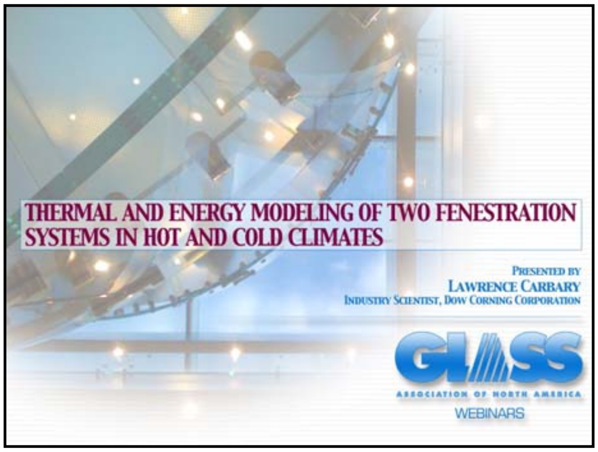


Agenda

- Introduction
- Objectives
- Scientific Approach
  - Descriptions of Glazing Systems
  - Descriptions of Curtain Wall Systems
  - Descriptions of Spacers
- Results
  - Comparisons of U-value, SHGC and Temperatures
  - Comparisons of Energy Consumption
  - Comparisons of CO_2 Emissions
- Conclusions

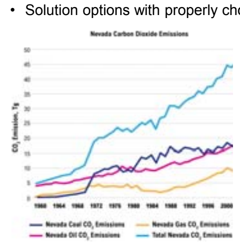
Challenge in the Desert: Las Vegas

- Population increase, urbanization and spatial expansion

Satellite images courtesy of NASA

Continuing Climate Challenges

- Economic growth leads to increased CO_2 emissions
- Hot, dry climate creates challenges for building cooling
- Solution options with properly chosen façade systems



Energy Efficiency and Sustainable Construction: Hot Topic!

Global drivers:

- Urbanization
- Energy and raw material prices
- Security of energy supply
- CO_2 emissions and climate changes

Actions:

→ Necessity to reduce CO_2 emissions/energy consumption

22% Transportation
35% Domestic → >50% energy use in heating/cooling
→ 25% of global energy consumption
43% Industrial → High-energy vs. low-energy processes

- Western construction consumes 40% of total energy
- Built environment emits 25% of Western greenhouse gas (CO_2)

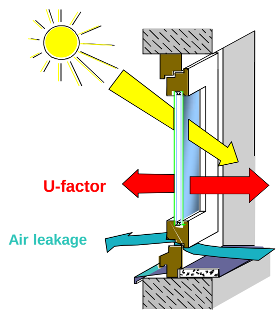
OBJECTIVES:

Study the energy efficiency of commercial curtain wall systems in hot and cold climates

- Comparing dry glazed curtainwall systems to structural silicone glazed systems
- Comparing high-performance glass to standard clear glass
- Comparing silicone foam warm edge IG spacers to aluminum IG spacers
- Comparison of frame temperatures at exterior conditions at 0°F, 104°F and 122°F+ high solar load
- Comparison of U-values and SHGC
- Comparison of energy consumption for a whole building
- Comparison of CO_2 emissions for a whole building

Scientific Approach

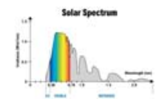
- Calculate and compare U_{facade} value and SHGC of different generic curtain wall systems used in commercial construction
  - Glazing and frame system
  - THERM and WINDOW (LBNL) software
- Compare energy use of different curtain wall systems based on U, SHGC, air leakage
  - EFEN software (CARLI)

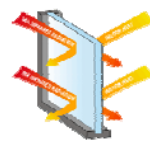


Choice of Glazing Systems in Hot and Cold Climates

- Essential in order to:
  - Control incoming heat without losing light
  - Increase savings on HVAC size and running costs
  - Increase comfort of inhabitants
- Sun energy = 50% visible range (light) + 50% IR range
  - Reduce light: ↑reflection (reflective glass)
    ↑absorption (tinted, dark coatings)
    combination
  - Reduce IR: ↑reflection (green glass, IR-reflect. coat.)
    ↑absorption (tinted, dark coatings)
    combination

→ Compare clear glass IG unit with high-performance IG with increased IR absorption and high visible light transmission

