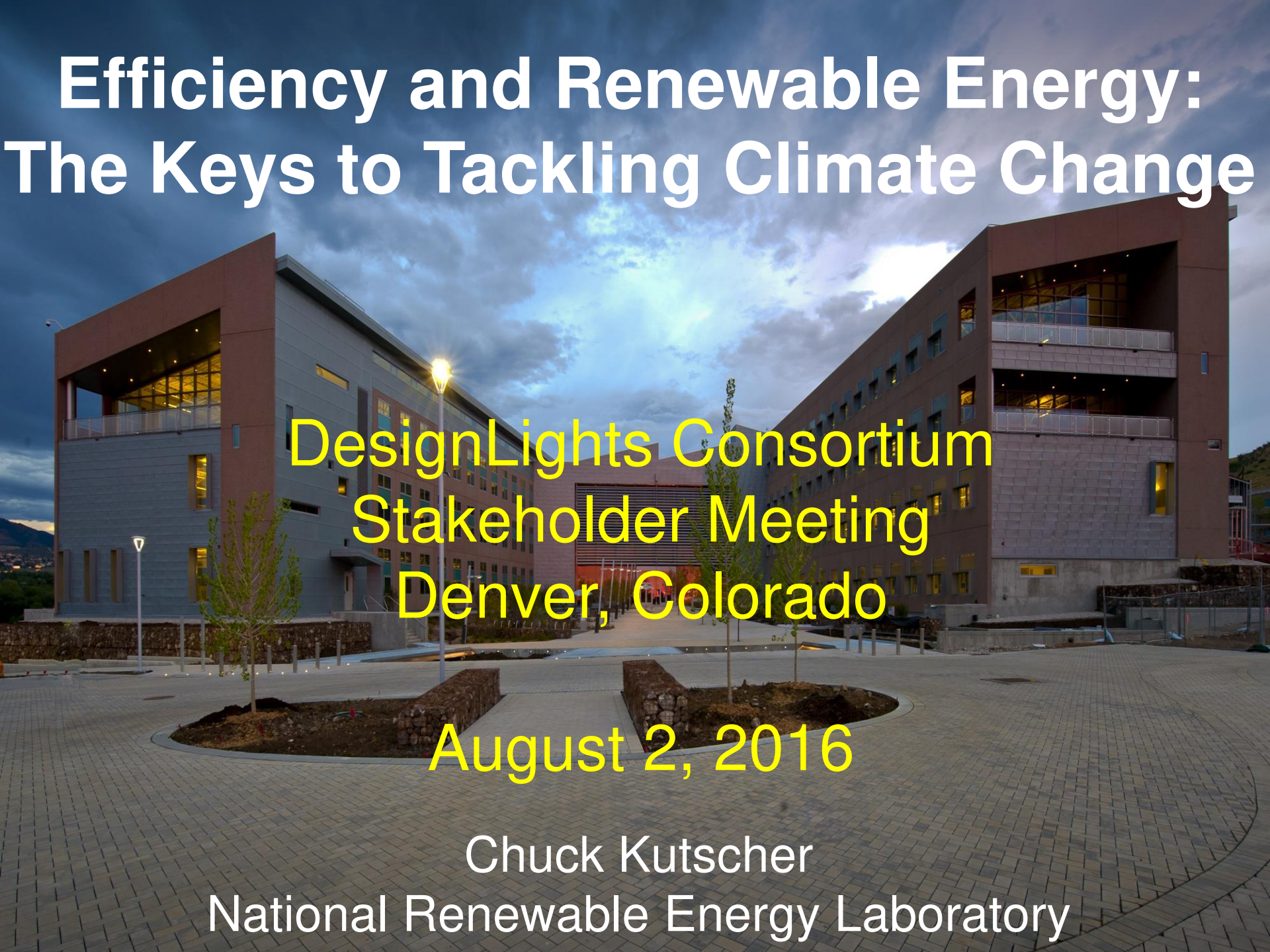
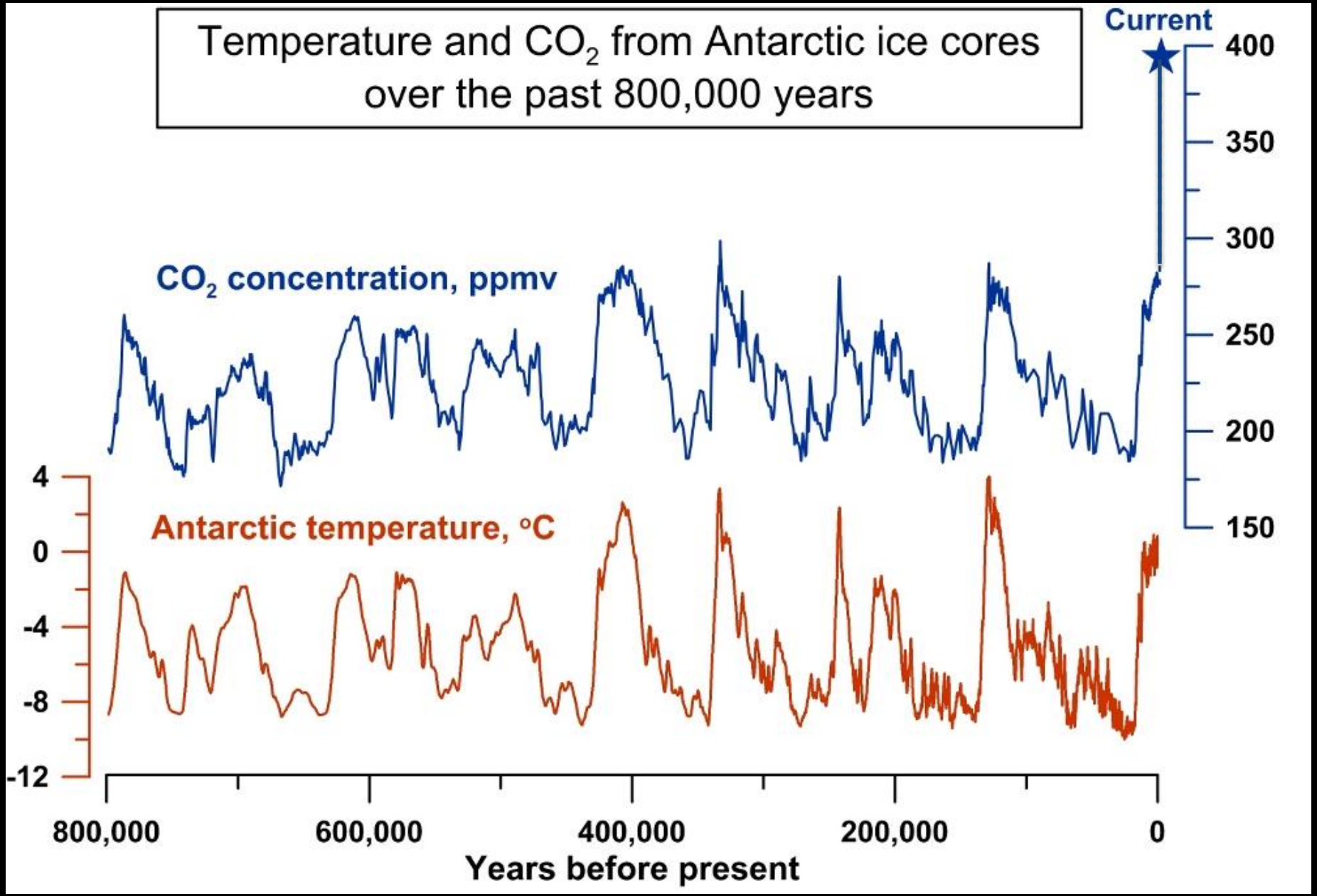
Efficiency and Renewable Energy: The Keys to Tackling Climate Change

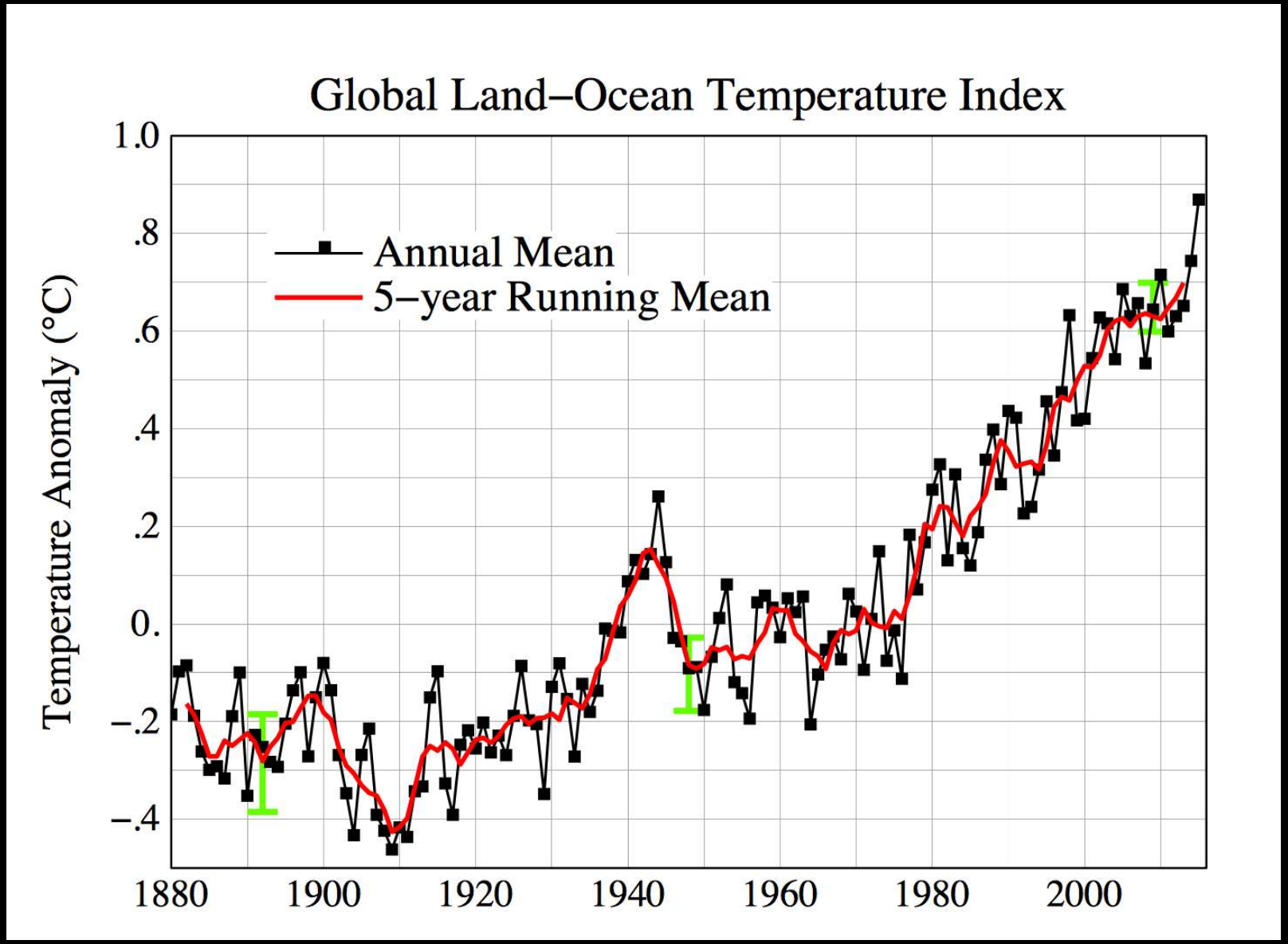


DesignLights Consortium
Stakeholder Meeting
Denver, Colorado

August 2, 2016

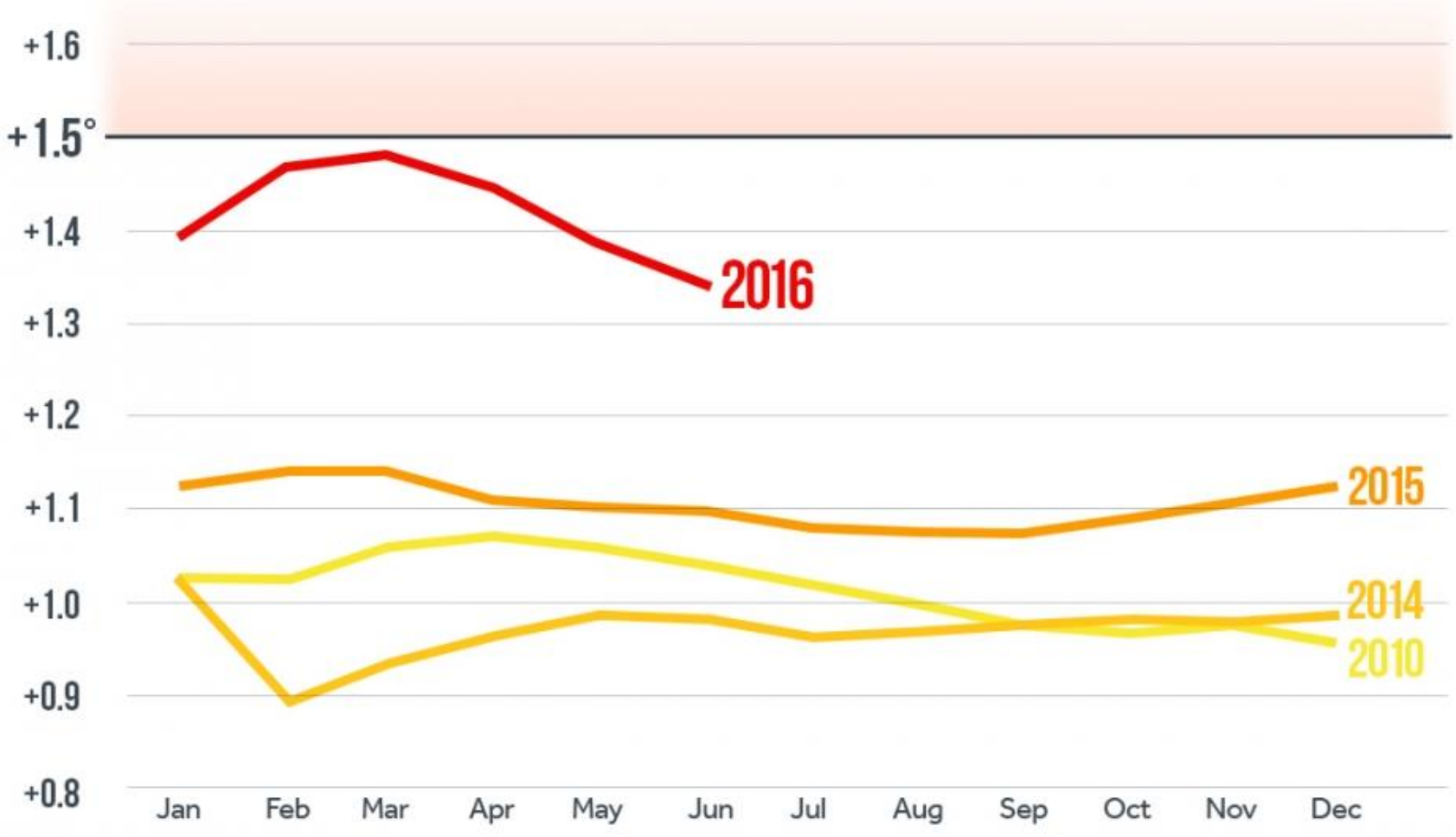
Chuck Kutscher
National Renewable Energy Laboratory


Temperature and CO_2 from Antarctic ice cores over the past 800,000 years
Current
400
350
300
250
200
150
CO_2 concentration, ppmv
4
0
-4
-8
-12
Antarctic temperature, °C
800,000
600,000
400,000
200,000
0
Years before present



NASA Goddard Institute for Space Studies

Global Average Temperature Anomaly (°C)

