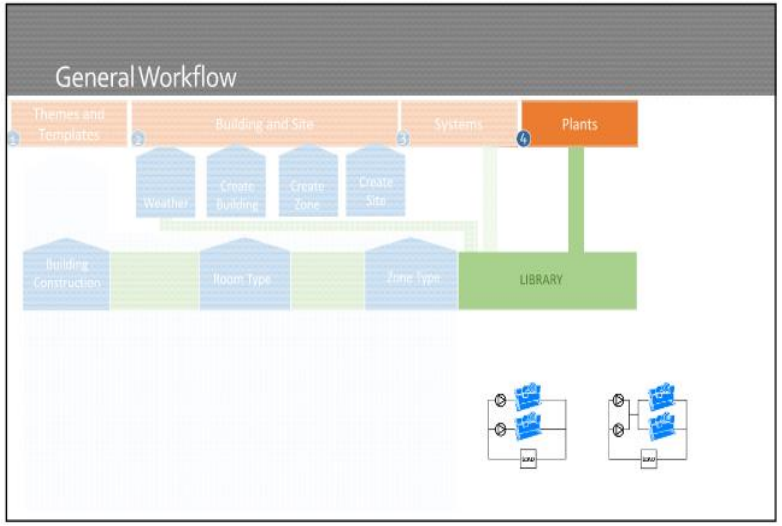




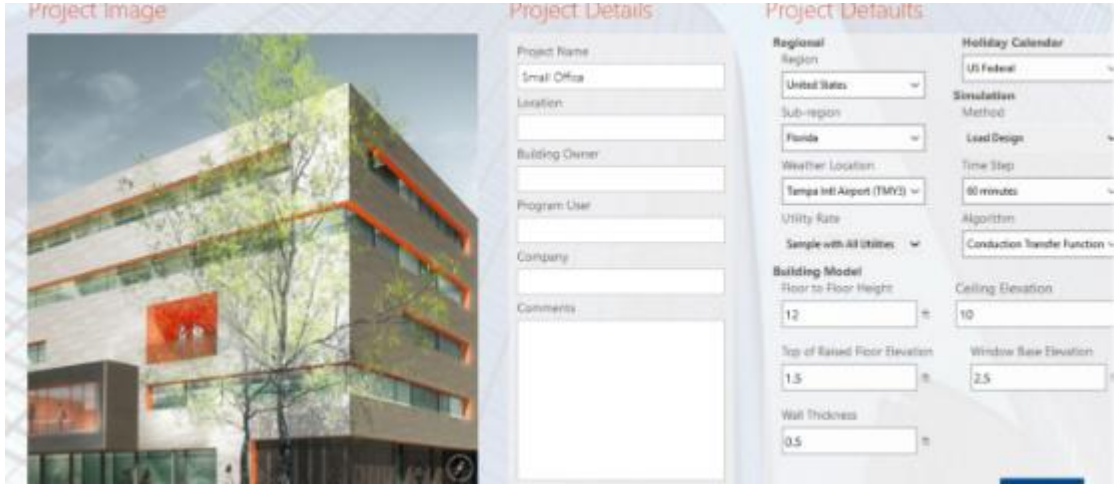


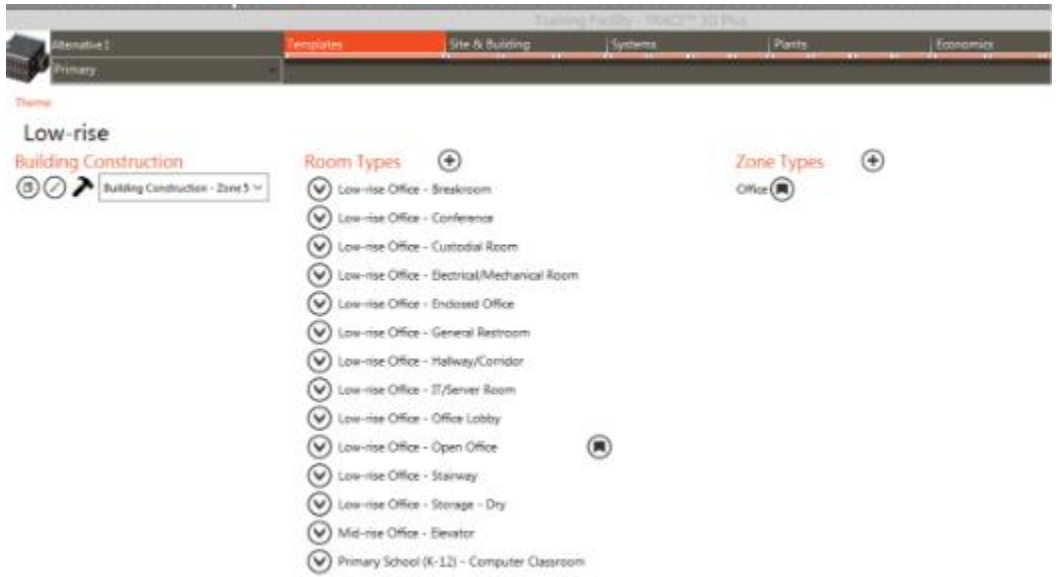




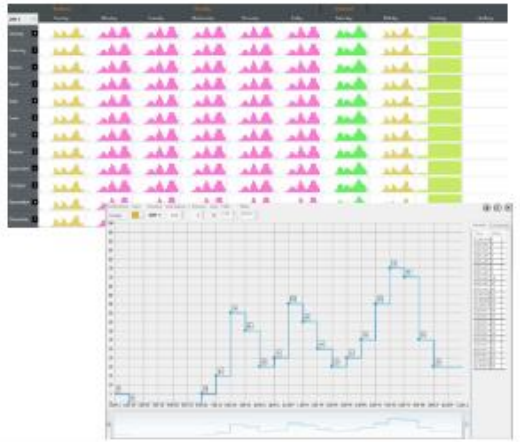
TRACE 3D Plus Energy Modeling
General Workflow

Allen + Shariff
MEP Engineering | Project Management





- Operating schedules are defined in the Library
  - Utilization (people, lights, etc.)
  - Utility Rates (time of day)
  - Equipment Availability
