Lessons from Engineering:
Design for Efficiency & Relevance

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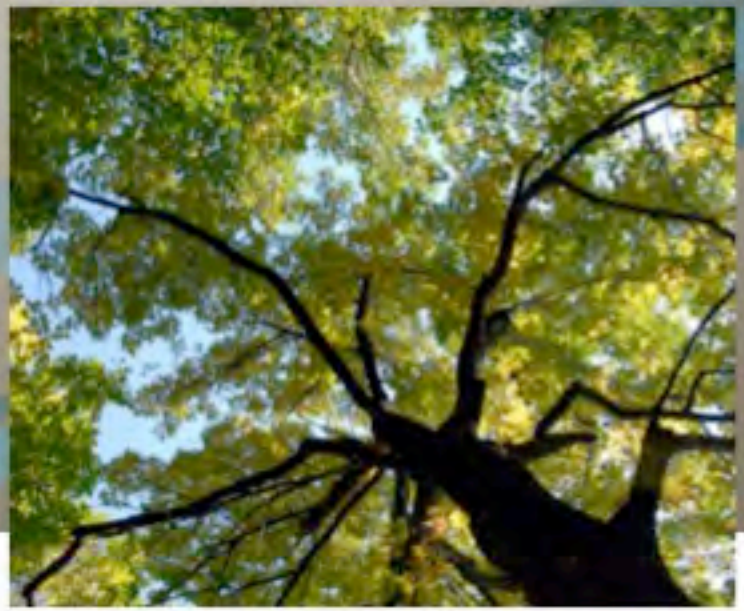
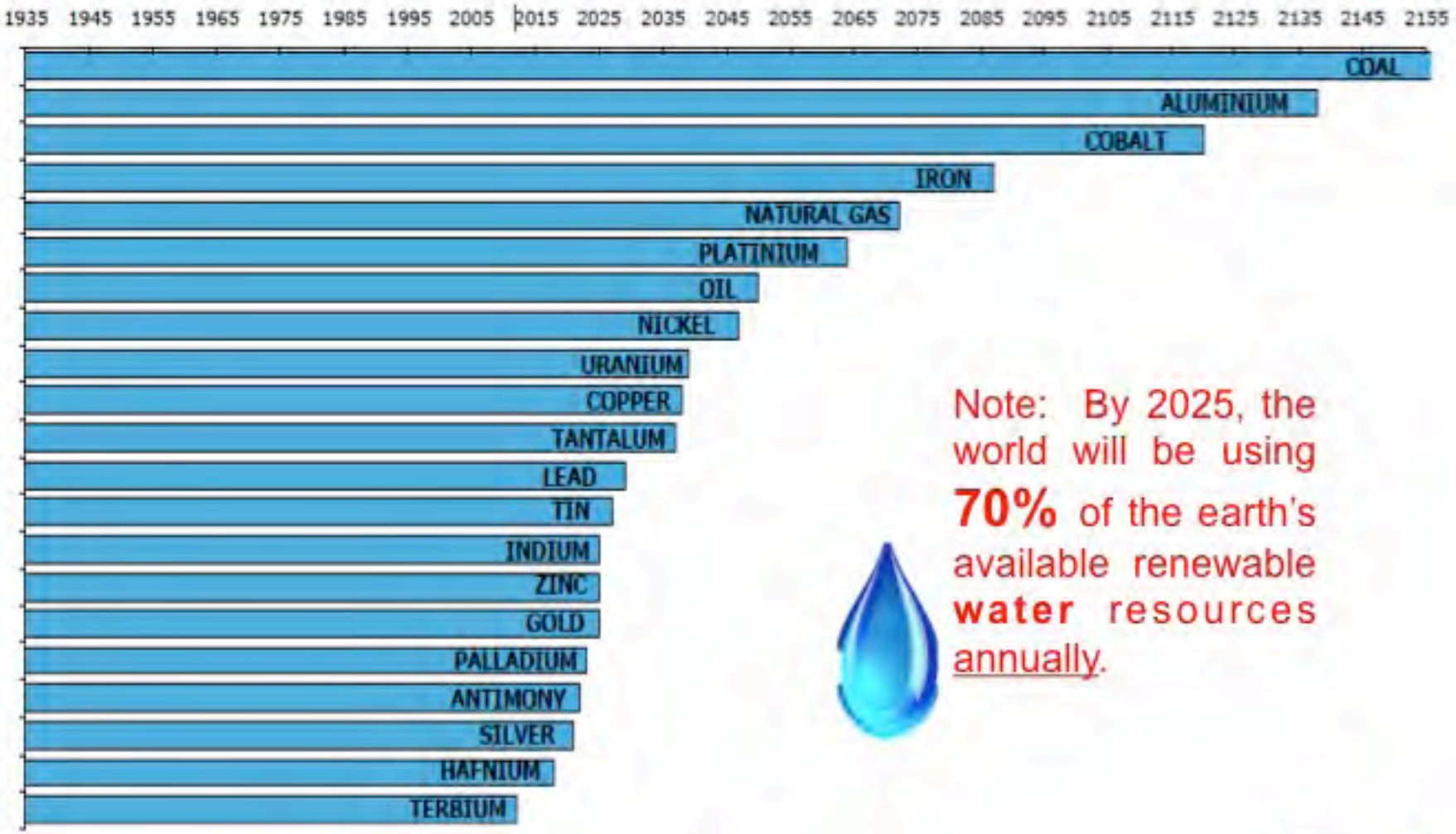


