Integrated Design Methods for Energy-Efficient and Cost-Effective Residential Construction

PARSONS THE NEW SCHOOL FOR DESIGN • MILANO THE NEW SCHOOL FOR MANAGEMENT AND URBAN POLICY STEVENS INSTITUTE OF TECHNOLOGY

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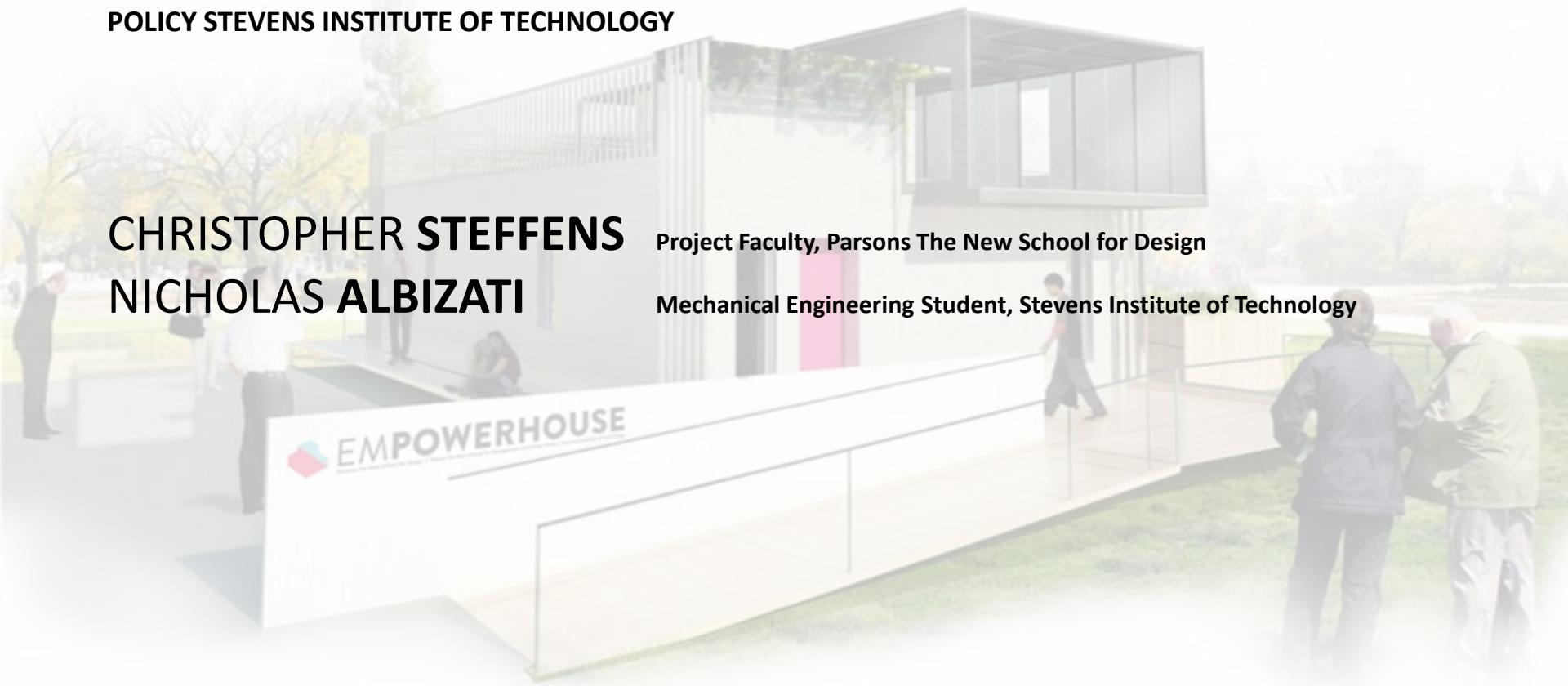
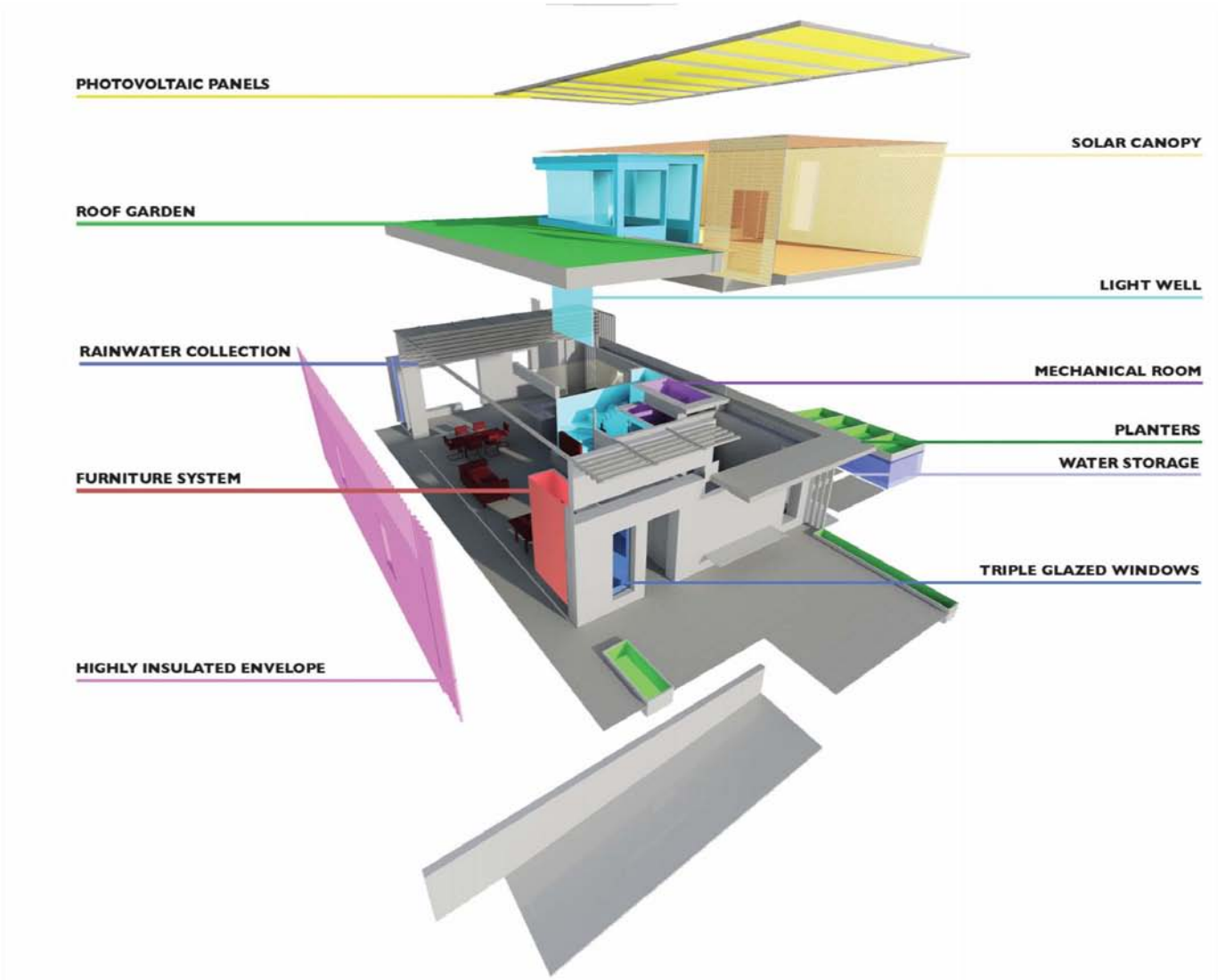


EMPOWERHOUSE

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

Empowerhouse Project Overview

Empowerhouse Features Overview



Project Stakeholders

PARSONS THE NEW SCHOOL FOR DESIGN

MILANO THE NEW SCHOOL FOR MANAGEMENT AND URBAN POLICY

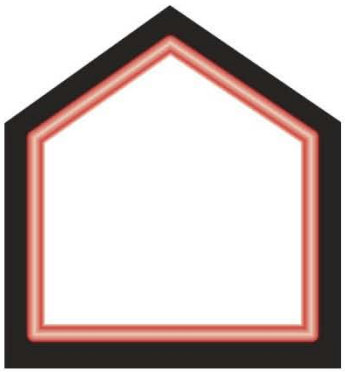
STEVENS INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY

Habitat for Humanity® of Washington, D.C.