  - Setpoint control for water and air
    - Outside Air Reset
  - Space Temperature Setpoint



TRACE 3D Plus Energy Modeling
Creating a Project

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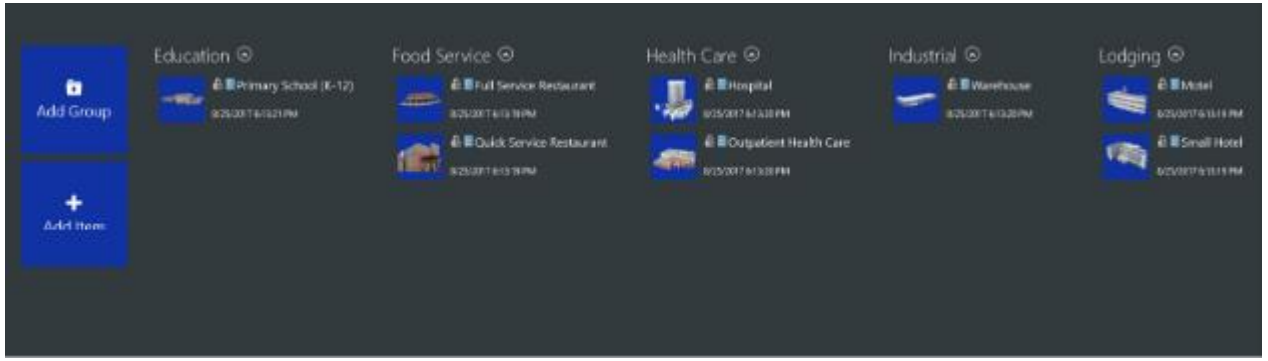
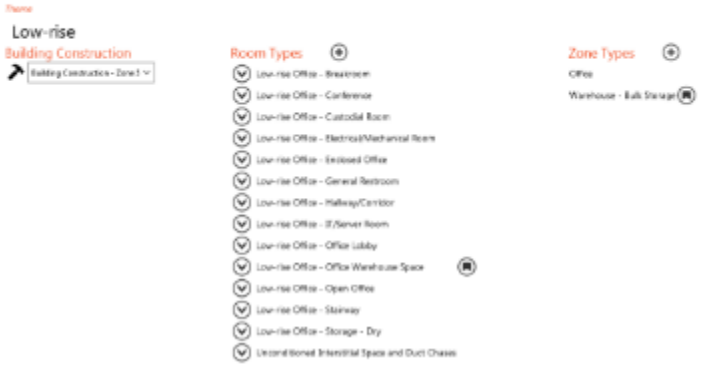
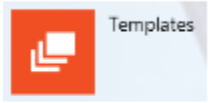
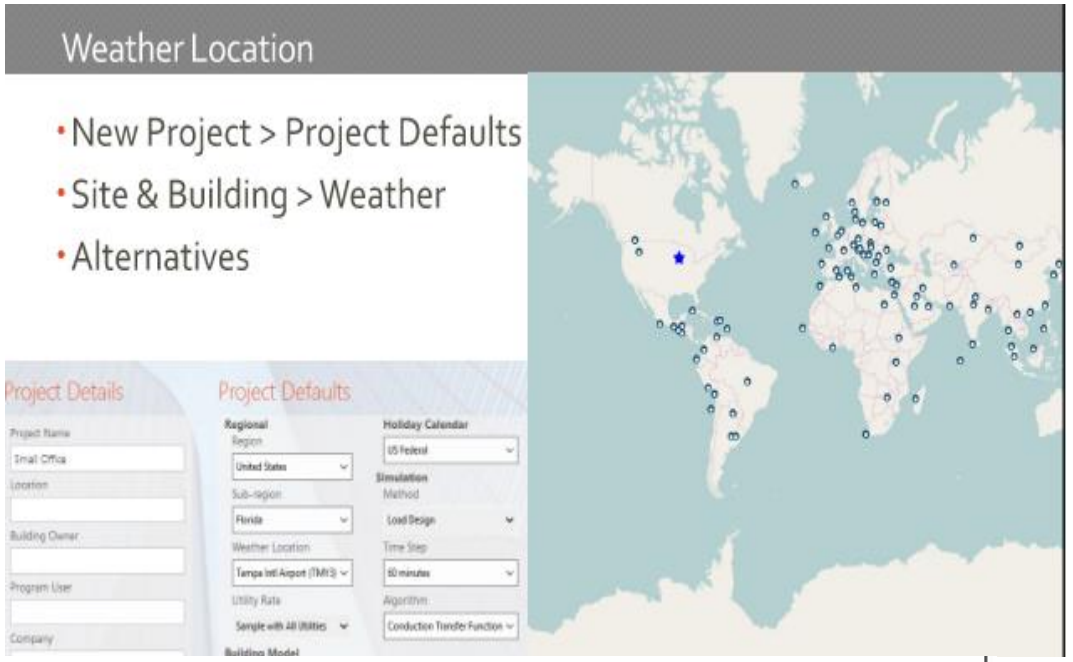
MEP Engineering | Project Management



