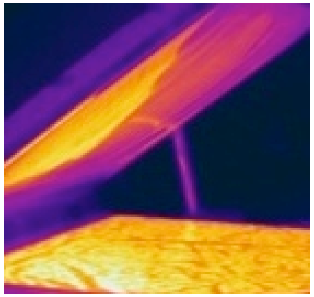
Keeping Energy Confined and Making Information Flow

The Smart Building of Tomorrow



Christian Hoepfner

Fraunhofer Center for Sustainable Energy Systems

Fraunhofer
USA

Boston City Hall
Source: wikimedia.org

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Atlantic Wharf,
Boston, MA
Source: bostonproperties.com

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Cape Cod Cottage
Source: flickr.com/photos/jeffreypitcher

Passive House
by Karawitz Architecture
Source: archdaily.com

Boley Building
Kansas City, MO
Source: Wikipedia

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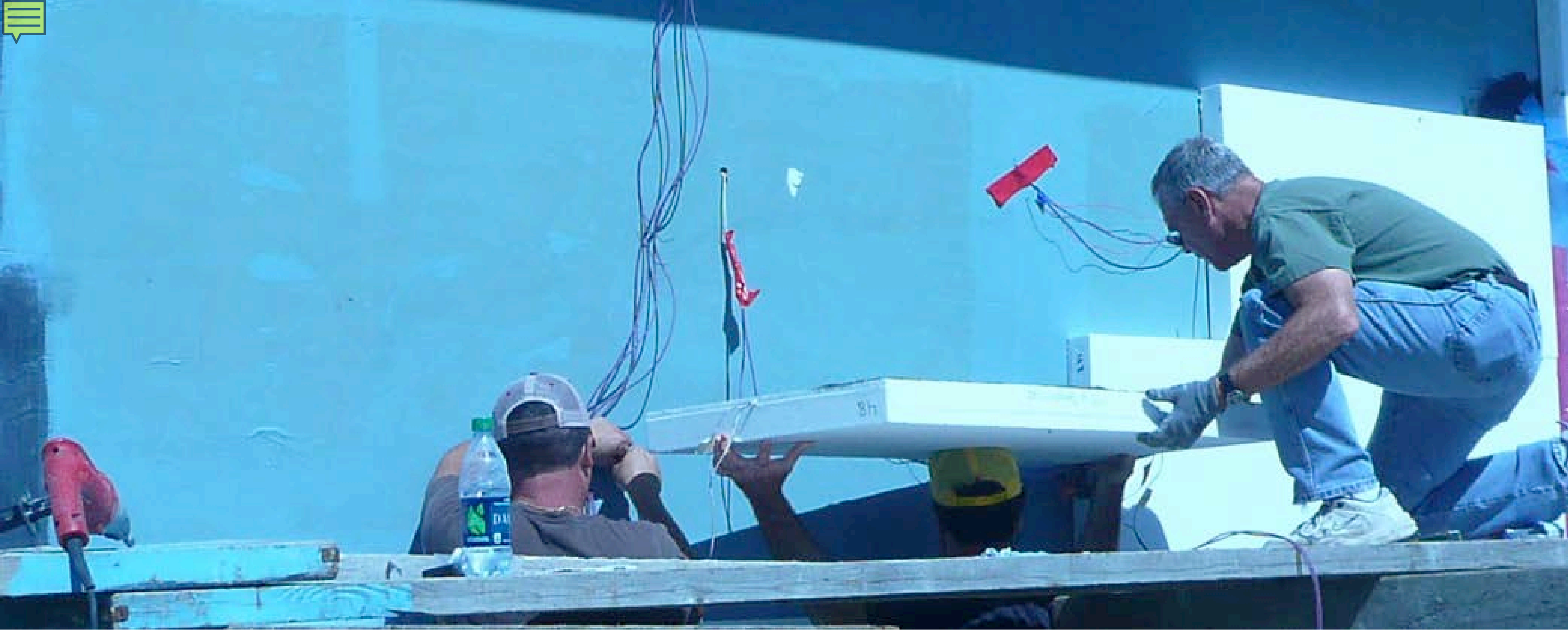
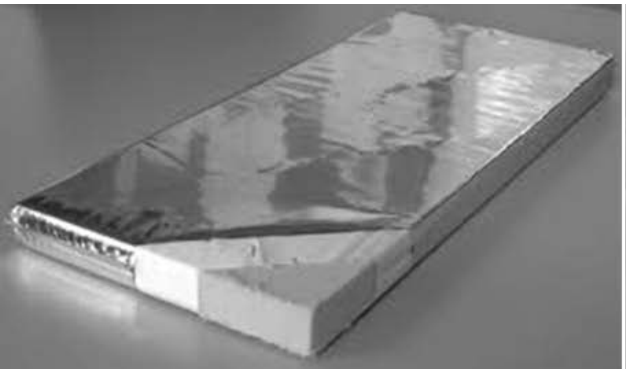
Lewis Center
Oberlin College, OH
Source: new.oberlin.edu



