BUILDING INNOVATION 2019
National Institute of BUILDING SCIENCES
CONFERENCE & EXPO

Back to the Future: Re-Cladding to the Past

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Goals & Topics of Discussion

- Why are present-day buildings performing similarly to early 1900's buildings?
  - Energy code and how it evolved to allow this to happen
  - High-rise commercial building glass exteriors
- Do we *have* to design with mostly glass assemblies?
  - Case study showing differences between recladding in fully-glazed systems vs. partially-glazed systems (40% WWR)

Agenda

1. Benchmarking
2. Energy Code
3. High-Rise Commercial Repositioning
4. Case Study: One South Wacker, Chicago, IL
5. Conclusions

01
Benchmarking

Benchmarking

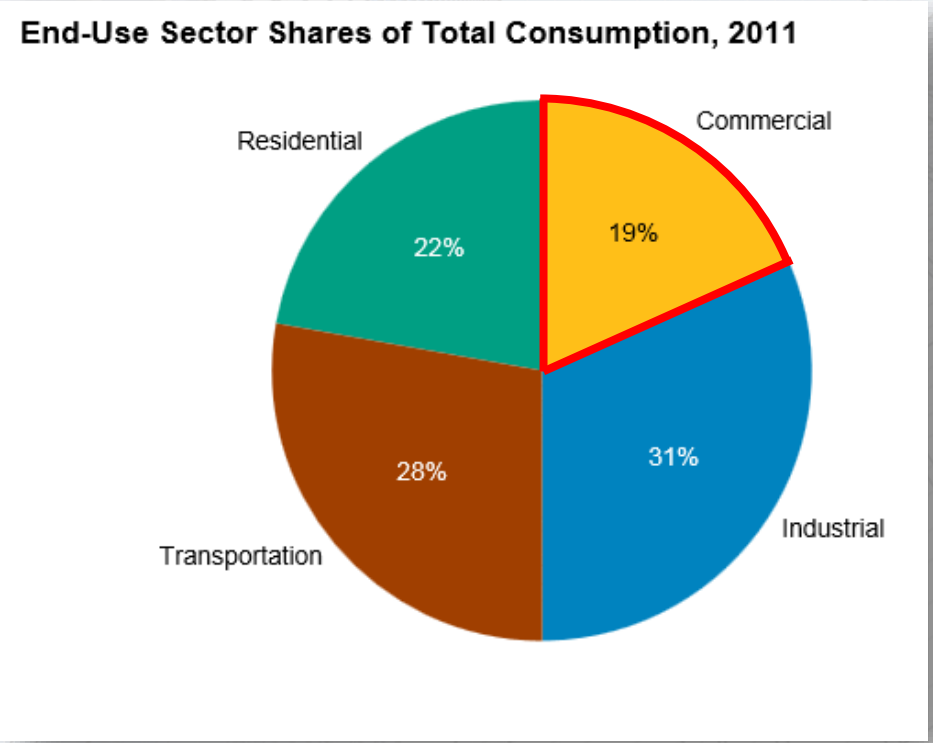
Fast Facts on Energy Use

Facts About Energy Use in Commercial and Industrial Facilities

- Combined number of commercial buildings (4.8 million) and industrial facilities (350,000) in the United States: **over 5 million**[1]
- Combined annual energy costs for U.S. commercial buildings ($107.9 billion) and industrial facilities ($94.4 billion): **$202.3 billion**[2]
- Portion of energy in buildings used inefficiently or unnecessarily: **30 percent**[3]
- Combined percentage of U.S. greenhouse gas emissions generated by commercial buildings (17 percent) and industrial facilities (28 percent): **45 percent**[4]
- Percentage of energy use reduction targeted by the ENERGY STAR Challenge: **10 percent**[5]
- Amount of money that would be saved if the energy efficiency of commercial and industrial buildings improved by 10 percent: **$20 billion**[6]
- Amount of greenhouse gas emissions that would be reduced if the energy efficiency of commercial and industrial buildings improved by 10 percent: **equal to about 30 million vehicles**[7]
- Number of registered automobiles in Illinois, New York, Ohio, and Texas combined: **about 30 million**[8]

Source: www.energystar.gov

Benchmarking



Source: U.S. Energy Information Administration: Annual Energy Review 2011 & State Energy Data System

Benchmarking

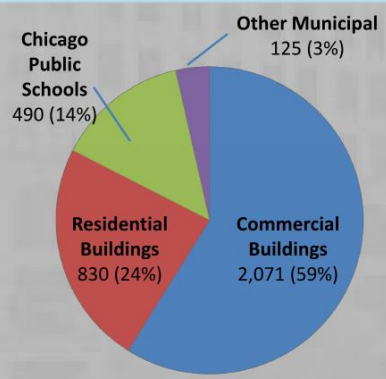
Less than 1% of buildings in Chicago are larger than 50,000 ft², but they represent 22% of the total energy used by all buildings

Building Energy Use and Sector Breakdown

Chicago Building Energy Use

	All Chicago buildings	Large Buildings (>50,000 ft²)	
		Amt.	%
Total Buildings	452,000 buildings	3,500 buildings	0.7%
Total Energy Use (million kBtu)	223,000 MkBtu	43,100 MkBtu	22%
Total Electricity (million kWh)	20,800 MkWh	6,600 MkWh	35%

Sector Breakdown of Large Buildings (>50,000ft²)



If all buildings larger than 50,000ft2 reduced energy use by 5%, it would amount to annual savings of ~2 trillion Btu energy, ~$40 million, & ~50,000 cars' worth of CO2e

Note: (*) With gas or electricity service. 488,000 total buildings
Source: Chicago Building Retrofit Acceleration project September 2011 (2010 data)

Benchmarking

Per Ordinance:

"Benchmark" means to track and input a building's energy consumption data and other relevant building information for twelve consecutive months, as required by the benchmarking tool, to quantify the building's energy use.

Benchmarking

Mayor Rahm Emanuel

- “Do you check the mileage before you purchase a car? Do you check the energy-efficiency of a utility before you purchase it? Do you do comparative? What is wrong with providing people information?”

- “Good data drives markets and innovation.”

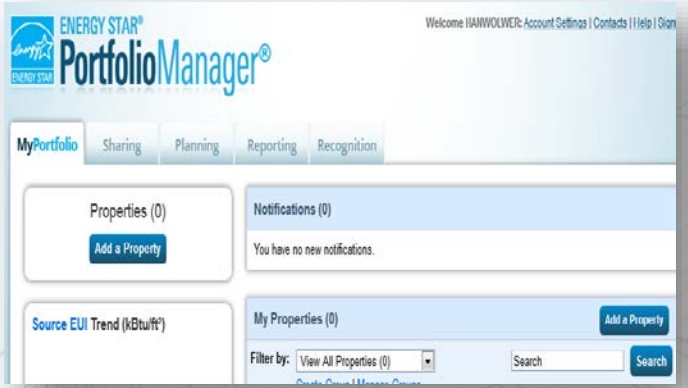
Benchmarking

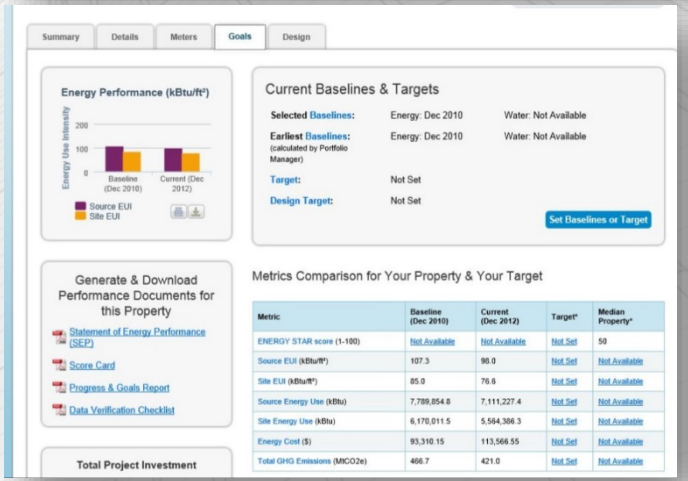
Source: Sustainable Chicago 2015; City of Chicago, September 2012

Benchmarking

Per Ordinance:

- "Benchmarking tool" means the website-based software, commonly known as "ENERGY STAR Portfolio Manager," developed and maintained by the U.S. EPA to track and assess the relative energy use of buildings nationwide.

