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**Building
AMERICA**
U.S. Department of Energy
Research Toward Zero Energy Homes

Innovations & Emerging Technology

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Outline

- What are the trends
- What are possible emerging technologies

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Predictions

- Are usually incorrect
- What follows are informed guesses ... and hopes of a select number of changes

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A Fuel-efficient Hummer

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Future Transportation

- More train and mass transit
 - Already happening
- Plug-in hybrid
 - 100 mpg average
- Light weight vehicles
- Diesel and diesel hybrid
- Fuel cells?:
 - where is the Hydrogen

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Competition Cars vs Buildings

- Chevy Volt (2010)
- Prius Plug-in (2010)
- European diesels are coming....
 - 2008 and on . . .

- Electrification of buildings will increase, but will compete with transport

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A new competitor for building energy



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Efficient Enclosures & HVAC

- Airtight buildings require ventilation systems
 - Don't over ventilate. Quality≠Quantity
- Better windows, insulation and lighting
 - = Low heat gain
 - = dehumidification, less sensible cooling
- Thermal mass matters more
- Different HVAC systems can now be applied
 - Radiant cooling

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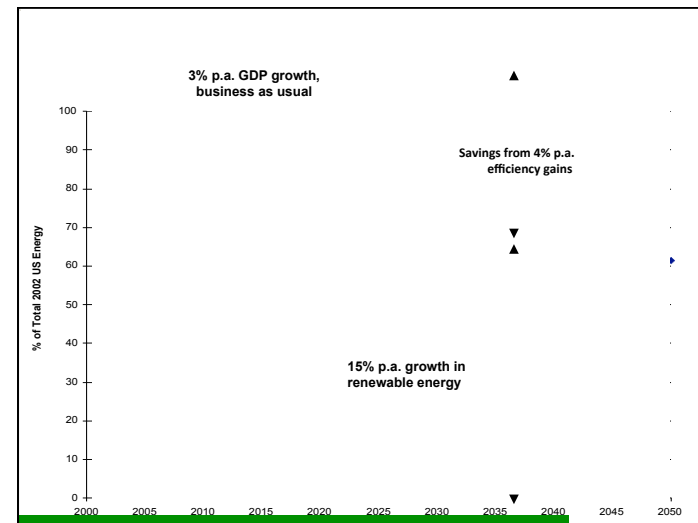
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Efficiency, Renewables, Retrofits

- Reducing energy wasted (efficiency) allows renewables to be economically and environmentally practical
 - Need to increase Energy Return on Investment
- Huge existing stock of buildings, means:
 - **Energy-efficient retrofits** must be part of any solution
- Both renewables and retrofit are needed!

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Renewables

- PV price is dropping, more silicon better prod.
- Installed cost likely under \$5/W before 2012
- Large Wind installations increasing
 - No serious contenders for micro wind turbines on the horizon
- Sophisticated Biomass (wood pellets, etc) growing

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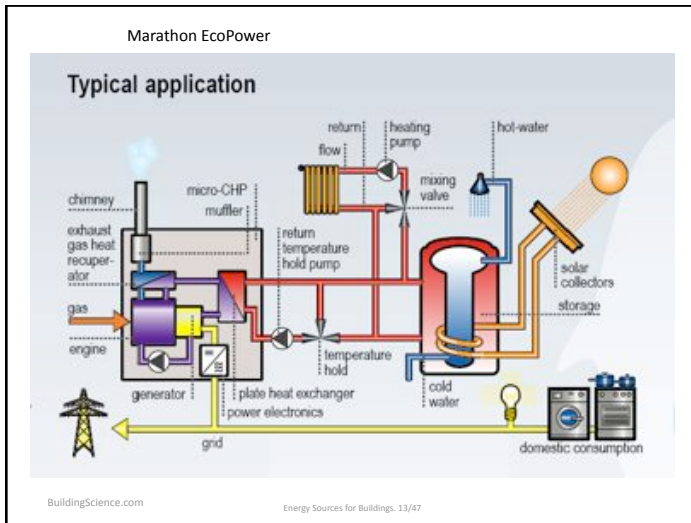
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Combined Heat Power-small

- Heat and power (roughly 3:1) on demand, 90% eff
- Capital cost (elec) Marathon EcoPower (\$20K/4.7 kW)
 - \$3 000- 20 000/kW
- Elec cost (if heat is free)
 - \$0.10-0.25 kWh
- Difficult to match home/office needs
- Can provide base load or peaking
- Sterling cycle, microturbines, diesels, fuelcell
 - maintenance

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Energy Sources for Buildings. 12/47



Mechanical systems

- Will get smaller and more efficient (right size)
- Tankless craze will mature to condensing boilers with microstorage
- Solar thermal costs are not dropping and storage costs \$: PV soon may usurp

