Analysis of Energy Consumption
for Building Operations in Los Angeles County

Giovanni Circella and Robert A. Johnston
University of California, Davis

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OVERVIEW OF THE RESEARCH

- Part of a study that investigates consumption of electricity and natural gas for several categories of residential and non-residential buildings

- Based on the integration of energy consumption data from utility companies with data from several other sources

- Creation of **comprehensive database** for analysis of energy consumption that includes information on:
  - *Energy consumption*
  - *Climate data*
  - *Geomorphomological data*
  - *Building characteristics*
  - *Socio-demographics*

- Investigation of energy consumption patterns and estimation of econometric models to explore relationships with several explanatory variables

Annual Electricity Consumption Data obtained from LADWP

Monthly Natural Gas consumption data available for Long Beach area
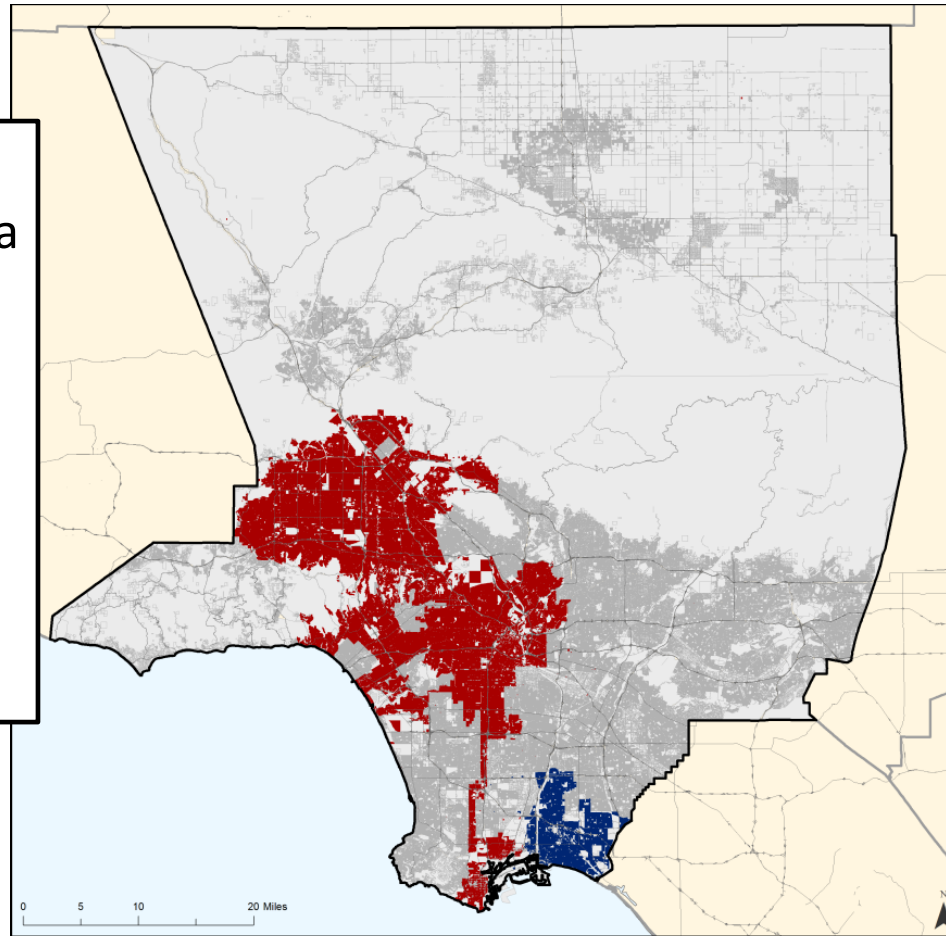
Utility Data Coverage

- Los Angeles Department of Water & Power - Electricity Consumption
- Long Beach Gas & Oil Department - Natural Gas Consumption

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ENERGY ANALYSIS ZONES

Lack of spatial overlap led to the creation of *Energy Analysis Zones*

Least Common Multiple between:
- Parcels (assessor's data)
- Zip+4 (energy data)

Total # EAZ	**449,539**
Total # EAZ in LADWP	150,743

Total # Parcels	**2,382,897**
Total # Parcels in LADWP	772,671
Total # Zip+4	**649,457**
Total # Zip+4 in LADWP	254,910

EAZ and Parcel

Legend

☐ EAZ

▨ Parcel

ENERGY DATABASE

INFORMATION ON AGE OF BUILDINGS

NUMBER OF BEDROOMS, BATHROOMS, BUILDING TECHNOLOGY

TOTAL SQFT BY USE TYPE

Additional information on:
- Zoning Type
- Use Type (Building)
- Year of Improvements/ Retrofitting
- Climate data by EAZ
- etc.