Based on Rocky Mountain Institute's 10xE Principals
www.rmi.org

The world has ecological limits

Energy Apathy

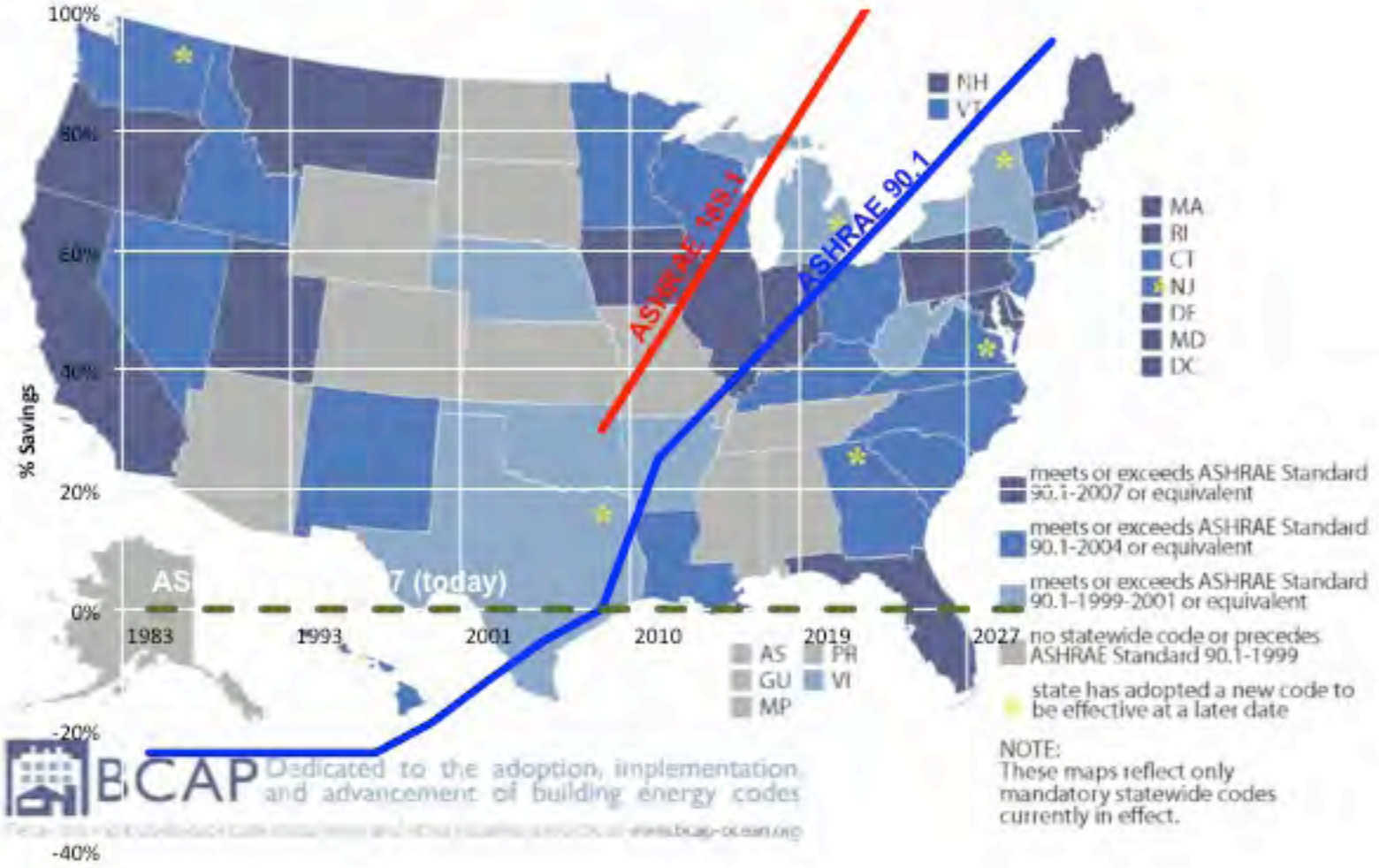
Resource Extinction



Note: By 2025, the world will be using **70%** of the earth's available renewable **water** resources annually.

