# Calit2: The Path Forward
# Energy Technical Working Group

**Energy Technical Working Group Kick-Off**
**October 13, 2009**

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

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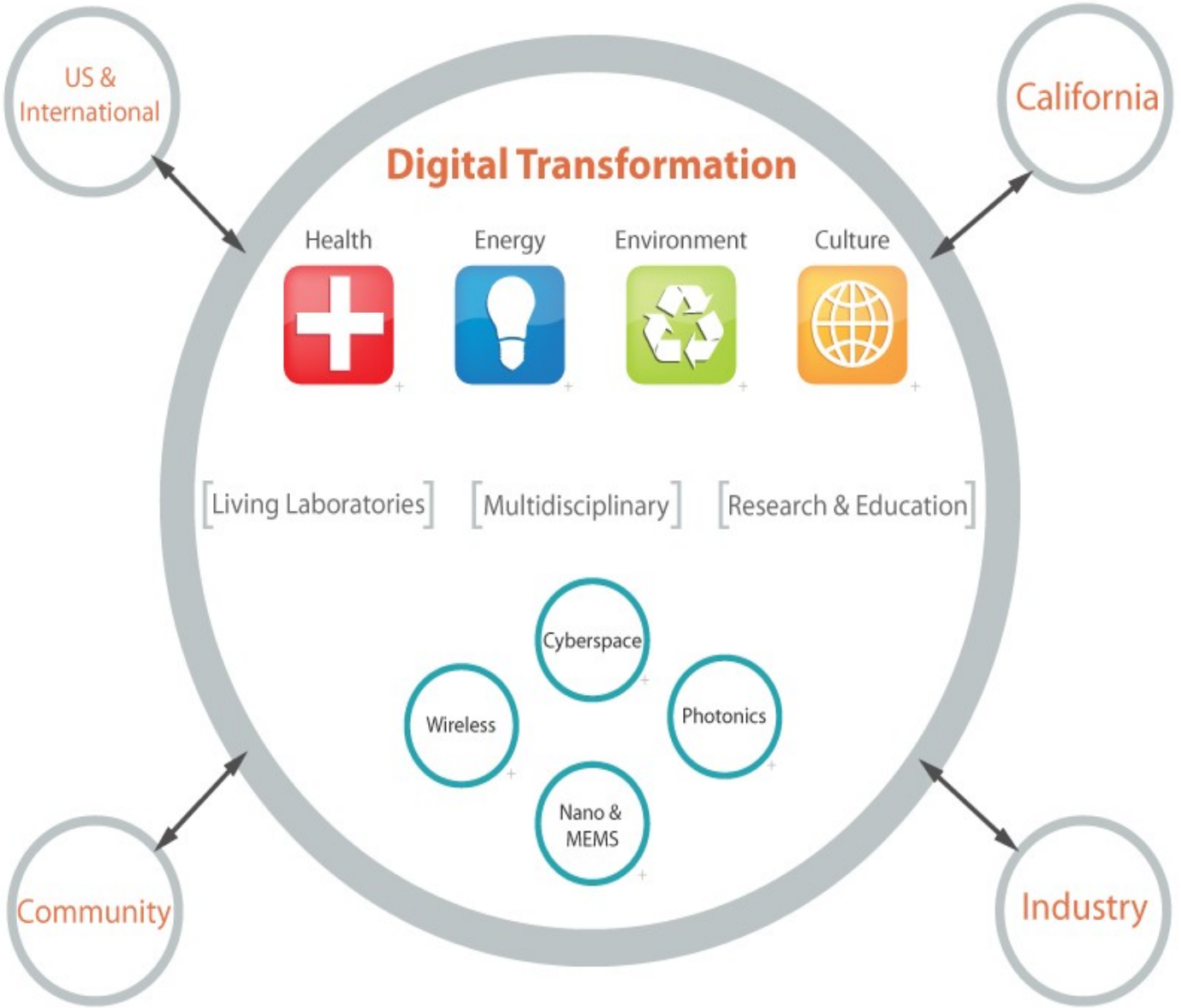
# Institutional Innovation Successes

- **Persistent Collaborative Framework**
- **Birthing and Housing of Centers and Large Grants**
- **Development of Shared Facilities**
- **Living Laboratories**

We Will Continue This Approach of
Decentralized Innovation

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# The Components on Which Calit2 Can Build the Next 5-10 Years




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# What Output Do We Want for the TWG?

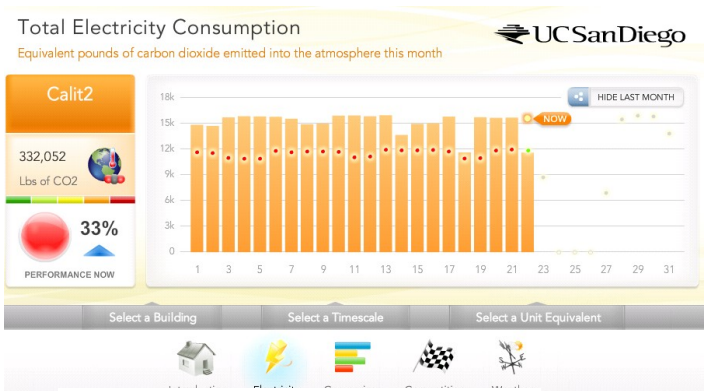
- **Technical White Paper of Calit2 Opportunities in Environment**
  - Maximum of 10 pages, high level vision, major stakeholders, needed technologies, Calit2 unique efforts, gap analysis (what do we have, what do we need to realize vision).
- **Executive Summary of Technical White Paper for Path Forward**
  - Maximum of 3 pages, summarizes details of more technical oriented white paper.
- **Strength, Weakness, Opportunities, Threats, Gap Analysis**
  - Maximum 2 page document that summarizes SWOT and Gap conversation.
  - SWOT's will be kept internal, not shared in public document.

