Research Dimensions

President's 2025 Carbon Neutrality Initiative

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UNIVERSITY OF CALIFORNIA

October 22, 2014

Applied Research Workshop

UC President's Carbon Neutrality Initiative

UCSB, October 8-9, 2014

Co-chairs: Sandy Brown & David Auston

Why Research Is Important to the Success of the Carbon Neutrality Initiative:

- UC is **a rich intellectual resource** with a wide range of research activity in renewable energy, energy storage, energy efficiency & relevant economics & policy.
- This initiative presents a special opportunity for the 10 UC campuses, the 3 National Labs & the ANR to **cooperate and collaborate**.
- Research is also an important vehicle for engaging each entity and **motivating the faculty, students & staff** to participate in the initiative.
- The concept of a **living laboratory** is a unique vehicle for testing and learning about emerging technologies developed by UC and its many partners.
- If successful, the initiative will have **impact far beyond UC** and will be a model for the state, the nation and the world.

Applied Research Workshop (cont'd)

Organization: The Applied Research Working Group of the UC Global Climate Leadership Council have developed the objectives, program, and helped to identify proposed participants.

Participants: 32 leading researchers and campus sustainability officers from all 10 UC campuses, the three affiliated national Labs & the ANR plus keynote speakers & UCOP staff + UCSB.

Sponsors: Jointly sponsored by UCOP and the Institute for Energy Efficiency at UCSB.

Report: A written report summarizing the proposed research agenda is in draft and will be available within a week.

Applied Research Workshop Agenda

- ***Address by President Napolitano (video)***
- ***Keynote speakers***
- ***Presentation of research inventory***
- ***Reports from UC units:*** Each campus, lab, & the ANR gave a brief summary of current status & research needs.
- ***Breakout sessions:*** Four intensive sessions focused on developing research priorities.
- ***Recommendations***
- ***Report:*** Discussion of structure and process for writing report.
- ***Next steps***

Keynote Speakers

- UC President Janet Napolitano
- Commissioner Andrew McAllister, California Energy Commission
- Scott Murtishaw, Special Advisor to the President, California Public Utilities Commission
- Wendell Brase, co-chair Global Climate Leadership Council

Research Inventory - Goals

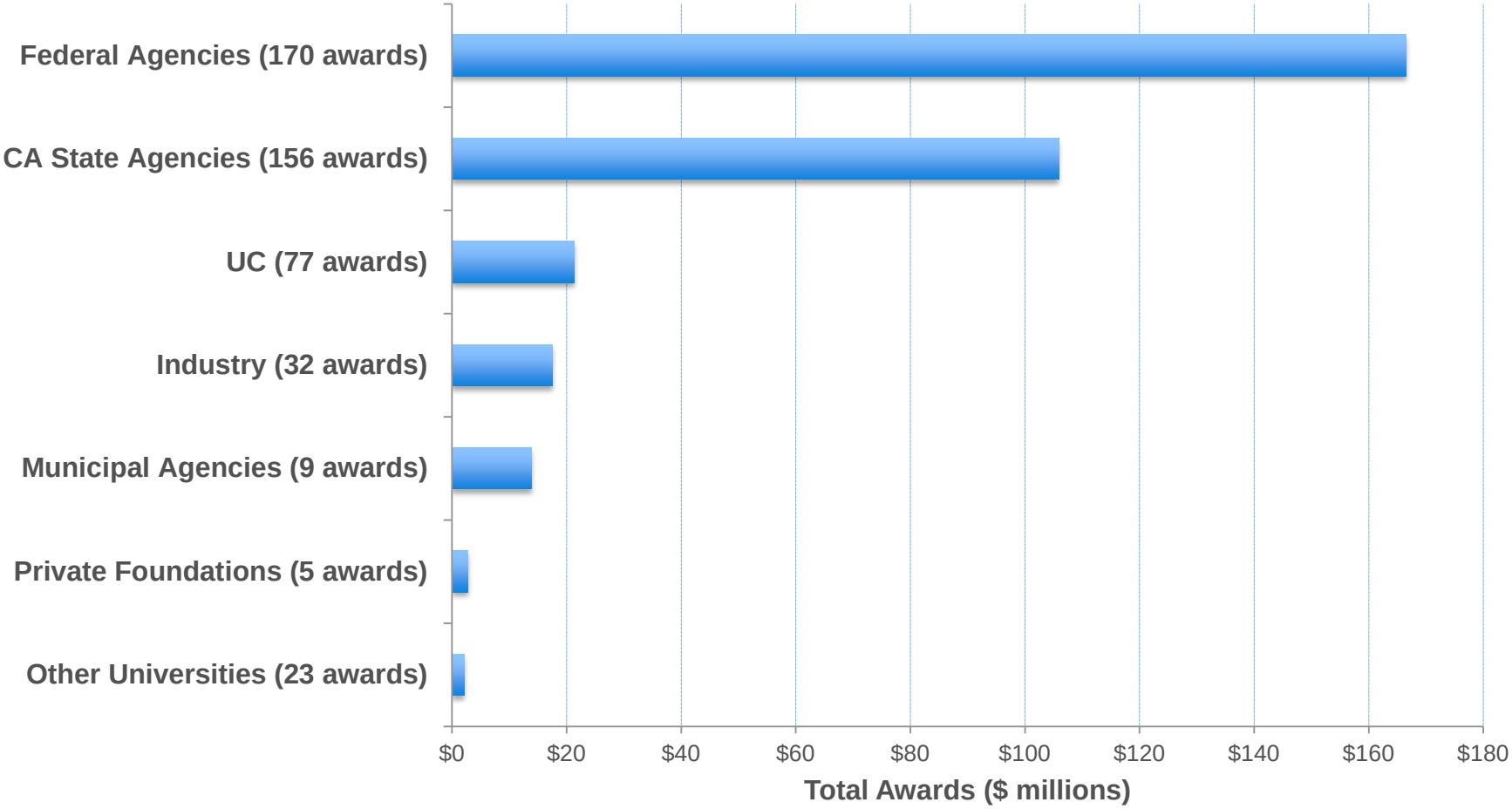
- Obtain picture of **overall research activity** related to carbon neutrality at UC
- Identify major **sources of funding**
- Identify **areas of strength**
- Identify **gaps** and areas needing further strengthening
- Access degree of **collaborative activity** among UC campuses

Research Inventory - Process

- **Source:** UCOP Contracts and Grants database
- **Period:** Five year period between April 1, 2009 and March 31, 2014
- **Search criteria:** Key words based on the NSF's Science and Engineering indicators on clean energy and pollution control.
- **Exclusions:** Awards less than $50,000 were excluded from the analysis. Limited access to National Labs Data.
- **Processing:** Data was cleaned and categorized according to the broadly defined research workshop topics, and sorted into relevant subcategories with input from Working Group members.