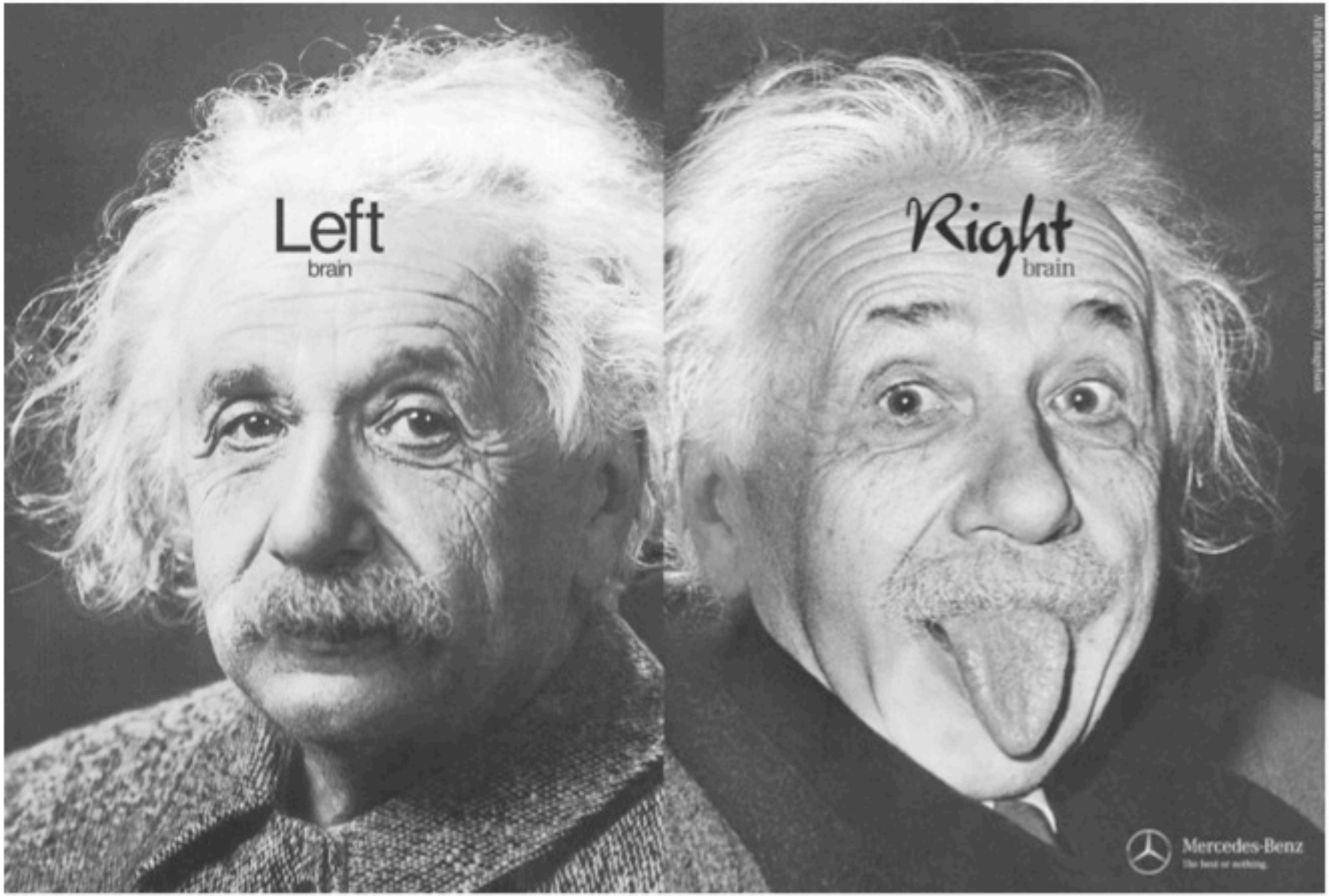
Source: terresacree.org based on 2007 USGS (US Geological survey) data

Energy Codes are GETTING TOUGHER



- No Oil
- No Coal
- No Nuclear
- Doubled Economic Growth
- Market-Driven Solutions
- Lead by Business for Profit

Radically Simple Approach to Superefficient Design



Principle 1. Set aggressive and inspiring goals.

Principle 2. Collaborate across disciplines.

Principle 3. Design nonlinearly.

Problem-seeking and identifying opportunities

Analysis and consultant collaboration

Implementation and verification

B.F.A.I.

