“Internet & Climate Change: Cyberinfrastructure for a Carbon-Constrained World.”

Invited Talk

Salk Institute Retreat

Scripps Seaside Forum, UC San Diego

October 30, 2019

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

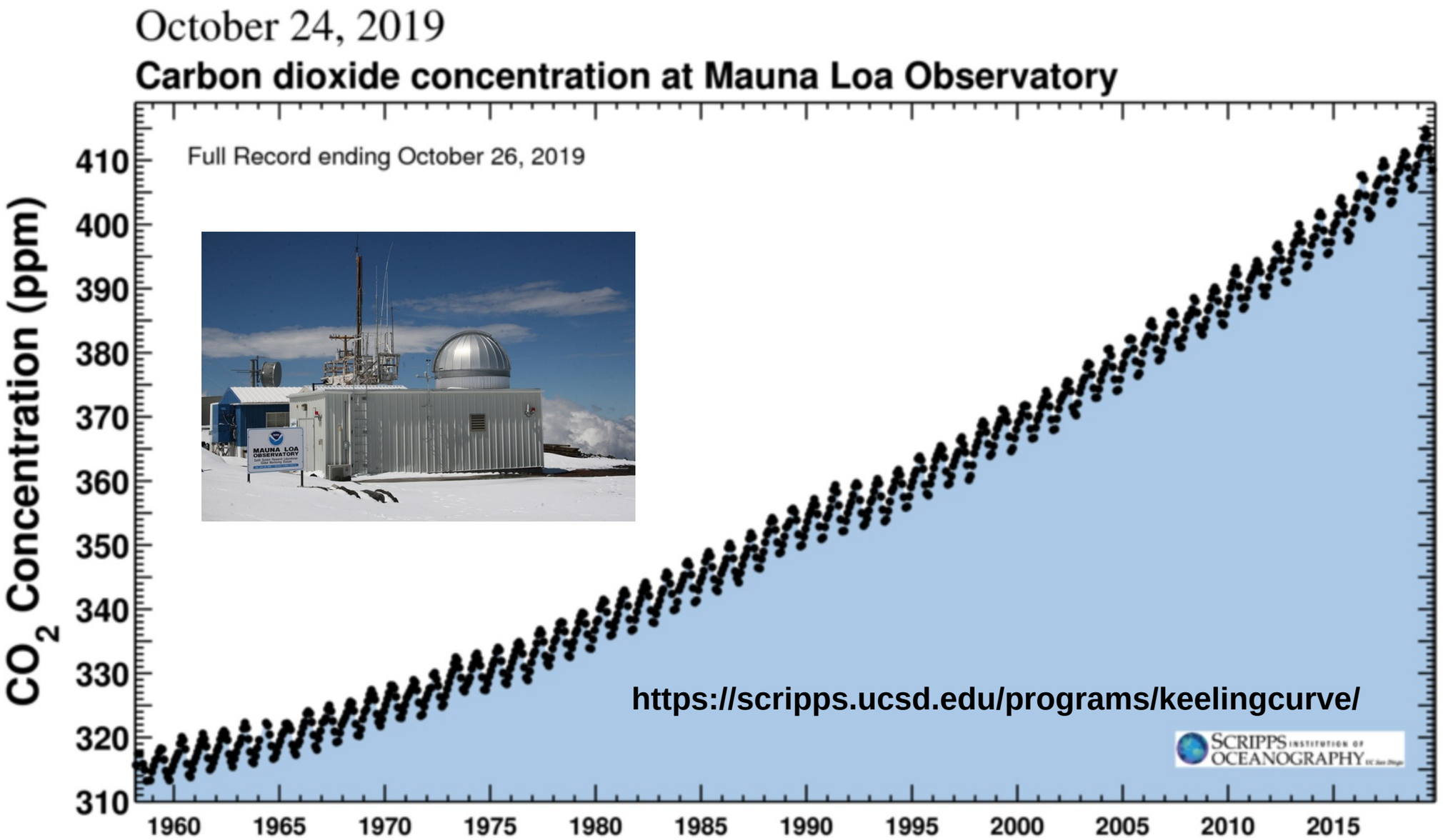
Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