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Low Temperature Heat Pumps

- New generation of air-to-air and air-to-water heat pumps
- COP over season of 2 to 3
- Much lower cost, easier installation than GSHP

Hyper-Heating Inverter vs. Other Units
% Heating Capacity vs. Outdoor Temperature

Outdoor Temperature (Degrees FWB)	Mitsubishi Electric Hyper-Heating Inverter (HDI) % Heating Capacity
-13	75%
-4	87%
5	100%
10	100%
17	100%
25	100%
30	100%
35	100%
40	100%
47	100%

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Integrated Heat Pumps

- Heat pumps that make hotwater as well as space heating
- Improve on electrical COP=1

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CO2 Refrigerant

- New generation of compressors available to handle R744
- Higher COP
- less environmental impact
- Lower temperature operation (-40)

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SANYO CO2 ECO hot water heater

SANYO CO2 ECO is a system that effectively utilises heat in the atmosphere

System flow of the Heat Pump Hot Water Supplier

The diagram shows a CO2 refrigerant cycle with a compressor, condenser, expansion valve, and evaporator. The condenser is connected to a water tank. The evaporator is connected to a heat pump unit. The system is labeled with temperatures: 60°C at the condenser, 70°C at the evaporator, and 14°C-45°C at the expansion valve. A 'Misting Tap' is shown with a 'Max 55°C' label. A 'Reducer for Space Heating' is also indicated.

Heat source Unit	SHP-C4SDEN	SHP-TH2Z2DN/DHN	SHP-TH4Z2DN
Performance			
P1 Heating capacity / input	kW	4.5 / 1.20	
E.O.P (Outdoor temp. 20°C)	W/W	3.75	
P2 Heating capacity / input	kW	4.5 / 1.45	
E.O.P (Outdoor temp. 7°C)	W/W	3.10	
P3 Heating capacity / input	kW	4.5 / 2.48	1.0
E.O.P (Outdoor temp. -13°C)	W/W	1.81	

Enclosures

- We will start to do some of the stuff we know how to do on a wider scale
 - Insulating sheathing
 - Airtightness
 - Insulate basements
- More bio-based and recycled content

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Enclosures

- Expansion of stressed skin panels (metal skins, fiber cement and OSB) and ICF
- More spray insulation
 - Fiberglass
 - Rockwool
 - Foams
- Wider range of spray foam:
 - ½ pcf, 2 pcf, and 0.8, 1.25, etc.

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Insulated Concrete Formwork

- Excellent enclosure system
- Concrete acts as air barrier
- No vapor barrier needed
- Expensive, but high performance

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Insulation at

Future products

- Vacuum panels: Depends on vacuum
 - R20-30/inch
 - VacuPor (Porextherm)
- Nanogel/aerogel
 - R12-20/inch
 - AspenAerogel

Building Science.com Insulation and Thermal Bridges No. 23/65

Concrete

24 cm

Masonry

36 cm

Massive pine wood

38 cm

Lightweight construction

226 cm

DELTA-COOL 24

2 cm

Equal thermal thicknesses having a heat storage capacity of 5,700 kJ (10 °C temperature increase).

- Phase Change
- Water storage tanks cellulose insulation additive

DELTA-COOL 24 is available in various forms of encapsulation. Building Science.com

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Windows

- R-value set to drop to 1/2 of current
- Triple glazing, heat mirror glazing get better
- Better frames and thermal breaks
- Price becoming more competitive
- Exterior shading becoming more important control solar heat gain