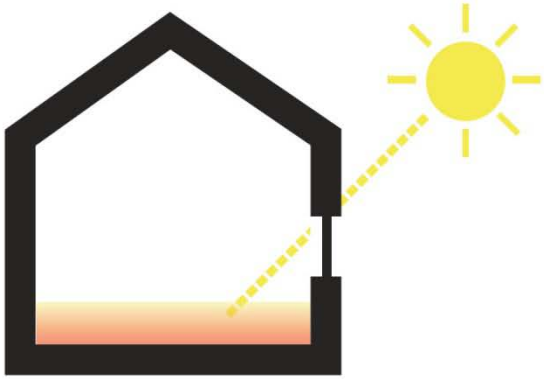
dhcd Department of Housing and Community Development
BUILDING ENDURING COMMUNITIES

Community of Deanwood, Washington DC

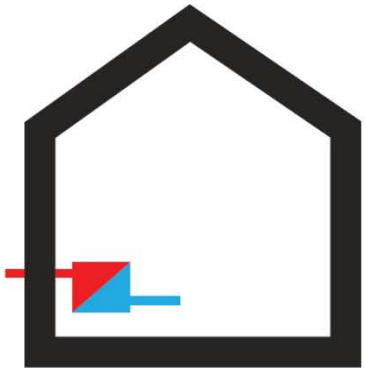
Principles of Passive House Design and Construction



AIR TIGHT &
WELL INSULATED



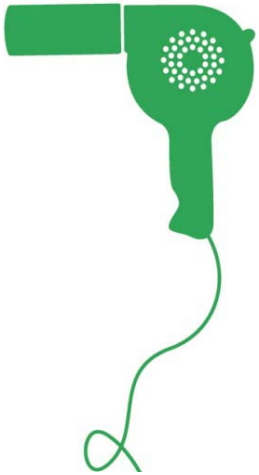
CAPTURE THE
SUN'S HEAT



HEAT RECOVERY

ENERGY DEMAND	PH REQUIREMENTS
Space Heating	4.75 kBTU / ft2 annual
Space Cooling	4.75 kBTU / ft2 annual
Primary (Source) Energy	38.0 kBTU / ft2 annual
Airtight Construction	0.6 ACH @ 50 pa

85% Heat & cooling savings



Architectural and Energy Modeling Integration

Architecturally-Driven Variables

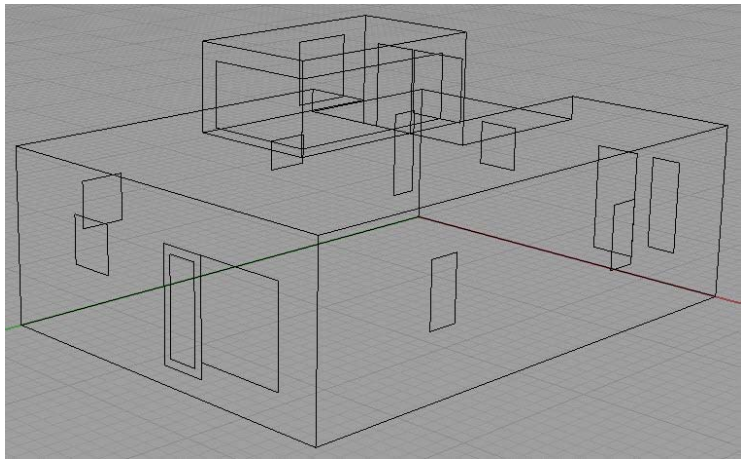
- Wall/Roof/Slab areas
- Treated floor area (TFA)
- Wall thickness
- Building materials
- Glazing areas
- Glazing types
- Glazing orientation
- And others…