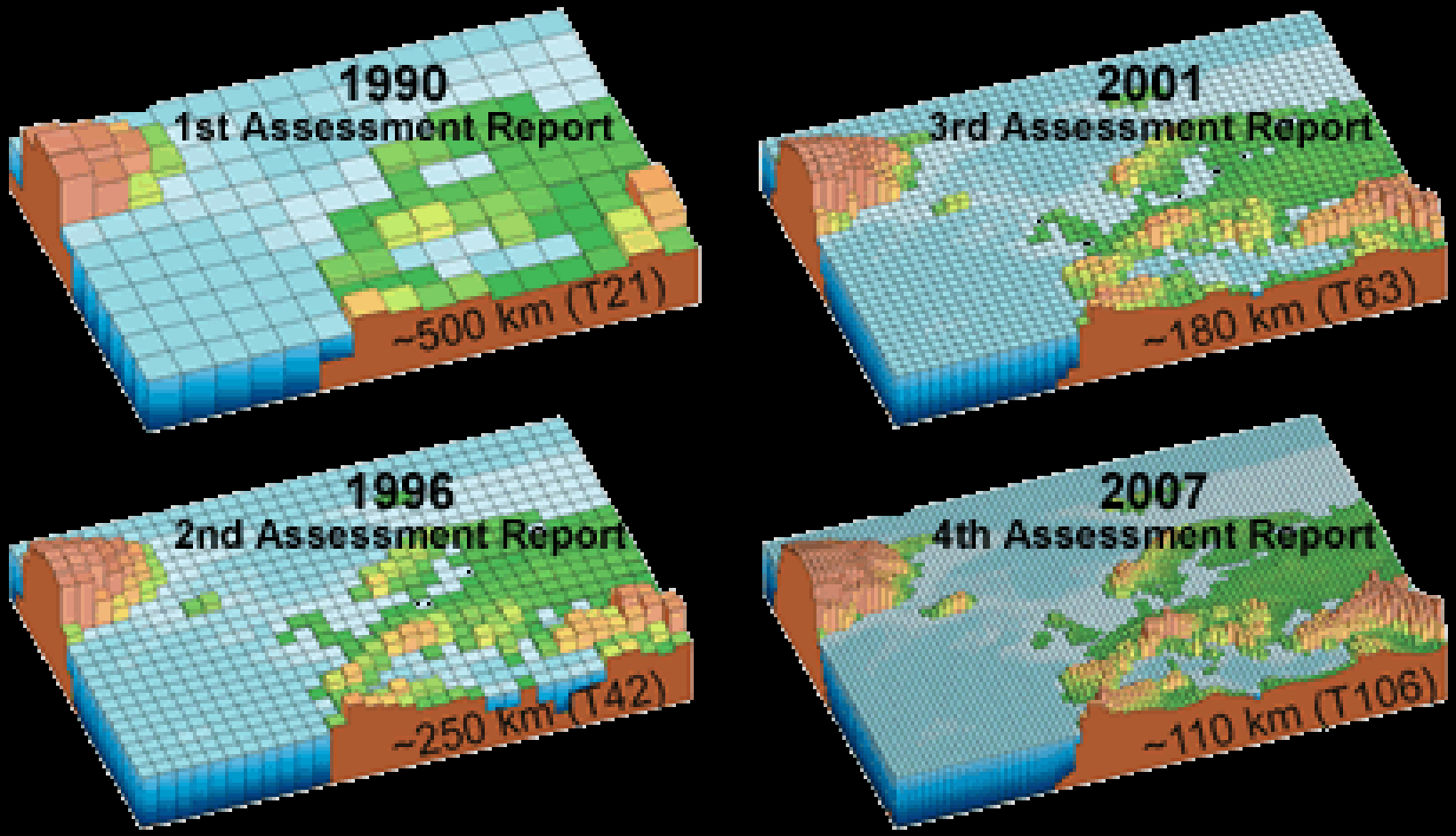


Source: NASA GISS and NOAA NCEI global temperature data averaged and adjusted to early industrial baseline (1881-1910). Data as of July 2016

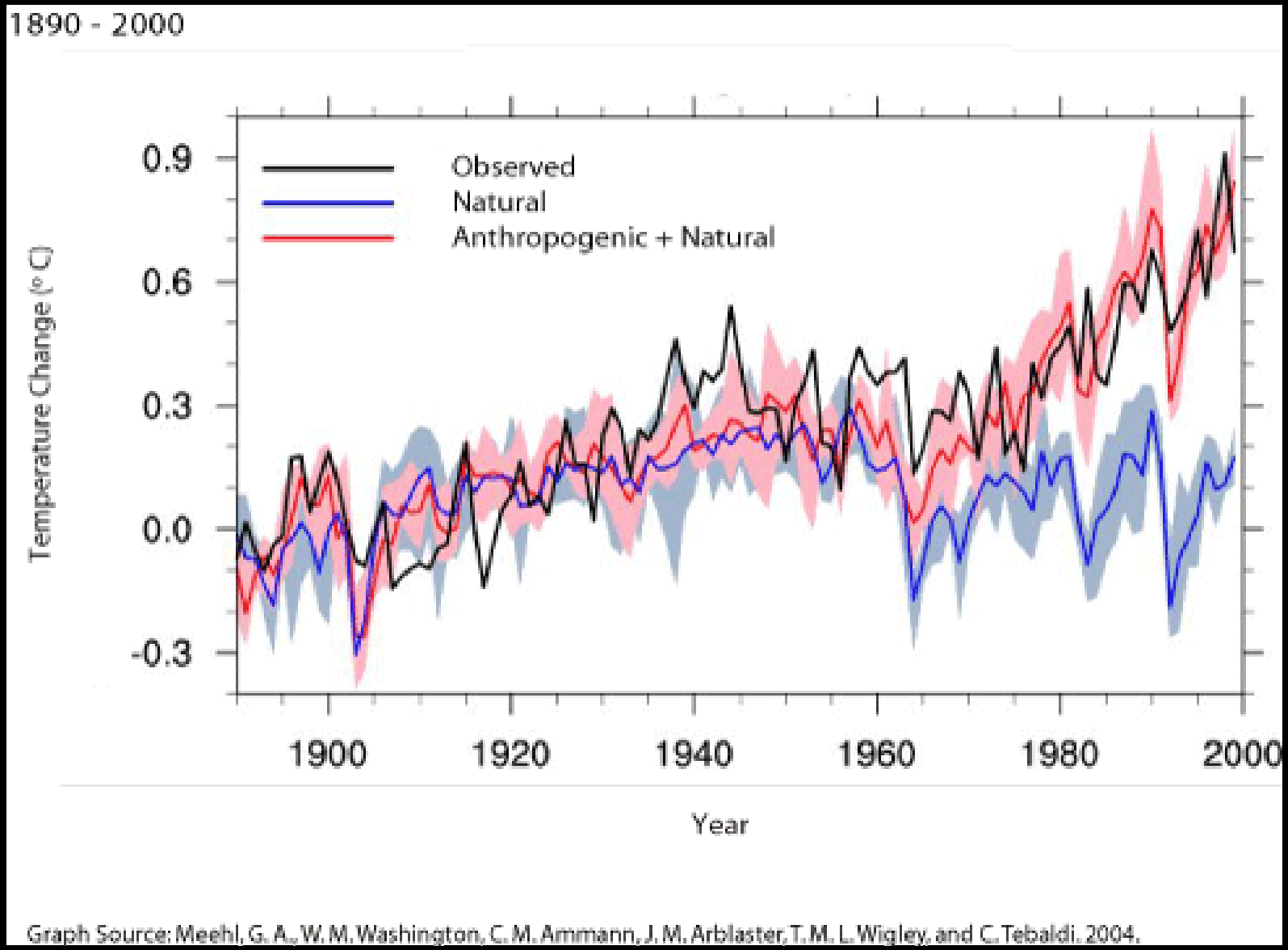
CLIMATE CENTRAL

How Do We Know Humans are Changing the Climate?

1.Computer Models

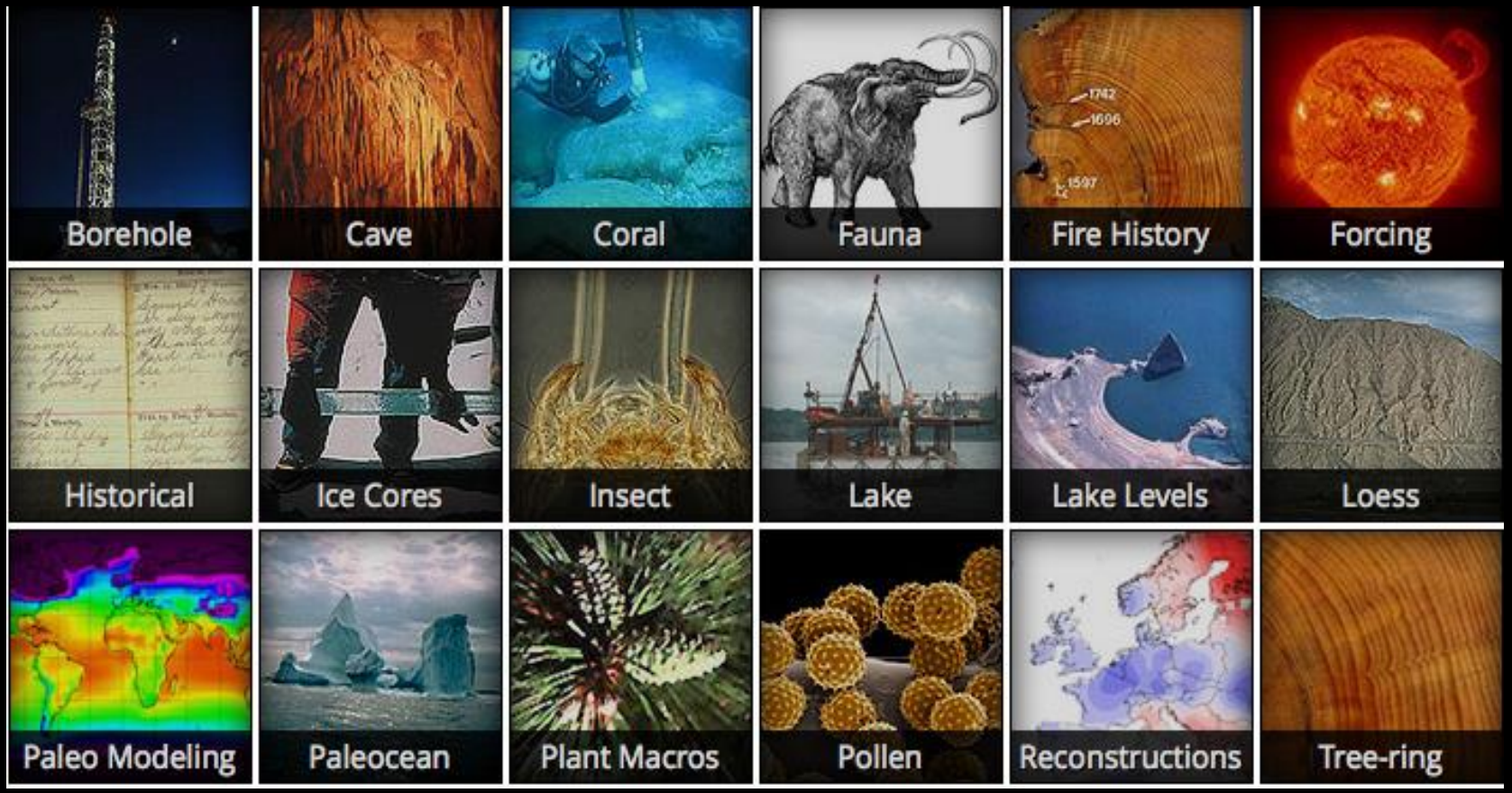


1.Computer Models



Graph Source: Meehl, G. A., W. M. Washington, C. M. Ammann, J. M. Arblaster, T. M. L. Wigley, and C. Tebaldi. 2004.

2. Paleoclimate Data



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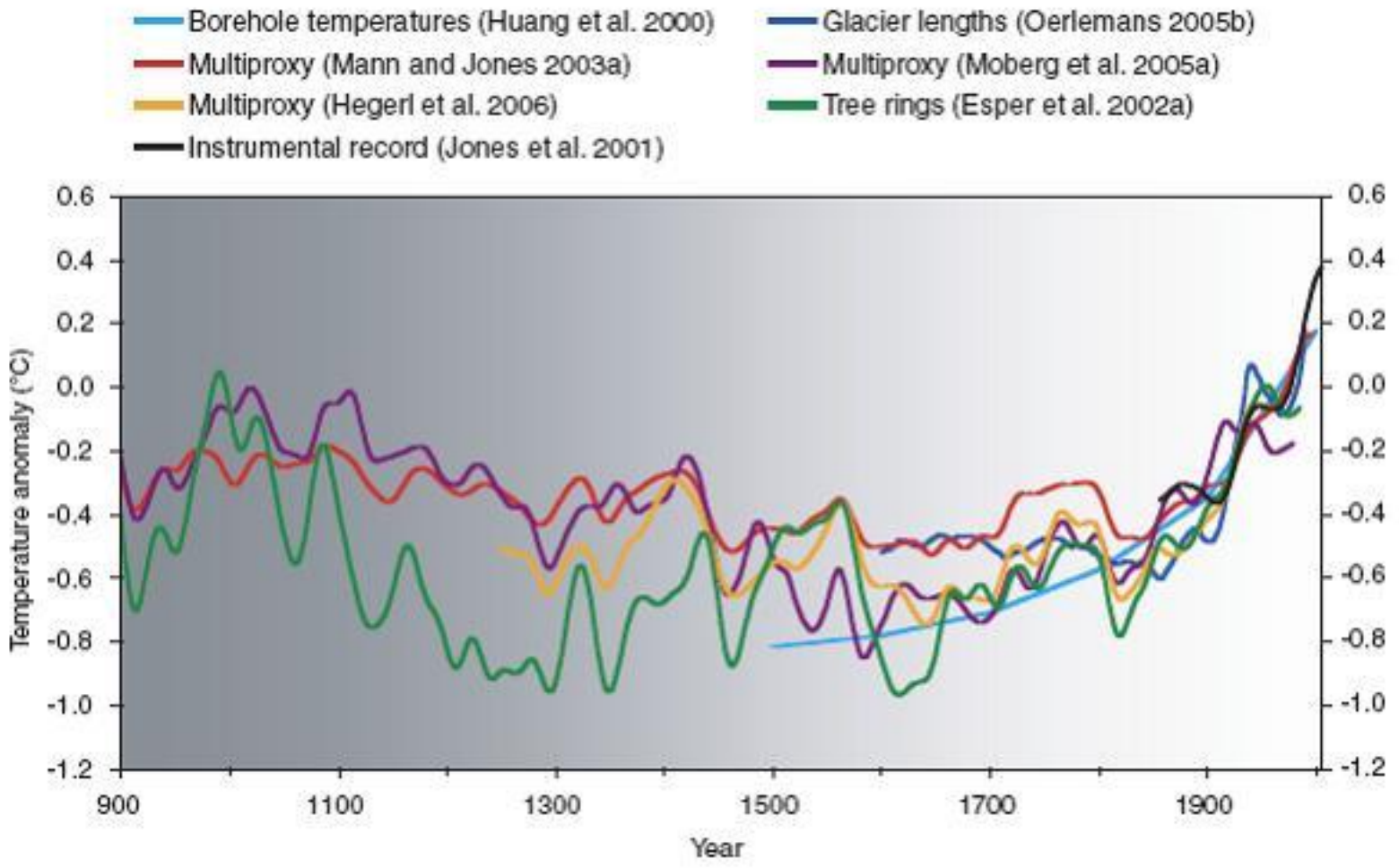
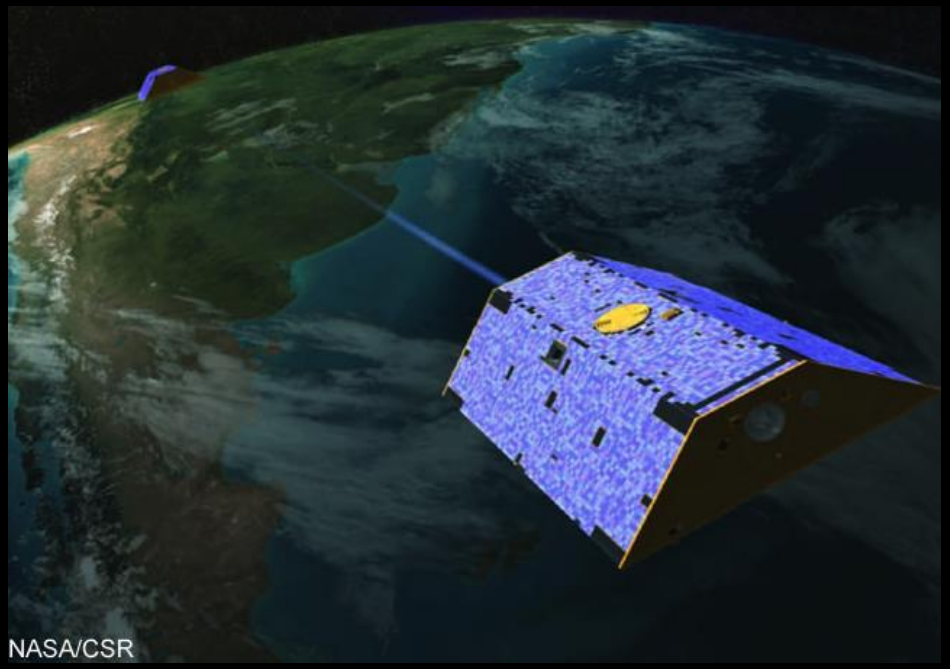
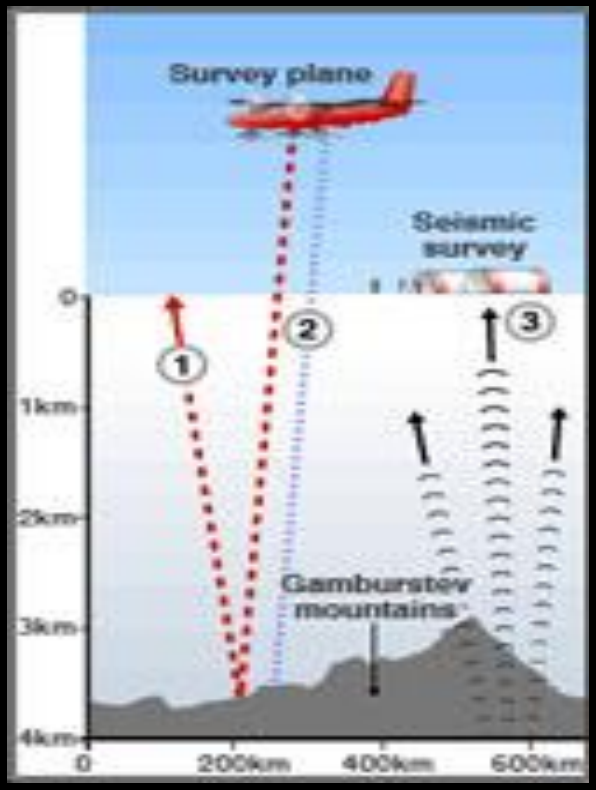