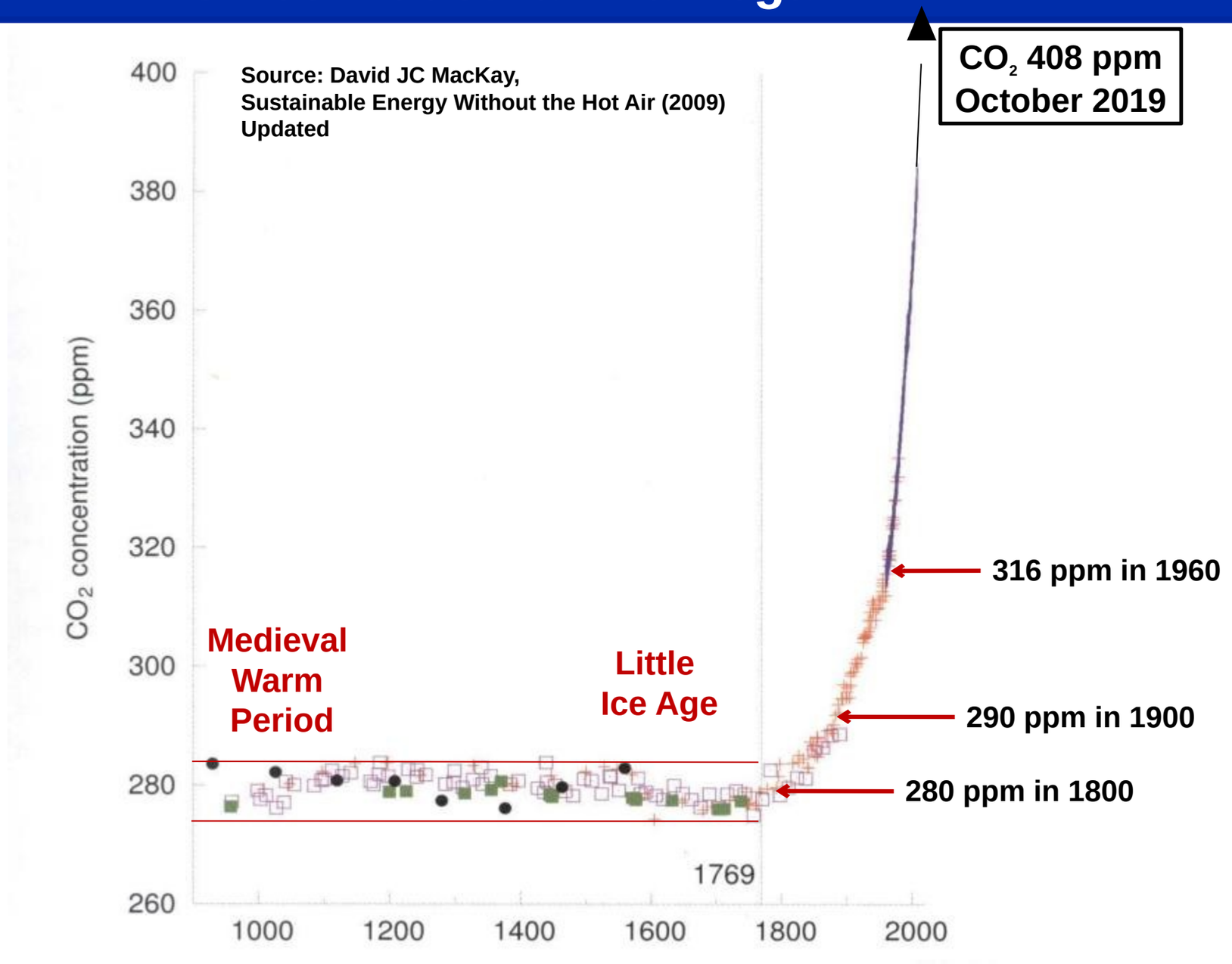
Jacobs School of Engineering, UCSD

http://lsmarr.calit2.net

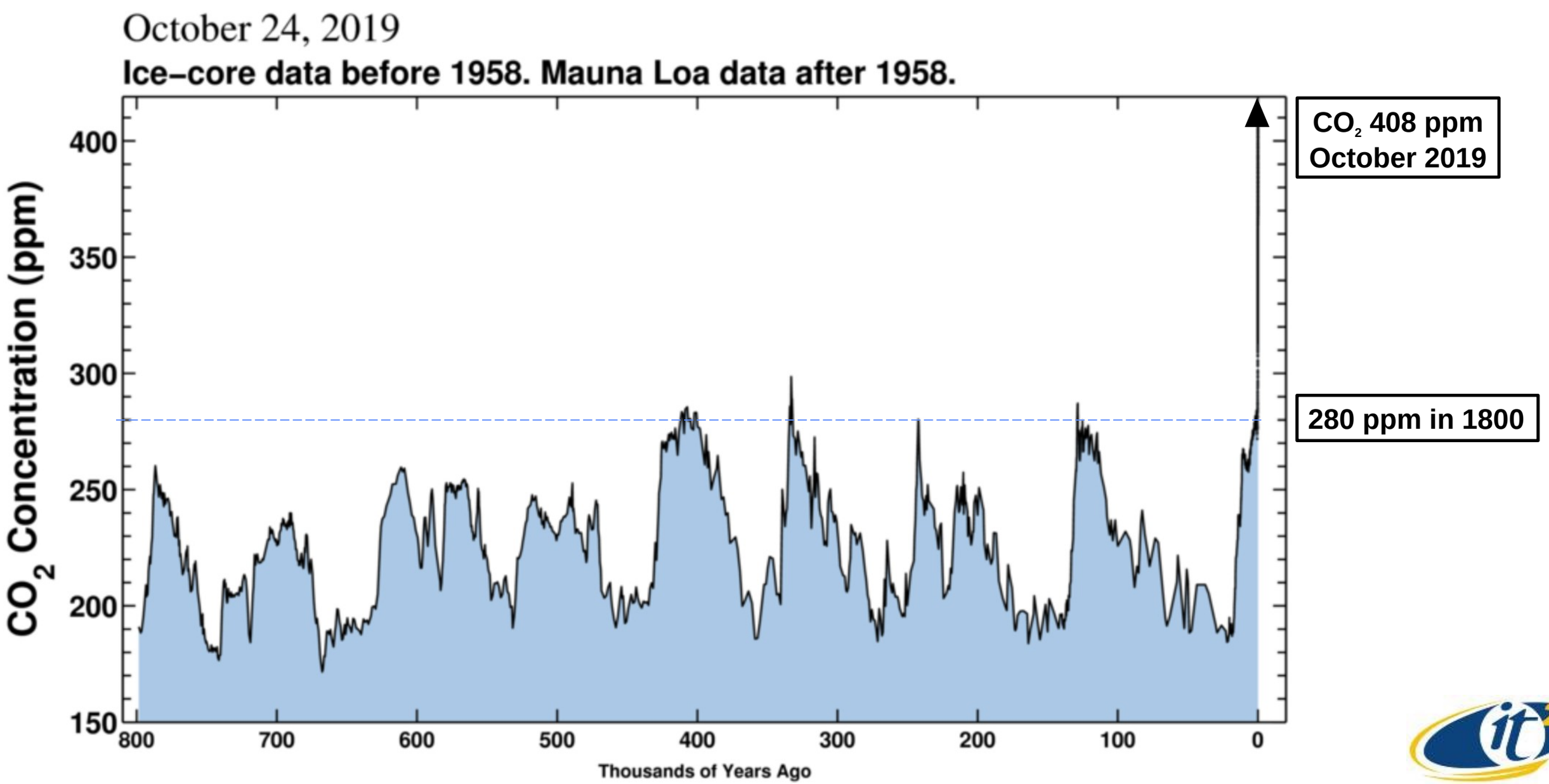
UCSD's Scripps Institution of Oceanography
Keeling Curve of Atmospheric CO2



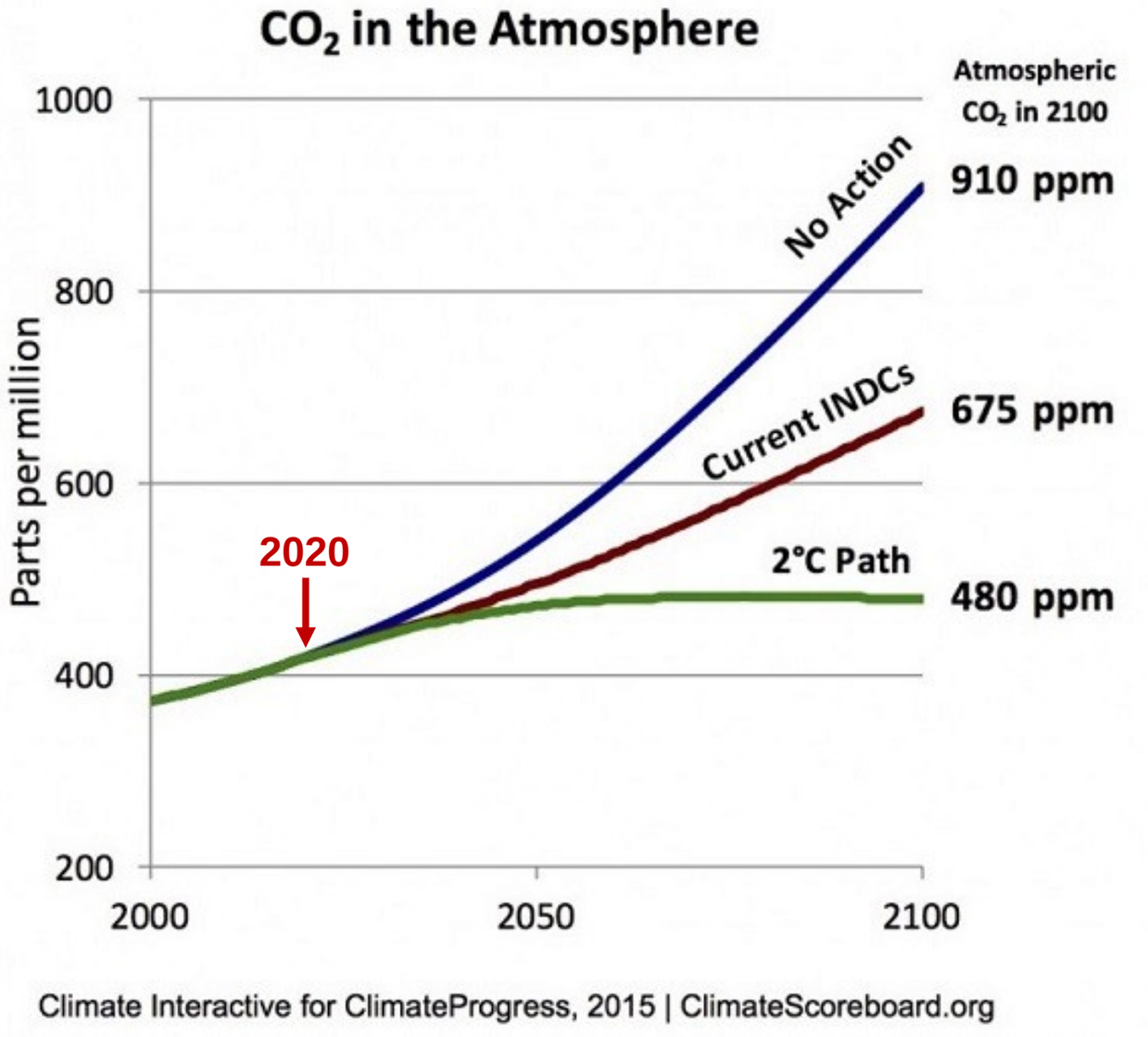
Accelerating Increase in the Greenhouse Gas CO_2 Since Industrial Era Began