Passive House Planning Package

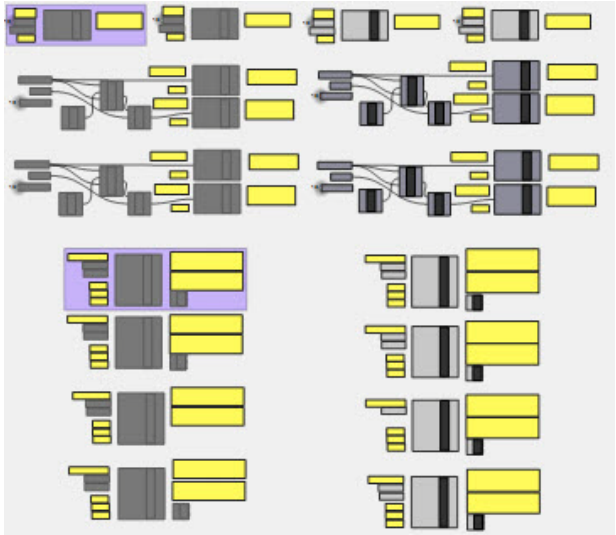
Envelope Area Input									Selection of the Corresponding Building Element Assembly	Nr.	R-Value [(hr.ft².°F)/BTU]
Building Element Description	Group Nr.	Assigned to Group	Quan-tity	x (	a [ft]	x	b [ft]	Area [ft²]			
Treated Floor Area	1	Treated Floor Area						0			
Wall 1	8	Exterior Wall - Ambient	1	x (	30	x	10	315.5	Sample Wall	1	50.0
Wall 2	8	Exterior Wall - Ambient	1	x (	30	x	10	285.0	Sample Wall	1	50.0
Wall 3	8	Exterior Wall - Ambient	1	x (	24	x	12	288.0	Sample Wall	1	50.0
Wall 4	8	Exterior Wall - Ambient	1	x (	24	x	12	248.0	Sample Wall	1	50.0
Wall 5	8	Exterior Wall - Ambient	1	x (	30	x	4	120.0	Sample Wall	1	50.0
Wall 6	8	Exterior Wall - Ambient	1	x (	30	x	4	120.0	Sample Wall	1	50.0
Wall 7	8	Exterior Wall - Ambient	1	x (	15	x	15	225.0	Sample Wall	1	50.0
Wall 8	8	Exterior Wall - Ambient	1	x (	15	x	15	225.0	Sample Wall	1	50.0
Basement Wall 1	9	Exterior Wall - Ground	1	x (	30	x	4	120.0	Sample Wall	1	50.0
Basement Wall 2	9	Exterior Wall - Ground	1	x (	15	x	4	60.0	Sample Wall	1	50.0
Basement Wall 3	9	Exterior Wall - Ground	1	x (	15	x	5	75.0	Sample Wall	1	50.0
Basement Wall 4	9	Exterior Wall - Ground	1	x (	30	x	5	150.0	Sample Wall	1	50.0
Roof 1	10	Roof/Ceiling - Ambient	1	x (	15	x	15	259.0	Sample Roof	2	70.0
Roof 2	10	Roof/Ceiling - Ambient	1	x (	15	x	15	165.0	Sample Roof	2	70.0
Roof 3	10	Roof/Ceiling - Ambient	1	x (	20	x	20	400.0	Sample Roof	2	70.0
Slab	11	Floor Slab	1	x (	40	x	40	1600.0	Sample Floor Slab	3	50.0

