Energy-Producing Glass
As an Architectural Element

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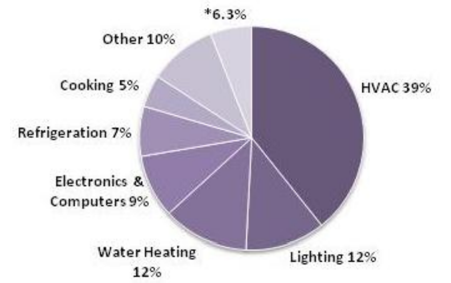
Outline

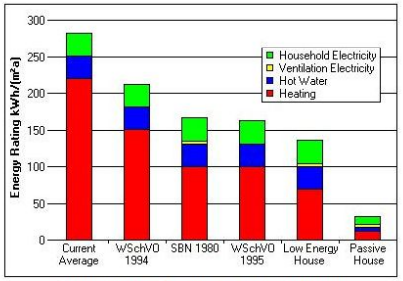
- Motivations
- Technology Portfolio
- Integration
- Solution Concepts
- Sourcing Guide

Motivations

- The residential sector accounts for 1/5th of the energy consumption in the U.S.
- Typically, 43% of your utility bill goes to heating and cooling.
- The primary cause of heat loss is air exchange with the outside environment.
- Managing air flows in an essential component of advanced heating and cooling devices.
- ***Solar insolation is an under-developed <u>heating</u> energy resource.***
- ***Windows can facilitate air flows used for <u>cooling.</u>***



Residential Buildings Total Energy End Use (2006)

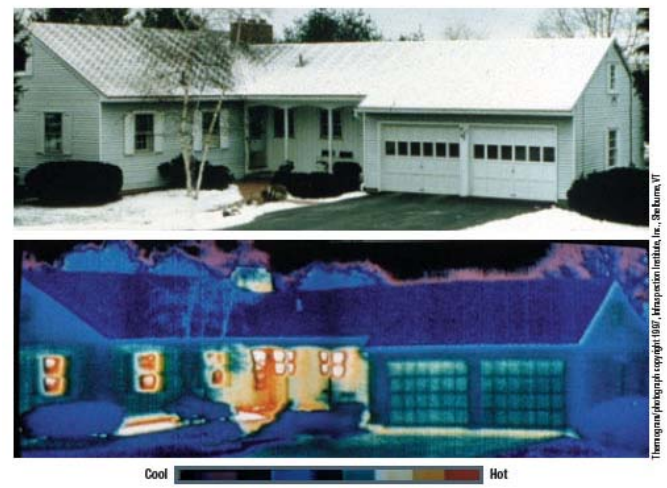


Comparison of Energy Ratings of Homes
WSchVO = German Heat Protection Regulation
SBN = Swedish Construction Standard