Research Grants & Contracts Related to Carbon Neutrality

Basic, Applied, Developmental & Other Research, Q4,FY 09 to Q3,FY13

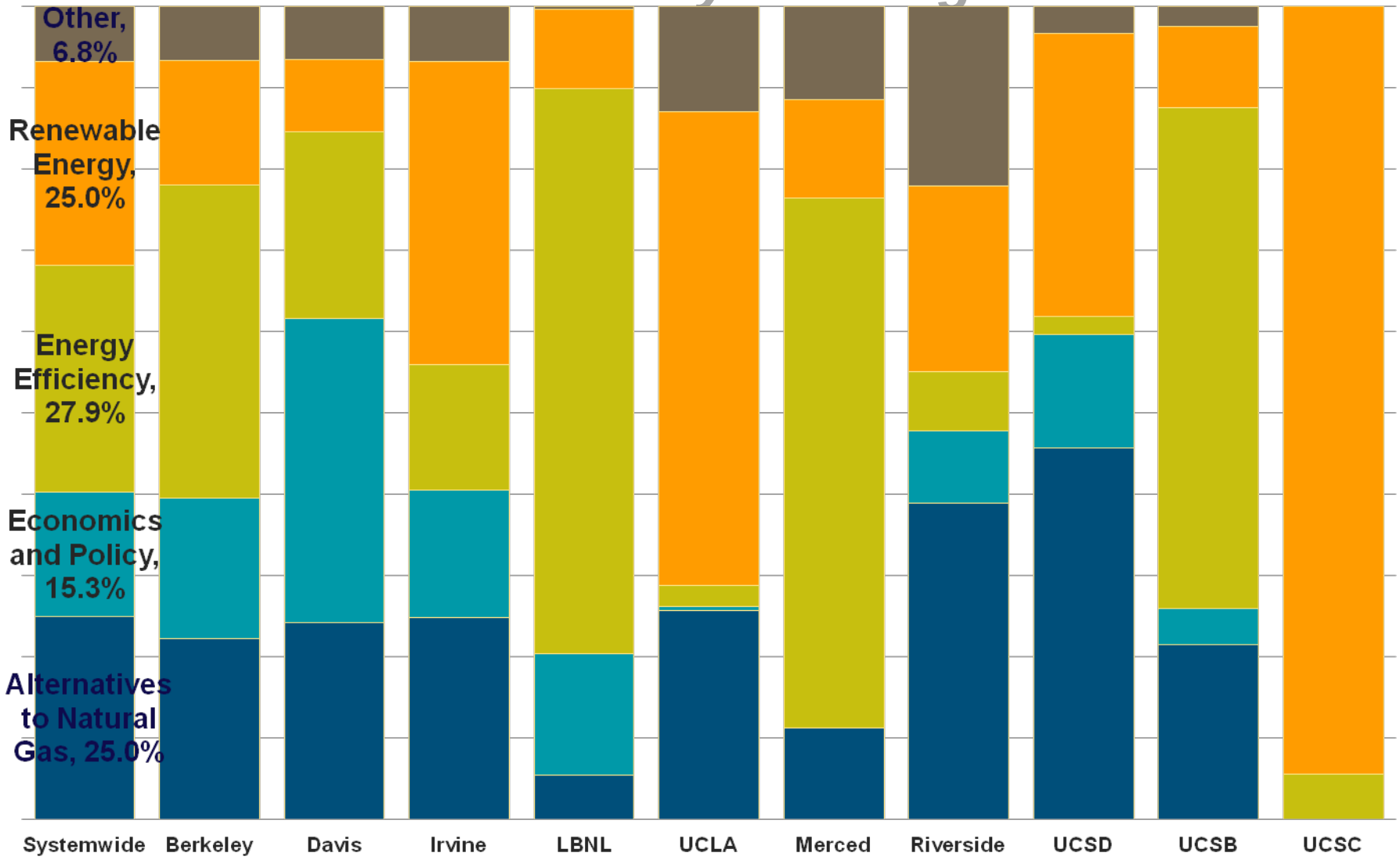


Research Grants by Subject

Time Frame: Q4 09-Q3 14	Basic Research	Applied Research	Other Research	Public Service	Developmental Research	Miscellaneous	Other Service	Total
Alternatives to Natural Gas	**$83,534,160**	**$17,002,961**	**$51,165**		**$5,254,056**	**$1,339,617**	**$138,581**	**$107,320,540**
Technology Development--Fuel Cells	$11,148,182	$4,759,246	$51,165		$678,321			$16,636,914
Technology Development--Other	$22,231,289	$605,001			$4,334,664	$52,740		$27,223,694
Fuel	$50,154,689	$11,638,714			$241,071	$1,286,877	$138,581	$63,459,932
Biogas from Agricultural Waste	*$4,075,474*	*$1,004,074*						*$5,079,548*
Biogas from Landfill	*$2,731,715*	*$1,760,383*						*$4,492,098*
Biomass Derived	*$35,356,636*	*$7,317,841*			*$92,751*	*$638,715*	*$138,581*	*$43,544,524*
From Solid Waste	*$2,632,241*	*$677,861*			*$148,320*	*$445,431*		*$3,903,853*
Nuclear Energy	*$5,358,623*	*$878,555*				*$202,731*		*$6,439,909*
Economics and Policy	**$30,225,708**	**$19,322,565**		**$1,441,234**	**$1,283,947**	**$13,287,775**		**$65,561,229**
Information on Economics	$8,304,174	$3,611,762			$122,500	$4,905,719		$16,944,155
Life Cycle Analysis & Emissions Impacts	$8,384,891	$7,012,492			$936,760	$1,649,704		$18,078,064
Policy for Regulators/Planners	$11,663,406	$3,897,855			$224,687	$2,867,001		$18,652,949
Policy for Technical Implementation	$1,873,237	$4,800,456		$1,441,234		$3,865,351		$11,980,278
Energy Efficiency	**$68,403,935**	**$22,974,637**	**$164,643**		**$10,720,499**	**$16,675,433**	**$753,509**	**$119,692,656**
Building Management Systems	$3,333,152	$6,974,373	$62,000		$865,399	$2,514,859	$50,000	$13,799,783
Building Retrofits	$2,970,023	$975,051			$350,000	$275,000	$304,499	$4,874,573
Demand Response	$16,822,835	$1,011,273			$133,920	$2,249,887		$20,217,915
New Building Designs	$25,516,912	$11,639,747			$1,349,982	$9,855,286		$48,361,927
Other	$17,247,103	$95,000						$17,342,103
Technology Improvements	$2,513,910	$2,279,193	$102,643		$8,021,198	$1,780,401	$399,010	$15,096,355
Insulation	*$1,364,946*	*$1,692,498*				*$199,580*		*$3,257,024*
Lighting	*$1,148,964*	*$586,695*	*$102,643*		*$8,021,198*	*$1,580,821*	*$399,010*	*$11,839,331*
Other	**$17,463,468**	**$8,249,405**	**$300,000**		**$888,306**	**$2,250,167**		**$29,151,346**
Refrigerants	$99,561							$99,561
Sequestration	$6,740,970	$230,445			$150,000			$7,121,415
Transportation	$4,309,892	$7,418,960	$300,000		$738,306	$2,250,167		$15,017,325
Alternative Fuel Development	*$1,460,880*	*$5,398,181*	*$300,000*					*$7,159,061*
Demand Reduction	*$486,714*					*$60,000*		*$546,714*
Energy Efficiency Strategies	*$2,267,298*	*$340,000*			*$666,286*	*$150,000*		*$3,423,584*
Technology Development--EV	*$95,000*	*$1,680,779*			*$72,020*	*$2,040,167*		*$3,887,966*
Other	$6,313,045	$600,000						$6,913,045
Renewable Energy, including Storage and System Integration	**$61,874,835**	**$30,471,904**	**$2,597,284**	**$2,000,000**	**$2,924,467**	**$7,582,765**		**$107,451,255**
System Improvement: Smart Grid & Integration	$20,257,839	$8,714,188			$2,399,551	$4,038,943		$35,410,521
Technology Development: Battery Storage	$11,570,446	$6,255,794			$335,666	$324,998		$18,486,904
Technology Development: Hydro	$655,336	$299,970				$2,679,097		$3,634,403
Technology Development: PV	$19,253,126	$11,202,425	$2,597,284	$2,000,000	$94,250	$278,912		$32,770,479
Technology Development: Thermal Storage	$7,544,573	$1,495,209						$9,039,782
Technology Development: Wave Energy	$1,556,932							$1,556,932
Technology Development: Wind	$1,036,583	$2,504,318			$95,000	$260,815		$3,896,716
Total	**$261,502,106**	**$98,021,472**	**$3,113,092**	**$3,535,451**	**$21,071,275**	**$41,135,757**	**$892,090**	**$429,177,026**