Architectural and Energy Modeling Integration

Schematic Wireframe Model



Graphical Programming



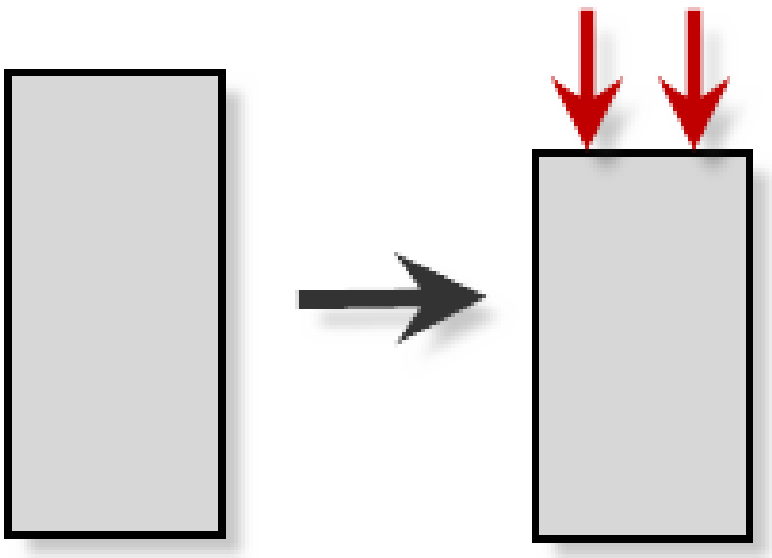
Data Export to Energy Model

Envelope Area Input												R-Value [(hr.ft².°F)/BTU]
Building Element Description	Group Nr.	Quan-tity	x (	a [ft]	x	b [ft]	) -	Subtraction Window Areas [ft²]	) =	Area [ft²]		
Treated Floor Area	1									0		
Wall 1	8	1	x (	30.00	x	10.00	) -	0.0	=	315.5		50.0
Wall 2	8	1	x (	30	x	10	) -	0.0	=	285.0		50.0
Wall 3	8	1	x (	24	x	12	) -	0.0	=	288.0		50.0
Wall 4	8	1	x (	24	x	12	) -	0.0	=	248.0		50.0
Basement Wall 1	9	2	x (	30	x	4	) -	0.0	=	240.0		50.0
Basement Wall 2	9	2	x (	30	x	4	) -	0.0	=	240.0		50.0
Roof 1	10	1	x (	15	x	15	) -	0.0	=	259.0		70.0
Roof 2	10	1	x (	15	x	15	) -	0.0	=	165.0		70.0
Roof 3	10	1	x (	20	x	20	) -	0.0	=	400.0		70.0

