

# Urban sustainability and energy research at PSU: An opportunity for differentiation



***Intel Symposium on Urban Sustainability  
and Personal Energy Management  
January 18, 2011***

## **What's the problem? What's the opportunity?**

- 1) Large numbers of people are moving to cities**
- 2) Equitable, efficient cities help achieve global sustainability goals**
- 3) Every city is now experimenting with new policies**
- 4) Companies, NGOs, universities also trying to improve cities**
- 5) How can cities learn from each other more effectively?**
- 6) How can embedded technologies make cities work better?**
- 7) Can Portland make urban sustainability a major export?**
- 8) Can PSU help expand the definition of urban sustainability?**



## **What's the PSU situation?**

- 1) Only comprehensive research university in Portland**
- 2) Motto: “Let Knowledge Serve the City”**
- 3) Pockets of academic excellence, many in non-traditional areas**
- 4) Engineering, natural, social sciences aim at urban/energy problems**
- 5) Some Computer Science and System Science expertise from OGI**
- 6) Research connectivity throughout the region**
- 7) Student internships build bridges to organizations**



## **Questions for today's discussion**

- 1) What urban/energy partnering opportunities for Intel and PSU?**
- 2) What grant proposals can forge stronger research ties?**
- 3) Can we build urban bridges to higher-ranked universities?**
- 4) Can PSU serve as a convener for different sectors?**
- 5) Can Portland become the partner-of-choice for urban solutions?**
- 6) Is there value in PSU having an over-arching research theme?**



## Four sectors help conduct urban experiments

### *Government*



### *Universities*



**Fund  
Protect  
Regulate  
Negotiate**

**Educate  
Discover  
Convene  
Integrate**

**Advocate  
Defend  
Inform  
Solicit**

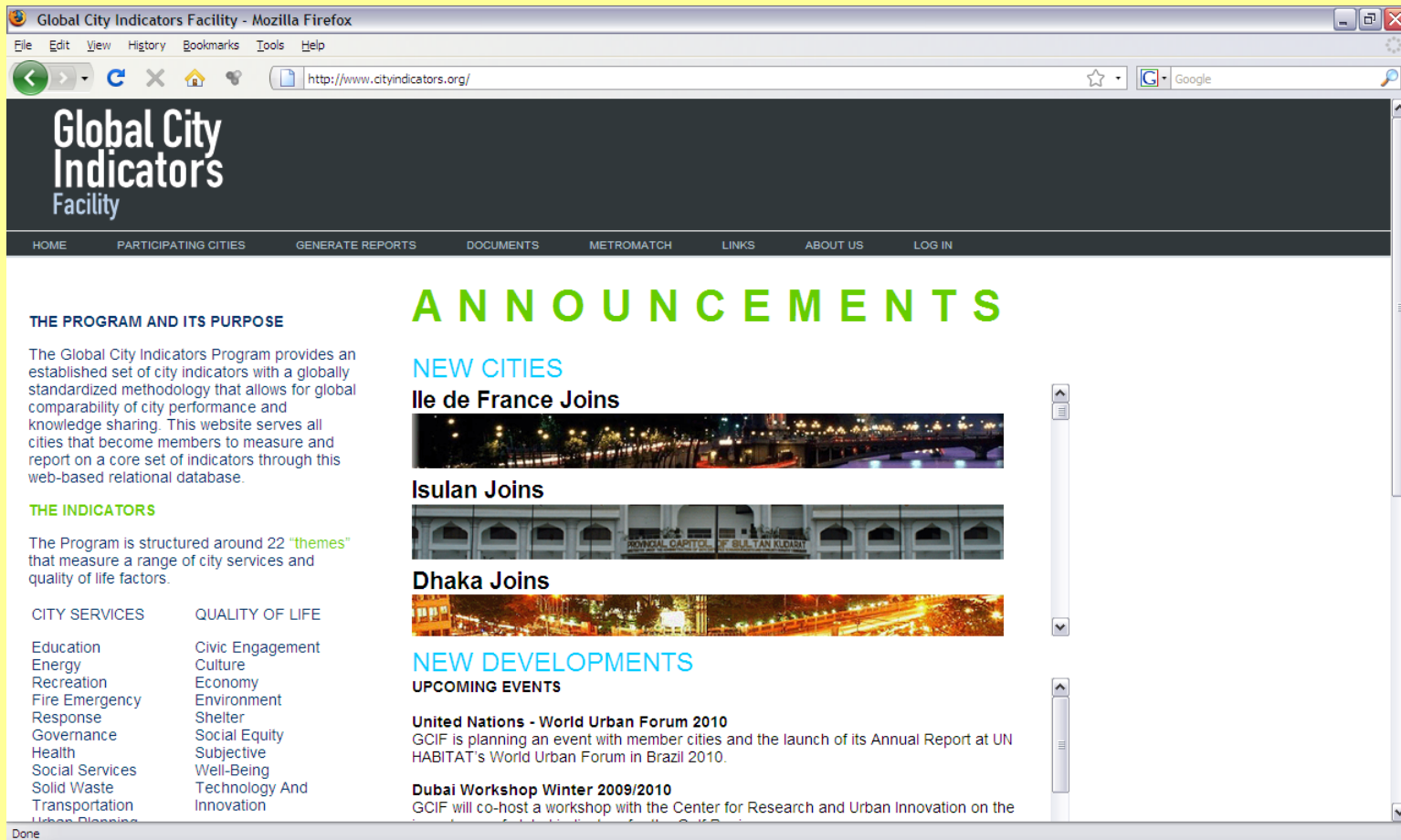
**Contribute  
Innovate  
Employ  
Invest**



### *NGOs*

### *Corporations*

## World Bank's Global City Indicators Facility



The screenshot shows the Global City Indicators Facility website in a Mozilla Firefox browser window. The browser's address bar displays <http://www.cityindicators.org/>. The website has a dark header with the "Global City Indicators Facility" logo and a navigation menu with links: HOME, PARTICIPATING CITIES, GENERATE REPORTS, DOCUMENTS, METROMATCH, LINKS, ABOUT US, and LOG IN.

**THE PROGRAM AND ITS PURPOSE**

The Global City Indicators Program provides an established set of city indicators with a globally standardized methodology that allows for global comparability of city performance and knowledge sharing. This website serves all cities that become members to measure and report on a core set of indicators through this web-based relational database.

**THE INDICATORS**

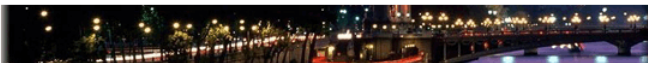
The Program is structured around 22 "themes" that measure a range of city services and quality of life factors.

CITY SERVICES	QUALITY OF LIFE
Education	Civic Engagement
Energy	Culture
Recreation	Economy
Fire Emergency	Environment
Response	Shelter
Governance	Social Equity
Health	Subjective
Social Services	Well-Being
Solid Waste	Technology And
Transportation	Innovation
Urban Planning	


