

Urban Metabolism Analysis to Better Understand Complex Urban Systems

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International Symposium on Life Cycle Assessment for
Pavements

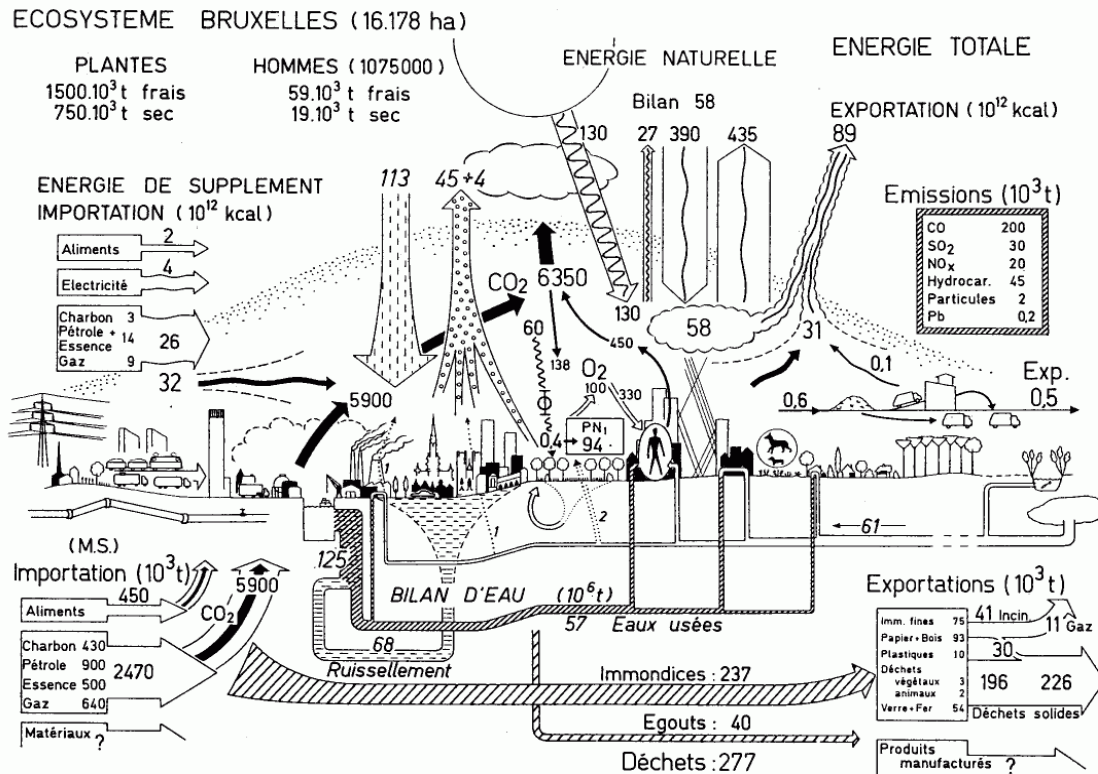
Urban Metabolism

- The sum total of the technical and socio-economic processes that occur in cities resulting in growth, production of energy and elimination of waste.

Kennedy et al 2007

CITIES

- Our built environment is a large in-use repository or *stock* humans have accumulated
- Humans use approximately 60 billion tons of material every year, or the equivalent of the natural production of all plants on earth
- *Urban* metabolism studies are the quantification of the flows into cities or communities (electrons, water, wood, air, other materials, food. . .) flows out as pollution, other waste or losses in the form of heat and distribution losses, plus what has remained inside.



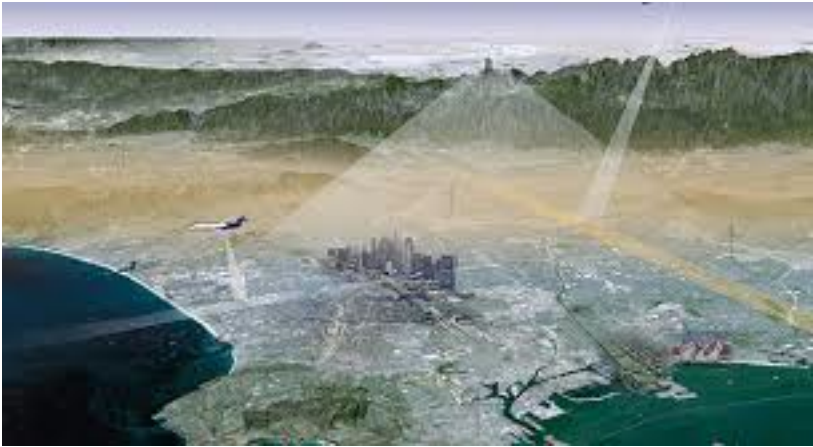
Brussels, Belgium early 1970s. Source:
Duvigneaud and Denayeyer-De Smet 1977

What is Missing in UM Today?

- Systems approach – LCA and environmental impacts (EIO-LCA)
- Embedded Energy
- Ground-up analysis
- Linking to policy drivers – the soft infrastructures of codes, conventions, rules, laws and cultural expectations.

Los Angeles County, a UM 2.0 Experiment in Research

- UM a good integrative framework
- Lends itself to systems analysis
- With more ground-up data, relevance could be enhanced
- Highly empirical to start
- Policy drivers to be derived, or selected.
- Mission: science for action