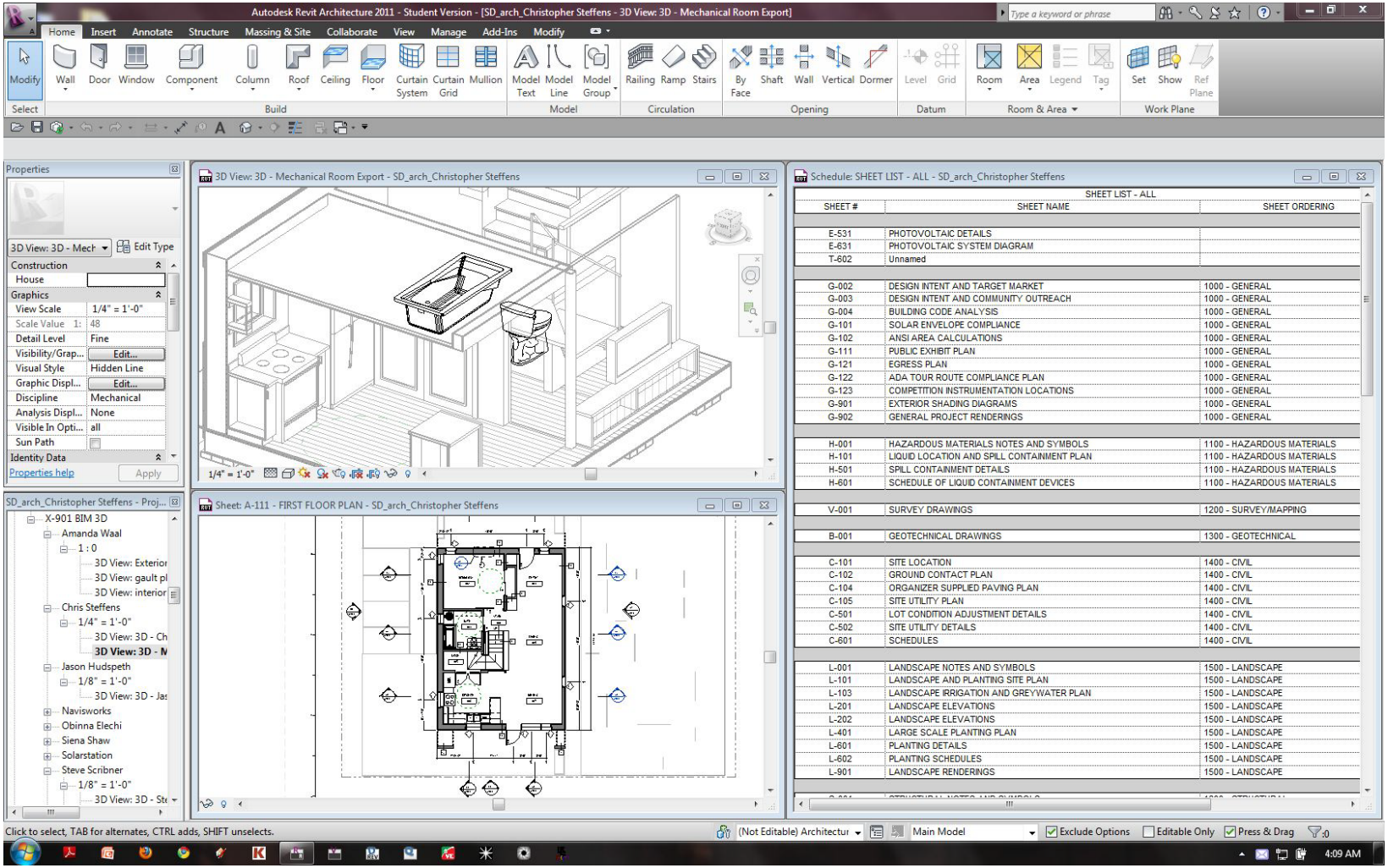
Architectural and Energy Modeling Integration

One way we used the tool…

- Needed to decrease house length
  - Easier transportation
  - Square footage requirements
  - Allowed for modular construction
- Modified schematic design
  - (Quick change in 3D model)
- <u>Automatic</u> analysis update
  - Saved us time
  - Small thermal impact



Building Information Modeling (BIM) for Residential Construction



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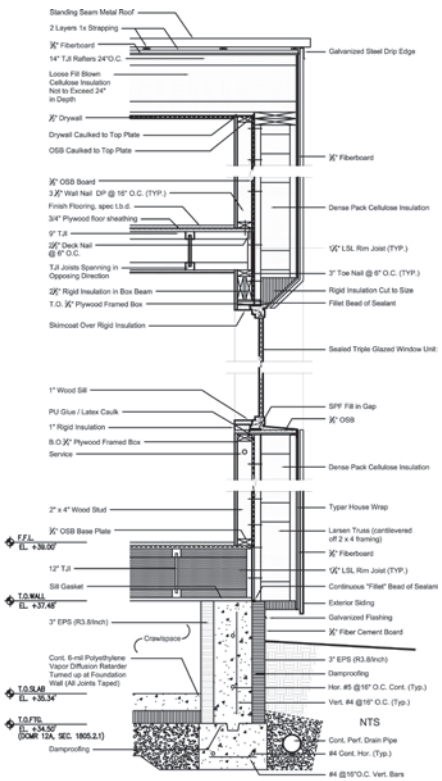
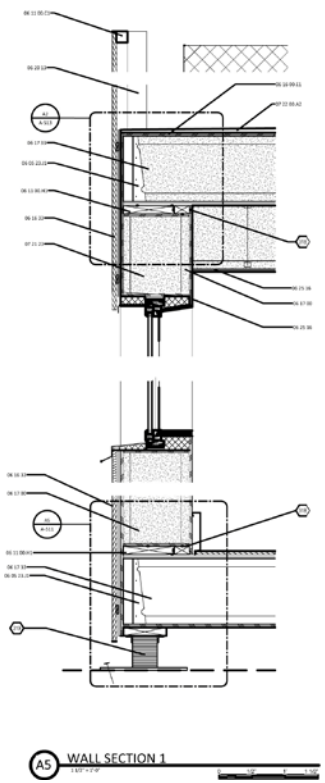