- Theme selection
- Templates usage
- Theme and Template libraries







- Weather methodology
- Select a location
- Weather library
- Weather file import

TRACE 3D Plus Energy Modeling
Creating a Project

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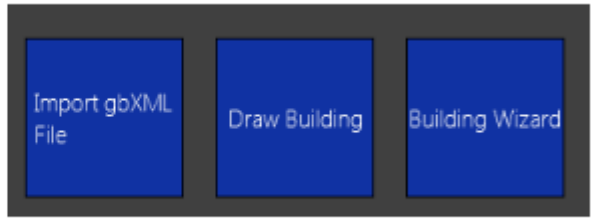
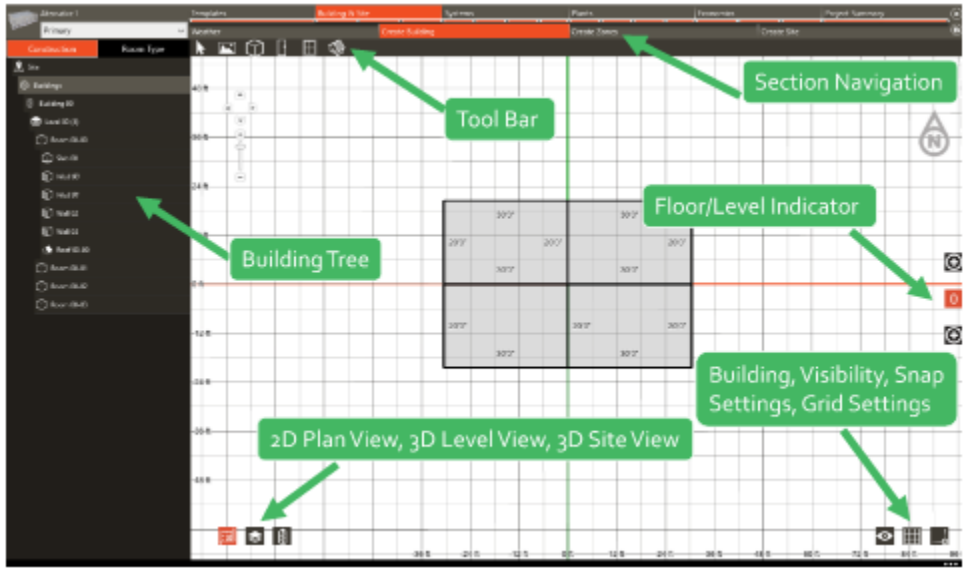
Building Drawing Options:

- Import GBXML
- Draw Building
- Building Wizard

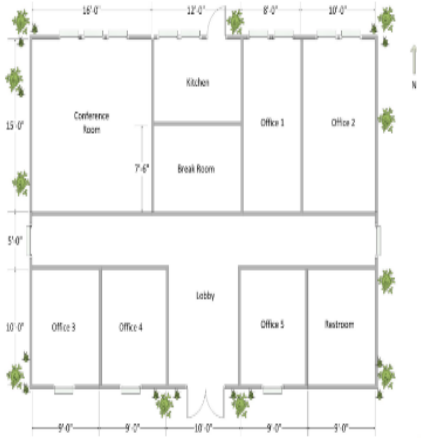


- Drawing tools
- Inputs
- Exercise



- The tool bar shows all of the tools used in drawing your building including:
  - Selection
  - Floor Plan Image
  - Room Drawing
  - Door Drawing
  - Window Drawing
  - Roof Drawing