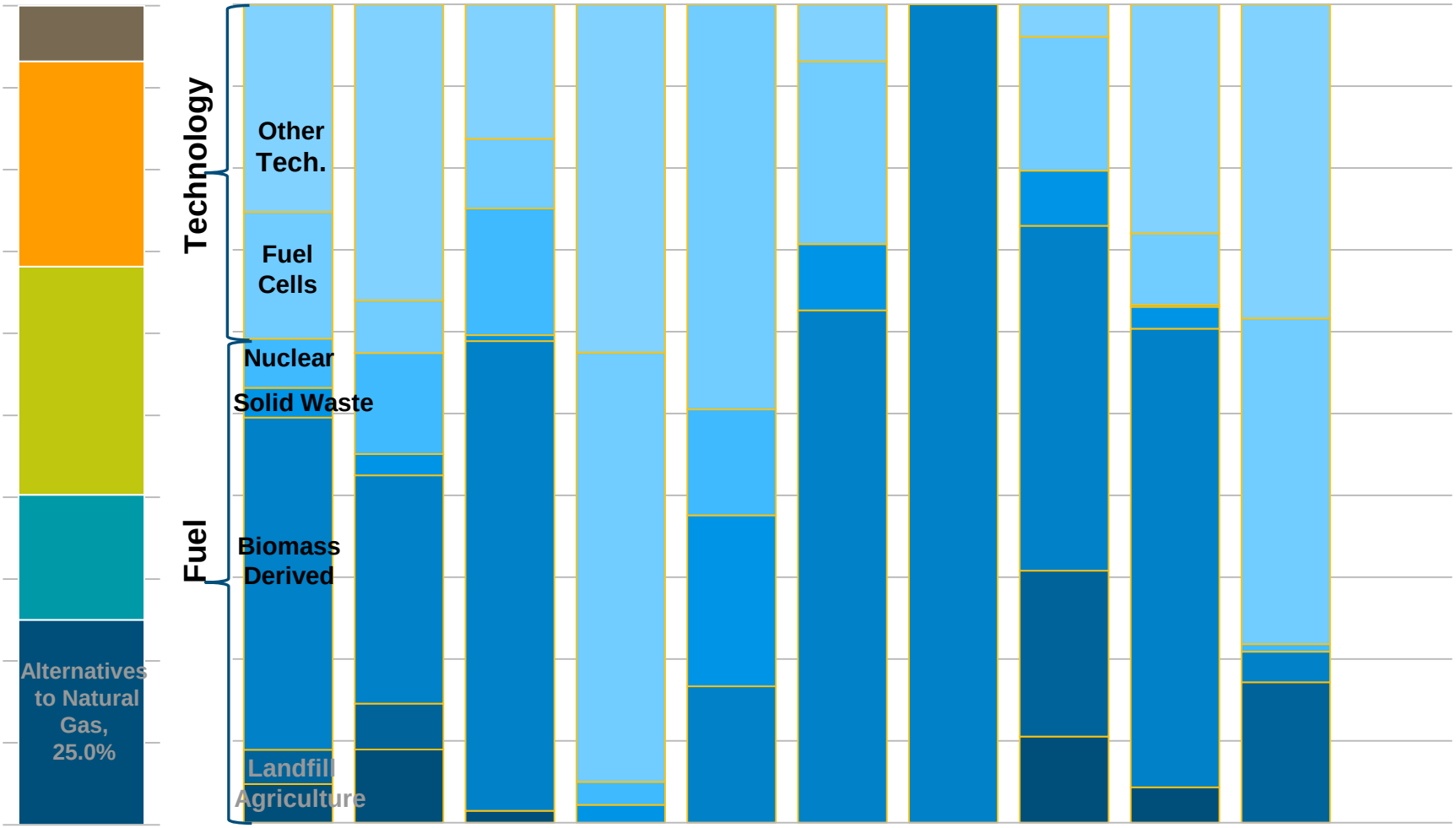
Research Grants & Contracts Related to Carbon Neutrality by UC Campus