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# The Digital Transformation of Energy

- **Campus as Living Laboratories for Greener Future**
  - **Moving Energy Sources from High Carbon to Low Carbon**
  - **Increasing Energy Efficiency Through Smarter Infrastructure**
  - **Trends in Future Energy Sources and Climate Change**









**Toyota Delivers Plug-in Prius to UC Irvine and UC Berkeley as Part of Clean Mobility Partnership**





TORRANCE, Calif., Nov. 9, 2007 -- Toyota Motor Sales, U.S.A.,

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# UCSD as a Model Campus

The *University of California, San Diego* (UCSD), with 45,000 daily occupants, is the second-largest user of electricity (~40 MW) in San Diego (after the city itself, which is the seventh-largest city in the United States). UCSD has an aggressive program to reduce its carbon footprint for generating electricity, which saves approximately $8 million annually in energy costs. UCSD operates a natural gas cogeneration facility that supplies about 90 percent of the campus electricity, which reduces reliance on out-of-state coal-burning power generation. UCSD's carbon-reduction program also includes installing 1.2 MW of solar panels (with an additional 2 MW likely), acquiring a 2.8 MW fuel cell powered by locally sourced methane from a San Diego waste-treatment plant, and exploring the use of cold seawater for cooling to reduce energy and freshwater use. This program will allow UCSD to move approximately 15 percent of its fossil fuel power generation to renewable energy in just a few years. Because of its energy savings and cogeneration, UCSD was able to export over 3 MW of electricity to the region during the San Diego wildfires in 2007, when four of the five California electrical grid connections to San Diego had been rendered inoperable.

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Source: Arnaud, Smarr, DeFanti, Sheehan, EDUCAUSE Review

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# UC Irvine as a Model Campus

The *University of California, Irvine* (UCI), is the only university campus cited in the "Best Overall" category of California's Flex Your Power statewide energy-efficiency campaign in December 2008. UCI led in efficiency by saving 3.7 million kWh of electricity during the 2007–8 fiscal year, reducing peak demand by up to 68 percent and saving nearly 4 million gallons of water annually. UCI's 2008 calendar-year GHG reduction program (e.g., green building construction, low-carbon generation infrastructure, energy efficiency) annually eliminates 62,000 $mTCO_2e$ and saves the campus $28.9 million. In 2008, UCI agreed to have SunEdison finance, build, and operate a solar energy system at UCI. In March 2009, UCI began purchasing energy generated by the system, which is expected to produce more than 24 million kWh (equivalent to offsetting nearly 12,000 $mTCO_2e$) over twenty years. UCI also has an 18 MW combined heating, power, and cooling co-generation plant and employs a 62,000 ton-hour chilled-water thermal energy storage system capable of reducing up to 6 MW of electrical peak demand on the regional electrical system.

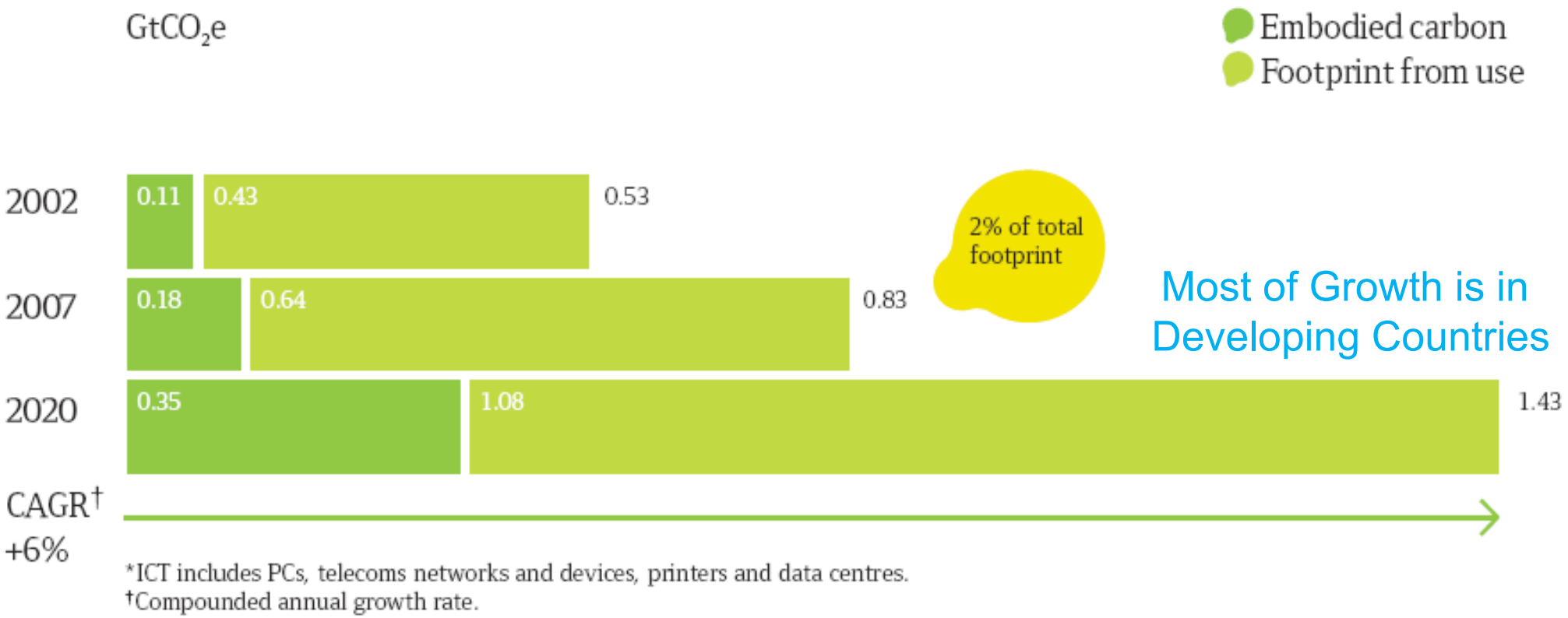
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Source: Arnaud, Smarr, DeFanti, Sheehan, EDUCAUSE Review

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# The Global ICT Carbon Footprint is Roughly the Same as the Aviation Industry Today

But ICT Emissions are Growing at 6% Annually!




the assumptions behind the growth in emissions expected in 2020:

- takes into account likely efficient technology developments that affect the power consumption of products and services
- and their expected penetration in the market in 2020