Atmospheric CO_2 Levels for Last 800,000 Years



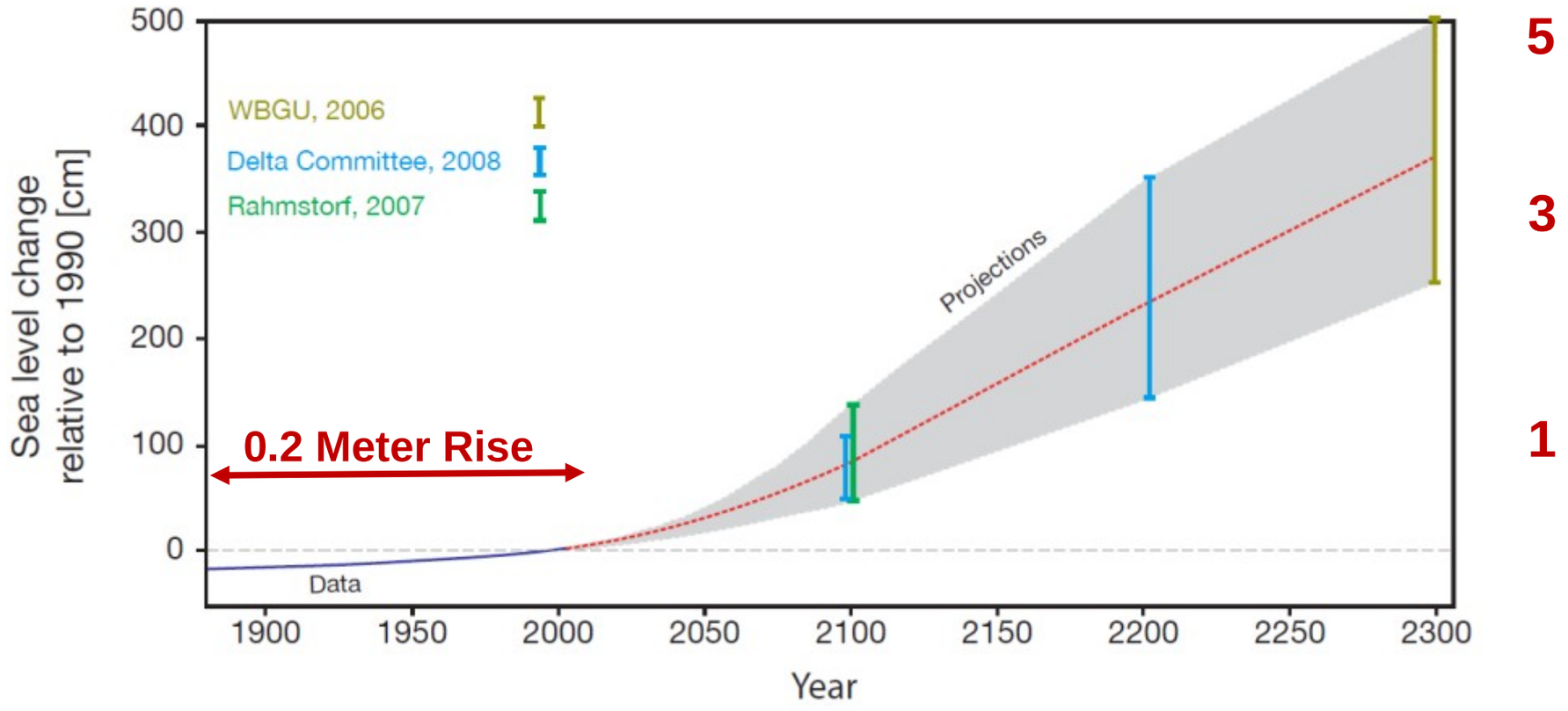
Paris Agreement (COP21) December 2015
Limit Temperature Climb to <2°C or CO_2<450ppm



Intended Nationally Determined Contributions (INDCs)

Human Induced Sea Level Rise Will Continue for Centuries

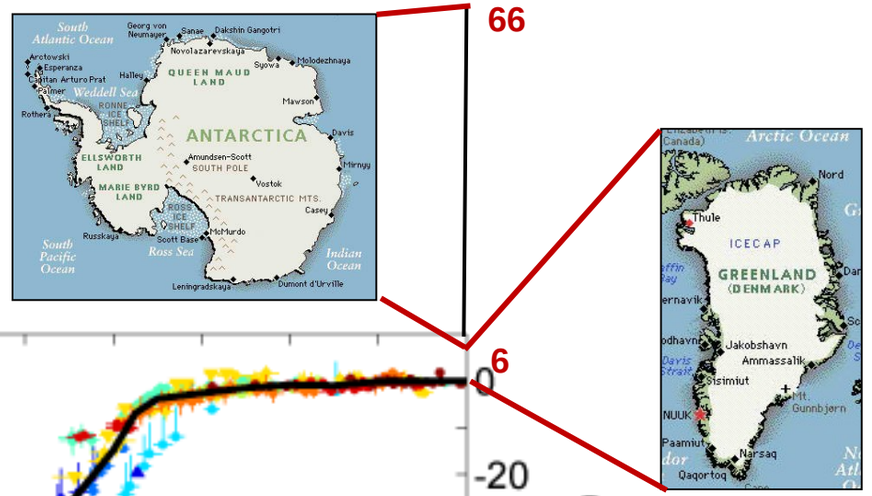
Source: The Copenhagen Diagnosis, Allison, et al. (2009)