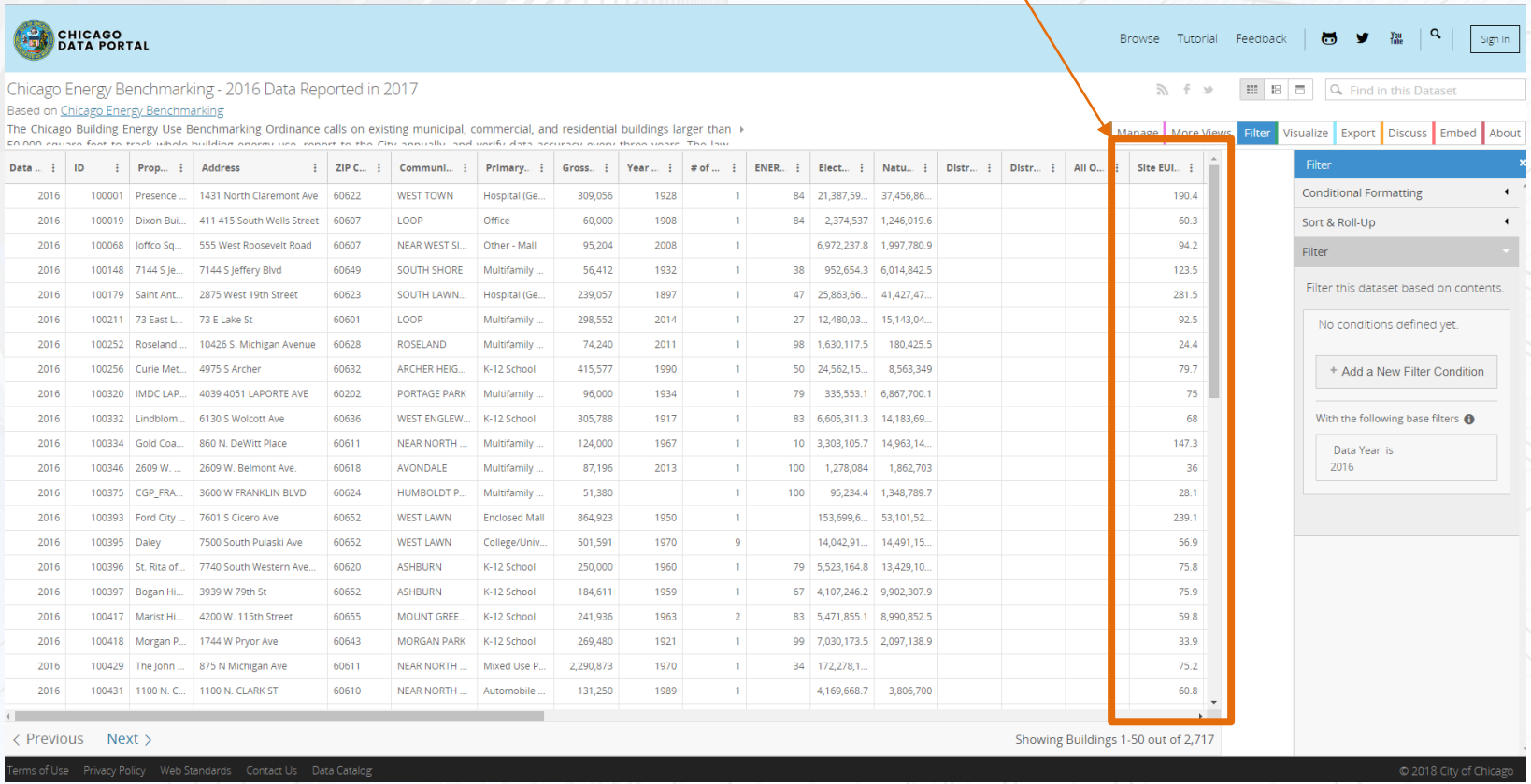




Benchmarking

Benchmarking

Site EUI

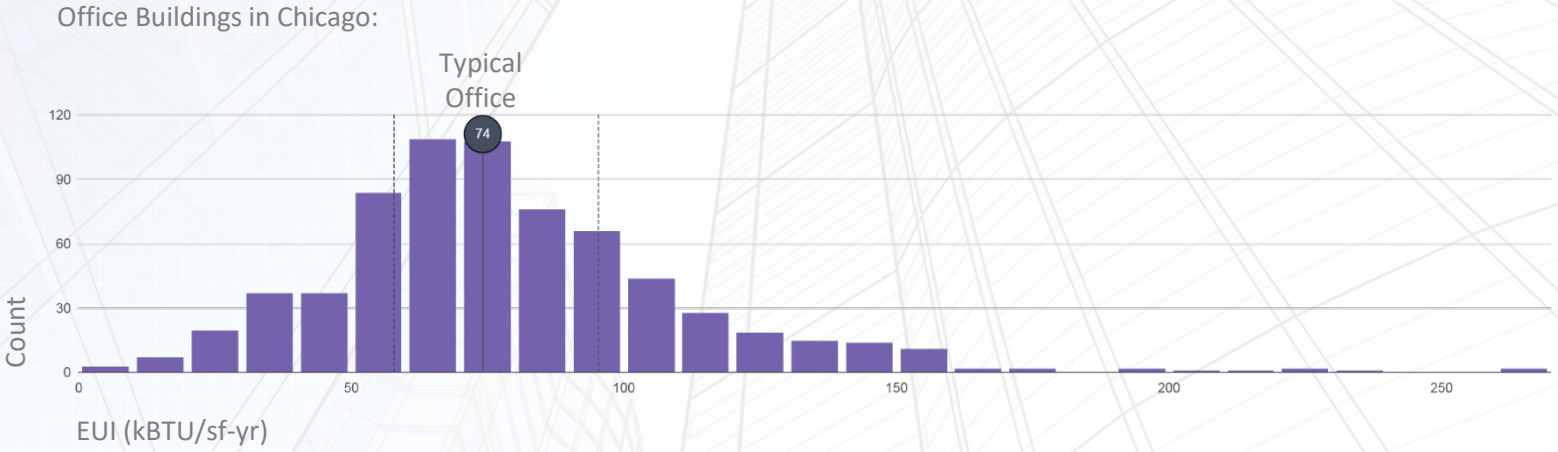


Data ..	ID	Prop...	Address	ZIP C...	Communi...	Primary...	Gross...	Year ...	# of ...	ENER...	Elect...	Natu...	Distr...	Distr...	All O...	Site EUI...
2016	100001	Presence ...	1431 North Claremont Ave	60622	WEST TOWN	Hospital (Ge...	309,056	1928	1	84	21,387,59...	37,456,86...				190.4
2016	100019	Dixon Bui...	411 415 South Wells Street	60607	LOOP	Office	60,000	1908	1	84	2,374,537	1,246,019.6				60.3
2016	100068	Joffco Sq...	555 West Roosevelt Road	60607	NEAR WEST SI...	Other - Mall	95,204	2008	1		6,972,237.8	1,997,780.9				94.2
2016	100148	7144 S Je...	7144 S Jeffery Blvd	60649	SOUTH SHORE	Multifamily ...	56,412	1932	1	38	952,654.3	6,014,842.5				123.5
2016	100179	Saint Ant...	2875 West 19th Street	60623	SOUTH LAWN...	Hospital (Ge...	239,057	1897	1	47	25,863,66...	41,427,47...				281.5
2016	100211	73 East L...	73 E Lake St	60601	LOOP	Multifamily ...	298,552	2014	1	27	12,480,03...	15,143,04...				92.5
2016	100252	Roseland ...	10426 S. Michigan Avenue	60628	ROSELAND	Multifamily ...	74,240	2011	1	98	1,630,117.5	180,425.5				24.4
2016	100256	Curie Met...	4975 S Archer	60632	ARCHER HEIG...	K-12 School	415,577	1990	1	50	24,562,15...	8,563,349				79.7
2016	100320	IMDC LAP...	4039 4051 LAPORTE AVE	60202	PORTAGE PARK	Multifamily ...	96,000	1934	1	79	335,553.1	6,867,700.1				75
2016	100332	Lindblom...	6130 S Wolcott Ave	60636	WEST ENGLEW...	K-12 School	305,788	1917	1	83	6,605,311.3	14,183,69...				68
2016	100334	Gold Coa...	860 N. DeWitt Place	60611	NEAR NORTH ...	Multifamily ...	124,000	1967	1	10	3,303,105.7	14,963,14...				147.3
2016	100346	2609 W. ...	2609 W. Belmont Ave.	60618	AVONDALE	Multifamily ...	87,196	2013	1	100	1,278,084	1,862,703				36
2016	100375	CGP_FRA...	3600 W FRANKLIN BLVD	60624	HUMBOLDT P...	Multifamily ...	51,380		1	100	95,234.4	1,348,789.7				28.1
2016	100393	Ford City ...	7601 S Cicero Ave	60652	WEST LAWN	Enclosed Mall	864,923	1950	1		153,699,6...	53,101,52...				239.1
2016	100395	Daley	7500 South Pulaski Ave	60652	WEST LAWN	College/Univ...	501,591	1970	9		14,042,91...	14,491,15...				56.9
2016	100396	St. Rita of...	7740 South Western Ave...	60620	ASHBURN	K-12 School	250,000	1960	1	79	5,523,164.8	13,429,10...				75.8
2016	100397	Bogan Hi...	3939 W 79th St	60652	ASHBURN	K-12 School	184,611	1959	1	67	4,107,246.2	9,902,307.9				75.9
2016	100417	Marist Hi...	4200 W. 115th Street	60655	MOUNT GREE...	K-12 School	241,936	1963	2	83	5,471,855.1	8,990,852.5				59.8
2016	100418	Morgan P...	1744 W Pryor Ave	60643	MORGAN PARK	K-12 School	269,480	1921	1	99	7,030,173.5	2,097,138.9				33.9
2016	100429	The John ...	875 N Michigan Ave	60611	NEAR NORTH ...	Mixed Use P...	2,290,873	1970	1	34	172,278,1...					75.2
2016	100431	1100 N. C...	1100 N. CLARK ST	60610	NEAR NORTH ...	Automobile ...	131,250	1989	1		4,169,668.7	3,806,700				60.8

Benchmarking

ENERGY USE INTENSITY (EUI):

The amount of annual energy consumption per square foot of a building (kBtu/sf-yr). This allows comparisons of energy performance across many different categories & sizes of buildings.



Source: Building Performance Database - https://bpd.lbl.gov

Benchmarking

Analysis:

- Chicago, IL
- 2016 Data
- Commercial – Office
- GSF > 1 mil. SF (High-Rise)

	Property Name	Address	Primary Type	Gross SF	Year Built	Site EUI (kBtu/sq ft)	Source EUI (kBtu/sq ft)
2	111 East Wacker Drive	111 East Wacker Drive	Office	1,281,847	1969	87.6	184.1
3	233 North Michigan Avenue	233 North Michigan Avenue	Office	1,215,747	1972	84.8	184.5
4	20 North Wacker Drive	20 North Wacker Drive	Office	1,742,899	1929	67.2	144.3
5	Aon Center	200 E. Randolph Street	Office	3,193,966	1972	85.6	146.2
6	The Franklin (227 West Monroe; 222 West Adams	227 West Monroe	Office	2,960,211	1989	71.6	224.1
7	311 S. Wacker	311 South Wacker	Office	1,433,821	1990	60.1	188.7
8	55 East Monroe	55 East Monroe Street	Office	1,674,462	1972	96	223.4
9	70 W Madison	70 W. Madison St	Office	1,515,404.30	1981	64.4	200.7
10	131 S. Dearborn 3	131 S. Dearborn	Office	1,652,550	2002	99	310.9
11	500 West Monroe	500 West Monroe	Office	1,153,491	1992	50.6	157.6
12	500 West Madison	500 West Madison Street	Office	1,855,810	1986	66.1	207.7
13	175 W. Jackson	175 W. Jackson	Office	1,809,140	1928	81.9	168
14	71 South Wacker	71 S. Wacker Drive	Office	1,687,710	2005	70.7	220.6
15	300 E Randolph	300 East Randolph	Office	2,218,838	2010	81.7	189.8
16	James R Thompson Center	100 W. Randolph St.	Office	1,200,000	1985	102.8	254.5
17	One North Wacker	1 North Wacker Drive	Office	1,603,374	2001	95.9	234.4
18	161 North Clark	161 North Clark	Office	1,200,836	1992	70	219.9
19	One South Wacker	1 South Wacker	Office	1,343,438	1982	49.2	154.5
20	222 South Riverside Plaza	222 South Riverside Plaza	Office	1,237,455	1971	83.5	206
21	Harris Bank Building	115 S. LaSalle Street	Office	1,526,102	1974	116.4	247.4
22	Leo Burnett Building	35 W. Wacker Dr.	Office	1,392,096	1989	67.5	209.6
23	77 West Wacker Drive	77 W. Wacker Drive	Office	1,153,218	1992	53.3	167.3
24	181 West Madison	181 W Madison Street	Office	1,082,248	1990	70.7	221.9
25	10 and 30 South Wacker	10 South Wacker Drive	Office	2,662,457	1983	68.7	214
26	333 West Wacker	333 West Wacker Drive	Office	1,012,961	1982	53.2	166.9
27	200 West Madison	200 West Madison	Office	1,001,834	1982	56.3	176.8
28	303 E. Wacker	303 E. Wacker	Office	1,015,129	1979	61	191.2
29	Michigan Plaza	205/225 N Michigan Ave	Office	2,059,714	1981	57.6	180.7
30	One North Dearborn	1–17 N. Dearborn Street	Office	1,046,276	1902	65.6	164.8
31	100/150 S. Wacker	150 South Wacker	Office	1,281,114	1971	85.2	196.5
32	321 N. Clark Property, LLC	321 North Clark	Office	1,025,053	1987	57.5	180.5
33	Prudential Plaza	130 East Randolph & 180 North Stetso	Office	2,751,035	1972	69.1	181.4
34	NBC Tower	455 North Cityfront Plaza Drive	Office	1,006,126	1988	83.9	282.4
35	Chicago Board of Trade Building	141 W. Jackson Blvd.	Office	1,559,956	1930	105	239.1
36	30 North LaSalle Street	30 North LaSalle Street	Office	1,095,104	1974	62.7	146.3
37	222 North LaSalle	222 North LaSalle Street	Office	1,217,630	1986	53	158.2
38	525 West Monroe	525 West Monroe Street	Office	1,028,492	1983	52.9	164.9
39	Willis Tower	233 S Wacker Drive	Office	4,518,811	1973	90.3	283
40	135 S LaSalle Property LLC	135 S. LaSalle Street	Office	1,547,120	1934	113.1	213.6
41	Four40	440 South LaSalle	Office	1,157,744	1984	81.8	257
42	River North Point	350 North Orleans Street	Office	1,883,966	1975	101.6	265.4
43	Merchandise Mart	222 Merchandise Mart Plaza	Office	4,101,281	1930	63.4	131.2
44	300 South Riverside Plaza	300 South Riverside Plaza	Office	1,222,064	1983	60.8	190.9
45	Sullivan Center	1 S State Street	Office	1,114,203	1903	70	153.3
46	333 South Wabash	333 S. Wabash	Office	1,274,198	1974	118.3	277.6
47	111 South Wacker	111 South Wacker	Office	1,248,730	2004	67.8	212.9
48	AMA Plaza	330 North Wabash	Office	1,930,764	1971	89	191.1
49	353 North Clark	353 North Clark Street	Office	1,364,257	2009	71.7	211.8
50	33 West Monroe	33 W. Monroe Street	Office	1,085,869	1980	63.3	160.3
51	155 North Wacker	155 N. Wacker	Office	1,327,735	2009	79.2	190.7
52	300 North LaSalle	300 N LaSalle	Office	1,506,959	2007	60	179.5
53	231 South LaSalle	231 S. LaSalle Street	Office	1,123,407	1924	87.9	174.7

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Benchmarking

Year Built	Average EUI
1902-1934	**81.7**
1969-1979	87.9
1980-1992	64.6
2001-2010	**78.2**

Sorted by Year Built

	Property Name	Address	Primary Type	Gross SF	Year Built	Site EUI (kBtu/sq ft)	Source EUI (kBtu/sq ft)
2	One North Dearborn	1-17 N. Dearborn Street	Office	1,046,276	1902	65.6	164.8
3	Sullivan Center	1 S State Street	Office	1,114,203	1903	70	153.3
4	231 South LaSalle	231 S. LaSalle Street	Office	1,123,407	1924	87.9	174.7
5	175 W. Jackson	175 W. Jackson	Office	1,803,140	1928	81.9	168
6	20 North Wacker Drive	20 North Wacker Drive	Office	1,742,899	1929	67.2	144.3
7	Chicago Board of Trade Building	141 W. Jackson Blvd.	Office	1,559,956	1930	105	239.1
8	Merchandise Mart	222 Merchandise Mart Plaza	Office	4,101,281	1930	63.4	131.2
9	135 S LaSalle Property LLC	135 S. LaSalle Street	Office	1,547,139	1931	113.1	213.6
10	111 East Wacker Drive	111 East Wacker Drive	Office	1,281,847	1969	87.6	184.1
11	222 South Riverside Plaza	222 South Riverside Plaza	Office	1,237,455	1971	83.5	206
12	100/150 S. Wacker	150 South Wacker	Office	1,281,114	1971	85.2	196.5
13	AMA Plaza	330 North Wabash	Office	1,930,764	1971	89	191.1
14	233 North Michigan Avenue	233 North Michigan Avenue	Office	1,215,747	1972	84.8	184.5
15	Aon Center	200 E. Randolph Street	Office	3,193,966	1972	85.6	146.2
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21	333 South Wabash	333 S. Wabash	Office	1,274,198	1974	118.3	277.6
22	River North Point	350 North Orleans Street	Office	1,883,966	1975	101.6	265.4
23	303 E. Wacker	303 E. Wacker	Office	1,015,129	1979	61	191.2
24	55 West Monroe	55 W. Monroe Street	Office	1,065,065	1980	65.9	180.5
25	70 W Madison	70 W. Madison St	Office	1,515,404.30	1981	64.4	200.7
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33	Four40	440 South LaSalle	Office	1,157,744	1984	81.6	257
34	James R Thompson Center	100 W. Randolph St.	Office	1,200,000	1985	102.8	254.5
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= *Majority Opaque Exterior* = *Majority Glazed Exterior*

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9	[illegible]	[illegible]	Office	1,547,139	1931	[illegible]	[illegible]
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41	311 S. Wacker	311 South Wacker	Office	1,433,821	1990	60.1	188.7
42	181 West Madison	181 W Madison Street	Office	1,082,248	1990	70.7	221.9
43	500 West Monroe	500 West Monroe	Office	1,153,491	1992	50.6	157.6
44	161 North Clark	161 North Clark	Office	1,200,836	1992	70	219.9
45	77 West Wacker Drive	77 W. Wacker Drive	Office	1,153,218	1992	53.3	167.3
46	One North Wacker	1 North Wacker Drive	Office	1,603,374	2001	95.9	234.4
47	131 S. Dearborn 3	131 S. Dearborn	Office	1,652,550	2002	99	310.9
48	111 South Wacker	111 South Wacker	Office	1,248,730	2004	67.8	212.9
49	71 South Wacker	71 S. Wacker Drive	Office	1,687,710	2005	70.7	220.6
50	300 North LaSalle	300 N LaSalle	Office	1,506,959	2007	60	173.5
51	353 North Clark	353 North Clark Street	Office	1,364,257	2009	71.7	211.8
52	155 North Wacker	155 N. Wacker	Office	1,327,735	2009	79.2	190.7
53	[illegible]	[illegible]	Office	2,213,828	2010	[illegible]	[illegible]