**ANNOUNCEMENTS**

**NEW CITIES**


**Ile de France Joins**



**Isulan Joins**



**Dhaka Joins**



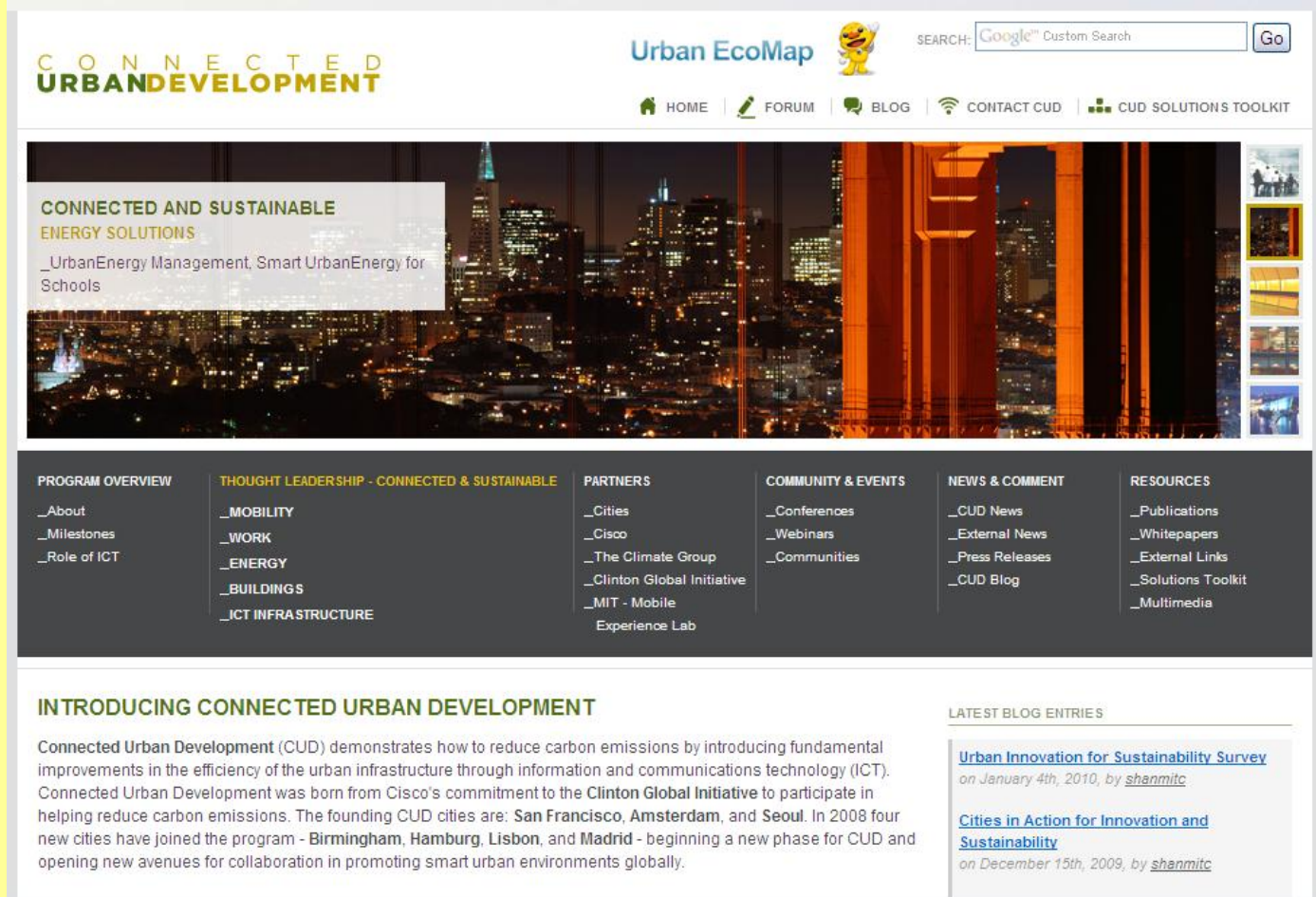
**NEW DEVELOPMENTS**

**UPCOMING EVENTS**

**United Nations - World Urban Forum 2010**  
GCIF is planning an event with member cities and the launch of its Annual Report at UN HABITAT's World Urban Forum in Brazil 2010.

**Dubai Workshop Winter 2009/2010**  
GCIF will co-host a workshop with the Center for Research and Urban Innovation on the

## Cisco Systems' Connected Urban Development



The screenshot shows the homepage of the Connected Urban Development (CUD) website. The header features the 'CONNECTED URBAN DEVELOPMENT' logo on the left, the 'Urban EcoMap' logo with a cartoon character in the center, and a search bar on the right. Below the header is a navigation menu with links for HOME, FORUM, BLOG, CONTACT CUD, and CUD SOLUTIONS TOOLKIT. The main content area has a large banner image of a city skyline at night with the text 'CONNECTED AND SUSTAINABLE ENERGY SOLUTIONS' and a sub-header '\_UrbanEnergy Management, Smart UrbanEnergy for Schools'. Below the banner is a grid of six columns: PROGRAM OVERVIEW, THOUGHT LEADERSHIP - CONNECTED & SUSTAINABLE, PARTNERS, COMMUNITY & EVENTS, NEWS & COMMENT, and RESOURCES. Each column contains a list of links. At the bottom, there is a section titled 'INTRODUCING CONNECTED URBAN DEVELOPMENT' with a paragraph of text, and a 'LATEST BLOG ENTRIES' section with two blog post links.

**CONNECTED AND SUSTAINABLE ENERGY SOLUTIONS**  
\_UrbanEnergy Management, Smart UrbanEnergy for Schools

**PROGRAM OVERVIEW**  
\_About  
\_Milestones  
\_Role of ICT

**THOUGHT LEADERSHIP - CONNECTED & SUSTAINABLE**  
\_MOBILITY  
\_WORK  
\_ENERGY  
\_BUILDINGS  
\_ICT INFRASTRUCTURE

**PARTNERS**  
\_Cities  
\_Cisco  
\_The Climate Group  
\_Clinton Global Initiative  
\_MIT - Mobile Experience Lab

**COMMUNITY & EVENTS**  
\_Conferences  
\_Webinars  
\_Communities

**NEWS & COMMENT**  
\_CUD News  
\_External News  
\_Press Releases  
\_CUD Blog

**RESOURCES**  
\_Publications  
\_Whitepapers  
\_External Links  
\_Solutions Toolkit  
\_Multimedia

**INTRODUCING CONNECTED URBAN DEVELOPMENT**  
Connected Urban Development (CUD) demonstrates how to reduce carbon emissions by introducing fundamental improvements in the efficiency of the urban infrastructure through information and communications technology (ICT). Connected Urban Development was born from Cisco's commitment to the Clinton Global Initiative to participate in helping reduce carbon emissions. The founding CUD cities are: San Francisco, Amsterdam, and Seoul. In 2008 four new cities have joined the program - Birmingham, Hamburg, Lisbon, and Madrid - beginning a new phase for CUD and opening new avenues for collaboration in promoting smart urban environments globally.

**LATEST BLOG ENTRIES**  
[Urban Innovation for Sustainability Survey](#)  
on January 4th, 2010, by [shanmitc](#)  
[Cities in Action for Innovation and Sustainability](#)  
on December 15th, 2009, by [shanmitc](#)

## CUD's Urban EcoMap for Amsterdam, San Francisco and Seoul

### Urban EcoMap

#### Working Together to Improve Urban Environments

Urban EcoMap is an interactive decision space that empowers individual citizens to make informed decisions about their daily lives, along with how to participate in the vitality of their communities. We aim to build awareness, fostering a sense of community, and provide actions for citizens to take to enable the reduction of greenhouse gas emissions in cities. Please join us.

#### Amsterdam

Population: **746,935**



##### Residential CO2 Emissions:

 Transportation: **45.1%**

 Energy: **50.0%**

 Waste: **4.9%**

[Explore](#)

Residential CO2 per capita: **4.3 t**

Total CO2 per capita, Netherlands: 11.2 t \*

#### San Francisco

Population: **762,611**



##### Residential CO2 Emissions:

 Transportation: **78.1%**

 Energy: **19.4%**

 Waste: **2.5%**

[Explore](#)

Residential CO2 per capita: **8.2 t**

Total CO2 per capita, United States: 19.1 t \*

Together we can strive to achieve a reduction in carbon emissions to 2 metric tonnes(t) per capita. [Learn More](#)

## EcoMap shows environmental impact by zip code



## EcoMap shows individuals how to reduce their footprint

**Urban EcoMap** AMSTERDAM

Home Explore Act Resources

English San Francisco »