Source: http://buildingsdatabook.eren.doe.gov/

Energy Savings: The Whole House Approach

Key Parameters



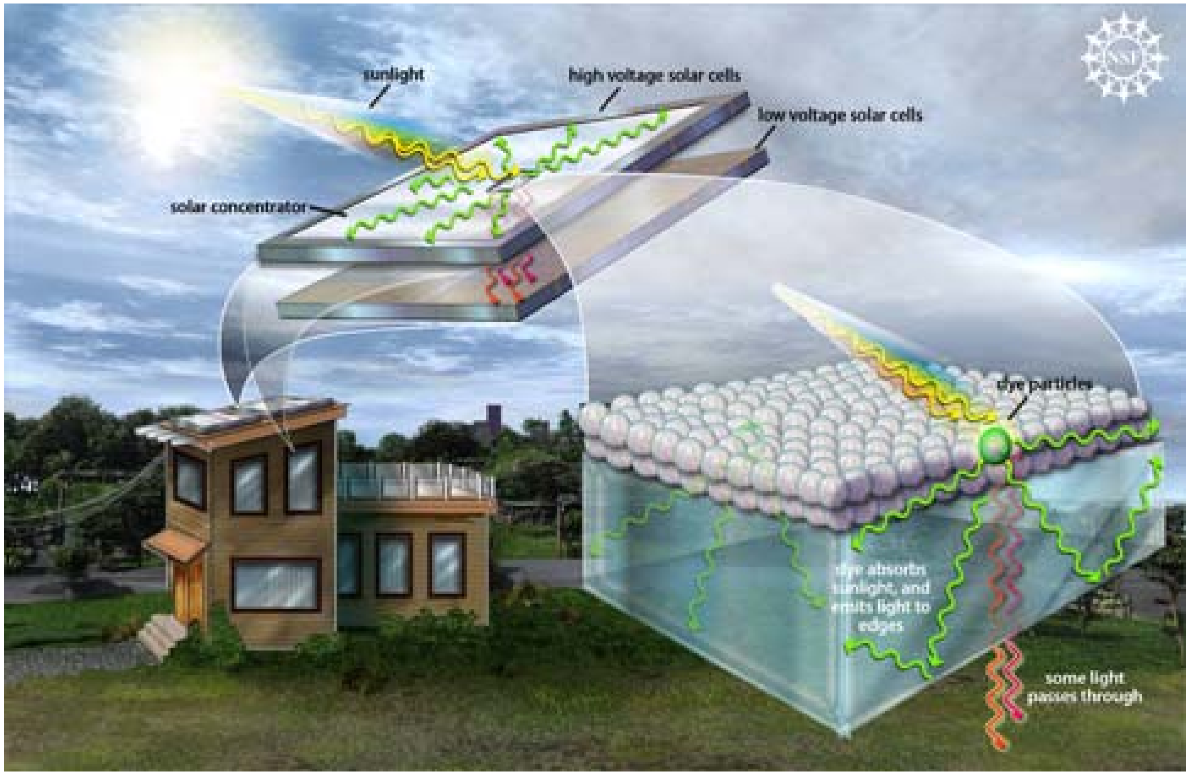
- Air Leakage
  - Sealing the building "envelope"
  - Controlling air flows, when desired
- Solar Intake Modulation
  - Leverage as an energy source
  - Control reflectivity & site of absorption
- R-Value
  - Measure of insulation heat loss
  - Higher number = Greater resistance to heat flow

Source: http://buildingsdatabook.eren.doe.gov/

Technology Portfolio

- Active Solar
  - COVALENT Solar Concentrator
- Passive Solar
  - Optically Variable Glass
- Ventilation
  - Trombe Wall
  - Window Louvers

