October 2019

Climate ACTION for Engineers

NSPE Webinar Series

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Klepper, Hahn & Hyatt

Structural Engineering
Landscape Architecture
Building Envelope Systems

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Presenter Bio – Jim D'Aloisio

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Principal, Klepper, Hahn & Hyatt

P.E. in NY and MA   SECB   LEED AP

Member, NYSSPE, ASCE, SEAoNY

Chair, SEI Climate Action Team

Former Chair, SEI Sustainability Committee

Former Chair USGBC NY Upstate Chapter

Former USGBC National Board Member

Member, Climate Reality Leadership Corps

Trainer, Urban Green Council Energy Code

Thermographer, consulting & forensic engineer

Climate Action for Engineers
Webinar Series

Part 1 – Anthropogenic Climate Change Overview
Thursday 9 October 2019

Part 2 - Categories of Action
Thursday 23 October 2019

Part 3 - Structural and Infrastructure Mitigation
Thursday 30 October 2019

All Webinars 2:00 – 3:30 PM Eastern Time

Climate Action for Engineers
Webinar Series
Part 2 - Categories of Action

What to do? Lots of different actions can be taken. We'll clarify mitigation vs. adaptation and resilience, as well as the various categories of mitigation - personal, professional, and political action, the effectiveness of different types of action, the economics of carbon reduction, as well as activities that have an immediate short-term benefits versus long-term effects. We'll review the concept of geo-engineering pros and cons. We'll also consider the role of the engineering community in the development and implementation of solutions, and what steps have already been taken by some engineering organizations.

Learning Objectives

1. Compare and contrast mitigation and adaptation measures.
2. Become familiar with the amount of CO2eq is emitted by various activities.
3. Consider the possibilities and limitations of geo-engineering solutions.
4. Consider the potential impact of climate change mitigation policies by professional organizations.

OUTLINE - Part 2

Climate Action for Engineers: Categories of Action

1. Part 1 Summary
2. Mitigation vs. Adaptation and Resilience
3. Metrics: Quantifying Carbon
4. Solution Strategies
5. Our Role / Your Role

1. Part 1 Summary

1. The climate is changing
   1. 1.8-degree F rise in temperatures since 1880
   2. 7-inch rise in sea level over past 100 years
   3. Increase in severe drought events
   4. Increase in severe rain events
   5. Decrease in Arctic ice thickness
2. Earth's atmosphere is changing
   1. Humans emit over 100 millions tons GHG/day
   2. CO_2 at 310 ppm, compared to historical 270
   3. CH4, NO2 and HFC's have also increased
   4. No other climatic forcing can account for T rise
3. Reducing emissions now will reduce future effects
4. A refundable carbon tax will reduce carbon emissions, improve health, and be good for the economy.

2. Mitigation vs. Adaptation/Resilience


First comes
AWARENESS
of Anthropogenic Climate Change
Then must come
ACTION
MITIGATION
→ Stop it! ←
ADAPTATION
→ Deal with it! ←
Personal Action
Professional Action
Political Action
Divestment
Emergency Response
Resilience

Adaptation / Resilience

- Taking changing conditions into account in design of buildings and infrastructure
- Changing conditions include rising water levels, droughts, warmer temperatures, increased storm intensities
- Reactive, not proactive – although necessary
- Increasing awareness and acknowledgment by cities, communities, and professional engineering societies and organizations

Completely different than MITIGATION

Cities Taking Adaptive Measures

- New York City, NY
- Boston, MA
- Miami, FL
- Others

RESILIENCY

ASCE Tackles Climate Change

Insurance companies, governments and some businesses are looking to engineers to build more-resilient structures to accommodate changing climate and weather extremes. But some engineers may not know how to incorporate into their designs consistently the unknowns of future rainfall and storms.

"Engineers are improvising," says Bilal Ayyub, a professor of civil engineering at the University of Maryland. "Some owners are asking for ASCE standards that we don't have yet."

That should all change early next year when the American Society of Civil Engineers releases a 240-page manual of practice on adaptive design and risk management. That manual, currently under peer review, is expected to provide the foundation for ASCE standards.

Along with his co-authors, Ayyub, lead author and editor of the manual, presented an outline of the manual on Oct. 10 in New Orleans at ASCE's annual conference. The manual does not

emphasized, "There is no getting around the fact that we need to be able to become more cognizant of future changes." Construction of a more-resilient future could hinge on standards based on the manual. "Once the standard begins to evolve, then the codes can begin to evolve," says Walker. Until then, Fields says, "Developers are going to look to code minimum." ■

By Pam Radtke Russell

Responses to Climate Change

(Representative actions only)		PERSONAL	PROFESSIONAL*	POLITICAL
MITIGATION	IMMEDIATE	Try to use minimal A/C	Reduce CO_2e of infrastructure construction	Advocate for CO_2e redux
	LONG-TERM	Insulate and air seal your home	Shift to low CO_2e modes of transportation	Advocate for pricing of CO_2e
ADAPTATION	IMMEDIATE	Practice natural ventilation	Emergency response aid	Increasing help for storm victims
	LONG-TERM (i.e. resilience)	Insulate and air seal your home	Design for higher storm surges	Improve codes for resiliency

* - actual response varies with the profession

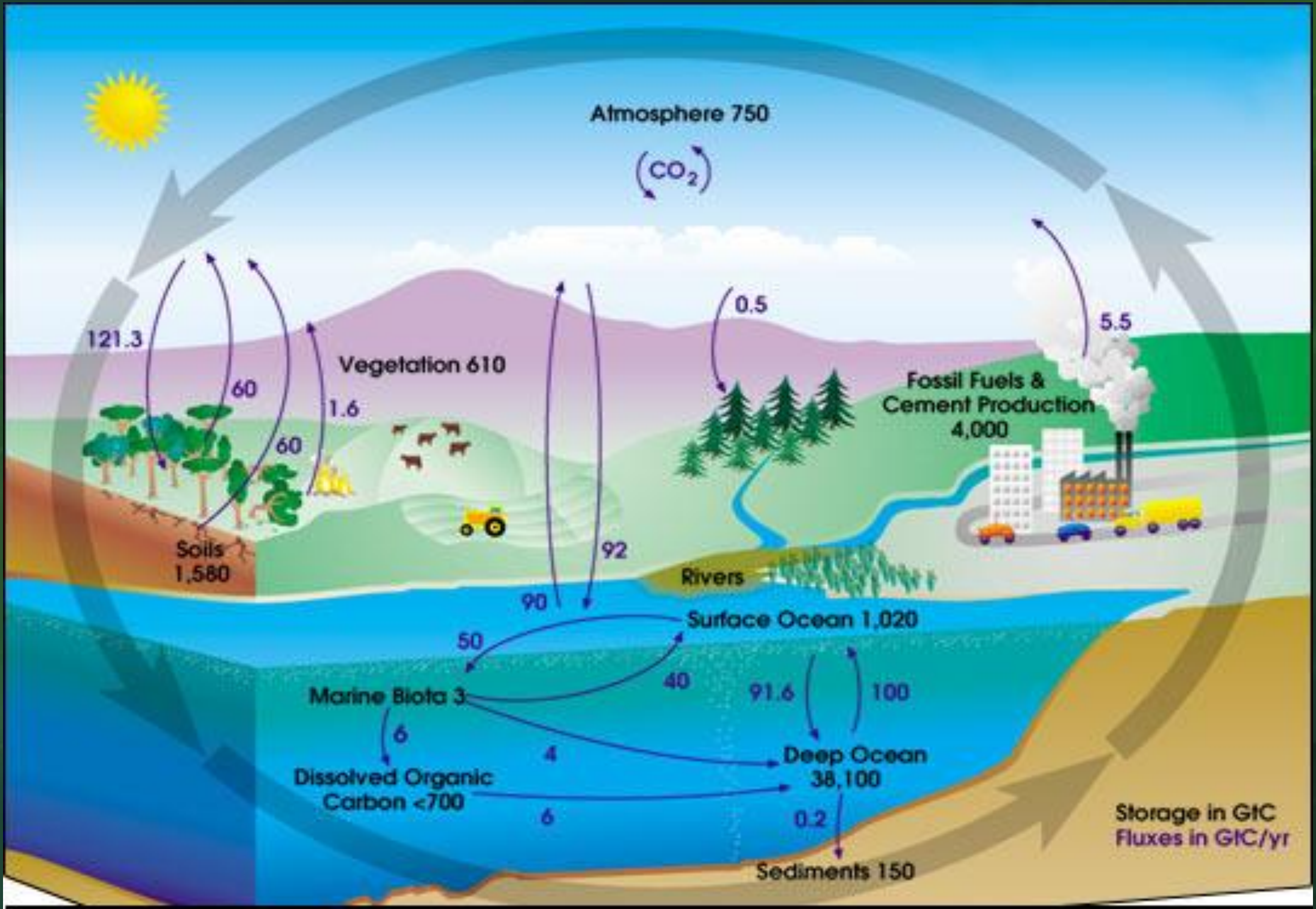
Spot Quiz

Is it Mitigation or Adaptation?

- Raising coastal highways ....Adaptation
- Switching to solar power..........................Mitigation
- Reducing thermal bridging......................Mitigation
- Using fly ash to reduce cement...............Mitigation
- Decreasing A/C usage ....Mitigation
- Increasing A/C usage..............................Adaptation
- Improving building envelope performance.....Both!

2. Metrics: Quantifying Carbon

The Global Carbon Cycle



http://www.global-greenhouse-warming.com/

Sources of Anthropogenic CO_2e Emissions - Personal

- US avg. CO_2 /person -38,800 lbs./yr.
- 10-min. shower ea. day - 900 lbs./yr.
- Breathing – 1.5 to 12 lbs/day, say 1000 lbs./year
- Soda – ½ gallon has about 0.05 lbs.
- Driving – avg. 13,500 miles/year X 25 lbs./gallon / 24 mpg = 14,000 lbs.

Sources of Anthropogenic CO_2e Emissions - Energy

- Electricity – In New York State
  - Half of E generated is from natural gas
  - Nuclear and hydro are most of the rest
- Water and Wastewater
  - Collection, distribution, & treatment of potable water and wastewater - approx 116 billion lbs. CO_2/year
  - 116,000,000,000 / 316,000,000 = 367 lbs. / person / year = 1 lb. / person / day

Sources of Anthropogenic CO_2e Emissions - Energy

New York State Energy Use
by End-Use Sector (2015)

Residential	1,115 trillion Btu
Commercial	1,139 trillion Btu
Industrial	394 trillion Btu
Transportation	**1,077 trillion Btu**