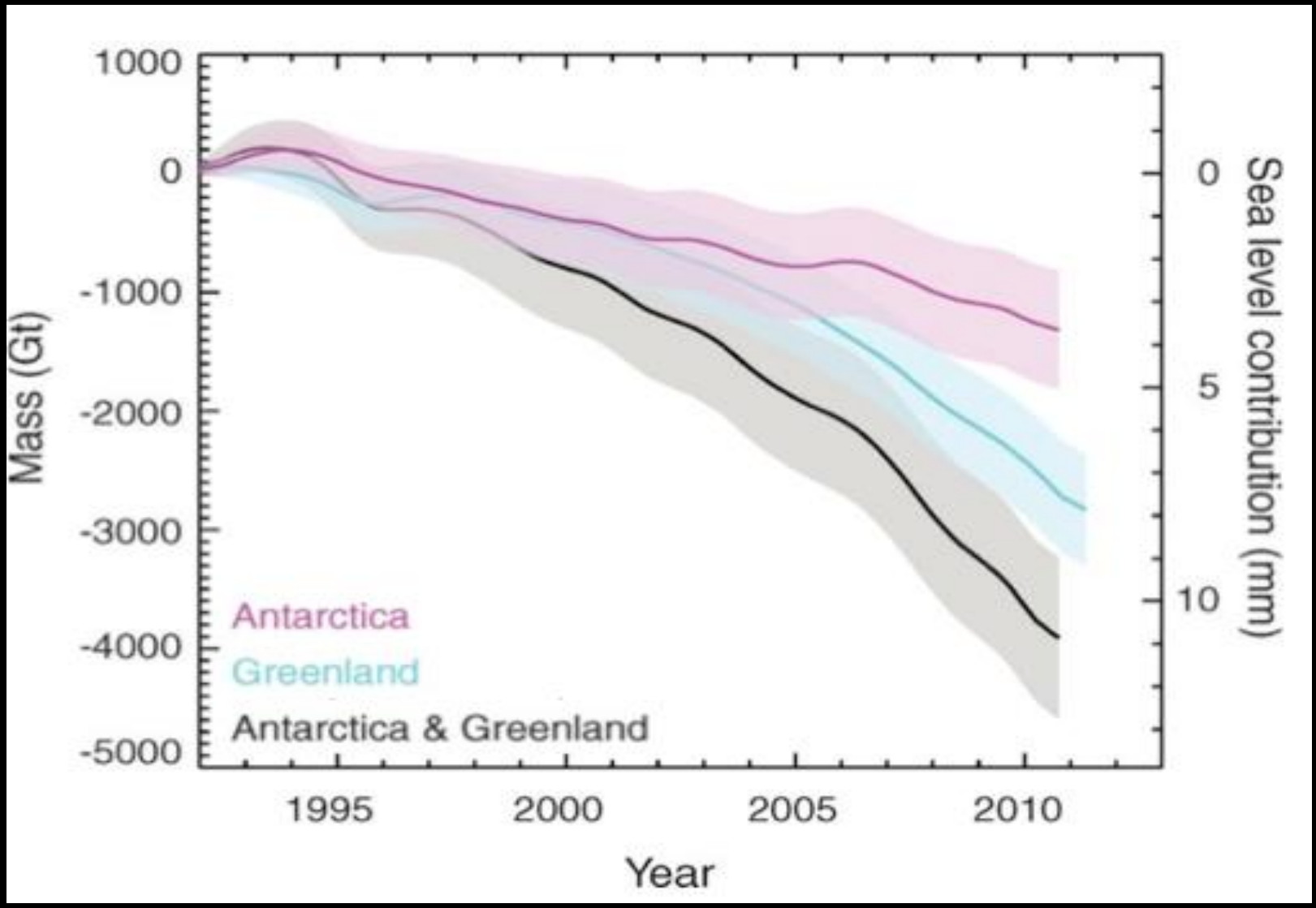
3. Direct Experimental Measurements





Land-Based Polar Ice Mass

3. Direct Experimental Measurements



Land-Based Polar Ice Mass

Manmade climate change is happening now.

Seawater Flooding of Miami

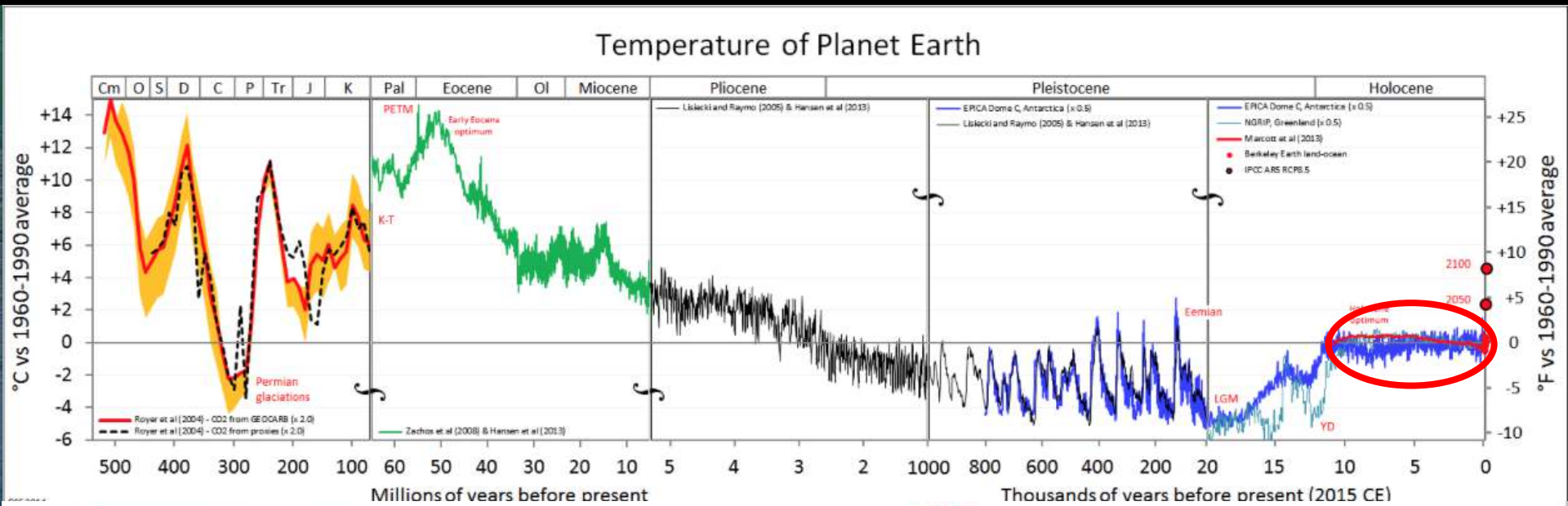
Severe Droughts

Longer Wildfire Season

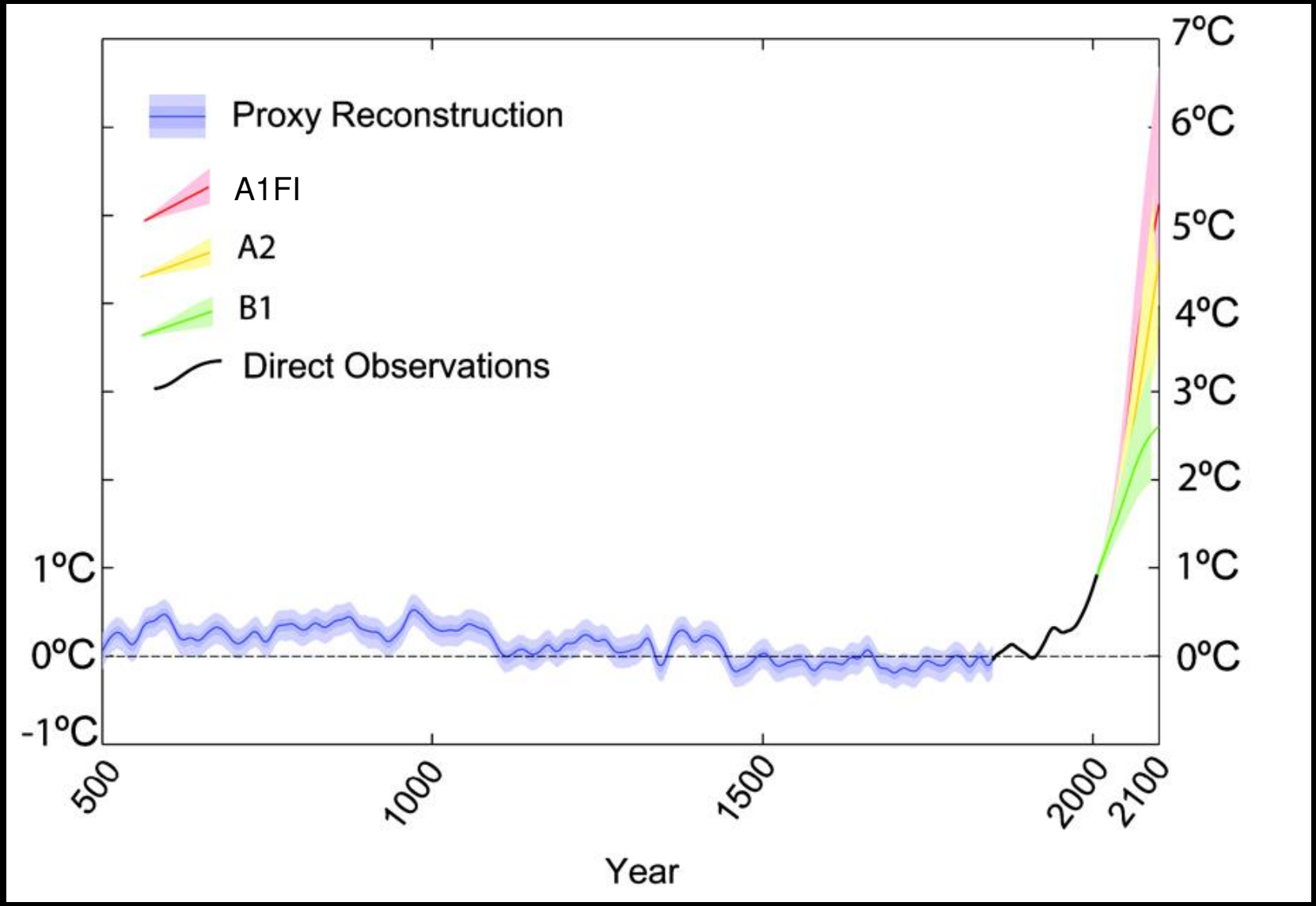
Record Coral Bleaching

Ellicott City, Maryland: 6” of rain in 2 hours, July 30, 2016

500 Million Years of Climate

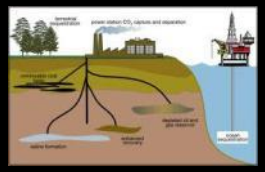


Global Temperature Relative to 1800-1900 (^{0}C)