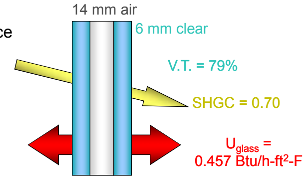




Glazing Systems

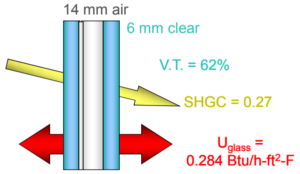
Calculate and compare performance with WINDOW

- Low performance:
  - 6 mm clear
  - 14 mm air
  - 6 mm clear

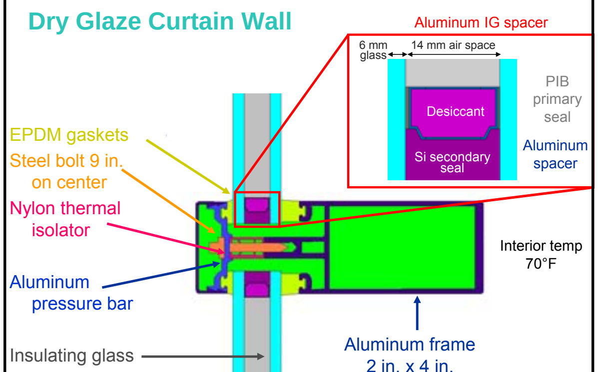


- High performance:
  - 6 mm low-E3 coating on face 2
  - 14 mm air
  - 6 mm clear

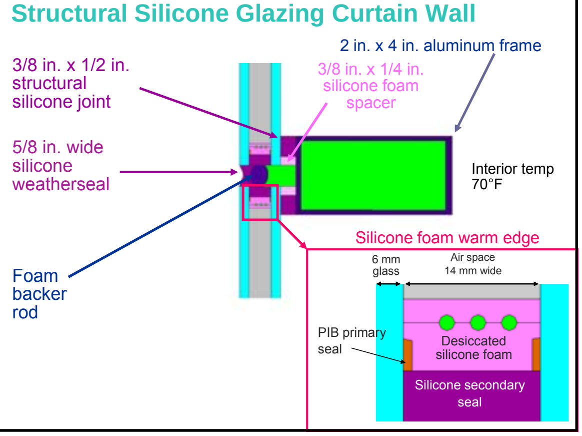
→ **Increase IR reflection and absorption + maximize visible transmission**



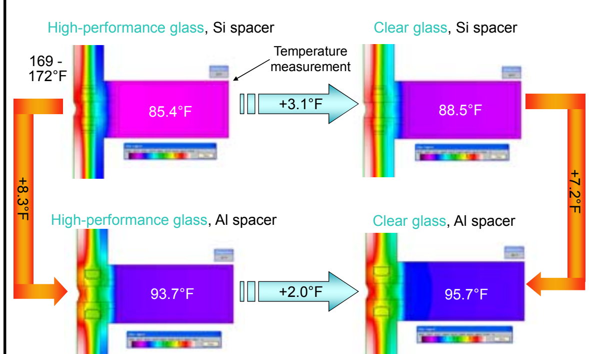
Dry Glaze Curtain Wall



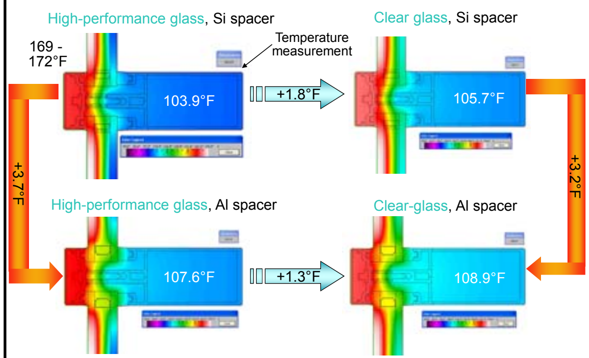
Structural Silicone Glazing Curtain Wall