https://www.eia.gov/

Anthropogenic CO_2 Release

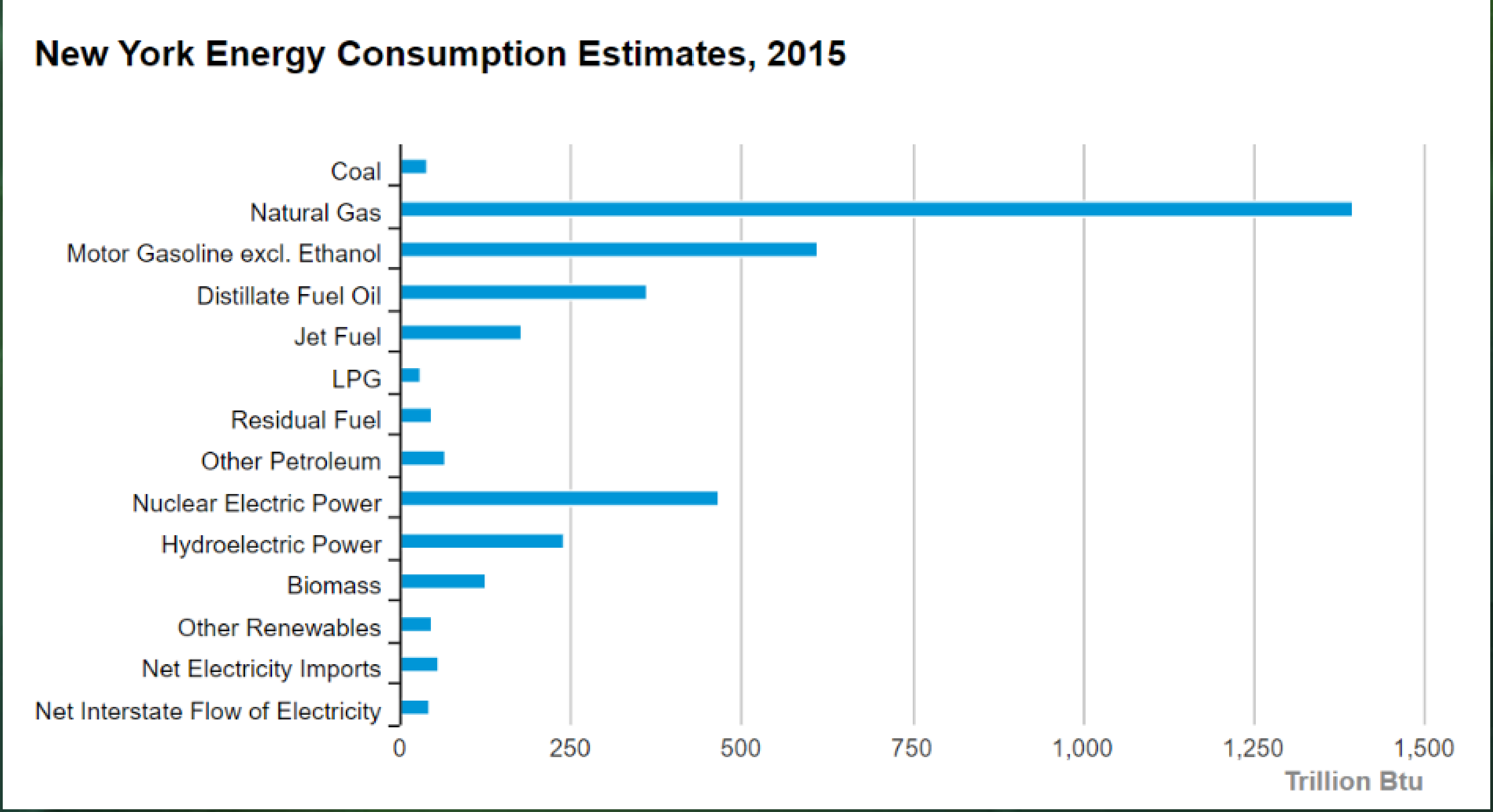
- Transportation
  - Combustion of 1 gallon of gasoline releases 19 lbs. CO_2 (+ impact of extraction, refining, transport, etc.) *
  - Combustion of 1 gallon of diesel releases 22 lbs. CO_2
  - 100 miles in a plane releases about 64 lbs. CO_2
  - 100 miles in a bus or train releases about 35 lbs. CO_2

- CO_2 Released during Generation of 1M BTU Energy
  - Coal - 205 to 227 lbs.
  - Municipal Solid Waste - 200 lbs.
  - Wood - 195 lbs.
  - Tires - 190 lbs.
  - Natural Gas - 117 lbs.
  - #2 Heating Oil - 161 lbs.

*** - "Well-to-Wheel" CO_2e impact of gasoline = about 25 lbs. per gallon**

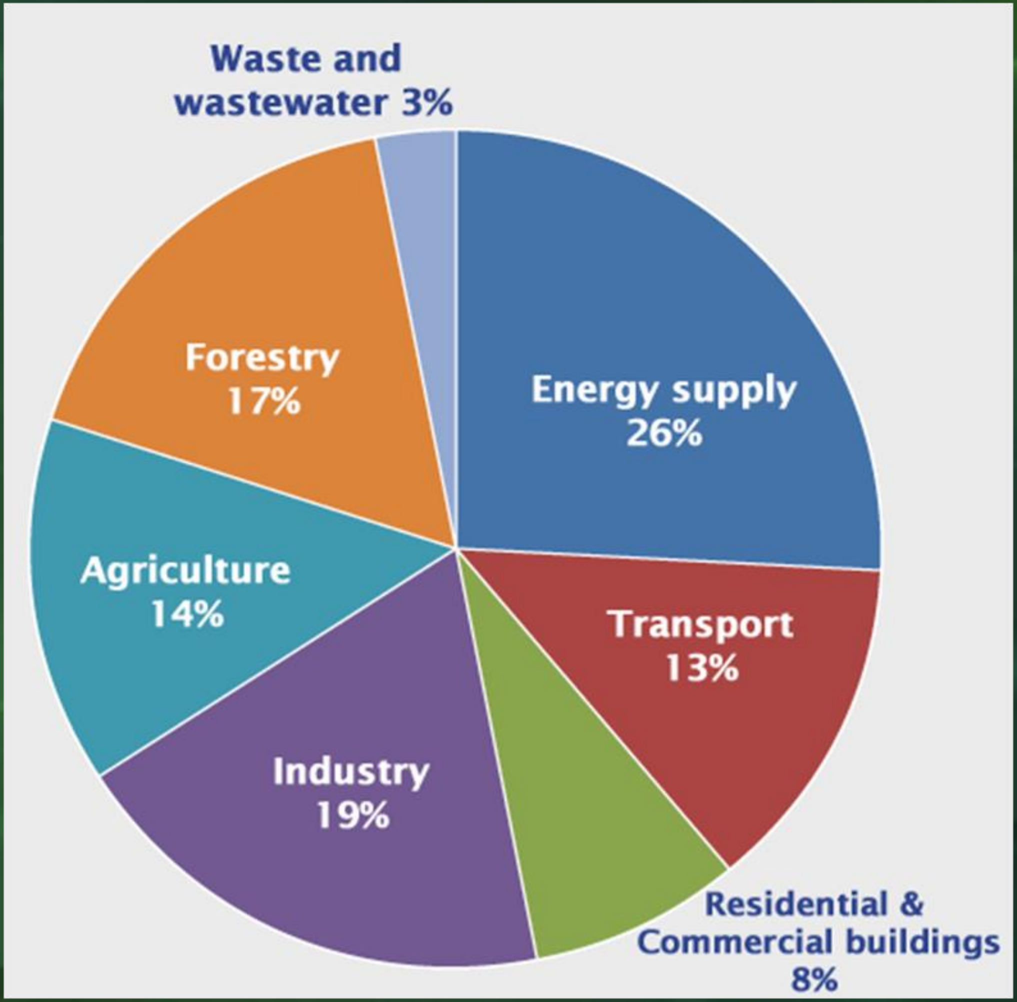
Sources of Anthropogenic CO_2e Emissions - Energy

https://www.eia.gov/



Greenhouse Gas Emissions by Category

- **Source: IPCC (2007); based on global emissions from 2004**



Source: www.ipcc.org

Insulation Material	R-value R/inch	Density lb/ft³	Emb. E MJ/kg	Emb. Carbon $kgCO_2/kg$	Emb. Carbon $kgCO_2/ft^2 \cdot R$	Blowing Agent (GWP)	Bl. Agent kg/kg foam	Blowing Agent GWP/ bd-ft	Lifetime GWP/ $ft^2 \cdot R$
Cellulose (dense-pack)	3.7	3.0	2.1	0.106	0.0033	None	0	N/A	0.0033
Fiberglass batt	3.3	1.0	28	1.44	0.0165	None	0	N/A	0.0165
Rigid mineral wool	4.0	4.0	17	1.2	0.0455	None	0	N/A	0.0455
Polyisocyanurate	6.0	1.5	72	3.0	0.0284	Pentane (GWP=7)	0.05	0.02	0.0317
Spray polyurethane foam (SPF) – closed-cell (HFC-blown)	6.0	2.0	72	3.0	0.0379	HFC-245fa (GWP=1,030)	0.11	8.68	1.48
SPF – closed-cell (water-blown)	5.0	2.0	72	3.0	0.0455	Water (CO_2) (GWP=1)	0	0	0.0455
SPF – open-cell (water-blown)	3.7	0.5	72	3.0	0.0154	Water (CO_2) (GWP=1)	0	0	0.0154
Expanded polystyrene (EPS)	3.9	1.0	89	2.5	0.0307	Pentane (GWP=7)	0.06	0.02	0.036
Extruded polystyrene (XPS)	5.0	2.0	89	2.5	0.0379	HFC-134a[1] (GWP=1,430)	0.08	8.67	1.77

1. XPS manufacturers have not divulged their post-HCFC blowing agent, and MSDS data have not been updated. The blowing agent is assumed here to be HFC-134a.

GWP of insulation types

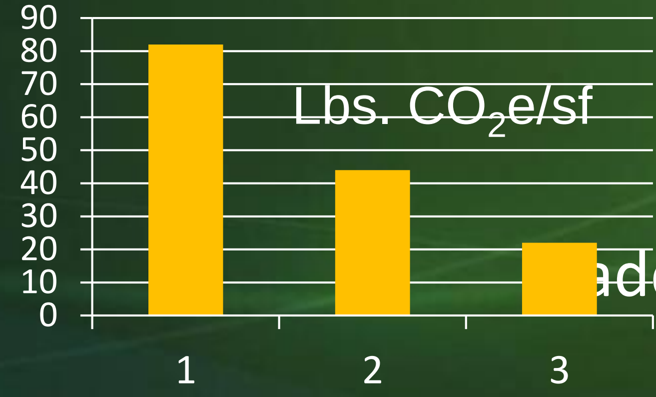
New options: GPS rigid insulation and rigid-board phenolic foam!

Source: Environmental Building News/ BuildingGreen

Carbon Emissions – Asphalt

- National Asphalt Pavement Association (NAPA) EPD Program – Emerald Eco Label http://www.asphaltpavement.org/EPD
- NAPA Greenhouse Gas Calculator www.asphaltpavement.org/ghgc
- Asphalt Pavement Alliance
  - **http://www.asphaltroads.org/assets/_control/**content/files/carbon_footprint_web.pdf
  - Charts do not include CO_2 of asphalt cement
  - 100% can be reused
  - Recommends assessing 50-year life cycle

Window Footprints



add

1 m^2 of window pane = 10.76 sf
for frame = 12.9 say 13 sf

1 kg = 2.2 lbs.   1m = 3.28 feet

- **Aluminum**
  486 kg = 1070 lbs. /13 sf =   82 lbs. CO_2e/sf
- **PVC**
  258 kg = 568 lbs. / 13 sf =   44 lbs. CO_2e/sf
- **Wood**   130
  kg =   286 lbs. / 13 sf =   22 lbs. CO_2e/sf

Source: http://www.mdpi.com/2075-5309/2/4/542/htm

Jobsite Emissions

Gasoline – 25 lbs. CO_2 /gallon ("well to wheel")

Hypothetical Labor Situation

12 workers, driving
12 trucks that get
12 mpg,
12 miles to and from jobsite, for
12 weeks….