- Energy consumption data from utility companies at zip+4 level
- Assessor's data provide information on the building stock
- Sociodemographics from ACS and Census data
- Other ICE/ULTRANS projects for geomorphological and climate data

ENERGY DATABASE

Population by EAZ

Population
- 0 - 25
- 26 - 50
- 51 - 100
- 101 - 200
- 201 - 400
- 401 - 3612

Income Distribution

Median Income
- ≤ 30,000
- 30,001 - 60,000
- 60,001 - 90,000
- 90,001 - 120,000
- > 120,000
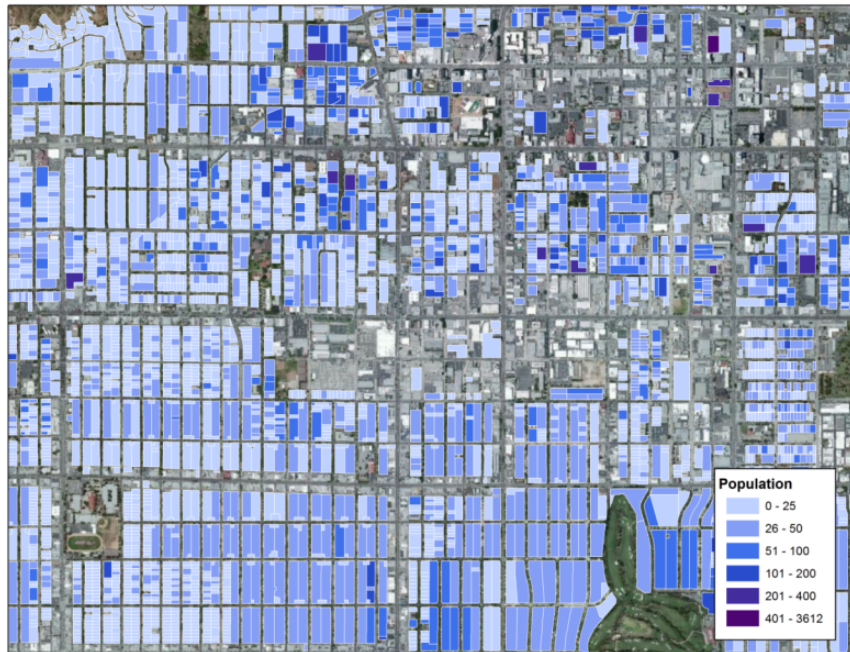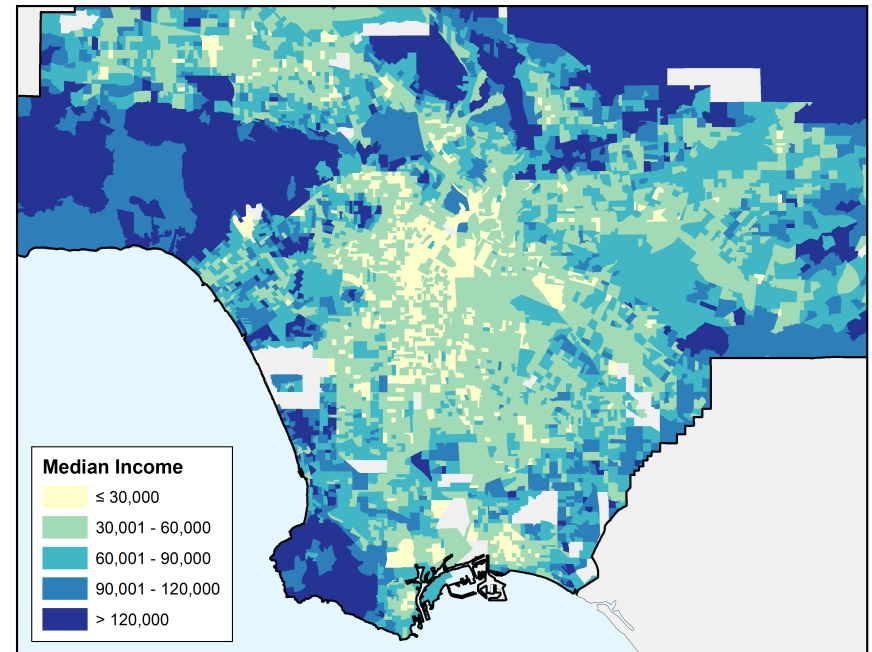
ENERGY DATABASE