NASA views of Los Angeles County

Image above: sensors for GHG emissions Monitoring, proposed by NASA



Our Approach

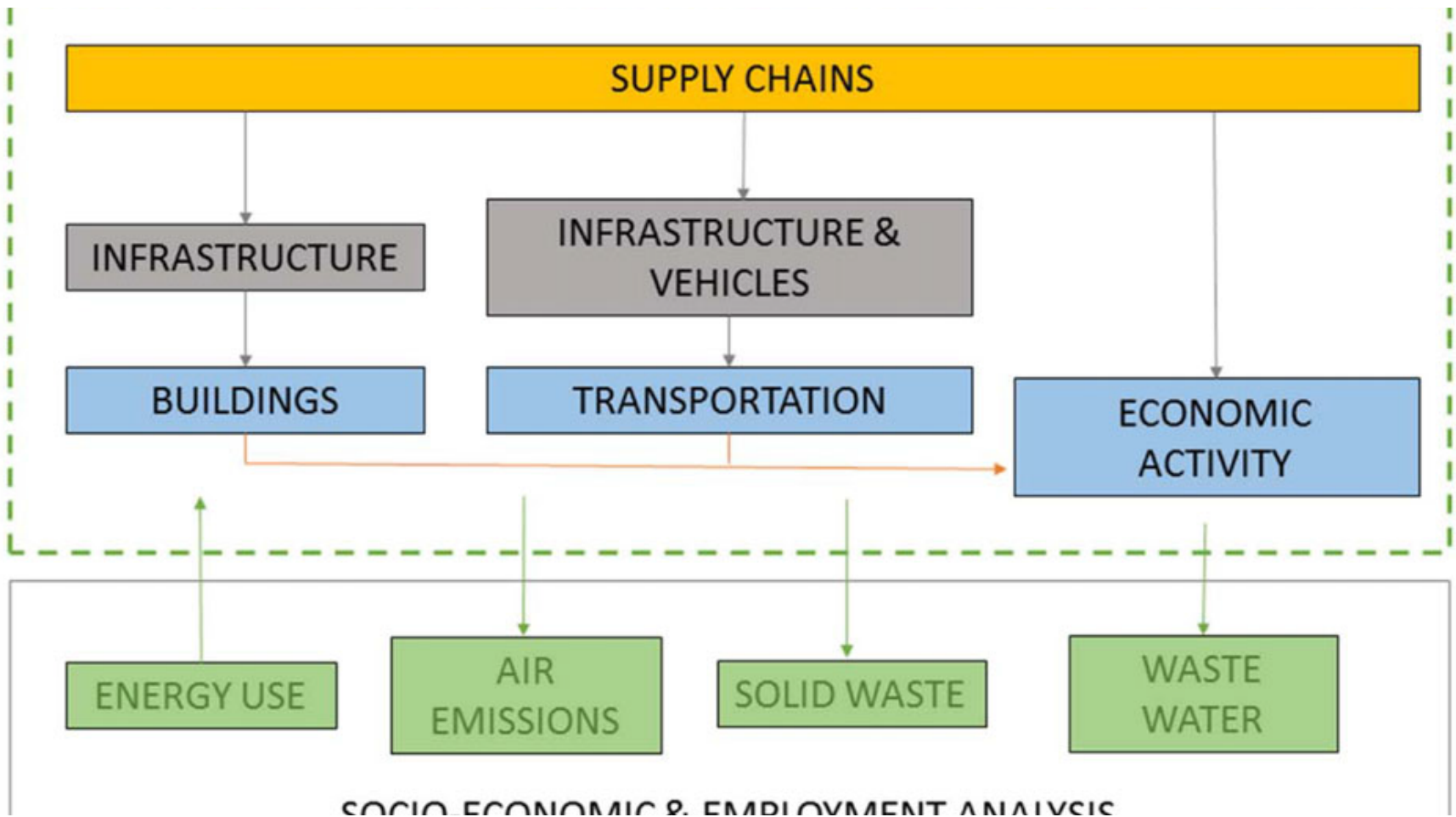
- Quantifying flows from the ground up
- Matching the flows to
 - census characteristics,
 - Building types, vintages, sizes, construction types
 - NAICS codes
 - Cal Enviro Screen and other as possible
- Putting a face on the uses/users
- Linking to embedded energy and materials



Different than top down – NASA– or imputed use generated by models or generalizing from a few studies based on self-reported data or small survey samples. Can yield baselines and longitudinal understandings.

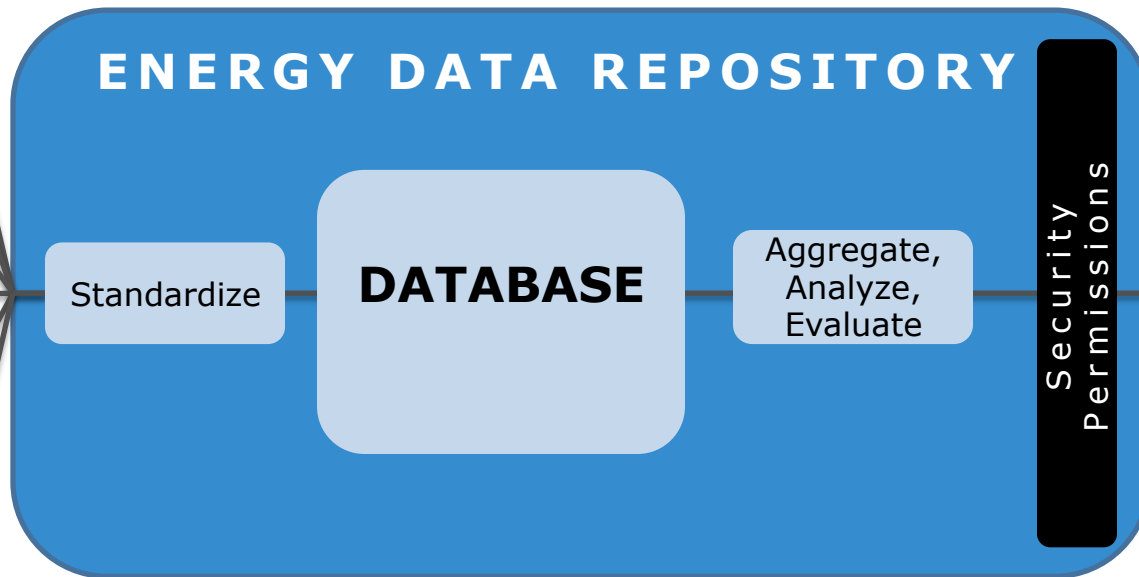
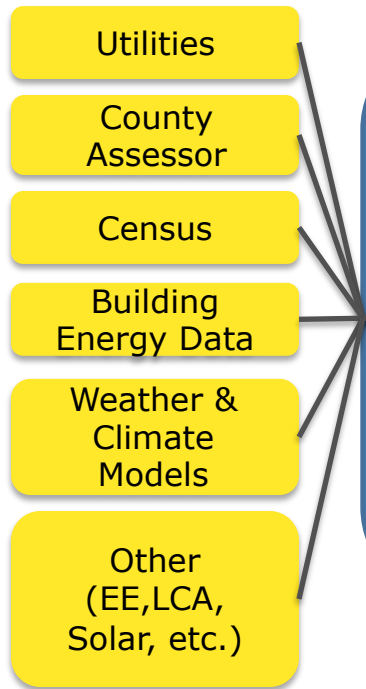