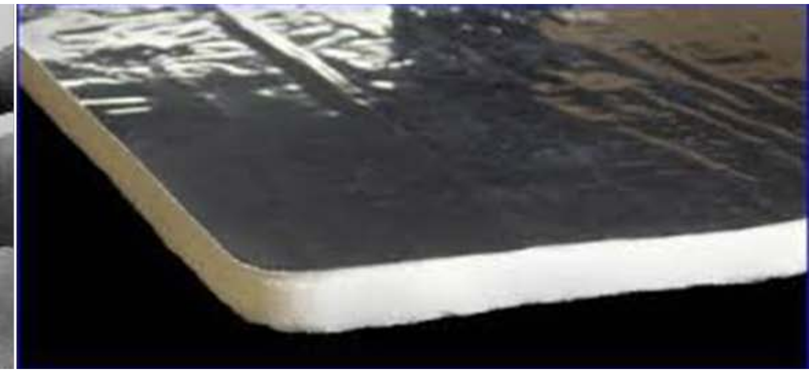
BUILDING ENCLOSURES: HIGH PERFORMANCE & SUSTAINABLE

High-Performance Thermal Insulations



IEA Annex 39 report 2007

Bjørn Petter Jelle - BEST3 Conference 2012



ASPEN Aerogels

Potential of high-performance insulation systems is high …

- Superior thermal performance – R-10 to R-50/inch (depends on technology and applications)
  - Perfect for heating dominated climates
- Thin profiles often eliminate need for costly installation
- Installation process different than for most conventional systems – adhesion, blankets
- Up to 70% reduction in space conditioning loads from reduced conduction and infiltration
- Cost example: Actual material costs of vacuum insulation much lower than system costs
  - Due to low manufacturing volumes, lack of installation practice

… but cost and implementation challenges remain

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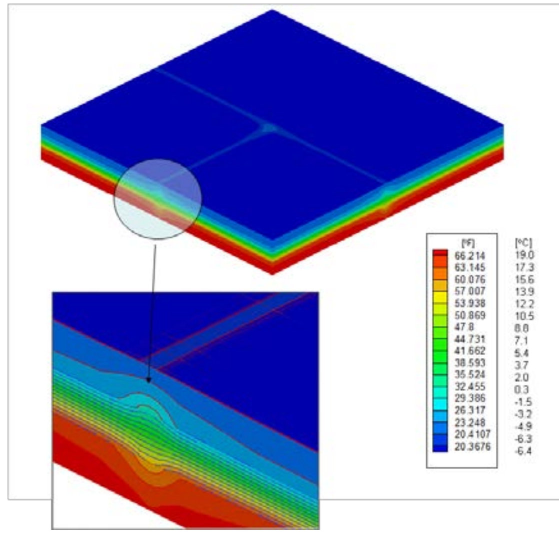
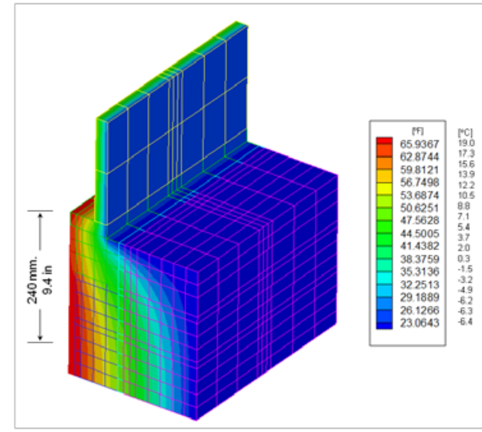
Example of Enabling Work for Advanced Insulations:

Thermal Optimization of VIP –Based Wall Insulation Systems





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- VIPs packaging can significantly decrease nominal R-value due to thermal bridging
- Example shown:
  - VIP with fumed silica: R-40 per inch
  - VIP - foam assembly protects panels from mechanical damage
  - Nominal R-value reduction over 60%
- Solution: Optimize VIP packaging to reduce thermal bridging
  - Testing and 3-D thermal modeling
  - Optimize installation methods for interior and exterior wall applications
  - Development of specific framing system for walls

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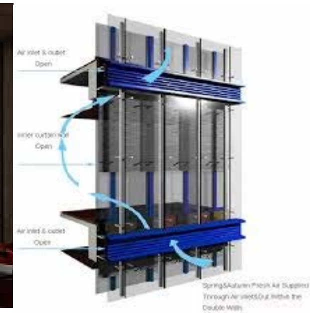
Kleinfeldt Mychajlowycz Architects Inc. Toronto, Canada

DYNAMIC ENVELOPES TO MATCH DYNAMIC ENVIRONMETAL LOADS

Dynamic Envelope Strategies

Solar Energy Kosny et al. 2013

Fraunhofer ISE, Germany



www.tjskl.org.cn

Kingspan, UK

Cosella-Dorken, Germany

- Thermal design of building envelopes - walls, roof, and attic assemblies is still based on steady-state, “thermally static” criteria, but they are subject to dynamic climatic conditions
  - Results in relatively low thermodynamic (exergy) efficiencies
- Diminishing returns of adding increasingly more thermal insulation
  - Incremental energy savings
  - Insulation embodied energy and emissions of ozone- depletion gases (for some insulations)
- Value of dynamic strategies:
  - Up to 50% reduction of space conditioning loads
  - Load shifting: up to 90% reduction in peak-hour cooling loads
  - Enhanced comfort

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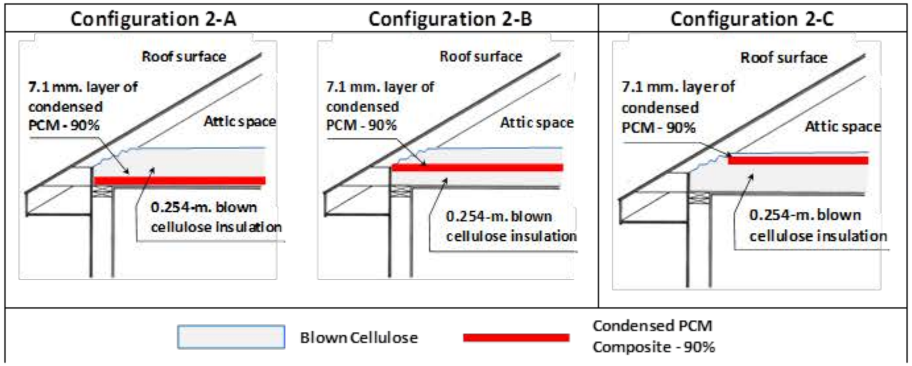
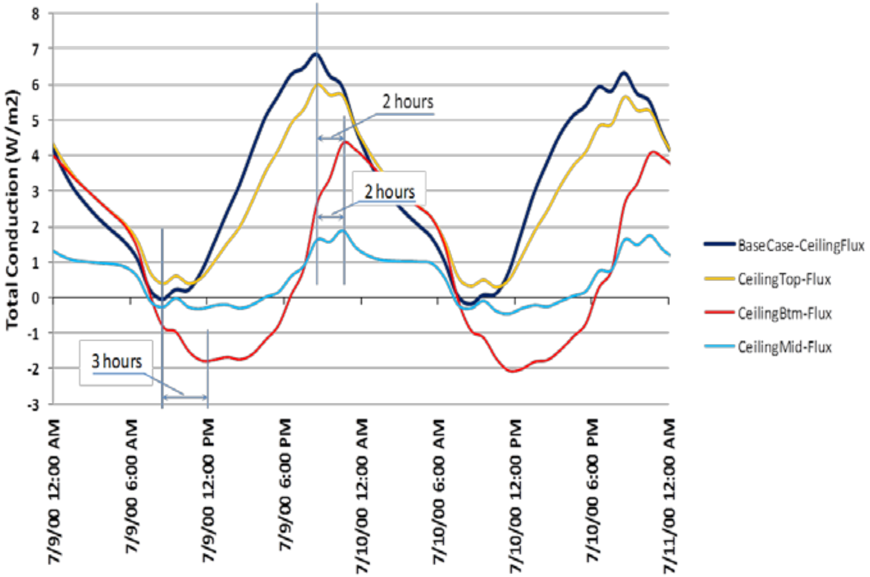
PCM-enhanced Attic Insulation Systems