$12 \cdot 25$ lbs. CO_2/g/12 mi./g $\cdot$ 12 mi. $\cdot$ $12 \cdot 5$ =

18,000 lbs. CO_2

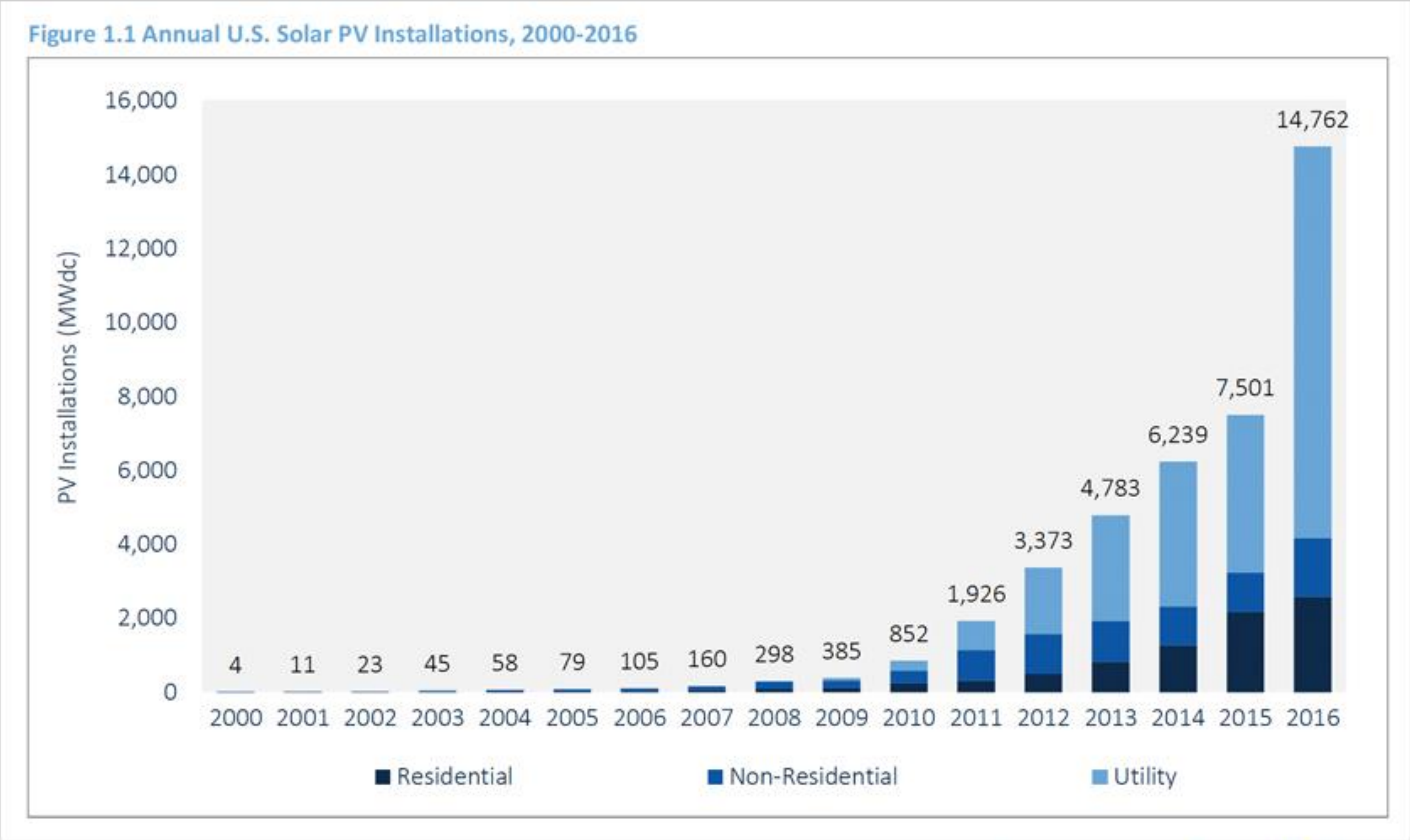
3. Solution Strategies

Energy Innovation and Carbon Dividend Act – H.R. 763

- EFFECTIVE – will reduce CO_2 emissions by 40% in first 12 years
- GOOD FOR PEOPLE – increased health, more $ for lower income
- GOOD FOR THE ECONOMY – 2.1 million new jobs, increased GDP
- BIPARTISAN – Cosponsored by Republicans and Democrats
- REVENUE NEUTRAL – No $ kept or spent by the government

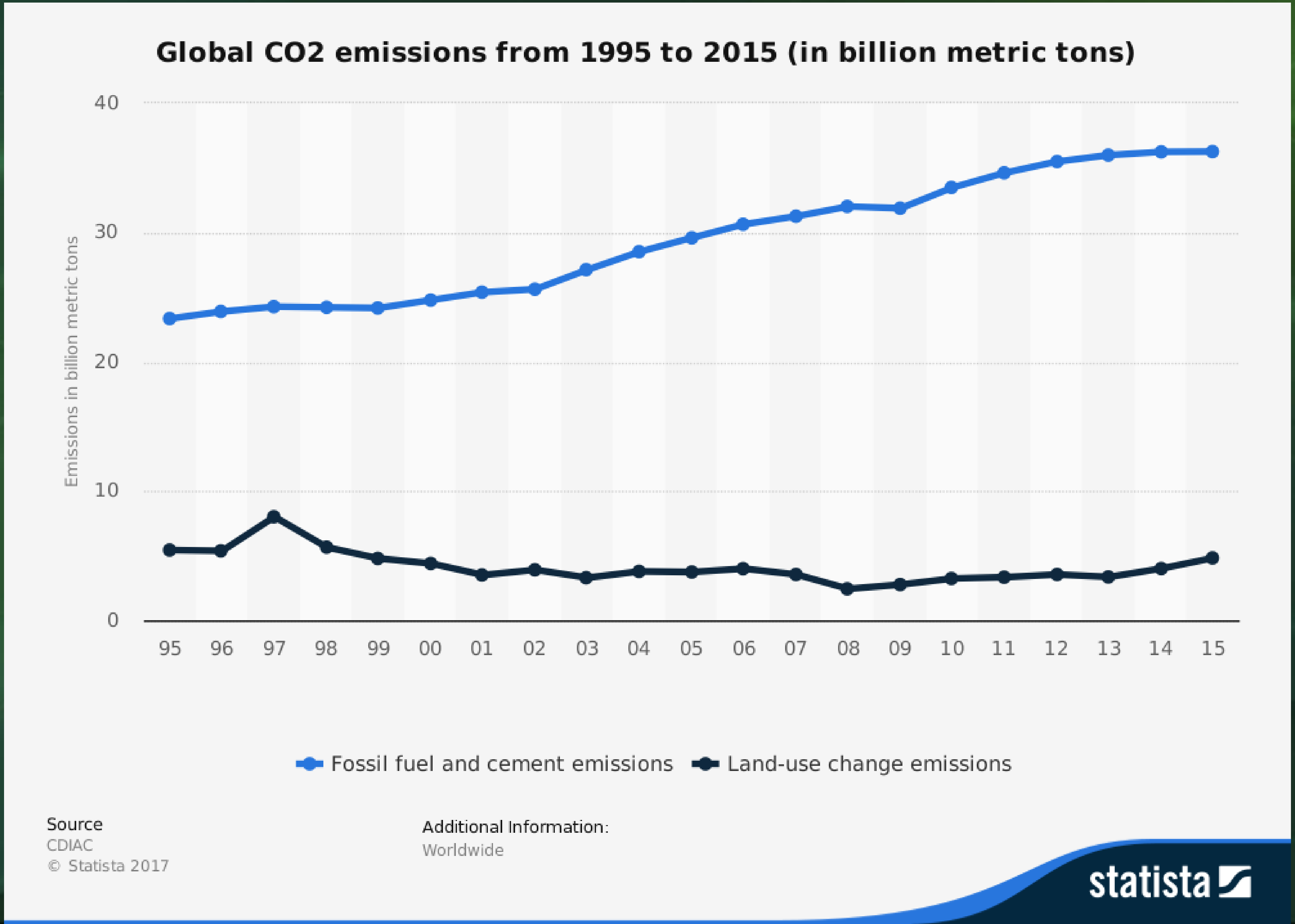
https://citizensclimatelobby.org/energy-innovation-and-carbon-dividend-act/