Urban Metabolism analysis of Los Angeles County



A Flexible and Responsive Research Platform

DATA SOURCES



Security Permissions

END USERS

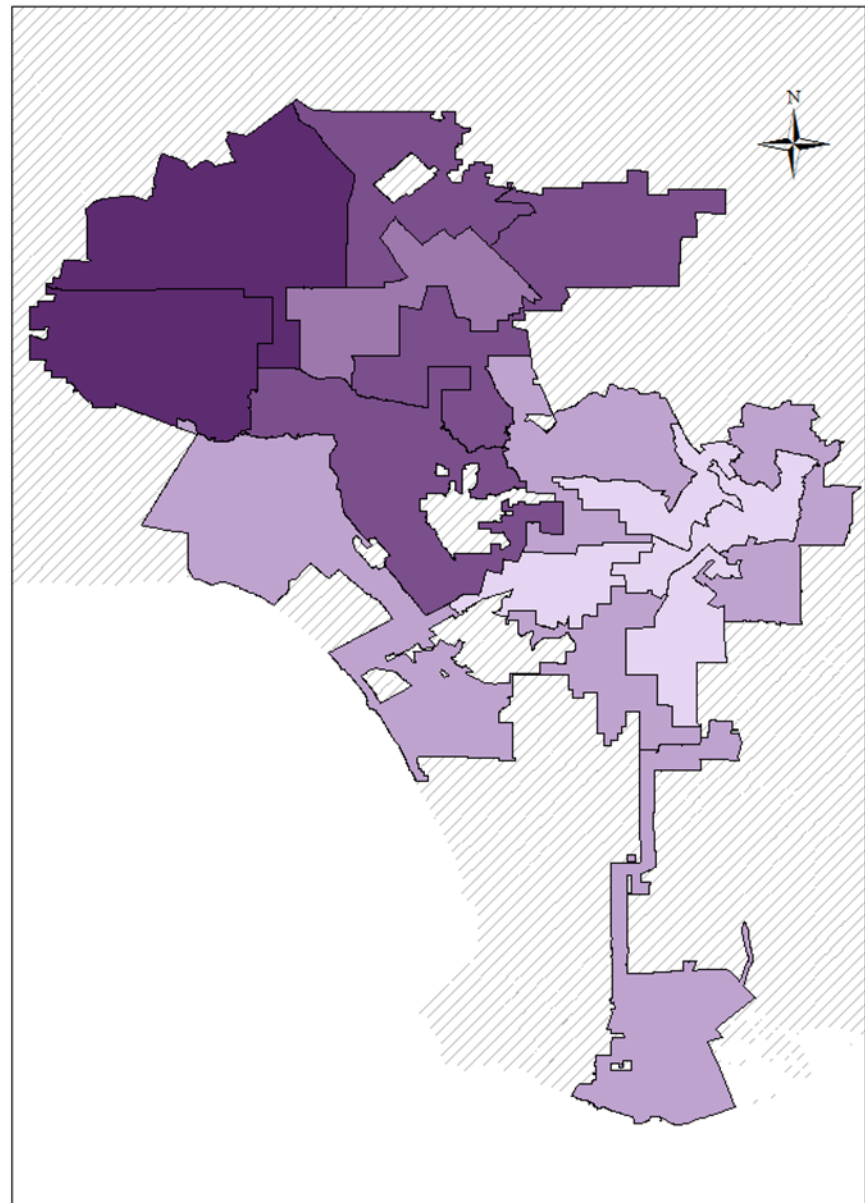
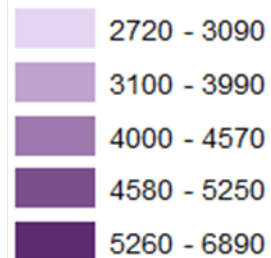


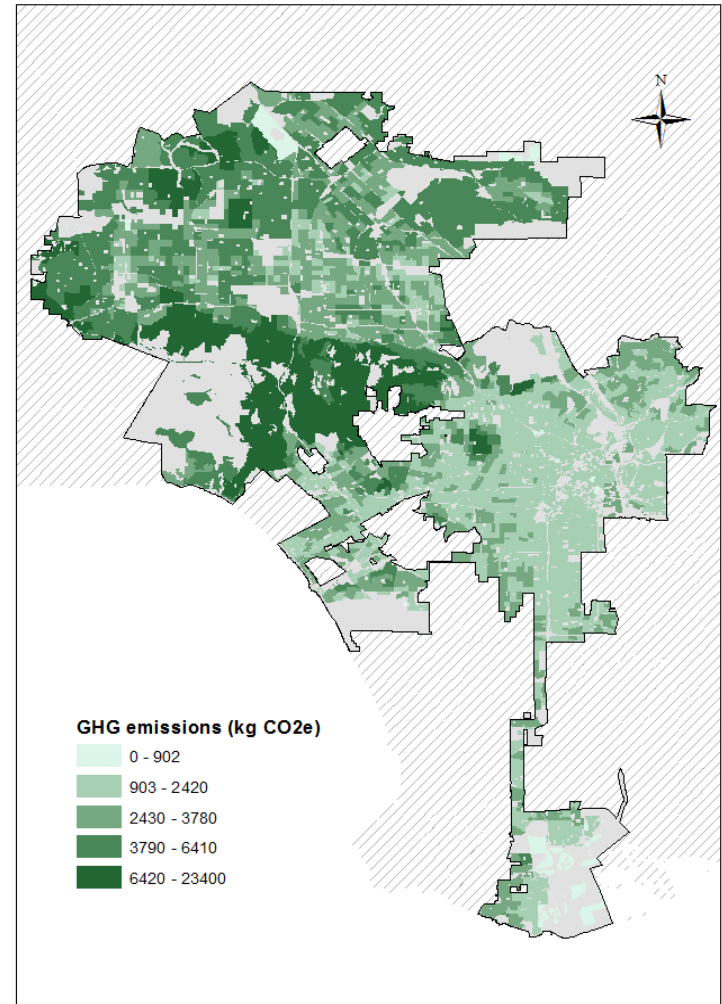
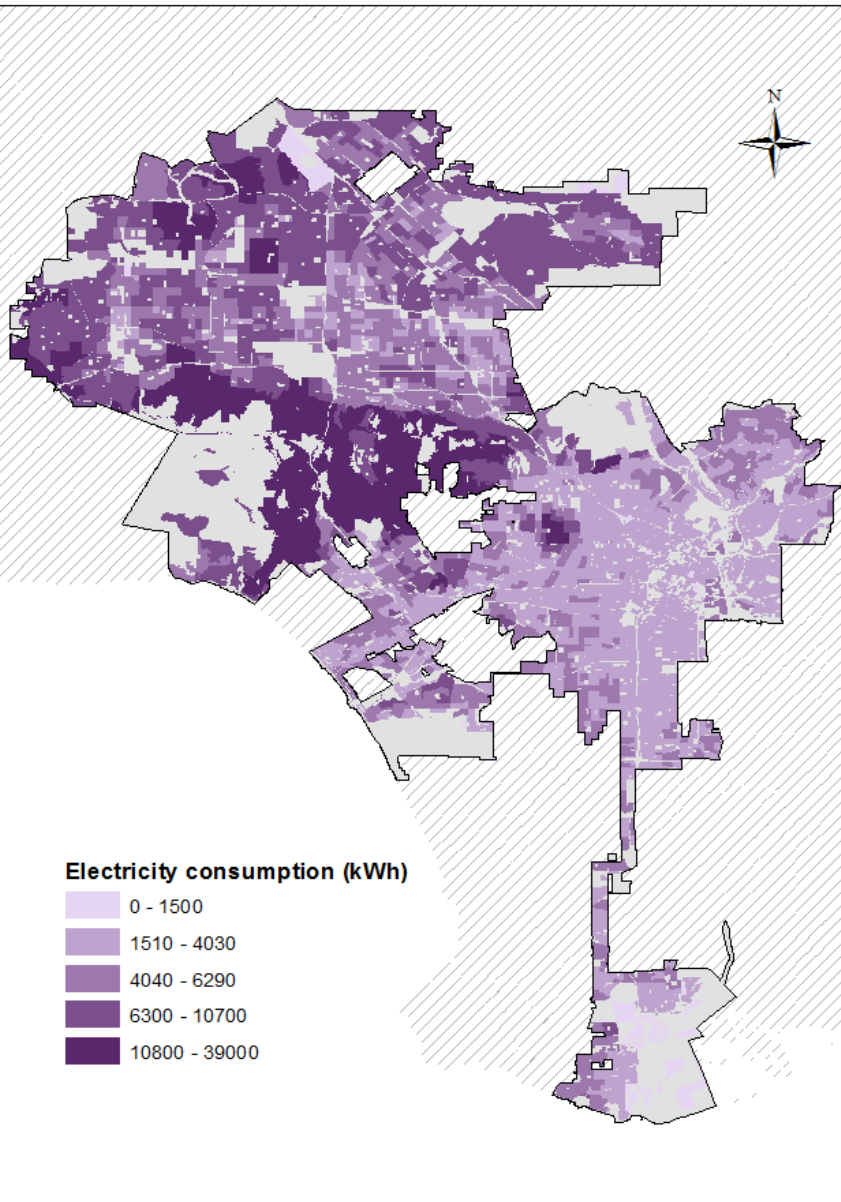
** CCSC has already completed for LA County (25% of statewide energy consumption)*