### Reduce Your Carbon Emissions

#### 1 Set Your Goals

Move the sliders to adjust your starting point

**By Effort**

off lower higher

**By Cost**




off lower higher

**By Impact**

off lower higher

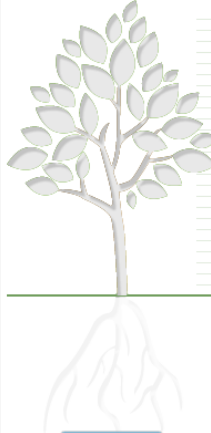
#### 2 Plan Your Actions

Identify actions that you will take in each of the following areas

 Transportation	 Energy	 Waste
<input type="checkbox"/> Walk to work once per week	<input type="checkbox"/> Turn off electronic devices	<input type="checkbox"/> Place a notification sticker on your door to deter pamphlets
<input type="checkbox"/> Walk to work daily	<input type="checkbox"/> Use energy-efficient lamps instead of normal lamps	<input type="checkbox"/> Recycle Newspaper, Paper and Cardboard
<input type="checkbox"/> Car share to work 2-3 times per week	<input type="checkbox"/> Update your faucets and showerhead(s)	<input type="checkbox"/> Reuse paper
<input type="checkbox"/> Drive according to the new standards - 'het nieuwe rijden'	<input type="checkbox"/> Utilize "Radiator Foil"	<input type="checkbox"/> Use refillable containers
<input type="checkbox"/> Plan ahead and combine trips	<input type="checkbox"/> Turn down heating and cooling	<input type="checkbox"/> Use rechargeable batteries
<input type="checkbox"/> Travel outside of the rush hour	<input type="checkbox"/> Manage heating and cooling systems with programmable thermostats and timers.	
<input type="checkbox"/> Bike to work one day a week	<input type="checkbox"/> Minimize dryer usage	
<input type="checkbox"/> Bike to work daily	<input type="checkbox"/> Wait for a full laundry load	
<input type="checkbox"/> Commute to work daily by public transit	<input type="checkbox"/> Radiator and heating vents should be unobstructed	
<input type="checkbox"/> Commute to work via public transport once a week	<input type="checkbox"/> Lower the heat 1-2 degrees	
<input type="checkbox"/> Acquire a Hybrid or other fuel efficient automobile	<input type="checkbox"/> Install solar panels	

#### 3 See Your Results


Chart your contribution



[Take Action](#)

[Delete All](#)

## IBM's Smarter Cities Program



The screenshot shows the IBM Smarter Cities website. At the top is the IBM logo and a navigation bar with links: Home, Solutions, Services, Products, Support & downloads, and My IBM. A search bar is also present. Below the navigation bar is a large graphic with the text "A Smarter Planet Cities" and a stylized cityscape. The main heading is "Smarter Cities" with the subtext "Safe neighborhoods. Quality schools. Affordable housing. Traffic that flows. It's all possible." Below this is a section titled "The most livable cities in the world in 2008" with a list of 10 cities. To the right of this list is a section titled "India needs sustainable cities" with two paragraphs of text. The website also features a "Visions" tab and a "Next steps" tab.

**IBM** United States [change]

Home Solutions Services Products Support & downloads My IBM Welcome [ IBM Sign In ] [ Register ]

A Smarter Planet Cities

### Smarter Cities

Safe neighborhoods. Quality schools. Affordable housing. Traffic that flows. It's all possible.

Visions Ideas Perspectives Next steps

#### The most livable cities in the world in 2008

1. Vancouver, Canada
2. Melbourne, Australia
3. Vienna, Austria
4. Perth, Australia
5. Toronto, Canada
6. Helsinki, Finland
7. Adelaide, Australia / Calgary, Canada
8. Geneva, Switzerland / Sydney, Australia / Zürich, Switzerland

Based on five broad categories: stability, healthcare, culture and environment, education, and infrastructure. economist.com, April 28, 2008

#### India needs sustainable cities

Every minute during the next 20 years, 30 Indians will leave rural India for urban areas. At this rate, India will need some 500 new cities in the next two decades. If there were ever a time to focus on developing solutions for sustainable cities, that time is now.

As population centers grow, they are placing greater demands on the city infrastructures that deliver vital services such as transportation, healthcare, education and public safety. Adding to the strain are ever-changing public demands for better education, greener programs, accessible government, affordable housing and more options for senior citizens.

Replacing the actual city infrastructures is often unrealistic in terms of cost and time. However, with recent advances in technology, we can infuse our existing infrastructures with new intelligence. By this, we mean digitizing and connecting our systems, so they can sense, analyze and integrate data, and respond intelligently to the needs of their jurisdictions. In short, we can revitalize them so they can become smarter and more efficient. In the process, cities can grow and sustain quality of life for their inhabitants.

**Combining new  
sensor technologies  
with computer  
models for better  
management  
decisions**

***Portland is IBM's  
chosen test bed***

## Non-IT companies can be partners for urban sustainability research

- Wal-Mart: (retail supply chain)
- Waste Management Inc: (material flows)
- KB Home: (residential construction)
- CEMEX: (construction materials)
- Veolia: (urban environmental monitoring)
- BP Solar: (urban renewable energy)
- U Haul: (social mobility)
- Henkel/Dial: (home products)
- Arizona Public Service: (electricity generation)
- Salt River Project: (urban water and power delivery)



## MIT SENSEable Cities Lab “Copenhagen Wheel”

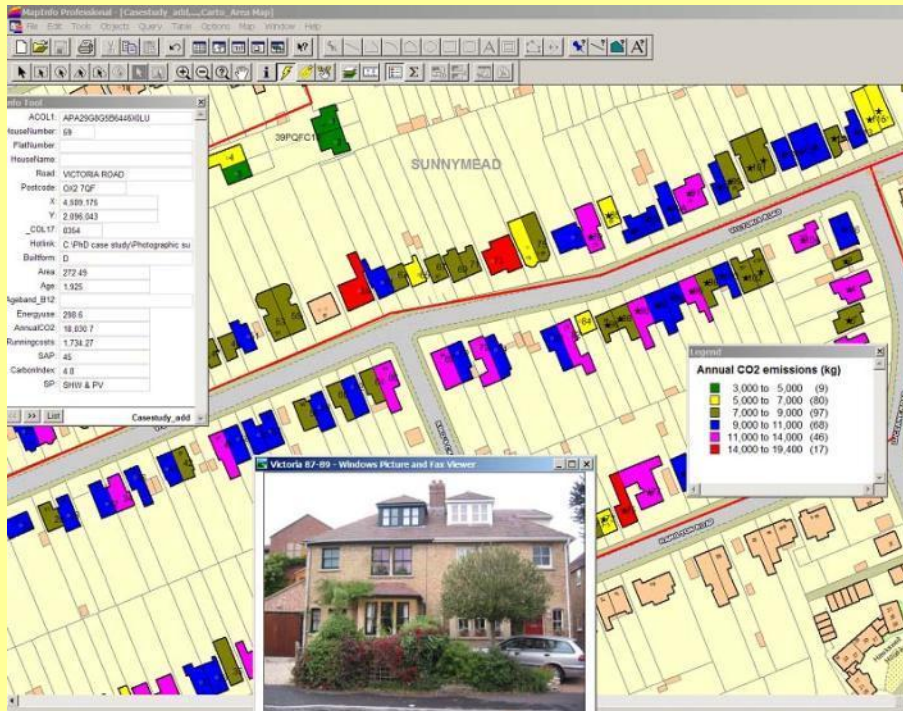


## **What can we learn from other cities?**

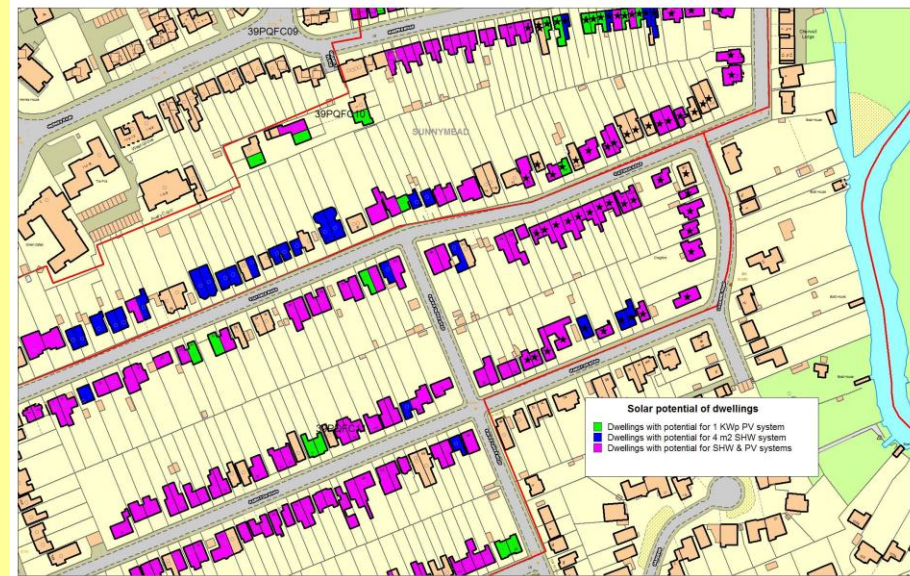


- **Cities taking the lead in discovering sustainable solutions**
- **Each city has unique challenges and opportunities**
- **Competition to be “green” is helping cities find new ideas**
- **Regional cooperation is essential**