Conceptualization | *Schematic Des* | *Design Dev* | *Construction Docs* | *Construction* | *Operations*

Charrette
Sustainable Goal Setting
Environmental Programming
Feasibility Studies

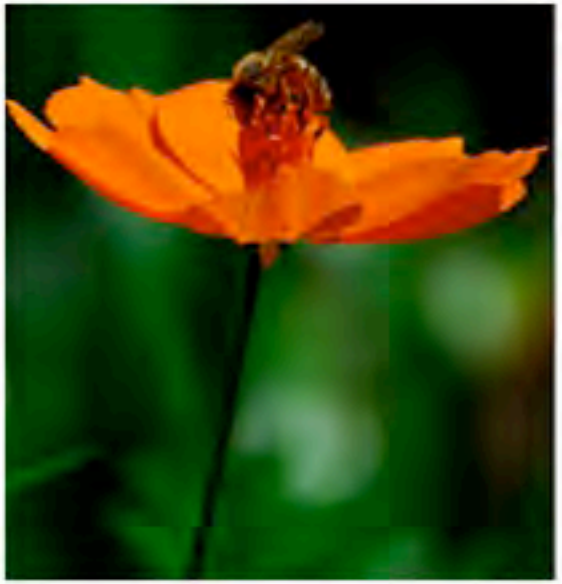
Charrette
Technical Analysis

Charrette
Technical Analysis
Design-side
Commissioning

Commissioning
Inspection

Commissioning
Inspection
Measurement & Verification
Impact Assessment
Education and Training
Continual Performance
Improvement

Principle 4. Reward desired outcomes.



LIVING BUILDING CHALLENGE™ 2.0

A Visionary Path to a Restorative Future

INTERNATIONAL LIVING BUILDING INSTITUTE™

Reward efficiency & accomplishment, not waste.

Principle 5. Define the end-use.

Form follows function.

- Louis Sullivan

Principle 6. Seek systemic causes.

Ask “why” five times to find the root problem.

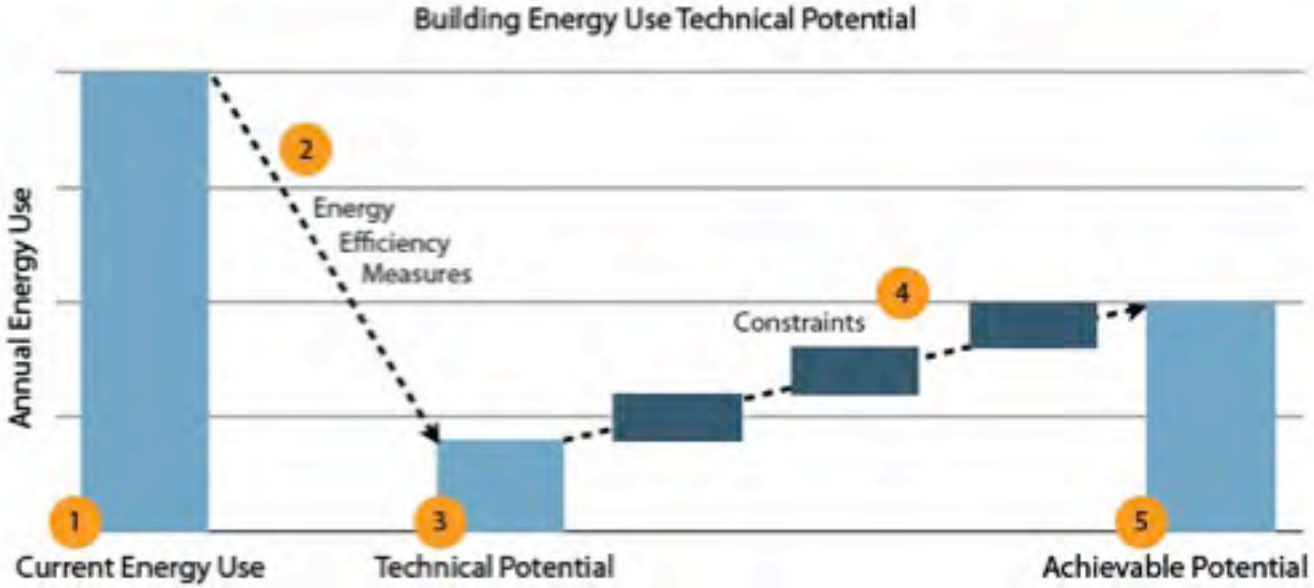
Principle 7. Optimize over time and space.

Design in four dimensions.

Principle 8. Establish baseline parametric values.

Identify relevant baselines and metrics.