The Goal:
Reduce all carbon emissions to zero as rapidly as possible

Carbon-Free Energy Options



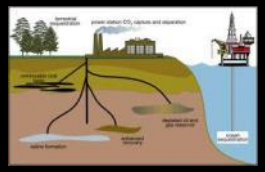
Carbon Capture & Storage

Nuclear

Efficiency

Renewable Energy

Carbon-Free Energy Options



Carbon Capture & Storage

Nuclear

Efficiency

Renewable Energy

Geothermal

PV

Biofuels

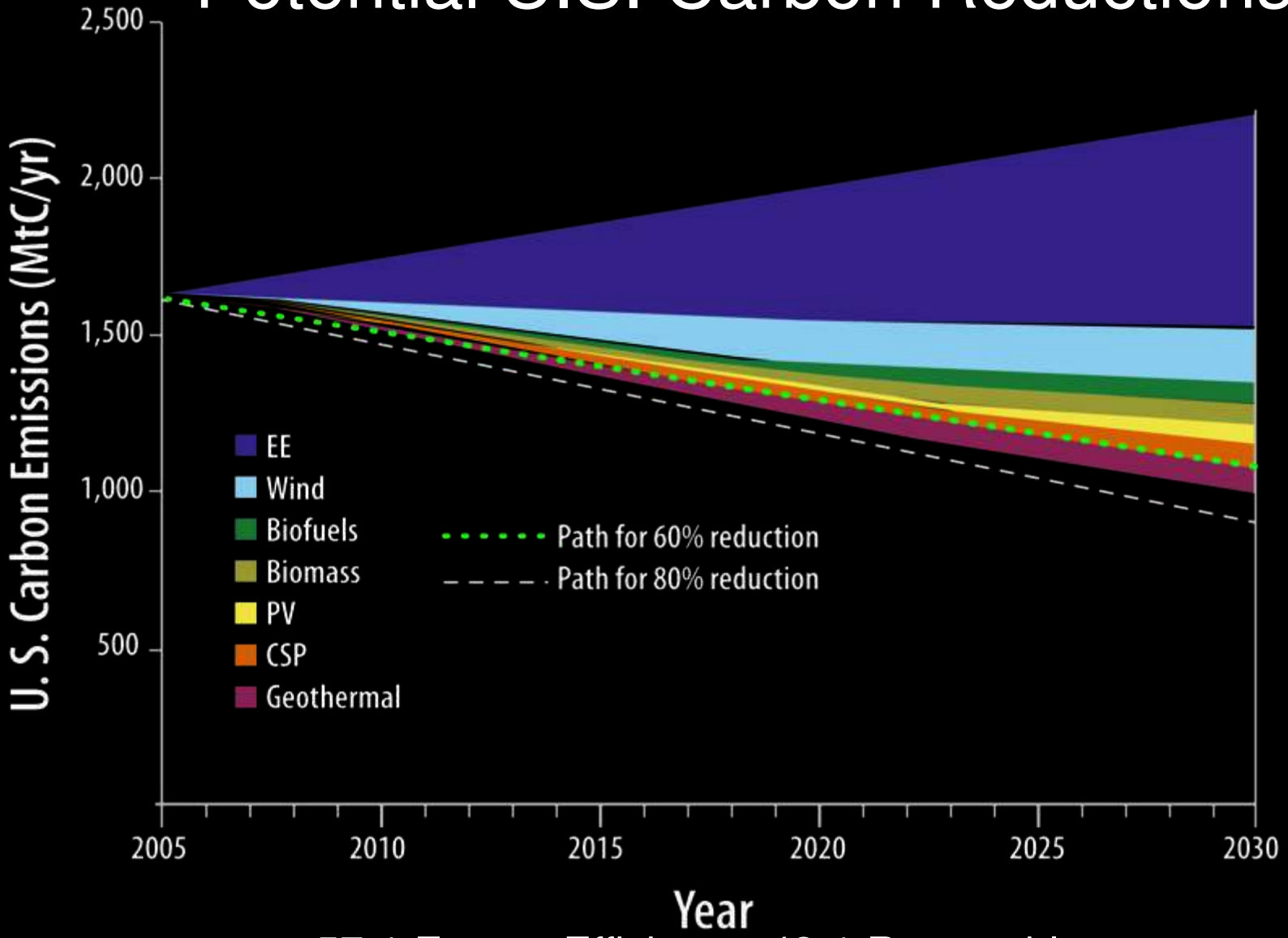
Efficiency

CSP

Biomass

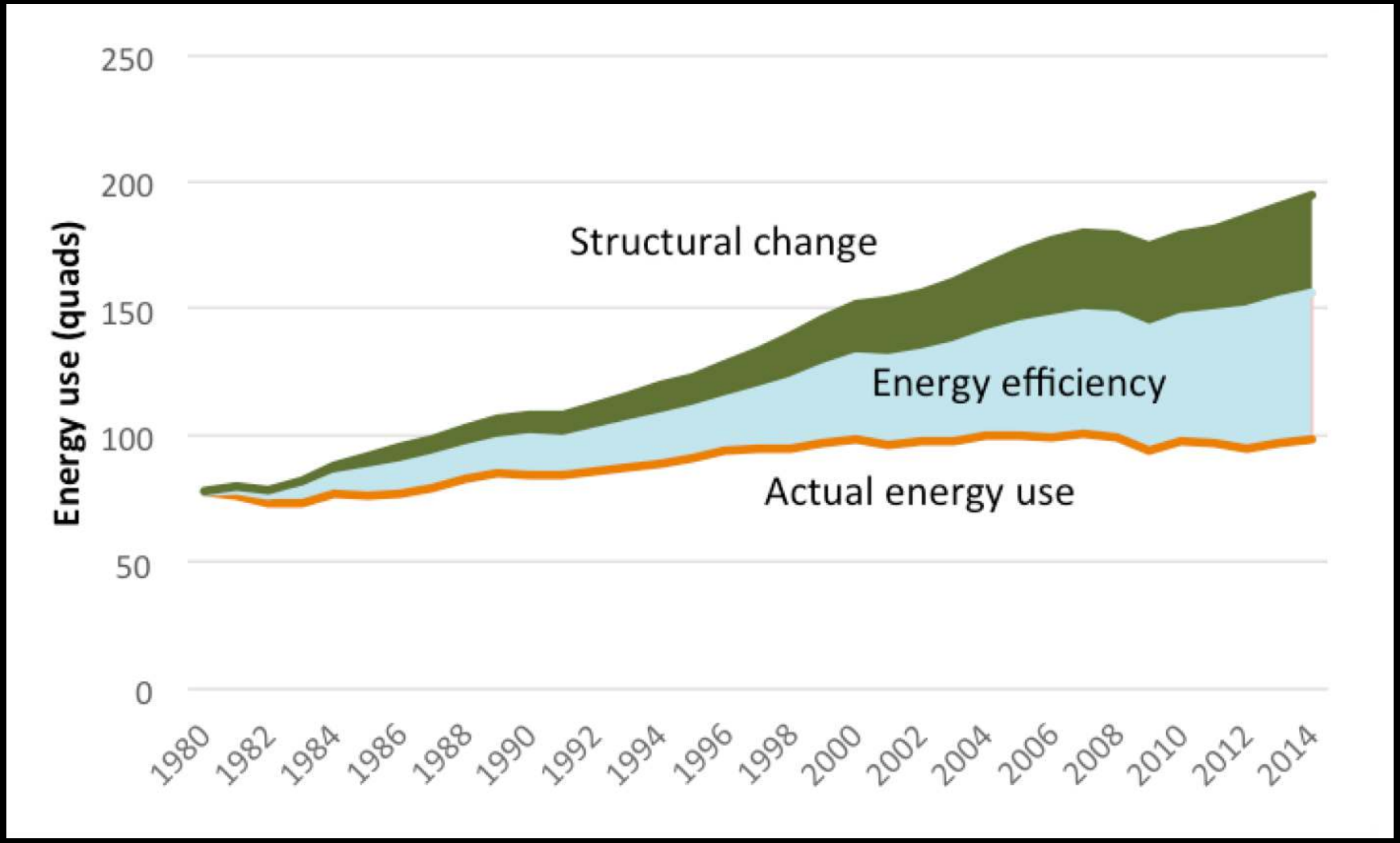
Wind

Potential U.S. Carbon Reductions



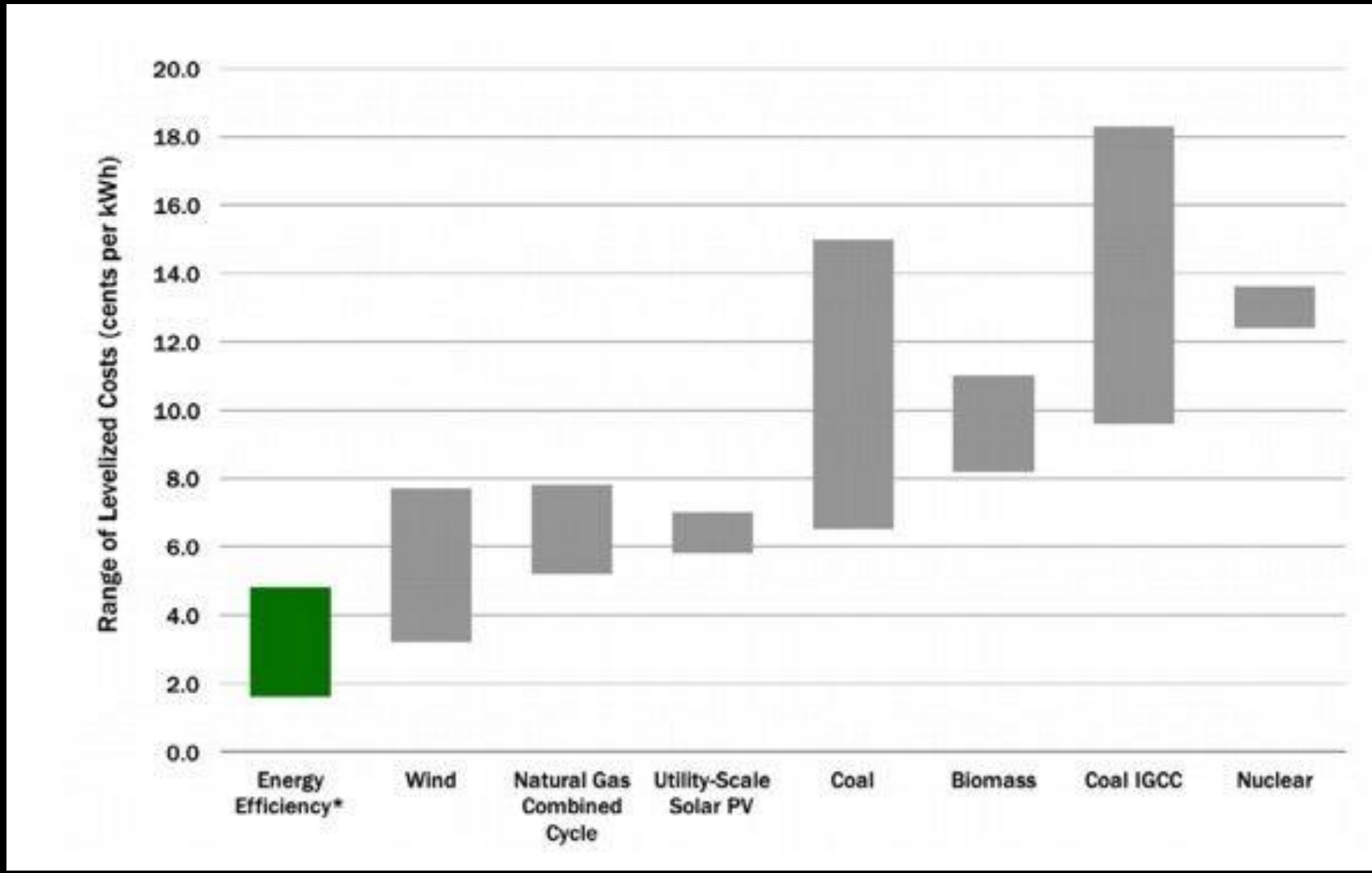
57% Energy Efficiency, 43% Renewables

Impact of Energy Efficiency



Energy Efficiency in the United States: 35 Years and Counting, ACEEE, 2015

Negawatts Are Cheaper than Megawatts



Building Energy Efficiency

Percent of Fossil Fuel CO_2 Emissions Due to Buildings

40%

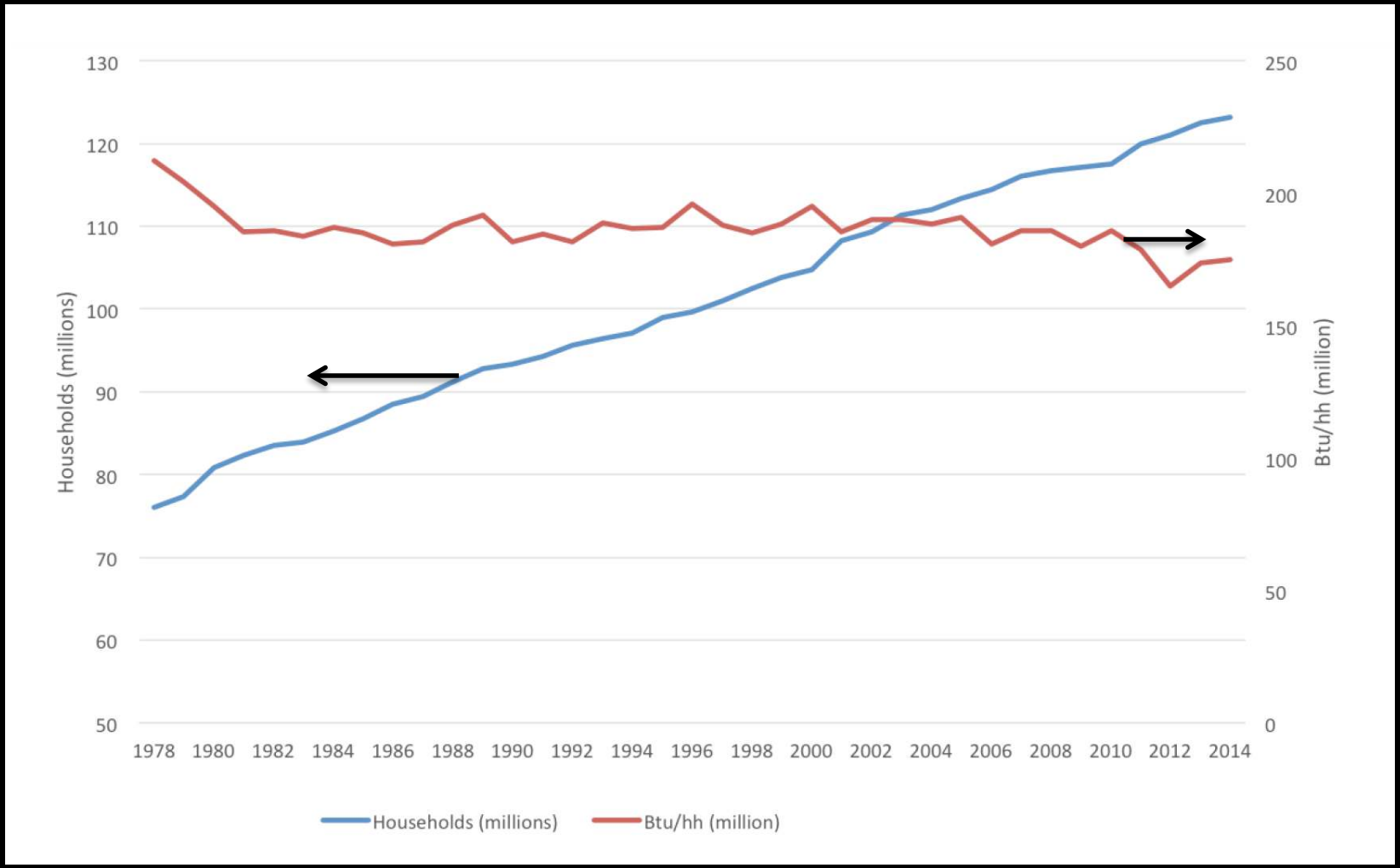
U.S. Energy Information Administration

U.S. Electricity Consumed by Buildings

74%

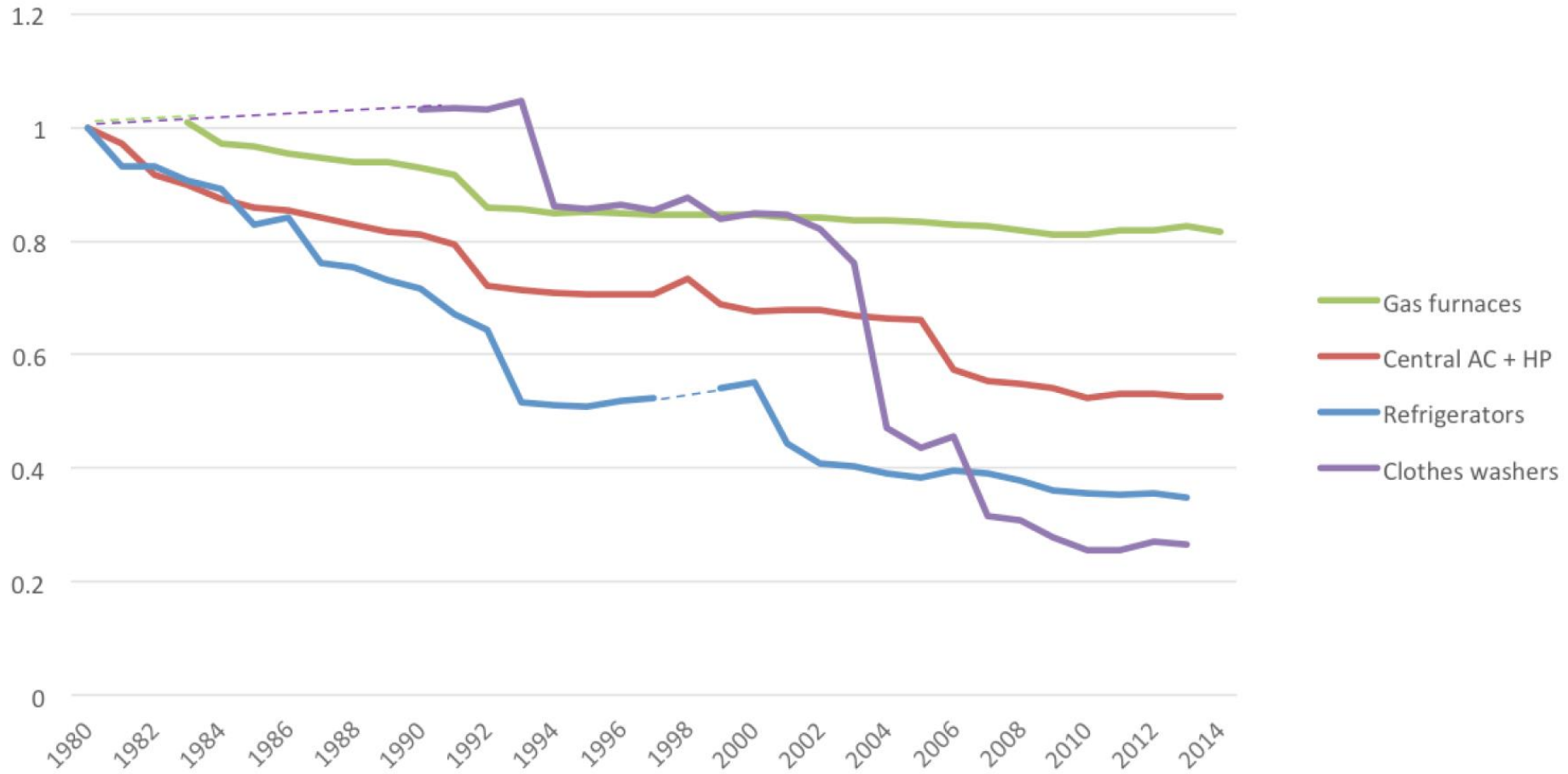
U.S. Energy Information Administration

Growth of U.S. Households and Energy Use, 1978-2014



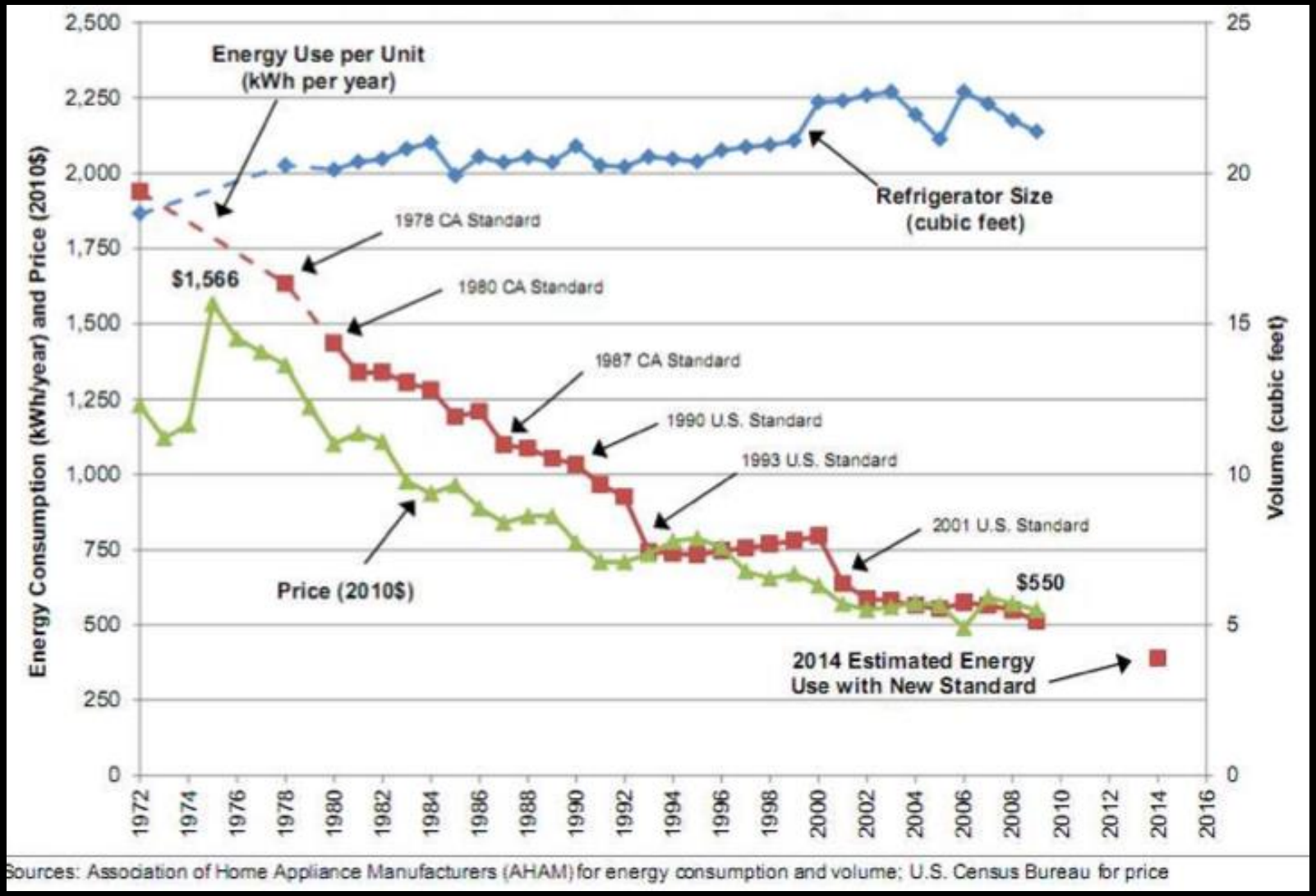
Energy Efficiency in the United States: 35 Years and Counting, ACEEE, 2015

Relative Average Energy Use of Appliances, 1980-2014



Energy Efficiency in the United States: 35 Years and Counting, ACEEE, 2015

Average US Home Refrigerator Energy Use, Volume and Price vs. Time



Sources: Association of Home Appliance Manufacturers (AHAM) for energy consumption and volume; U.S. Census Bureau for price

