

POWERING ACCRA: PROJECTING ELECTRICITY DEMAND FOR GHANA'S CAPITAL CITY

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About me

- Professional Urban Planner for more than 5 years in Florida and Georgia
 - Qualified as American Institute of Certified Planners (AICP)
 - Numerous Public and Private Sector Projects, Qualified Expert in Urban Planning and Land Development (Southwest Florida Circuit Courts)
- Graduate of the Georgia Institute of Technology (2001), Master of City and Regional Planning
- Researcher / PhD Fellow at the Zentrum for Entwicklungsforschung in Bonn since 2006
 - Research funded (employed) as part of GLOWA – Volta
 - Lived in Accra for a year in 2007 & 2008, returned twice
 - Completing PhD in Geography at the University of Bonn (expected later this year)

Goals

- To demonstrate that the fundamental tenets of urban and regional planning are the same in west African mega cities as they are in modern cities (the US, Europe, etc...)
- To demonstrate that useful land use data exists in west African mega cities as in modern cities.
- To build a disaggregated demand electricity demand model of a west African mega-city based on parcel land use and its performance standards.
- To explore and understand the dynamics (macro & micro) of a west African mega-city and how urban planning can be used as a transformative tool towards an alternative sustainable (social, economic, environmental) future.

Central Research Questions

- Which land development patterns are most likely in the Greater Accra Region over the next 30 years?
- What is the projected electricity demand in the Greater Accra Region over the next 30 years?
- Which set of policies will be the most cost effective in advancing a sustainable energy use plan in the Greater Accra Region over the next 30 years?

Energy and Urban Modelling

□ Accounting Frameworks

- LEAP – Long Range Energy Alternative Planning System

□ Optimization Models (MARKAL)

□ Equilibrium Models (GAMS)

- Cournot Competition, Supply Function Equilibrium (SFE)
- Demand is difficult to project

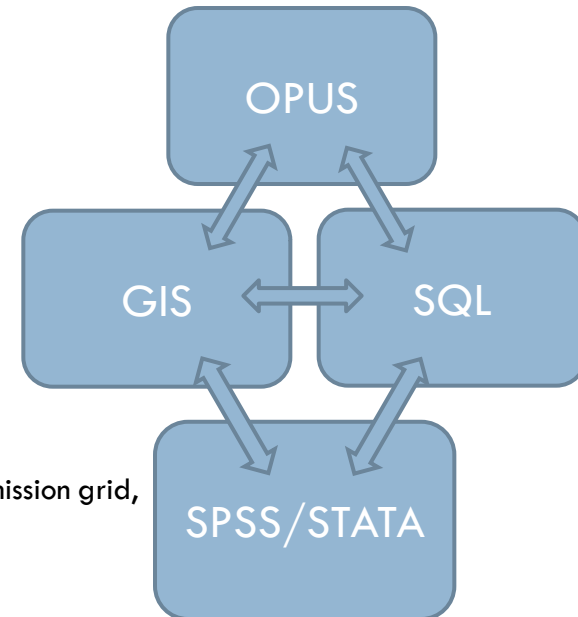
□ Simulation Platforms

□ AMES Wholesale Power Market Test Bed (Supply Side)

- RePast Symphony, Open Source
- Agent-based computational laboratory for wholesale power markets
- Strategically-learning traders, ISO-managed wholesale power market, transmission grid, generators, demand
- Iowa State, Leigh Tesfatsion

□ OPUS – Open Platform for Urban Simulation (Demand Side)