## Carbon mapping on an urban scale (DECoRuM)



*Distribution of CO<sub>2</sub> emissions on a house-by-house level in Oxford*



*Estimating the solar potential of dwellings in Oxford*

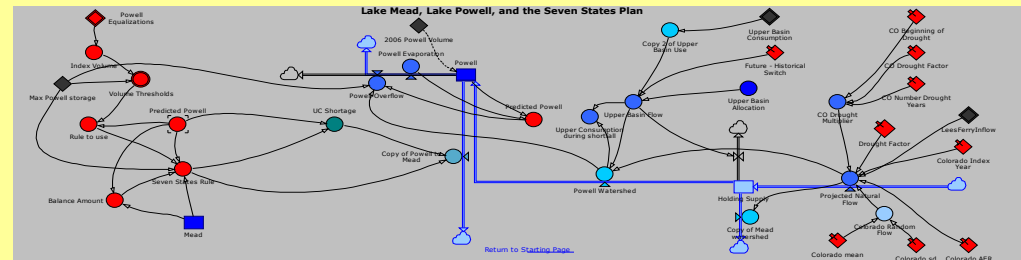
- GIS-based, domestic carbon-counting and carbon-reduction model
- Bottom-up toolkit helps planners measure, model, map, & reduce energy use and carbon emissions on a house-by-house level

## **Domestic Energy, Carbon Counting and Reduction Model (DECORUM)**

- Led by Professor Rajat Gupta of Oxford Brookes University
- Provides urban- and dwelling-level, GIS-based carbon mapping
- Does not require access to property
- Links to thermal infrared remote sensing measurements
- Cost-benefit analysis enables comparisons of different options
- Helps estimate value of citywide solar energy installation
- Being applied in Oxford (UK), ASU-Tempe, Phoenix, London
- Helps persuade homeowners to install energy-saving options
- [www.decorum-model.org.uk](http://www.decorum-model.org.uk)

# Decision Center for a Desert City

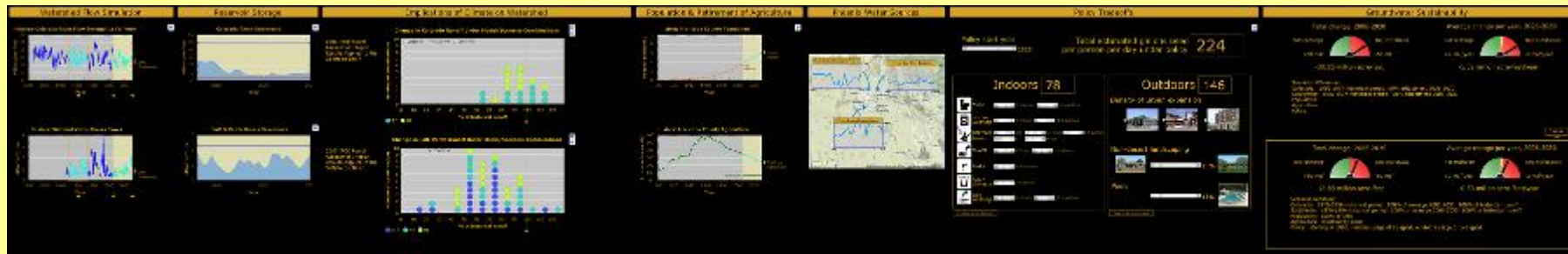
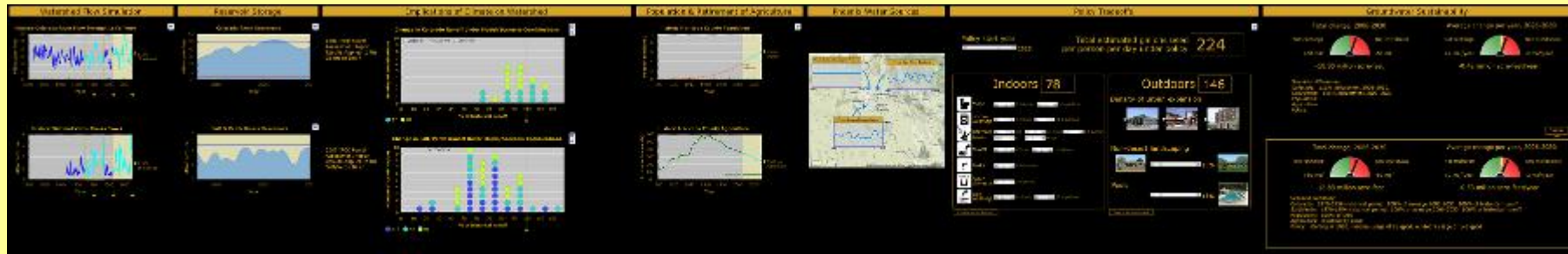
- **Addresses urban water decision-making under uncertainty**
- **Regional stakeholders engaged from start to finish**
- **Decision Theater helps them assess alternative futures**
- **Could also apply to air pollution, energy, traffic, food**