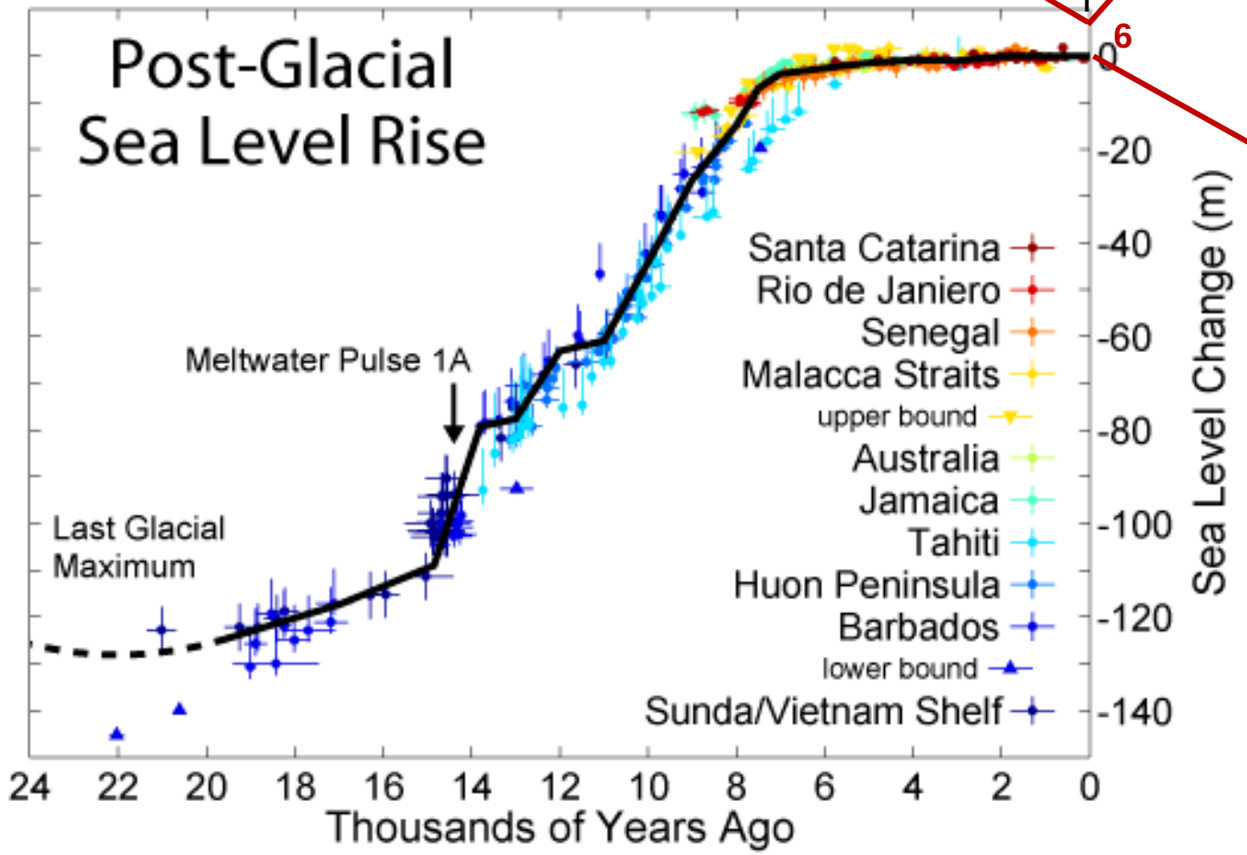


1 Meter will Submerge Over 2 Million sq. km of Land Where ~150 Million People Live, Mostly in Asia

If Greenland Melts, Sea Level Rises 6 meters
If Antarctica Melts, Sea Level Rises 60 meters Further

Future Potential Sea Level Rise If Greenland and Antarctica Melt





http://nsidc.org/cryosphere/quickfacts/icesheets.html

It is Technically Possible, But Politically Challenging To Meet the Paris Goal of <2 Degree Temperature Rise

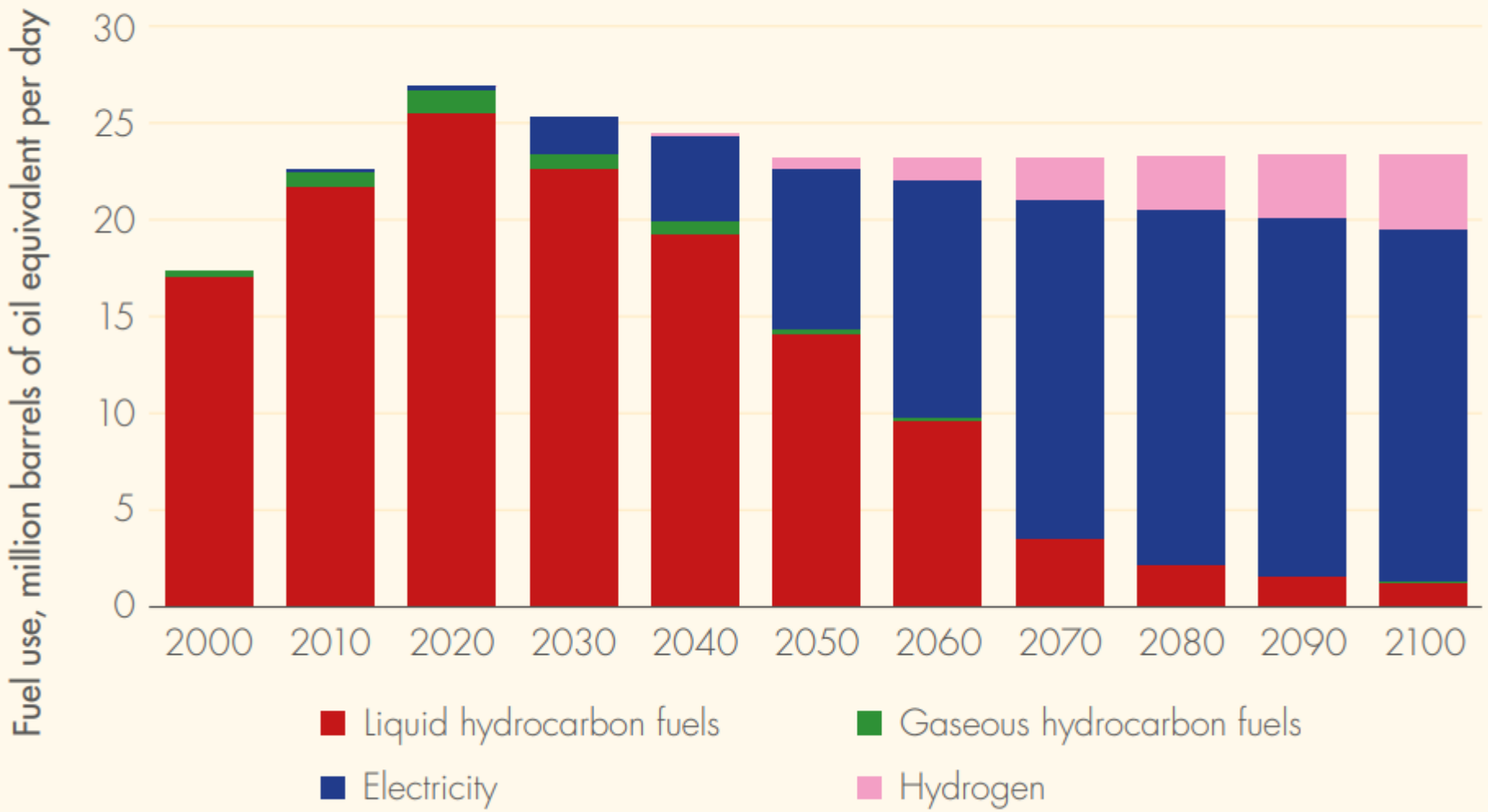


- **From 2020 to 2070:**
  - Reforest an Area the Size of Brazil
  - Install Solar Panel Arrays the Size of Spain
  - By 2030 Half of All Car Sales Globally are Electric
  - 10,000 Large Carbon Capture and Storage Facilities are Built, <50 in operation in 2020
    - Transportation and Storage Site Infrastructure 2x Today's Global Natural Gas Infrastructure
  - Carbon Price Set Internationally During the 2020s
    - Price Rises 20x Over 2020 Price