- Trace over floor plan
- Import scaled floor plan (Smalloffice.jpg)
- Align drawing with axis
- Scale west wall to 30 ft.
- Draw rooms
- Rename rooms



TRACE 3D Plus Energy Modeling
Floor plan and room zoning

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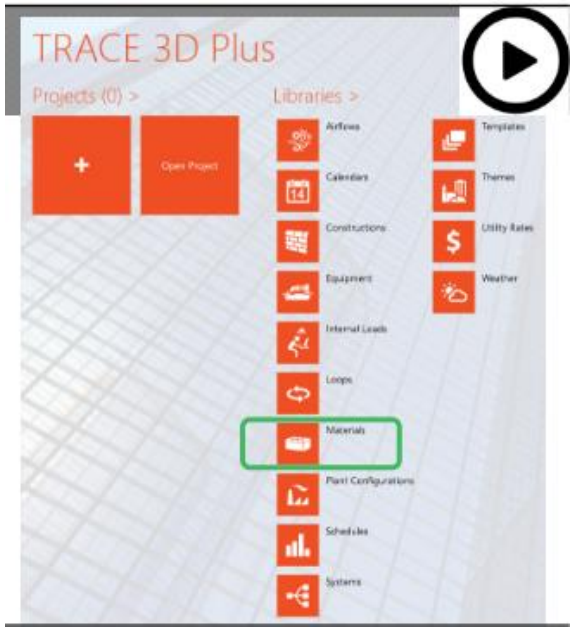