Median residential electricity use by city council district

FY 2011-2012, LADWP

Electricity consumption (kWh)





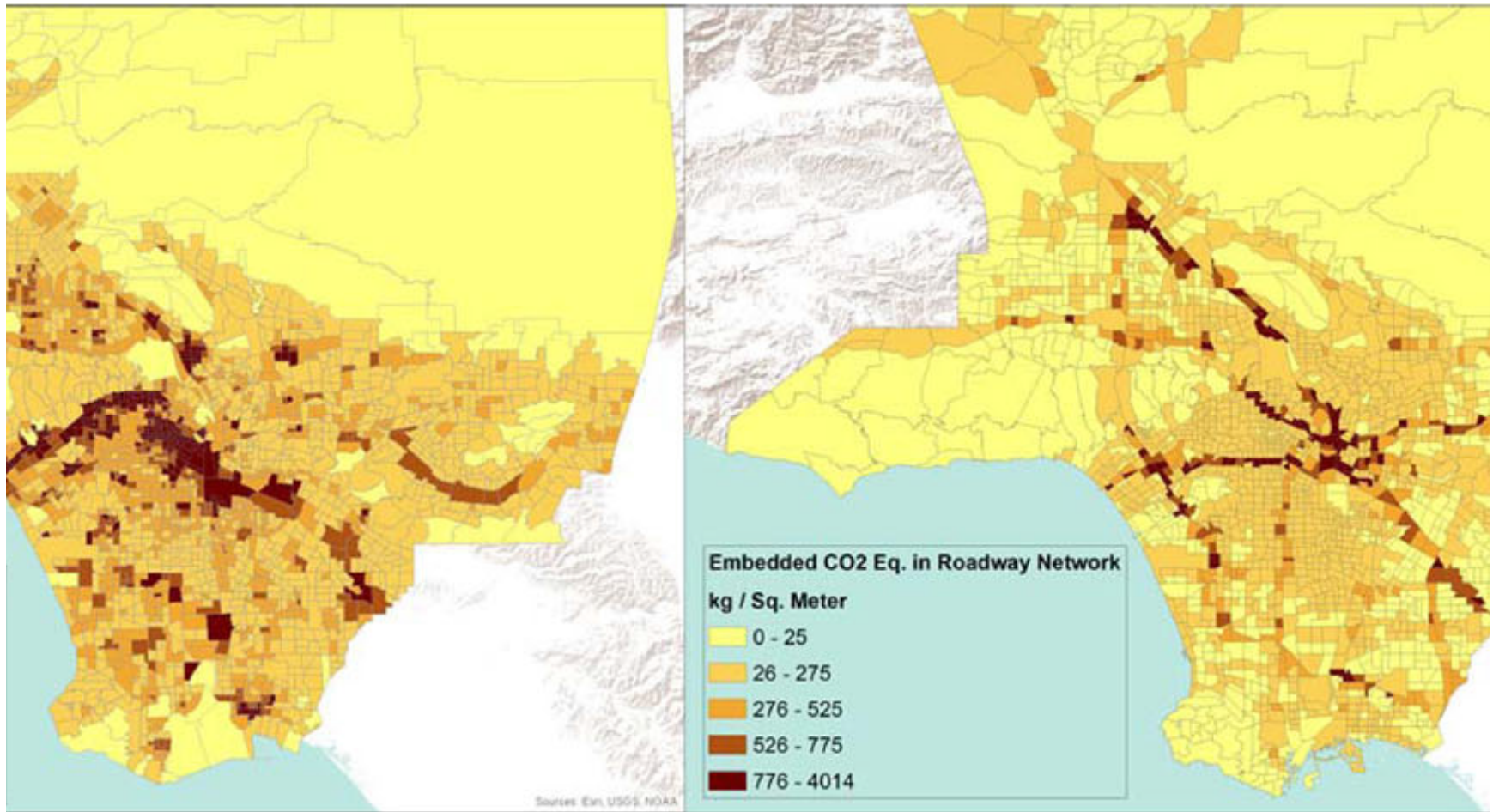
Sample Interactive Maps

- Interactive GIS tools allow users to play with data and get a big picture sense of how energy patterns vary across space and relate to different variables
- <http://devmaps.environment.ucla.edu/profiles/neighborhoods/>
- <http://devmaps.environment.ucla.edu/profiles/cities/>
- <http://devmaps.environment.ucla.edu/memo/results>
- <http://devmaps.environment.ucla.edu/cities/>

| Industry | Employment 2011 | Wage Tier 5 = Best | Annual Average Wage 2011 | MT GHG per Job from Establishment Activities & Customer Trips 2011 | GHG Tier 5 = Best |
|-------------------------------------|--------------------|-----------------------------|-----------------------------------|---|----------------------------|
| Agriculture | 5,720 | 1 | \$28,679 | 35 | 1 |
| Petroleum Extraction & Refining | 6,269 | 5 | \$148,884 | 8,231 | 1 |
| Electric Power Generation & Distrib | 16,560 | 5 | \$109,316 | 1,439 | 1 |
| Other Utilities | 12,684 | 5 | \$81,520 | 6,238 | 1 |
| Construction | 107,683 | 3 | \$53,360 | 0.08 | 5 |
| Food & Apparel Manufacturing | 104,947 | 2 | \$38,487 | 4.52 | 2 |
| Wood, Chem, Plastic, Cement Mfg. | 64,274 | 3 | \$47,889 | 14 | 1 |
| Metal & Other Durable Mfg. | 197,272 | 4 | \$69,723 | 2.18 | 4 |
| Wholesale Trade | 208,856 | 3 | \$55,451 | 0.11 | 5 |
| Retail Trade | 396,780 | 1 | \$30,596 | 8.88 | 2 |
| Air Transportation | 18,033 | 4 | \$63,155 | 1,445 | 1 |
| Trucking & Couriers | 44,029 | 2 | \$42,763 | 290 | 1 |
| Other Transportation | 102,650 | 3 | \$52,287 | 35 | 1 |
| Information | 197,255 | 5 | \$94,125 | 0.60 | 4 |
| Finance, Insurance, Real Estate | 215,407 | 5 | \$81,127 | 4.02 | 2 |
| Prof., Scientific, & Tech. Srv. | 314,693 | 5 | \$87,794 | 0.27 | 5 |
| Admin. Support & Waste Mgmt. | 239,952 | 2 | \$33,574 | 2.24 | 3 |
| Education | 351,631 | 3 | \$49,837 | 2.50 | 3 |
| Health Care & Social Assistance | 469,446 | 3 | \$52,070 | 2.42 | 3 |
| Arts, Entertainment, & Recreation | 78,751 | 5 | \$90,451 | 2.84 | 3 |
| Hotels & Restaurants | 334,825 | 1 | \$19,395 | 17 | 1 |
| Personal & Repair Services | 256,118 | 1 | \$24,849 | 2.48 | 3 |
| Public Administration | 151,279 | 4 | \$75,553 | 17 | 1 |