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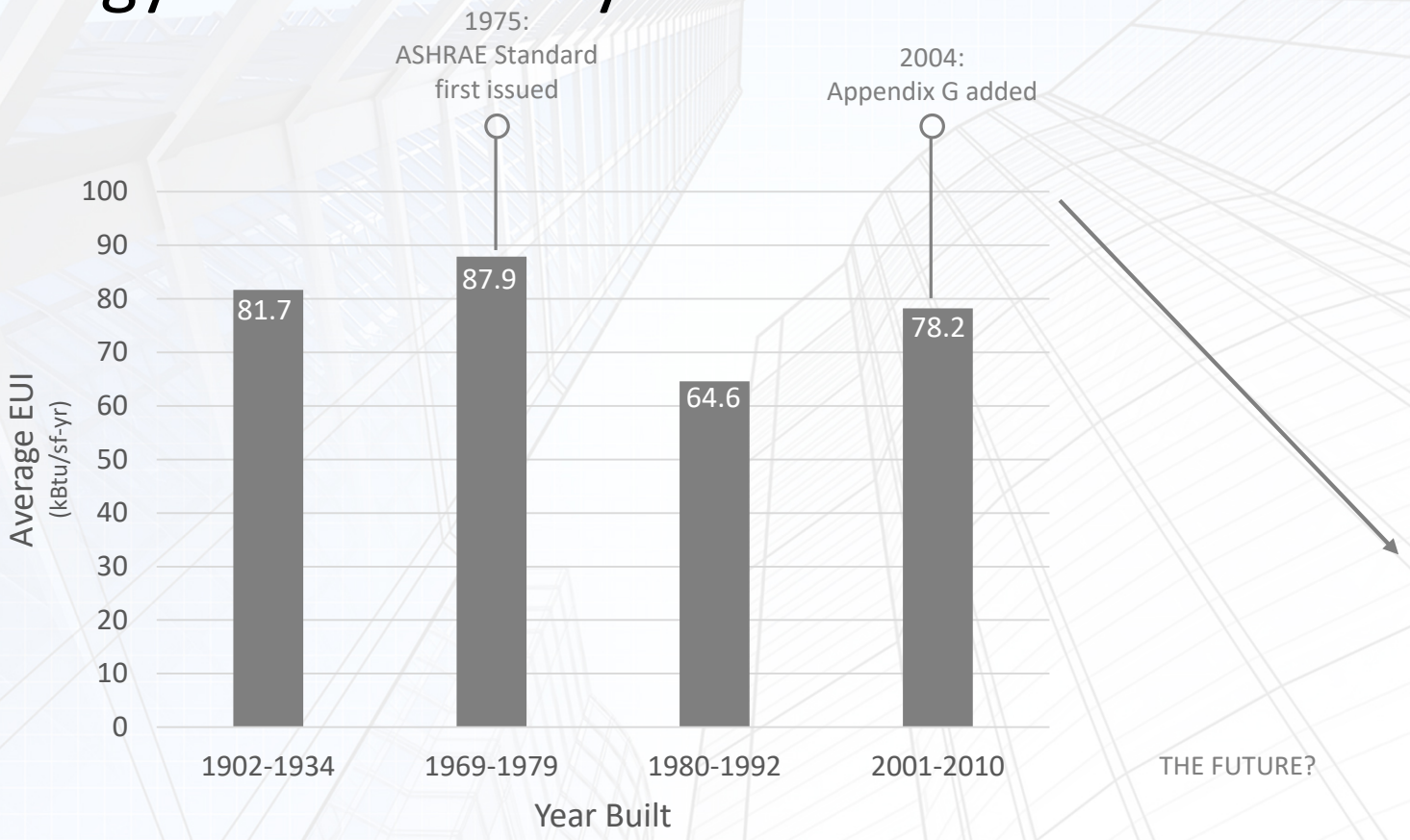
02
Energy Code

Energy Code: History of ASHRAE

- Energy crisis of 1973: ASHRAE president Robert R. Kirkwood "Optimum Energy Utilization Through Technology"
- February 1974: ASHRAE winter meeting in LA, National Bureau of Standards presented the idea of a building energy standard (Standard 90P) to 200 ASHRAE participants, and ASHRAE took over
- January 14, 1975: ASHRAE Standard 90-1975 issued
- ASHRAE 2004 edition: Appendix G (Energy Modeling) was added

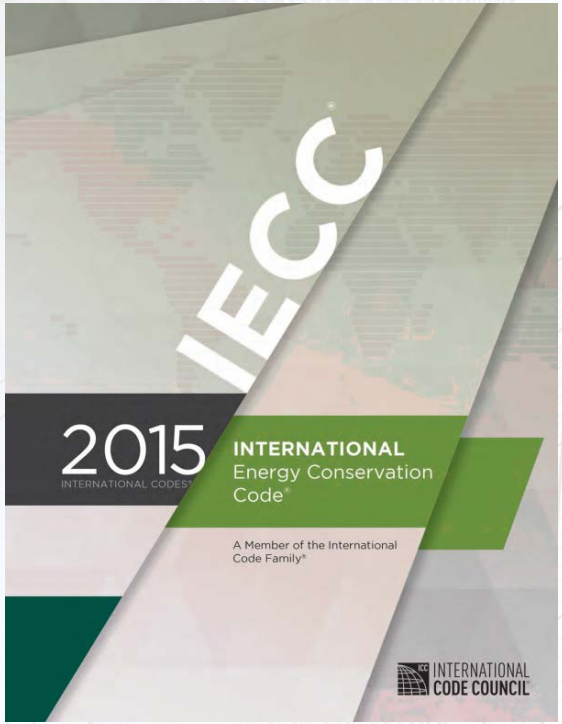
Source: https://en.wikipedia.org/wiki/ASHRAE_90.1#History_and_development

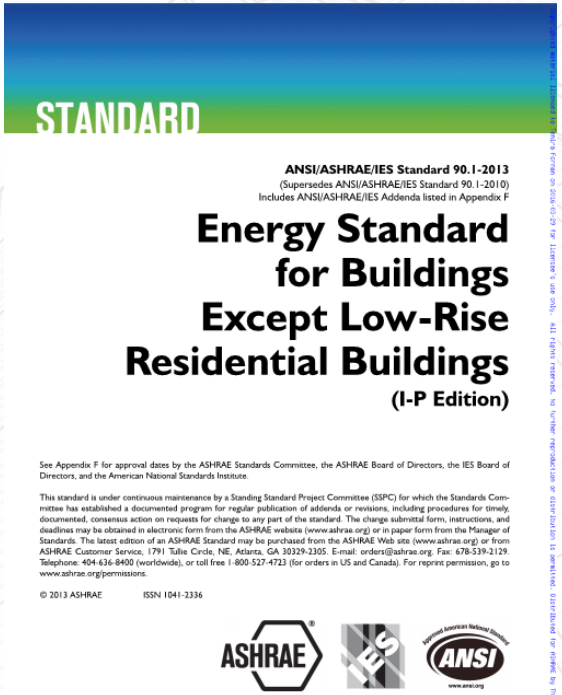
Energy Code: History of ASHRAE



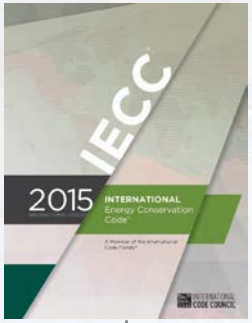
Energy Code: Paths

IECC OR ASHRAE 90.1



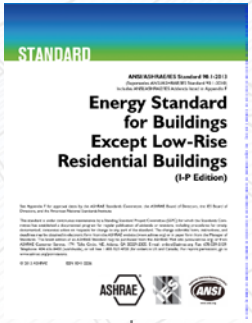


Energy Code: Paths



Prescriptive OR Envelope Trade-off

COMcheck



Prescriptive OR Performance OR Envelope Trade-off

COMcheck

Section 11 OR **Appendix G**

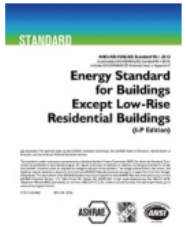
Energy Cost Budget Method (ECB)

Performance Rating Method (PRM)

Energy Code: Prescriptive

Prescriptive Window to Wall Ratio

30%*	*2 options for 40%
	≥50/25% conditioned sf is Daylight Zone
	& Daylight Zoned & VT=1.1*SHGC



40%

Source: Energy Code Impacts on the Design Process, Allison McSherry, Klein & Hoffman

Energy Code: Prescriptive

Prescriptive envelope requirements by climate zone

Table 5.5-5 Building Envelope Requirements for Climate Zone 5 (A,B,C)*

Opaque Elements	Nonresidential			Residential			Semiheated		
	Assembly Maximum	Insulation Min. R-Value		Assembly Maximum	Insulation Min. R-Value		Assembly Maximum	Insulation Min. R-Value	
Fenestration	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Min. VT/SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Min. VT/SHGC**	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Min. VT/SHGC**
Vertical Fenestration, 0%–40% of Wall		(for all frame types)			(for all frame types)			(for all frame types)	
Nonmetal framing, all	U-0.32			U-0.32			U-0.45		
Metal framing, fixed	U-0.42			U-0.42			U-0.62		
Metal framing, operable	U-0.50	SHGC-0.40	1.10	U-0.50	SHGC-0.40	1.10	U-0.70	NR	NR
Metal framing, entrance door	U-0.77			U-0.68			U-0.77		
Skylight, 0%–3% of Roof									
All types	U-0.50	SHGC-0.40	NR	U-0.50	SHGC-0.40	NR	U-0.98	NR	NR

* The following definitions apply: c.i. = continuous insulation (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), Ls = liner system (see Section A2.3.2.4), NR = no (insulation) requirement.
a. When using the R-value compliance method for metal building roofs, a thermal spacer block is required (see Section A2.3.2).
b. Exception to Section 5.5.3.2 applies for mass walls above grade.

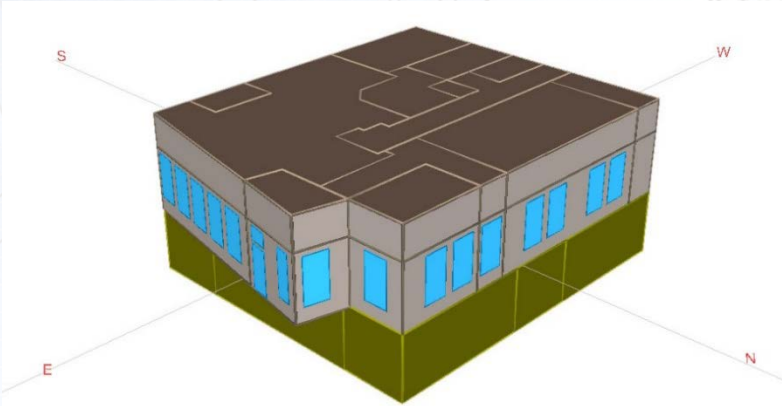
Table 5.5-5 Building Envelope Requirements for Climate Zone 5 (A,B,C)*

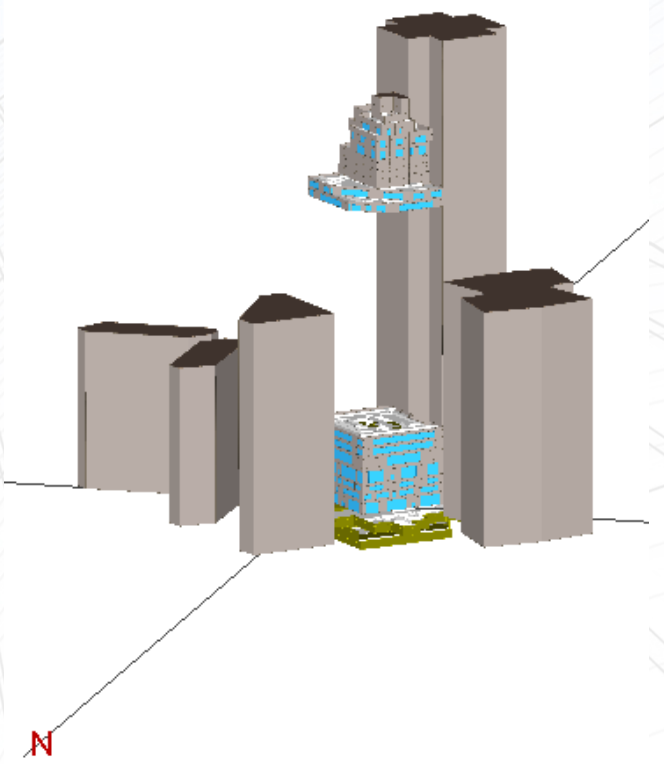
Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.032	R-30 c.i.	U-0.032	R-30 c.i.	U-0.063	R-15 c.i.
Metal Building[a]	U-0.037	R-19 + R-11 Ls or R-25 + R-8 Ls	U-0.037	R-19 + R-11 Ls or R-25 + R-8 Ls	U-0.082	R-19
Attic and Other	U-0.021	R-49	U-0.021	R-49	U-0.034	R-30
Walls, above Grade						
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[b]	R-5.7 c.i.[b]
Metal Building	U-0.050	R-0 + R-19 c.i.	U-0.050	R-0 + R-19 c.i.	U-0.094	R-0 + R-9.8 c.i.
Steel Framed	U-0.055	R-13 + R-10 c.i.	U-0.055	R-13 + R-10 c.i.	U-0.084	R-13+R-3.8 c.i.
Wood Framed and Other	U-0.051	R-13 + R-7.5 c.i. or R-19 + R-5 c.i.	U-0.051	R-13 + R-7.5 c.i. or R-19 + R-5 c.i.	U-0.089	R-13
Wall, below Grade						
Below Grade Wall	C-0.119	R-7.5 c.i.	C-0.092	R-10 c.i.	C-1.140	NR
Floors						
Mass	U-0.057	R-14.6 c.i.	U-0.051	R-16.7 c.i.	U-0.107	R-6.3 c.i.
Steel Joist	U-0.038	R-30	U-0.038	R-30	U-0.052	R-19
Wood Framed and Other	U-0.033	R-30	U-0.033	R-30	U-0.051	R-19
Slab-on-Grade Floors						
Unheated	F-0.520	R-15 for 24 in	F-0.510	R-20 for 24 in.	F-0.730	NR
Heated	F-0.688	R-20 for 48 in.	F-0.688	R-20 for 48 in.	F-0.900	R-10 for 24 in.
Opaque Doors						
Swinging	U-0.500		U-0.500		U-0.700	
Nonswinging	U-0.500		U-0.500		U-1.450	