Kosny et al. Solar Energy - 108 (2014) pp.164-77)



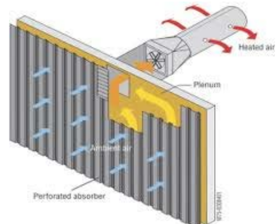
- Attics with significant thermal insulation are not best performing design options
- Integrating PCM into attic floor insulation can significantly reduce (20% to 35%) attic-generated thermal loads
- Greatest benefit from PCM at bottom or middle of attic floor insulation
- Cooling load shifting
- Inorganic PCMs have large cost reduction potential

Advanced Insulations & Dynamic Envelopes: Solutions for Any North American Climate

REFLECTIVE INSULATION

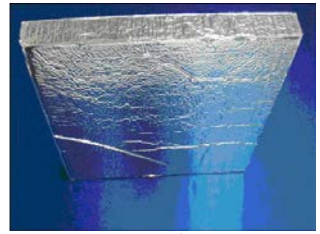
http://funbuzz.com/Page5.html

BI SOLAR THERMAL ENVELOPES



NIBS, WBDG, 08-24-2012

ADVANCED INSULATIONS



ZAE BAYERN, Germany

PCMs

ThermaCool, Datum, UK

COOL ROOFS

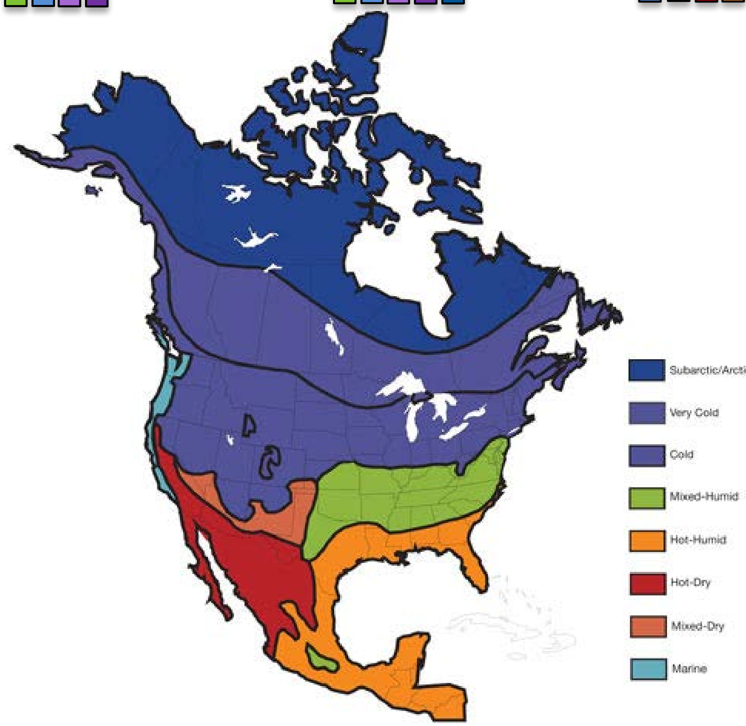
Albright Roofing, Tampa, USA

BUILDING INTEGRATED PV

Greenbang 06, 27, 2011, Gridovate

PASSIVE SOLAR & THERMAL MASS

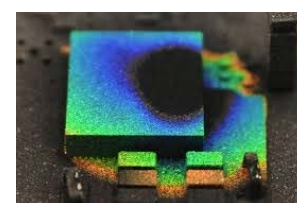
Viahouse.Com



DYNAMIC ROOF VENTILATION

ORNL

SWITCHABLE COATINGS



gardnerlaboratories.com

Miasolé on Walmart Rooftop
Source: Walmart

Ballasted PV on Walmart Rooftop
Source: Walmart

SunPower Installation Westport, CT
Source: SunPower Success Stories

Transformations Zero Energy Home – Devens Green, MA
Source: greenenergytimes.net


Dow Powerhouse
Source: Dow Powerhouse Facebook


CertainTeed Apollo II
Source: certainteed.com


Ubiquitous Energy
Source: Miles Barr

BISEM PV Curtain Wall Retrofit
Source: Bisem-USA

An Integrated and Sustainable Vision: Affordable Net-Zero Energy Homes

Source: Scott (2013)