Geomorphological data: e.g. slope

Average Slope
- 0 - 1
- 1 - 5
- 5 - 12
- 12 - 25
- > 25

Building climate zones

Zone 16

Zone 14

Zone 16

Zone 9

Zone 6

Zone 8

Zone 10

Legend

EAZ
TMAX0802
- 17.51 - 18.70
- 18.70 - 18.90
- 18.90 - 19.10
- 19.10 - 19.20
- 19.20 - 19.43
- Parcel
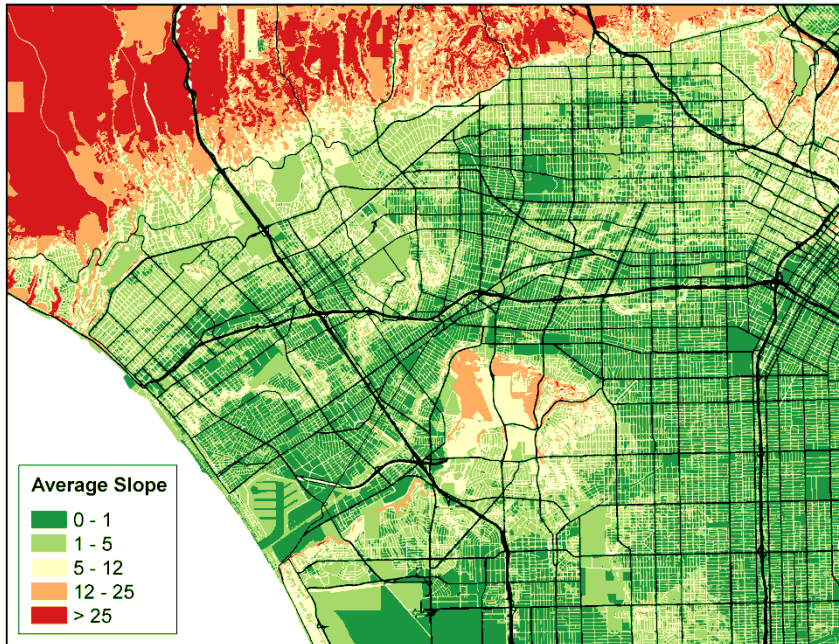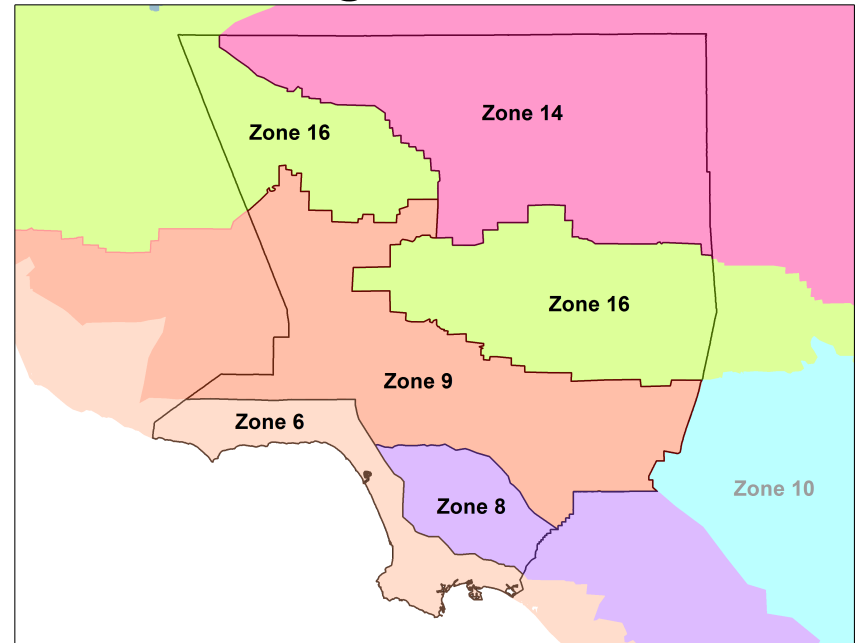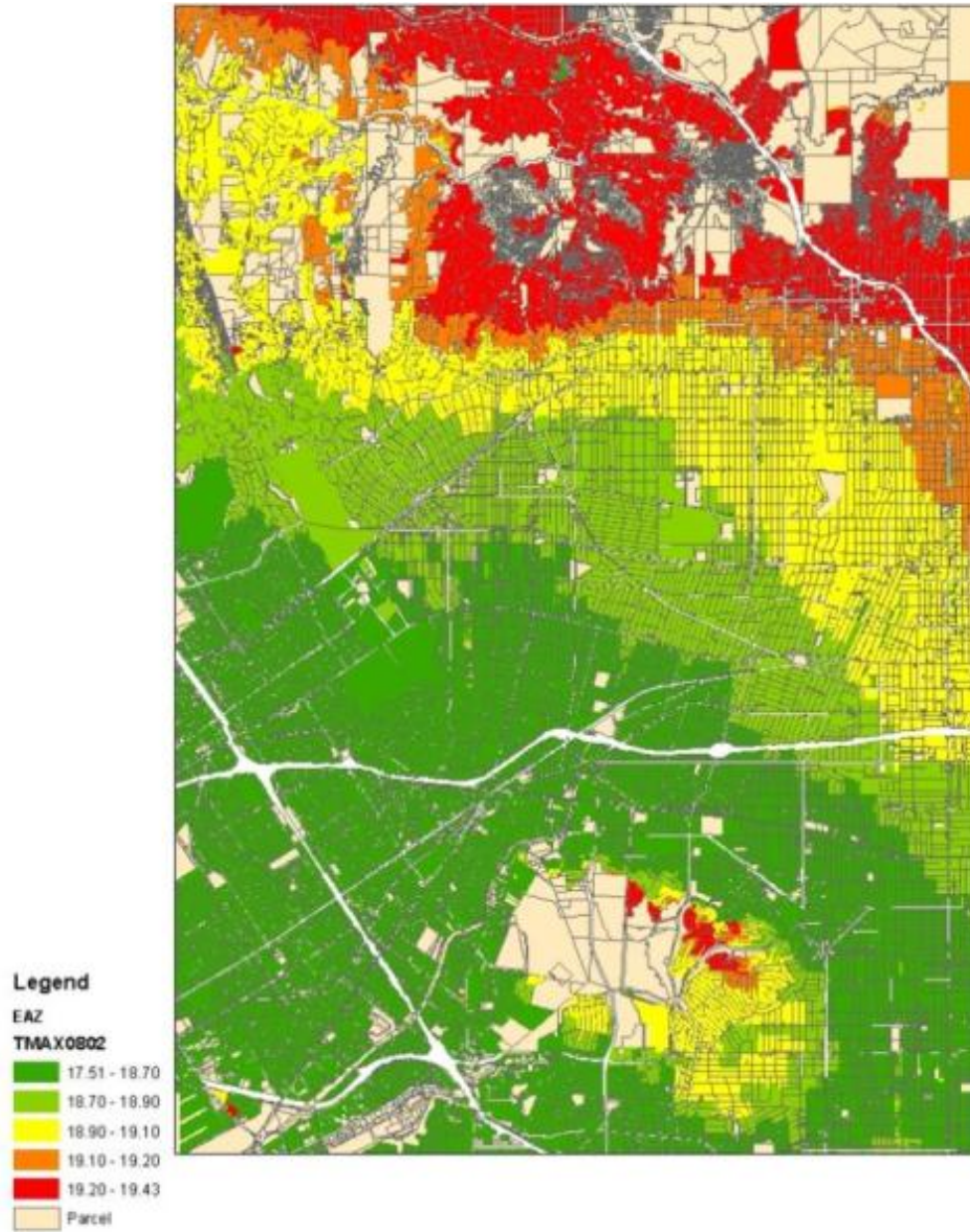
Detailed Climate Data (e.g. *Max Temperature*, in this figure)