COVALENT Solar Concentrator

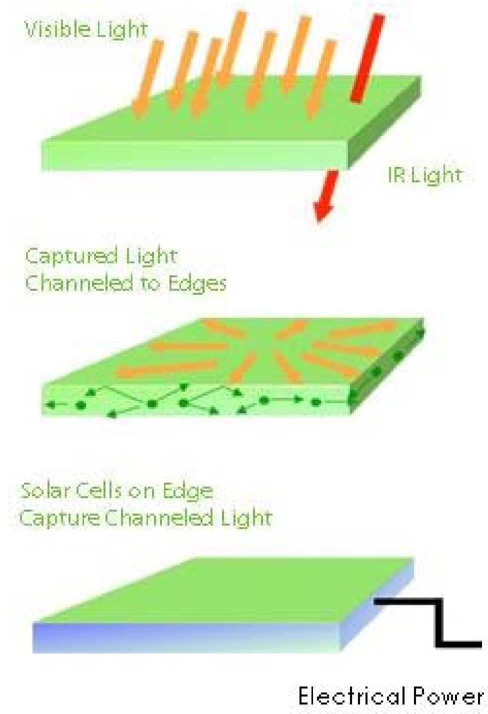


Source: http://www.covalentsolar.com/Technology

COVALENT Solar Concentrator

Characteristics

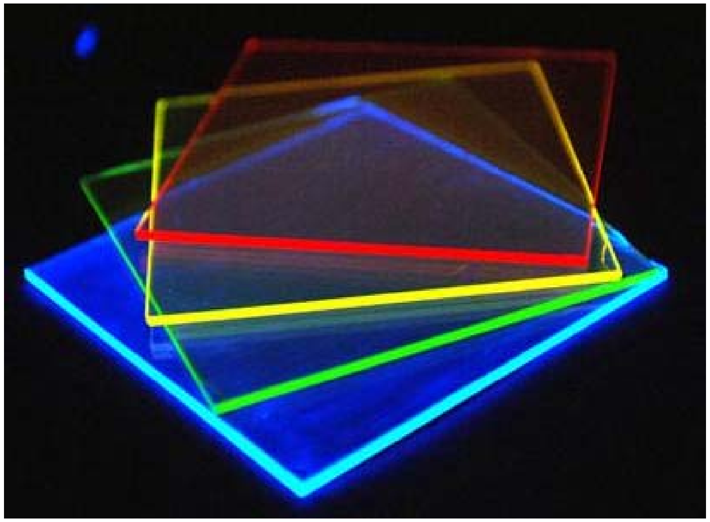
- Developed by Michael J. Currie, Jonathan K. Mapel, Timothy D. Heidel, Shalom Goffri, Marc A. Baldo.
- Leverages organic phosphorescence, and in-pane wave-guiding.
- Light absorbed by dyes is re-emitted inside the pane at a different wavelength to aid in transmission.
- No need for solar tracking.
- Could increase the efficiency of existing solar panels by as much as 50 percent.



Source: http://www.covalentsolar.com/Technology

COVALENT Solar Concentrator

- Production involves coating glass with a mixture of semi-transparent dyes which redirect light to the edges of the frame.
- Incident photons are carefully guided within the cell using organic-dye-tinted plates
- Each pane directs a portion of the incident light to the edges, allowing light at longer wavelengths to continue to the next pane.
- High efficiency solar cells are placed at the edges of the pane to receive the concentrated light.
- Reduced solar cell area=lower cost.



Source: http://www.covalentsolar.com/Technology

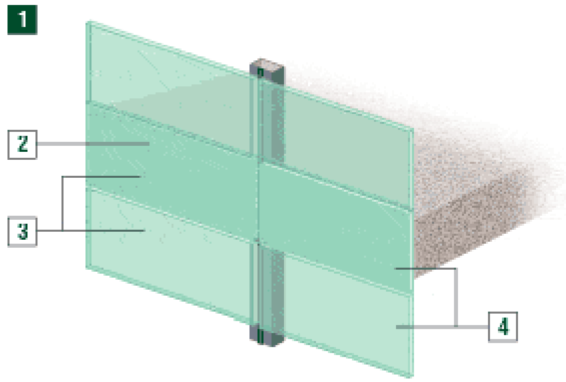
Optically-Variable Glass

Characteristics:

- Low-emissivity glass
  - A special coating on the surface reduces radiant heat transfer, thereby increasing the R-value.
  - The incoming visible light is reflected only slightly, so low-e glass appears almost clear rather than mirror-like.
  - Window units with low-e coatings cost about 10 percent to 15 percent more than regular units but can reduce energy flow though a window by 30 percent to 50 percent.
- Heat absorbing glass
  - Contains special tints that allow it to absorb as much as 45 percent of the incoming solar energy, thereby reducing heat gain.
- Reflective glass
  - Coated with a reflective film. It is useful in controlling solar heat gain during the summer, but it also reduces the passage of light all year long.
  - Ionized gasses can also be used to allow for variable opacity at the "flip of a switch."

Source: www.dnr.mo.gov/ENERGY/residential/windows.htm

Optically-Variable Glass



Spandrel

- Opaque section of glass between the panes of vision glass in a glass clad building. Often hides the mechanical or structural components of the building. Opacifying agents such as ceramic enamels and urethanes can be sprayed on, roller coated, or screen printed on surface. Spandrel glass can be variably tinted in order to harmonize with the vision glass.

Vision Glass

- Refers to glass that exhibits some degree of transparency. Designated for areas covering surfaces where occupants wish to see the outside surroundings. Can have any of the characteristics designated on the previous slide.

