Ultra-Thin, Energy-Efficient Façades - a Contradiction in Terms?

- Challenges and Novel Strategies

Hans-Peter Ebert

Bavarian Center for Applied Energy Research (ZAE Bayern)
Division: Functional Materials for Energy Technology
Würzburg, Germany
Energy Use in Europe

- Industry: 28%
- Transport: 32%
- Building: 40%

Thermally optimized façades reduces energy consumption for heating and for cooling
History of Ultra-Thin, Energy-Efficient Façades

Wall thickness: 60 to 70 mm
U-value ≈ 1.3 W/(m²K)
Average temperature -3.2 °C
Advantages of Ultra-Thin Façades

- saving of space (centre of cities)
- low weight
- more design freedom
Critical Aspects of Ultra-Thin Façades

- low heat capacity
- need for control, PCM
- high U-Value
- improved thermal insulations
- thermal bridges
- more planning work
Further Content

- Motivation
- Vacuum Insulation Panels (VIP)
- Vacuum Glazing
- Textile Architecture
- Conclusion - Outlook
Comparison of Thermal Insulation Materials

- AIR
- solid + radiation
- standard thermal insulation (e.g. mineral wool)
- vacuum insulation panel (VIP)

Thermal conductivity $\lambda$ [W/m·K]
Components of a VIP

- Nanostructured high-barrier laminate
- Nanoporous load-bearing filler material
Retrofitting a Terrace House with VIPs

U-value\textsubscript{before} = 1.0 W/(m\textsuperscript{2}K)

U-value\textsubscript{after} = 0.15 W/(m\textsuperscript{2}K)

Thermal imaging:
Blue areas indicate excellent thermal insulation performance
Vacuum insulation glass (VIG)

Windows represent thermal weak spots of buildings

- **façade:**
  \[ U \leq 0.3 \text{ W/(m}^2\text{K)} \]

- **double glazing:**
  \[ U \approx 1.1 \text{ W/(m}^2\text{K)} \]

- **triple glazing:**
  \[ U \approx 0.6 \text{ W/(m}^2\text{K)} \]
Analyses of Heat Transfer

Thermal insulation glazing:

\[ U_g = 1.3 \text{ W/(m}^2\text{K)} \]
\[ \varepsilon = 0.03 \]
\[ \text{gap: 16 mm air} \]

Components of the U-value

- Radiative heat transfer: 90.2%
- Thermal conduction: 9.8%
VIG-Design

Thinner and lighter than triple glazing:

- system thickness ≤ 9 mm
- 2 x 4 mm float glass

U < 0.5 W/(m²K)

Diagram:
- Spacers
- Low-ε coating
- Evacuated gap
- Glass
- Airtight seal
Challenges

- Thermal optimization
- Innovative edge construction
- Optical optimization (spacers!)
- Gas tightness
- Mechanical stability
VIG Prototypes

U-value = 0.5 W/(m$^2$K)

prototypes at glasstec 2007

commercial production planned for 2009
Thermally Improved Window Frames
TopTherm 90

- PU-foam kernel for thermal insulation
- thin polymeric layer for improved mechanics and surface texture
- $U_f = 0.7 \text{ W/(m}^2\text{K)}$ @ 90 mm system thickness
- low weight
- simple production and installation
Thermal Performance of Windows
Northern Side, test reference year Würzburg, Germany

Effective U-value / W(m²K)

- 2-Iso
- 3-Iso
- VIG

System thickness / mm


© ZAE Bayern
Textile Architecture

Source: Herzog + Partner, Lang, Munic

Entwurf:
LangHuggerRampp GmbH
Architekten

© Foster and Partners

Textile Architecture
Multifunctional Membranes

- thermal insulation
- heat storage (PCM)
- low-ε coatings
- photovoltaic

…
Textile Architecture
Properties of low-ε coatings

- low emission of thermal radiation
- high reflection of thermal radiation
- low thermal emittance $\varepsilon \Rightarrow$ low emission of thermal radiation $\Rightarrow$ saving of energy

NBIA

glass fiber fabrics with aluminum coating

Textile Architecture
Transparent low-$\varepsilon$ coatings

- TCO (transparent conductive oxide) layers on textiles
- TCO: e.g. ITO: Indium Tin Oxide, AZO: Aluminum Zinc Oxide
- coating by a sol-gel process
Conclusion

Ultra-thin façades could be energy efficient!

Innovative materials and systems offer the potential for more energy-efficient systems (VIP, VIG, PCM, low-\(\varepsilon\) coating)

Textile architecture is an challenging field with a great potential for the realization of energy efficient façades.
Thank you for listening!

Further information:

www.vip-bau.de
www.vig-info.de
www.hwff.info
www.pcm-demo.de
www.zae-bayern.de

R&D work is funded by the German Federal Ministry of Economics and Technology within the framework of the research programme Energy-Optimized Building (EnOB)