Land Use Types by EAZ

Predominant Use Type
- Single Family Res
- Multi-Family Res
- Mixed Density Res
- Commercial
- Industrial
- Mixed/Vacant/Other

Age of Buildings

Average Year Built
- 1801 - 1900
- 1901 - 1920
- 1921 - 1940
- 1941 - 1960
- 1961 - 1980
- 1981 - 2000
- 2001 - 2009
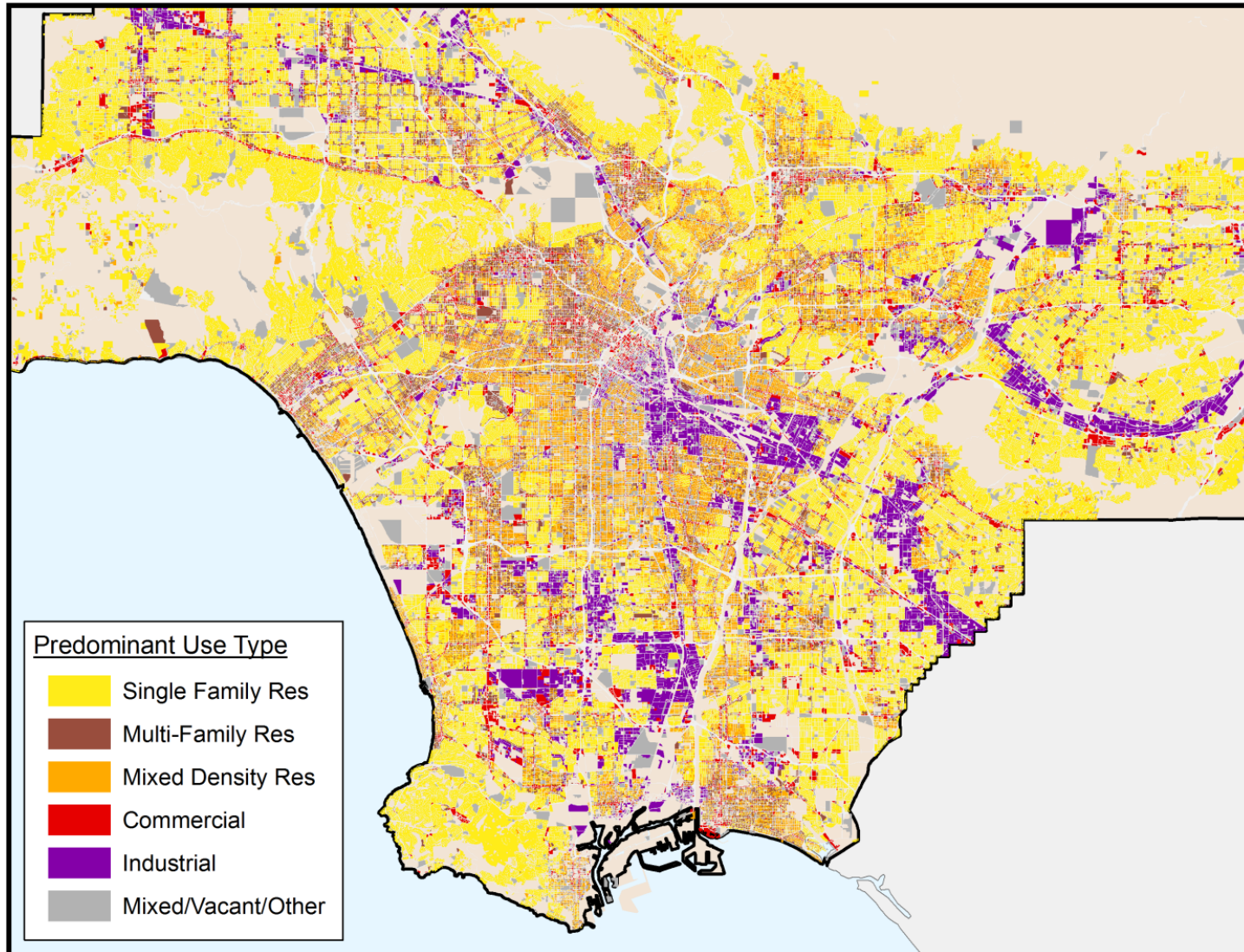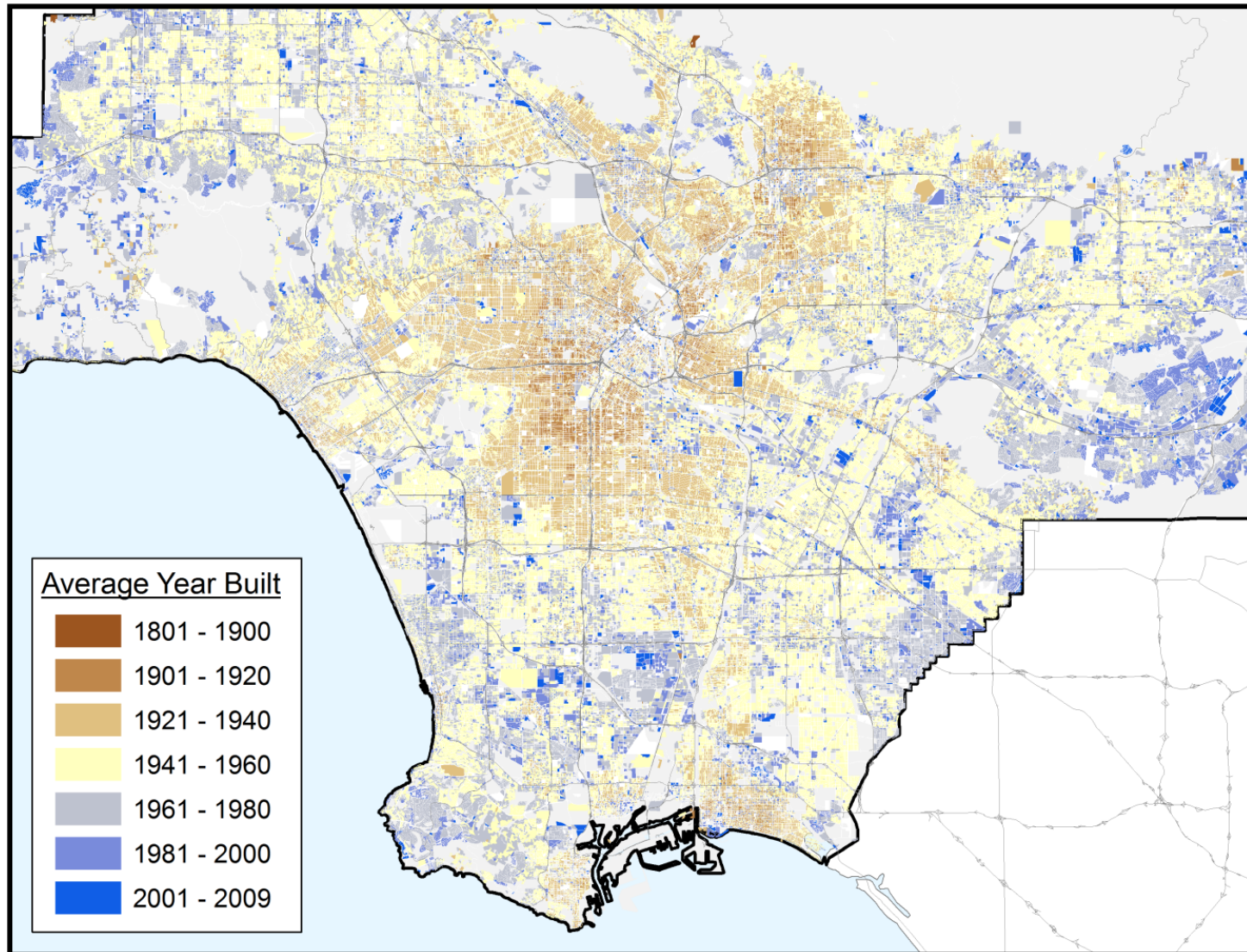
- ✓ *WHERE is energy consumed, HOW and by WHOM?*

- ✓ Impact of several variables, e.g. building characteristics, socio-demographics, geographical location and climate data.