## **“WaterSim” forecasting tool in Decision Theater**



***WaterSim has many user-adjustable variables***



**Watershed  
Simulation**

**Climate  
Change**

**Land Use &  
Population**

**Policy  
Tradeoffs**

**Groundwater  
Sustainability**

**More technical**

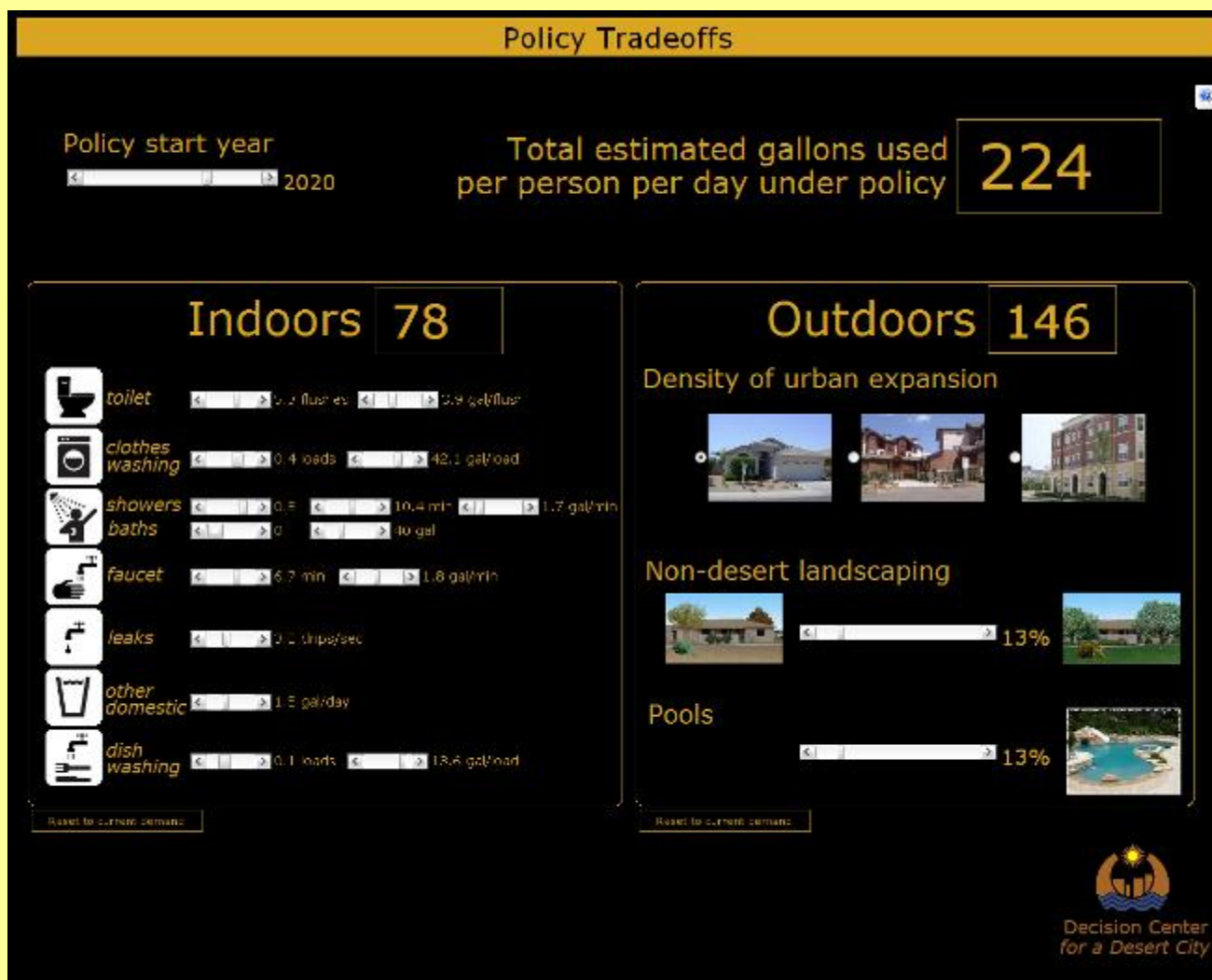


**Less Technical**

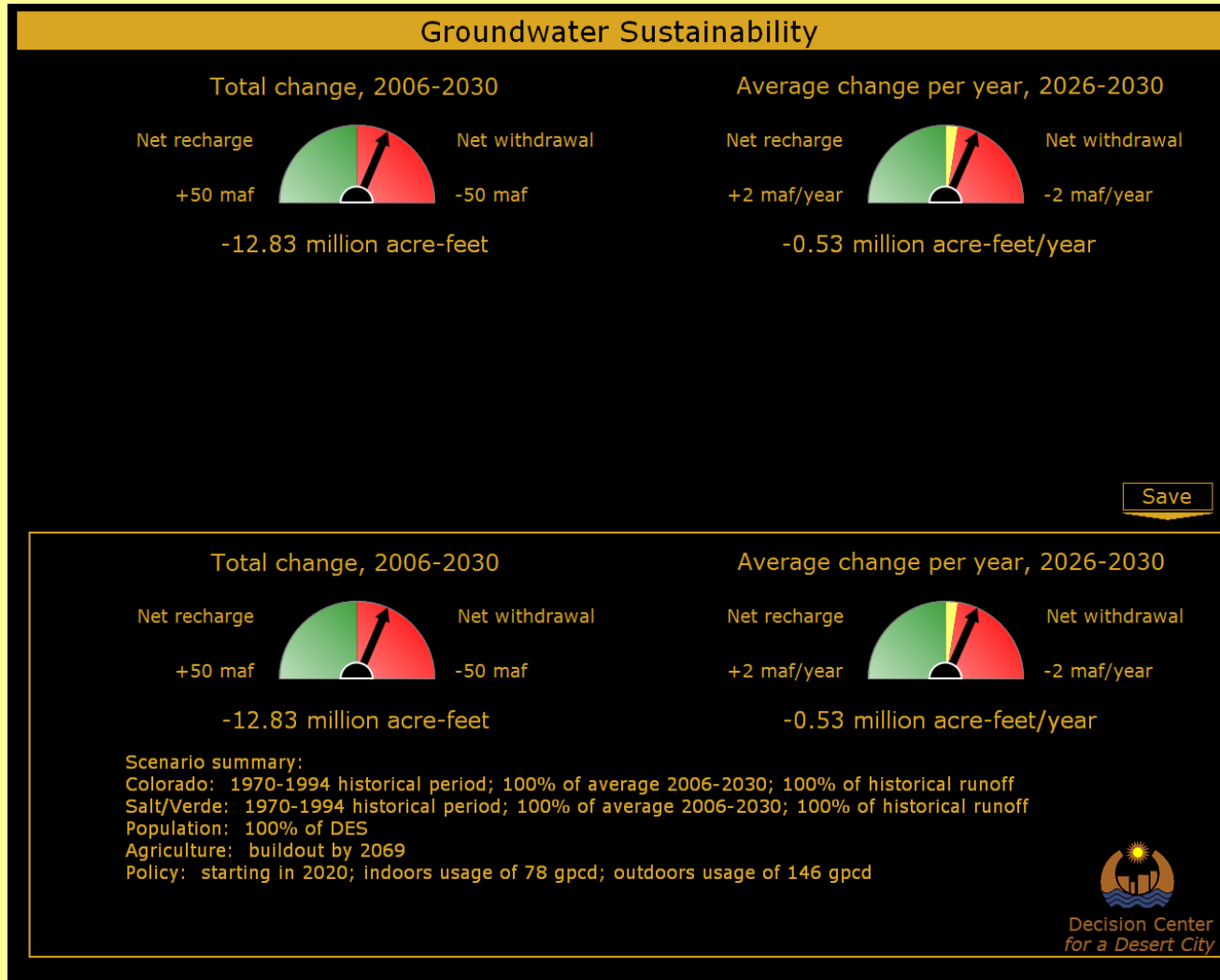
*Slider bars on graphs allow alternate futures to be assessed in real time*

**WaterSim also available online at <http://watersim.asu.edu>**

## Policy Tradeoffs



## Groundwater Sustainability





Arizona's Solar Market Analysis and Research Tool



☒ Move ☐ New

Analysis

Clip



LEGEND X

✓

Arizona Boundary

Buffer Transmission

BLM Lands

Habitat Blocks

BLM Available Area

BLM Blockout Area

BLM Study Areas

Extended Area East

Extended Area West

Less Limited Area

## System Options

**Scenario**

Capital cost assumptions  
for transmission

for non-transmission

Size of peak plants

Coal additions (\$/kW)

Power Grid

Regional Transmission

Road Network Connectivity

## Policy & Technology Options

**Policy**

Peak Carbon Price (\$/ton) per MWh hour

Alternative Solar Investment Tax Credit (%)

**Technology**

Power plant type

Planting

**Custom Solar Technology**

Name of Technology

Installed capital cost (\$ per kW)

Annual Rate Rate of Decline = Capital Cost (%)

Removal cost (\$ per kW)

Capacity factor (%)

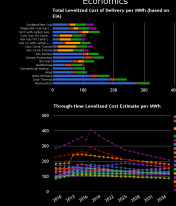
Resources: Life (years)

WPPV cost per MWh (cents)

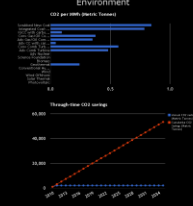
Drop cost per MWh (cents)