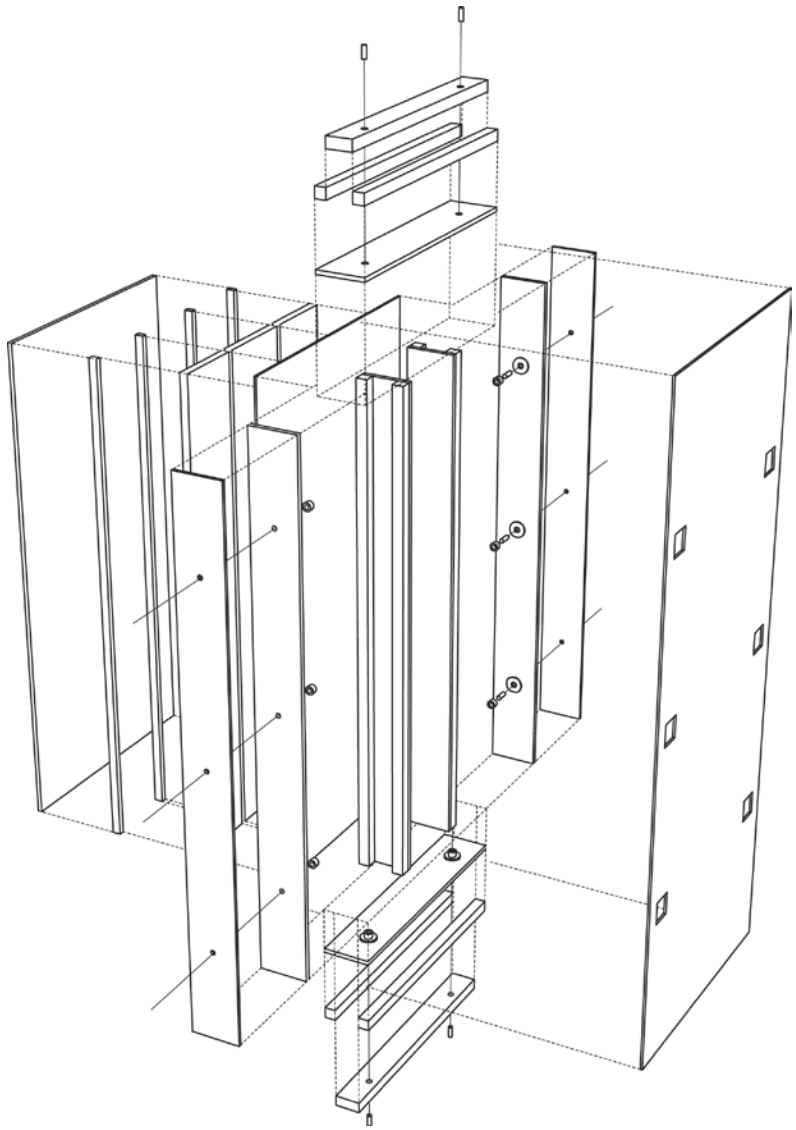
BALLOON-FRAMED STUD AND TRUSS WALL OPTION



PANELIZED WALL SYSTEM OPTION

- Development of a library of construction details and design tools specific to homebuilder methods and market
- Component parameters such as cost, labor, and thermal resistance are embedded in the modeling environment; updated as needed
- Single information source for generation of design options, cost estimation, energy modeling data, quantity takeoffs and construction documentation