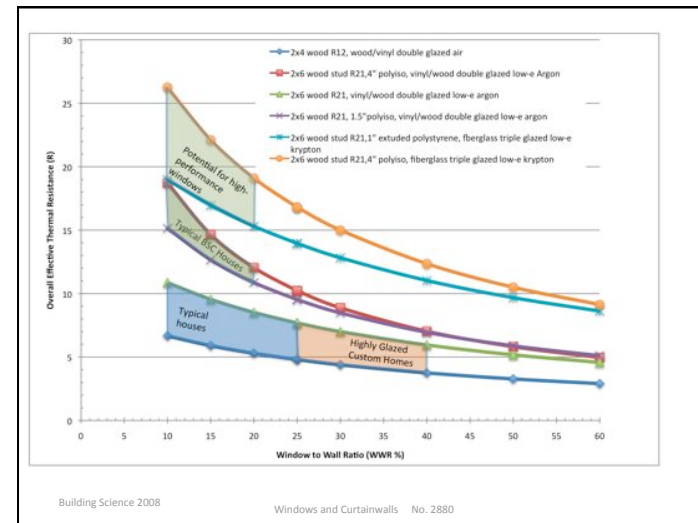
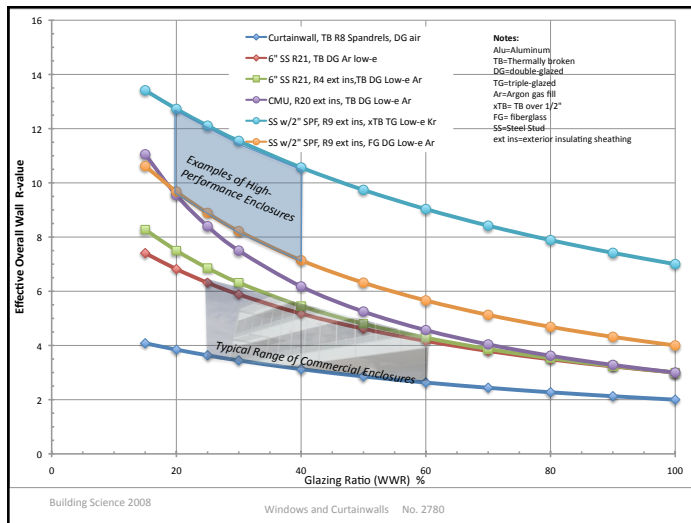
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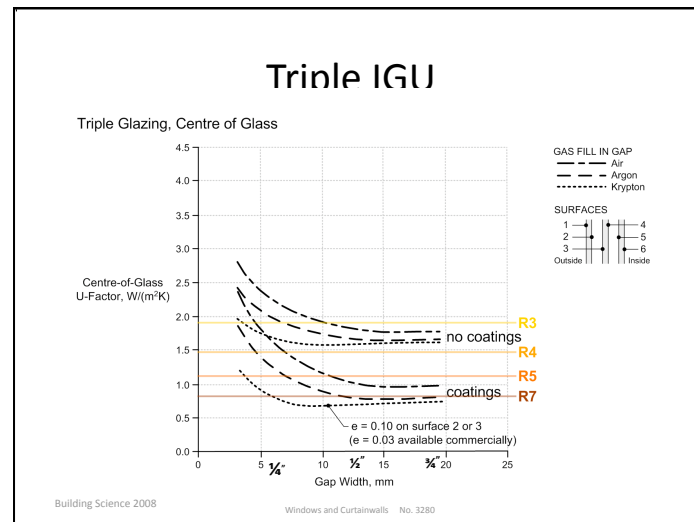
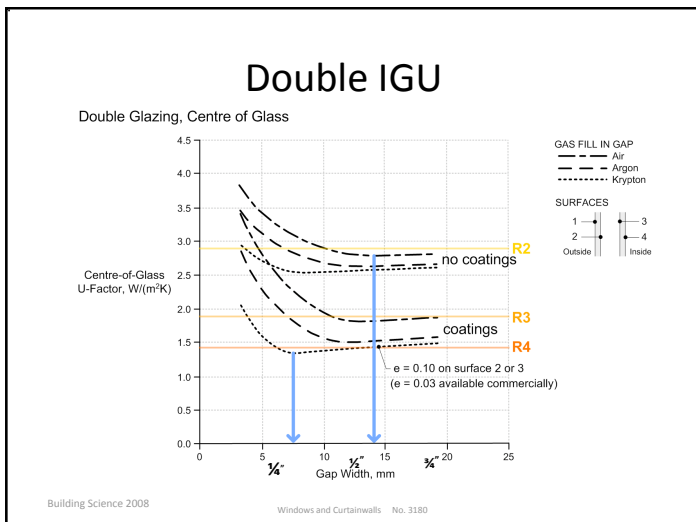
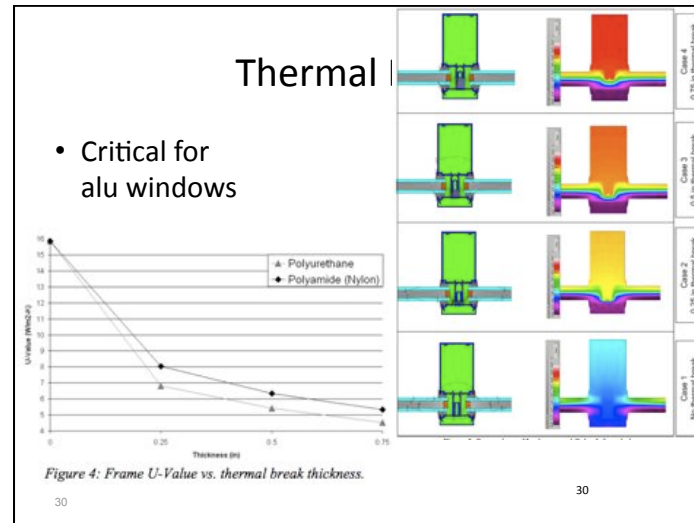
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Industry Leading Performance	Center of Glass (COG) Performance*				AlpenGlass+™	
	U-Value	R-Value	SHGC	VT	Glazing	Fill
	0.05	20.00	0.29	0.44	Dual Pane, Triple Low Solar Heat Coefficient Film	Xenon
Premium Performance	U-Value	R-Value	SHGC	VT	Glazing	Fill
	0.07	14.29	0.24	0.43	Dual Pane, Dual Low Solar Heat Coefficient Film	Krypton
High Performance	U-Value	R-Value	SHGC	VT	Glazing	Fill
	0.11	9.09	0.51	0.65	Dual Pane, Dual High Solar Heat Coefficient Film	Krypton
	0.11	9.09	0.30	0.55	Dual Pane, Single Low Solar Heat Coefficient Film	Krypton
	0.19	5.26	0.60	0.73	Dual Pane, Single High Solar Heat Coefficient Film	Krypton