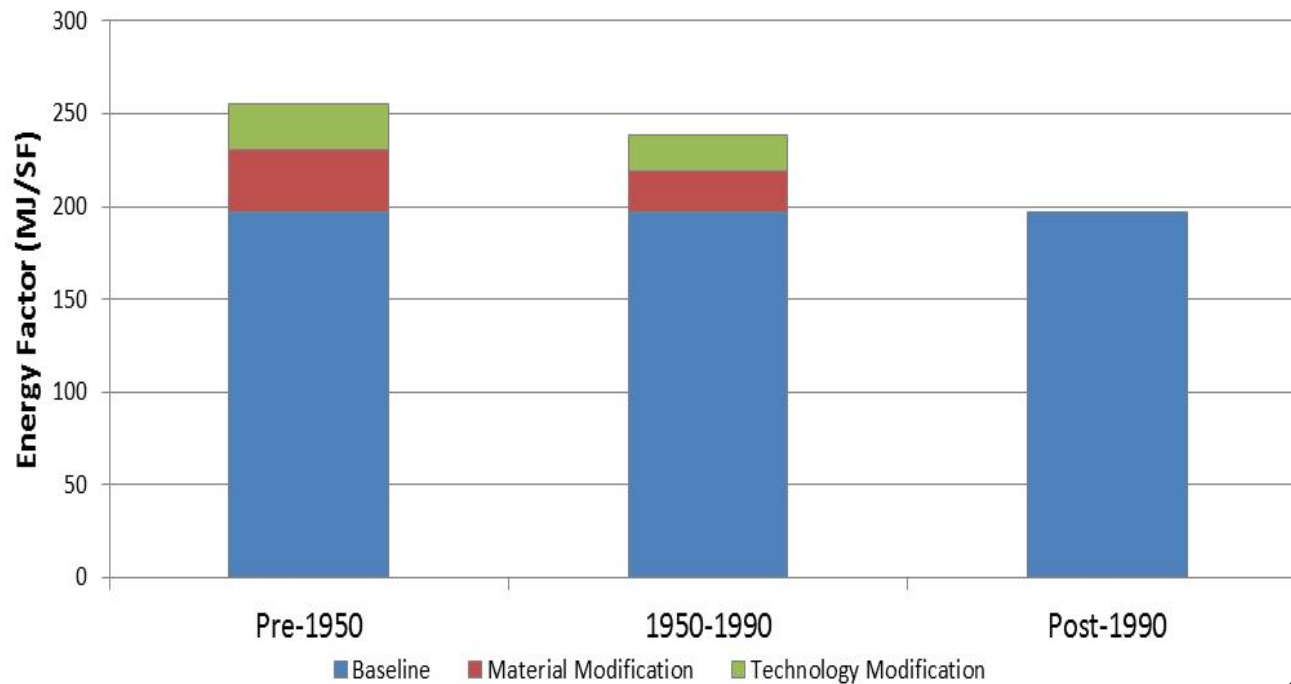
**Quintile Ranking of Los Angeles County Industry Sectors
Economic Round Table**