Preliminary Findings



Alternatives to Natural Gas

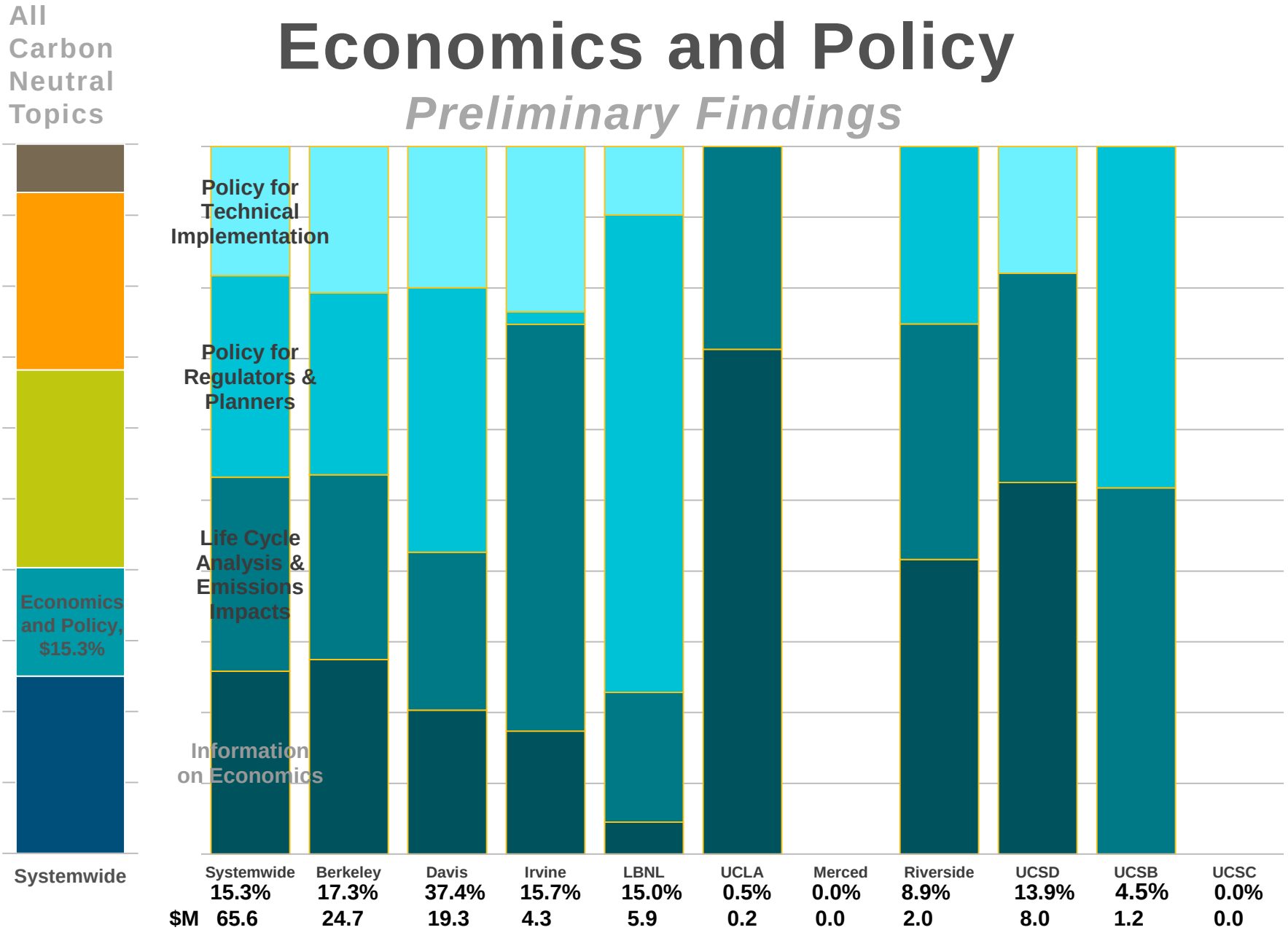
Preliminary Findings



	Systemwide	Berkeley	Davis	Irvine	LBNL	UCLA	Merced	Riverside	UCSD	UCSB	UCSC
	25.0%	22.2%	24.3%	24.8%	5.5%	25.7%	11.2%	39.0%	45.7%	21.5%	0.0%
$M	107.3	31.7	12.5	6.8	2.2	13.4	0.1	8.7	26.4	5.5	0.0