**Performance numbers are center-of-glass values based on ANSI Window 1.7 values*

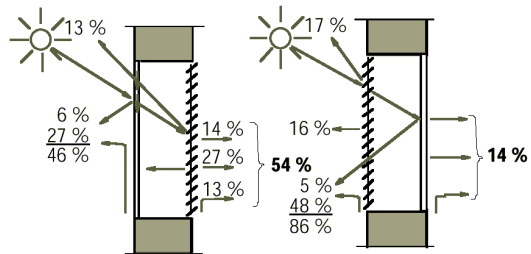
Courtesy of ThermoProof Windows and AlpenGlass+





Interior or Exterior Shade

- Exterior Shades always beat low SHGC
 - But the cost capital and maintenance
- Interior shades don't work well with good windows



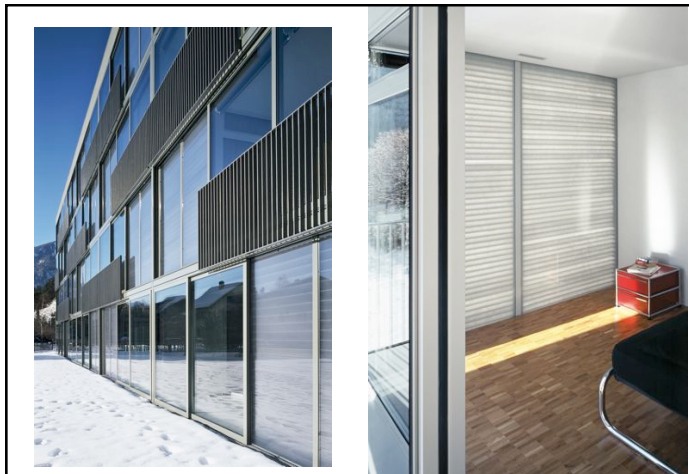
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Windows and Curtainwalls No. 3380



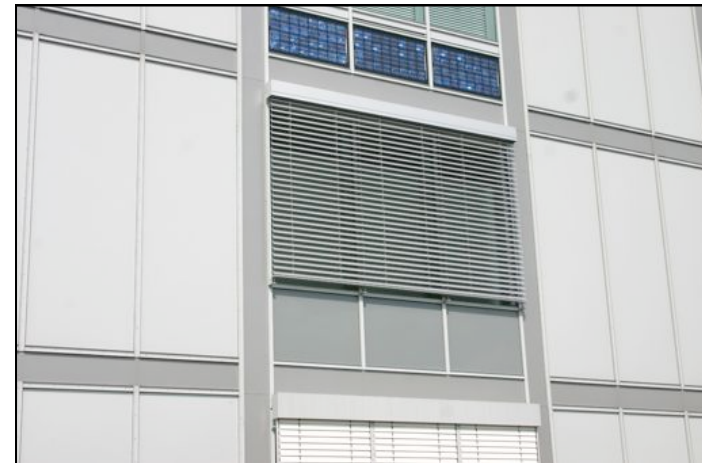
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Windows and Curtainwalls No. 3480



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Windows and Curtainwalls No. 3580



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Windows

- Vacuum panels
- Edge effects

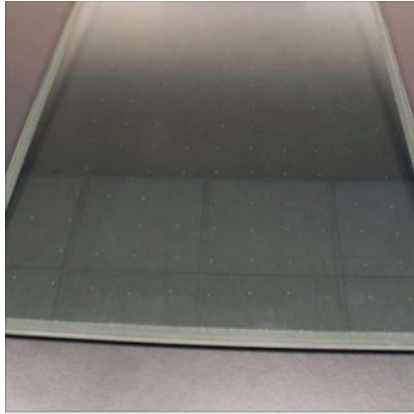


Photo: Dwayne Folks, Guardian Industries

Summary

- Few of these innovation are needed to solve climate crisis
- PV, heat pumps, plug-in hybrids are most likely to make it much easier to achieve clean, low resource future

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