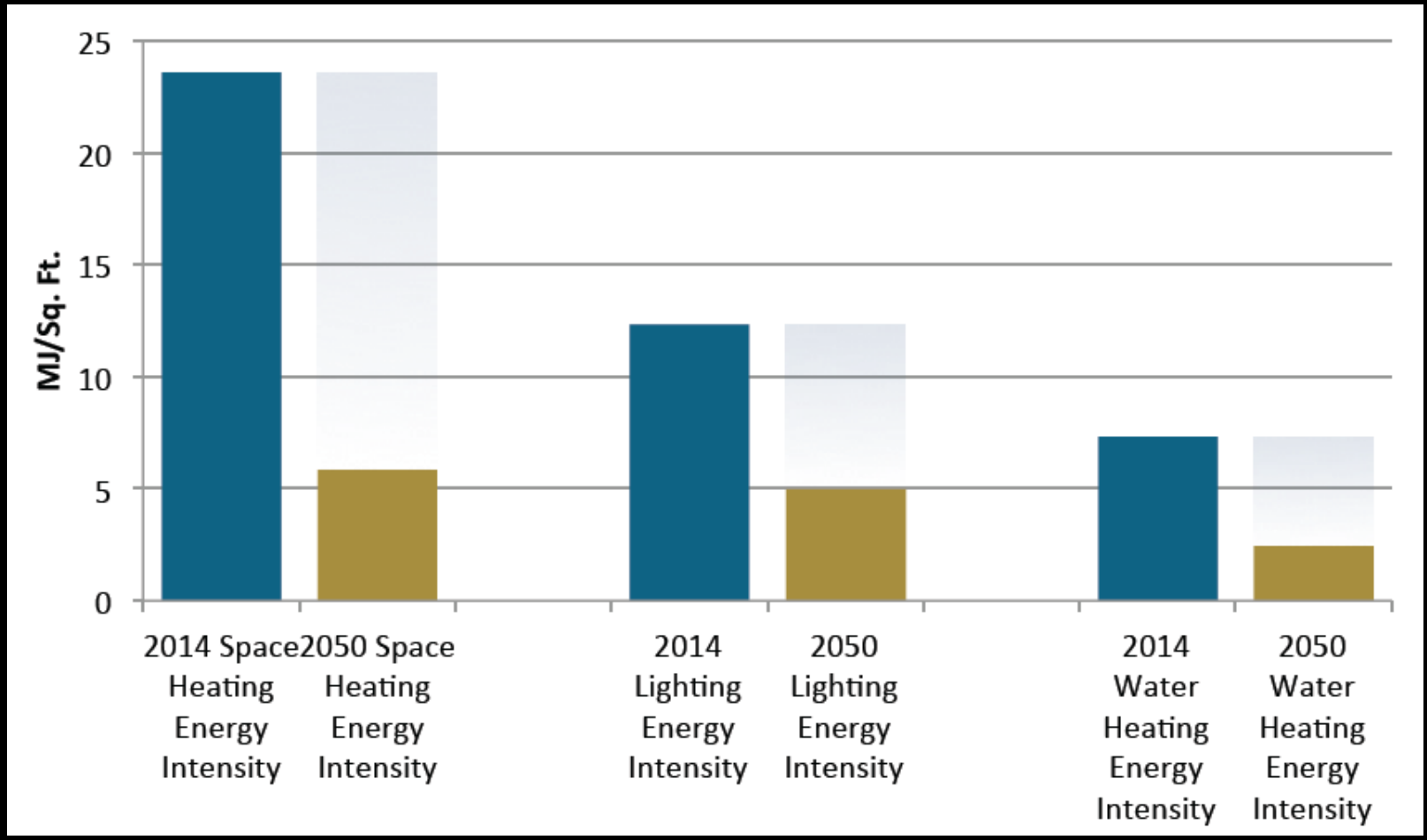
Electricity Used for Lighting in Commercial Buildings

19%

Lighting is the single largest consumer of electricity in commercial buildings.

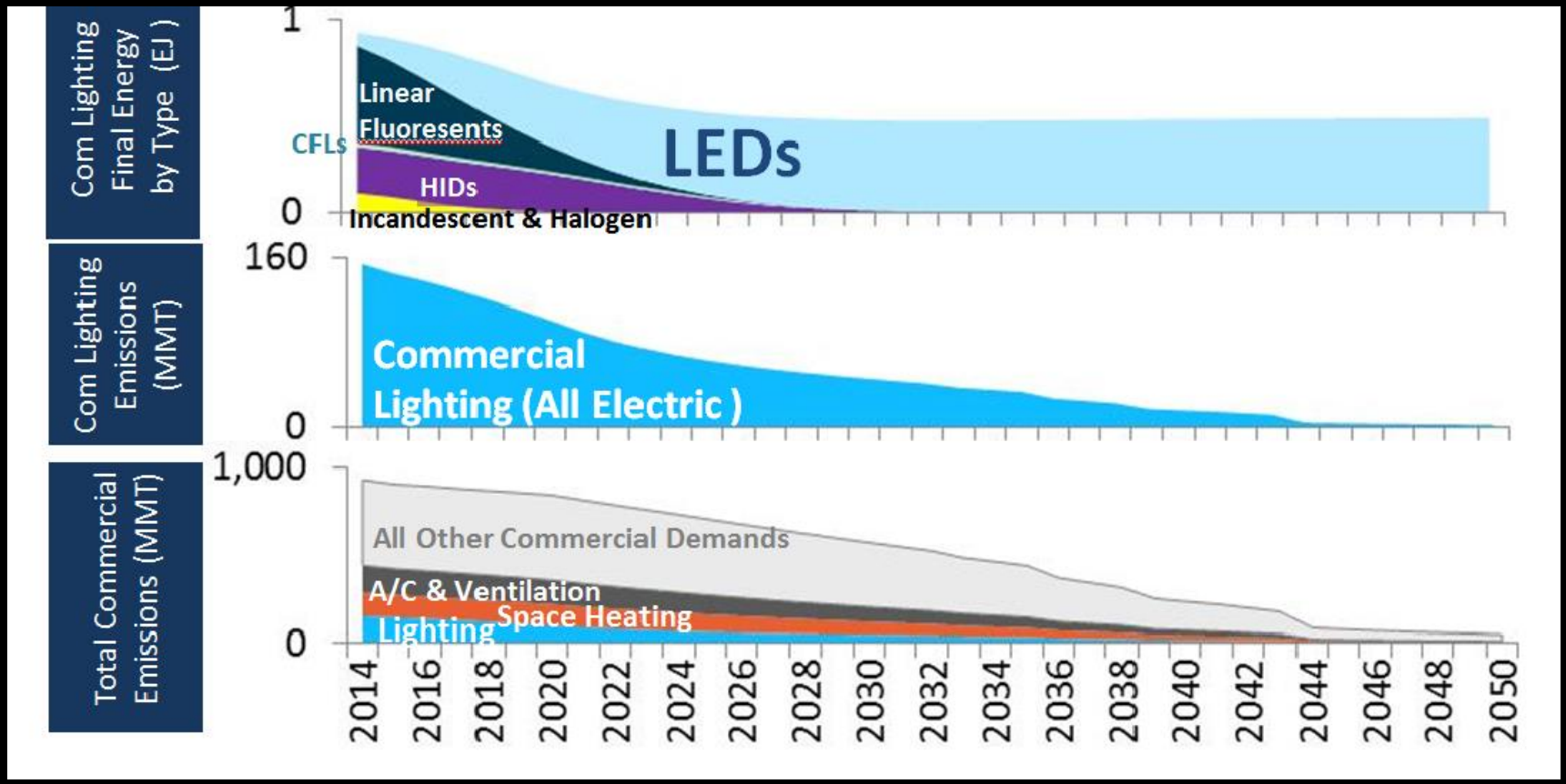
U.S. Energy Information Administration

Potential Reductions in Energy Intensity of US Commercial Buildings



US 2050 Report: Pathways to Deep Decarbonization in the United States, Sustainable Development Solutions Network, November 2014

Commercial Lighting Transition



US 2050 Report: Pathways to Deep Decarbonization in the United States, Sustainable Development Solutions Network, November 2014

NREL's Energy-Efficient Campus

SERF
1993

S&TF
2006

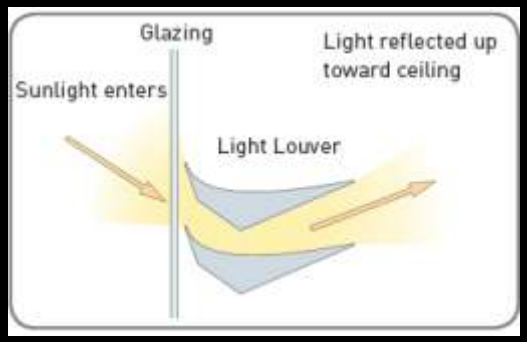
RSF
2010

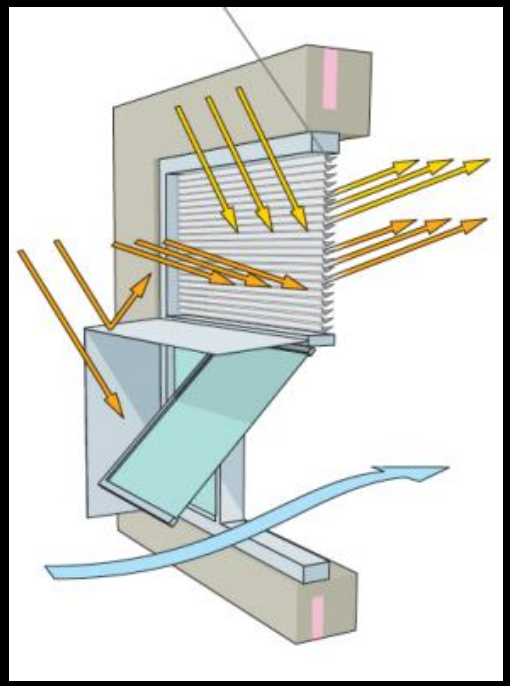
ESIF
2013

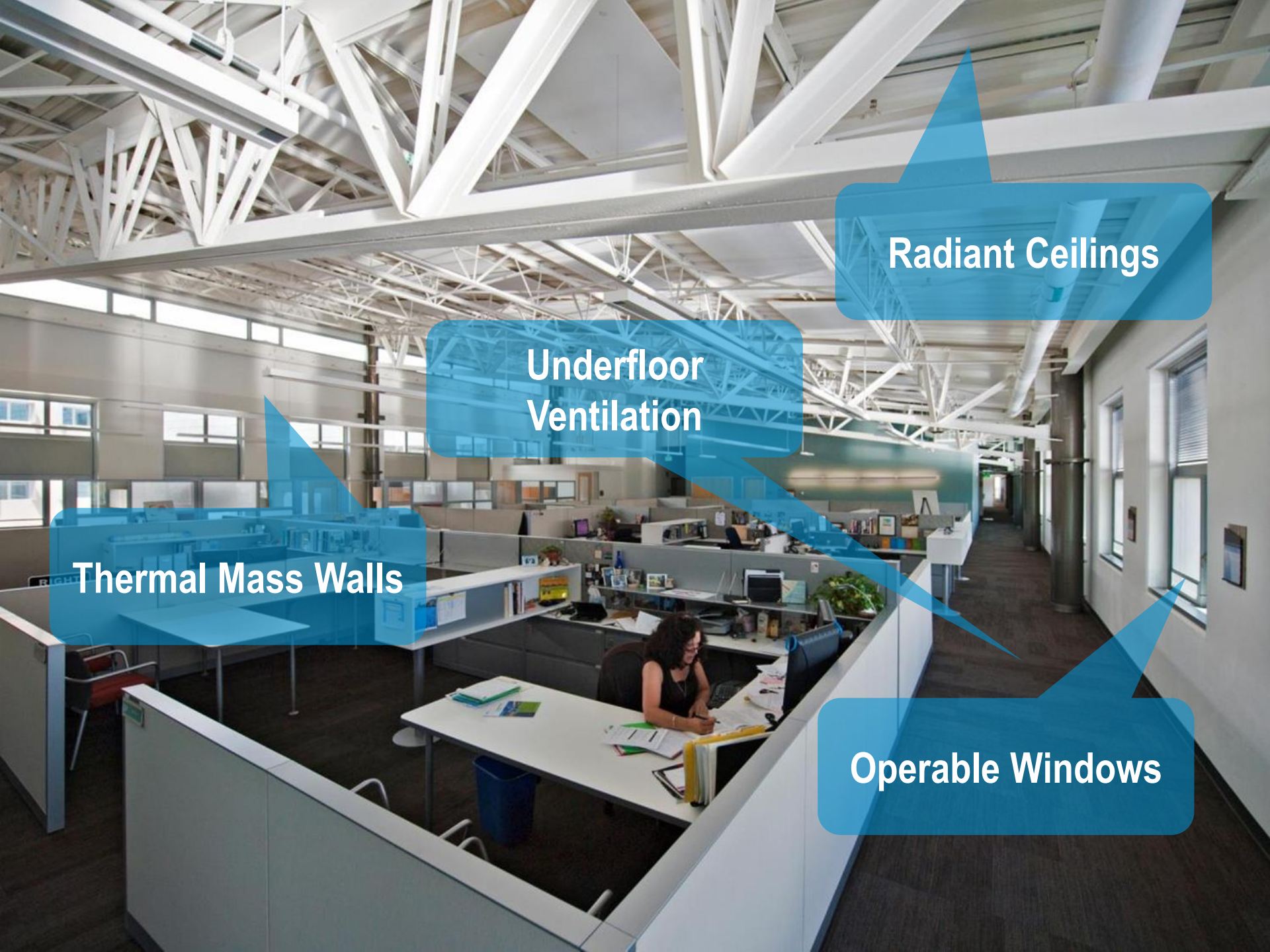
Energy Performance-Based Contracting: NREL Research Support Facility


35 kBtu/SF-yr
$259/SF

Daylighting: Glare Control

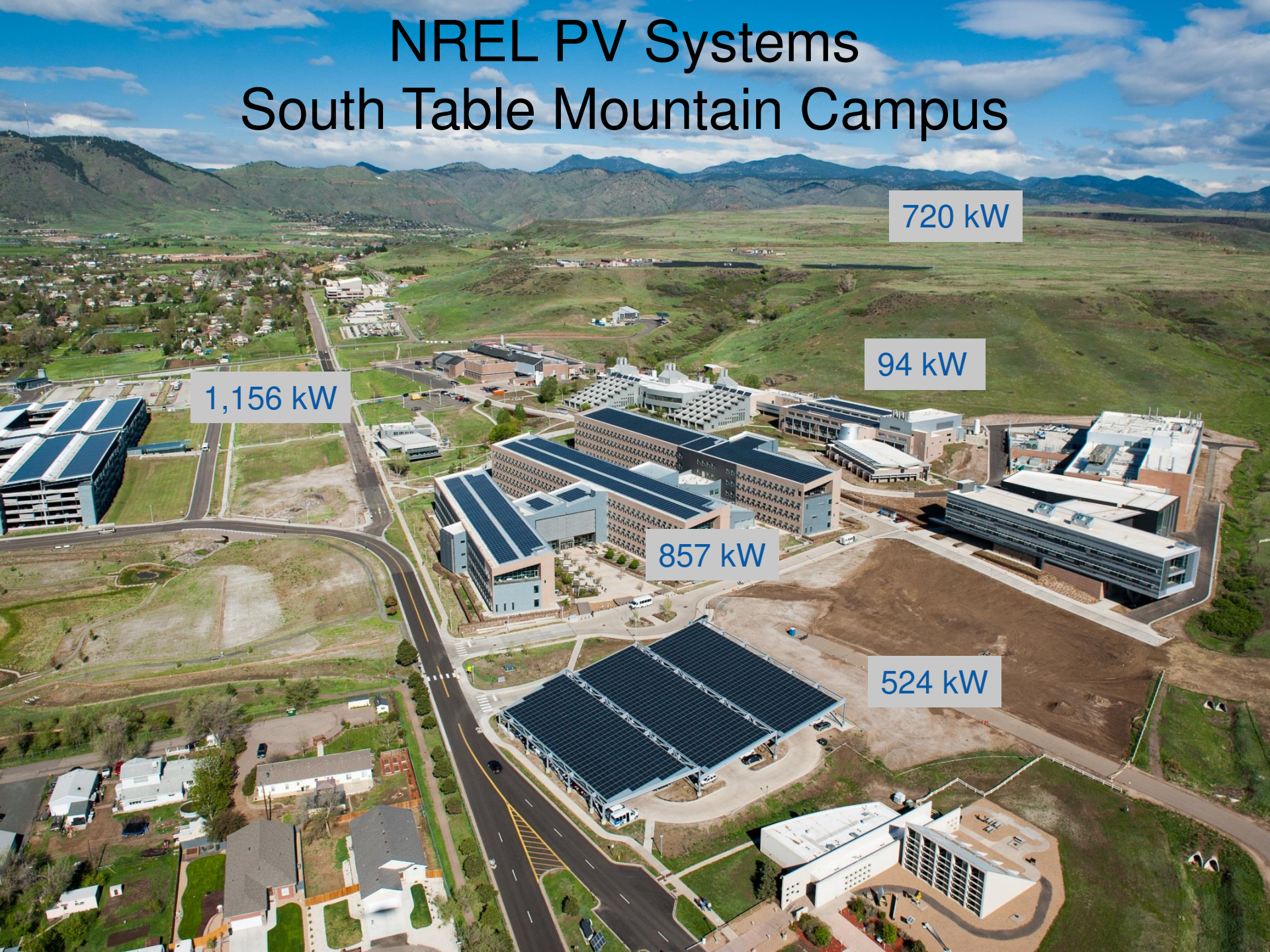





Radiant Ceilings
Underfloor Ventilation
Thermal Mass Walls
Operable Windows


Ambient daylight
Ambient lighting with daylight sensors for 25 fc
6 watt task light 50 fc