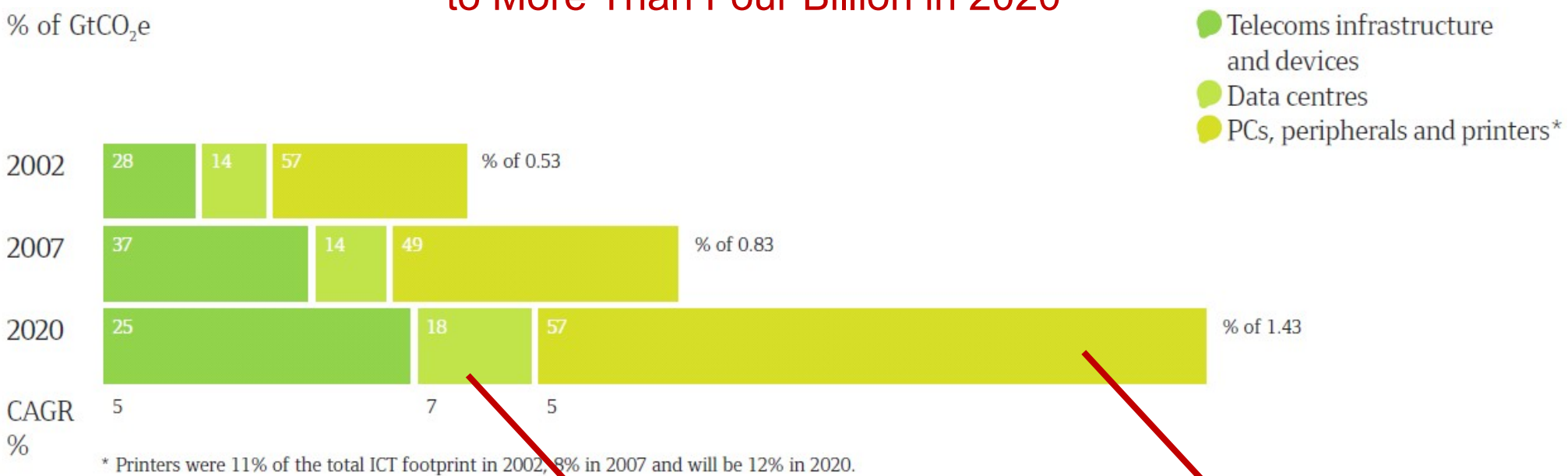
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www.smart2020.org

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# The Global ICT Carbon Footprint by Subsector

The Number of PCs (Desktops and Laptops) Globally
is Expected to Increase
from 592 Million in 2002
to More Than Four Billion in 2020