## Economics



## Environment

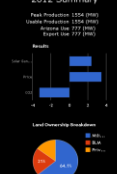


## Site Analysis

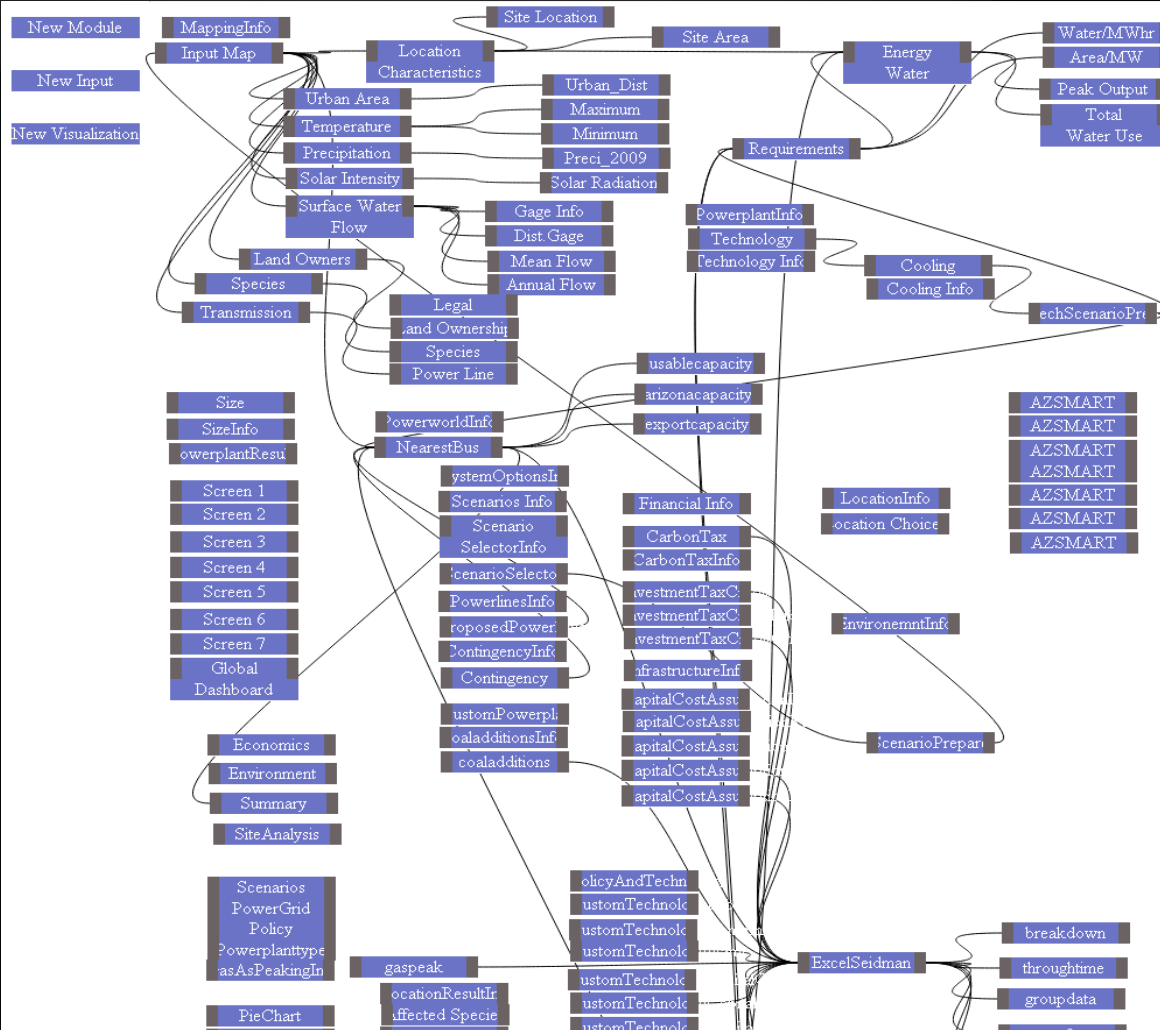
**Location Information**

Location	32.12 N, 102.87 W (km, lat)
County	Maricopa, Arizona
Closest Urban Area	Phoenix, AZ, 45.50 (km)
Distance to nearest transmission line	15.10 km
State boundaries	270 km (light blue)
Max Temp	47.7 (degrees F)
Min Temp	16 (degrees F)
Yearly solar insolation	642 (kWh/m2)
Population (2010)	1,700,000 (47 years)
Closest weather station	Phoenix, AZ, 45.50 (km)
Current Ownership	22.4
Top 5 Affected Species	See below

## 2012 Summary



# TECHNOLOGY PLATFORM



## Welcome

Welcome to the graphical dependency editor.

# System Options

## Scenarios

Scenarios:	<input type="text" value="Do your own"/>
Capital cost assumption for renewables:	<input type="text" value="reference"/>
for non-renewables:	<input type="text" value="reference"/>
Gas as peak plants:	<input type="checkbox"/>
Coal Additions (BAU):	<input type="checkbox"/>
Power Grid	
Proposed Transmission:	<input checked="" type="checkbox"/>
Most Severe Contingency:	<input checked="" type="checkbox"/>

# Policy & Technology Options

## Policy

Real Carbon Price (2010\$ per metric ton)

30

Alternative Solar Investment Tax Credit (%)