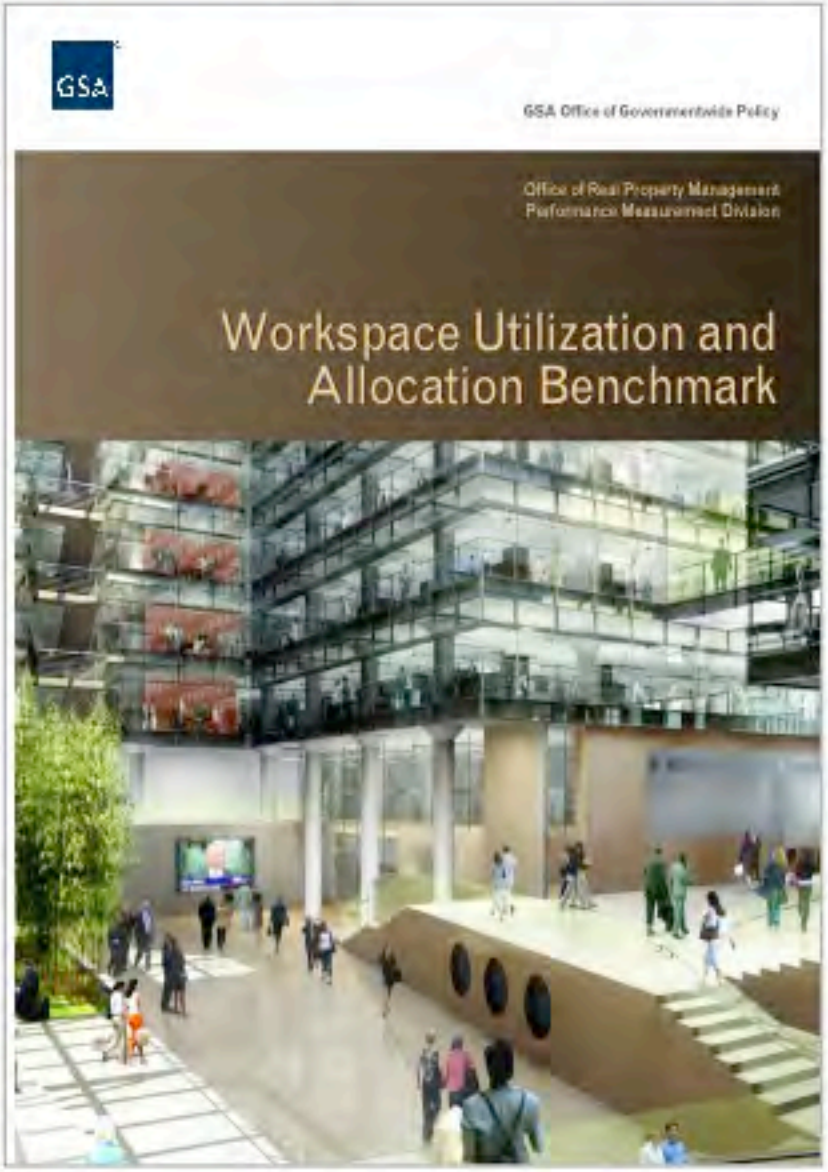
Principle 9. Establish lowest technical potential.

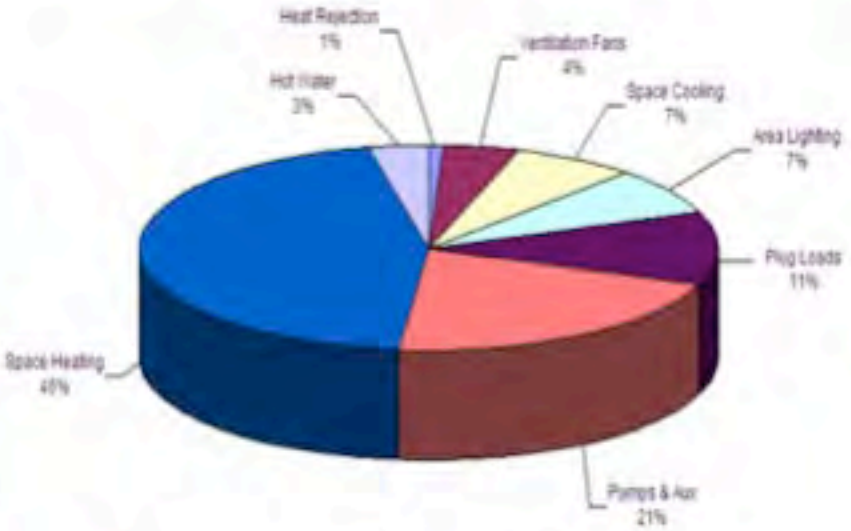


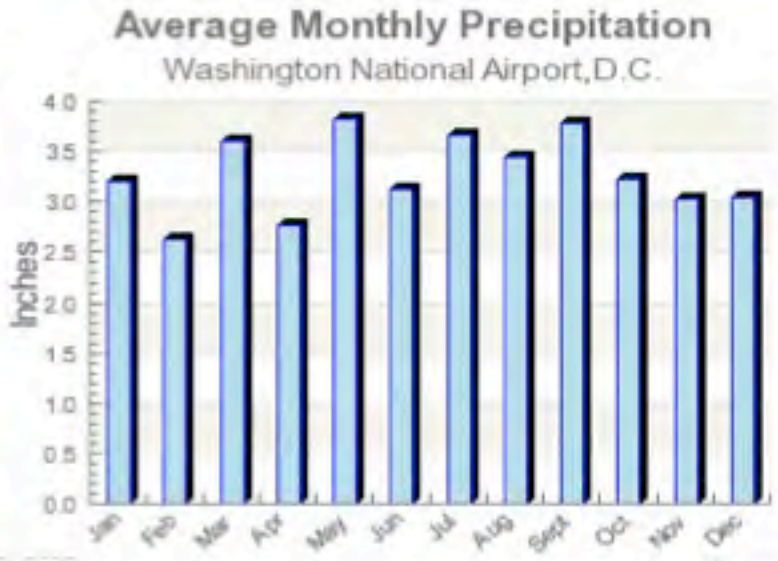
Principle 10. Start with a clean sheet.