Data Centers Are Rapidly Improving

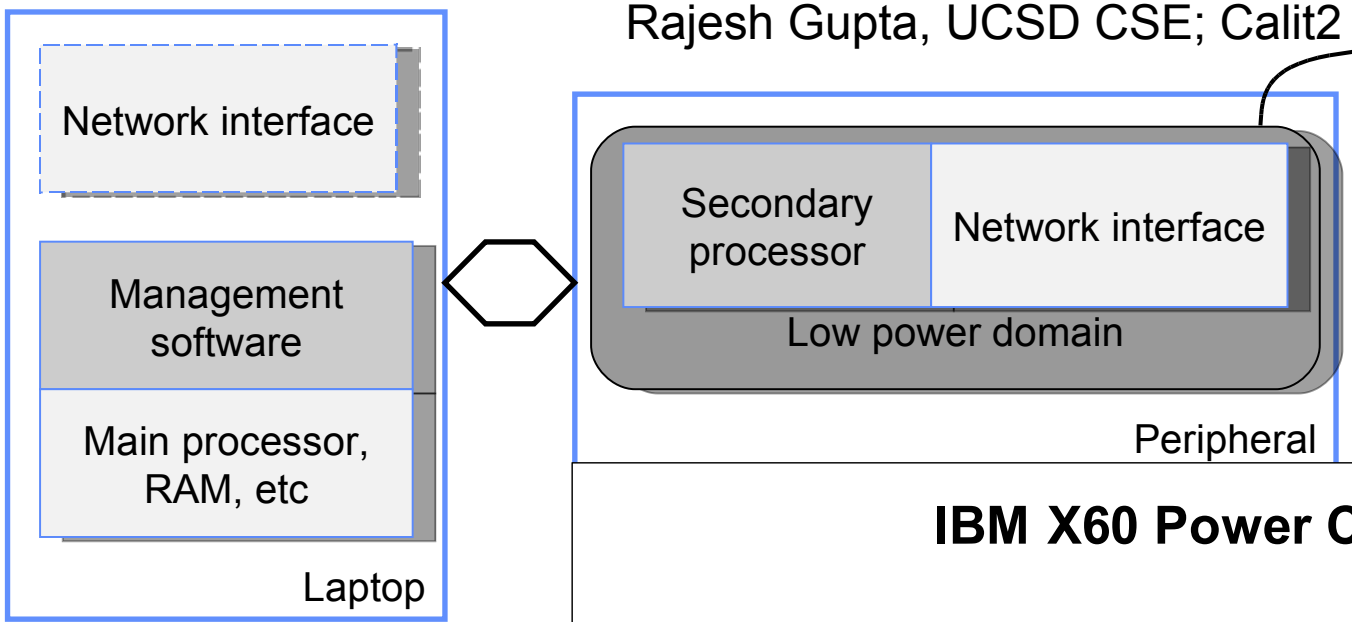
PCs Are Biggest Problem

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www.smart2020.org

# Increasing Laptop Energy Efficiency: Putting Machines To Sleep Transparently

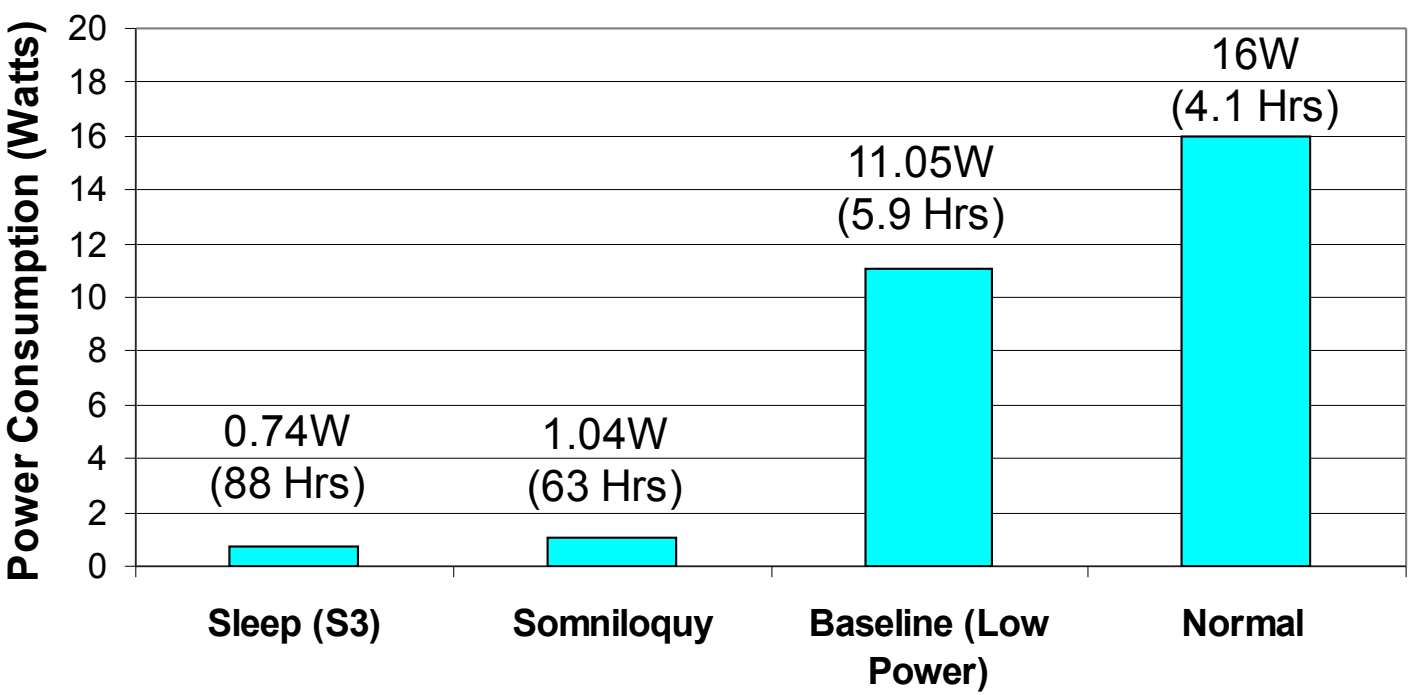
Rajesh Gupta, UCSD CSE; Calit2







*Somniloquy Enables Servers to Enter and Exit Sleep While Maintaining Their Network and Application Level Presence*




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# Research Needed on How to Deploy a Green CI




- **Computer Architecture**
  - Rajesh Gupta/CSE
- **Software Architecture**
  - Amin Vahdat, Ingolf Kruger/CSE
- **CineGrid Exchange**
  - Tom DeFanti/Calit2
- **Visualization**
  - Falko Kuster/Structural Engineering
- **Power and Thermal Management**
  - Tajana Rosing/CSE
- **Analyzing Power Consumption Data**
  - Jim Hollan/Cog Sci
- **Direct DC Datacenters**
  - Tom Defanti, Greg Hidley

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http://greenlight.calit2.net

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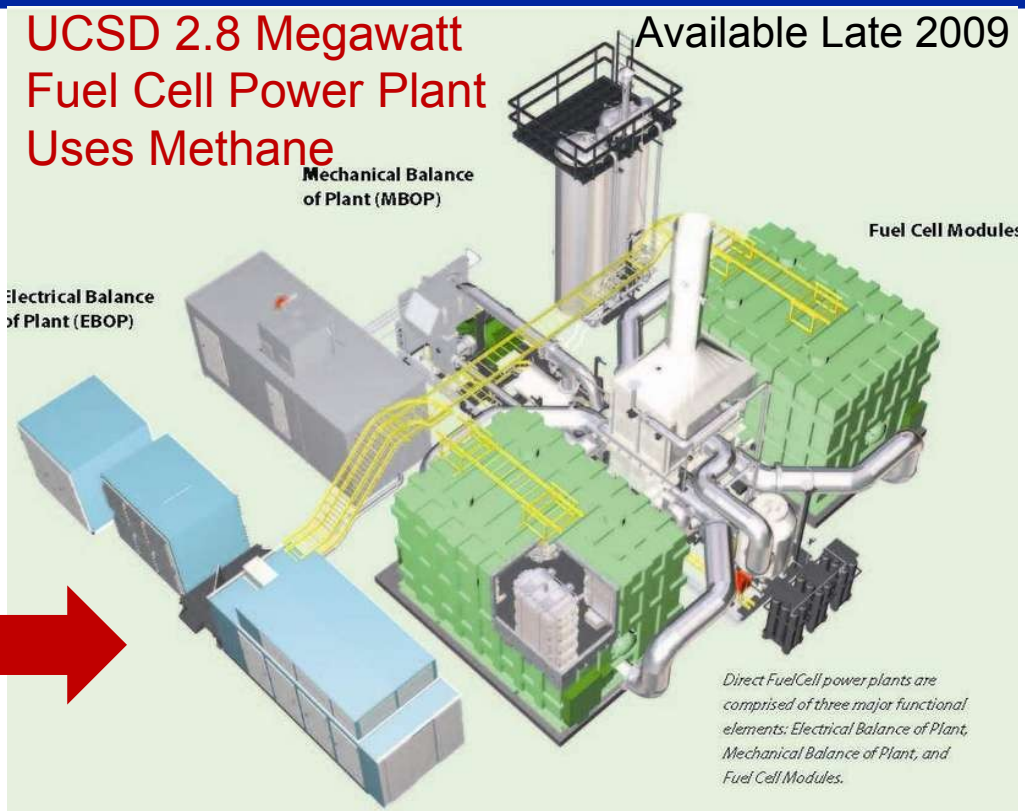
# UCSD is Installing Zero Carbon Emission Solar and Fuel Cell DC Electricity Generators

San Diego's Point Loma Wastewater Treatment Plant Produces Waste Methane



UCSD 2.8 Megawatt Fuel Cell Power Plant Uses Methane

Available Late 2009




Use to DC Power Local Data Centers



2 Megawatts of Solar Power Cells Being Installed

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# Cooperative Test Beds Funded by Industry Partners
# Calit2@UCSD's Wireless Power Amplifier Lab

freescale semiconductor

Power Transistor Tradeoffs

Si-LDMOS, GaN, & GaAs

Price & Performance

Eudyna

TriQuint SEMICONDUCTOR

Power Amplifier Tradeoffs

WiMAX & 3.9GPP LTE

Efficiency & Linearity

STMicroelectronics

HUAWEI

NOKIA

ERICSSON

Digital Signal Processing Tradeoffs

Pre-Distortion, Memory Effects & Power Control

MIPS & Memory

QUALCOMM

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# Applying ICT – The Smart 2020 Opportunity for Reducing GHG Emissions by 7.8 $GtCO_2e$