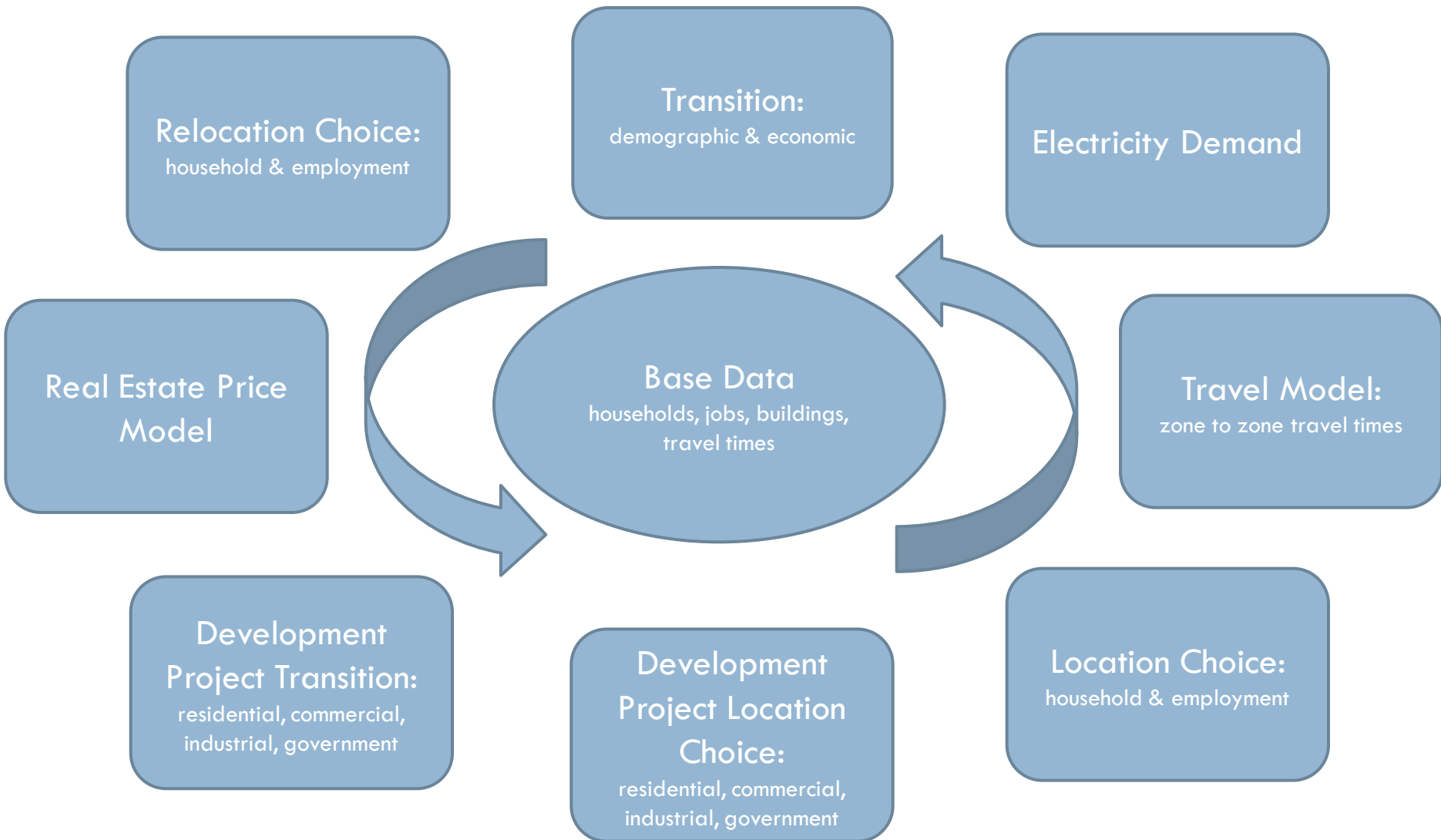
- Python/XML, GUI, import/export to SQL/GIS, Open Source
- Center for Urban Simulation and Policy Analysis at the University of Washington
 - Paul Waddell and Alan Borning
- UrbanSim OPUS package
 - Southeast Michigan Council of Governments - Detroit, Michigan
 - Puget Sound Regional Council - Seattle, Washington
 - Maricopa Association of Governments - Phoenix, Arizona
 - Denver Regional Council of Governments - Denver, Colorado