Growth in Photovoltaics



gtmresearch SEIA

Recent Changes in CO_2 Emissions



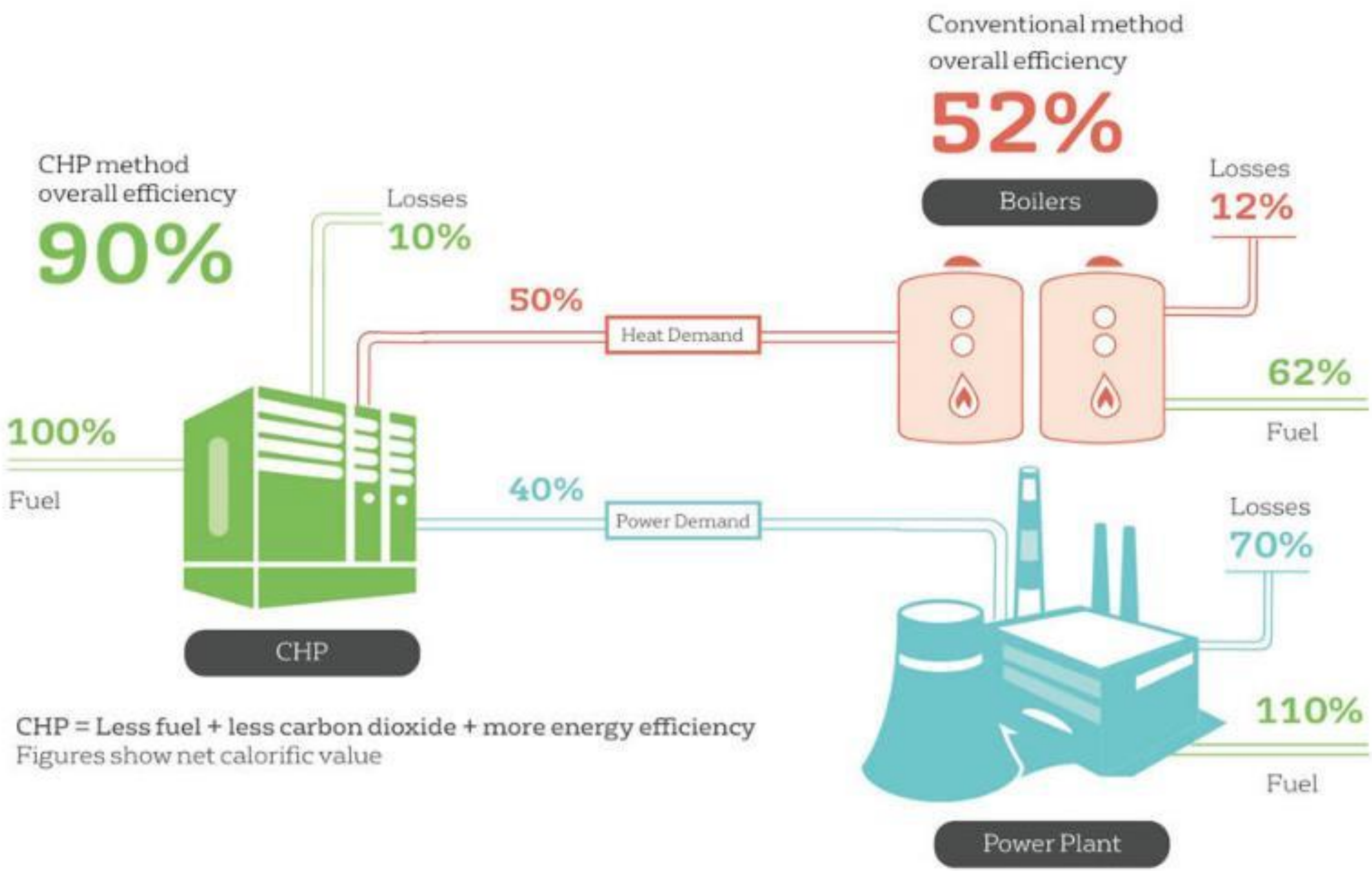
Power and Energy & GWP Gas Emissions

Wind Power

Photovoltaic

CARBON CAPTURE AND SEQUESTRATION

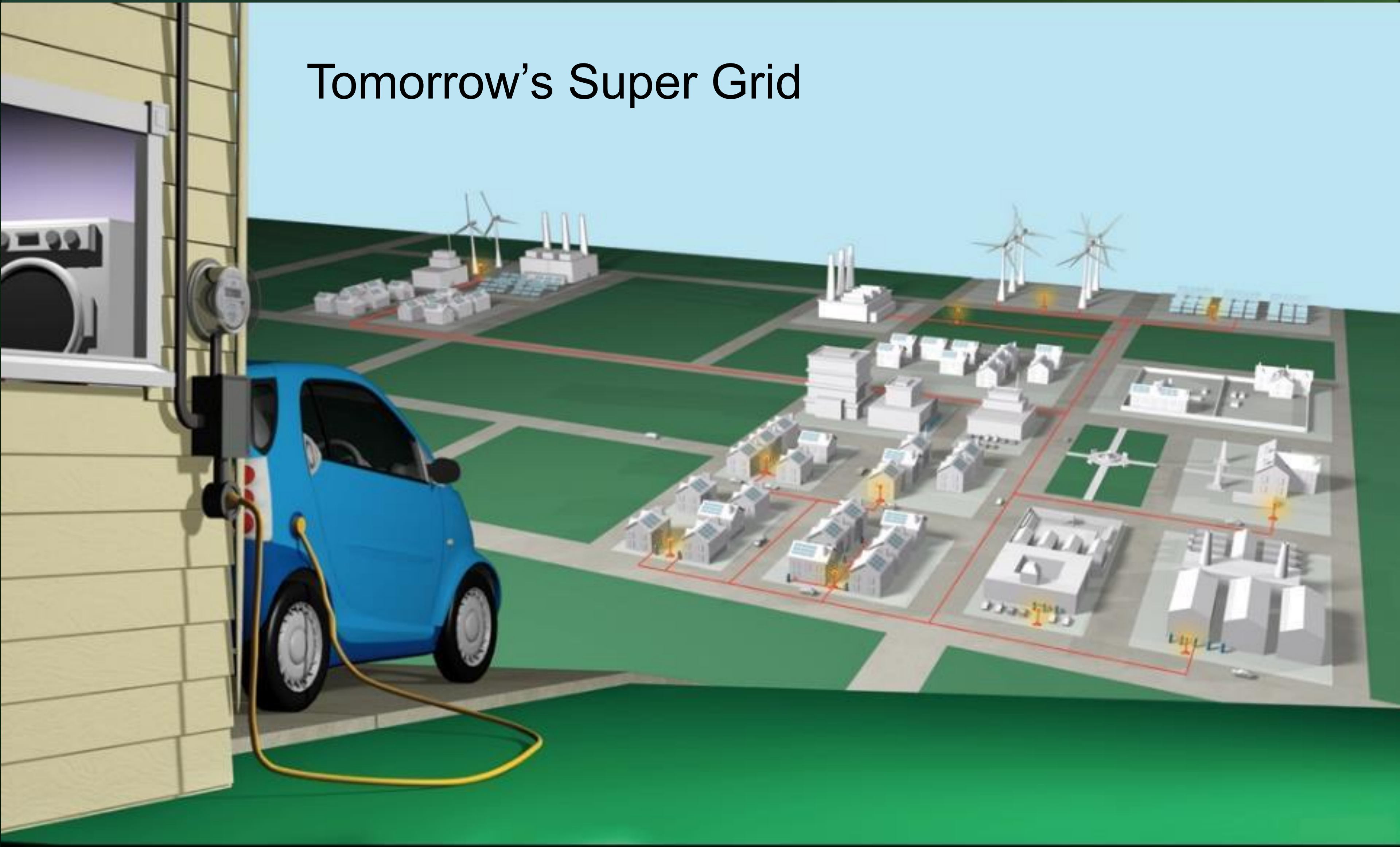
Cogeneration



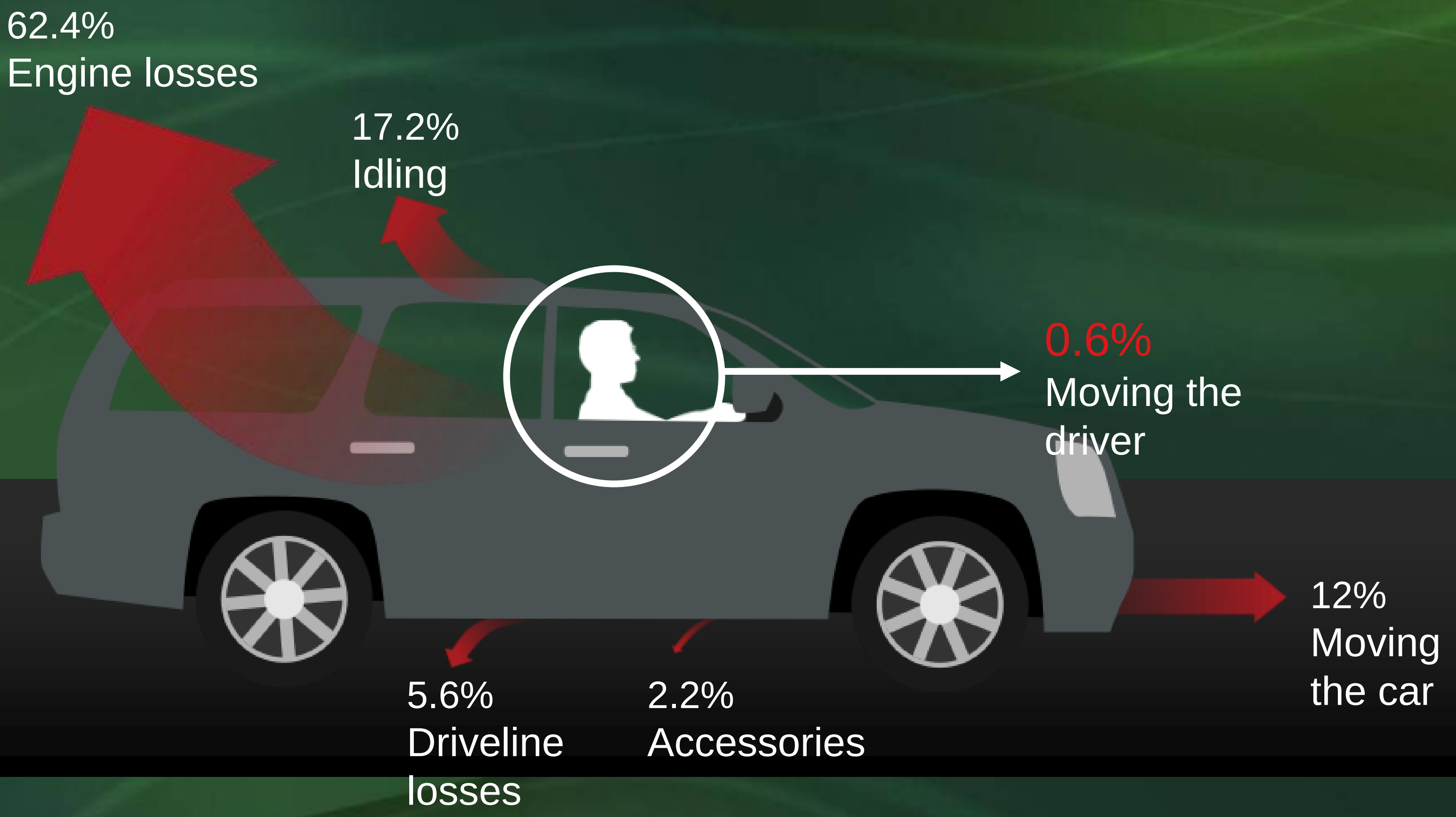
CHP = Less fuel + less carbon dioxide + more energy efficiency
Figures show net calorific value

Transportation & GWP Gas Emissions

Tomorrow's Super Grid



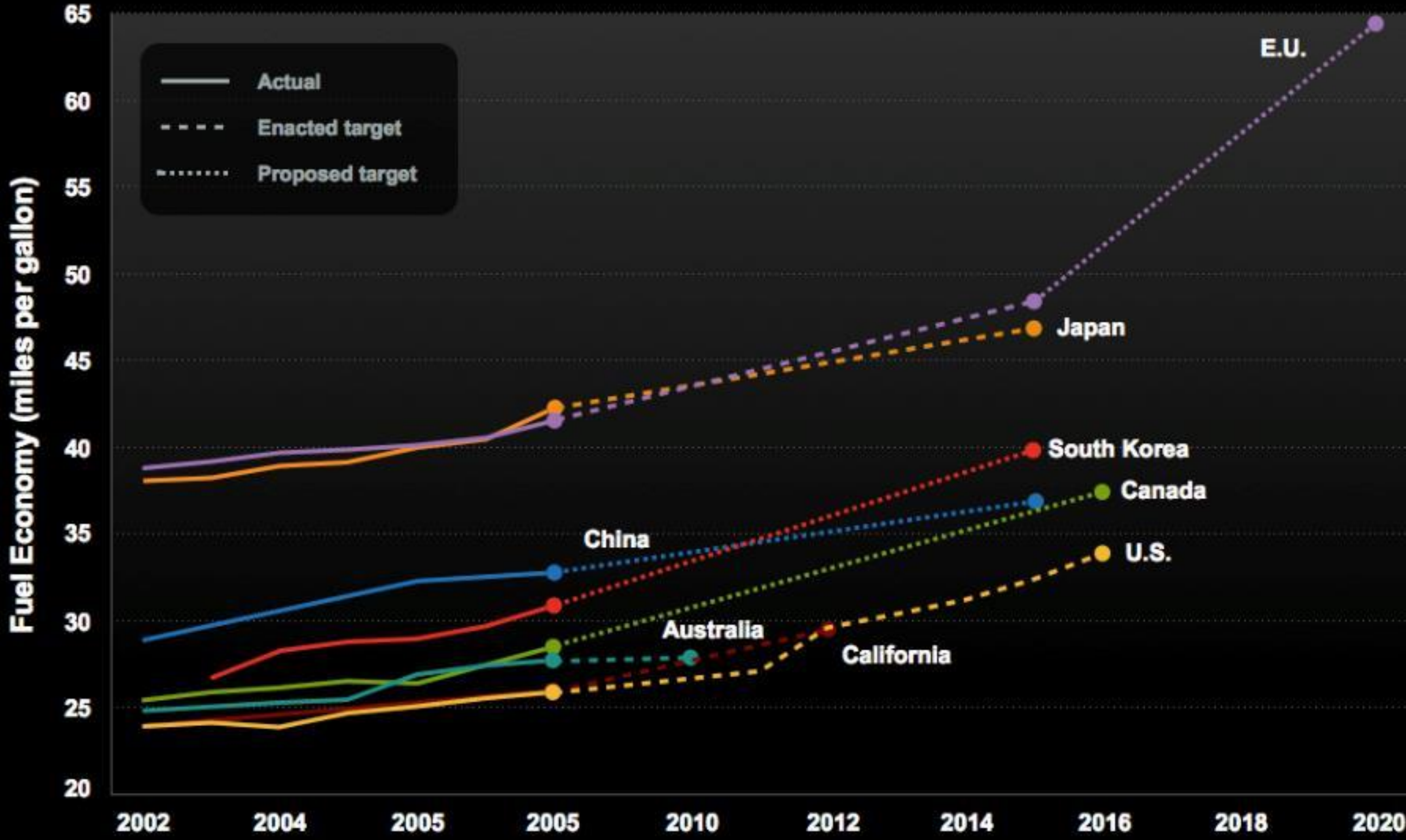
Where Does the Energy Go?