Source: http://www.pg1inc.com/spandrel_overview.php

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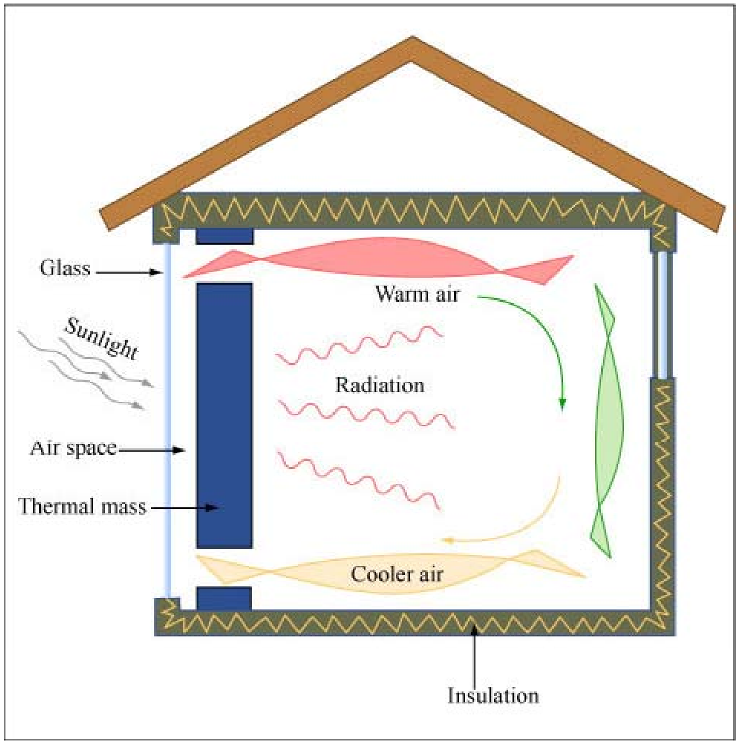
Trombe Wall

Characteristics

- Directs solar input onto an insulating mass.
- This heated mass creates a thermal gradient, which drives air circulation.
- The air between the glazing and the thermal mass warms (via heat conduction) and rises, taking heat with it (convection).
- The mass also acts as a radiative heat source.
- In many cases, heating costs could be more than 50% lower by incorporating passive solar design.



Source: www1.eere.energy.gov/consumer/tips/pdfs/energy_savers.pdf

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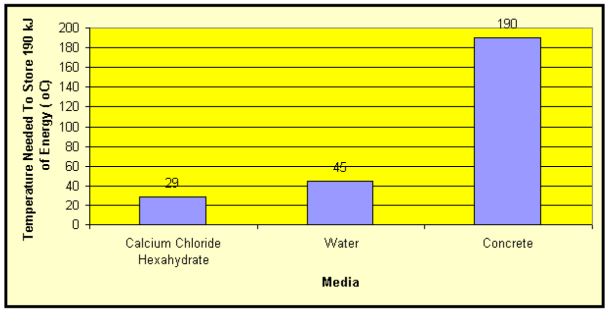
Trombe Wall

- The thermal mass acts a time-shifted heating element.
- Warmer air moves through vents at the top of the wall and into the living area while cool air from the living area enters at vents near the bottom of the wall.
- At night, a one-way flap on the bottom vent(s) prevents backflow, which could act to cool the living area, and heat stored in the thermal mass radiates into the living area.
- Materials like concrete, earth, or CaCl (PCM) can be selected for their thermal storage properties.

  *PCM = phase change materials



Source: http://freespace.virgin.net/m.eckert/

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Window Louvers

Characteristics

- Deflect thermal gain from incident sun, integrating light control into the building envelope.
- Louver shapes, composition, and finish create specific day lighting effects as well as establishing a different aesthetic.

Source: http://archtopia.com/2009/10/02/hunter-douglas-contract-nysan-aerofoil-louvers/

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Integration

Balance of Systems Equation:

$$E_{Consumption}(Appliances + Heating + Cooling + Insulation) =$$
$$E_{Generation}(Solar_{Active} + Solar_{Passive} + Ventilation + Input_{Grid})$$

Considerations

- Net Energy Requirement
- Technical
- Economic
- Aesthetic (yes, aesthetic!)