- Traditional home designs, ~1,800 ft^2, 3 BR
- Cost-optimized Passive House – Cost ~ \$125/ft^2
  - Excludes incentives, land, road, engineering, permits, septic, soft costs and fill
- Highly efficient homes for cold climates
  - Passive solar measures – More southern windows, few northern, strategic overhangs
  - Highly insulated double-stud walls (R-47) and attic (R-63)
  - Tight construction - ~0.5 ACH – mechanical ventilation systems
  - Ductless minisplits for heating and cooling – peak heating load <11,000 Btu in Massachusetts
- Actual energy consumption: 915 kWh/year (~0.5kWh/(sf x yr); ~\$15/month)
- Next: Plus energy houses to power electric vehicles

THE SMART BUILDING OF TODAY & TOMORROW

Building Energy Management Solutions of the Future: Automated and People-centric

- Provision of superior comfort tailored to the needs of individual people
- Optimization of whole-building energy and energy cost performance
- Continuous evaluation of building systems' performance to automatically detect and diagnose subpar building operations (ongoing commissioning)
- Support of the electric grid as PV penetration continues to dramatically increase
- Integration of new devices (highly scalable)

Source: Building Robotics, CrowdComfort

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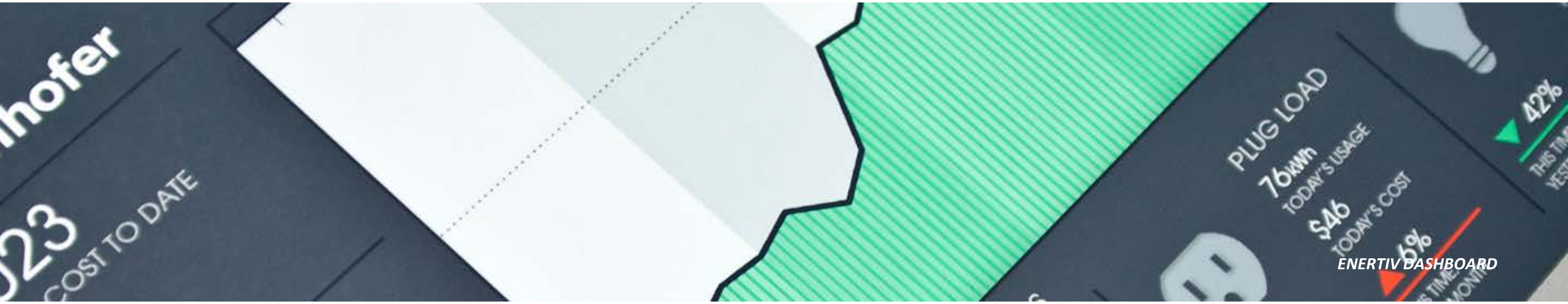
Ongoing Commissioning and Optimal Whole-building Control: Applying data to enhance building performance



- Ongoing Commissioning: Continuous monitoring of building performance to ensure buildings function as intended
  - Automated fault detection and diagnostics: Actionable information to address faults
  - Typical energy savings of 5 – 20% of whole-building energy consumption
  - Becomes more important as sophistication of building HVAC systems and controls increases
  - Improve occupant comfort
- Optimal Building Control: Dynamic selection of the optimum set of control strategies to minimize whole-building energy costs and consumption
  - Approaches include machine-learning algorithms and model-predictive control
  - Greatest value currently for peak demand management – energy cost savings of up to 30%

Sources: Brambley et al. (2005), Roth et al. (2008)