www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenario-sky.html

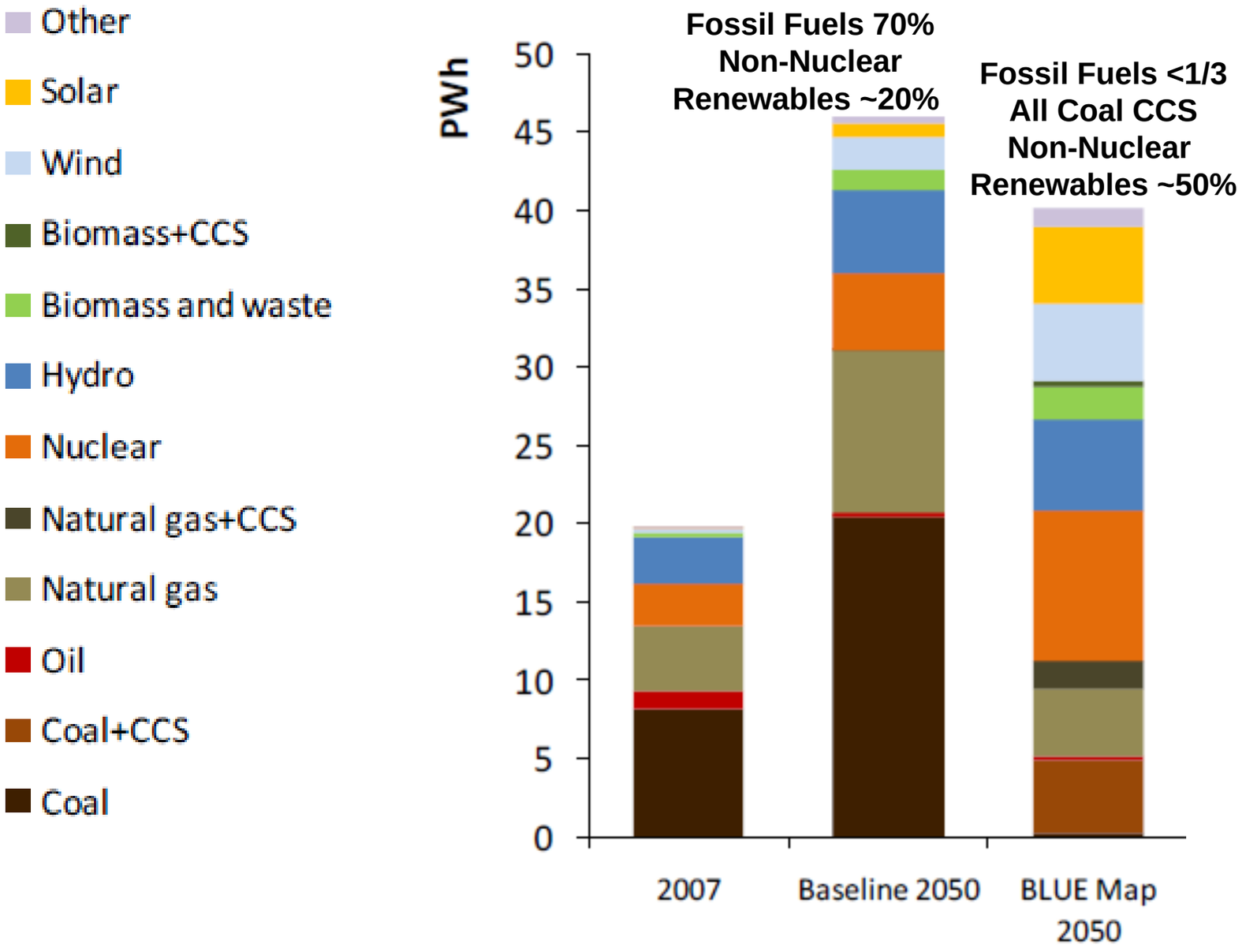
The Automobile System Must Be Electrified

THE FUEL MIX FOR PASSENGER VEHICLES SHIFTS RAPIDLY IN **SKY**, WITH ELECTRICITY DOMINATING BY 2070 AND LIQUID FUELS NEARLY HALVING FROM 2020 TO 2050



Source: Shell analysis

Electricity Generation Must be De-Carbonized





Must Greatly Accelerate Installation of Off-Shore Wind and Solar Electricity Generation

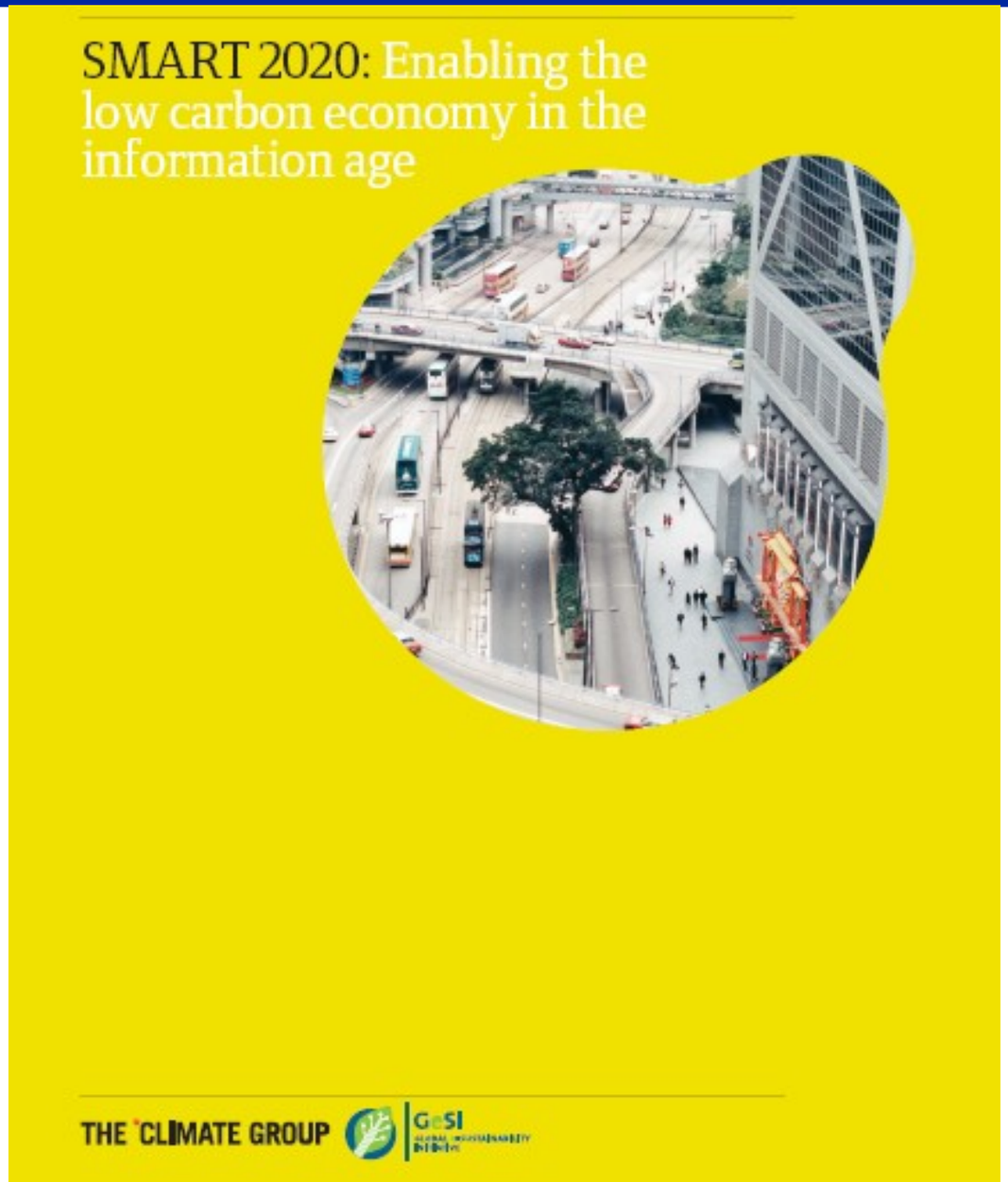
Each of These Projects Has Been Underway for a Decade with Intense Public Controversy





Need to Install ~30 “Cape Wind’s” (170 Turbines, 0.5 GW) Per Year Off-Shore Wind Farms: ~15GW Total Every Year Till 2050	**Need to Install ~20 “Anza Borrego” Arrays (30,000 Dishes, 0.75 GW) Per Year of Concentrated Solar Power: ~14 GW Total Every Year Till 2050**

ICT is a Critical Element in Achieving Country's Greenhouse Gas Emission Reduction Targets



Application of ICT Can Lead to a 5-Fold Greater Decrease in GHGs Than its Own Carbon Footprint

While the sector plans to significantly step up the energy efficiency of its products and services, ICT's largest influence will be by enabling energy efficiencies in other sectors, an opportunity that could deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020.