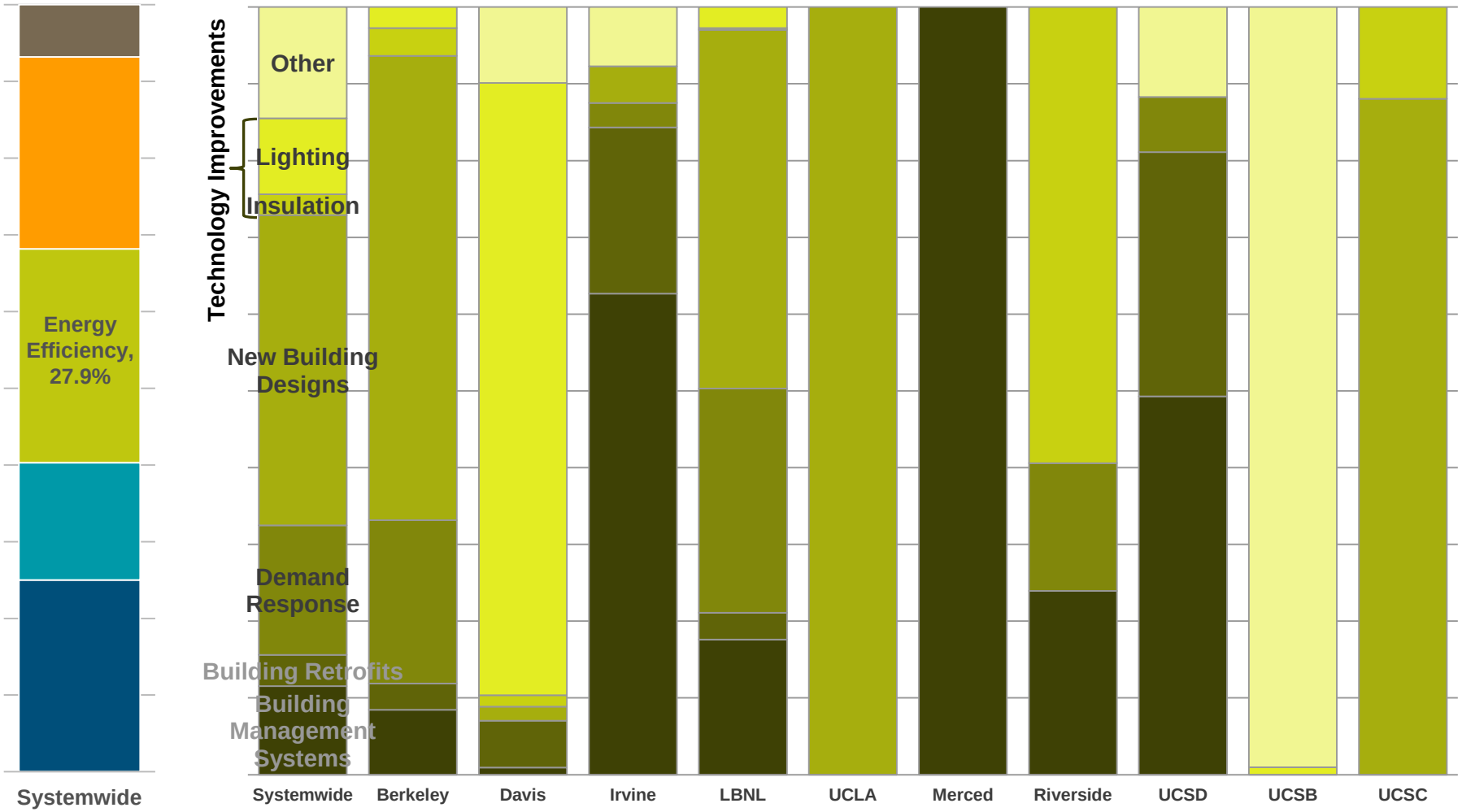
Economics and Policy

Preliminary Findings



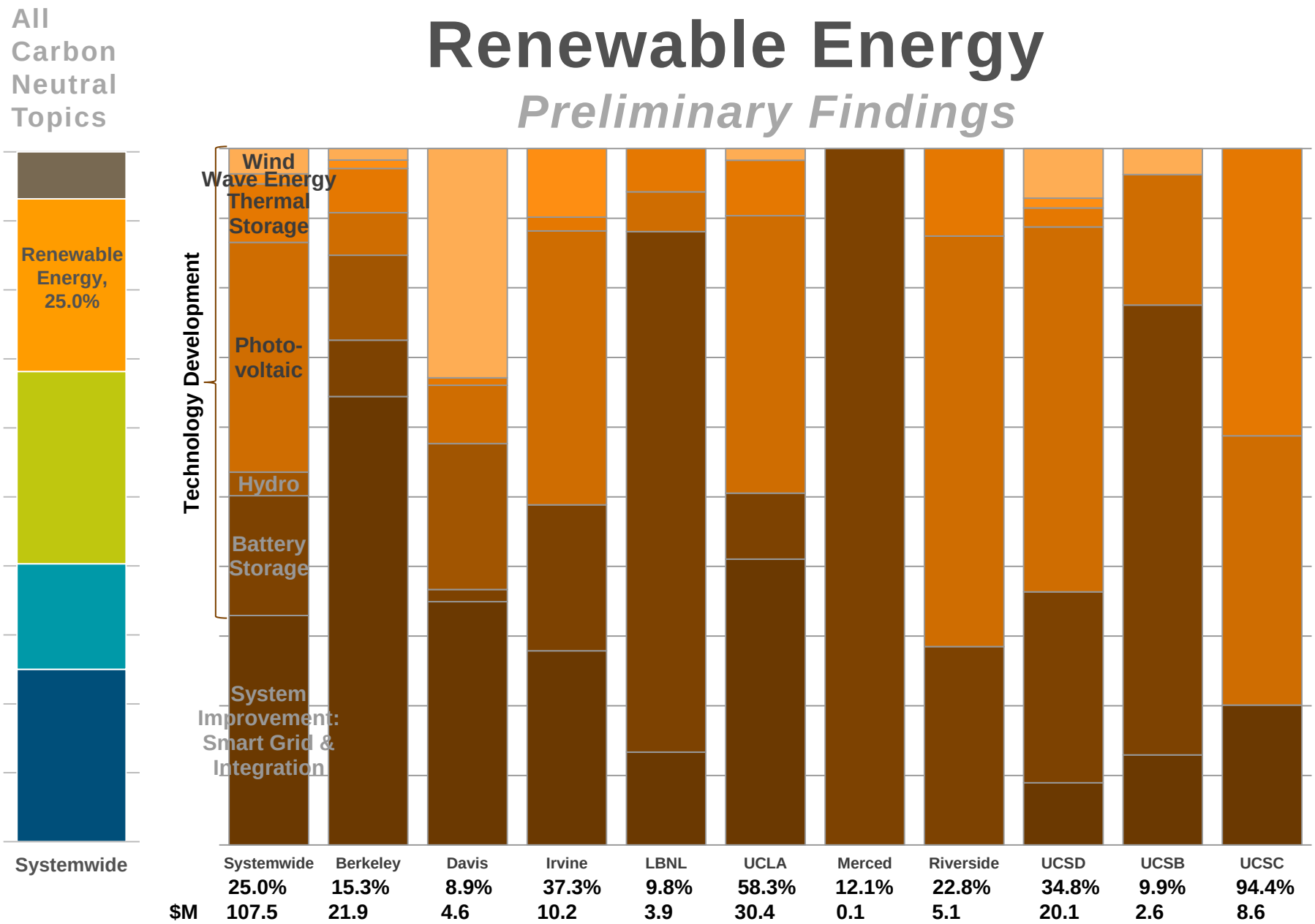
Energy Efficiency

Preliminary Findings



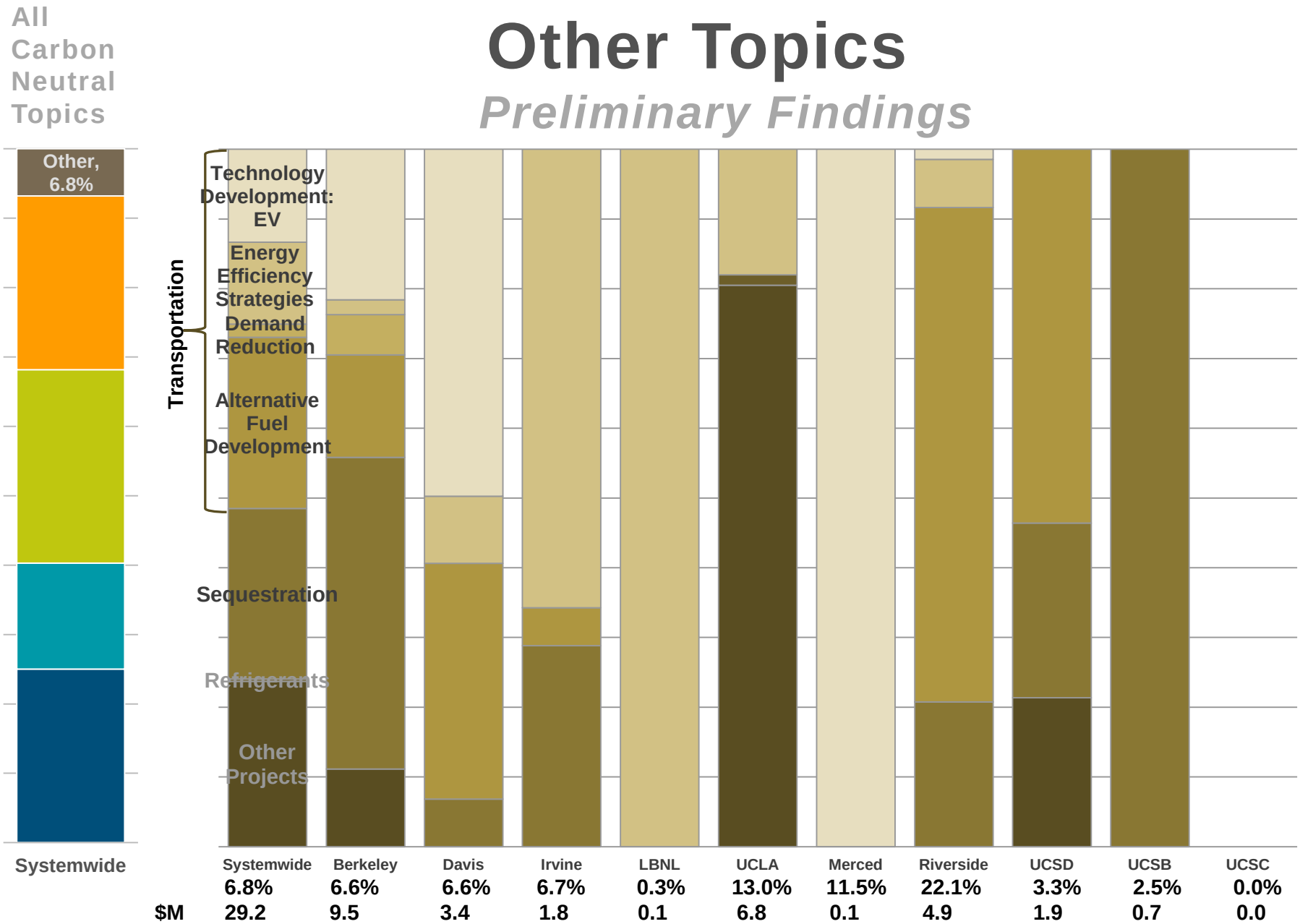
Renewable Energy

Preliminary Findings

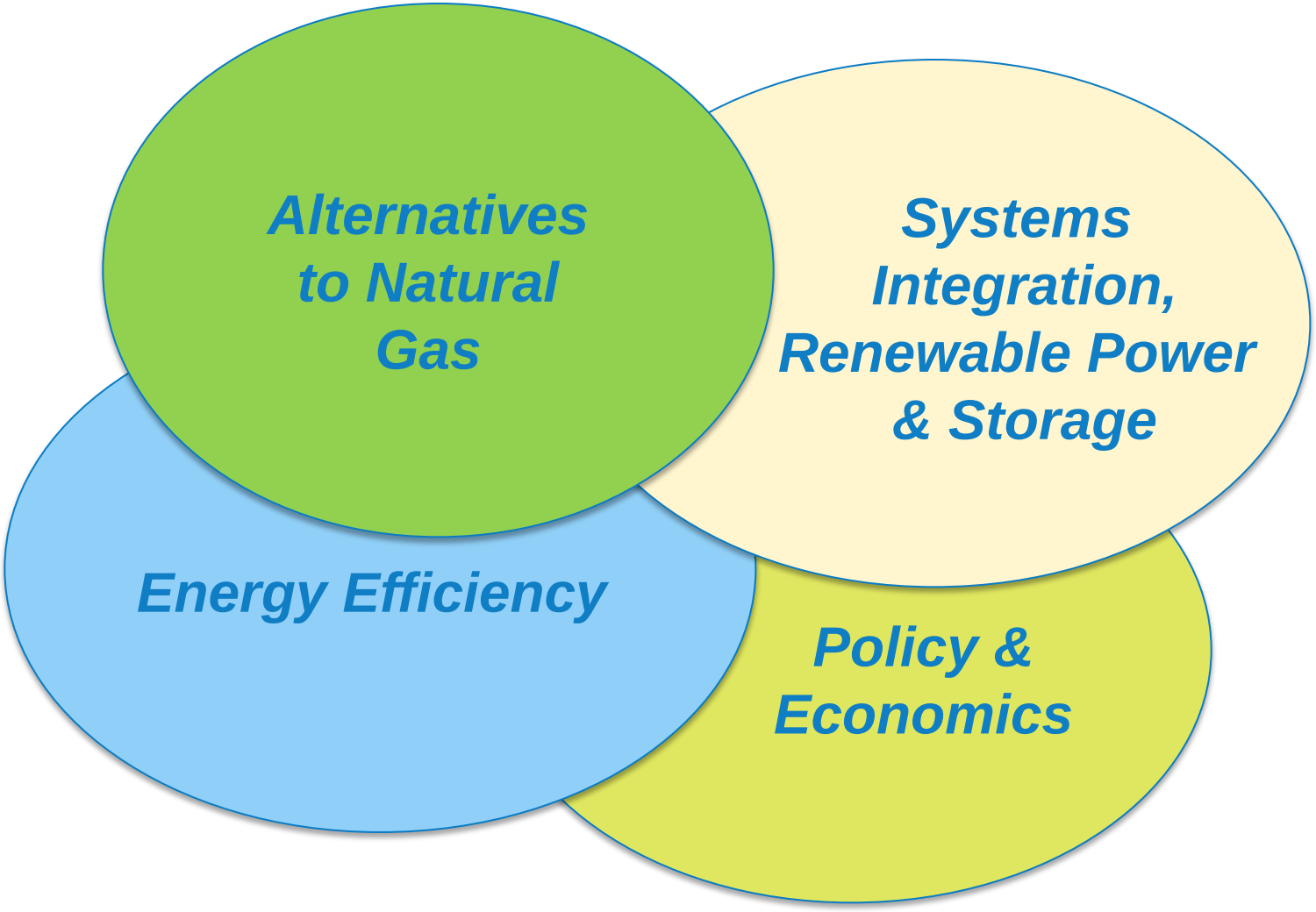


Other Topics

Preliminary Findings



Breakout Groups



Energy Efficiency

- **Intelligent building** management systems & controls.
- More accurate **modeling** tools