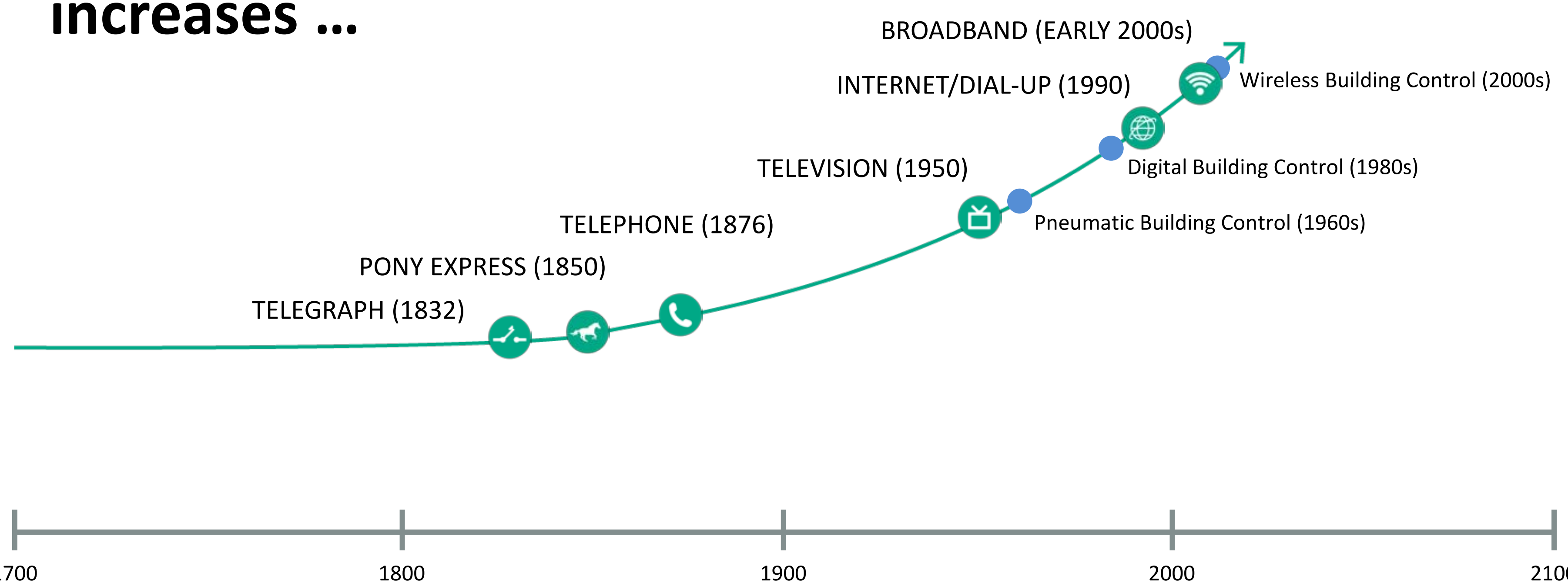
Building Energy Management to Enhance Grid Performance

- Today: Limited demand response, frequency regulation, locational marginal pricing
- Future: Dynamic building load management in response to the dynamic state of the grid - not just shedding load to avoid demand charges
- Reduce building operating costs by monetizing additional grid support functions
- Increase the amount of renewable energy that can be deployed on a feeder
  - Particularly for high-penetration PV scenarios – mitigate mid-day PV production surplus
- Integration with energy storage greatly increases potential
  - Increase building resilience: Prioritize building operations to enable extended islanded operation

Source:

Fraunhofer USA

Amount of information in and out of buildings increases …



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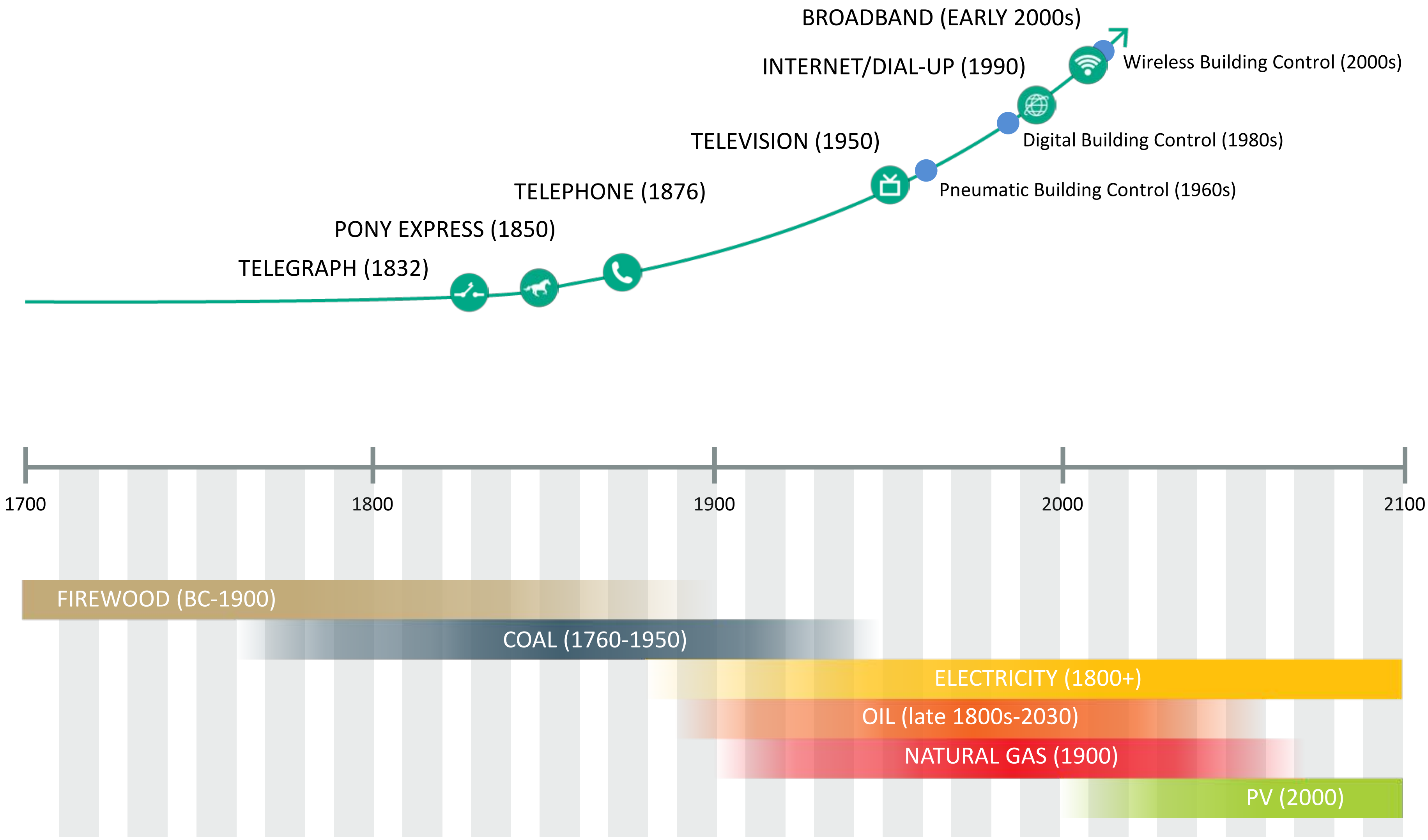
… as does it for energy …



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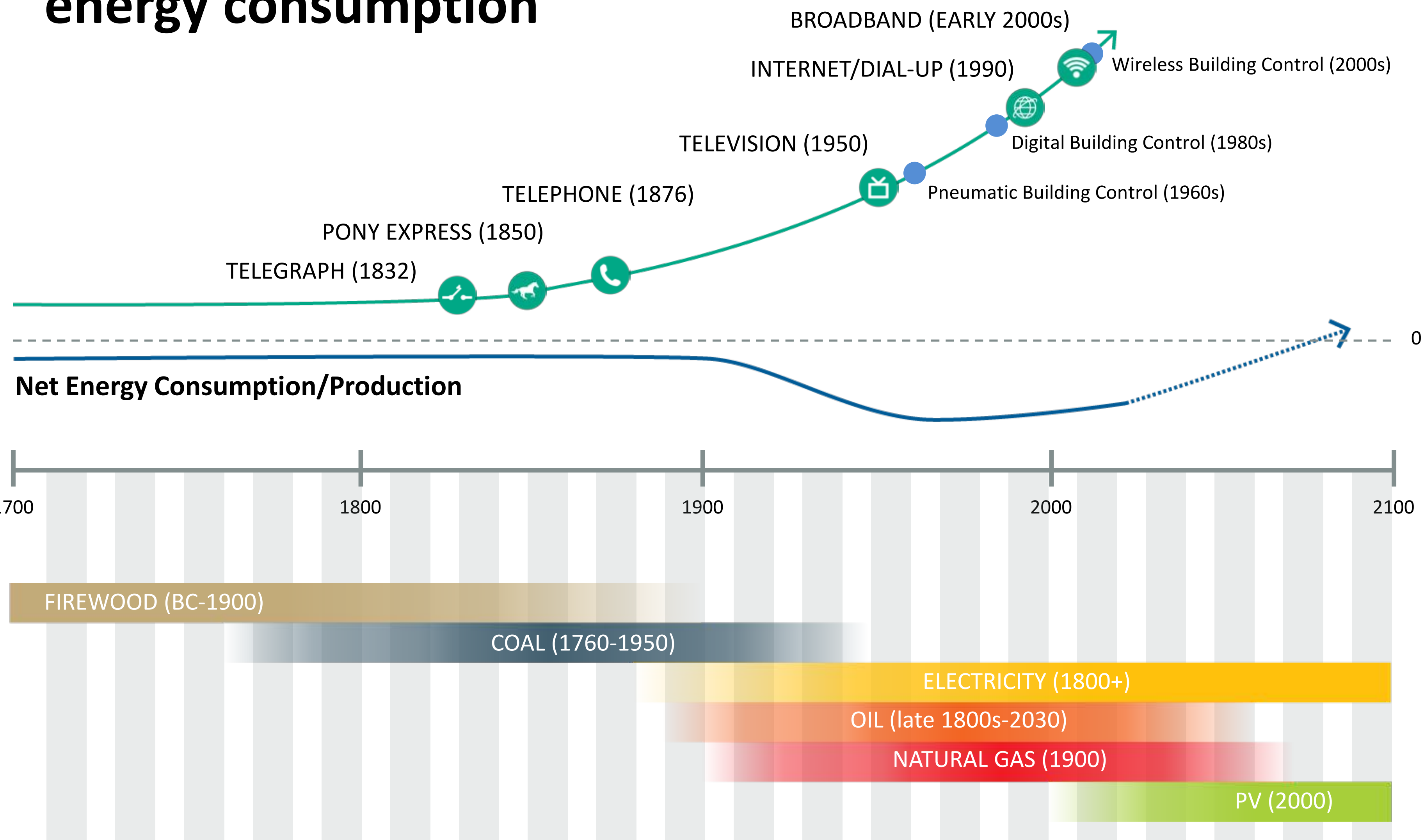
… but more information will enable to decrease energy consumption