Energy Code - Performance

Performance path (energy modeling):

- Different Purposes: Design assistance, general energy savings, code/LEED Compliance
- Test Energy Conservations Measures (ECMs): envelope, insulation, glazing, HVAC, controls



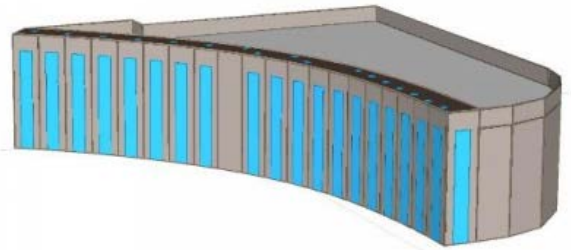


Energy Code - Performance

Most common reasons to perform an energy model rather than use the prescriptive path:

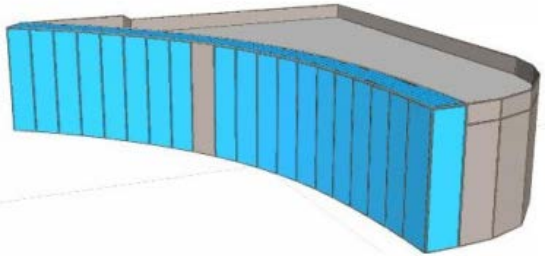
- High WWR
  IECC requires ≤ 30% WWR
  ASHRAE 90.1 requires ≤ 40% WWR
- ‘Transparent’ single pane glass
  > U-value requirements
- Tradeoffs (envelope, lighting, HVAC)

Baseline eQuest model



U-0.42
40% WWR
Code HVAC

Proposed Design eQuest model

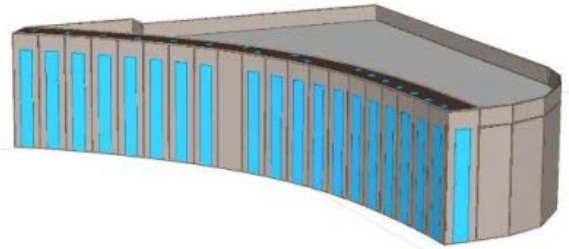


U-1.0
100% WWR
Efficient HVAC

Energy Code

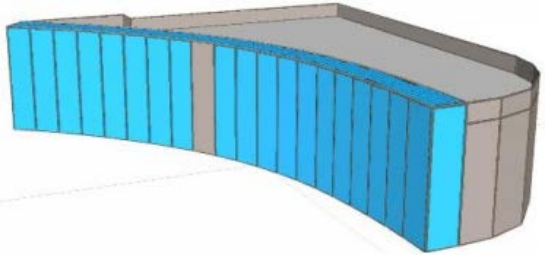
- "Trade-Off:"
  Envelope vs Mechanical System
- Is it a "fair-trade?"
- *Energy is not the only thing that matters!*
  - Aesthetics
  - Cost
  - Views
  - Usable SF
  - Daylight & visual comfort
  - Thermal comfort
  - Condensation potential & moisture issues

Baseline eQuest model



U-0.42
40% WWR
Code HVAC

Proposed Design eQuest model



U-1.0
100% WWR
Efficient HVAC

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03
High-Rise Commercial Repositioning

High-Rise Commercial Repositioning

- Mid-Century Modern and Post-Modern High Rises (1950 – 1990)

	Property Name	Address	Primary Type	Gross SF	Year Built	Site EUI (kBtu/sq ft)	Source EUI (kBtu/sq ft)
2	One North Dearborn	1-17 N. Dearborn Street	Office	1,046,276	1902	65.6	164.8
3	Sullivan Center	1 S State Street	Office	1,114,203	1903	70	153.3
4	231 South LaSalle	231 S. LaSalle Street	Office	1,129,407	1924	87.9	174.7
5	175 W. Jackson	175 W. Jackson	Office	1,809,140	1928	81.9	168
6	20 North Wacker Drive	20 North Wacker Drive	Office	1,742,899	1929	67.2	144.3
7	Chicago Board of Trade Building	141 W. Jackson Blvd.	Office	1,559,956	1930	105	239.1
8	Merchandise Mart	222 Merchandise Mart Plaza	Office	4,101,281	1930	63.4	131.2
10	111 East Wacker Drive	111 East Wacker Drive	Office	1,281,847	1969	87.6	184.1
11	222 South Riverside Plaza	222 South Riverside Plaza	Office	1,237,455	1971	83.5	206
12	100/150 S. Wacker	150 South Wacker	Office	1,281,114	1971	85.2	196.5
13	AMA Plaza	330 North Wabash	Office	1,930,764	1971	89	191.1
14	233 North Michigan Avenue	233 North Michigan Avenue	Office	1,215,747	1972	84.8	184.5
15	Aon Center	200 E. Randolph Street	Office	3,193,966	1972	85.6	146.2
16	55 East Monroe	55 East Monroe Street	Office	1,674,462	1972	96	223.4
17	Prudential Plaza	130 East Randolph & 180 North Stetso	Office	2,751,035	1972	69.1	181.4
18	Willis Tower	233 S Wacker Drive	Office	4,518,811	1973	90.3	283
19	Harris Bank Building	115 S. LaSalle Street	Office	1,526,102	1974	116.4	247.4
20	30 North LaSalle Street	30 North LaSalle Street	Office	1,095,104	1974	62.7	146.3
21	333 South Wabash	333 S. Wabash	Office	1,274,198	1974	118.3	277.6
22	River North Point	350 North Orleans Street	Office	1,883,966	1975	101.6	265.4
23	303 E. Wacker	303 E. Wacker	Office	1,015,129	1979	61	131.2
24	33 West Monroe	33 W. Monroe Street	Office	1,085,869	1980	63.3	160.3
25	70 W Madison	70 W. Madison St	Office	1,515,404.30	1981	64.4	200.7
26	Michigan Plaza	205/225 N Michigan Ave	Office	2,059,714	1981	57.6	180.7
27	One South Wacker	1 South Wacker	Office	1,343,438	1982	49.2	154.5
28	333 West Wacker	333 West Wacker Drive	Office	1,012,961	1982	53.2	166.9
29	200 West Madison	200 West Madison	Office	1,001,834	1982	56.3	176.8
30	10 and 30 South Wacker	10 South Wacker Drive	Office	2,662,457	1983	68.7	214
31	525 West Monroe	525 West Monroe Street	Office	1,028,492	1983	52.9	164.9
32	300 South Riverside Plaza	300 South Riverside Plaza	Office	1,222,064	1983	60.8	190.9
33	Four40	440 South LaSalle	Office	1,157,744	1984	81.8	257
34	James R Thompson Center	100 W. Randolph St.	Office	1,200,000	1985	102.8	254.5
35	500 West Madison	500 West Madison Street	Office	1,855,810	1986	66.1	207.7
36	222 North LaSalle	222 North LaSalle Street	Office	1,217,630	1986	53	158.2
37	321 N. Clark Property, LLC	321 North Clark	Office	1,025,053	1987	57.5	180.5
38	MBC Tower	455 North Cityfront Plaza Drive	Office	1,006,126	1988	89.3	282.4
39	The Franklin (227 West Monroe; 222 West Adams	227 West Monroe	Office	2,360,211	1989	71.6	224.1
40	Leo Burnett Building	35 W. Wacker Dr.	Office	1,392,096	1989	67.5	209.6
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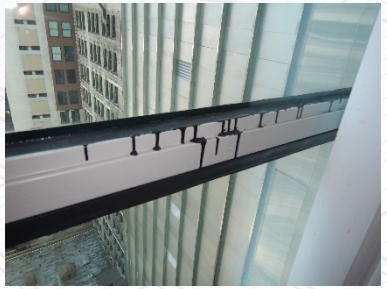
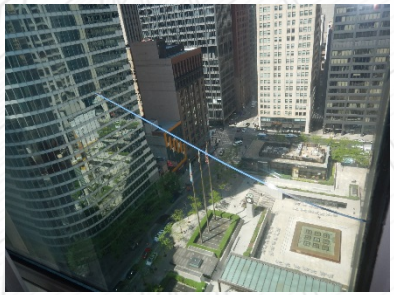
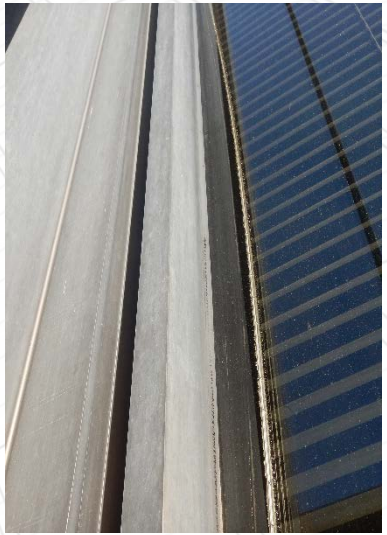
51	353 North Clark	353 North Clark Street	Office	1,364,257	2009	71.7	211.8
52	155 North Wacker	155 N. Wacker	Office	1,327,735	2009	79.2	190.7
53	300 E Randolph	300 East Randolph	Office	2,218,838	2010	81.7	189.8

High-Rise Commercial Repositioning

- Curtain wall and window wall service life
  - Open joints at split-mullion and stack joints
  - Deteriorated seals at sills/jambs
  - Deteriorated sealants and gaskets
  - Deteriorated IGU seals and spacer bars
- Older glazing technology vs. present-day design loads







High-Rise Commercial Repositioning

1095 Avenue of the Americas

New York, NY

1974

2009

High-Rise Commercial Repositioning

5 Manhattan West

New York, NY

1969

2017

High-Rise Commercial Repositioning

Anthony J. Celebrezze Federal Building

Cleveland, OH

1966

2014

High-Rise Commercial Repositioning

Unitized Curtain Wall Advantages:

-Aesthetics

-Installation

-Cost

High-Rise Commercial Repositioning

Insulated Opaque Wall Advantages:

-Performance

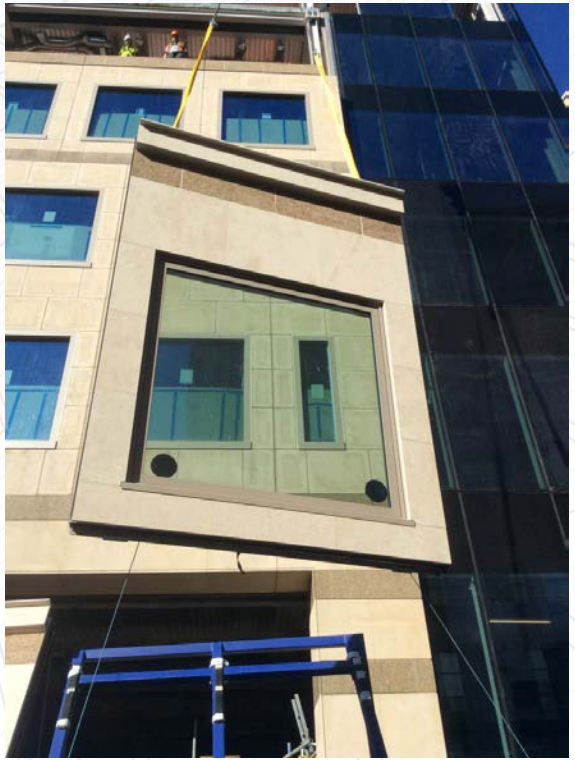
-Durability

-Installation

-Cost

Easi Set: https://easiset.com/

Island Exterior Fabricators: https://islanddef.com



EAG: https://www.eag.uk.com

High-Rise Commercial Repositioning

TYPICAL METAL PANEL | CONSTRUCTION PROCESS

STEP 1 | Island's aluminum and steel stud framing system assembled.

STEP 2 | Sheathing + waterproofing membrane application.

STEP 3 | Perimeter frame extrusions and visual gasket applied.

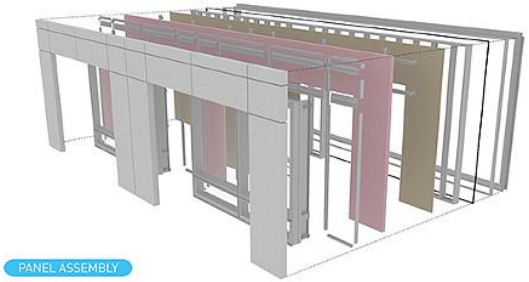
STEP 4 | Horizontal and vertical sub-frame girts installed.

STEP 5 | Semi-rigid insulation and stickpins are applied and waterproofed.

STEP 6 | Window gaskets, structural silicone and glazing installed.

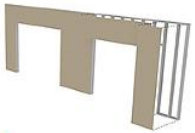
STEP 7 | Aluminum composite metal panels and clips installed.

STEP 8 | Panel is water-sealed, cleaned, checked for quality control, and is ready for shipment + erection.