Temperature Evolution for SSG System at 122°F, 1120W/m²



Temperature Evolution for Dry System at 122°F, 1120W/m²

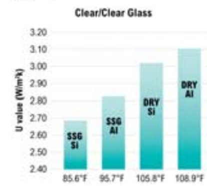


Comparisons: U value, SHGC and Temperature

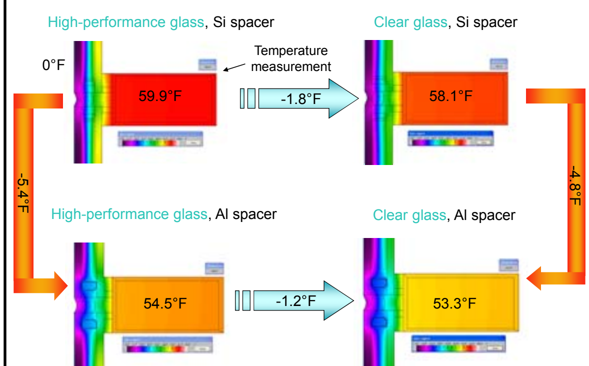
SYSTEM	SPACER	GLASS	U VALUE (W/m²K)	SHGC	VISIBLE TRANSMITTANCE	INTERIOR MULLION TEMPERATURE (EXTERIOR 122°F) HIGH LOAD 1120 W/m²
SSG	Si	LoE3/clear	1.80	0.28	0.59	85.6
SSG	Si	Clear/clear	2.72	0.68	0.74	88.5
SSG	Al	LoE3/clear	2.01	0.30	0.59	93.7
SSG	Al	Clear/clear	2.87	0.69	0.74	95.7
Dry	Si	LoE3/clear	2.19	0.27	0.58	104.0
Dry	Si	Clear/clear	3.07	0.67	0.74	105.8
Dry	Al	LoE3/clear	2.30	0.27	0.58	107.6
Dry	Al	Clear/clear	3.17	0.67	0.74	108.9

Decreasing performance

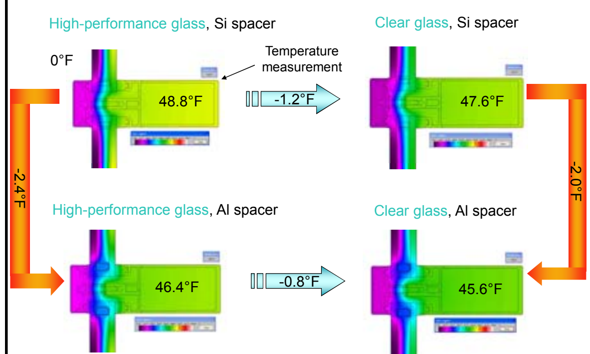
- SSG gives better (lower) U values than dry systems in all combinations
- SSG gives lower internal temperatures than dry in all combinations
- Si spacer provides a better (lower) U value than aluminum spacer in all combinations



Temperature Evolution for SSG System at 0ºF Cold



Temperature Evolution for Dry System at 0°F Cold

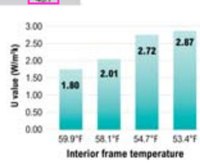


Comparisons: U value, SHGC and Temperature

SYSTEM	SPACER	GLASS	U VALUE (W/m²K)	SHGC	VISIBLE TRANSMITTANCE	INTERIOR MULLION TEMPERATURE (EXTERIOR 0°F)
SSG	Si	LoE3/clear	1.80	0.28	0.59	59.9
SSG	Al	LoE3/clear	2.01	0.30	0.59	58.1
SSG	Si	Clear/clear	2.72	0.68	0.74	54.7
SSG	Al	Clear/clear	2.87	0.69	0.74	53.4
Dry	Si	LoE3/clear	2.19	0.27	0.58	48.7
Dry	Al	LoE3/clear	2.30	0.27	0.58	47.7
Dry	Si	Clear/clear	3.07	0.67	0.74	46.4
Dry	Al	Clear/clear	3.17	0.67	0.74	45.7

Decreasing performance

- SSG gives better (lower) U values than dry systems in all combinations
- SSG gives higher internal temperatures than dry in all combinations
- Si spacer provides a better (lower) U value than aluminum spacer in all combinations



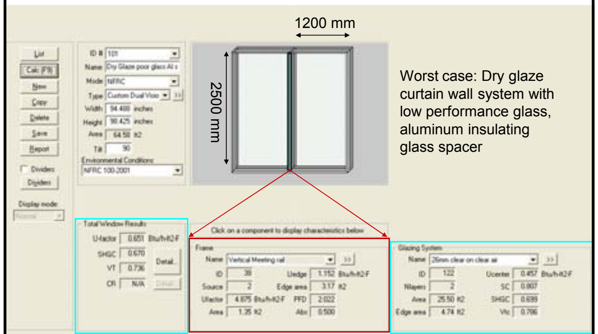
Comparisons for Various Temperature Loads