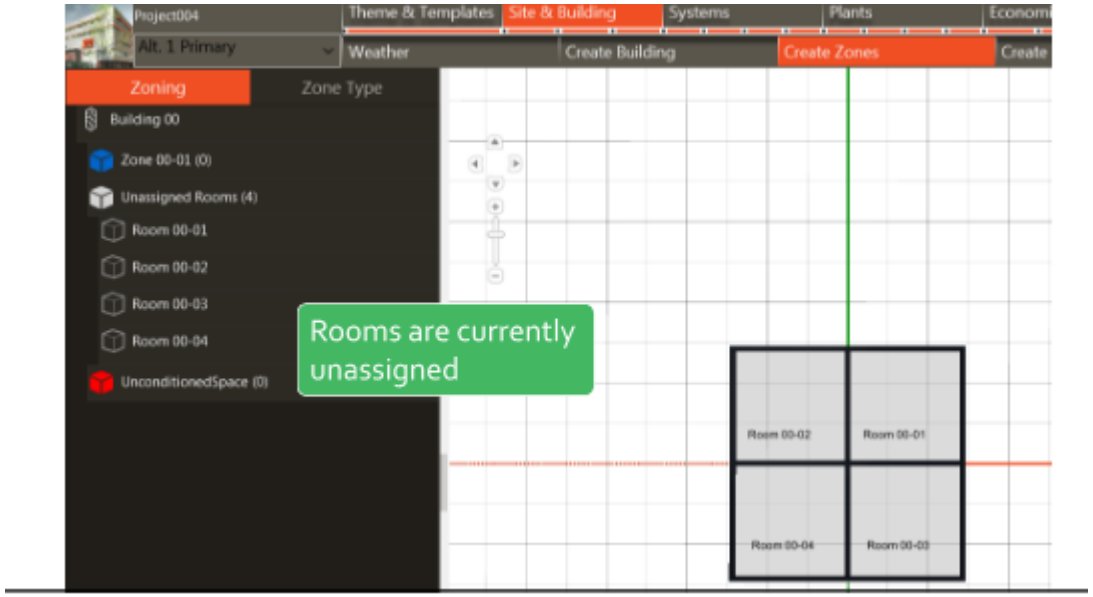

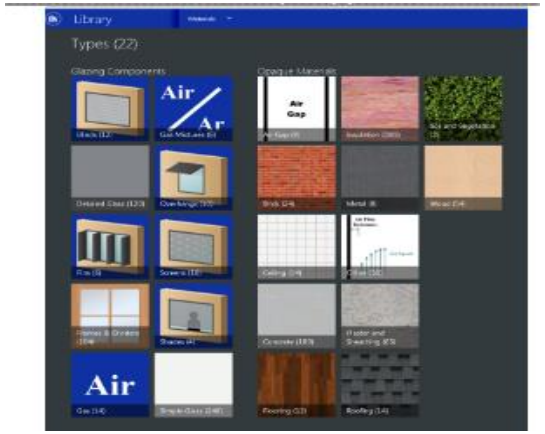

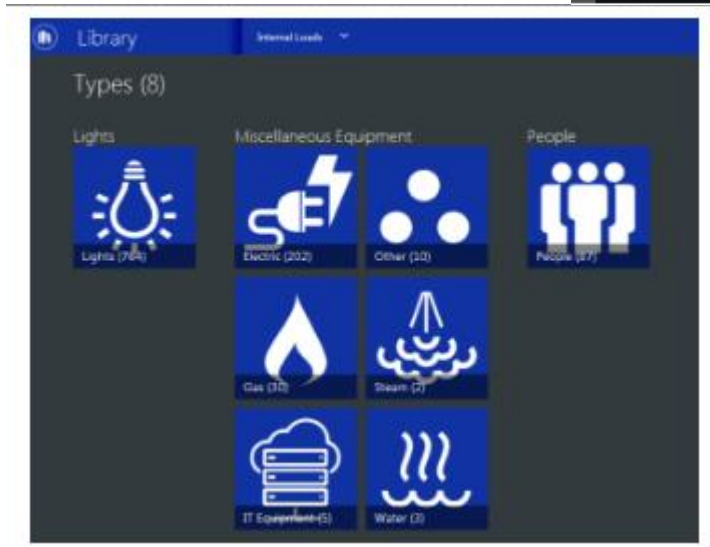

- Auto Assign will automatically zone all rooms
- Each room will be in its own zone

TRACE 3D Plus Energy Modeling
Inputting room information

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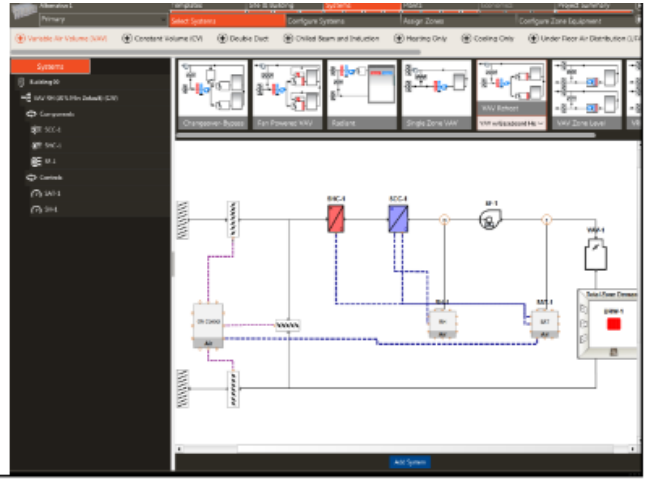
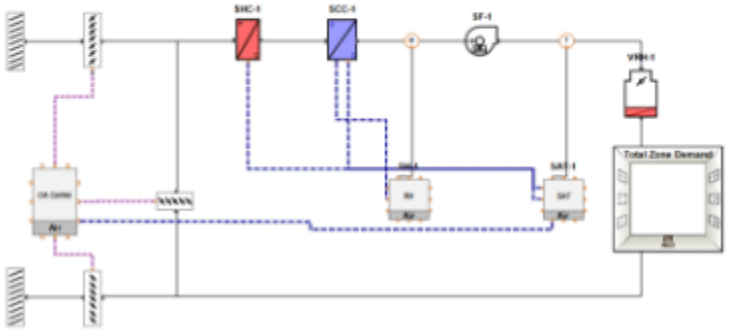
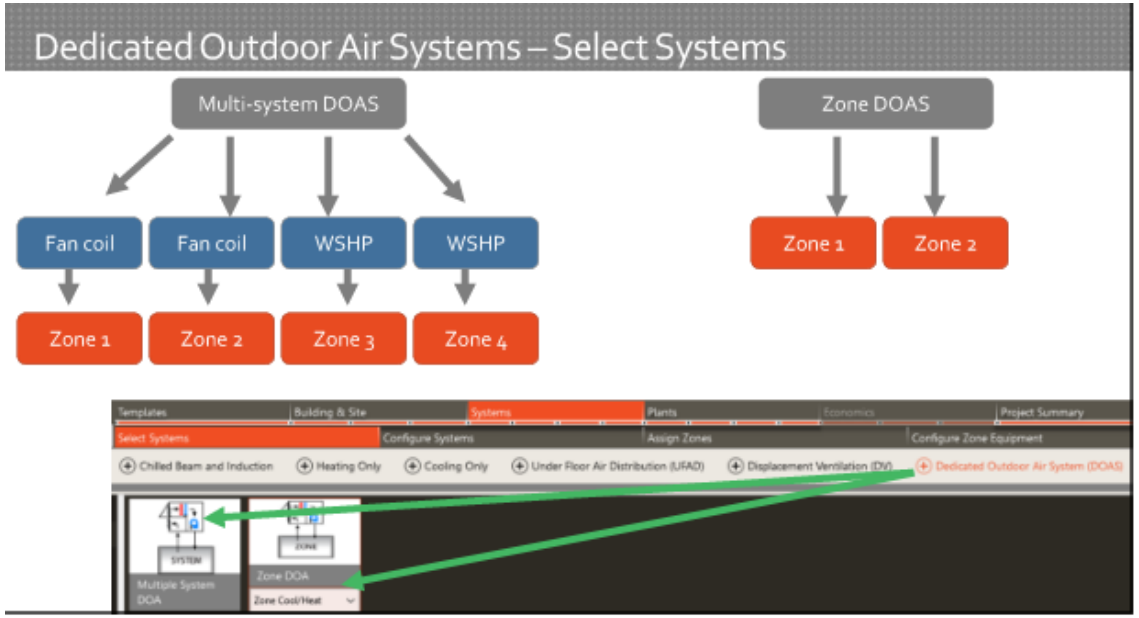
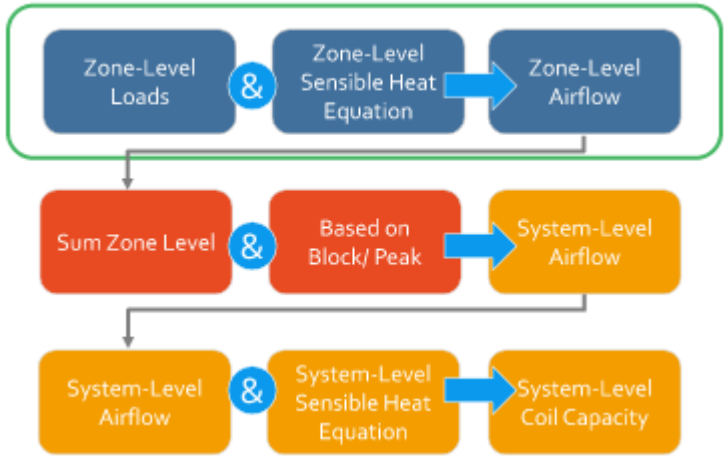
- Select systems to be used in project
- View read-only properties