PANEL ASSEMBLY

STEP 1



STEP 2

STEP 3

STEP 4

STEP 5

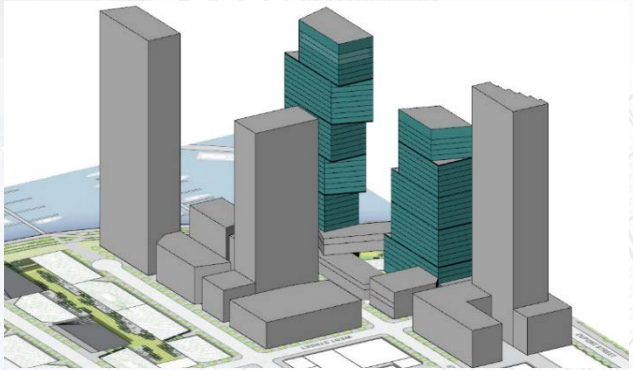
STEP 6

STEP 7

STEP 8

Island Exterior Fabricators: https://islanddef.com

High-Rise Commercial Repositioning



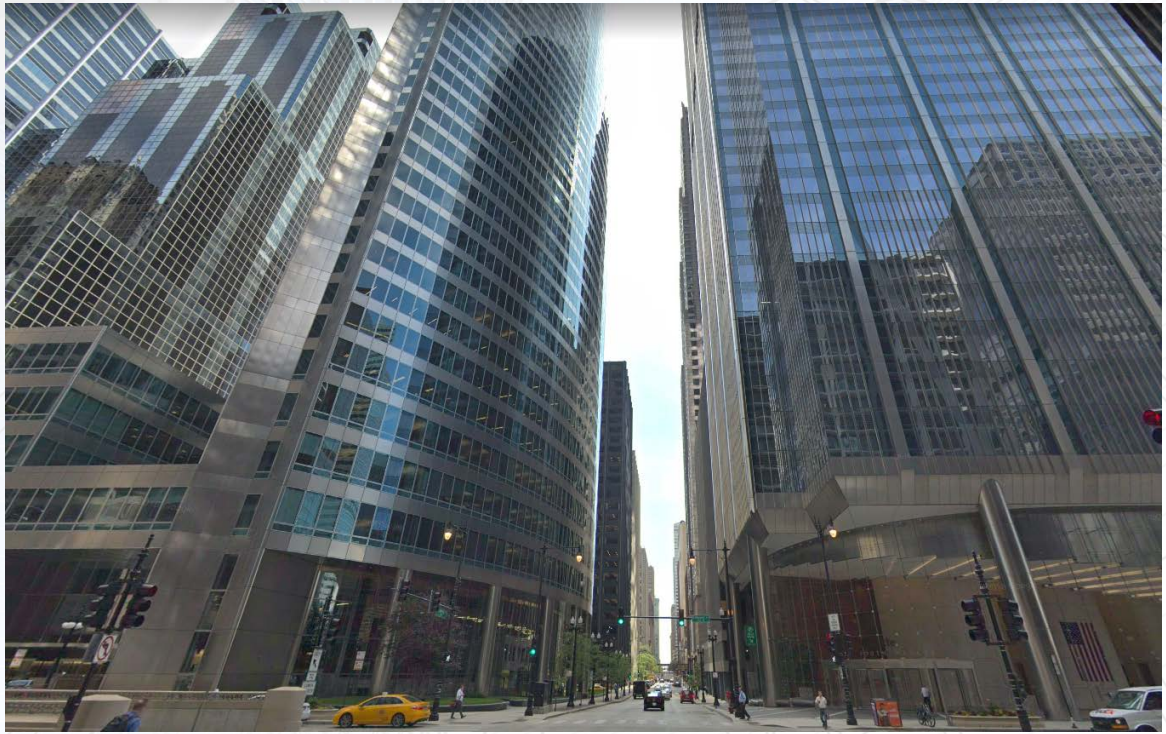
Fully-Glazed Exterior

Punched Openings w/ Opaque Walls

Aesthetics	✓	
Cost	✓	✓*
Energy Performance		✓
Occupant Comfort		✓
Views	✓*	

High-Rise Commercial Repositioning

Views?



High-Rise Commercial Repositioning

Usable Square Footage

-Chicago Commercial Office Real-Estate = **$140 / SF**

-Perimeter Baseboard Systems: (180'x180' footprint) = **576 SF per Floor**

-Potential SF value:

$140/SF x 576 SF x 40 Floors = **$3,225,600.00**

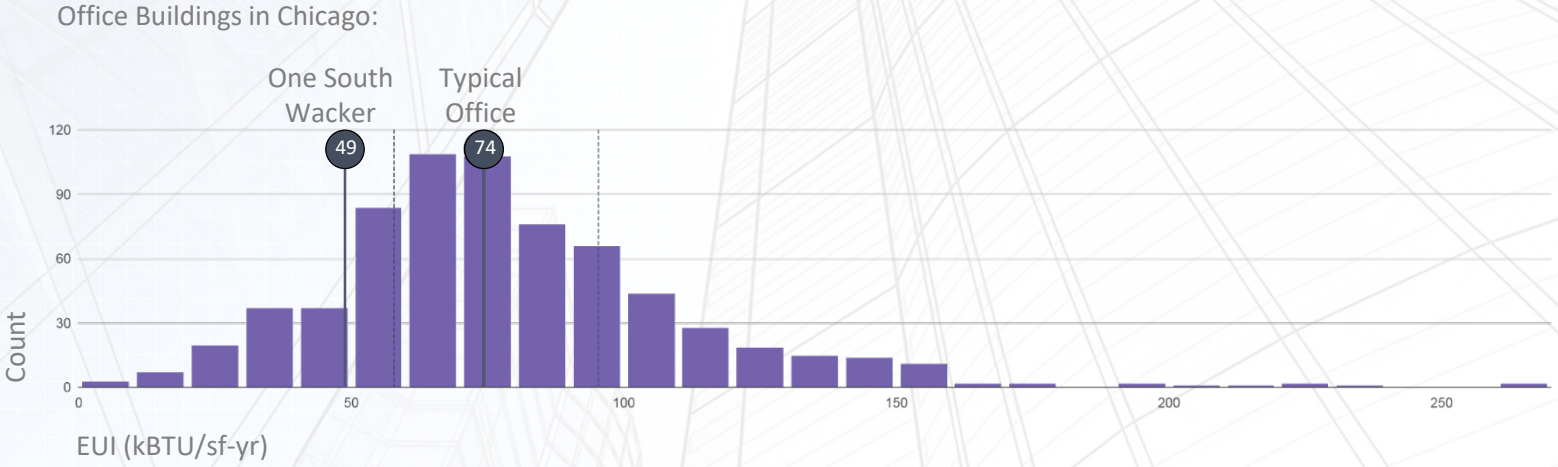
04
Case Study

Case Study: One South Wacker, Chicago, IL

Property Name	Address	Primary Type	Gross SF	Year Built	Site EUI (kBtu/sq ft)
70 W Madison	70 W. Madison St	Office	1,515,404.30	1981	64.4
Michigan Plaza	205/225 N Michigan A	Office	2,059,714	1981	57.6
One South Wacker	1 South Wacker	Office	1,343,438	1982	49.2
333 West Wacker	333 West Wacker Dri	Office	1,012,961	1982	53.2
200 West Madison	200 West Madison	Office	1,001,834	1982	56.3
10 and 30 South Wacker	10 South Wacker Driv	Office	2,662,457	1983	68.7

Case Study - Existing

- Data from Chicago Energy Benchmarking Ordinance shows **One South Wacker** at an **EUI of 49.2 kBtu/sf-yr**
- It's already doing pretty well (relatively), but why not be better? Improvements can be made to optimize for energy, as well as comfort, etc.



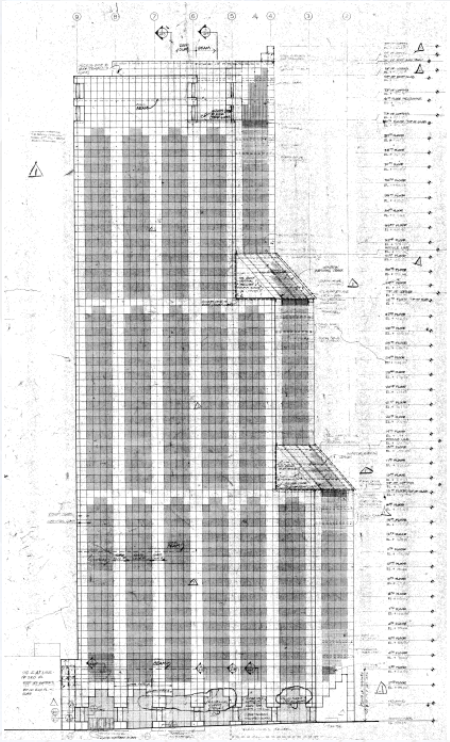
Source: Building Performance Database - https://bpd.lbl.gov

Case Study: One South Wacker, Chicago, IL

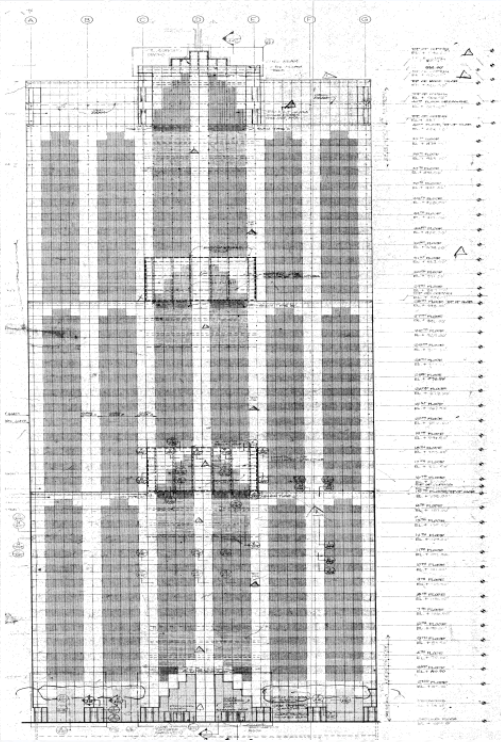
Energy Analysis:

1) Existing building
2) Re-Clad: Fully-Glazed Curtain Wall System
3) Re-Clad: 40% Glazed with Opaque Wall Assemblies

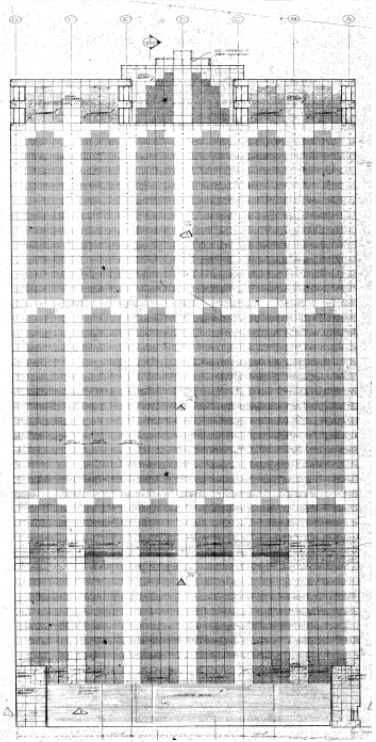
Case Study - Existing



North



West



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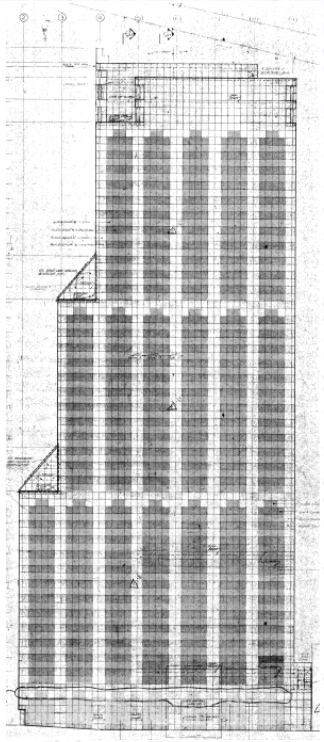
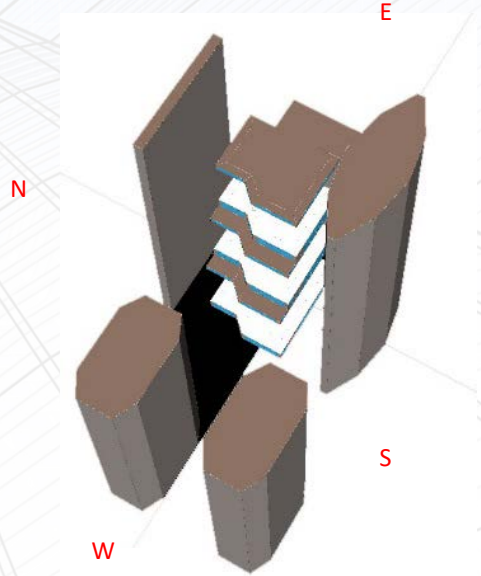


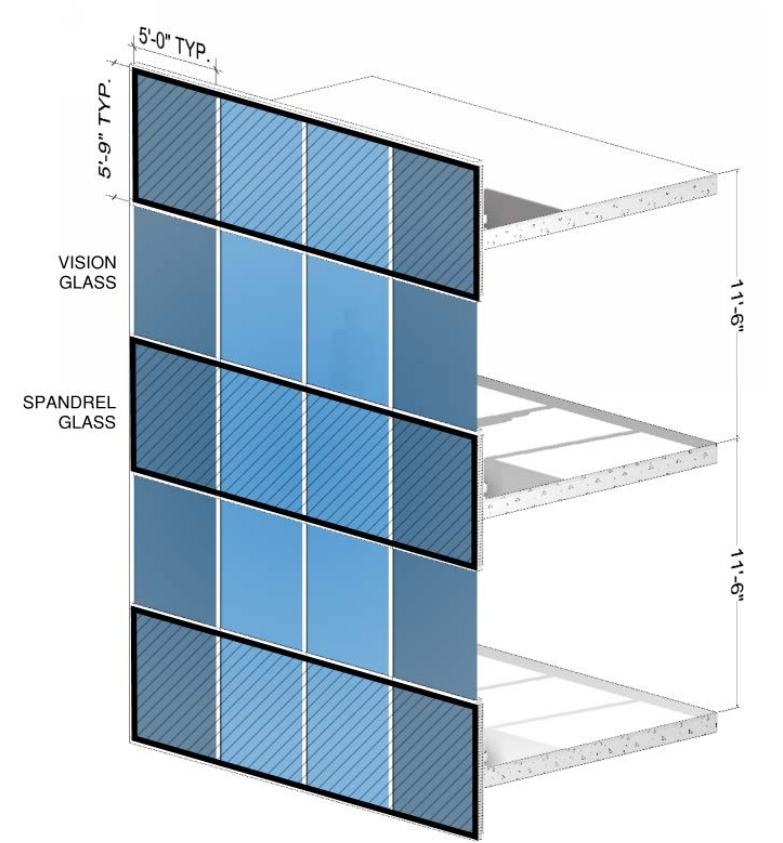
South

Case Study - Existing

- Wall assembly: Overall R-5.2
- Glazing: U-0.68, SHGC 0.47
- WWR: Overall 45%
  (20-65% depending on orientation & floor)
- Mechanical systems:
  VAV w/Electric Reheat + Unit Heaters