--Smart 2020 Report

Major Opportunities for the United States*

- Smart Electrical Grids
- Smart Transportation Systems
- Smart Buildings
- Virtual Meetings

*** Smart 2020 United States Report Addendum**

www.smart2020.org

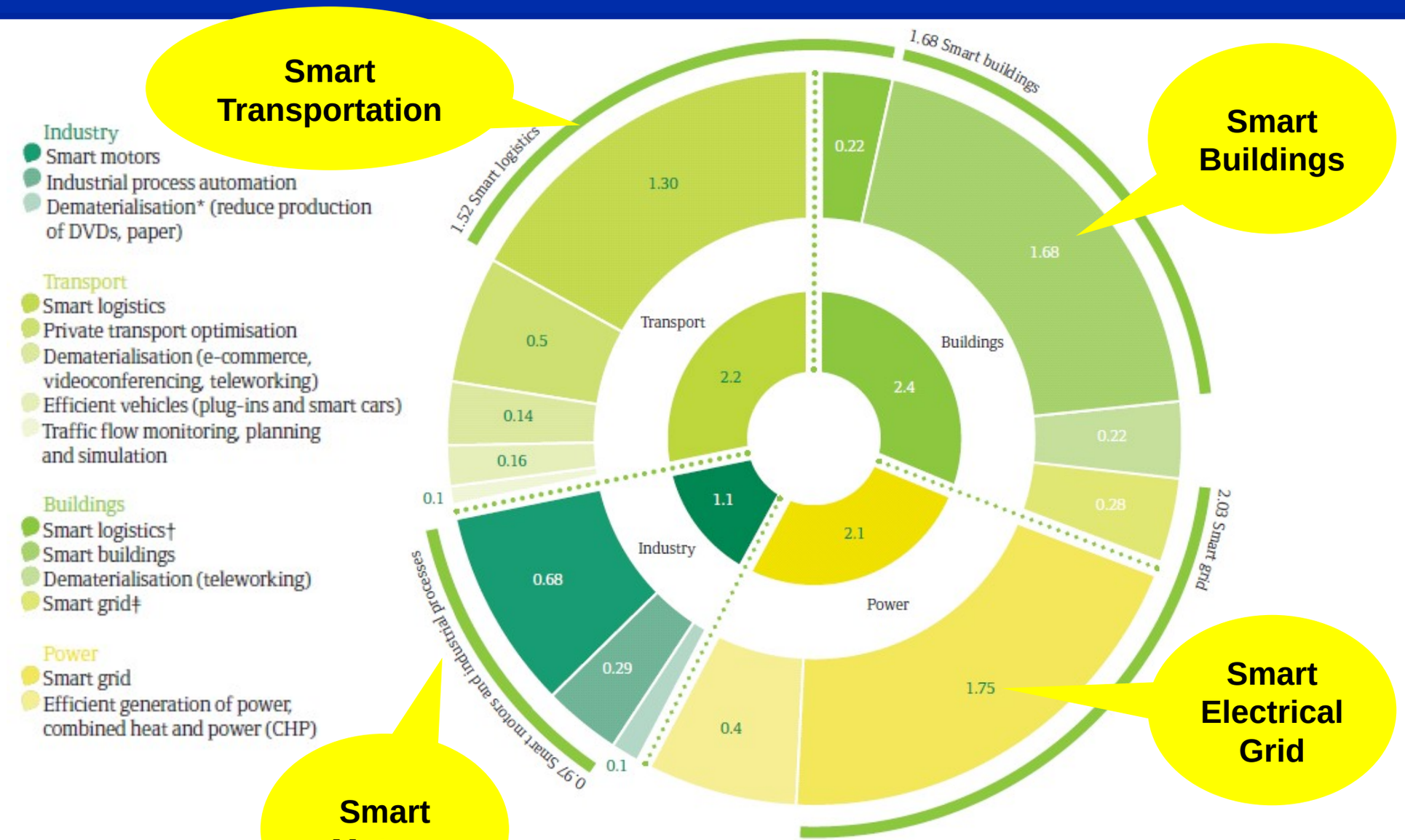
Applying ICT – The Smart 2020 Opportunity for 15% Reduction in GHG Emissions

Smart Transportation

Smart Buildings

Smart Motors

Smart Electrical Grid



www.smart2020.org

Calit2 Has Hosted Symposia on Green ICT for a Decade: Greening ICT and Applying ICT to Green Infrastructures