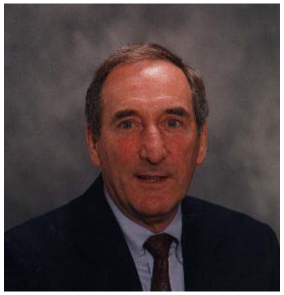
Construction Constraints:
Voices from the Industry

In New Construction:

"Being a delicate and relatively expensive material, glass requires careful transportation, and additional skill in installation. This points to Prefab as a method of controlling quality, cost, and transportation issues."

Lyle Green, Senior Architect, Cooper Carry, Center for Connective Architecture

In Existing Structures:



Bill McNulty, Realtor, Keller Williams Realty

"Glass can be altered using aftermarket screens or coatings to change the optical properties to suit the homeowner's need, and at lower cost than comprehensive renovation."

Source: Interviews

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Aesthetic Constraints

- Photovoltaic devices have intrinsic visual characteristics, based upon their absorption profile and surface texture.
- These visual characteristics require the technology be thoughtfully situated, so as not to detract from the aesthetic character of the surroundings.
- In some cases, PV devices can be engineered so as to create a pleasing exterior appearance by creating patterns out of disparate materials.
- In other cases, screens can be placed in tandem (on the surface, or behind the panel) to either neutralize or color-match the panels to their surroundings.

Source: Ingrid Hermannsdorfer, Christine Rub, Solar Design: Photovoltaics for Old Buildings, Urban Space, Landscapes, Jovis: 2006