CW SYSTEM	GLAZING SYSTEM	SPACER	0°F	104°F	122°F (1120 W/m²)
SSG	High-performance	Si	59.9	75.6	85.6
SSG	Clear	Si	58.1	76.5	88.5
SSG	High-performance	Al	54.7	78.3	93.7
SSG	Clear	Al	53.4	78.9	95.7
Dry	High-performance	Si	48.7	81.7	104.0
Dry	Clear	Si	47.7	82.2	105.8
Dry	High-performance	Al	46.4	82.6	107.6
Dry	Clear	Al	45.7	83.1	108.9

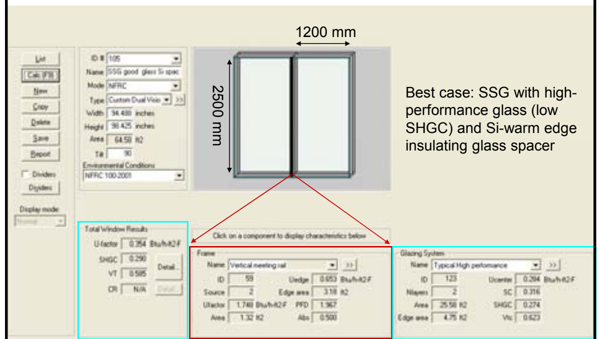
Temperature changes are more important for extreme climate

INFLUENCE OF	CW SYSTEM	GLASS TYPE	TEMPERATURE CONDITIONS 0°F	104°F	122°F (1120 W/m²)
Spacer: Si better than Al	Dry	HP	2.3°F	0.9°F	3.6°F
		CL	2.0°F	0.9°F	3.1°F
	SSG	HP	5.2°F	2.7°F	8.1°F
		CL	4.7°F	2.4°F	7.2°F
INFLUENCE OF	SPACER	GLASS TYPE	0°F	104°F	122°F (1120 W/m²)
System: SSG better than dry	Si	HP	11.2°F	6.1°F	18.4°F
		CL	10.4°F	5.7°F	17.3°F
	Al	HP	8.3°F	4.3°F	13.9°F
		CL	7.7°F	4.2°F	13.2°F

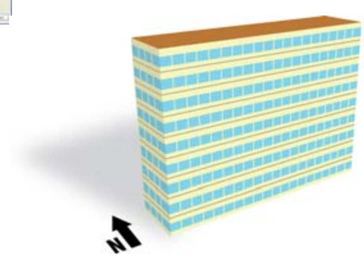
Total Frame Results



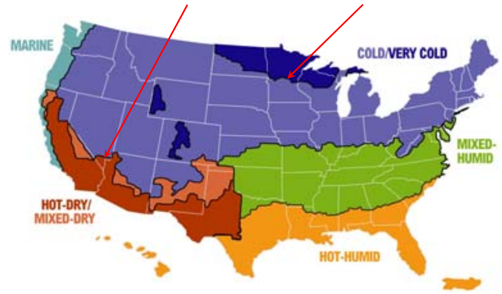
Total Frame Results



9-Story Rectangular Building Facing South – Calculating Energy Usage



Locations



Scientific Approach

- Compare energy use (electricity for cooling and lighting and gas for heating) of different curtain wall systems based on:
  - U_{value}, SHGC: as calculated with THERM and WINDOW
  - EFEN software (CARLI)
    - Air leakage: from 0 (new gasket or SSG system) to 0.9 in order to simulate aging of old gasket
    - Daylighting calculations – More daylight, less lighting

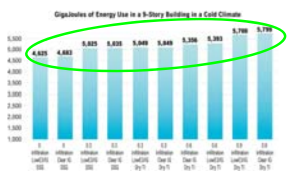
- Calculate CO_2 emissions based on:
  - 1kWh electricity from a mixed generation = 0.480 kg CO_2 emissions
  - 1GJ gas = 53.8 kg CO_2 emissions