Embedded GHGs in Urban Fabric



Los Angeles Embedded Energy

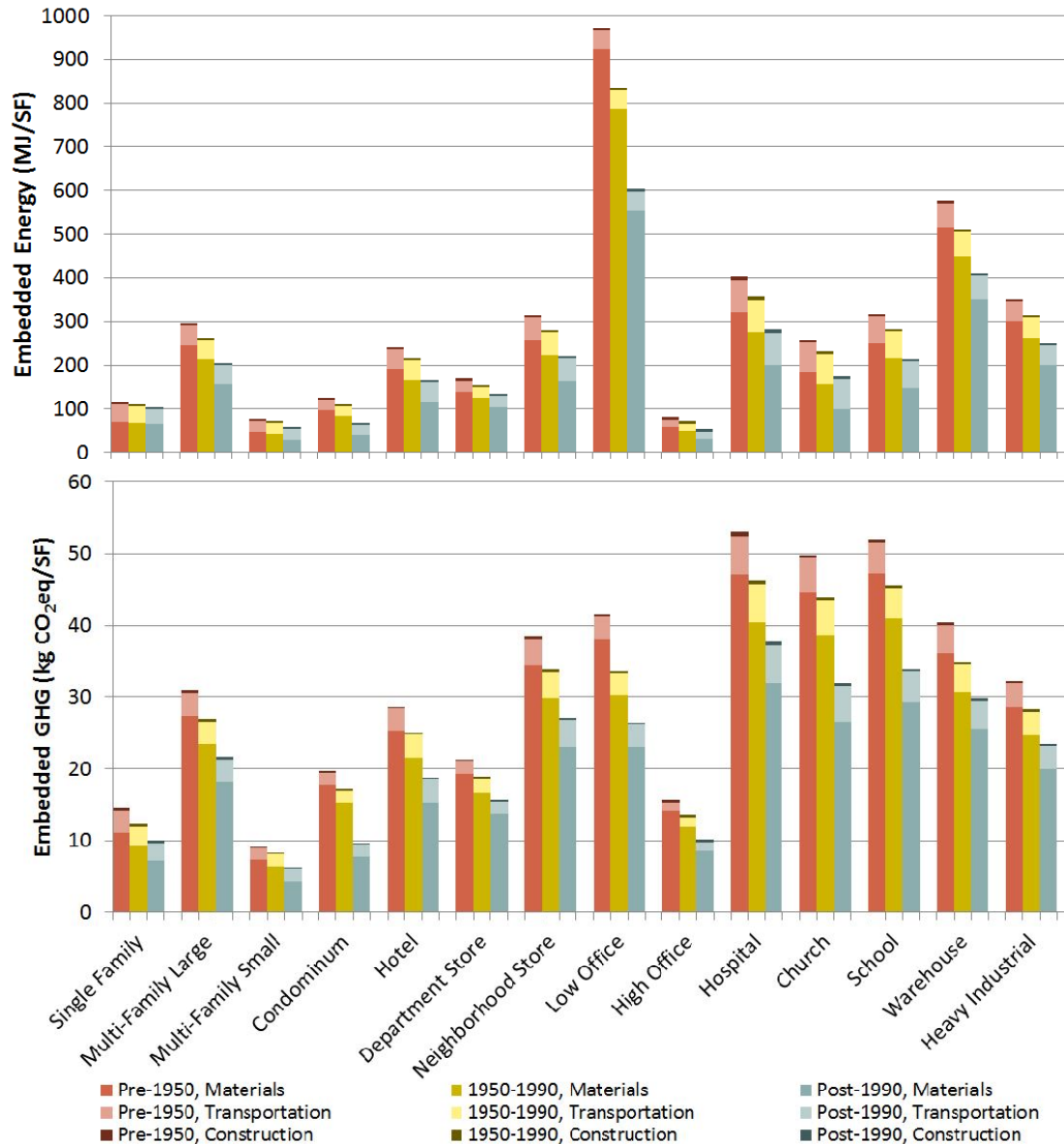
- Single Family energy factors

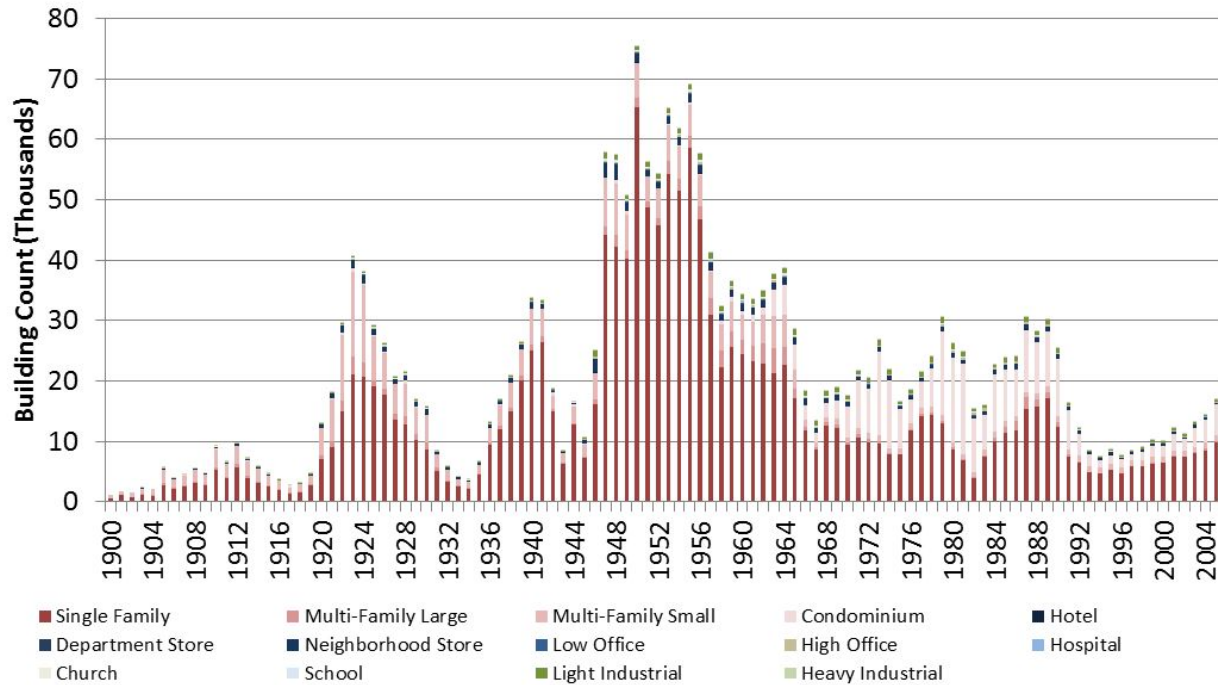


Chester et al. 2014

Factors by Category and Time Period

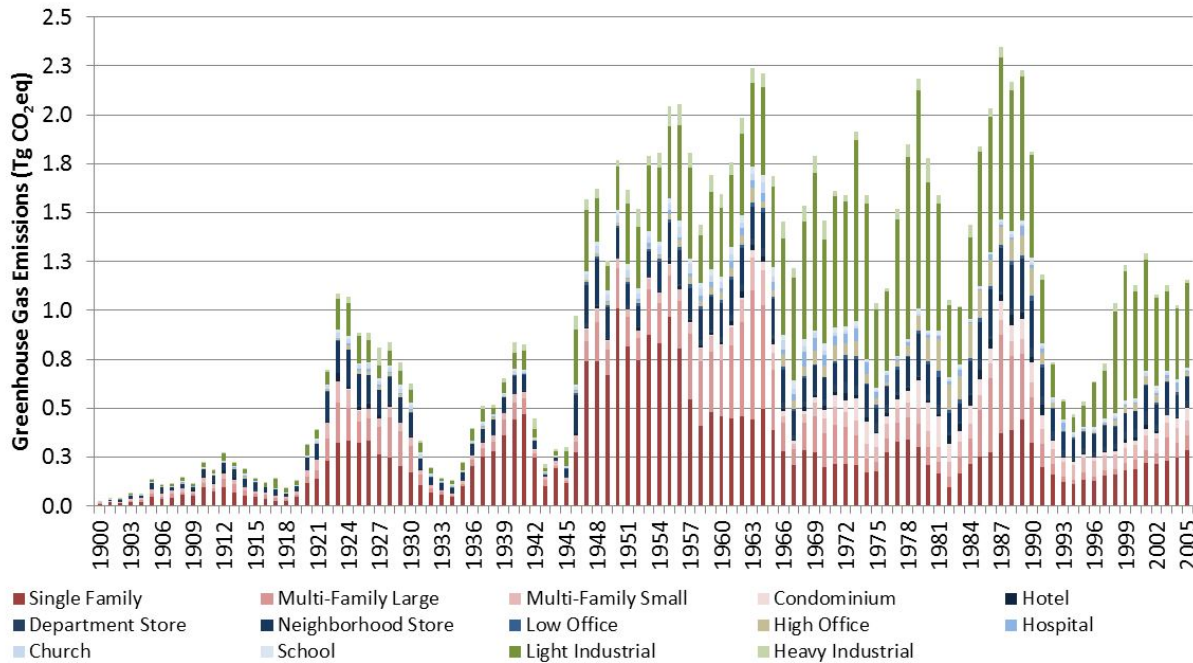
Chester et al





Building Count by Vintage and Type

Chester et al 2014