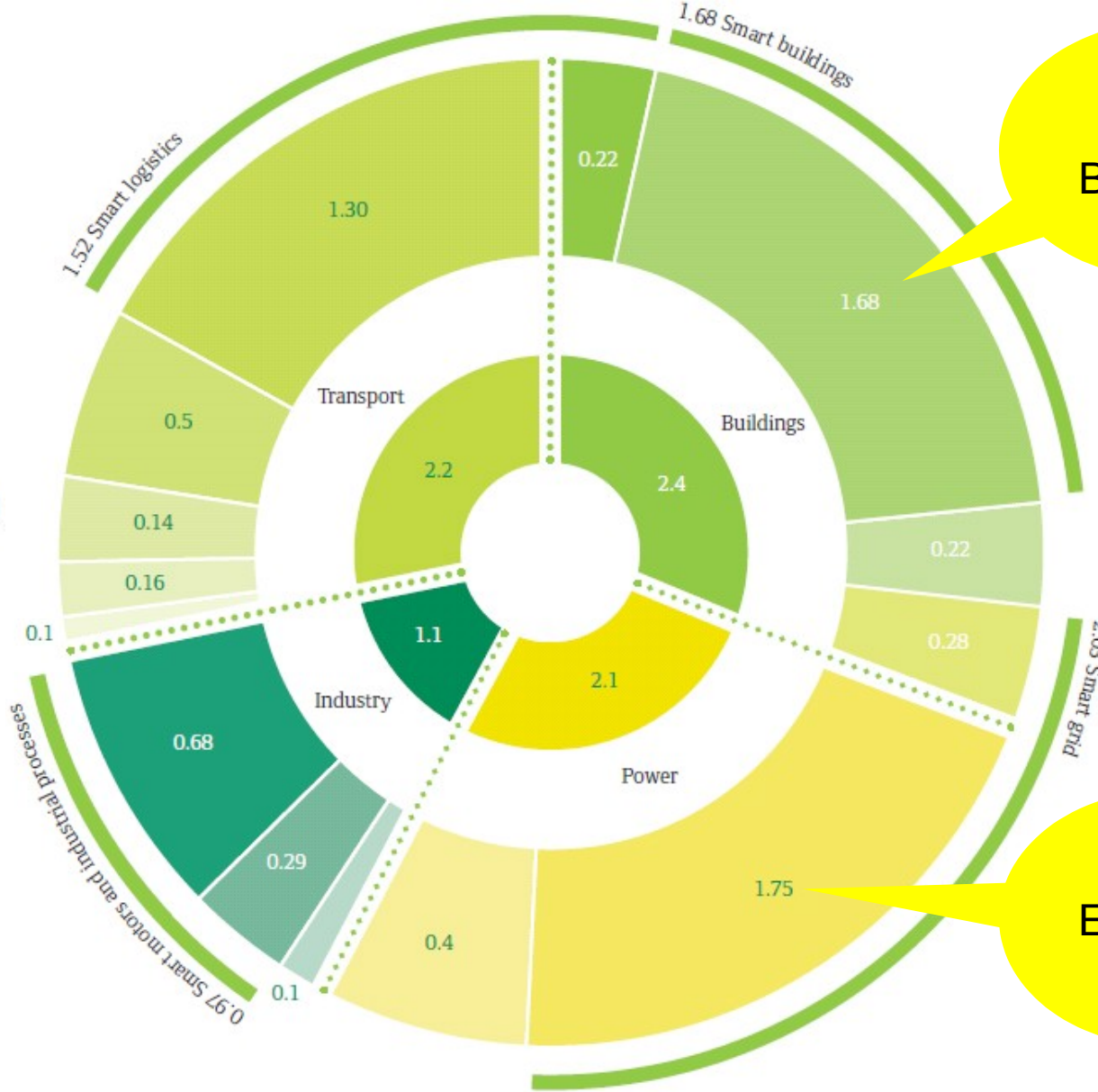
www.smart2020.org

Industry
- Smart motors
- Industrial process automation
- Dematerialisation* (reduce production of DVDs, paper)

Transport
- Smart logistics
- Private transport optimisation
- Dematerialisation (e-commerce, videoconferencing, teleworking)
- Efficient vehicles (plug-ins and smart cars)
- Traffic flow monitoring, planning and simulation

Buildings
- Smart logistics†
- Smart buildings
- Dematerialisation (teleworking)
- Smart grid‡

Power
- Smart grid
- Efficient generation of power, combined heat and power (CHP)




Smart Buildings

Smart Electrical Grid

Recall Total ICT 2020 Emissions are 1.43 $GtCO_2e$

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# Green Scanner
# Helping Everyone go Green




## Innovation

- Online database of community-generated environmental impact reviews
- Indexed via UPC codes
- Accessible via desktops and mobile phones

## Green Impact

- Database of 900,000 consumer products
- Helps people engage in environmentally preferable purchasing
- Provides incentive for companies to respond to environmental issues

## Milestones

- April 2006 - Prototype released
- April 2007 - Approx. 31,000 hits to date
- April 2008 - Implement version 1.0, focusing on more precise life cycle assessment (LCA).
- Summer 2008 - Deploy version 1.0. Apply for EPA grant.
- Fall 2008 - Expand database and mobile capabilities. Contact supermarkets and CA legislature.
- 2009 - Expand user base. Seek large-scale corporate and governmental support.

## Cost (Pilot)

- GSR - prototype development/testing ($10k)
- GSR - research in life cycle assessment (LCA) ($10k)
- Travel to interact with corp./gov. ($5k)
- Total: $25k