- **Data Management & Research -** Making performance data actionable. A central repository for energy efficiency data & best practices.
- **Electrification of heating** by heat pumps using solar & other renewable electricity.
- **Behavioral research:** The inexorable human factor
- **Advanced technologies:** : E.g: photochromic windows, advanced lighting systems, phase change insulation.

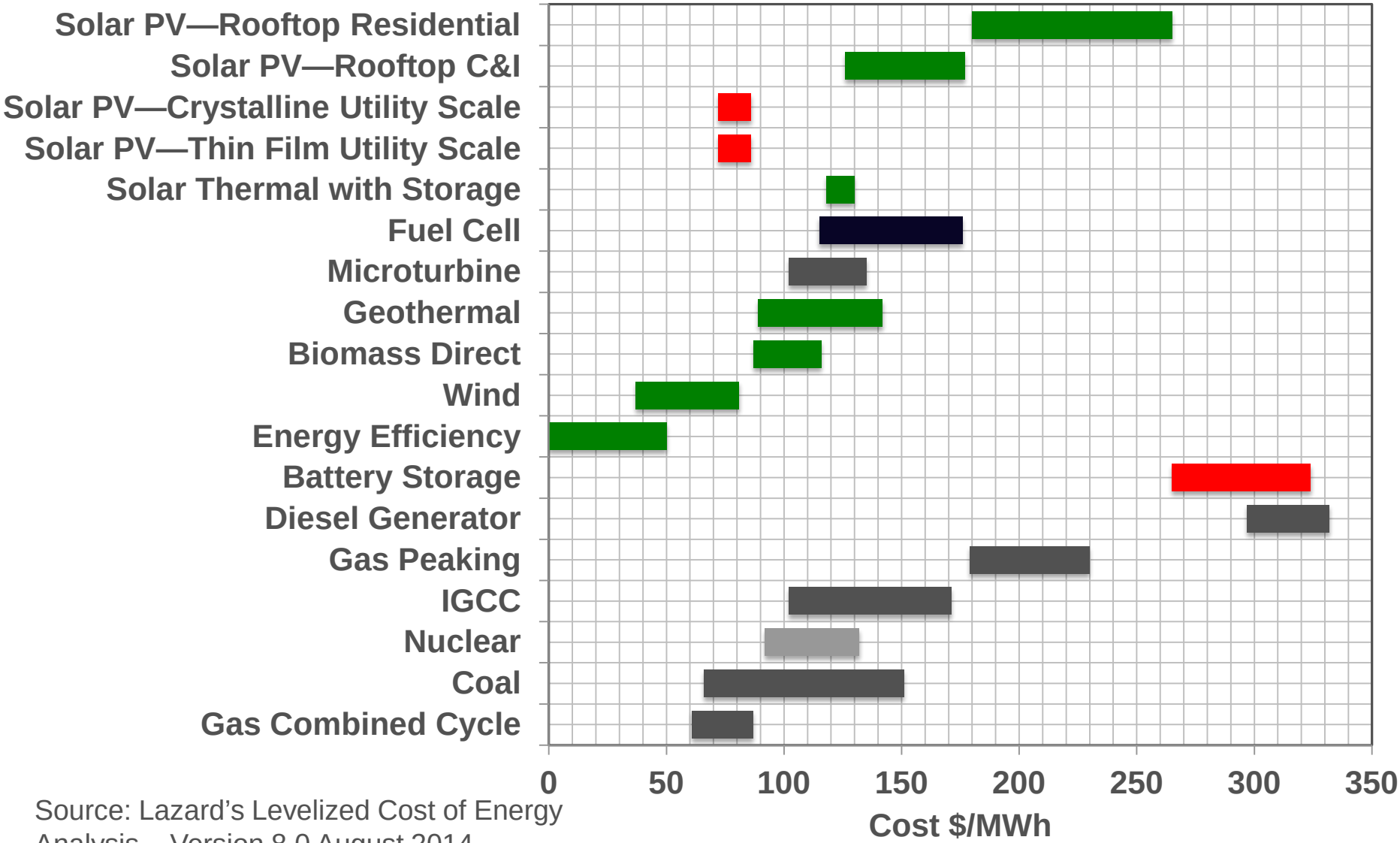
Renewable Energy, Systems Integration & Storage