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Aesthetic Constraints

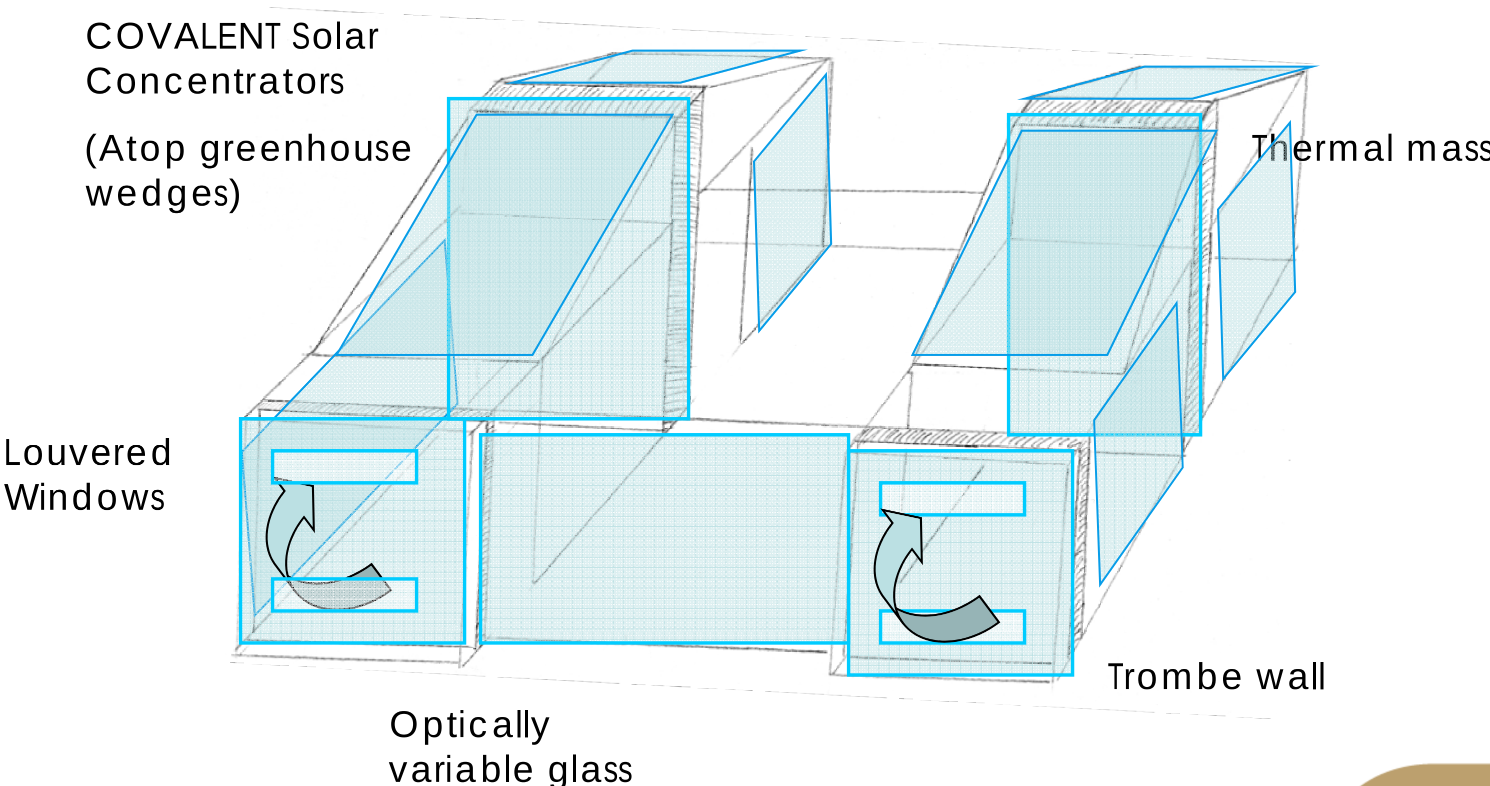
Case Study: PVACCEPT

- PVACCEPT, an interdisciplinary German-Italian research and demonstration project was launched in 2000 by several Berlin architects. The project started from the notion that the aesthetic design of PV technology has been considerably underestimated as an important acceptance factor and that improved and more variable design could open new application possibilities, especially in the context of existing buildings. The research focuses on applying degrees of texturing, color variation, and transparency, in order to enhance the range of applications of PV.

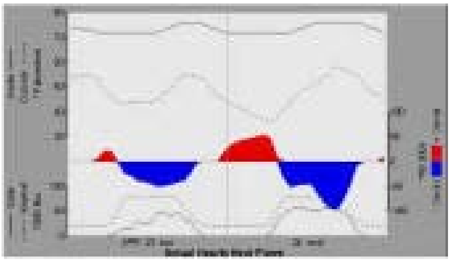
Location:	Duisburg, Germany
Owner:	ThyssenKrupp Stahl
Architect:	Czerny - Gunia
Energy consultant:	ThyssenKrupp Solartec
System provider:	ThyssenKrupp Solartec
Year:	2002
Energy output:	51.06 kW_p
Energy yield:	32 130 kWh/a
Area:	1 000 m^2

Source: Ingrid Hermannsdorfer, Christine Rub, Solar Design: Photovoltaics for Old Buildings, Urban Space, Landscapes, Jovis: 2006

Solution Concepts



Calculating Energy Savings



- Many quantitative tools exist that model building size, site orientation, and construction materials.
- These tools output the projected energy consumption, thermal efficiency, air and moisture exchange, and cost of construction.

Source: http://www.builditsolar.com/References/energysimsrs.htm

Home Energy Modeling Tools

- Build It Solar Compendium of Energy Auditing Tools
  - http://www.builditsolar.com/References/energysimsrs.htm
- U.S. Department of Energy eQUEST Home CAD Modeling Tool
  - http://www.doe2.com/eQuest/

Glass Sourcing Guide

- SWEETS Architectural Catalog
  - http://products.construction.com/SearchResults/Top/windows
- ARCAT Building Materials and Manufacturer's Specifications
  - http://www.arcat.com/divs/building_products.shtml
- Payless Glass
  - http://www.pg1inc.com/index.php
- DWELL Magazine Modular Housing Suppliers
  - April 2010 Issue, Website: dwell.com

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Questions…