## Cost (Ultimate)

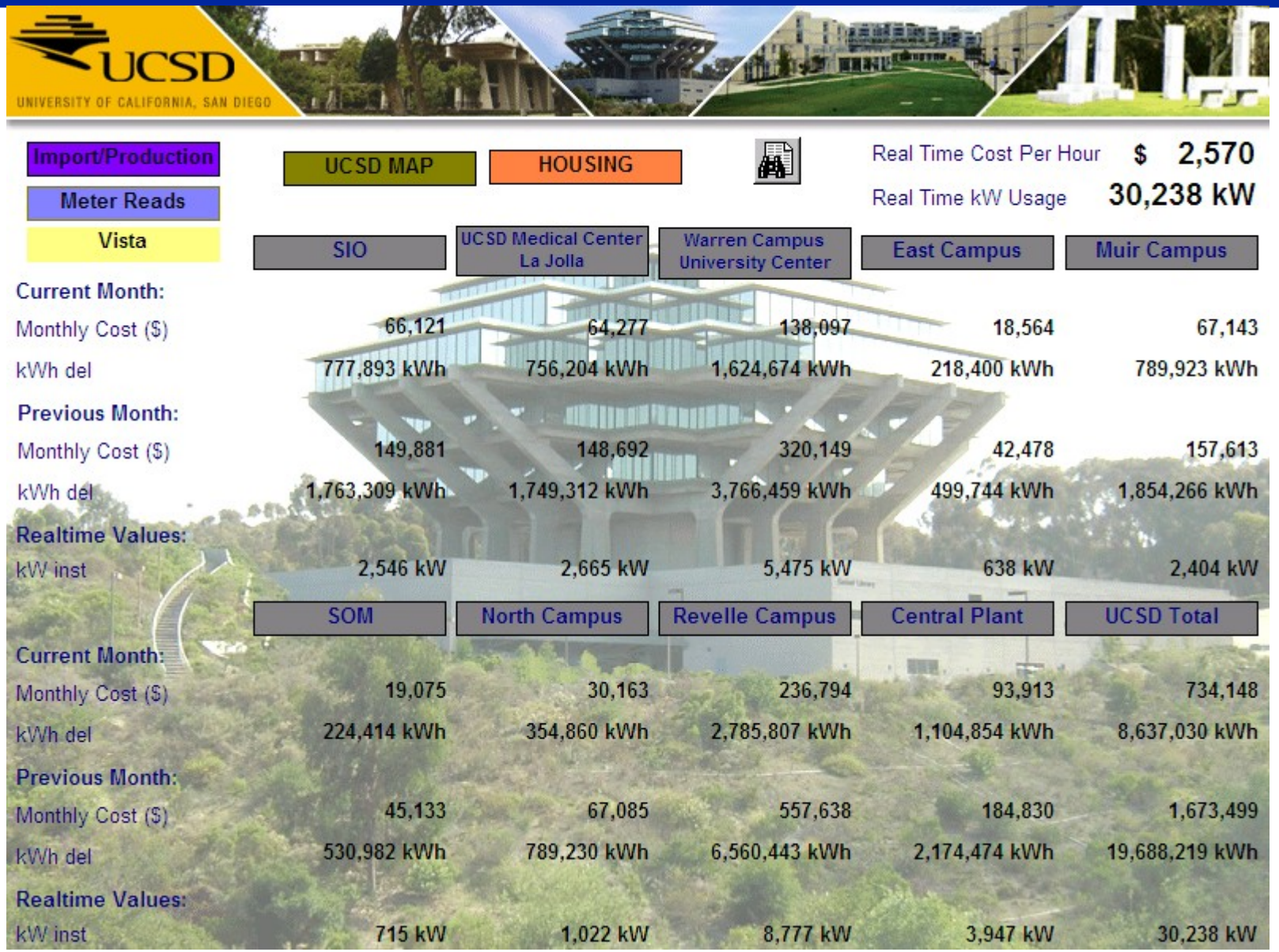
- Summer support for 2 faculty ($20k)
- GSR - usability/social SW ($60k)
- GSR - LCA ($60k)
- Web development ($10k)
- Advertising campaign ($10k)
- Total: $160k

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Source: Bill Tomlinson, UCI

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# Real-Time Monitoring of Building Energy Usage: UCSD Has 34 Buildings On-Line




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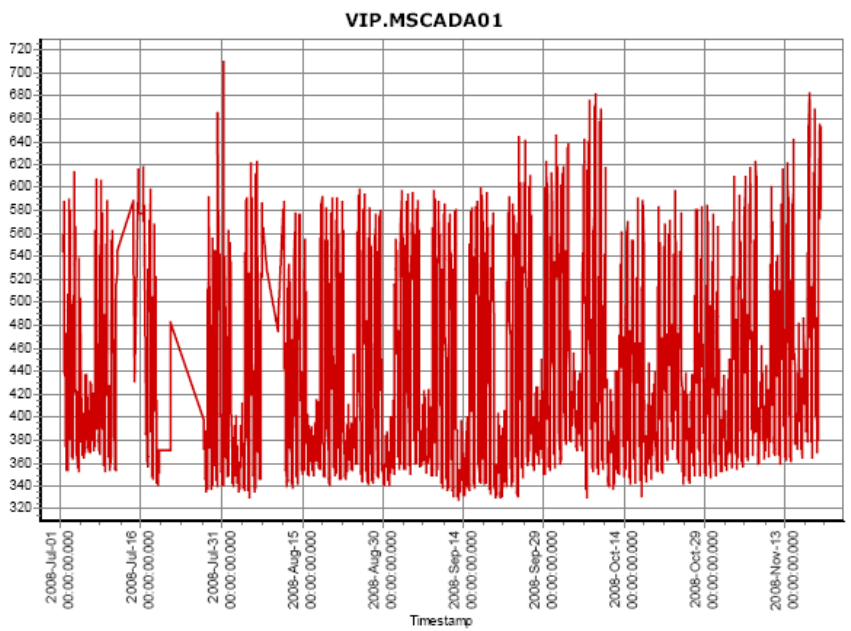
http://mscada01.ucsd.edu/ion/

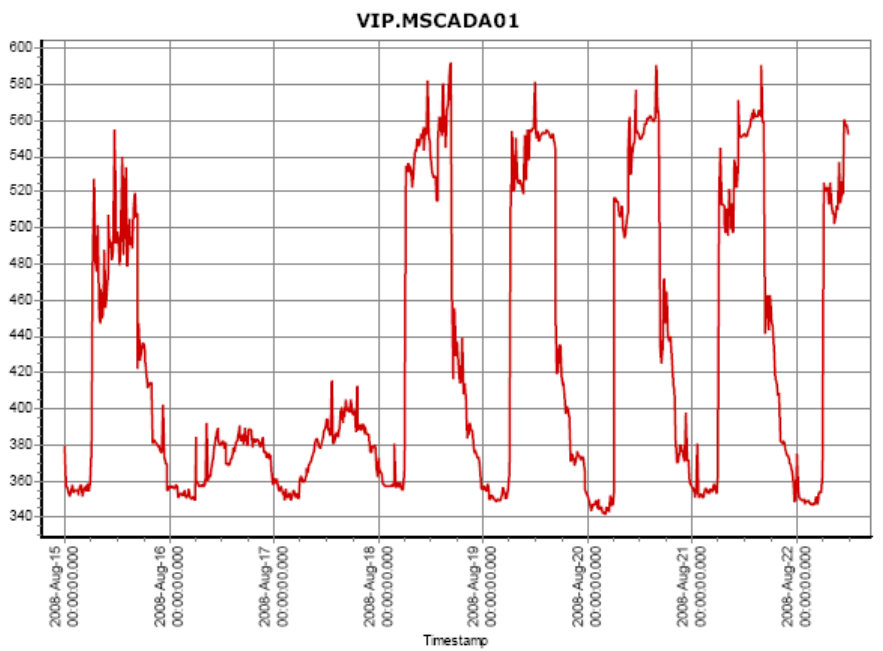
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# Power Management in Mixed Use Buildings: The UCSD CSE Building is Energy Instrumented