- **Systems integration:** Research needed to address intermittency challenge, micro-grid stability & optimization.
- **Storage:** A major challenge – more research needed on batteries and alternative storage technologies – H_2 generation by electrolysis for natural gas alternative.
- **Testbed**: LLNL site 300

UC San Diego self-generates 90% of campus energy needs through a 42 MWpeak Microgrid

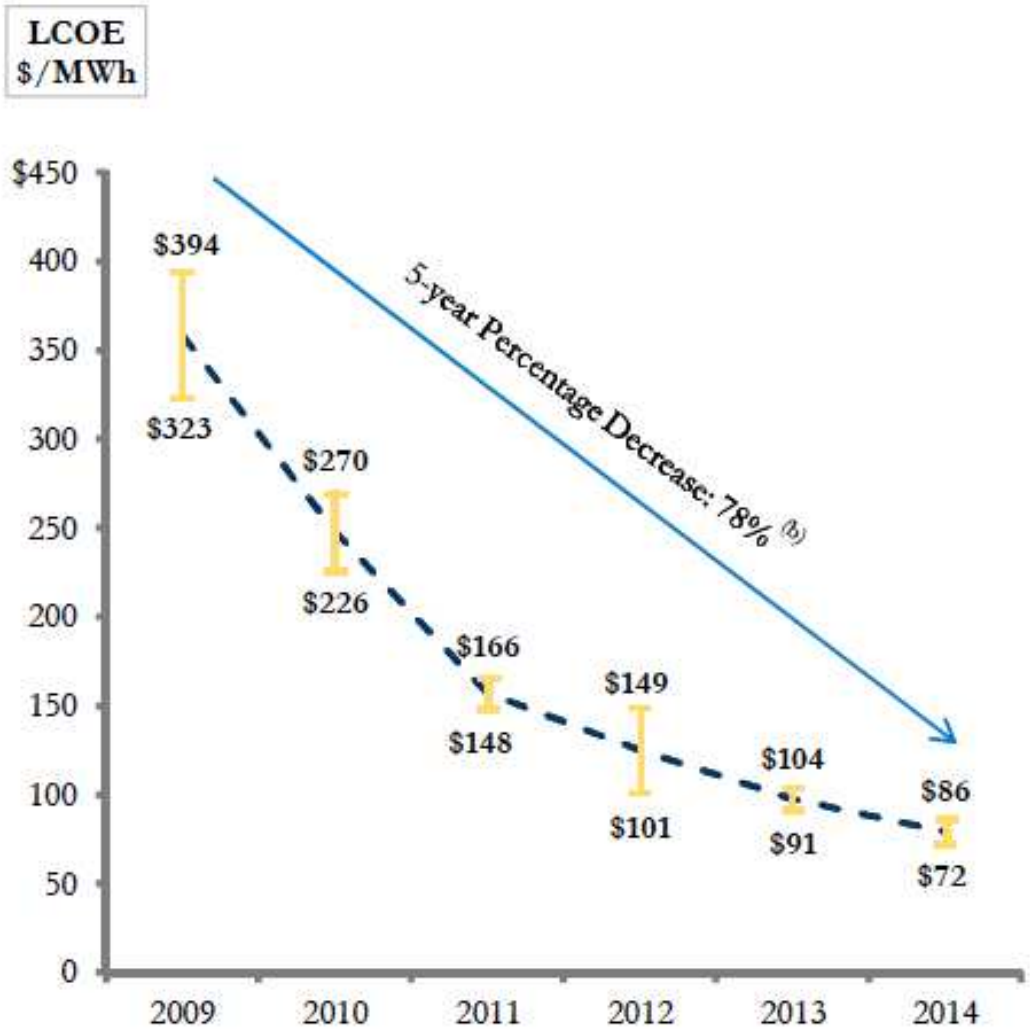
- **Solar Energy:** More power purchase agreements & on-site installations (business case studies & regulatory research).
- **Alternatives to solar PV:** Wind, solar thermal, concentrator solar, wave energy, geothermal.

Levelized Cost of Electricity (Unsubsidized)



Source: Lazard's Levelized Cost of Energy Analysis – Version 8.0 August 2014

Levelized Cost of Solar Electricity (PV)