- Add VAV w/Reheat (DX) system to the project
- Configure system:
  - Change to "Housed Forward Curve with VFD" fan
  - Static pressure = 2.5 in
  - System Leaving Cooling and Heating coil DB → 57F







TRACE 3D Plus Energy Modeling
Creating Systems

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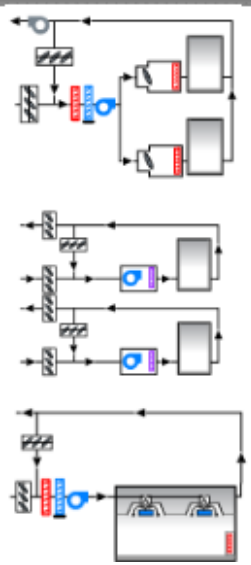
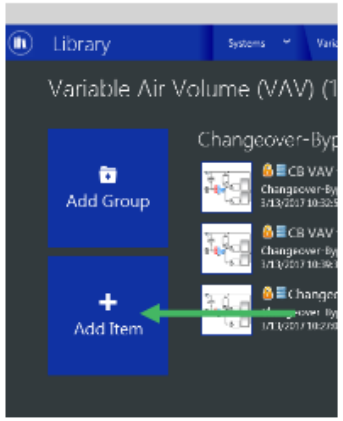
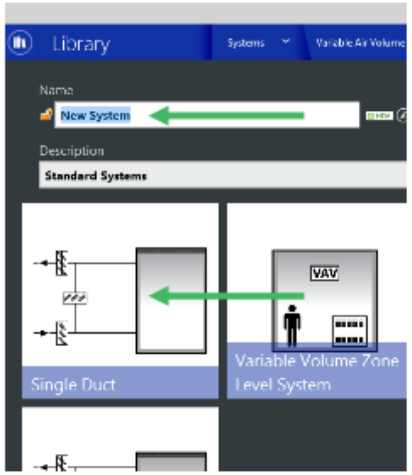
Standard System Libraries Available

- Variable Air Volume (VAV)
- Constant Volume (CV)
- Double Duct
- Chilled Beam and Induction
- Heating Only
- Cooling Only
- Underfloor Air Distribution (UFAD)
- Displacement Ventilation (DV)
- Outdoor Air System (DOAS)
- 90.1 Systems