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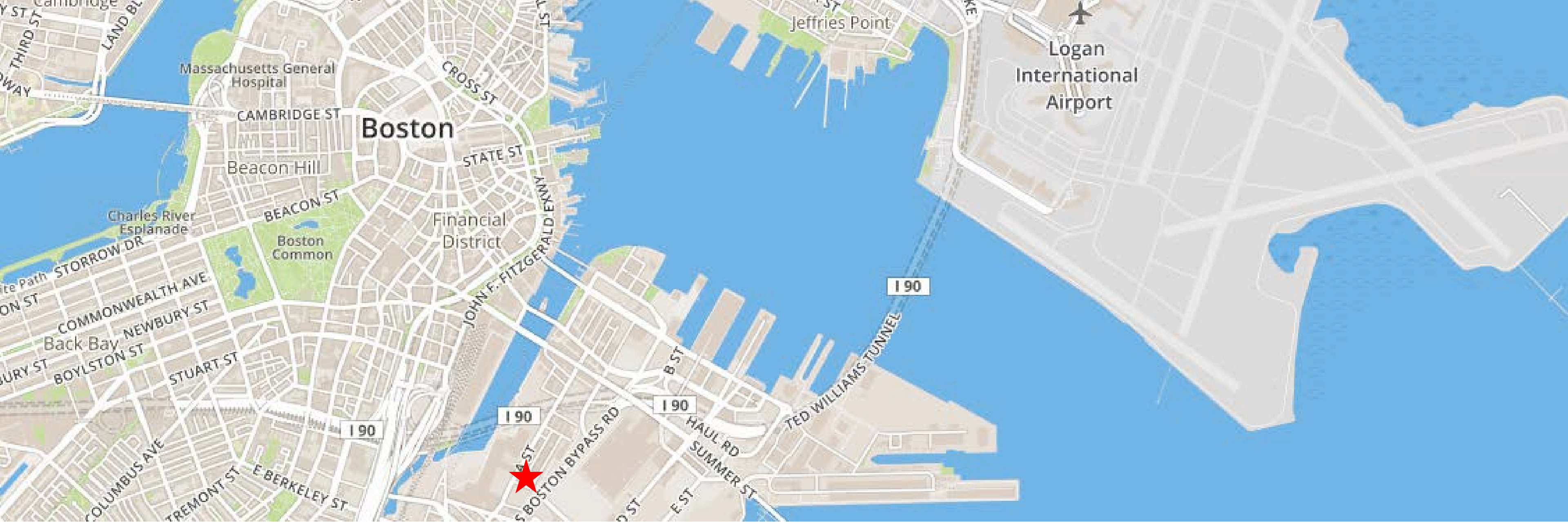
Freiburg Green City, Germany

Source: germany.travel

UC Davis West Village,
Davis, CA

Source: westvillage.ucdavis.edu



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