Case Study - Existing

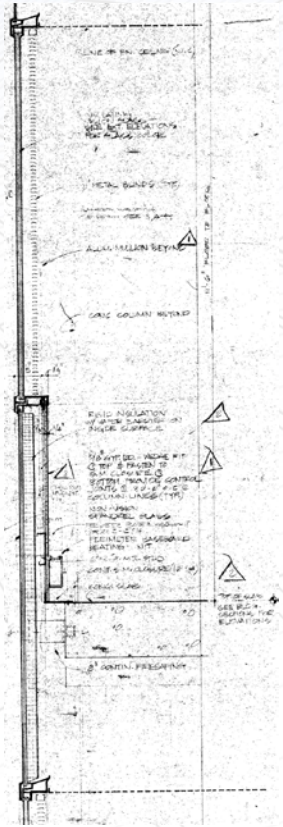


VISION GLASS

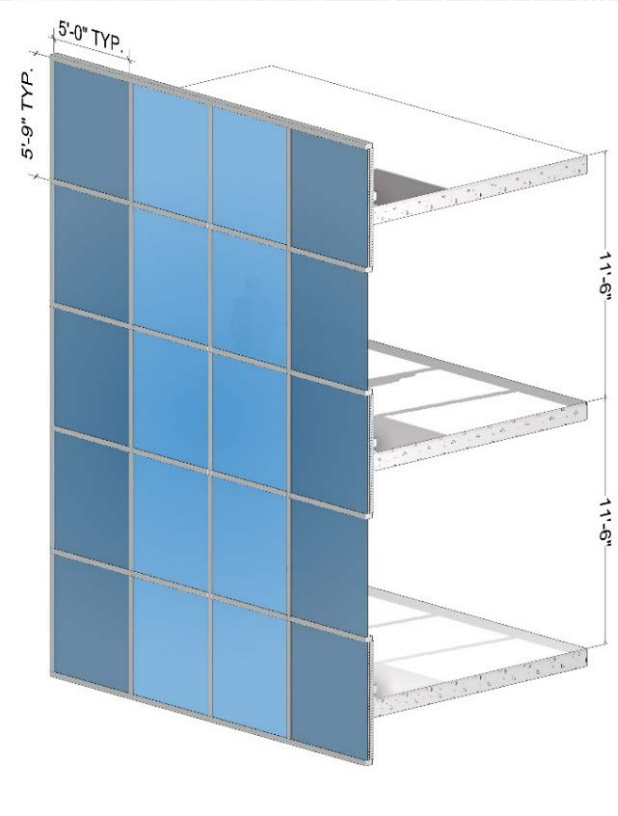
-Insulated Glass Unit (IGU), Tinted

SPANDREL GLASS

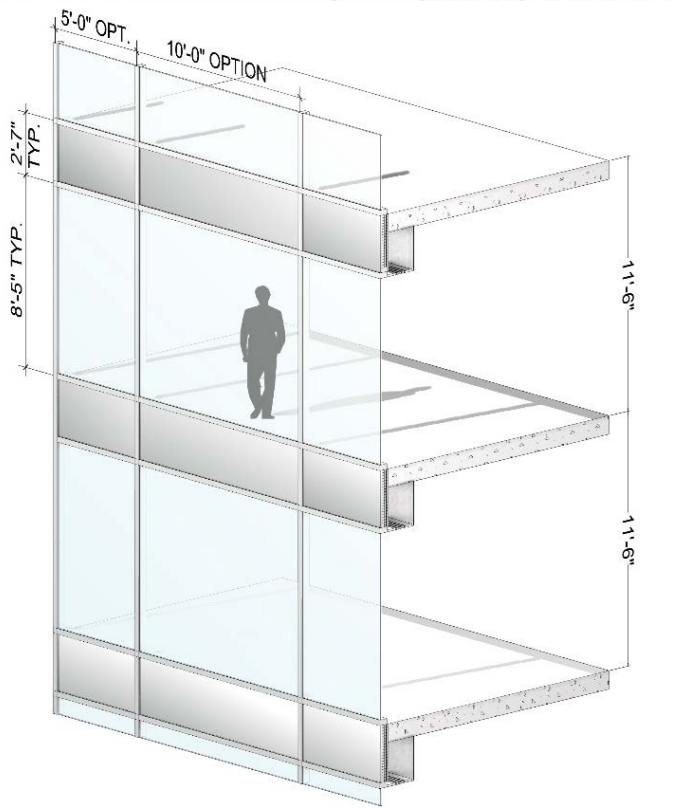
-Single Pane Glazing, Tinted
-Rigid Insulation
-Gyp. Board on Metal Stud Framing above Slab