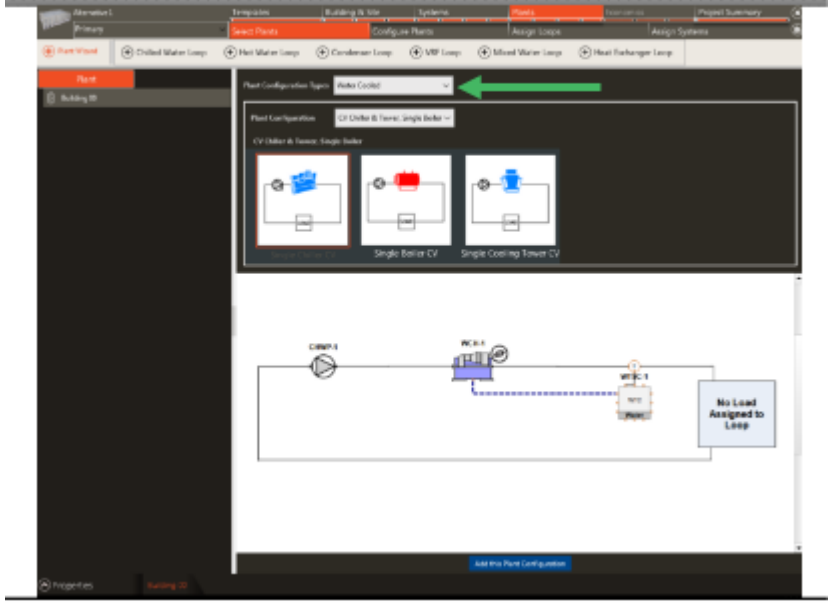






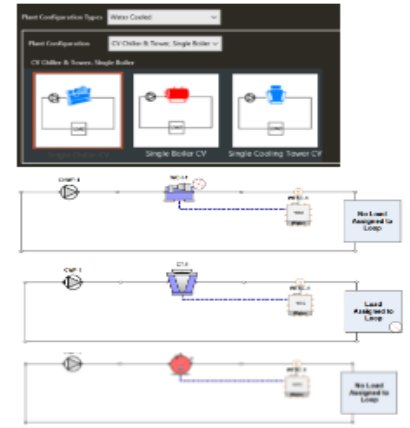
Zone Equipment Libraries

Select Plants



Standard Plant Libraries Available

- Heat Pump
  - Water source heat pump condenser plant
- Water Cooled
  - CV chiller and tower single boiler
  - Parallel CV chillers, single tower
  - Parallel CV chillers, two condensers
  - Primary secondary
  - VF chiller and tower, single boiler
- VRF
  - Air cooled VRF plant
  - Water cooled VRF
- Air Cooled
  - Single air cooled CV chiller, single boiler
  - Single air cooled VF chiller, single boiler



TRACE 3D Plus Energy Modeling
Creating plants

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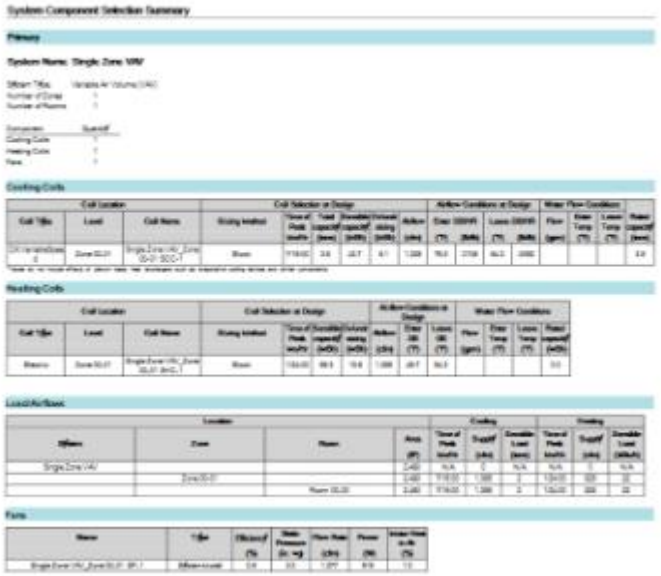
MEP Engineering | Project Management