NREL PV Systems
South Table Mountain Campus



NREL Energy Efficiency Projects

Before

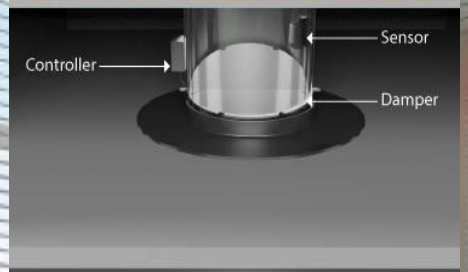
Electric Fixtures
(Electrical or lighting designer)

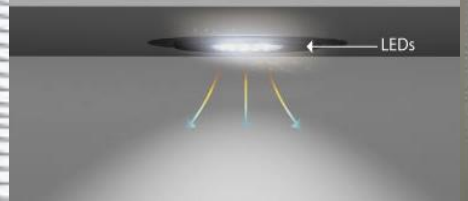
Lightshelf
(Architect)

Photosensor
(Controls manufacturer)

Integration
(Commissioning agent)

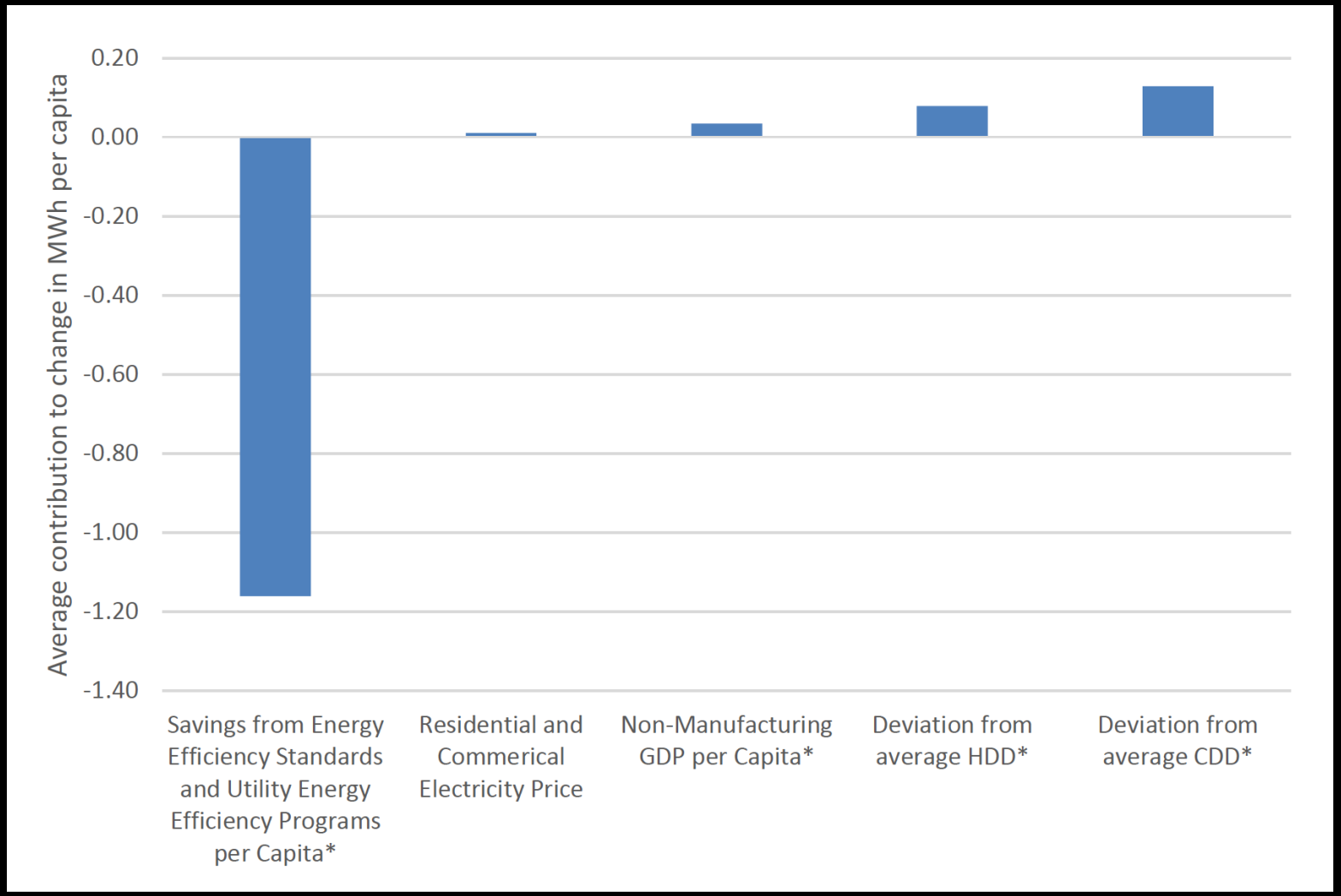
After



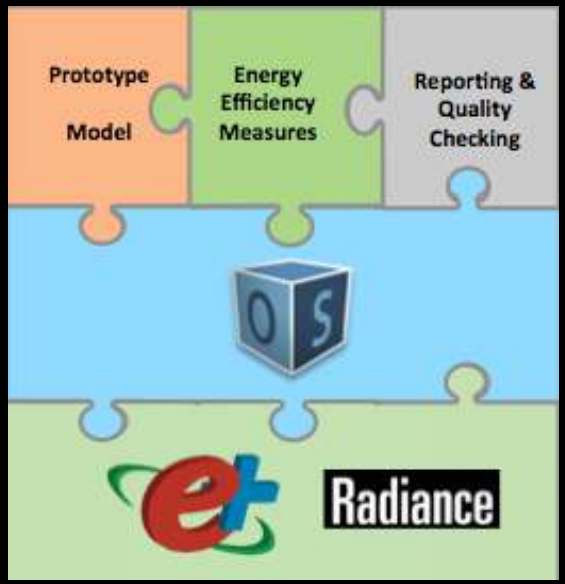


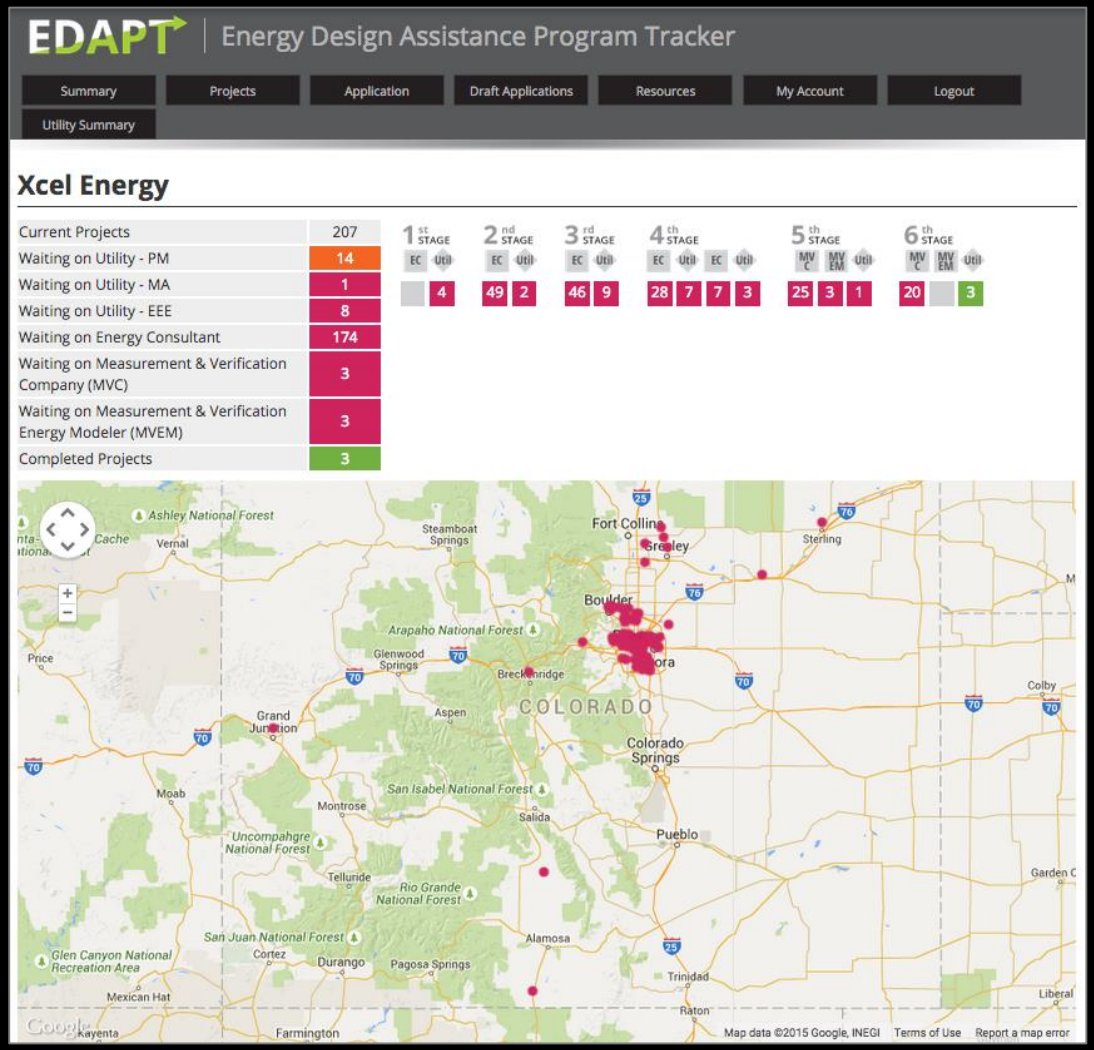

CHECKOUT

Impact of Building Codes and Utility DSM Programs, 2007-2013



Energy Design Assistance Program Tracker (EDAPT) for New Construction



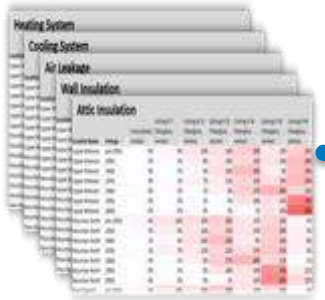


ResStock

Residential Sector EE Potential Tool

216 **Climate Locations**

Census Data (e.g. % Electric Heating)



Database of building component **probability distributions**

EE Potential Tool

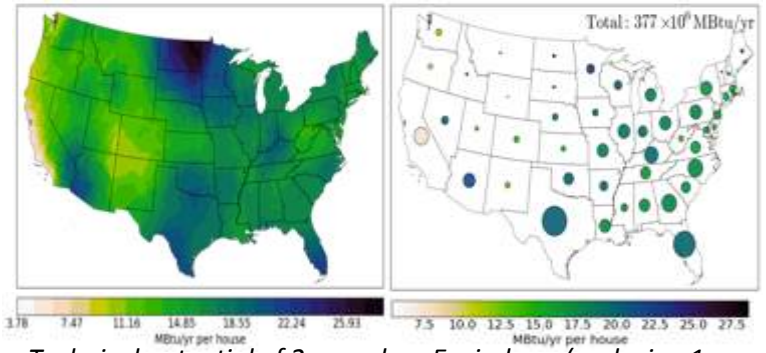
EnergyPlus

HPC

Energy Costs

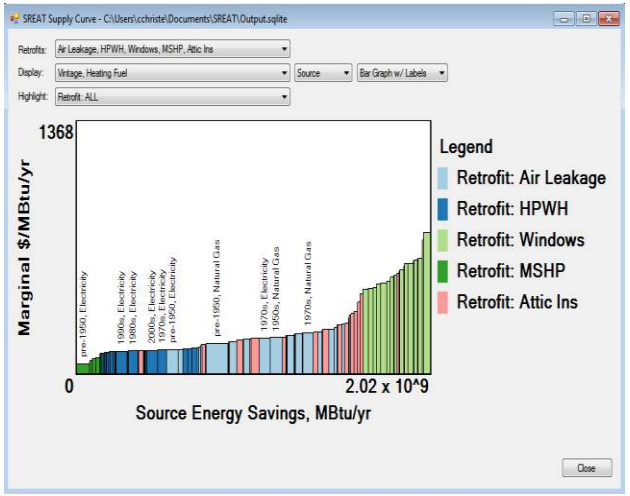
Per House *maps indicate local homeowner savings*

Aggregate *maps indicate market size/impact by state*



Technical potential of 2-pane low-E windows (replacing 1-pane)

High-granularity ***supply curves*** *show the value of* ***targeted deployment***