Case Study – Fully-Glazed

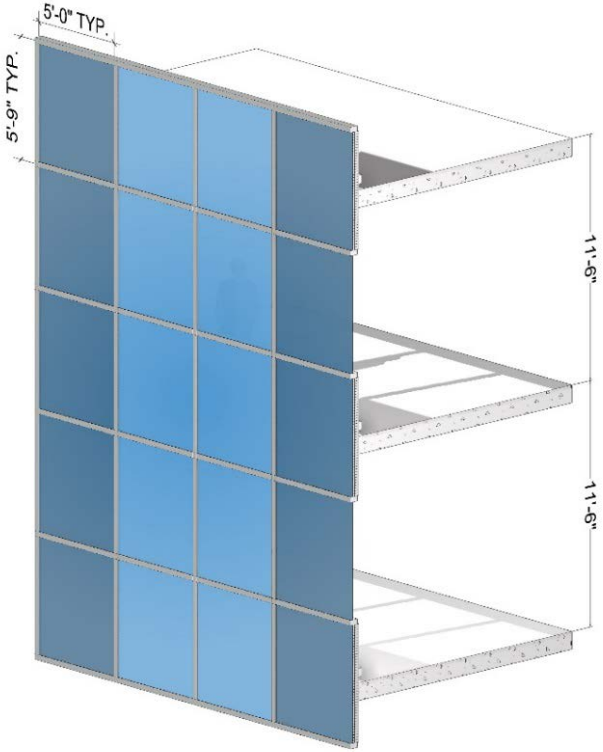


Existing

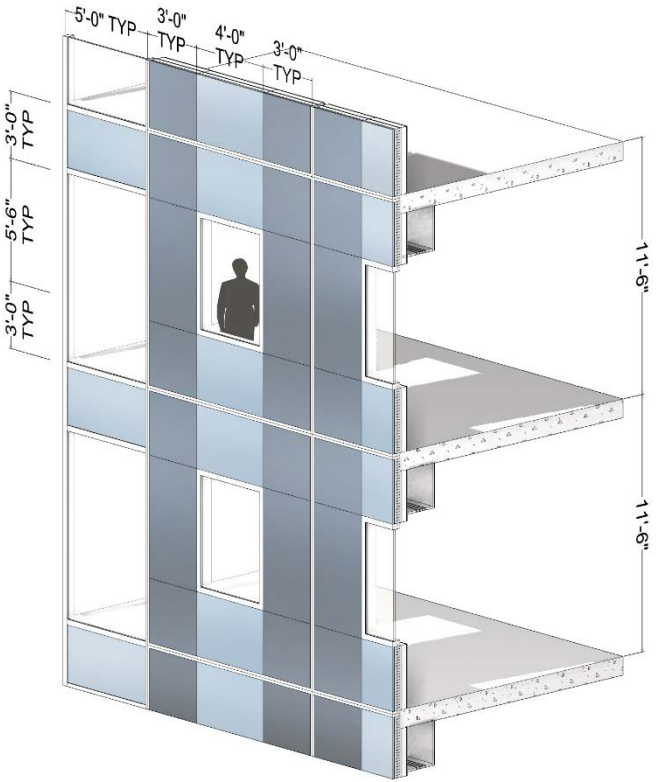


Re-Clad with Fully-Glazed System

Case Study – 40% Glazed with Opaque Walls

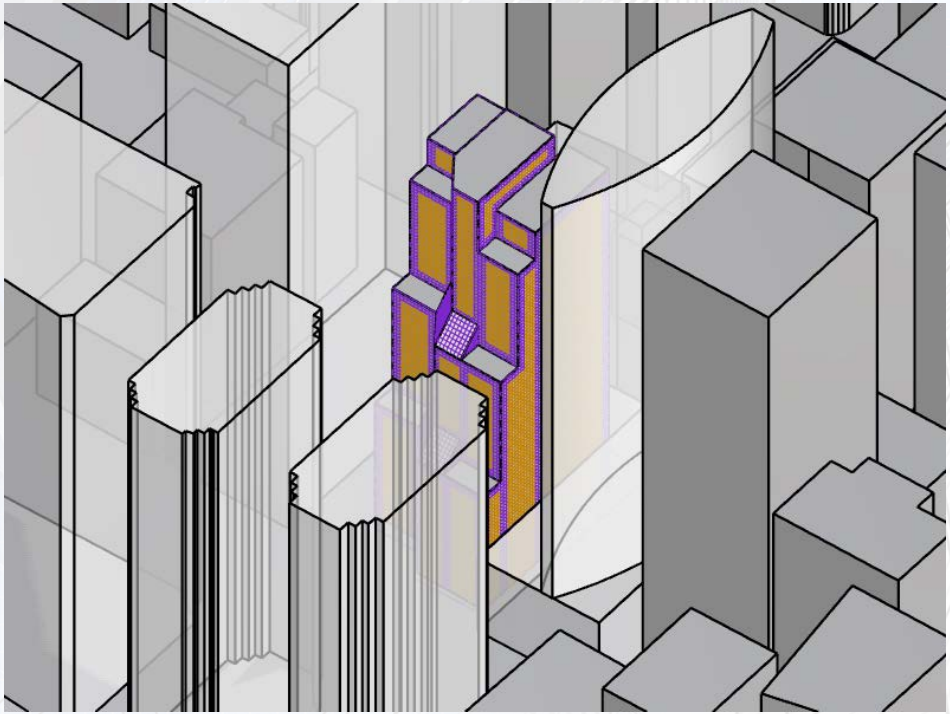


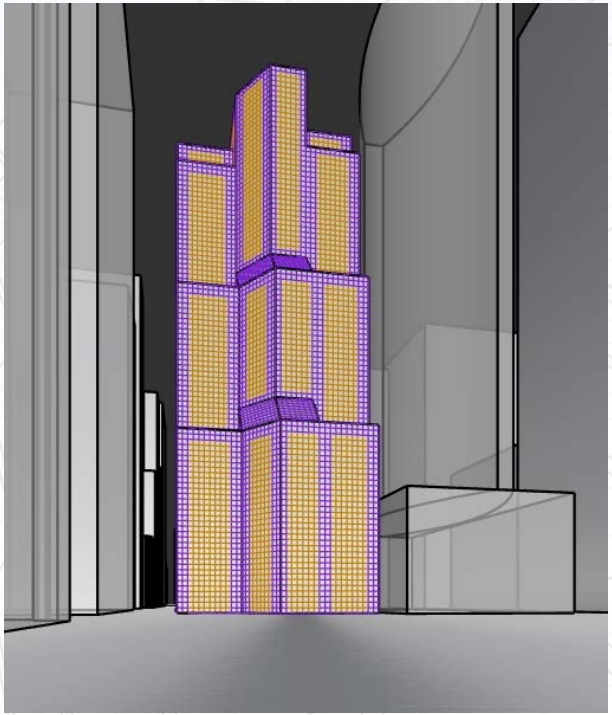
Existing



Re-Clad with Unitized Opaque Panels

Case Study – 40% Glazed with Opaque Walls

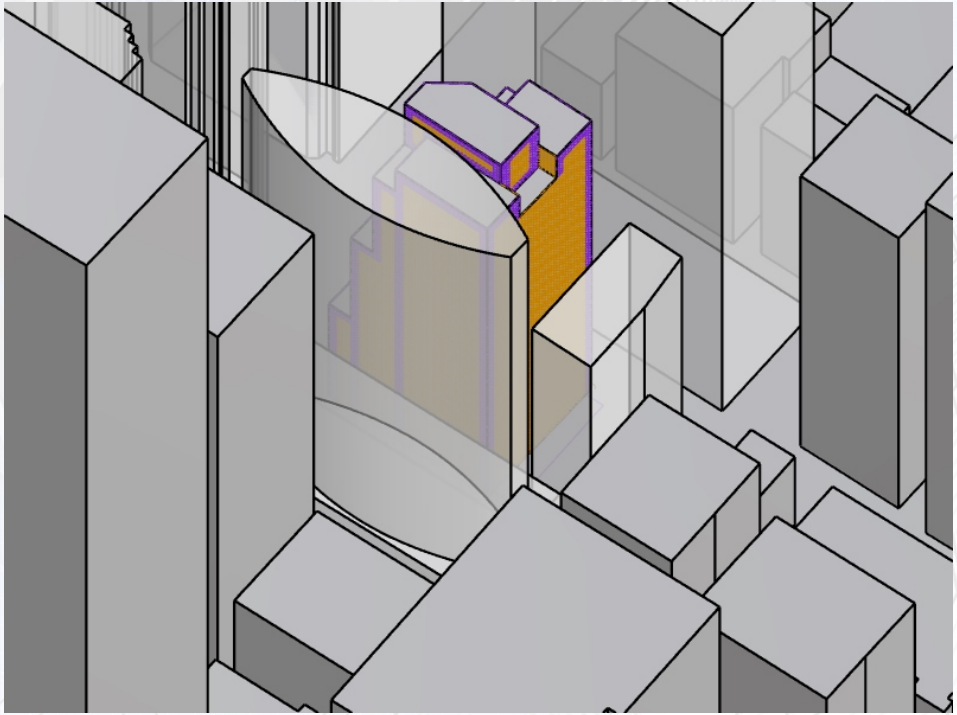




= *Fully-Glazed Areas*

= *Unitized-Opaque Wall with Windows (20%)*

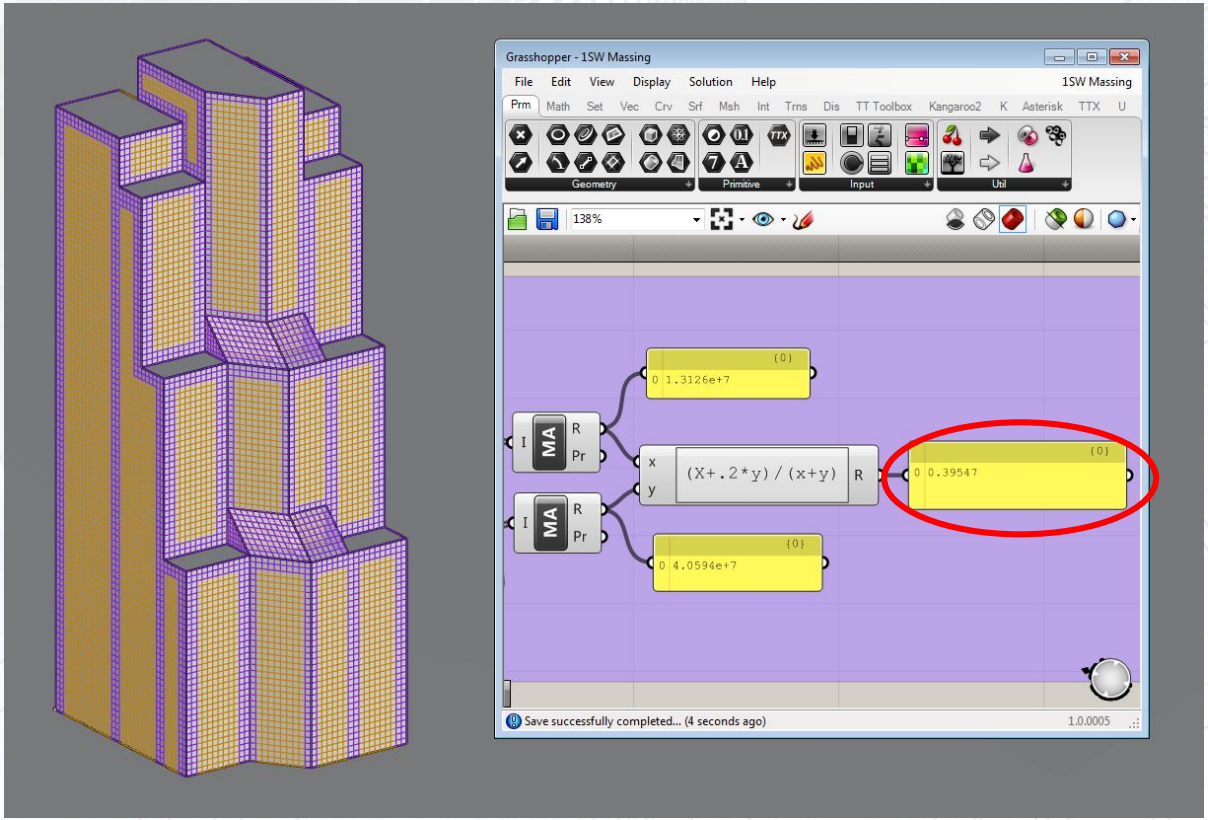
Case Study – 40% Glazed with Opaque Walls



= *Fully-Glazed Areas*

= *Unitized-Opaque Wall with Windows (20%)*

Case Study – 40% Glazed with Opaque Walls

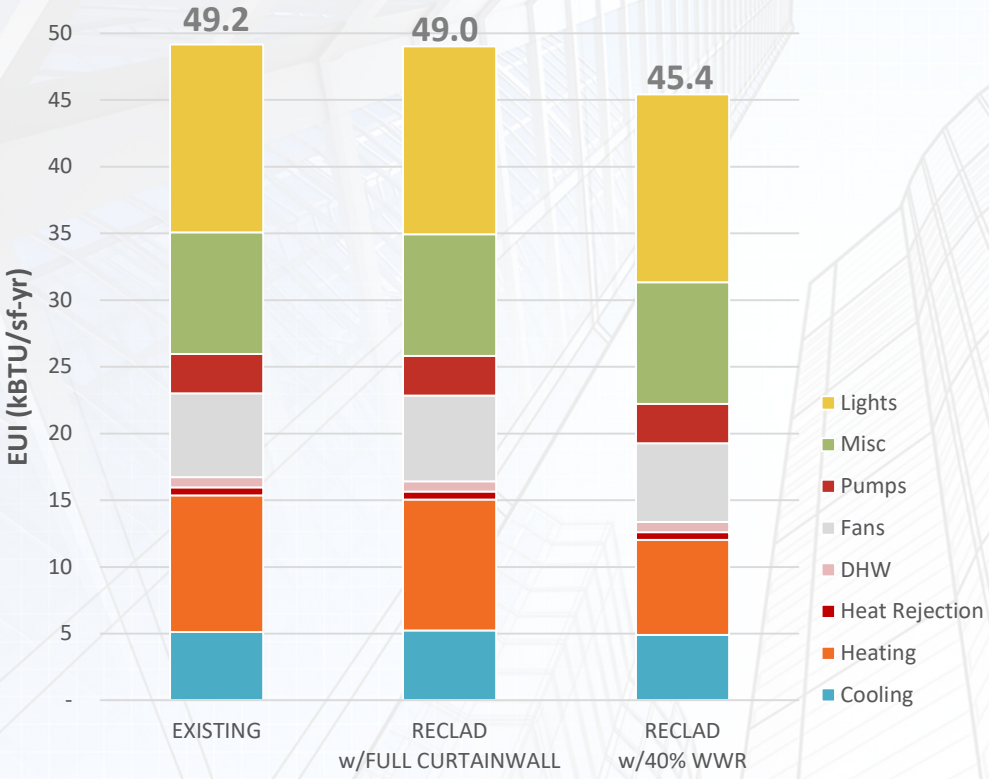


Window-to-Wall Ratio: 39.54%

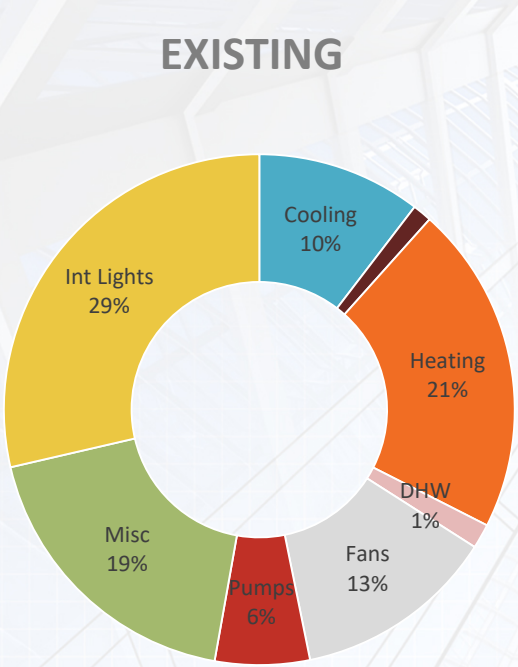
Case Study – Comparison Options

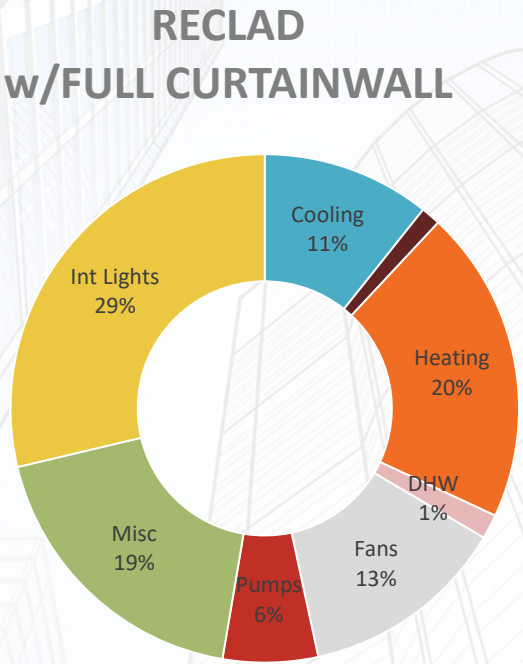
ENERGY MODEL INPUT PARAMETERS			
General Info			
Weather File	Chicago, IL		
Climate Zone	5A		
Flr-to-flr heights	11'-6"		
Flr-to-clg heights	10'-8"		
Model Input Parameter	**Existing Building**	**Re-Clad with Full Curtwainwall**	**Re-Clad with Curtainwall + Opaque Assemblies**
Building Envelope			
Roofs	Metal Frame, > 24 in. o.c. 1.5" polystyrene (R-6) exterior insulation U-0.092 (R-10.9)	Same as Existing	Same as Existing
Walls - Above Grade	Metal Frame, 2x4, 16 in. o.c. 1.5" polystyrene (R-6) exterior insulation U-0.192 (R-5.2)	R-5	U-0.066 (R-15.15)
Fenestration and Shading			
Vertical fenestration Area (% of Wall area)	Overall: 45.5% South - 50% North - 50% East - 20% West - 65%	75%	40% overall: South - 38% North - 40% East - 32% West - 47%
Vertical Glazing Description		Solarban60 Solarblue + Clear	Solarban60 Solarblue + Clear
Vertical Glazing U-factor	U-0.68	U-0.32	U-0.32
Vertical Glazing SHGC	0.47	0.30	0.30