- **500 Occupants, 750 Computers**
- **Detailed Instrumentation to Measure Macro and Micro-Scale Power Use**
  - **39 Sensor Pods, 156 Radios, 70 Circuits**
  - **Subsystems: Air Conditioning & Lighting**





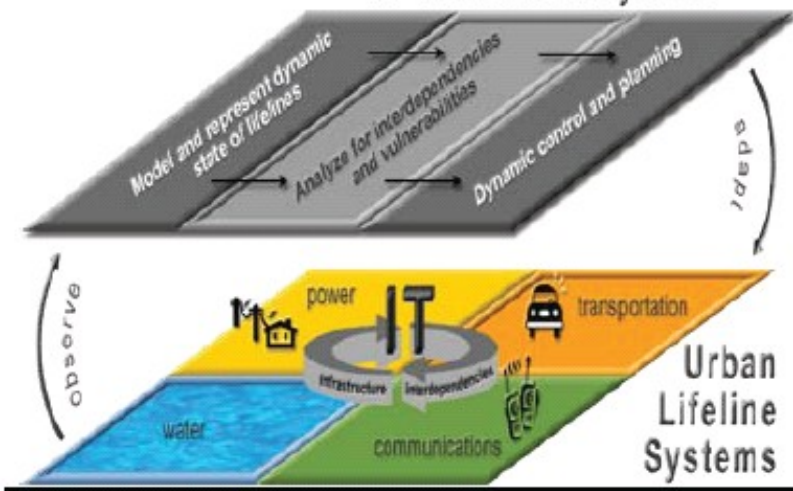




Source: Rajesh Gupta, CSE, Calit2

# TRUST-IT
# Monitoring Electrical Usage in Calit2@UCI

Marlon Boarnet, Sharad Mehrotra, Nalini Venkatasubramanian, et. al.

## IT based Metasystem




## Innovation

- IT driven urban infrastructure that enables systems to dynamically reconfigure to changing situations.
- Adaptation at all scales – real time control to long term planning and simulation.
- **DeviceWeb**: Societal scale middleware to connect lifelines

## Green Impact

- Exploiting IT to control consumption of non-renewable energy.
- Controlling/limiting waste.
- Planning tools to study long term impact over environment

## Milestones

- 2003-2007 various studies showing positive impact of IT on dynamically adapting real-world crisis response processes (part of RESCUE)
- 2006 – A transportation study showed evacuation time of Long Beach downtown can be cut to about ½ by proper information dissemination. (RESCUE study)
- March 2007 – formation of an ERC team including many centers that deal with lifeline issues at UCI.
- June 2007 – an initial (very preliminary) study based on monitoring electricity usage of Calit2 showed that proper control based on building occupancy patterns could lead to substantial savings.
- 2008-2009 – plans for resubmission and ground work.

## Cost (Pilot)

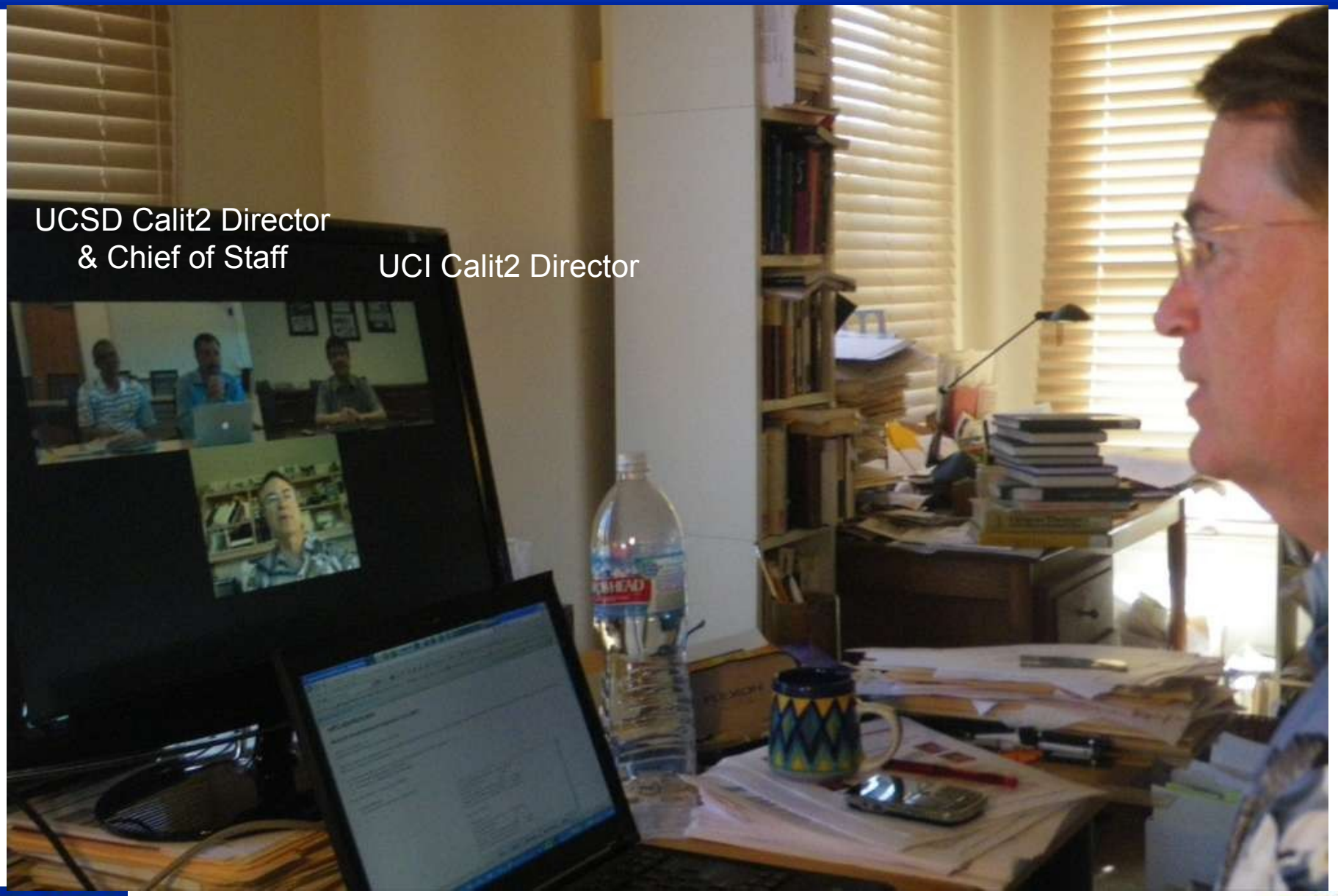
- Prototype study at a building level scale – 15K
- GSR/programmer for initial study of IT framework to control lifelines -25K
- Team building & sustaining the effort within UCI – 15K