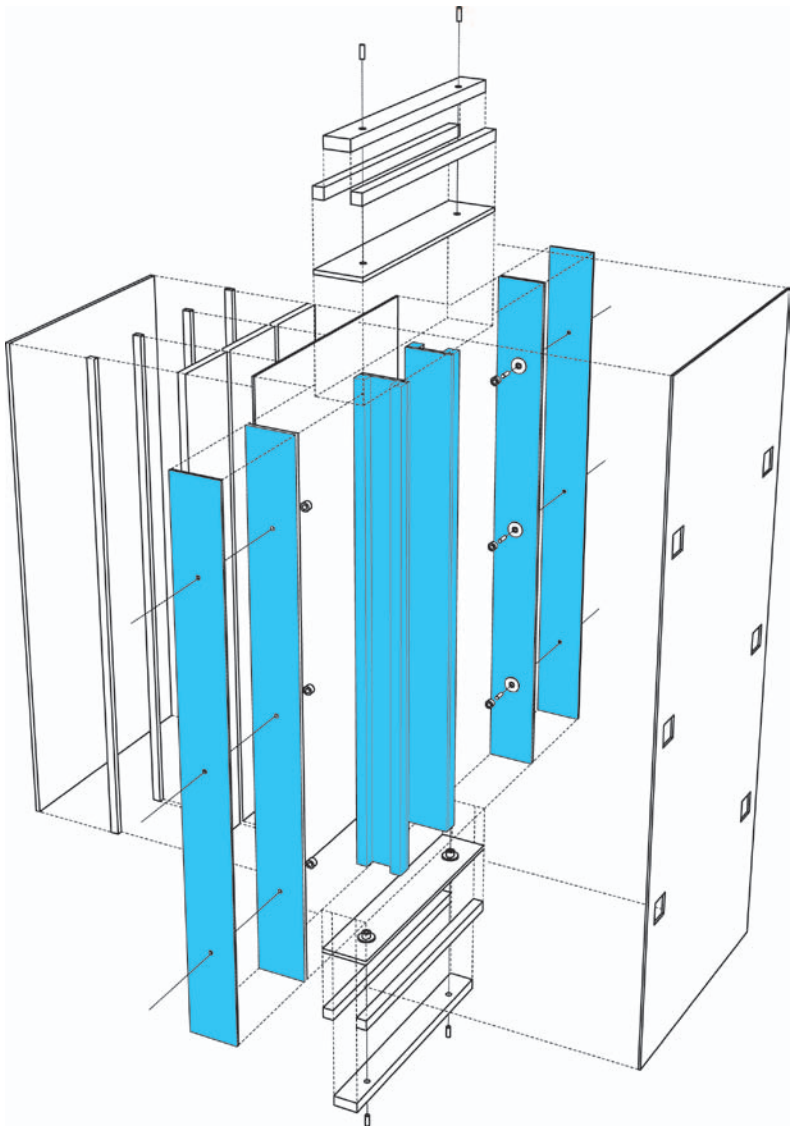
Building Information Modeling (BIM) for Residential Construction



Information Available:

- Quantity take-offs and schedules; areas, components, assemblies
- Costing, BOM, fabrication drawings
- R-values through whole wall section; U-values, areas and orientation of glazing
- 2D heat transfer analysis model
- Structural analysis model

Building Information Modeling (BIM) for Residential Construction



Parameters managed:

- Required R-value of entire wall system for thermal comfort
- Depth of panel section; required truss joist dimension for optimal thickness of insulation
- Profile of truss joist for localized structural loads, weight and material savings, services access

Our Team's Integrated Design Observations

- Building energy and information modeling tools can be part of workflows to facilitate integrated design; are not digital design solutions in themselves.
- Integrated design requires early collaboration, fast but rigorous iteration, and constant communication.
- Emerging tools and practical modes will likely increase accessibility to energy and information modeling for residential designers, builders, and contractors.