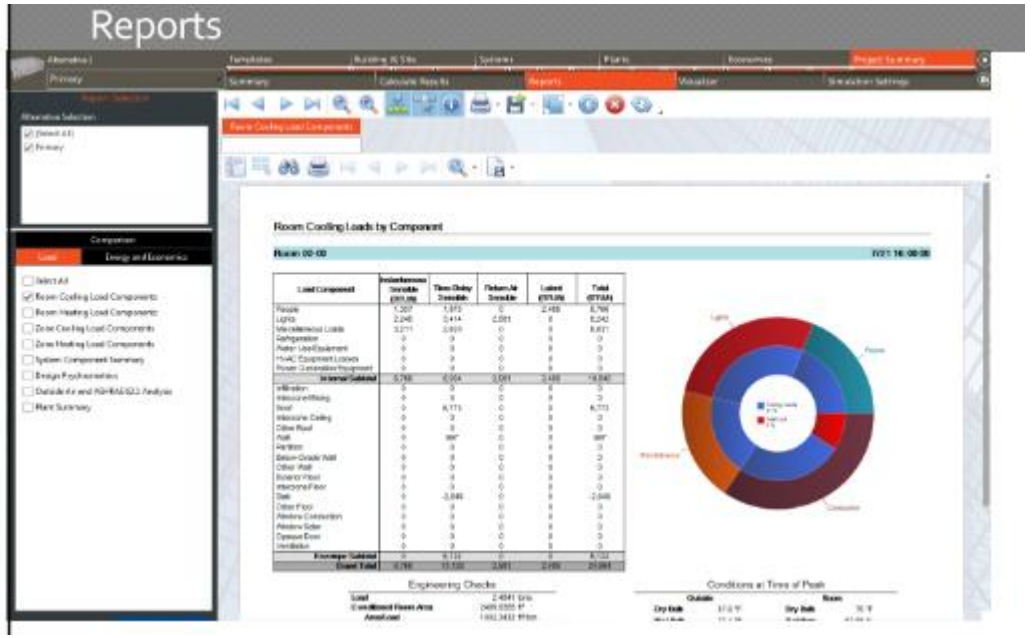
Objectives

- Understand Project Summary tab
  - Set simulation Settings
  - Calculate Results
  - Review Reports
- Create new alternatives

System Component Selection Summary Report



Reports



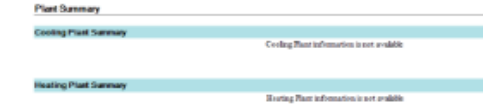
Loop Name: **Automated Chilled Water Loop**
Loop Type: Chilled Water Loop
Number of Assigned Coils: 0

Pumps

Name	Type	Contol	Head (psig)	Flow (gpm)	Power (W)	Power per Flow (W/gpm)
Automated Chilled Water LoopCHWP-1	Pump:ConstantSpeed	Intermittent	26	67.86	1493	22

Plant Equipment

Name	Type	Nominal Capacity (tons)	Efficiency (COP)
Automated Chilled Water LoopDC-1	Condenser Loop	28.39	0.00



TRACE 3D Plus Energy Modeling
Generating reports

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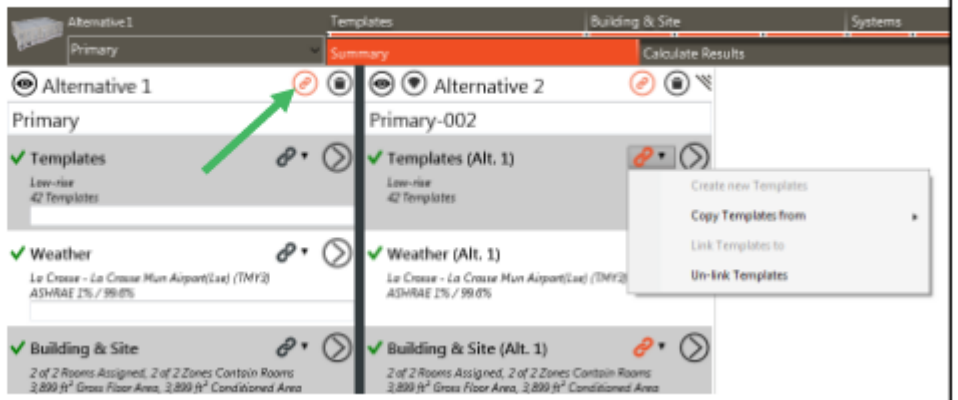
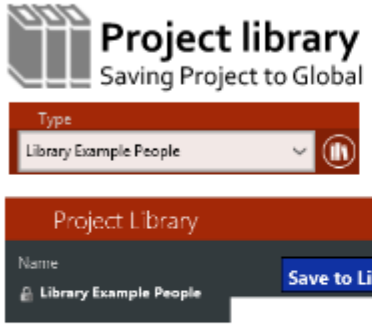
Creating Alternatives

- Create new
- Copy
- Link
- Un-Link



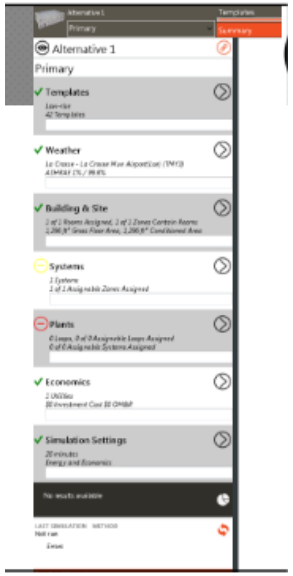


Save to library

Drop down menu in the project

Create an alternative based on Alt1:

- Alternative2: Copy Alt1 and modify the templates section
  - Change the type of lights to LED Linear Pendant, Direct Fixture
  - Conference Room and Lobby - 4 fixtures each
  - Rest of the spaces - 2 fixtures each
- Calculate and compare results
  1. How did the lighting load change when compared to the first alternative?
  2. Does this affect the cooling coil capacity?



Libraries

- Sharing libraries
- Import / export libraries: trl files
- Reconciliation
- Embedded libraries
- Search functionality
- Library grouping

TRACE 3D Plus Energy Modeling
Creating Alternatives and advanced features

Allen + Shariff
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Thank You!

Allen + Shariff
MEP Engineering | Project Management