30

## Technology

Power plant type

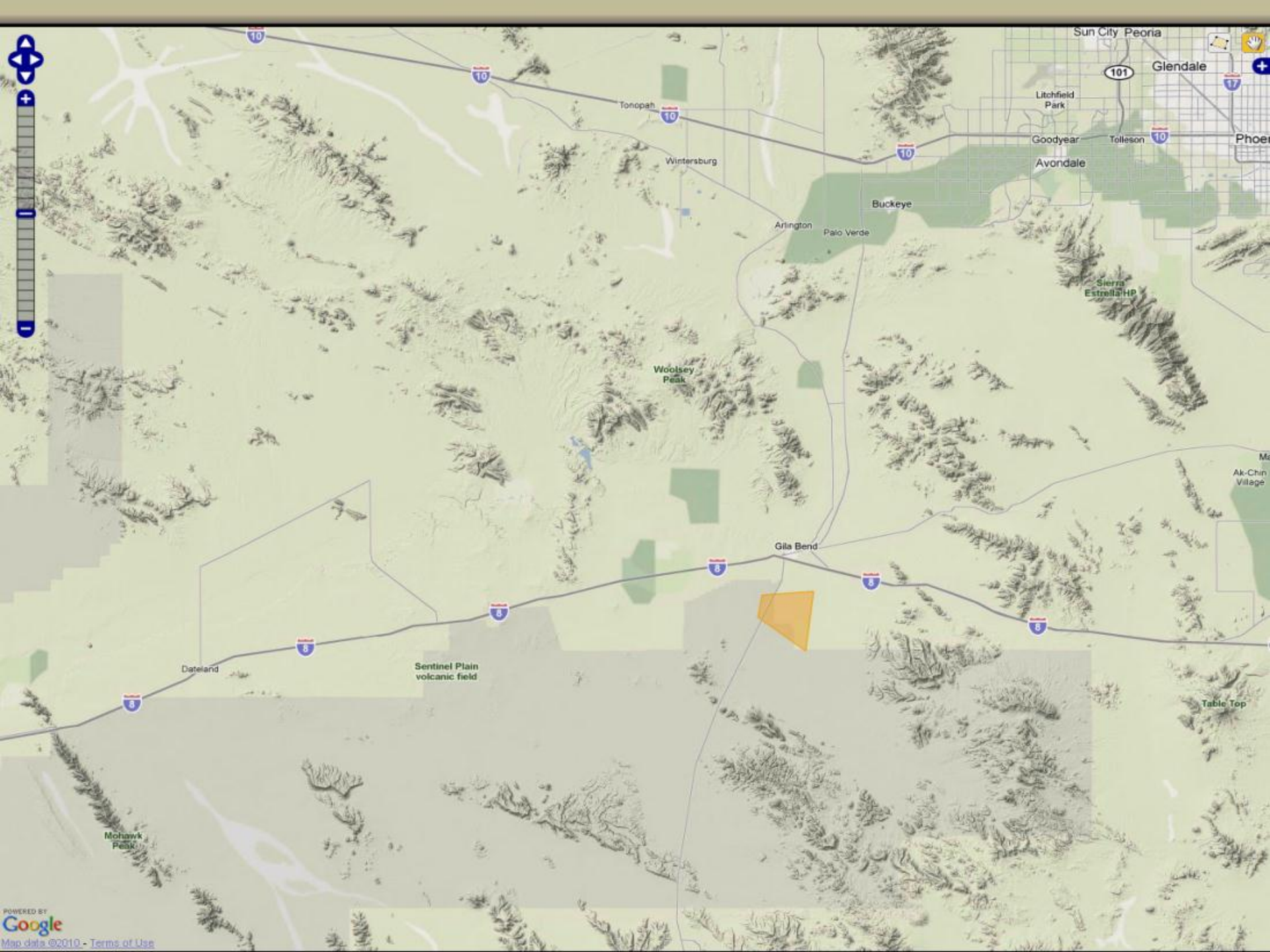
Photovoltaic ▼

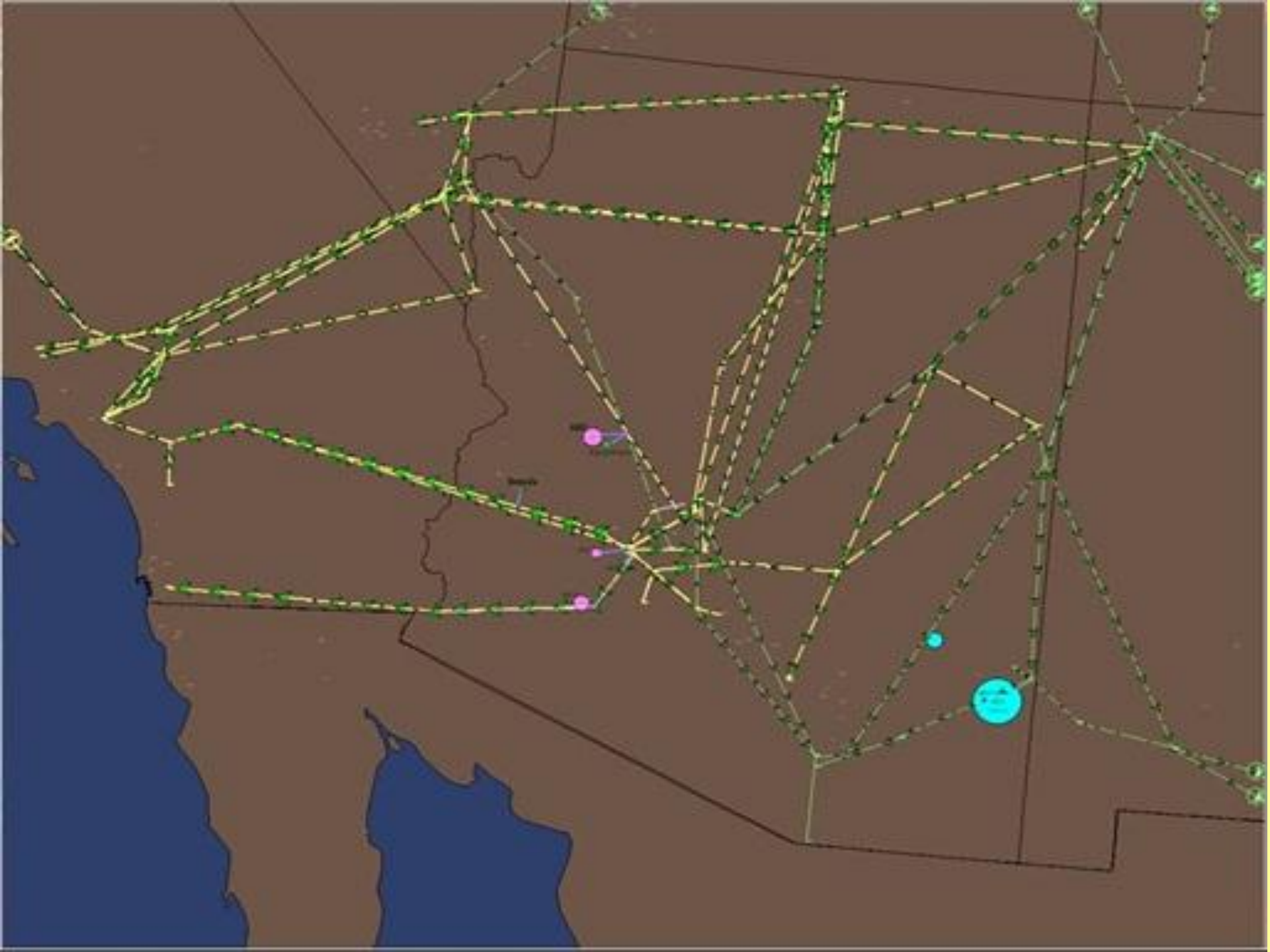
Cooling

Air Cooling ▼

## Custom Solar Technology

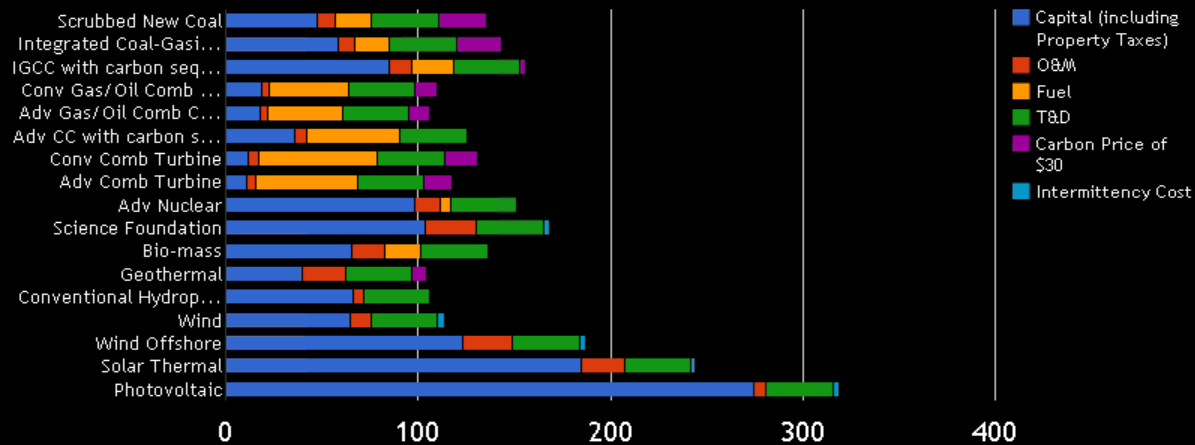
Name of Technology	Science Foundation
Nominal Capital Cost (\$ per kW)	3000
Annual Real Rate of Decline in Capital Cost (%)	3
Nominal O&M (\$ per kW)	54
Capacity Factor (%)	23
Economic Life (years)	30
Water use per MW (gallons)	2
Area use per MW (acres)	6