Systems Performance Lab

Zero Energy Districts: The Next Step

Zero Energy Buildings

Zero Energy Districts

Cities are responsible for

70%

of the world's fossil fuel CO_2 emissions

Source: Cities and Climate Change: an urgent agenda, World Bank, 2010

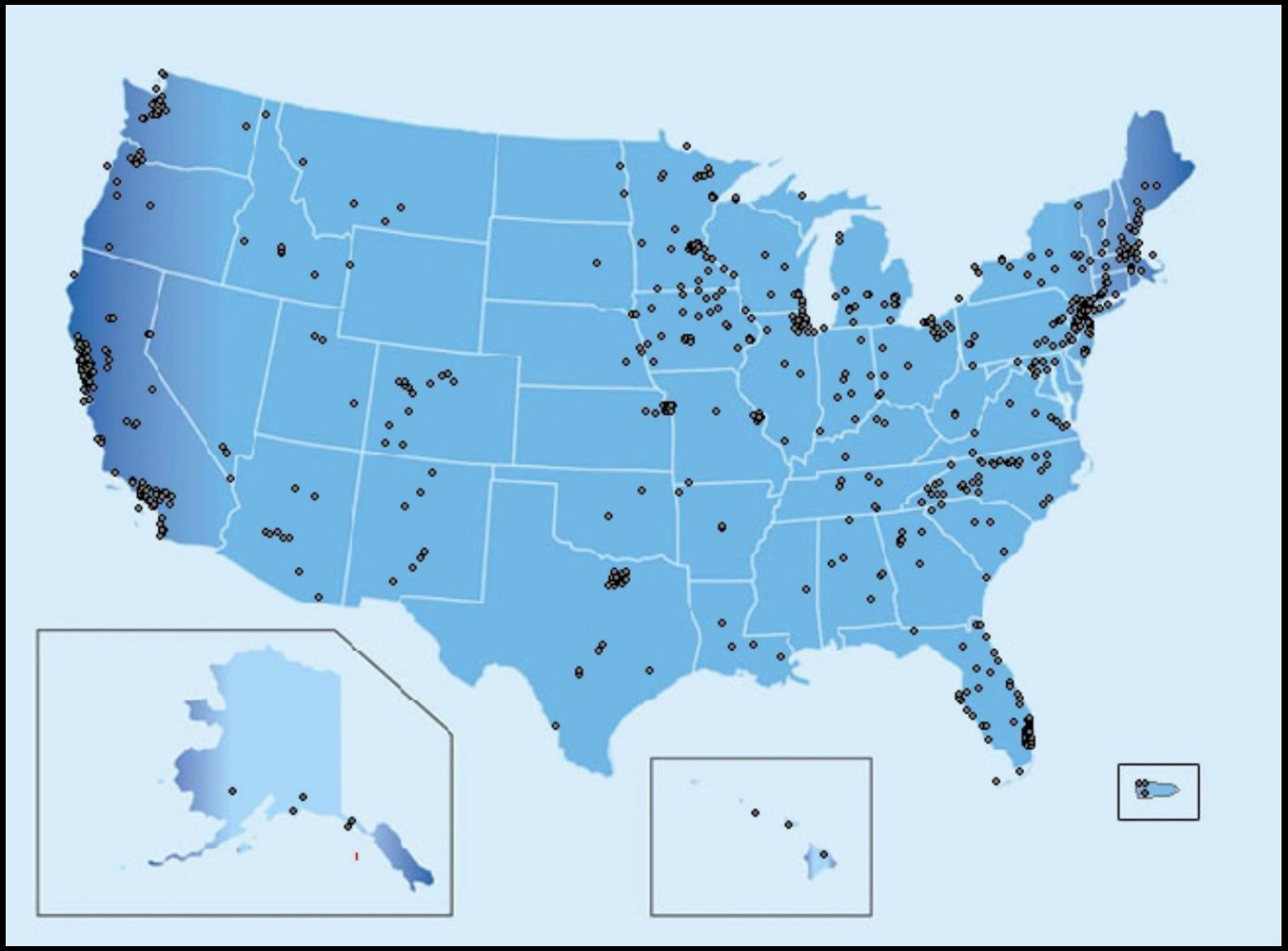
Image: NASA

By 2030

900 billion ft^2

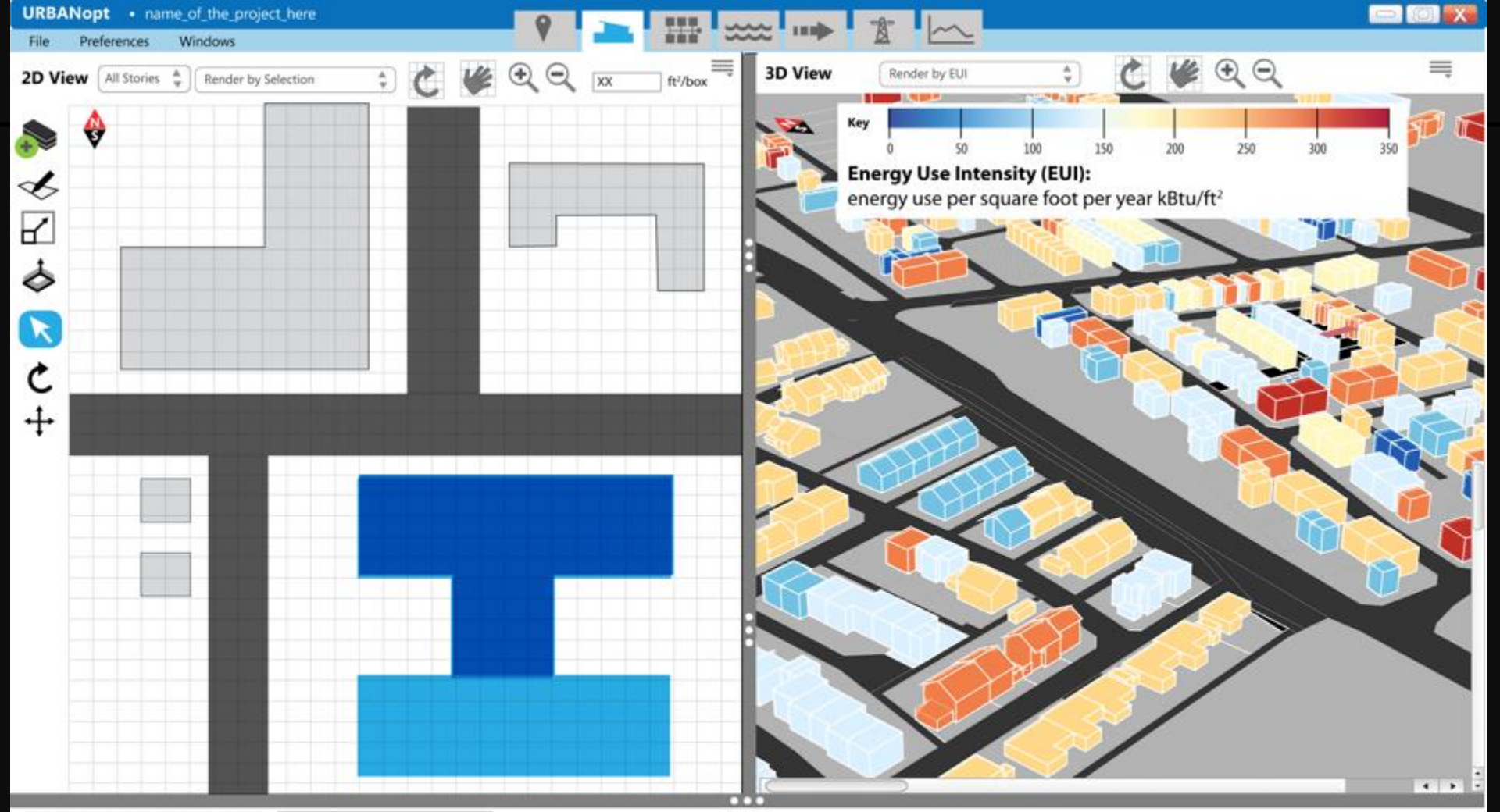
of new and rebuilt buildings will be constructed worldwide

Sources:
UN Habitat, *State of the World's Cities 2010/2011*; McKinsey Global Institute.



Cities signed onto the Mayors' Climate Protection Agreement
1,060 as of 8/19/15

URBANopt:
A zero energy district modeling tool



Edit and Add Buildings | Energy Estimates

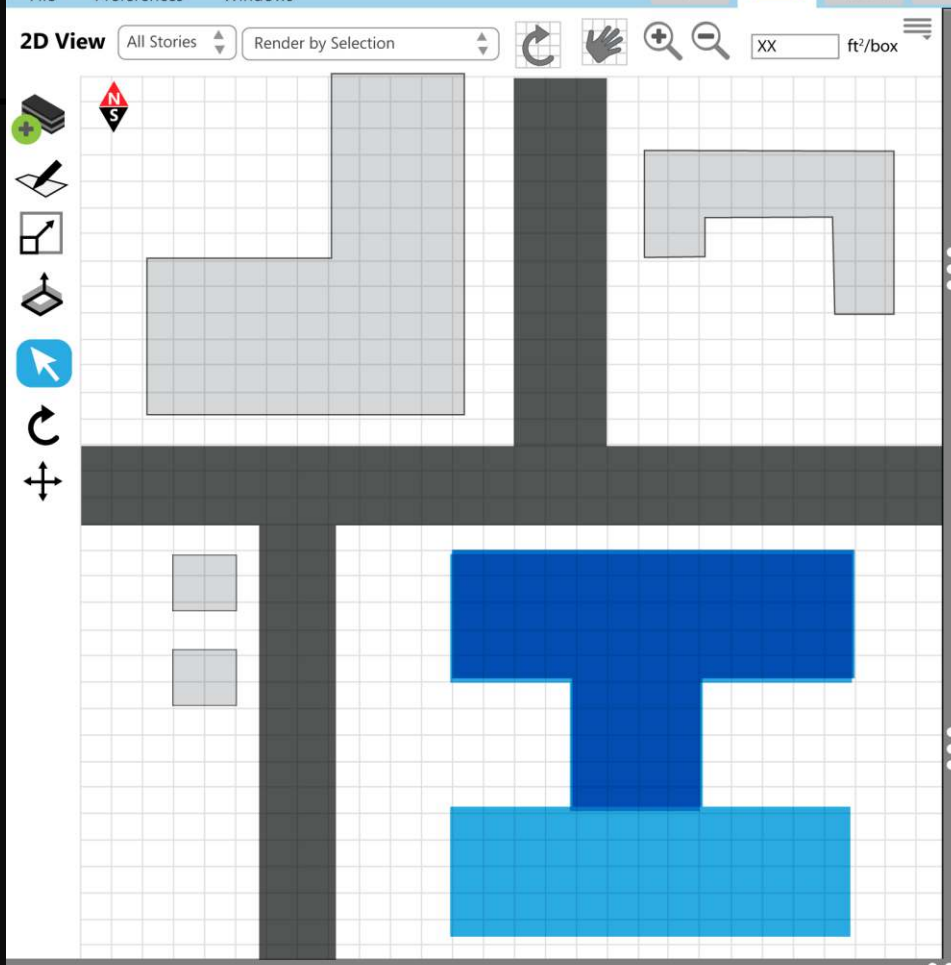
Building Name		Electricity			Natural Gas			Heating & Cooling Jan Dec	Total							Solar PV Potential		
Electrnics Superstore	1 Stories	kWh	tCO_2	$	therms	tCO_2	$		MMBTU	Site EUI	Peak Demand (kW)	% Electricity	% Gas	Carbon	$	Installed W	$/W	Cost
Baseline Standard	50% Savings Above Code	307,200	215	24,576	1,536	10	1,666		1,202	32	104	73	27	226	26,242	15,000	2.50	450,00
Alternatives (2)	30% Savings Above Code	384,000	269	30,720	1,920	13	2,083		1,502	40	130	73	27	282	32,803	0	2.50	0
	Net Zero	253,400	162	15,000	1,152	8	1,250		901	24	78	73	27	250	19,681	30,000	2.50	900,00
Parkplace Apartments	3 Story	kWh	tCO_2	$	therms	tCO_2	$		MMBTU	Site EUI	Peak Demand (kW)	% Electricity	% Gas	Carbon	$	Installed W	$/W	Cost
Baseline Standard	50% Savings Above Code	150,290	106	10,736	1,357	9	9,952		2,330	33	150	70	30	240	20,682	0	0	0
Alternatives (1)	Net Zero	113,000	80	8,072	1,020	7	7,483		1,400	19.4	100	70	30	200	15,550	15,000	2.50	450,00

Export Hourly Load Profile for Selected

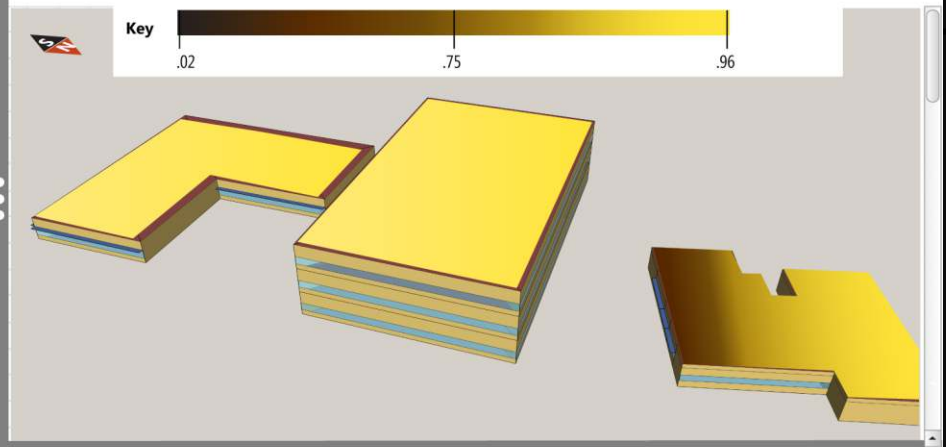
URBANopt • name_of_the_project_here

File Preferences Windows

2D View | All Stories | Render by Selection | XX ft²/box



3D View | Render by Roof Solar Potential



Project Targets

	Target Total ft²	Wider Bar is Target	Current Total ft²	Delete
Total	xxxxx		xxxxx	
Residential	xxxxx		xxxxx	
Multi-family	xxxxx		xxxxx	
Single family	xxxxx		xxxxx	
Commercial	xxxxx		xxxxx	
Office	xxxxx		xxxxx	
Retail	xxxxx		xxxxx	
Supermarket	xxxxx		xxxxx	
Parking	xxxxx		xxxxx	
Structured	xxxxx		xxxxx	

Edit and Add Buildings | Energy Estimates

Building Name		Electricity			Natural Gas			Heating & Cooling Jan–Dec	Total							Solar PV Potential		
Electrnics Superstore	1 Stories	kWh	tCO_2	$	therms	tCO_2	$		MMBTU	Site EUI	Peak Demand (kW)	% Electricity	% Gas	Carbon	$	Installed W	$/W	Cost
Baseline Standard	50% Savings Above Code	307,200	215	24,576	1,536	10	1,666		1,202	32	104	73	27	226	26,242	15,000	2.50	450,00
Alternatives (2)	30% Savings Above Code	384,000	269	30,720	1,920	13	2,083		1,502	40	130	73	27	282	32,803	0	2.50	0
	Net Zero	253,400	162	15,000	1,152	8	1,250		901	24	78	73	27	250	19,681	30,000	2.50	900,00
Parkplace Apartments	3 Story	kWh	tCO_2	$	therms	tCO_2	$		MMBTU	Site EUI	Peak Demand (kW)	% Electricity	% Gas	Carbon	$	Installed W	$/W	Cost
Baseline Standard	50% Savings Above Code	150,290	106	10,736	1,357	9	9,952		2,330	33	150	70	30	240	20,682	0	0	0
Alternatives (1)	Net Zero	113,000	80	8,072	1,020	7	7,483		1,400	19.4	100	70	30	200	15,550	15,000	2.50	450,00

Export Hourly Load Profile for Selected

An enormous, disruptive energy transition is underway!

Early 20th Century:

Early 21st Century:

COP 21: UN climate change conference | Paris

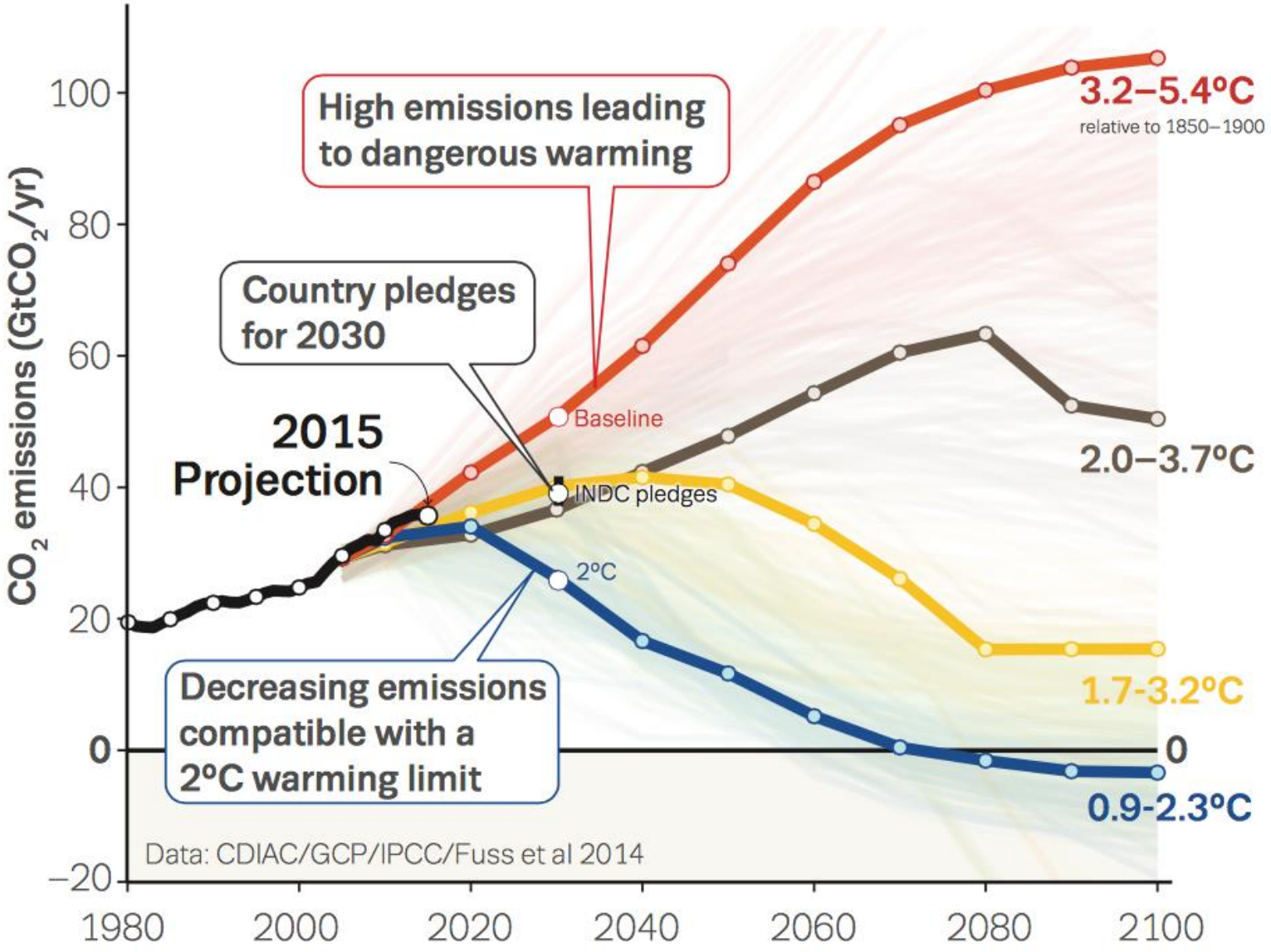
Paris climate change agreement: the world's greatest diplomatic success

With all 196 nations having a say, the UN climate deal, with all its frustrations and drama, has proven that compromise works for the planet