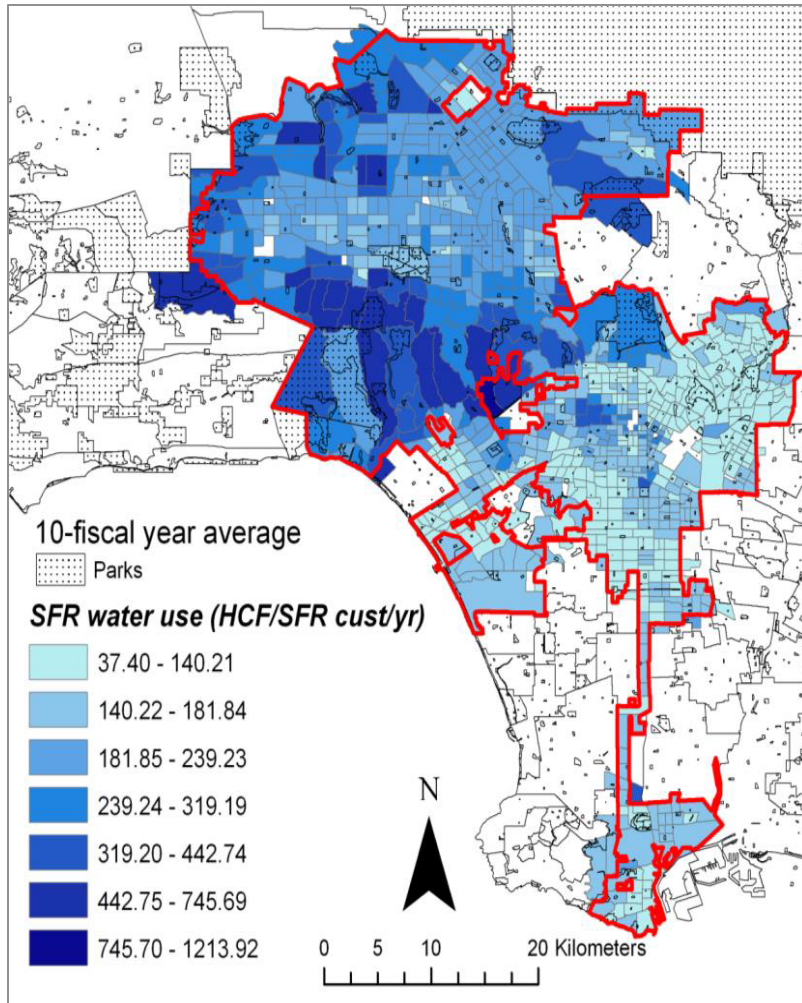
GHG Emissions by Vintage and Type

Chester 2014

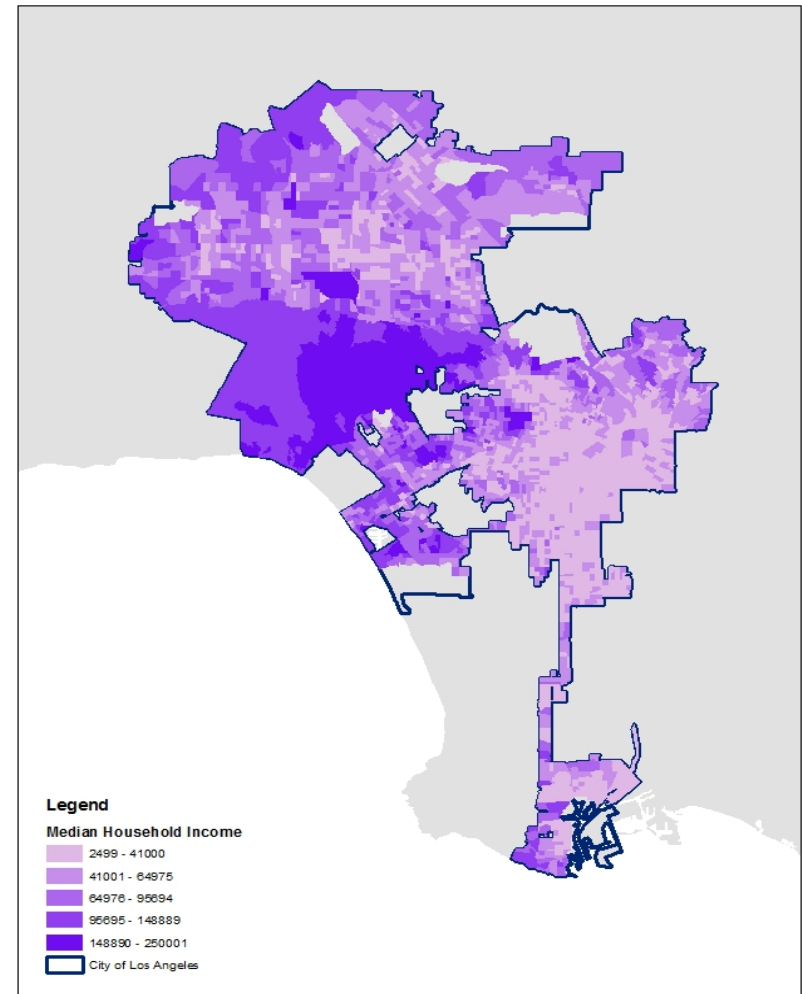
Next Steps

- Matching up the buildings and current energy use
- Developing trade-off analysis between densification and re-use and new building
- Thinking about roads and freeways and what the embedded energy means