## Cost (Ultimate)

- TRUST-IT budget was approx. 3M/year for 10 years!!

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# I Link Into Commercial H.323 Videoconfernces From My Laptop at Home



# Linking the Calit2 Auditoriums at UCSD and UCI with LifeSize HD for Shared Seminars

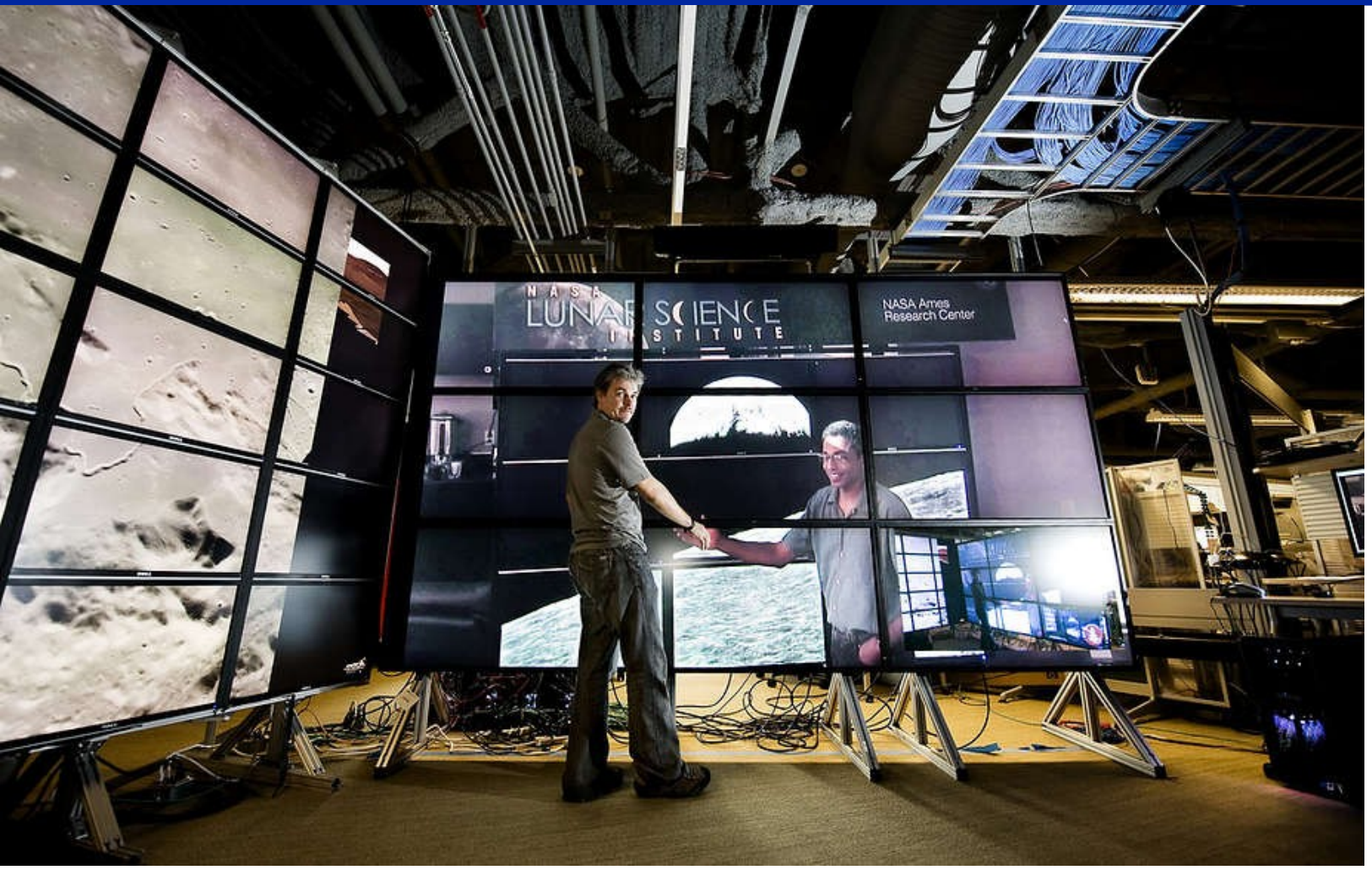



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Photo by Erik Jepsen, UC San Diego

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# High Definition Video Connected OptIPortals: Virtual Working Spaces for Data Intensive Research




LifeSize HD

NASA Ames
Lunar Science Institute
Mountain View, CA

NASA Interest in Supporting Virtual Institutes

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Source: Falko Kuester, Kai Doerr Calit2; Michael Sims, NASA

# Hosting Symposia on Green ICT and Smart Grid

SOUTHERN CALIFORNIA SMART GRID SYMPOSIUM
APRIL 7, 2009

Calit2
UNIVERSITY of CALIFORNIA IRVINE



January 22-23, 2009

Greening the Internet Economy
ICT & GLOBAL CHANGE

California Public Utilities Commission

Calit2

Co-Hosted By Calit2 & CPUC




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