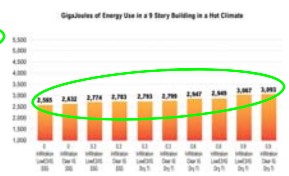
Gas and Electricity in Cold Climate

Energy Totals in Cold and Hot Climates

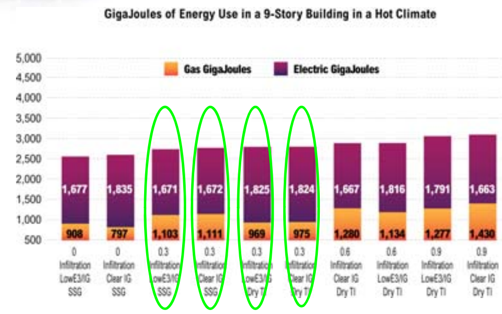
DRY/WET	LOW E3 IG/ CLEAR IG	INFILTRATION (cfm/ft²)	GAS GJ	ELECTRICITY kWh	TOTAL SITE GJ
SSG	Low E3 IG	0	3,135	413,656	4,625
SSG	Clear IG	0	3,083	444,450	4,683
SSG	Low E3 IG	0.3	3,532	414,678	5,025
SSG	Clear IG	0.3	3,437	443,917	5,035
Dry TI	Low E3 IG	0.3	3,555	414,864	5,049
Dry TI	Clear IG	0.3	3,452	443,709	5,049
Dry TI	Clear IG	0.6	3,760	443,563	5,356
Dry TI	Low E3 IG	0.6	3,897	415,587	5,393
Dry TI	Low E3 IG	0.9	4,201	416,200	5,700
Dry TI	Clear IG	0.9	3,944	515,405	5,799

DRY/WET	LOW E3 IG/ CLEAR IG	INFILTRATION (cfm/ft²)	GAS GJ	ELECTRICITY kWh	TOTAL SITE GJ
SSG	Low E3 IG	0	908	465,760	2,585
SSG	Clear IG	0	797	509,650	2,632
SSG	Low E3 IG	0.3	1,103	464,216	2,774
Dry TI	Low E3 IG	0.3	1,111	464,496	2,783
SSG	Clear IG	0.3	969	506,861	2,793
Dry TI	Clear IG	0.3	975	506,616	2,799
Dry TI	Low E3 IG	0.6	1,280	463,006	2,947
Dry TI	Clear IG	0.6	1,134	504,310	2,949
Dry TI	Clear IG	0.9	1,277	497,378	3,067
Dry TI	Low E3 IG	0.9	1,430	461,968	3,093

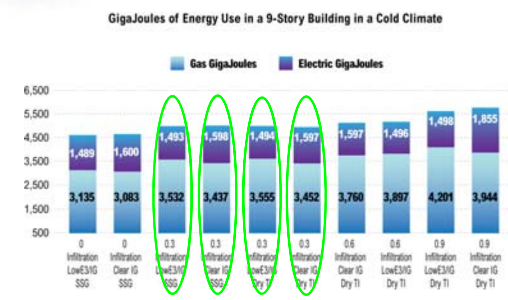




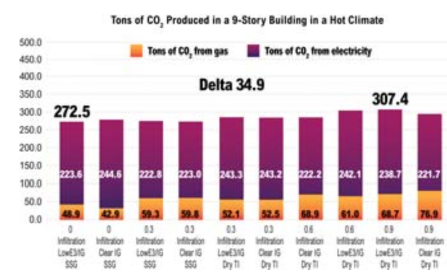
Hot Climate Specifics



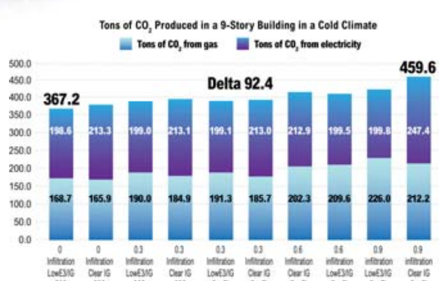
Cold Climate Specifics



CO_2 Impact Hot Climate



CO_2 Impact Cold Climate



Conclusions

- Proper choice of glass is critical to performance
- SSG systems outperform the dry glazed systems
  - Lower U values when compared to each other, all other items being equal
  - Frame temperatures are closer to interior ambient in both hot and cold climate
  - Lower energy consumption and CO_2 emissions
- Warm edge silicone spacers outperform aluminum spacers
  - Lower U values when compared to each other, all other items being equal
  - Frame temperatures are closer to interior ambient in both hot and cold climate
  - Lower energy consumption and CO_2 emissions
- A combination of both SSG and silicone warm edge system provided the best results
- Air infiltration is critical to minimize energy consumption; durable systems should be preferred

Leave Behind Presentation Materials

- White papers
- Report from EFEN on a specific building design and size comparing dry glaze and SSG, comparing aluminum IG and warm edge, and infiltration rates
- Graphs and charts converting energy to CO_2 emissions

THANK YOU FOR YOUR ATTENTION!

Any Questions?