Water Consumption

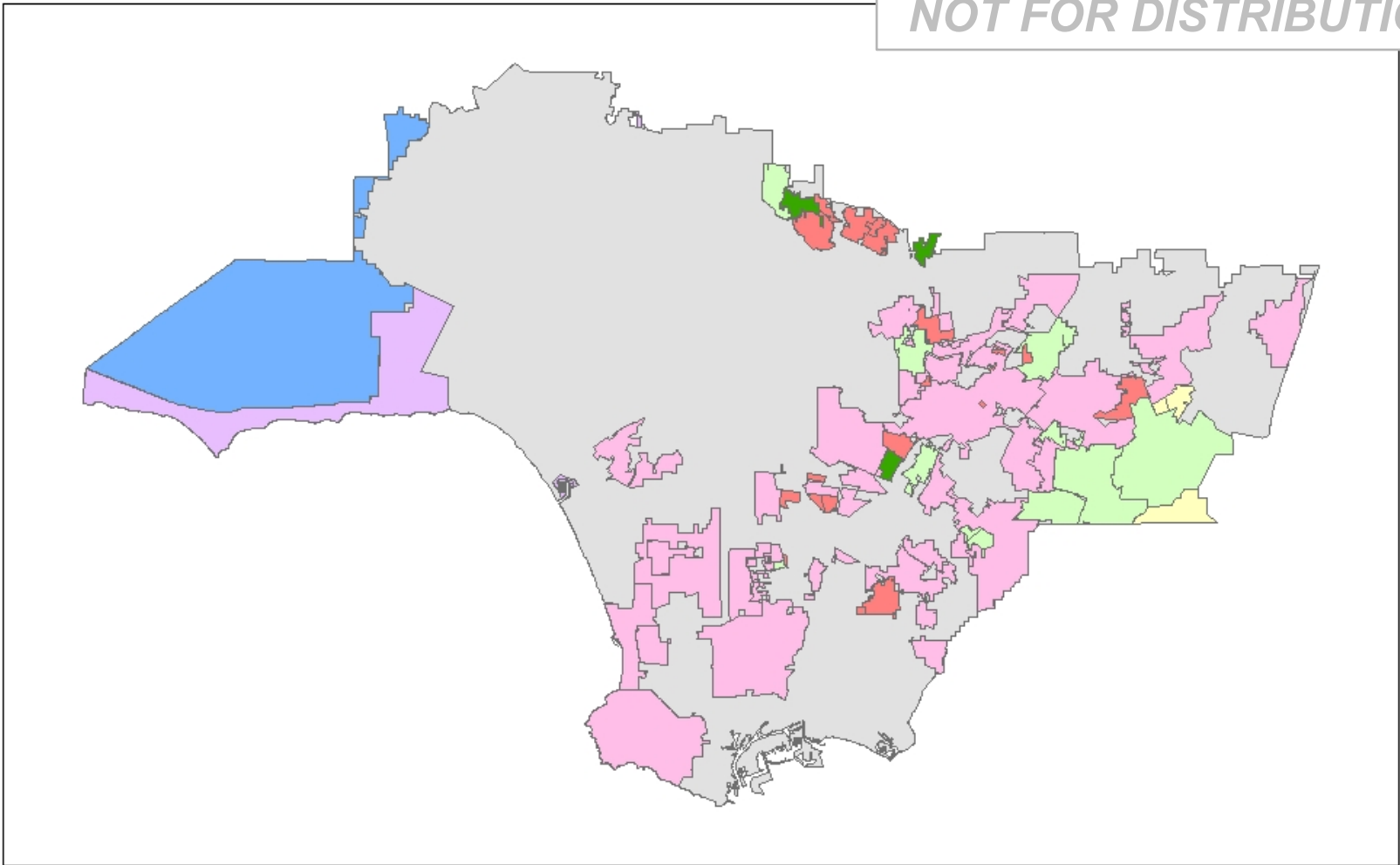


Income



Mini, C., T.S. Hogue, and S. Pincetl, 2014: Patterns and Controlling Factors of Residential Water Use in Los Angeles, California, *Water Policy*, doi:10.2166/wp.2014.029









NOT FOR DISTRIBUTION

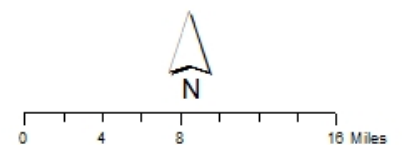


Special Districts, Customers, Mutual Water Companies, and Investor Owned Utilities

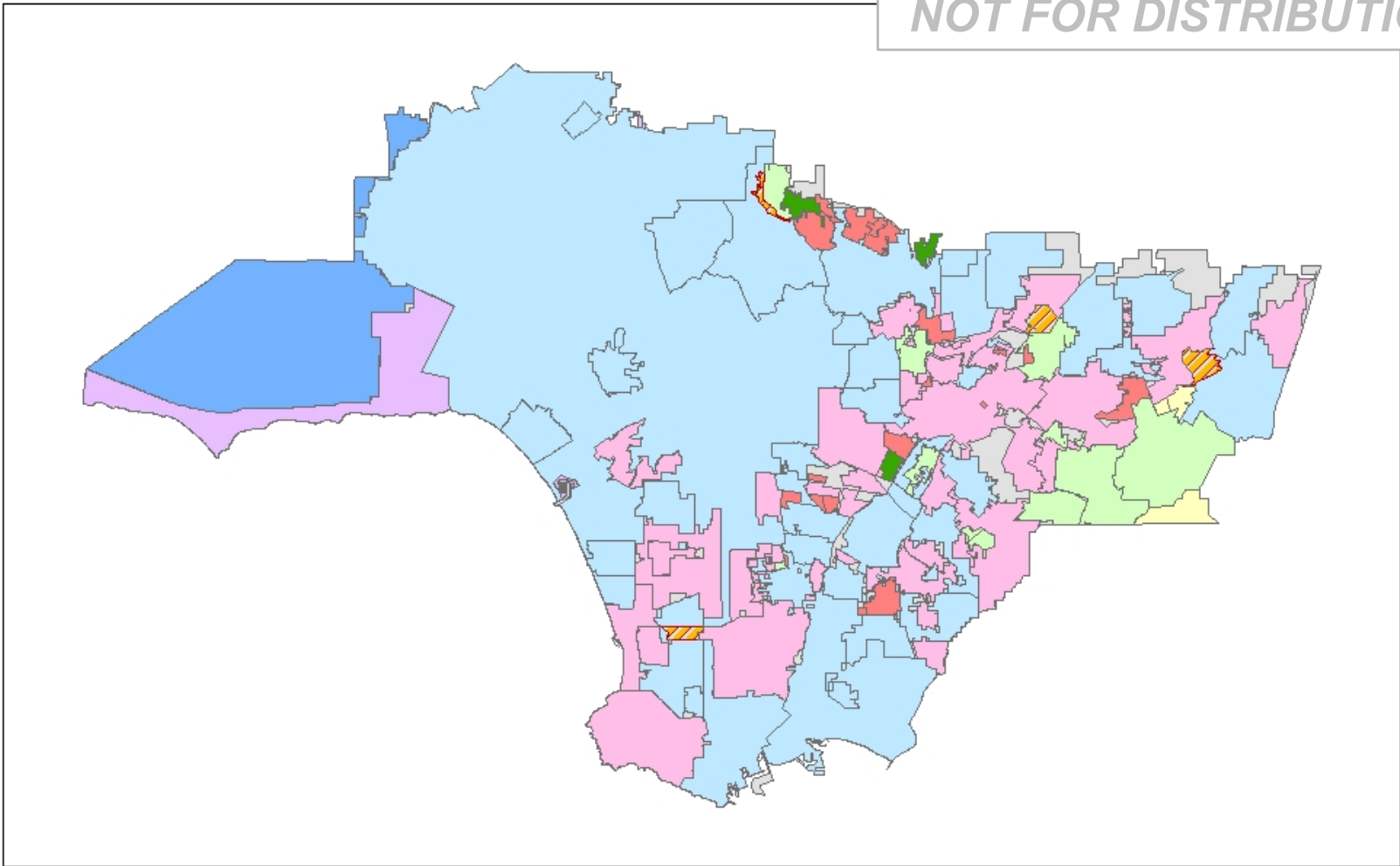
Legend

Water Suppliers

- | | |
|--|--|
|  COUNTY WATER DISTRICT |  INVESTOR OWNED UTILITY |
|  COUNTY WATERWORKS DISTRICT |  IRRIGATION DISTRICT |
|  CUSTOMER |  MUNICIPAL WATER DISTRICT |
| |  MUTUAL WATER COMPANY |
| |  STUDY AREA |













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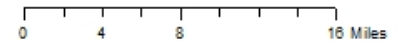


All Potable Water Suppliers

Legend

Water Suppliers

| | | | |
|---|----------------------------|---|--------------------------|
|  | CITY RETAILER |  | INVESTOR OWNED UTILITY |
|  | COUNTY WATER DISTRICT |  | IRRIGATION DISTRICT |
|  | COUNTY WATERWORKS DISTRICT |  | MUNICIPAL WATER DISTRICT |
|  | CUSTOMER |  | MUTUAL WATER COMPANY |
| | |  | OVERLAP |
| | |  | STUDY AREA |



Next Steps and Developing the Conceptual Framework

- Funding to expand to all of Southern California and the rest of the state
- Developing policy briefs and actionable analysis for stake holders
- Using the research to help move to a post carbon energy system
- Publishing peer reviewed papers and a web atlas
- Working on theorizing this approach under: *Thick Mapping, an Integrative Framework.*