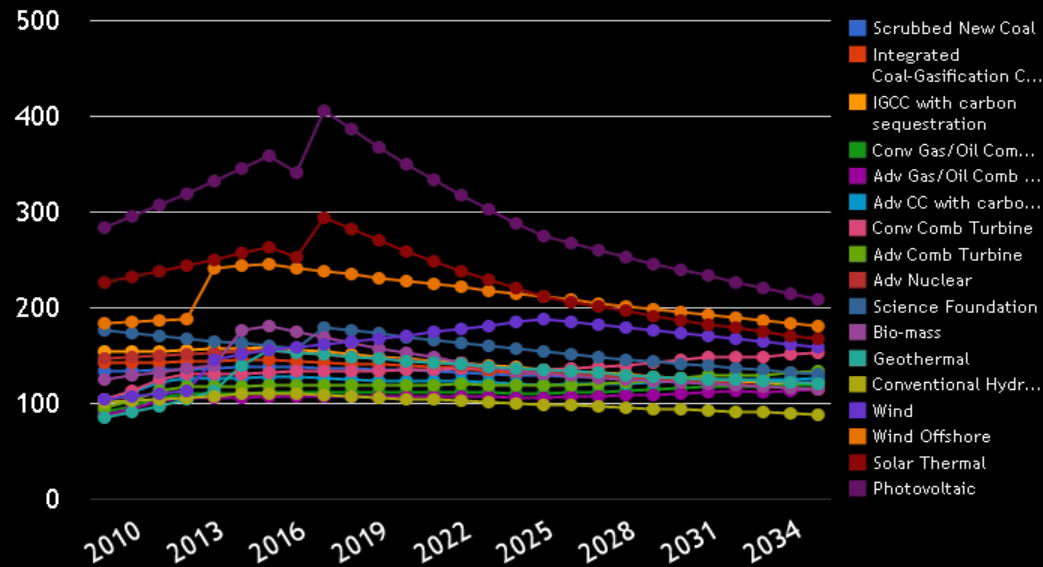


# Economics

**Total Levelized Cost of Delivery per MWh (based on EIA)**

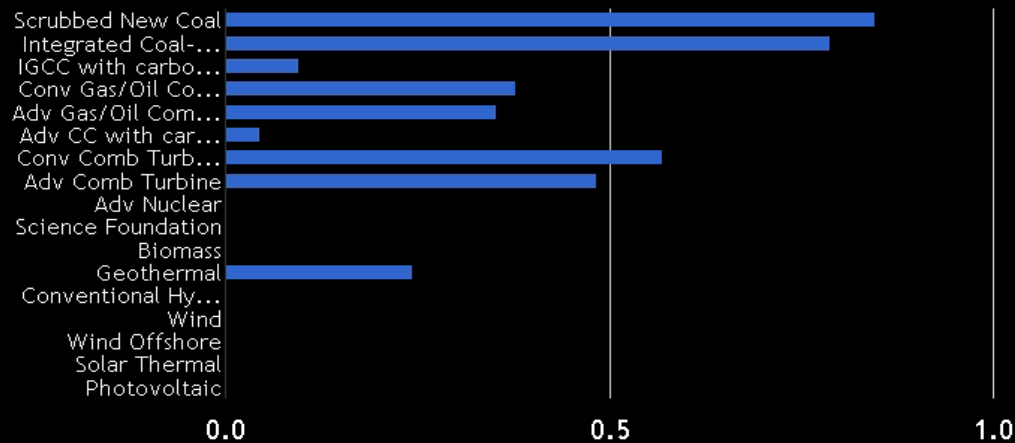


**Through-time Levelized Cost Estimate per MWh**

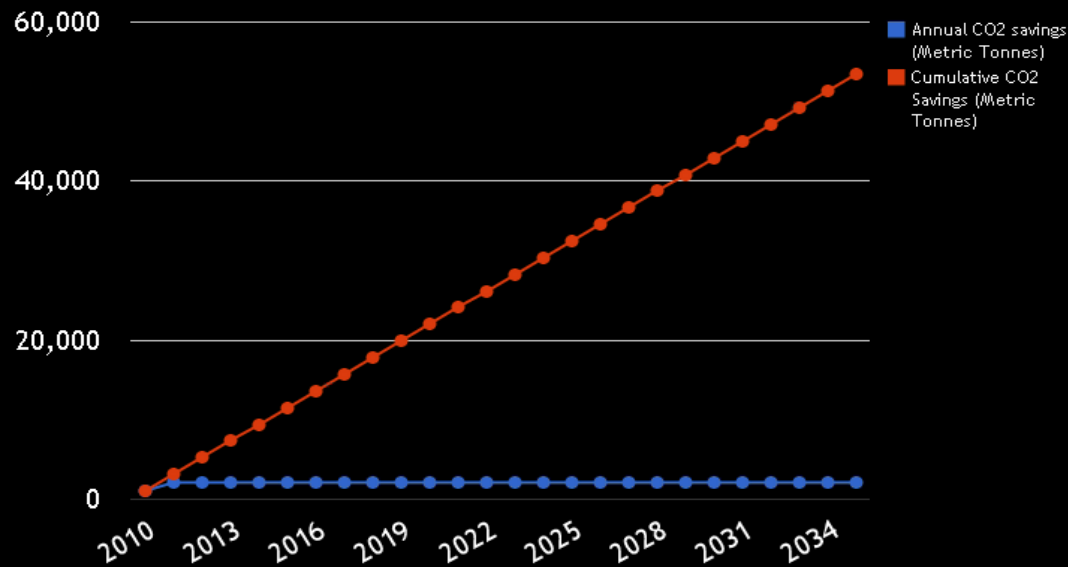


# Environment

## CO2 per MWh (Metric Tonnes)



## Through-time CO2 savings



# Site Analysis

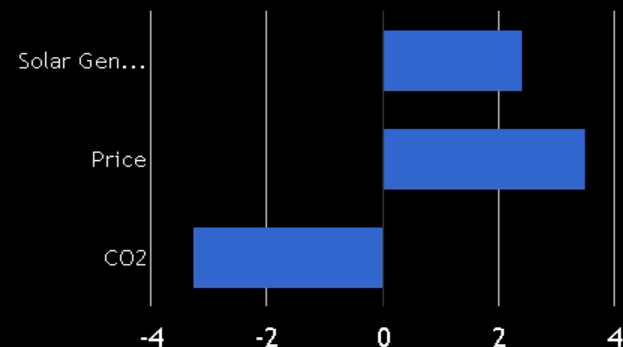
## Location Information

Location	-112.73, 32.87 (lon, lat)
Area	9326.1 (acres)
Closest Urban Area	Ajo, AZ, 48.36 (km)
Distance to closest transmission line	11.31 km
Solar Radiation	278.68 (gW h/Day)
Max Temp	107 (Degrees F)
Min. Temp	38 (Degrees F)
Total Water Use	192 (af/year)
Precipitation (2009)	1796.89 (af/year)
Closest Stream Gage	GILA RIVER below Painted Rock Dam, AZ (30.92km)
Current Discharge (af/year, 2009)	72.4
Top 5 Affected Species	Sonoran Desert Tortoise <sup>1b</sup>

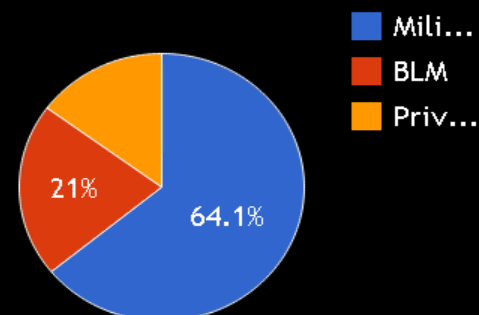
# 2012 Summary

Peak Production 1554 (MW)  
 Usable Production 1554 (MW)  
 Arizona Use 777 (MW)  
 Export Use 777 (MW)

## Results



## Land Ownership Breakdown



## **PSU Sustainable Energy Research**

***David Sailor***



**Professor  
Mech & Materials  
Engineering**

### **Performance testing of a retrofit window product**

Indow Windows Inc.

Testing thermal, acoustic, noise abatement properties

Funding from Oregon BEST

### **Phase change materials in buildings**

Testing materials that store heat in day and release it at night

### **Impact of roof technologies on energy consumption**

Green roof energy simulation model

## PSU Sustainable Energy Research

*Huafen Hu*



**Development of building energy model database  
for PSU campus**

First step toward model-based central energy control system

Asst Professor  
Mech & Materials  
Engineering

## PSU Sustainable Energy Research

***Raul Cal***



**Wind energy and turbulence**

Just built a wind tunnel facility

Asst Professor  
Mech & Materials  
Engineering

## **PSU Sustainable Energy Research**

***Graig Spolek***



**Lab measurement of building cooling energy reduction due to green roof**

Design and test green roofs with optimal performance  
Test around Metro Portland

Professor  
Mech & Materials  
Engineering

## PSU Sustainable Energy Research

***Nirupama Bulusu***



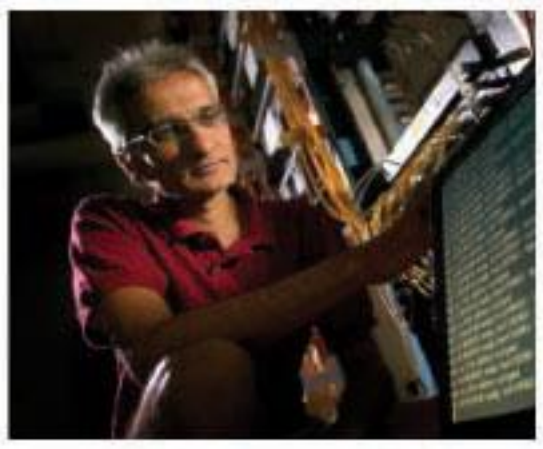
**Sensor networks**

Has PhD student, Thanh Dang, Intel intern on smart buildings

**Assoc Professor  
Computer Science**

## **PSU Sustainable Energy Research**

***Suresh Singh***



Professor  
Computer Science

**Power-Efficient Ad Hoc Mobile Networking**  
Low-power internet devices and protocols

## **PSU Sustainable Mobility Research**

***Dan Hammerstrom***



### **Electric Vehicle two-course sequence**

Intro to electric drives and drive control

Vehicles as systems

Professor  
Electrical and  
Computer Engineering

## **PSU Sustainable Energy Research**

***Loren Lutzenhiser***



**Links between urban energy use and global environmental change**

Behavioral influences on conservation in households and businesses

Professor  
College of Urban  
and Public Affairs

## PSU Sustainable Energy Research

*Carl Womser*



### Solar energy

Artificial photosynthesis using novel organic materials

Professor  
Chemistry

## **PSU Sustainable Mobility Research**

***Miguel Figliozzi***



Assoc Professor  
Civil & Environmental  
Engineering

**Optimizing transit bus fleet management**

**Integrated multimodal transportation, air quality, livability corridor study**

**Commercial electric vehicle fleet analysis**

**Impact of weather on bicycle ridership**

**Climate change impact on transportation infrastructure**

## **PSU Sustainable Mobility Research**

***Chris Monsere***



**Intelligent Transportation Systems  
Laboratory  
Analysis of freeway travel time reliability at  
the segment level for hotspot identification**

**Assistant Professor  
Civil & Environmental  
Engineering**

## PSU Sustainable Energy Research

***Peter Dusicka***



**Seismic evaluation of Green Building Structure**  
Combining seismic safety with green construction

Assistant Professor  
Civil & Environmental  
Engineering

## PSU Sustainable Energy Research

***Tugrul Daim***



**NW Regional efficiency roadmap**

Associate Professor  
Engineering & Tech.  
Management