Avoid “infectious repetitis”.

Principle 11. Use real data and explicit analysis.







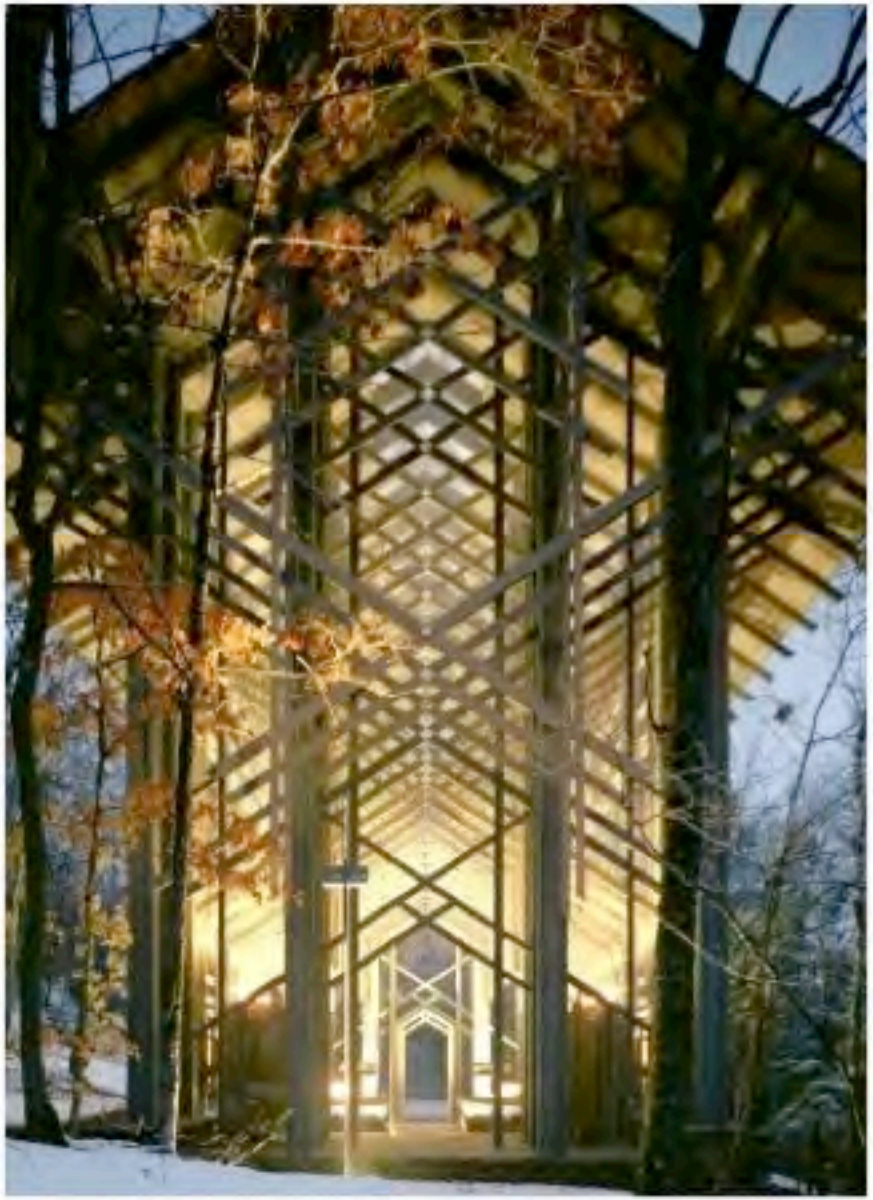
Principle 12. Start downstream.

Turn compound losses into compound savings.

Principle 13. Seek radical simplicity.

Less is more.