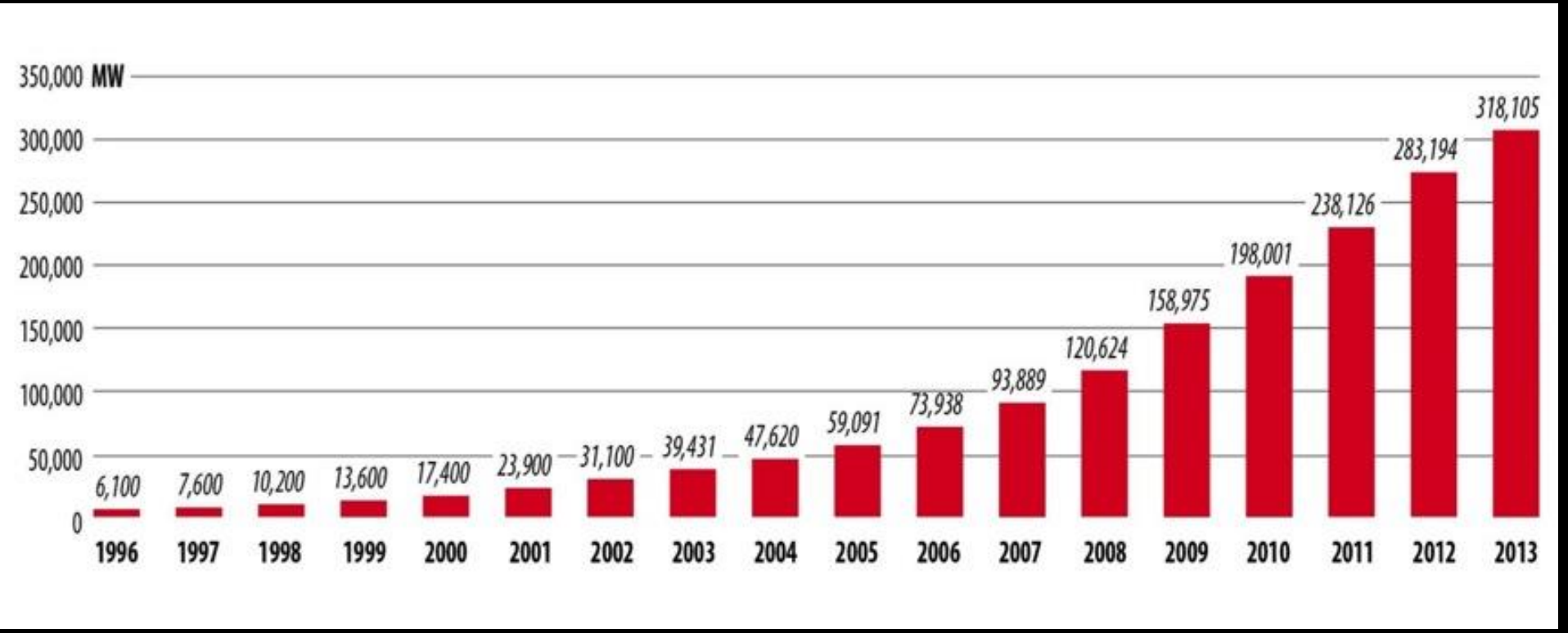
Fiona Harvey in Paris

Monday 14 December 2015 02.51 EST

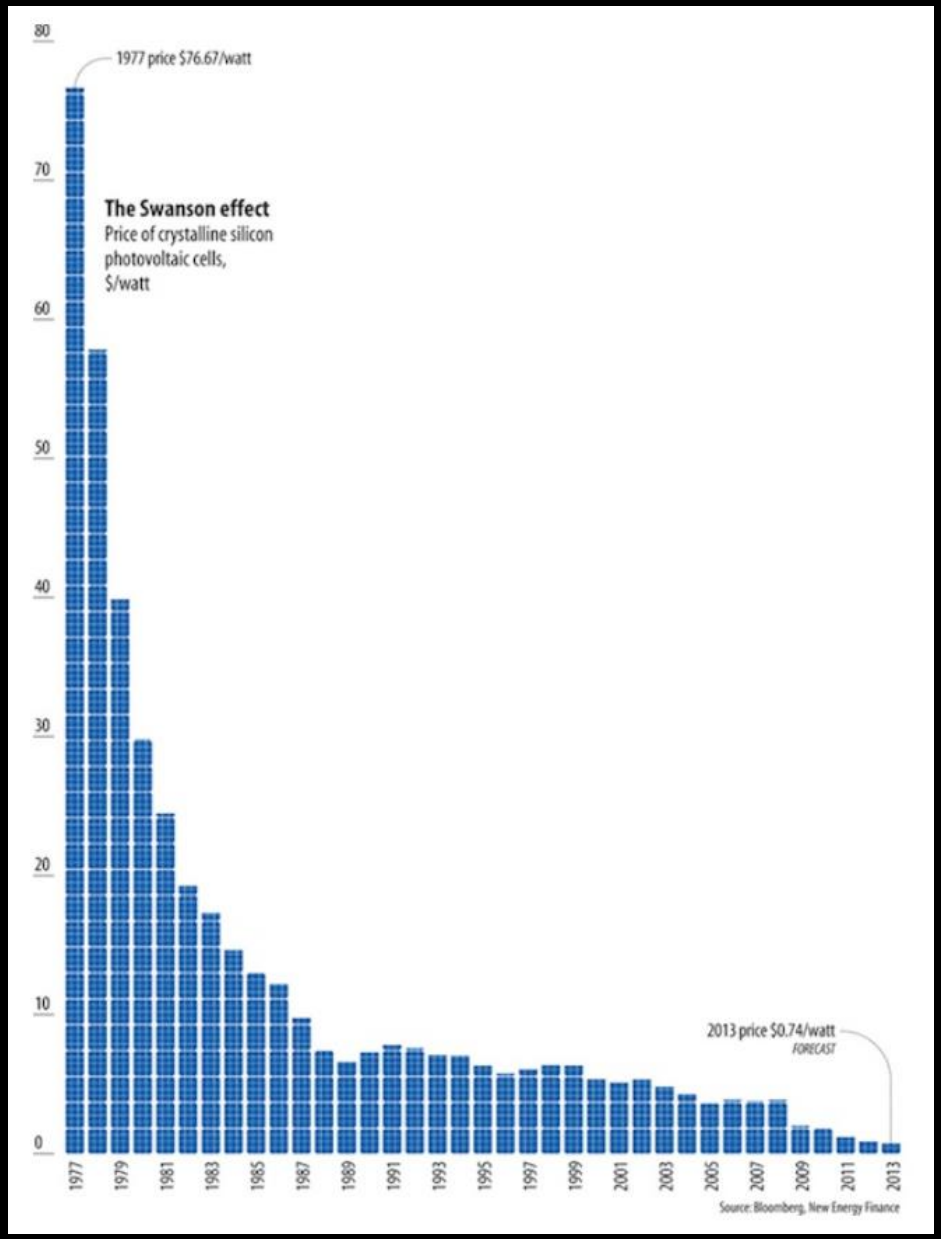
French foreign minister and president-designate of COP21 Laurent Fabius (centre), raises hands with UN secretary general Ban Ki Moon and French president François Hollande. Photograph: Francois Guillot/AFP/Getty Images

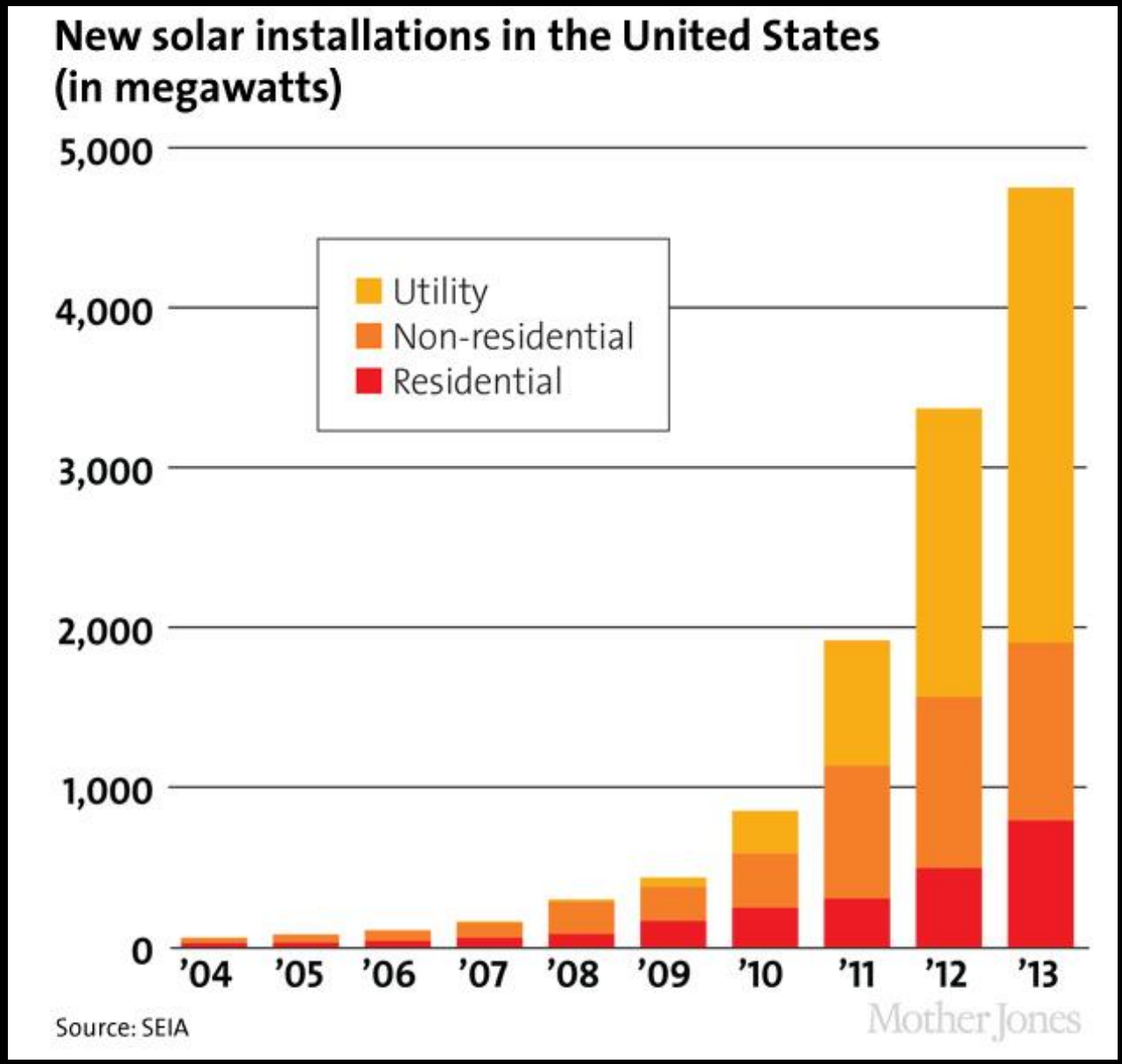

High emissions leading to dangerous warming
3.2–5.4°C
relative to 1850–1900
Country pledges for 2030
2015 Projection
Baseline
INDC pledges
2°C
2.0–3.7°C
1.7-3.2°C
0
0.9-2.3°C
Decreasing emissions compatible with a 2°C warming limit
Data: CDIAC/GCP/IPCC/Fuss et al 2014
CO2 emissions (GtCO2/yr)
100
80
60
40
20
0
–20
1980
2000
2020
2040
2060
2080
2100

World Wind Power (MW)

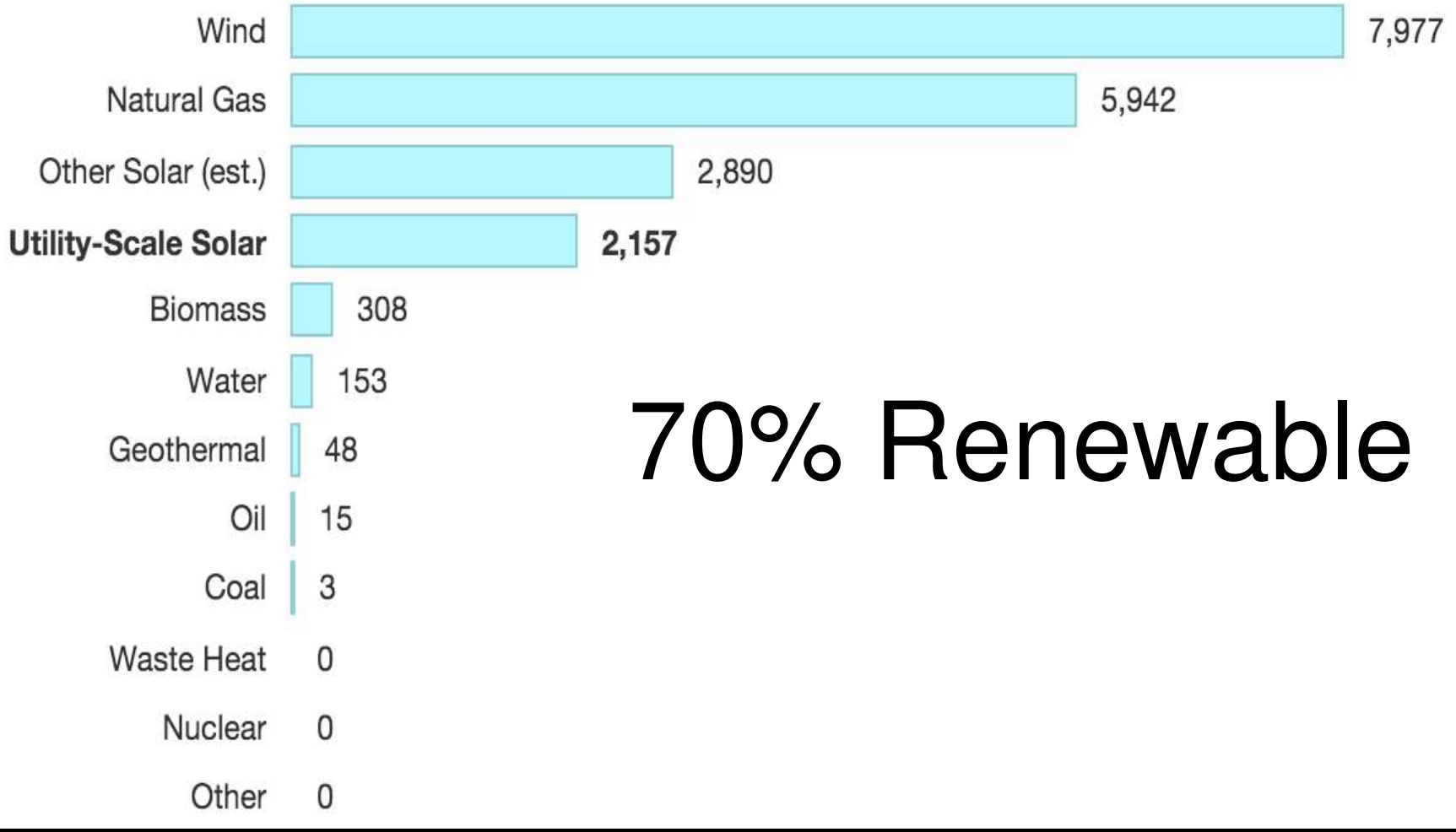


PV Module Prices




New solar installations in the United States
(in megawatts)
5,000
4,000
3,000
2,000
1,000
0
Utility
Non-residential
Residential
'04
'05
'06
'07
'08
'09
'10
'11
'12
'13
Source: SEIA
Mother Jones

New U.S. Electricity Generation (GW) 2015



70% Renewable

DAILY NEWS 1 March 2016

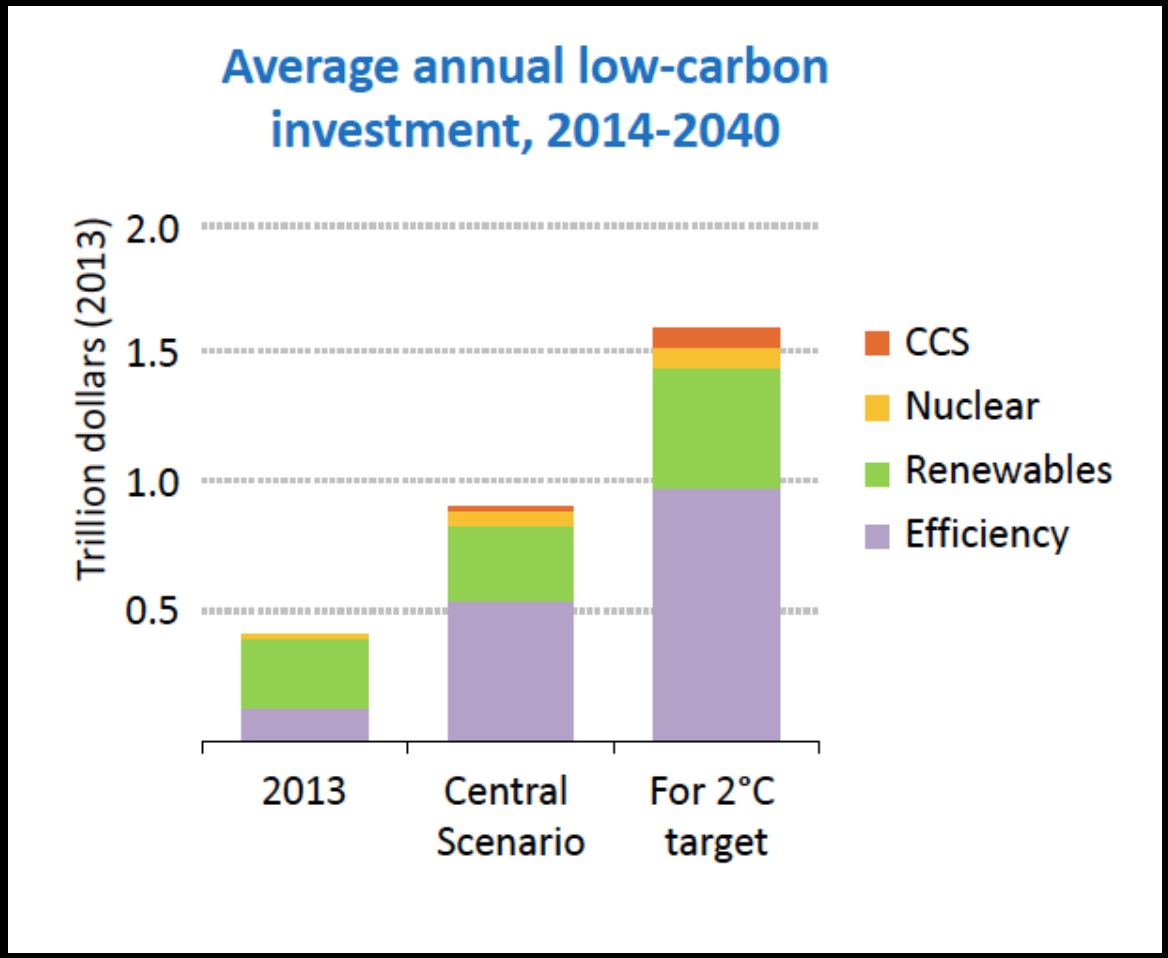
China set to surpass its climate targets as renewables soar

Wind and solar energy surged in China in 2015 to record levels, helping the country to pivot away from coal, which still provides two-thirds of its power

China installed a whopping 32.5 gigawatts of wind energy capacity last year
Xu Yu/Xinhua Press/Corbis

New Scientist, March 1, 2016

IEA Projected Energy Investments



NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Chuck Kutscher, Ph.D., P.E.
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