www.calit2.net/newsroom/article.php?id=1498

First Southern California Smart Grid Symposium

Tuesday April 7, 2009

Calit2 University of California Irvine

innovate integrate ignite



Greening the Internet Economy

ICT & GLOBAL CHANGE

January 22-23, 2009

California Public Utilities Commission

Calit2

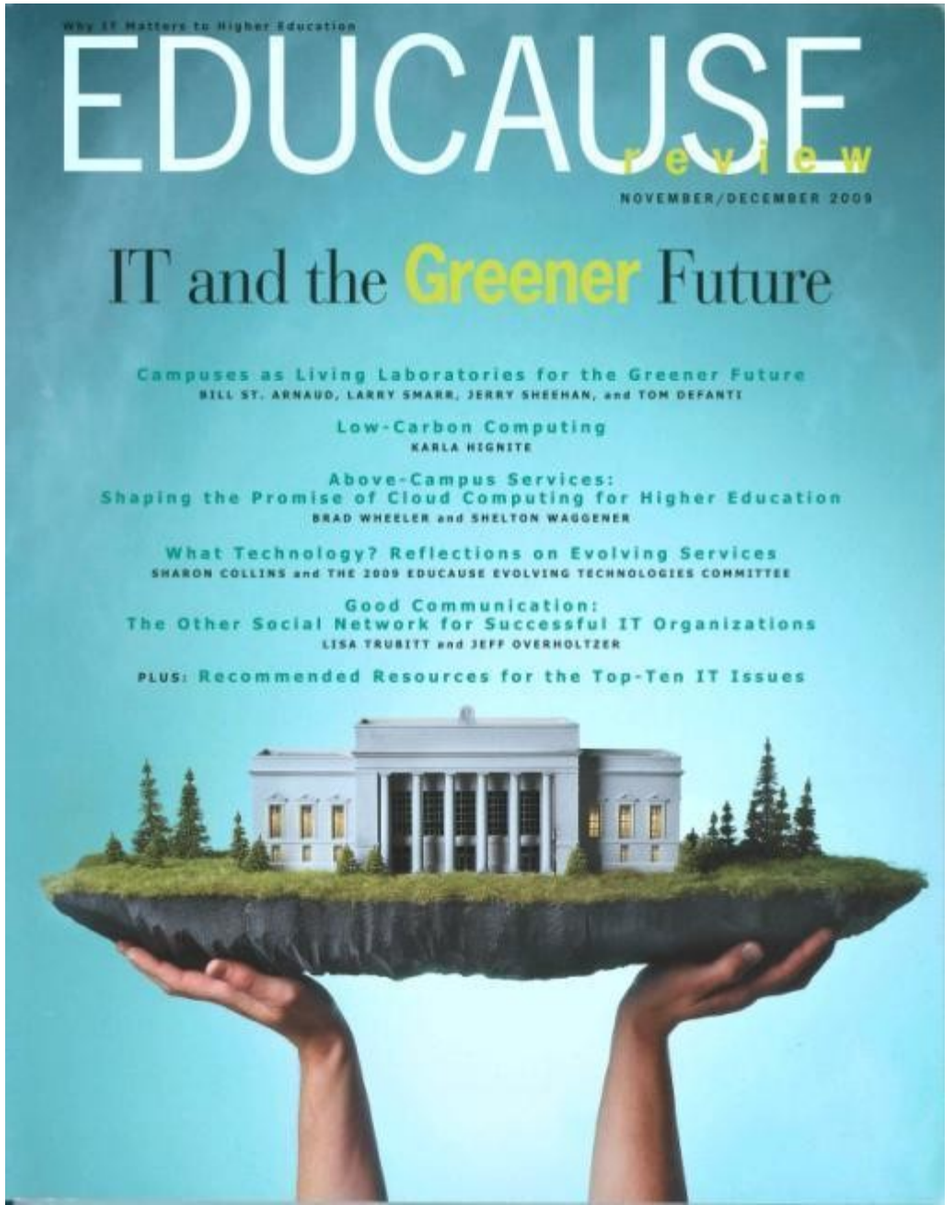
Co-Hosted By Calit2 & CPUC



Webcasts Available at:
www.calit2.net/newsroom/article.php?id=1456

Making University Campuses Living Laboratories for the Greener Future

www.educause.edu/EDUCAUSE+Review/EDUCAUSEReviewMagazineVolume44/CampusesasLivingLaboratoriesfo/185217



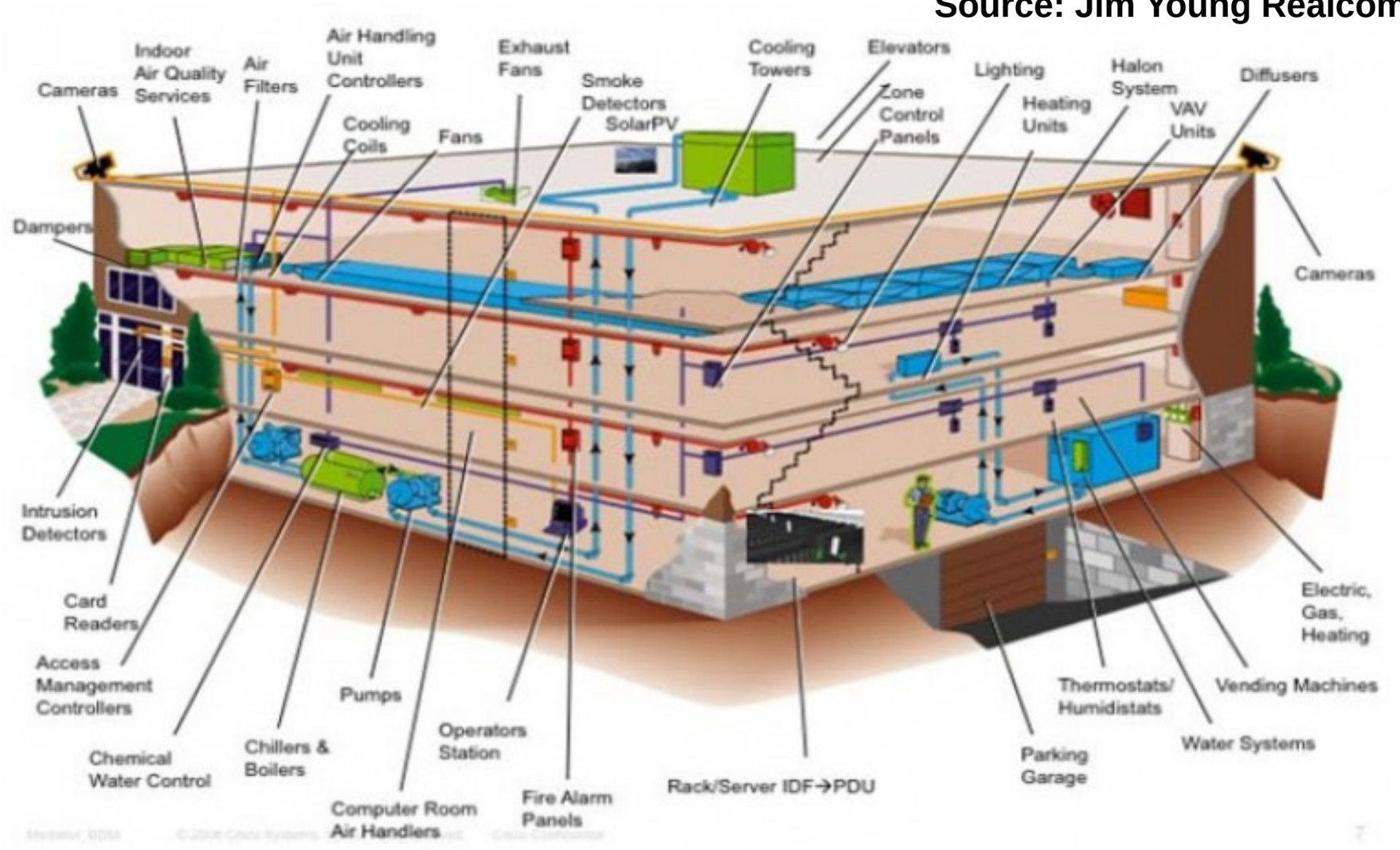
Calit2's Two Campuses, UCSD and UCI, Are Among the Greenest Campuses in the U.S.



In August 2011 the Sierra Club ranked UCI #6 and UCSD #3 among the Top 100 U.S. Greenest Colleges and Universities

Buildings Are Becoming "Internets of Things" Key to Reducing 40% of U.S. CO2 Emissions