- *Mies Van der Rohe*

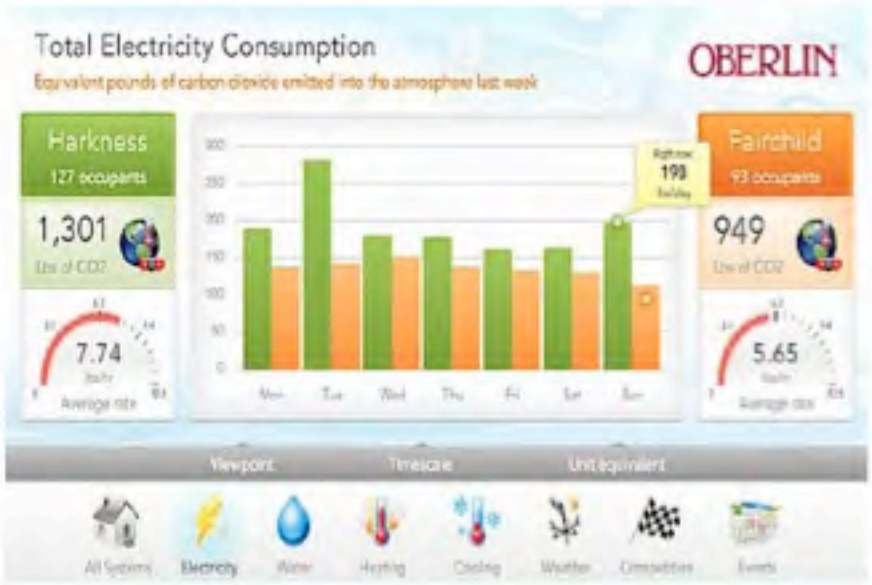


Principle 14. Tunnel through the cost barrier.

Principle 15. Find multiple benefits in single expenditures.

Principle 16. Meet optimized demand, not peak.

Principle 17. Integrate feedback.



Case Study: Collaborative Design

Indianapolis City County Building (1959)

ESPC (2009-present)
- 59% Energy Cost Savings ESPC
- LEED EB Gold Target

DRIVERS -
- Dark Work Spaces / High Lighting Load
- City Wants to Model Efficiency
- Unbalanced HVAC
- Energy Security

MEASURES –
- Retrofit Curtainwall Shading
- Upgrade Lighting & Controls
- Open Loop Geo-Exchange (Groundwater)
- Open Office Space Retrofits
- Occupant Awareness / Green Leases
- Datacenter Heat Recovery

….via opportunity charrette + ESPC implementation

Case Study: Tunneling

Grand Forks Office Building

Do the math….

Windows	$67,500
Daylighting	$18,000
Insulation	$17,200
Lighting	$21,000
HVAC	-$160,000
Total	-$36,300