- ✓ Identification of energy consumption patterns and support in evaluation of policies for energy efficiency

- ✓ Development of pilot methodology that can be later applied with more detailed data and to other regions

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ELECTRICITY USE (PER CAPITA)

Kilowatt-Hours / Person (2008)

- 0 - 1,000
- 1,001 - 2,000
- 2,001 - 3,000
- 3,001 - 4,000
- 4,001 - 5,000
- 5,001 - 6,000
- 6,001 - 7,000
- ≥ 7,001

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ELECTRICITY USE (PER SQ. FT.)

Kilowatt-Hours / sq. ft. (2008)

- 0.0 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0
- 5.1 - 6.0
- 6.1 - 7.0
- 7.1 - 8.0
- 8.1 - 9.0
- ≥ 9.1

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Linear regression model for residential electricity use per capita
(LADWP area, with modified constant for Multi-Family housing units)

Variable	Unstandardized Coefficients	Standardized Coefficients	p-value
Constant	3,104.219		<.001
MF Constant (modifier)	-926.914		<.001
Population per unit			<.001
Median Income			<.001
Avg. Slope			<.001
Avg. SF unit size (sq. ft.)			<.001
Avg. SF unit size, with po			<.001
Avg. MF unit size			<.001
Year Built		.044	<.001
Year B		.012	<.001
Climate		-.112	<.001
Climate 2	-334.472	-.067	<.001
Aspect - So	-153.161	-.043	<.001
Aspect - Nor	45.316	.006	.004
Sample Size (N)	115,987		
R Square	.578		

Dependant Variable: *Annual Electricity Consumption per capita* (KWh)

WE WILL NOT GO IN THE DETAILS OF ECONOMETRIC MODELS IN THIS PRESENTATION

ELECTRICITY CONSUMPTION IN RESIDENTIAL BUILDINGS

Significant impacts on *energy consumption (per capita)*:

- ✓ **Single Family vs. Multi-Family**
- \+ **Presence of a pool**
- \+ **Housing unit size (sq. ft.)**
- \+ **Income**
- – **Population per unit**
- – **Distance from ocean/climate zone**
- \+ **Slope**
- \+ **Age of building**
- – **Aspect (North)**

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Models of energy consumption were developed for several building types and used in a pilot assessment of energy consumption for building operations

Floorspace type	No. of Units	Sum of Sq. Ft.	Total Energy Consumption (MWh)
a) Residential Sector			
SF residential[1]	381,385	619,160,875	3,197,437
SF residential with pool	99,773	259,130,732	1,487,315
MF residential[2]	1,046,667	808,409,437	4,044,014
Total Residential Sector	**1,527,825**	**1,686,701,045**	**8,728,765**