Source: Lazard's Levelized Cost of Energy Analysis – Version 8.0 August 2014

Site 300 – Renewable Energy Research Facility

Utility scale Research

Utility scale Generation

Research, Testing, Demonstrations, and Education

- Wind, solar energy
- Energy storage
- Micro-grids
- Systems optimization
- …

Renewable Generation

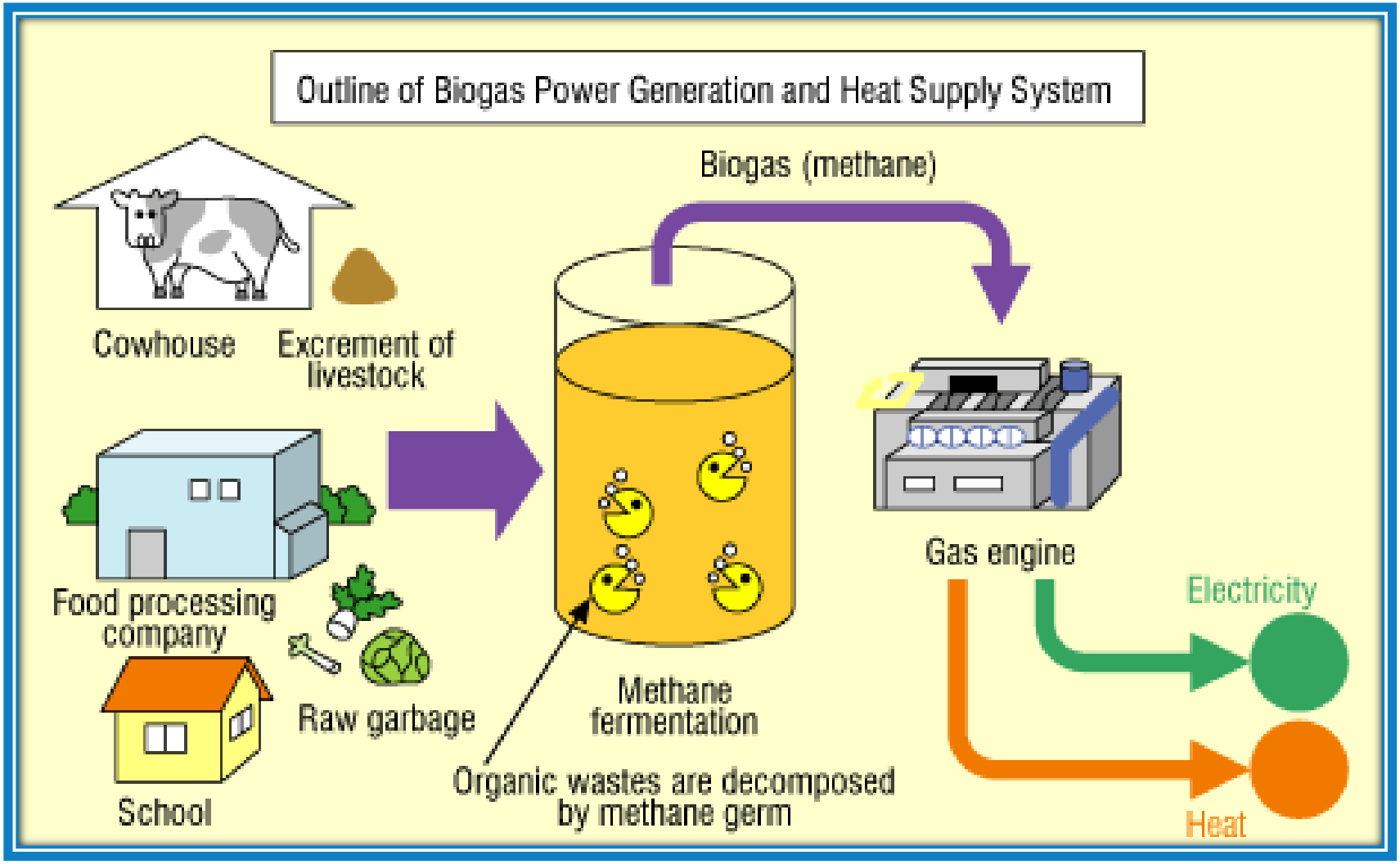
- 90 MWs Wind
- 60 MWs Solar

Natural Gas – A Major Challenge

65% of GHG emissions; 67% of power (10 campuses)

- Develop alternatives such as **biomethane** from municipal solid waste and agricultural waste (credit for capturing existing emissions)
- **Electrification of heating** by heat pumps using solar & other renewable electricity.
- **Fuel cells:** Research needed to increase efficiency and reduce emissions, cost.
- **Demonstration project**: Capture waste heat and CO_2 from a co-gen or central heating; use it to grow algae to produces methane; capture waste from algae process to power a bio-digester; use solids from bio-digester to feed algae.

Biomethane Generation



UC Davis Anaerobic Digester

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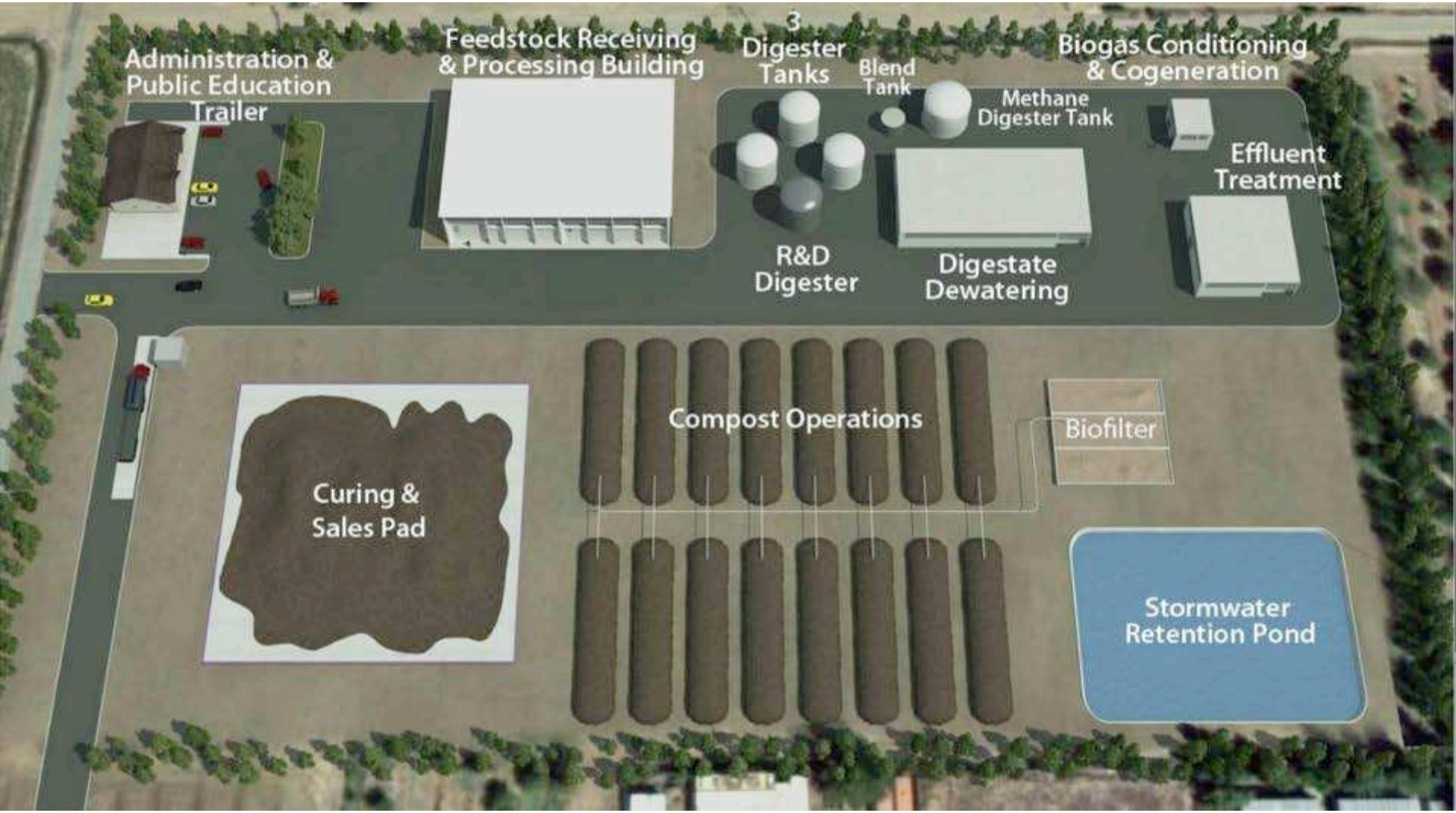

Economics & Policy

- **Regulatory and policy analysis:** E.g., no direct access to wholesale electricity for 5 campuses
- **Comprehensive Supply Curve Analysis:** A comprehensive look at technology trade-offs and breakpoints when technologies become viable.
- **Life Cycle Analyses:** Emphasize GHG emissions.
- **Behavior Change and Incentives**: Evaluate incentives & policies that encourage positive behavior re carbon emissions.

Next Steps

- **Solicit Research funding:** UCOP seed funding; CEC & other CA agencies; Federal agencies.
- **Develop Linkages to other Working Groups of Carbon Neutral Initiative:** Finance, Policy, Faculty Engagement, etc.
- **Develop Linkages to other Initiatives:** Water, Food, Mexico.
- **Advocates for Initiative:** Emphasize GHG emissions.
- **Foster System-wide collaborations**: funding incentives, test-beds, sharing data & best practices.
- **Additional Workshops**: Water/Energy nexus EERE; Medical Centers.; More detailed technology.

Acknowledgements

We are grateful to **President Napolitano** for her leadership and inspiration and for providing an opening statement via a video to set the initial tone and goals of the workshop.

In addition, We thank **Andrew McAlllister**, Commissioner of the California Energy Commission and **Scott Murtishaw**, Energy Advisor at California Public Utilities Commission for their insightful keynote remarks. We are also grateful **for Wendell Brase's** leadership, who as co-chair of the President Global Climate Leadership Council, made some key remarks that were central to guiding the Workshop.

Special thanks go to **Matthew StClair and Lifang Chiang** at **UCOP** who were centrally important in developing and supporting the Workshop, and to **Jen McJannet**, and her team at the **UCSB Institute for Energy Efficiency** for executing the workshop.

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Questions?

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