Source: U.S. Department of Energy; Amory Lovins, Rocky Mountain Institute

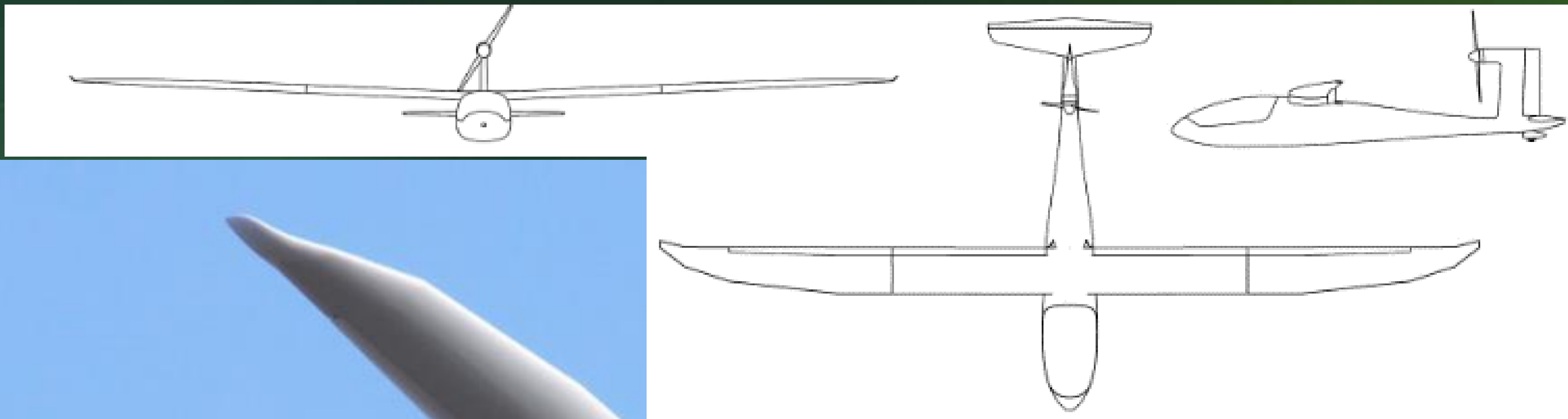
Passenger Vehicle Fuel Economy

Performance and Standards by Region



E-Genius

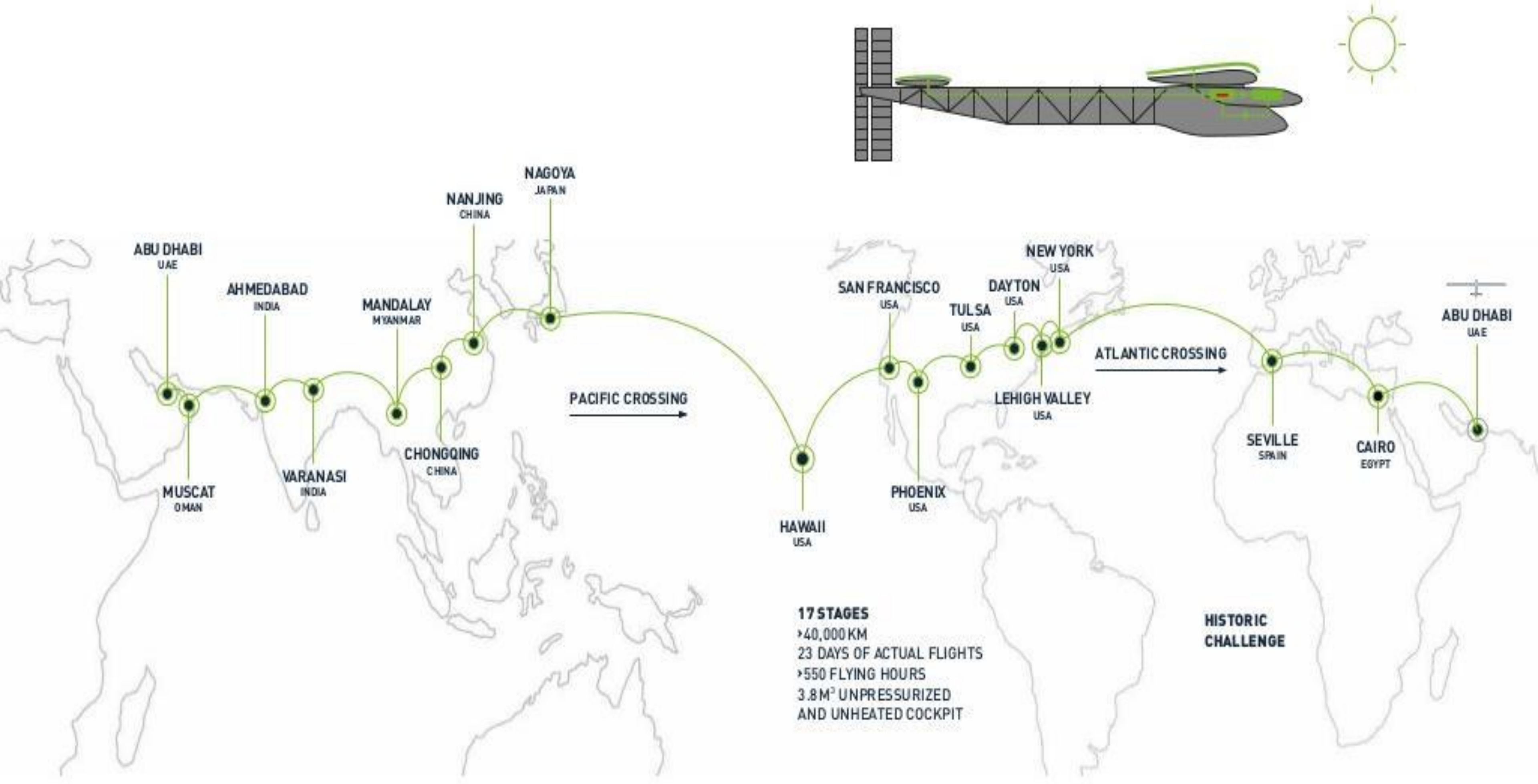
University of Stuttgart



Eviation's Alice Commuter Plane

Solar Impulse

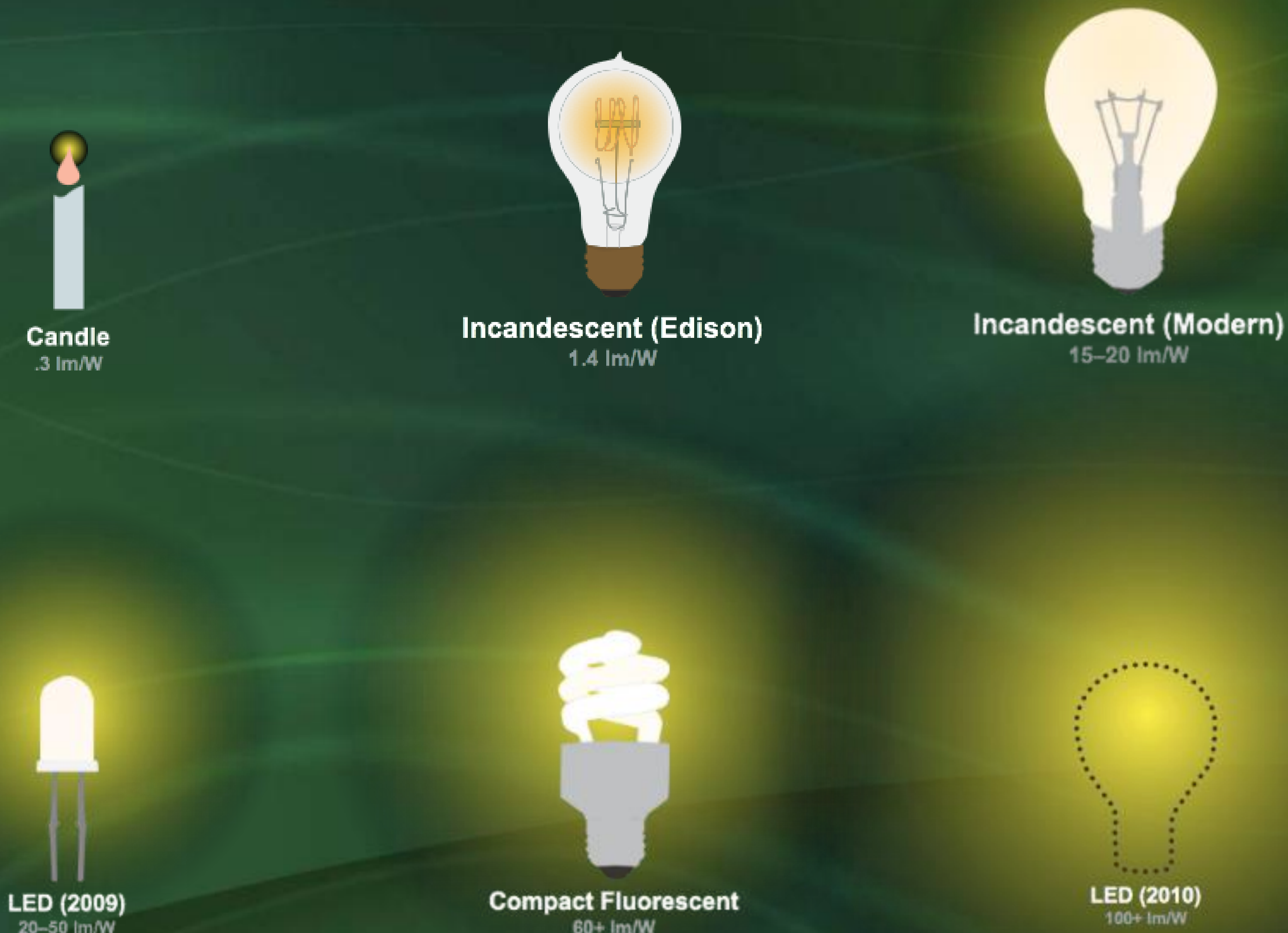
Solar Impulse



Synthetic Transportation Fuels

- CO_2 captured from ambient air
- Charging CO_2 with electricity creates kerosene-like fuel
- Companies include
  - Climeworks
  - SkyNRG
  - Urban Crossovers
- Rotterdam consortium produces 1,000 liters a day

A Better Lightbulb



RENEWABLE ENERGY

Three Wave Energy Developers Ready To Test Devices in Hawaii

HAWAII BOUND Ocean Energy's Buoy will be towed from Portland, Ore., once construction is complete.

Fabrication of a giant barge-like wave energy device is underway in Portland, Ore., in preparation for testing in Hawaii this summer.

The hull for the 125-ft-long by 59-ft-wide, 86-ton OE Buoy—with potential

Navy site. Columbia Power will test its $3-million dataRAY scalable low-power wave energy converter, and Oscilla Power plans to test its 100-KW Triton C, a full-scale multimode point absorber wave device. Oscilla is also developing a 30-ft by 20-ft utility-scale Triton wave energy con-

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Infrastructure and GWP Gas Emissions

Portland cement reduction (SCM, etc.)

Envision Rating System

- An infrastructure project rating system, administered by the Institute for Sustainable Infrastructure (ISI)
- Envision™ Sustainability Professional (ENV SP)
- Third-party verification by a "Verifier"
- 60 "sustainability criteria" divided into five sections:
  - Quality of Life
  - Leadership
  - Resource Allocation
  - Natural World
  - Climate and Risk

http://www.sustainableinfrastructure.org

Buildings and GWP Gas Emissions

Building Energy Conservation

- Energy Conservation Construction Codes
- Stretch Codes
- Code compliance and verification
- PassivHaus standards
- EnergyStar, Green Globes, LEED
- Living Building Challenge

EnergieSprong

- ZNE retrofit of existing houses
- Exterior wall and roof manufactured panels
- Exterior mechanical module – H, V, E, HW, controls
- 5000 homes in Netherlands, also France, UK, Italy, Germany
- NYSERDA RetrofitNY – $30M/yr – currently in proof-of-concept phase

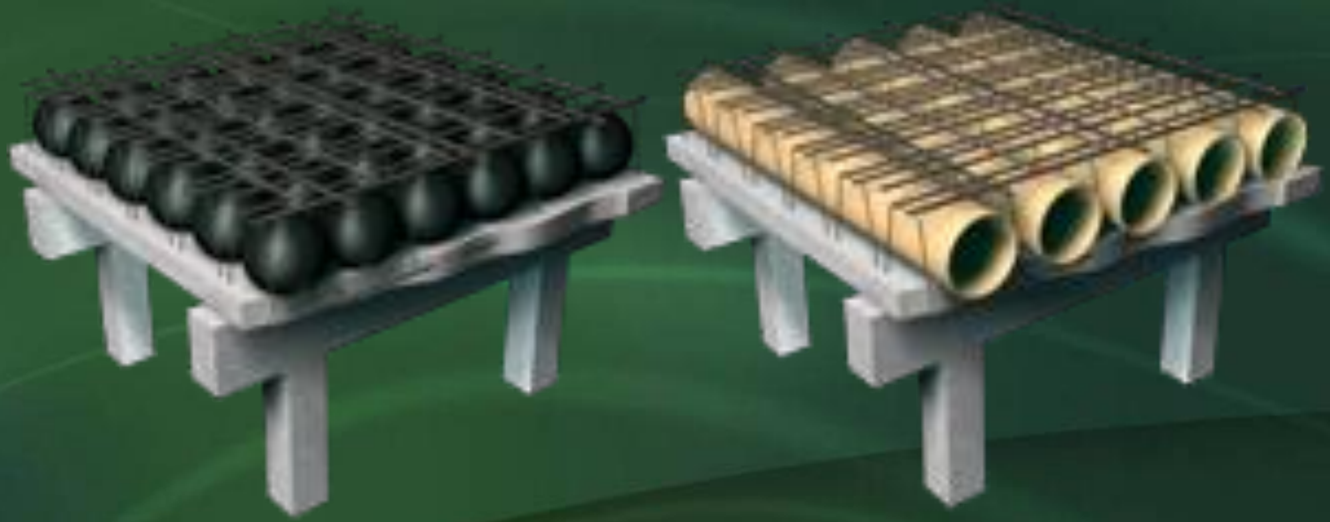
Tiny Houses

De-Materialization

- Reducing quantity of material usage on a building project
- A ton of steel saved is a ton of steel CO_2e footprint eliminated.
- Must maintain function, safety, redundancy
- Considerations include maintaining versatility, flexibility, future usage and adaptability.
- Usually requires more engineering effort
- May or may not be cheaper than the use of slightly oversized, repetitive similar units

Voided Slab Systems (VSS)

- Voids in concrete at non-structurally critical areas
- Reduces concrete, Portland cement, and weight
- Increases span capacity and/or reduce depth
- Design methodologies based on flat slab design



30–35% typ. reduction in cement and CO_2e

http://www.crsi.org/index.cfm/engineering/floor

Mitigation Strategies: Wood

- Consider wood structures and studs when possible
- Use engineered wood products
- Use Advanced Engineering principles
- Consider modular or panelized systems
- Be open to high-rise possibilities

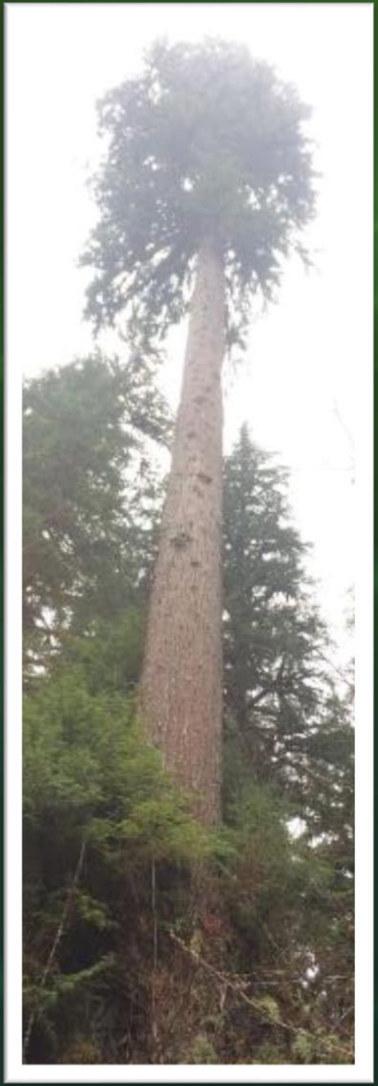
Drawdown - Biogenic Carbon

- Carbon comprises about 50% of the of dry wood fiber.
- 1 lbs. Carbon represents about 3.67 lbs. CO_2 removed from the atmosphere.
- Example

100 lbs. of 19% moisture content wood

Dry wood fiber = (100 lbs.)(1/1.19) = 84 lbs.