+ Energy Savings of $75,000/yr


RetroFit
AN RMI INITIATIVE

RetroFit DEPOT

Profitable Solutions for Commercial Retrofits

RMI RetroFit Guides

RetroFit CHALLENGE

Portfolio Energy RetroFit Challenge

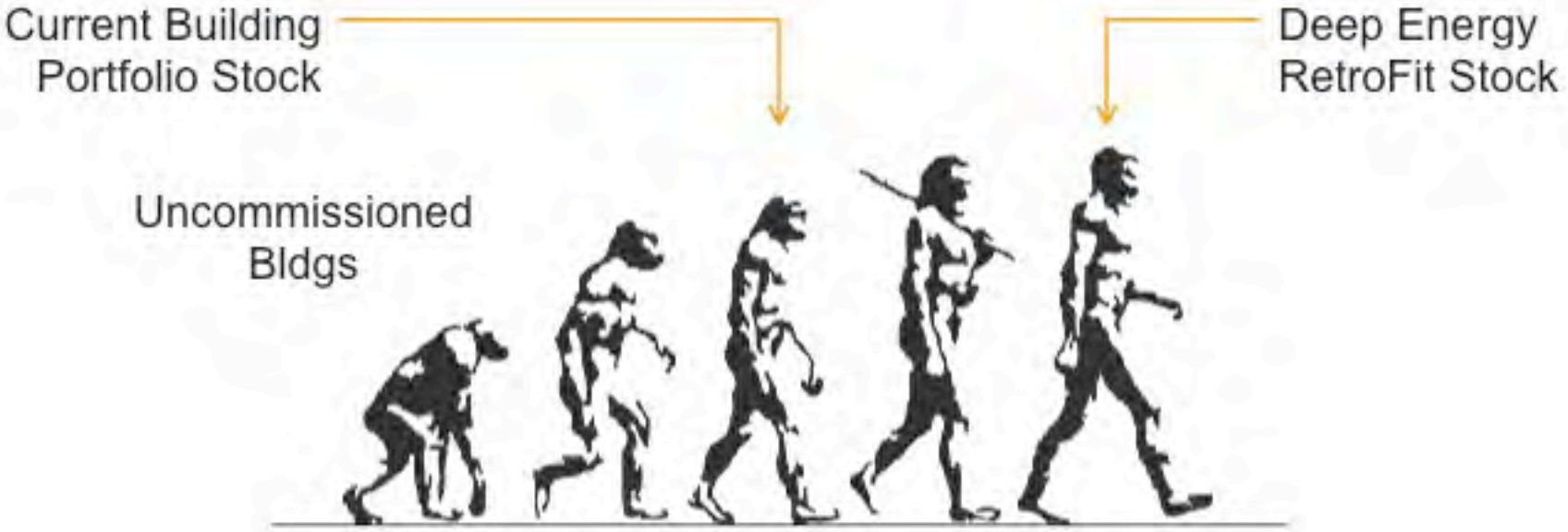
conservation

generation

consumption

innovation

efficiency

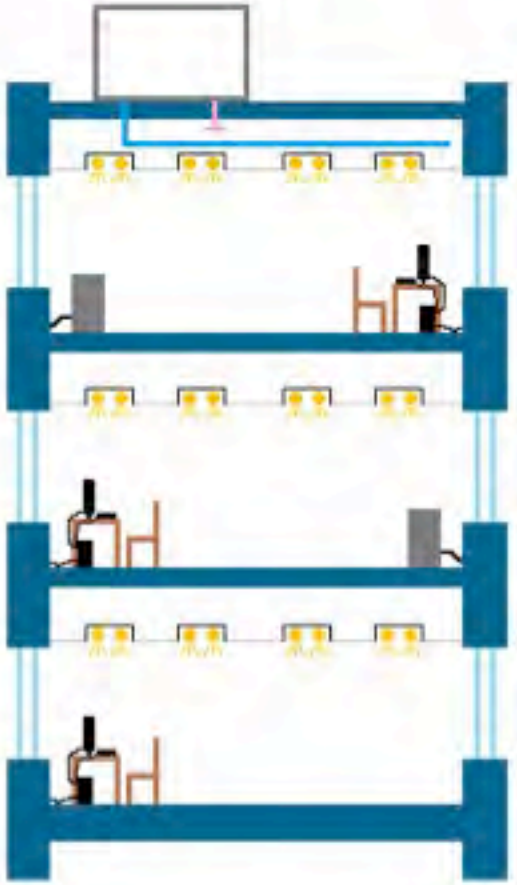


Step 1: Select Focus Area

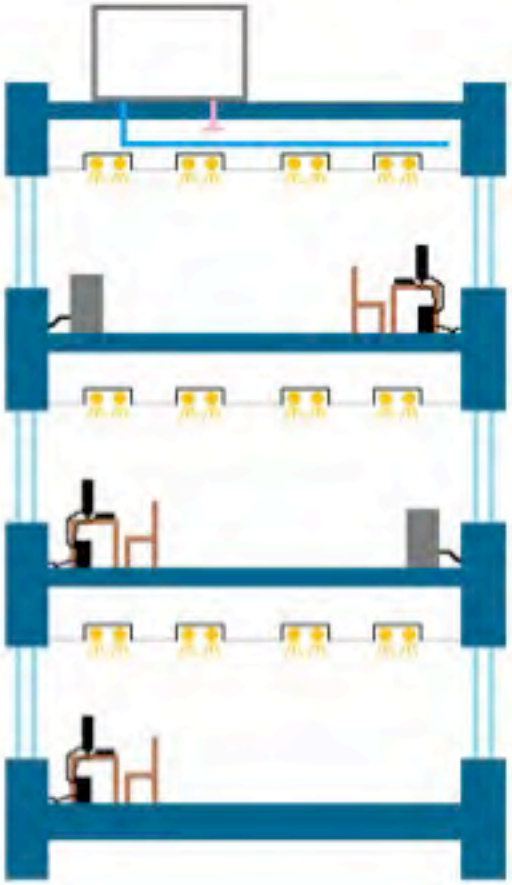
Step 2: Find Archetypal Subset

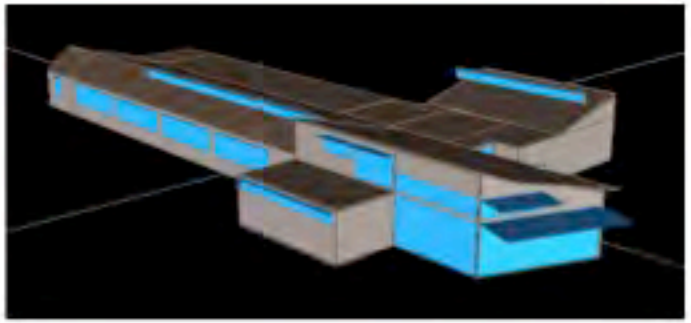
Step 3: Choose Representative Building

Step 4: Technical Potential Workshop



Step 5: Audit + Energy & Cost Analysis





$$\frac{\partial u}{\partial t} = \frac{k}{c_p \rho}\left(\frac{\partial^2 u}{\partial x^2}\right)$$

Step 6: Portfolio Rollout Strategy

RetroFit CHALLENGE

Portfolio Engagement Process

- **Discover** — Data, Baseline
- **Seed** — Archetypal Subsets
- **Analyze** — Bundles of Measures
- **Roll Out** — Portfolio Targets, Timing Across Bldgs, Financing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INSTITUTE