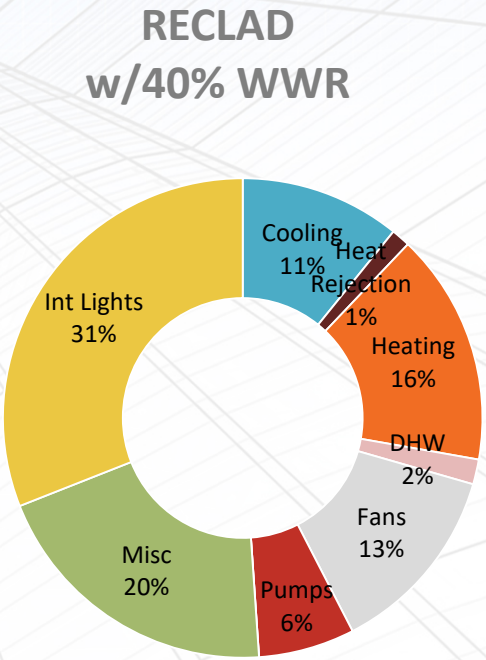
Case Study – Energy



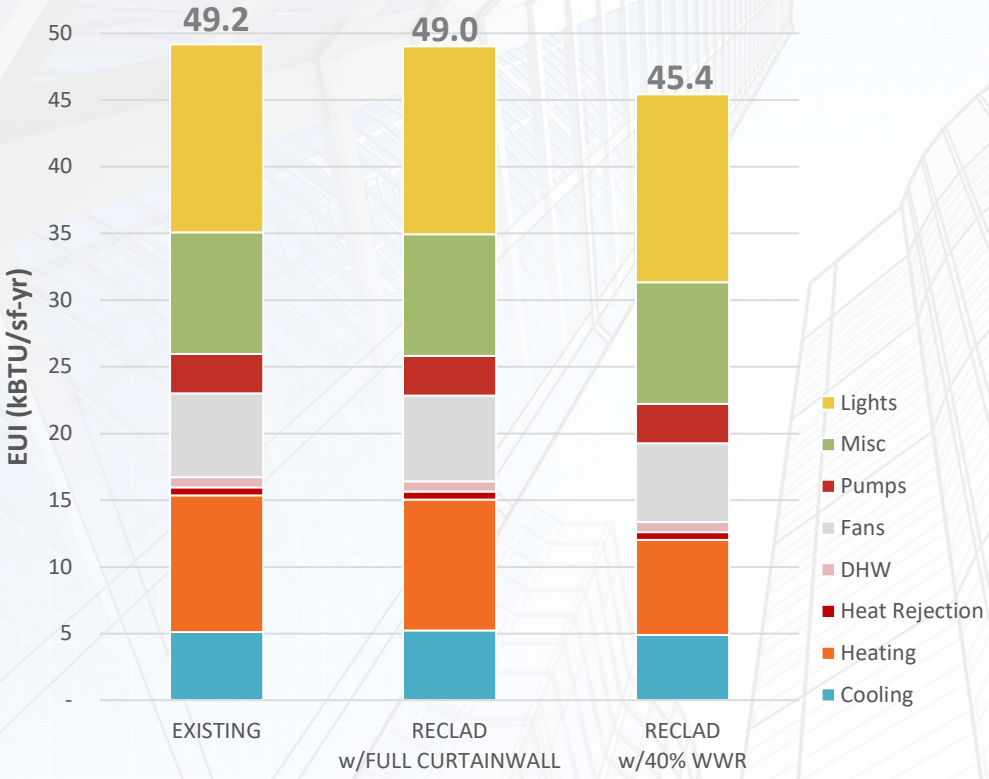
Case Study – Energy







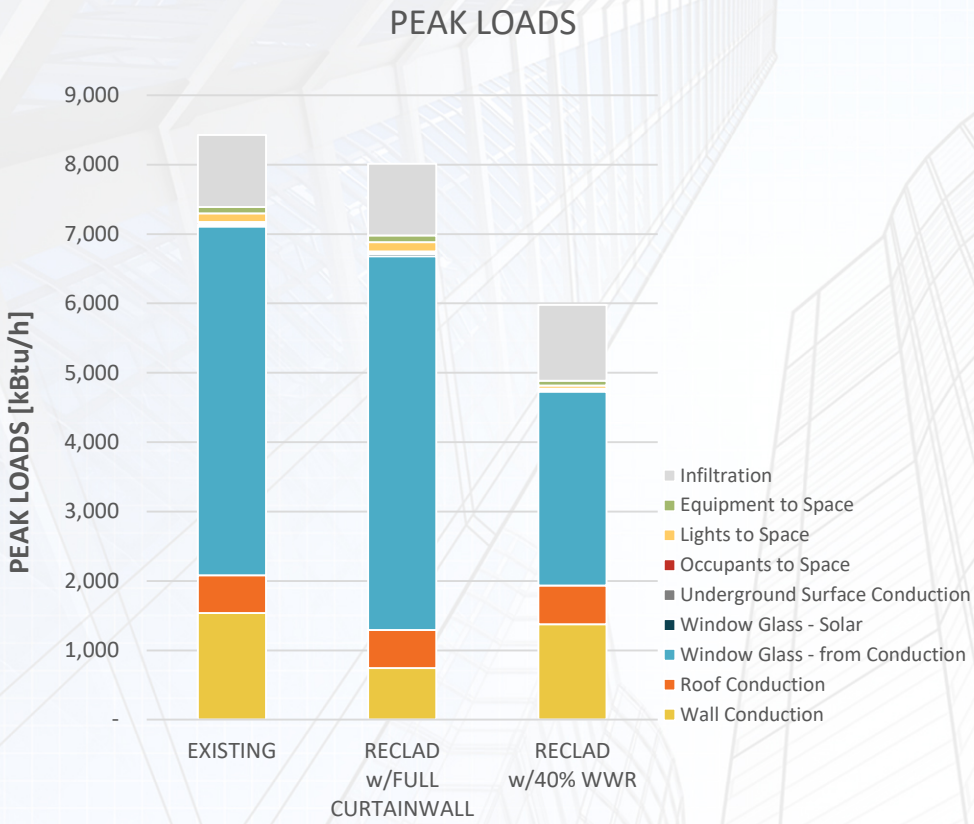
Case Study – Other Considerations



Other considerations:

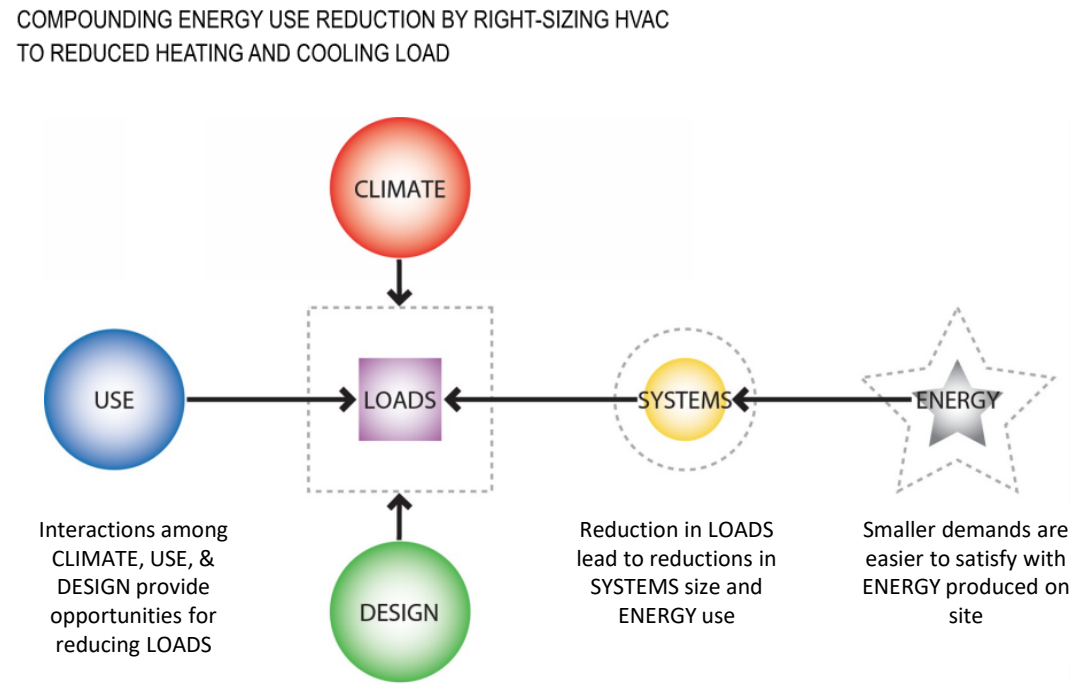
- Reduced loads
  -> reduced HVAC system needs
  -> increased usable SF
- Thermal comfort + usable SF
- Visual comfort
- Views
- Aesthetics

Case Study – Reduced Loads

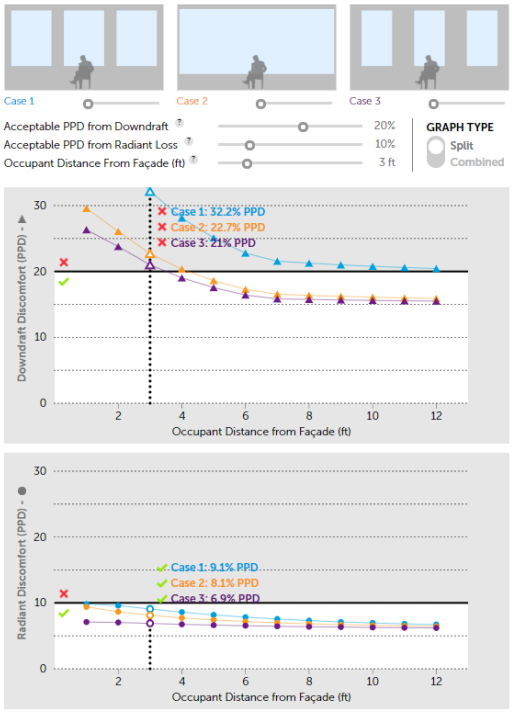


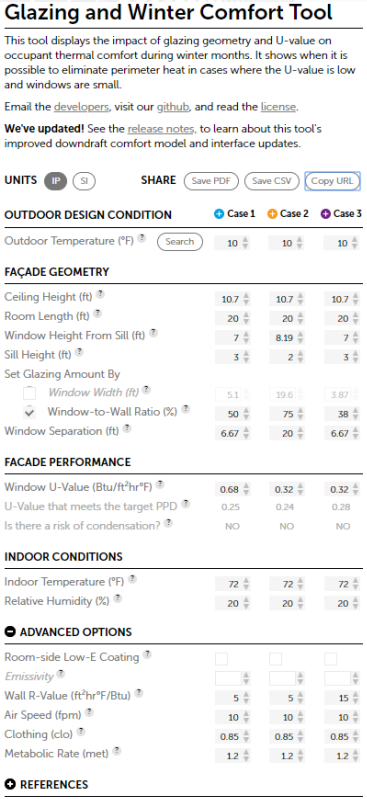
Case Study – Reduced Loads

Reduced loads -> reduced HVAC system needs -> increased usable SF



Case Study – Thermal Comfort





Existing:
Comfortable ~12 ft into the space

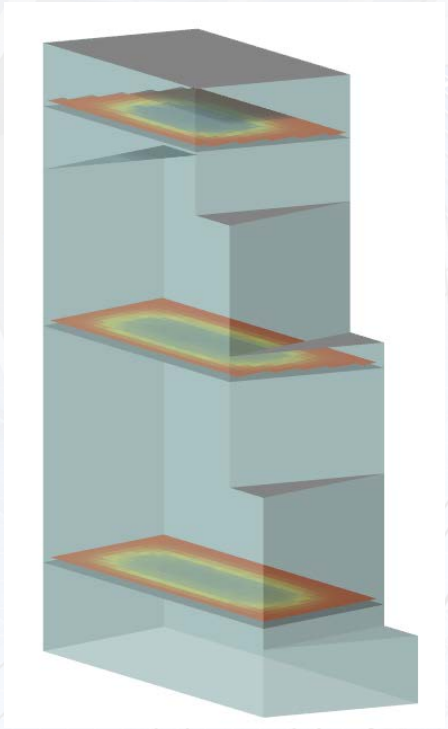
Reclad w/Full Curtainwall:
Comfortable ~4 ft into the space

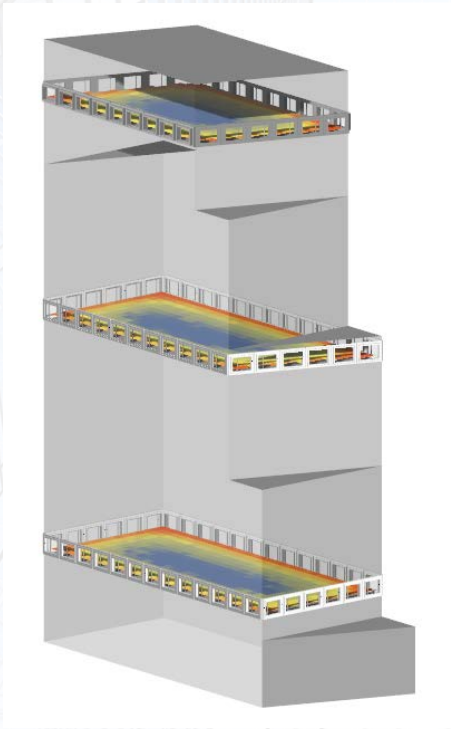
Reclad w/40% WWR:
Comfortable ~3 ft into the space

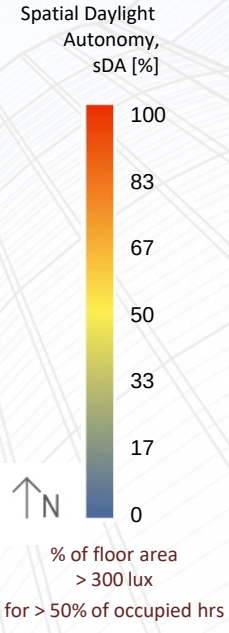
Impacts usable SF !

http://payettepeople.github.io/Thermal-Comfort-Tool/ http://bit.ly/2Dng9Ld

Case Study – Daylight & Visual Comfort





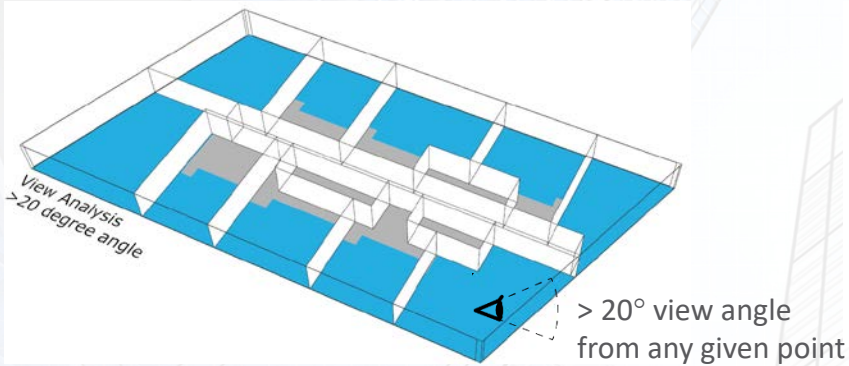


Daylight levels can be met with all options

Glare would be much higher in the Reclad w/Full Curtainwall than the Existing & Reclad w/40% WWR

Case Study – Views

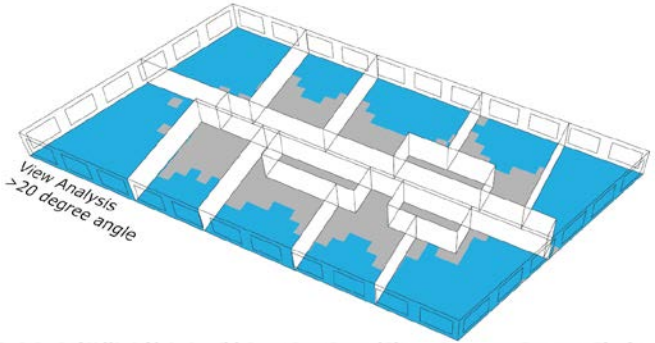
All Glass



View > 20°

No View > 20°

Punched Windows



Views can be met with all options, with slightly less view angle from the core of the Existing & Reclad w/40% WWR

Case Study – Priority Matrix

	Existing	Reclad w/Full Curtainwall	Reclad w/40% WWR
Aesthetics		✓	
Cost	✓		
Energy Use	✓	✓	✓
Energy Loads			✓
Thermal Comfort			✓
Daylight	✓	✓	✓
Visual Comfort	✓		✓
Views	✓	✓	✓

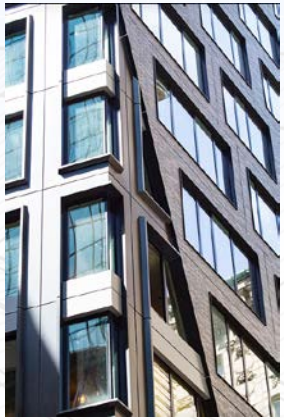
Case Study – Future Work

- Perform energy analysis for all ASHRAE climate zones
- Assess additional HVAC systems
- Evaluate additional ECMs (lighting, equipment, etc.) in addition to envelope & HVAC

05
Conclusions

Conclusions

- Benchmarking and Building Transparency
- The Future of the Energy Code and High-Rise Re-Clads
- Challenging developers, designers, and manufacturers to “Push the Envelope”



Island Exterior Fabricators: https://islanddef.com