Sequestered CO_2 = (84 lbs.)(.5)(3.67) = **154 lbs.**



1 lb. wood stores about 1.5 lbs. of atmospheric CO_2

Reused (Salvaged) Structural Materials

Many buildings designed and built today may be obsolete within 50 years. Materials will likely be much more valuable.

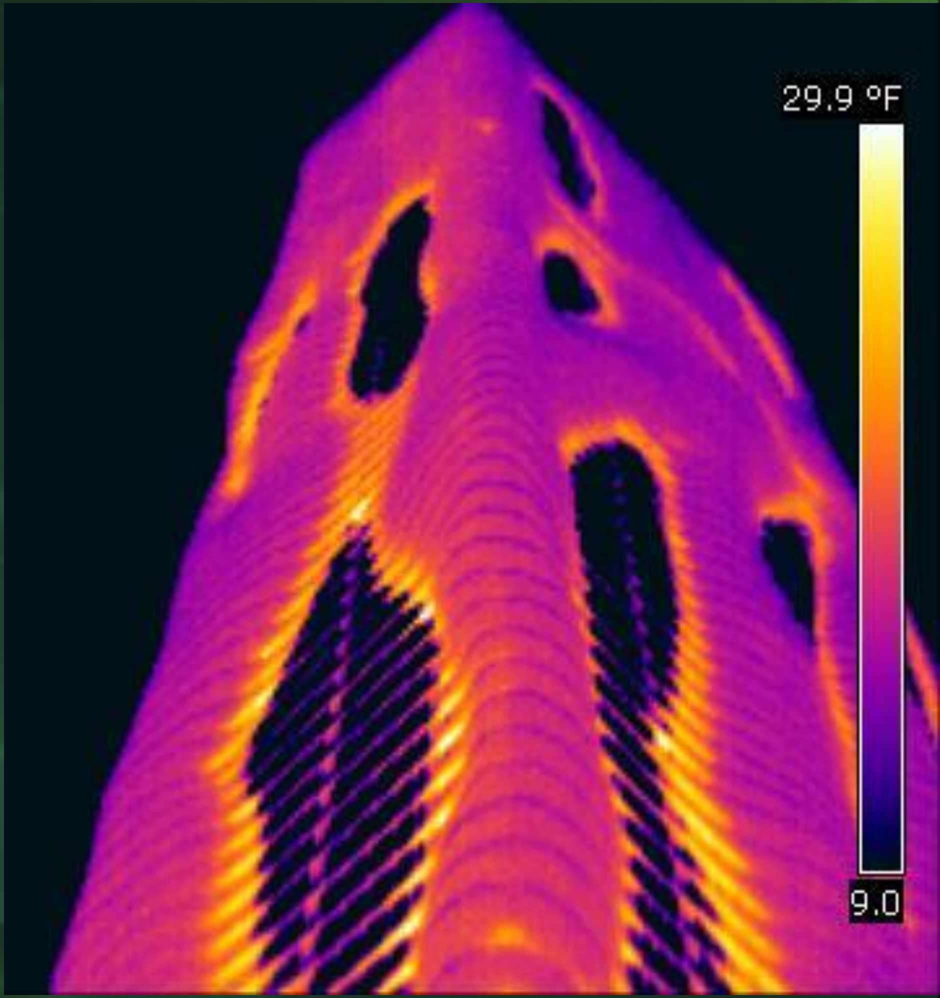
- Concrete – consider removability and reuse as aggregate or base material.
- Steel – minimize welding, maximize bolting
- Masonry – grouted walls are difficult to salvage, as are brick walls with excessively strong mortar bonds
- Wood – Would YOU approve use of salvaged lumber?

Salvaged Structural Elements

Removed, reconditioned, and reused open-web steel joists

Salvaged steel pipe sourced, inspected, reconditioned, fabricated, and erected for use as building columns

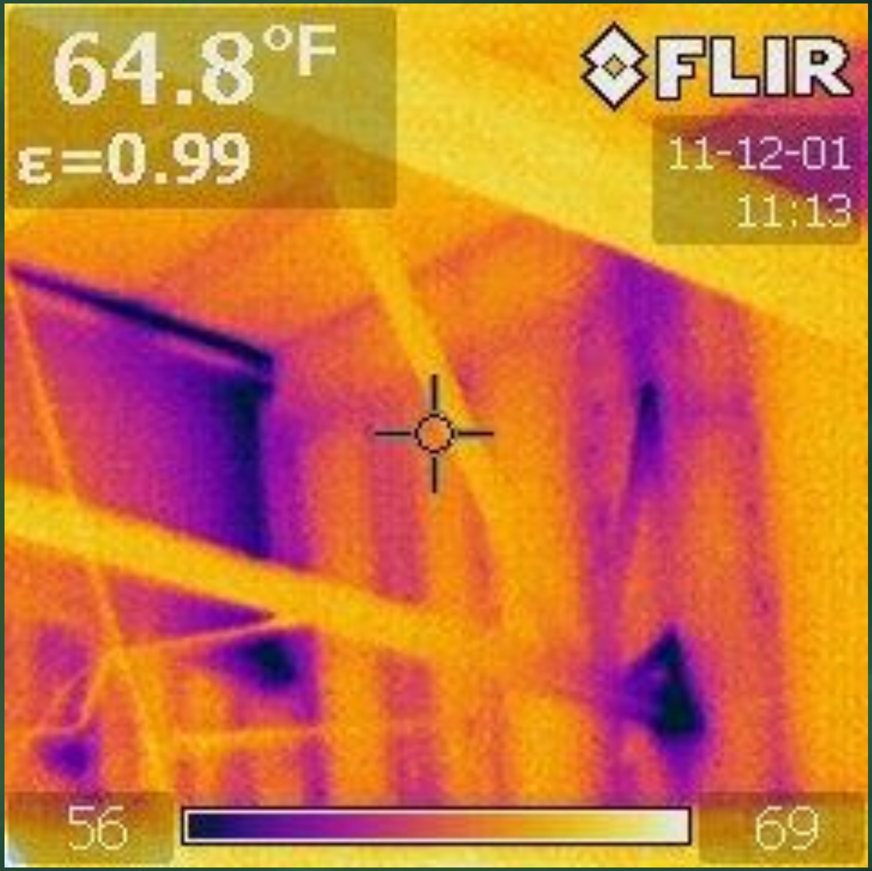
Thermal Bridging - Infrared Images

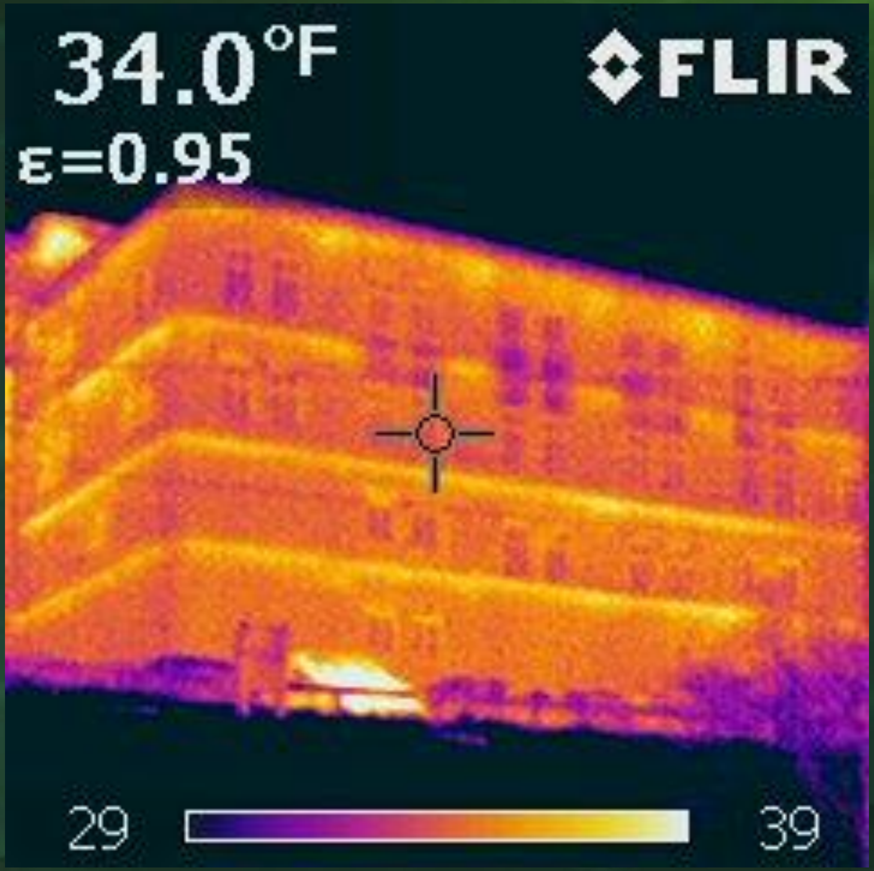


MSTBA – Concrete to Concrete

Manufactured Structural Thermal Break Assemblies (MSTBA's)

Thermal Bridging - Infrared Images

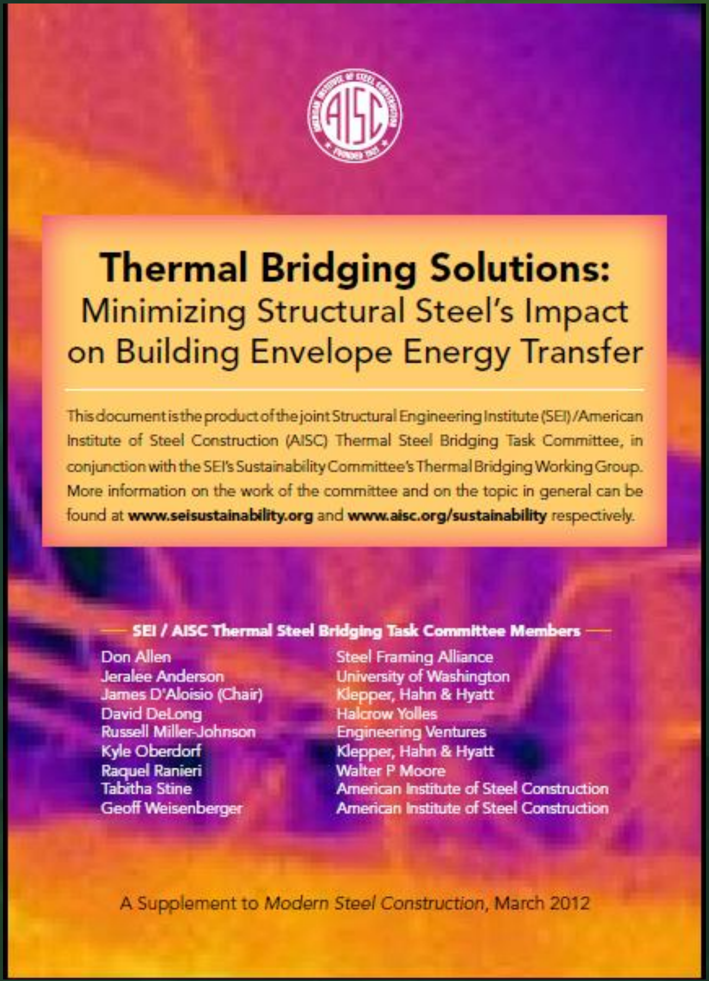




Thermal Steel Bridging – Modern Steel Construction Insert

Thermal Steel Bridging Task Committee

A joint venture between ASCE's Structural Engineering Institute and AISC



Thermal Bridging Solutions:
Minimizing Structural Steel's Impact on Building Envelope Energy Transfer