Floorspace type	Sum of Sq. Ft.	Total Energy Consumption (MWh)
b) Non-Residential Sector		
Developed amusement park space	747,662	18,972
General commercial	153,640,527	3,898,549
Government operations space	7,564,050	126,242
Office space[3]	168,855,095	2,818,140
Hospital space	20,594,888	501,920
Mall and big box retail space	34,669,370	879,717
Mixed use space	43,114,895	805,728
Primary K-12 education space	76,623,166	696,715
Secondary education space	3,770,901	34,288
Religious space	22,589,725	205,403
Warehouse & distribution space	94,140,152	1,077,337
Industrial space[4]	196,424,142	2,793,103
Total Non Residential Sector	**822,734,573**	**13,856,115**
Total LADWP area	**2,509,435,618**	**22,584,880**
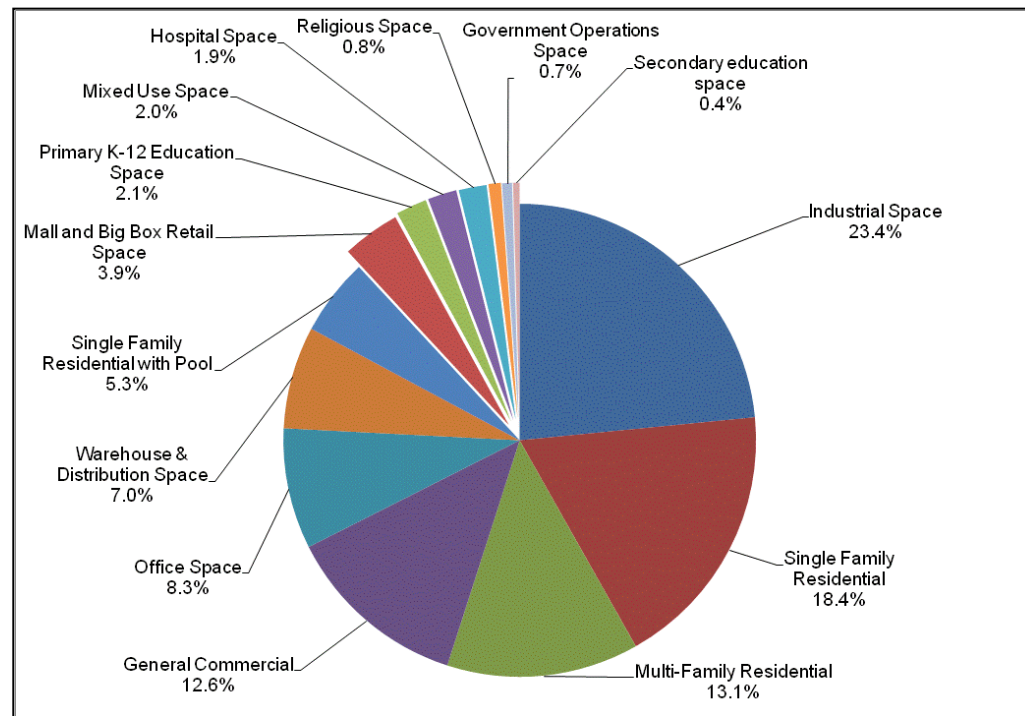
Note: [1]includes urban mobile homes; [2]includes apartments, joined and GQ residential; [3]high and low density office space; [4]light and heavy industrial space.

Pie chart of GHG emissions by building type: Industrial Space 23.4%, Single Family Residential 18.4%, Multi-Family Residential 13.1%, General Commercial 12.6%, Office Space 8.3%, Warehouse & Distribution Space 7.0%, Single Family Residential with Pool 5.3%, Mall and Big Box Retail Space 3.9%, Primary K-12 Education Space 2.1%, Mixed Use Space 2.0%, Hospital Space 1.9%, Religious Space 0.8%, Government Operations Space 0.7%, Secondary education space 0.4%

VALUE OF ENERGY DATA ANALYTICS AND NEXT STEPS

- Despite the limitations in the level of data aggregation, the project allows analysis of energy consumption depending on many variables (building types, building age, etc.)

- Pilot methodology – future studies can focus on impacts in specific areas or population targets (e.g. low-income)

- High-quality data fundamental for accurate analyses (temporal and spatial level of aggregation): on-going discussions on Smartmeter data at address level

- Analysis of energy consumption variation during the day/ depending on weather conditions

- Support policy evaluation, understanding customer needs and effectiveness of energy saving programs

- University as a trusted third party: analytic rigor and transparency, while protecting privacy and security

- Results produced at aggregate level, fulfilling requirements for confidentiality of the information

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- LADWP provided annual electricity consumption data

- Several colleagues at the University of California, Davis contributed to the analyses for this project, in particular Mike McCoy (now at the California Strategic Growth Council), Yang Wang, and Eric Lehmer.

For more information, please visit:
http://ultrans.its.ucdavis.edu/

For any question, please contact:

Dr. Giovanni Circella
Urban Land Use and Transportation Center
University of California, Davis
Phone: (530)-554-0838
e-mail: gcircella@ucdavis.edu