Source: Jim Young Realcomm



- **Microsoft Collects 500M Data Points/Day from its Campus**

Toward Zero-Carbon Research Buildings: Beyond Platinum LEED

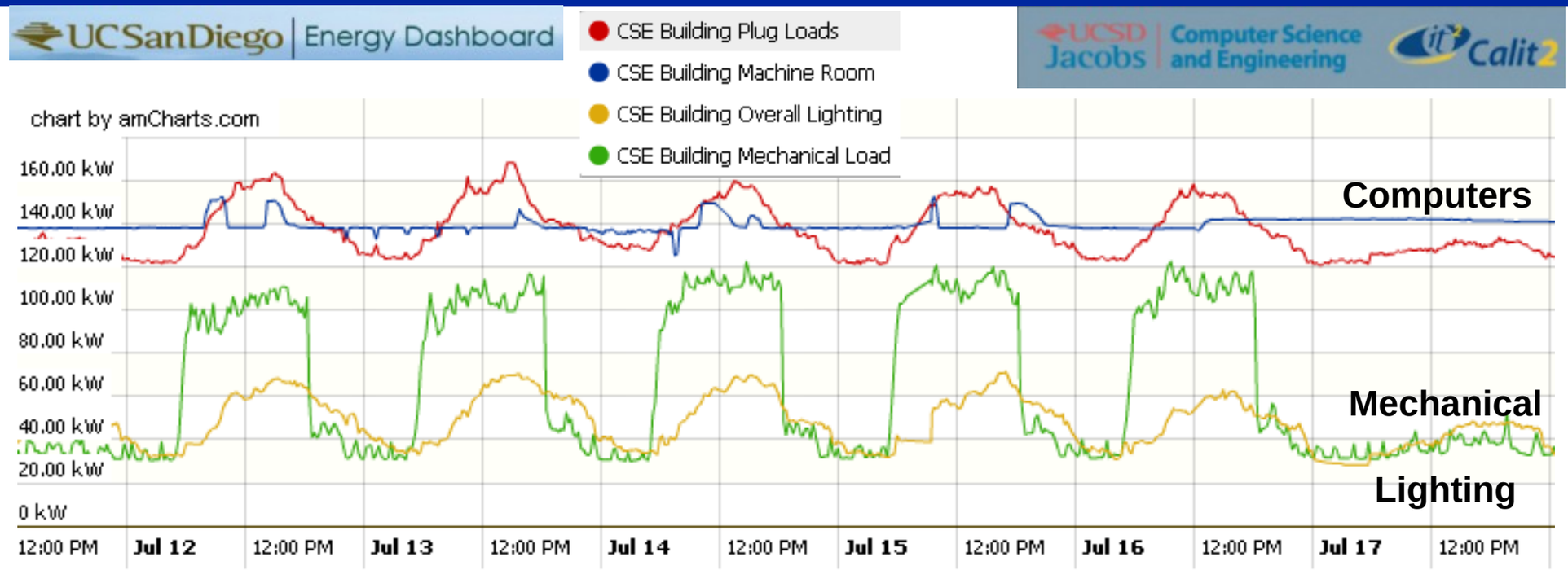


J. Craig Venter Institute,
UCSD, Sustainability Laboratory



NASA Ames Sustainability Base

Contributions to Base Load
UCSD Computer Science & Engineering Building



- **IT Loads Account for 50% (Peak) to 80% (Off-Peak)!**
- **Using IT to Save Energy:**
  - **SleepServer: 50-70% Savings on Plug Load and Machine Room**
  - **Estimated 40% HVAC Savings if Deployed Across Entire CSE!**
  - **LED Savings on Lighting**



Source: Yuvraj Agarwal, Thomas Weng, Rajesh Gupta, UCSD

http://energy.ucsd.edu

Reducing CO_2 From Travel:
Linking the Calit2 Auditoriums at UCSD and UCI



Photo by Erik Jepsen, UC San Diego

Reducing Energy Consumption of Data Centers Is an Imperative

27,093 views | Dec 15, 2017, 08:30am

Why Energy Is A Big And Rapidly Growing Problem For Data Centers

Radoslav Danilak Forbes Councils Member
Forbes Technology Council
COUNCIL POST | Paid Program

Innovation

- **Global data Centers Use ~ 3% of Total Electricity**
- **~ 40% More than UK**
- **Consumption Up 2x Every 4 Years**

Calit2's NSF-Funded GreenLight Project: Remotely Reducing Data Centers Energy Consumption



Source: Tom DeFanti, GreenLight PI

As Google Put Machine Learning Into All its Products Data Center Energy Became the Focus

CADE METZ BUSINESS 04.05.17 12:03 PM

BUILDING AN AI CHIP SAVED GOOGLE FROM BUILDING A DOZEN NEW DATA CENTERS

WIRED



Google server racks loaded with TPUs GOOGLE

Google's First Machine Learning Chip (TPU) Is 30x Faster Than CPUs And GPUs

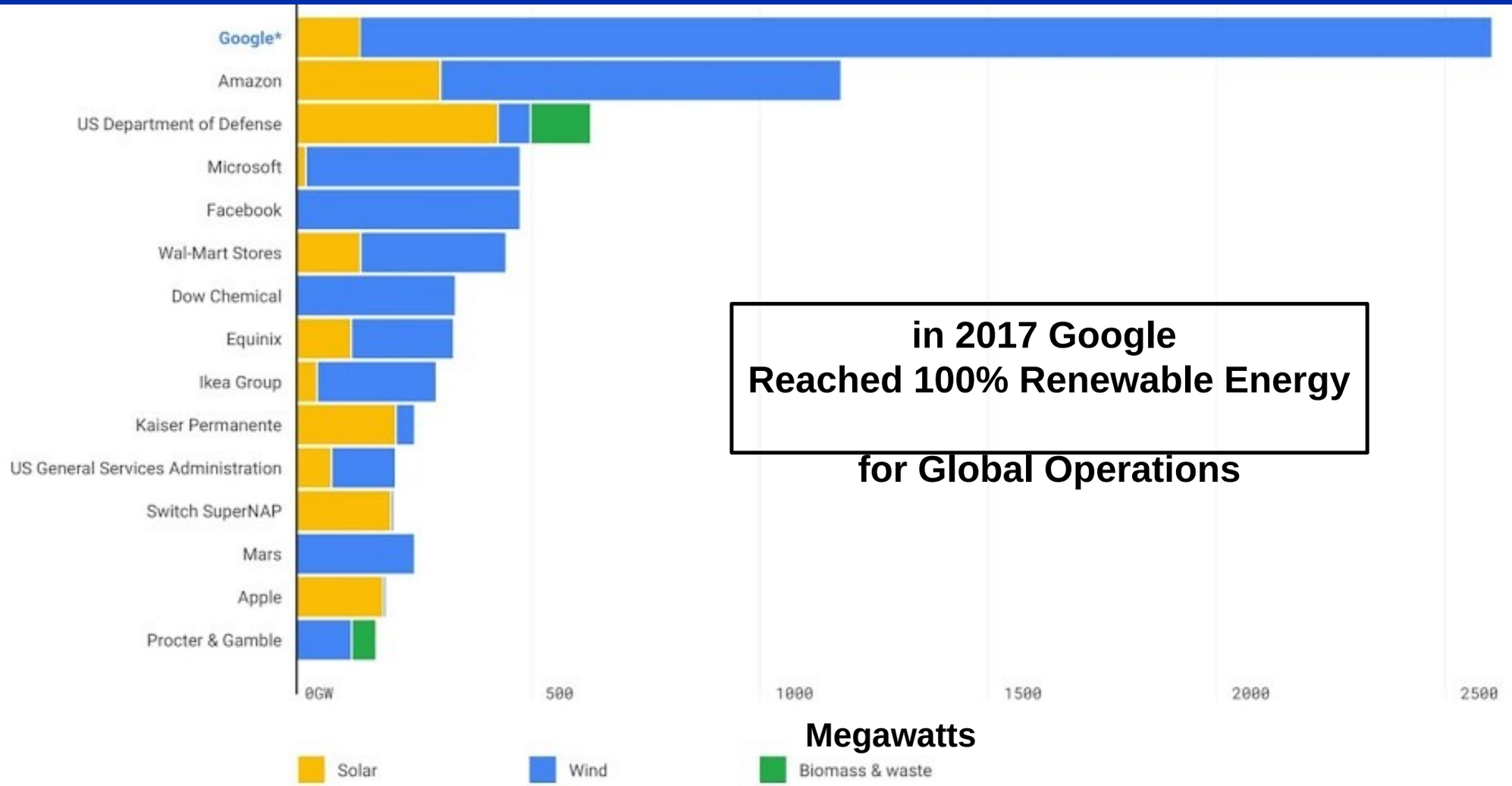
They didn't have to make a lot of new data centers.

April 7, 2017



Calit2 Has Access to Google TPUs

Tech Companies Are Leaders in Renewable Energy Purchases



in 2017 Google
Reached 100% Renewable Energy

for Global Operations

https://sustainability.google/projects/announcement-100/

The Exascale Power Conundrum: Why We Have to Turn to Brain-Inspired Computers

- **A Real Time Human Brain Scale Simulation May Be Possible at 1–10 Exaflop/s with 4 PB of Memory**
- **A Digital Computer with this Performance Might be Available in 2022–2024 with a Power Consumption of >20–30 MW**
- **The Human Brain Runs on 20 W**
- **Our Brain is a Million Times More Power Efficient!**



Horst Simon, Deputy Director,
Lawrence Berkeley National Laboratory

For Further Information:



http://lsmarr.calit2.net/