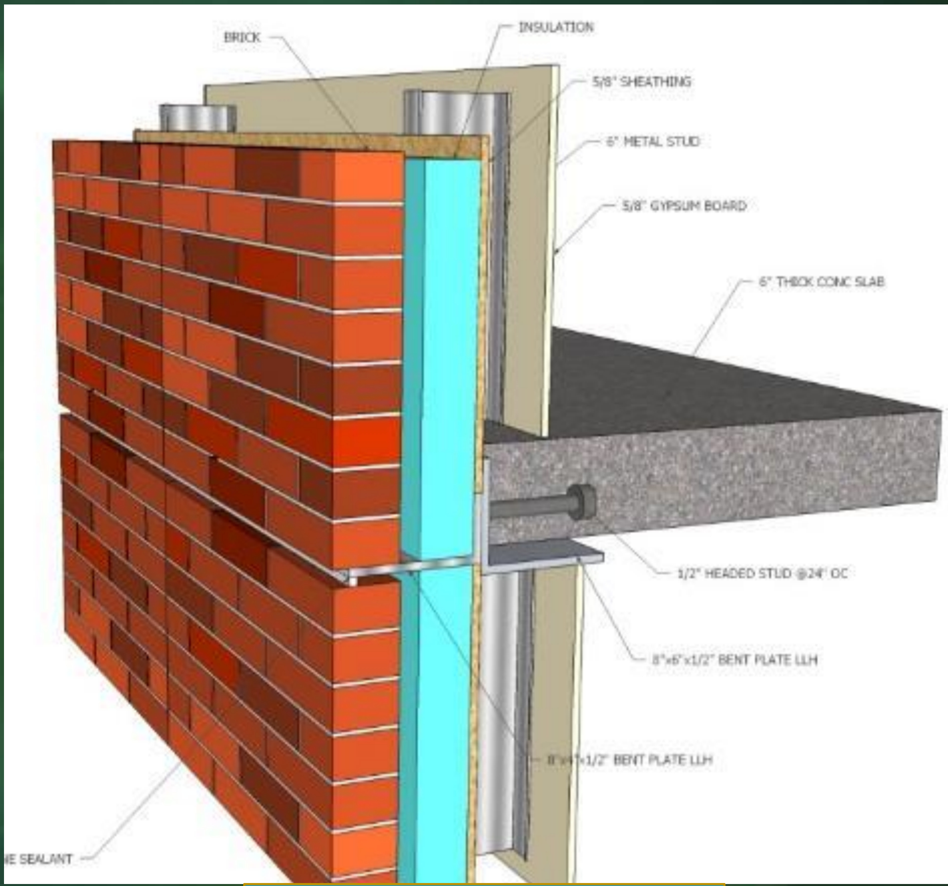
This document is the product of the joint Structural Engineering Institute (SEI)/American Institute of Steel Construction (AISC) Thermal Steel Bridging Task Committee, in conjunction with the SEI's Sustainability Committee's Thermal Bridging Working Group. More information on the work of the committee and on the topic in general can be found at **www.seisustainability.org** and **www.aisc.org/sustainability** respectively.

SEI / AISC Thermal Steel Bridging Task Committee Members

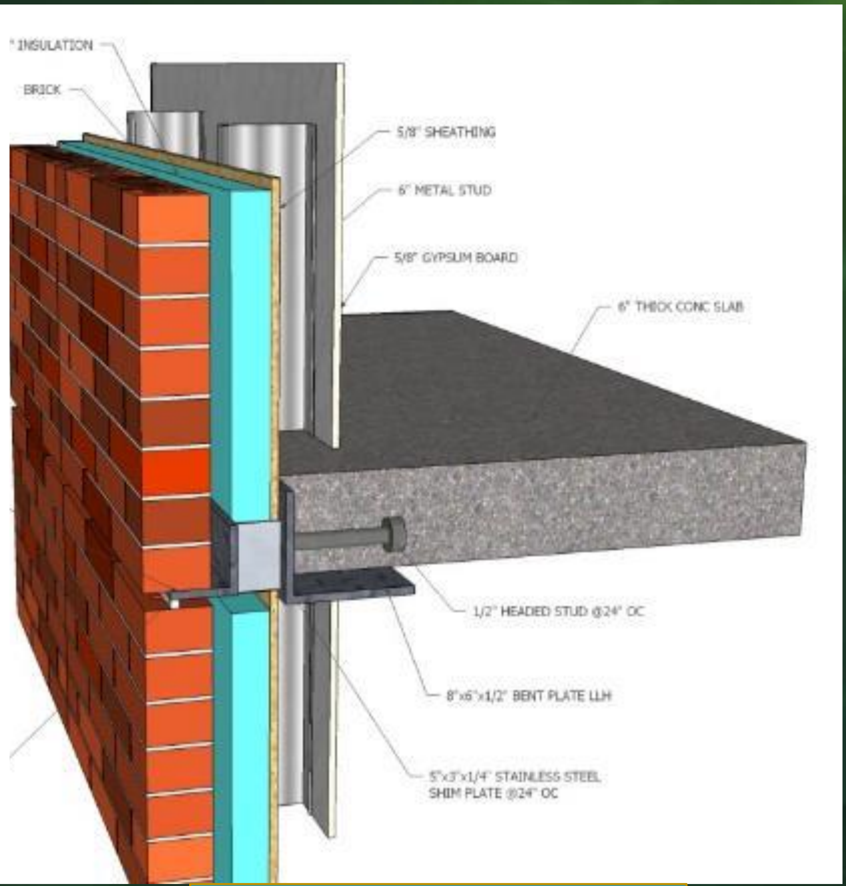
Don Allen	Steel Framing Alliance
Jeralee Anderson	University of Washington
James D'Aloisio (Chair)	Klepper, Hahn & Hyatt
David DeLong	Halcrow Yolles
Russell Miller-Johnson	Engineering Ventures
Kyle Oberdorf	Klepper, Hahn & Hyatt
Raquel Ranieri	Walter P Moore
Tabitha Stine	American Institute of Steel Construction
Geoff Weisenberger	American Institute of Steel Construction

A Supplement to *Modern Steel Construction*, March 2012

Thermal Bridging Mitigation: Discrete, Stainless Steel Elements

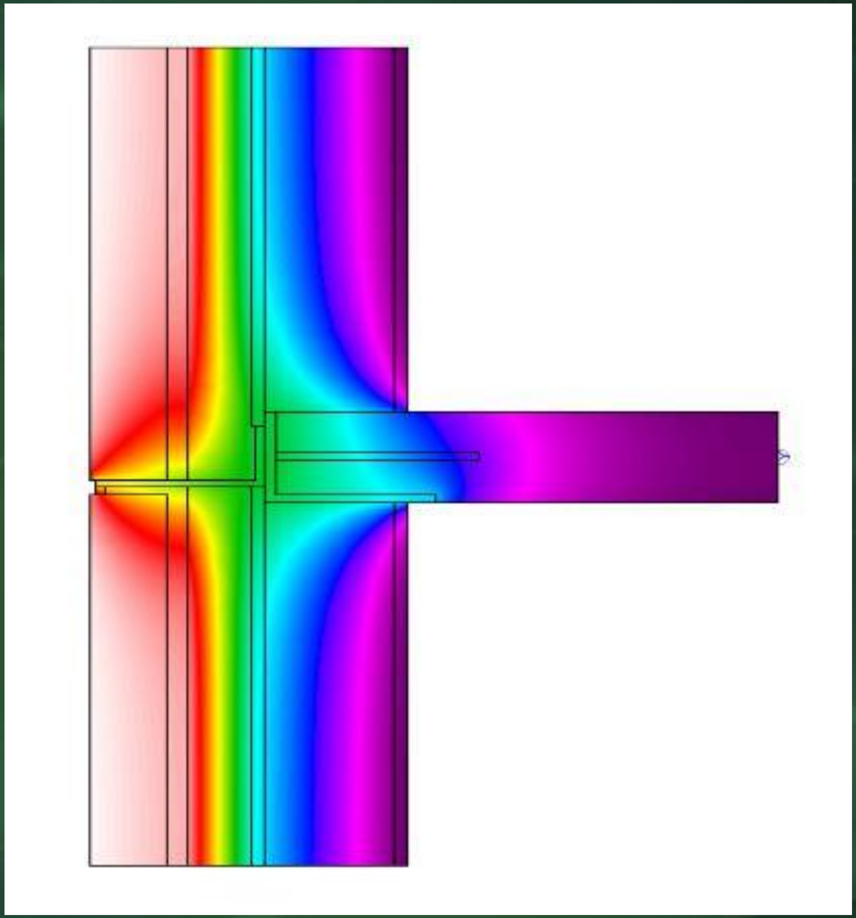


Original Detail



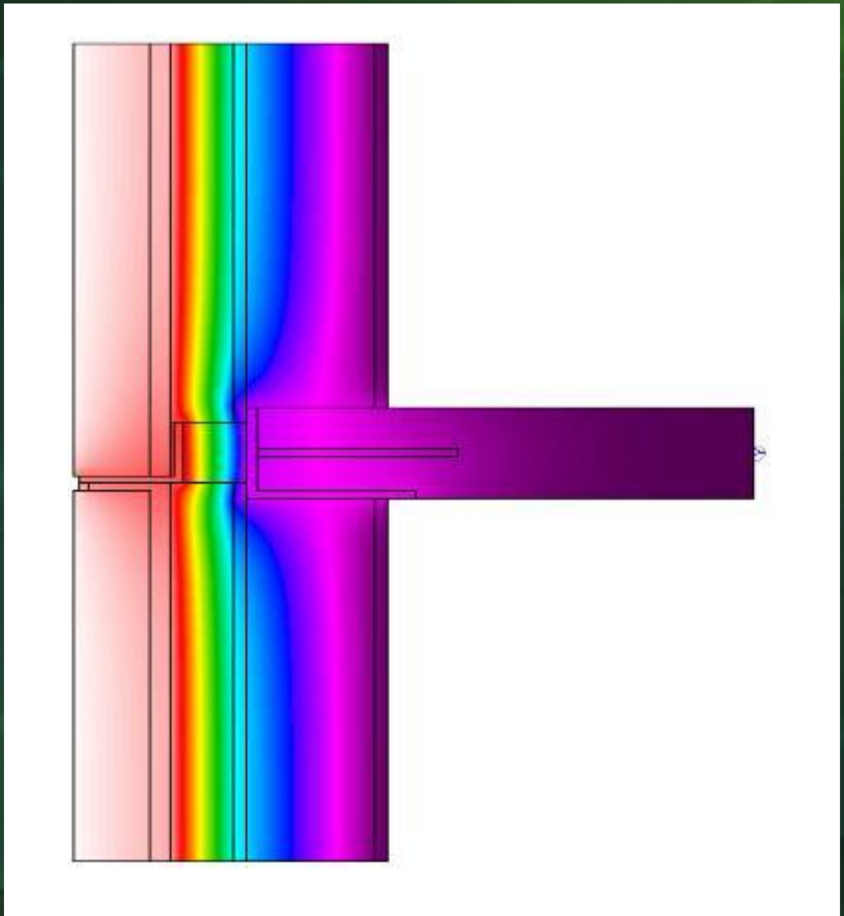
Modified Detail

Thermal Bridging Mitigation: Discrete, Stainless Steel Elements



Unmitigated Detail:

U-Factor for 36” height = 0.44



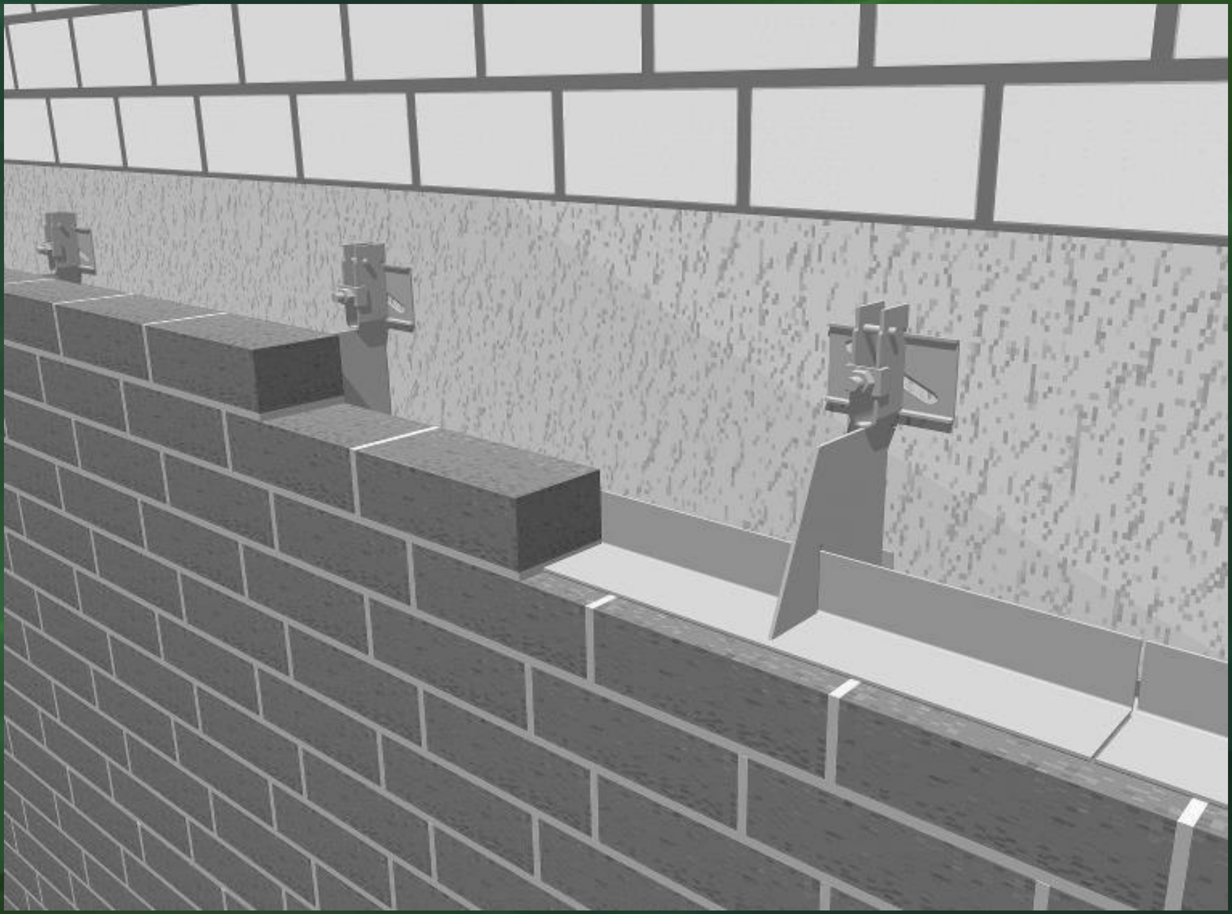
Alternate Detail:

U-Factor for 36” height = 0.13

Thermal Bridging Mitigation: Discrete, Stainless Steel Elements

Proprietary system for brick shelf angle support

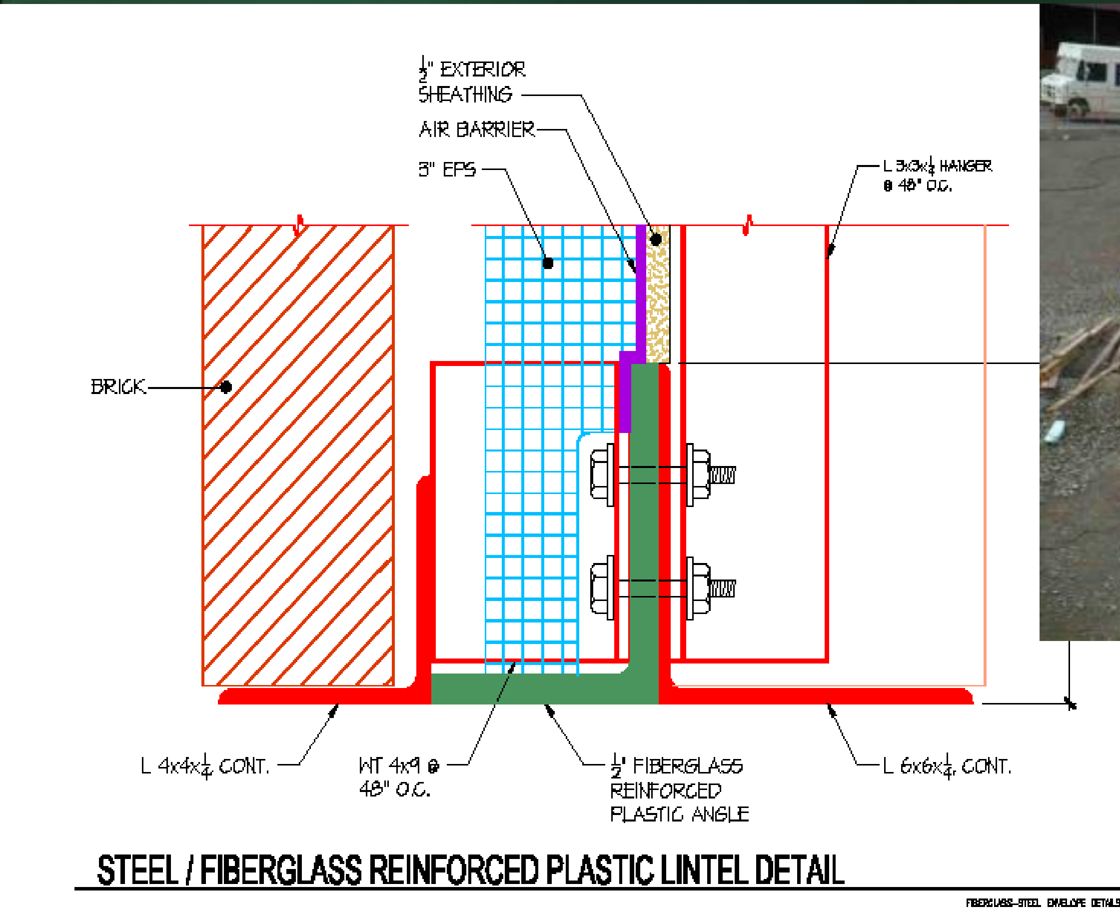
Comes in both galvanized & stainless steel



Thermal Bridging Mitigation: Manufactured Assemblies (MSTBA)

SYRACUSE UNIVERSITY MANLEY FIELDHOUSE
ICE STORAGE ADDITION - 2012

Thermal Bridging Mitigation: Non-Conductive Thermal Shims



High School, Upstate NY

Only supporting 24 inches of brick

Thermal Bridging Mitigation: Non-Conductive Thermal Shims

Geo-Engineering

The deliberate large-scale intervention in the Earth's climate system, in order to moderate global warming

- Atmospheric CO_2 Removal
- Solar Radiation Reduction

Tree Planting

Terra Preta

a.k.a.
Biochar

www. bbc.co.uk

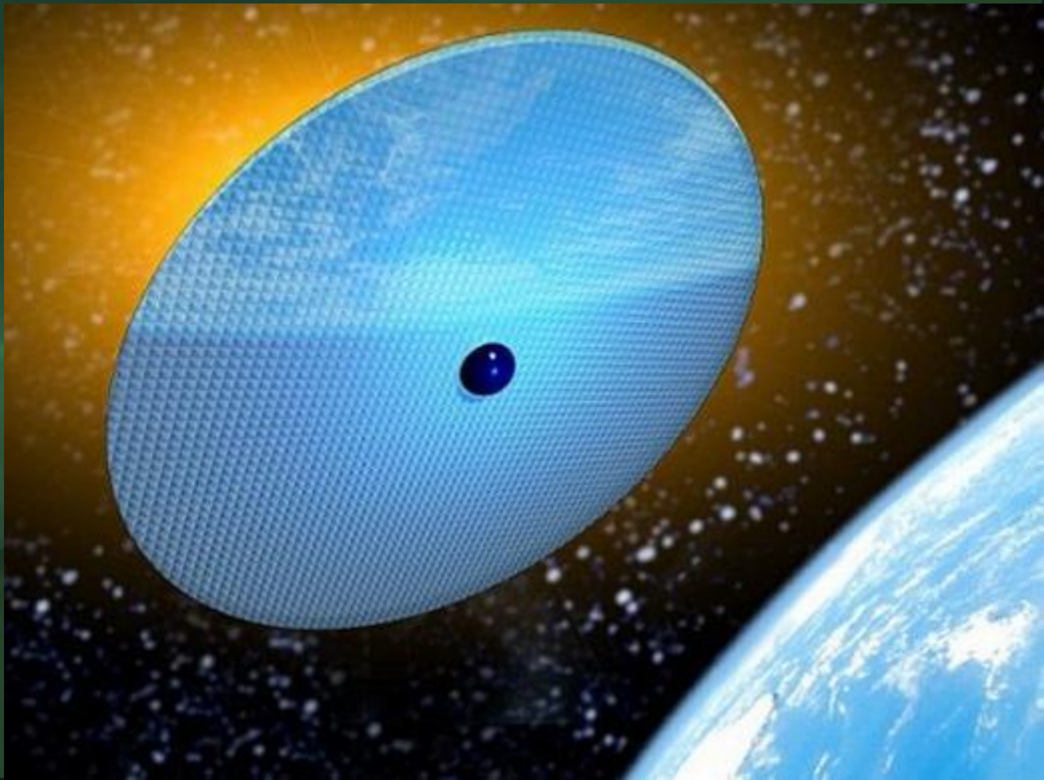
Concrete Carbonation

Ocean Nourishment

Carbon Air Capture

Geo-Engineering?

Cloud Whitening
Ocean Nourishment
Solar Shades



Geo-Engineering – Possible Solutions?

- End-of-pipe solutions
- None are proven
- False confidence?
- Part of the solution?
- … or red herrings?

▪

5. Our Role / Your Role

The Role of the Engineer

- Engineers are…
  - The people who take scientific knowledge and results and apply them to addressing society's needs and solving problems.
  - Creative, logical people with high credibility.
  - Involved with many aspects of society that cause ACC emissions.
  - By and large, as yet unaware of the magnitude of carbon emissions from their projects and operations.
  - Proven to have repeatedly exceeded expectations.

The Role of the Engineer

National Society of Professional Engineers (NSPE) Policy Statements

Value #1

Protection of the public welfare above all other considerations.

Goal #4

Advocate U.S. public policy pertaining to engineering matters in the interest of enhancing public health, safety, and welfare.

ASCE Policy Statement #488

Impact of Climate Change

The American Society of Civil Engineers supports government policies that encourage anticipation of and preparation for possible impacts of climate change on the built environment.

(Describes issue, and rationale)

(July 2012)

ASCE Policy Statement 488 – Greenhouse Gases

July 13, 2019

ASCE supports public and private sector strategies and efforts to achieve significant reductions in greenhouse gas (GHG) emissions through the planning, design, construction, renewal, operation, maintenance and decommissioning of existing and future infrastructure systems. Such strategies can include: (lists ten separate strategies)

https://www.asce.org/issues-and-advocacy/public-policy/policy-statement-488---greenhouse-gases/

ASCE Policy Statement 360 – Impact of Climate Change

Adopted by the Board of Direction on July 13, 2018 (first approved in 1990) - ASCE supports:

- Government policies that encourage anticipation of and preparation for impacts of climate change on the built environment.
- Revisions to engineering design standards, codes, regulations and associated laws that strengthen the sustainability and resiliency of infrastructure at high risk of being affected by climate change.
- Research, development and demonstration to advance recommended civil engineering practices and standards to effectively address climate change impacts.
- Cooperative research among engineers and climate, weather, and life scientists to gain a better understanding of the magnitudes and consequences of future extremes.
- Informing practicing engineers, project stakeholders, policy makers and decision makers about the uncertainty in predicting future climate and the reasons for the uncertainty.
- Developing a new paradigm for engineering practice in a world in which climate is changing but the extent and time of local impacts cannot be projected with a high degree of certainty.
- Identifying critical infrastructure that is most threatened by changing climate in a given region and informing decision makers and the public.

https://www.asce.org/issues-and-advocacy/public-policy/policy-statement-360---impact-of-climate-change/

AIChE Climate Change Policy Statement

- As a professional society, AIChE must be a source of sound inf… po… d to he… ain res… . Scientific an… ring and ha… gr… 017-18, AIChE members were provided an opportunity to critique the cu… En… ch… ocumented ev… e science. Ad… in… in the rea… sess the en…

Scientific analysis finds that non-natural climate change is occurring and has been strongly influenced by human-caused releases of greenhouse gases.

These threats fall squarely in the realm of the chemical engineer, who is well-positioned to assess the issues and develop solutions through well-founded engineering and economic approaches.

March 29, 2019

AIA Resolution for Urgent and Sustained Climate Action

- June 2019 - Passed 4860 to 312 (94% of 5172 delegates)
- “Be it resolved that, commencing in 2019 and continuing until zero-net carbon practice is the accepted standard of its members, the AIA prioritize and support urgent climate action as a health, safety, and welfare issue, to exponentially accelerate the ‘decarbonization’ of buildings, the building sector, and the built environment”
- Resolution calls for AIA to engage members, clients, policymakers, other professional organizations, and the public through “a multi-year strategy for education, practice, advocacy, and outreach.”

NOW is the Time to Act!

- Strong economy
- Prompt action = better results
- What are we waiting for?
- NOW IS THE TIME!

Thank you!

The world needs us to be the best engineers that we can be.

- Jim D'Aloisio 2017

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Climate Action for Engineers