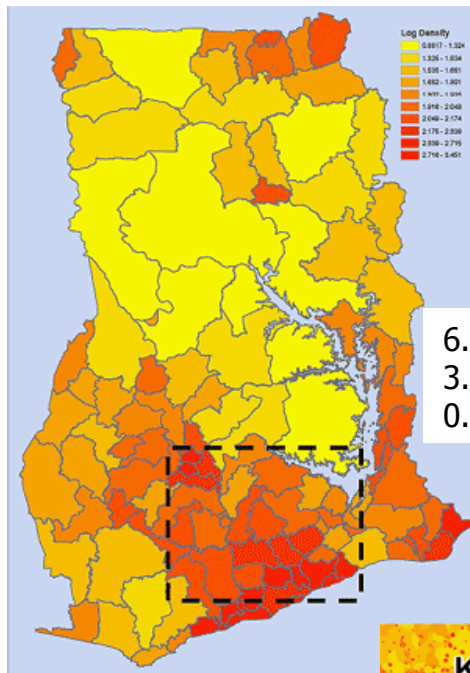
OPUS – Urbansim

- Data
 - ▣ Jobs, households, buildings, travel times (parcel, grid-cell, zone based projects)
- Models
 - ▣ Household transition: annual external control totals of population and households
 - ▣ Economic transition: annual external control totals of employment by sector
 - ▣ Household relocation: HHH age, HHH income, probability of relocating
 - ▣ Employment relocation: job relocation probability by sector
 - ▣ Real estate price model: unit price, jobs spaces or dwelling units, property value
 - ▣ Development project transition: residential, commercial, industrial, government development project location choice
 - ▣ Household Location Choice: multinomial logit model
 - ▣ Employment Location Choice: multinomial logit model
 - ▣ Travel: travel time by mode to/from all zones
- Scenarios
 - ▣ Control total growth rates: demographic & economic, high, medium and low
 - ▣ Development project controls: comprehensive planning & zoning

Urbansim - GAUS Annual Cycle



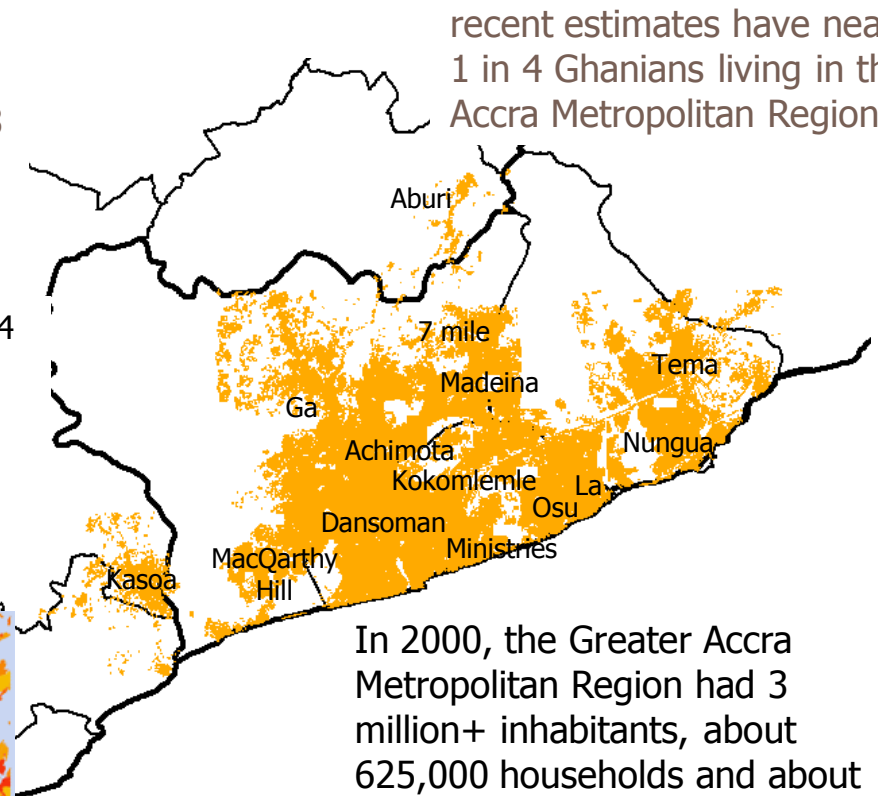
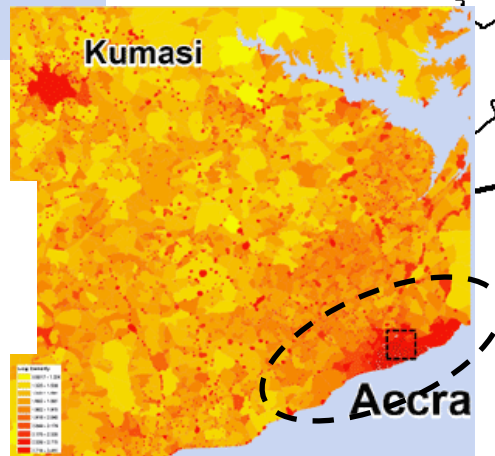
South Central Ghana



Ghana's population is currently about 23 million (2008)

6.6 million TOE total in 2004
3.8 TOE from wood-fuels
0.5 TOE from electricity

6000 GWhs generated in 2004, 50%+ of all consumption was by residential households

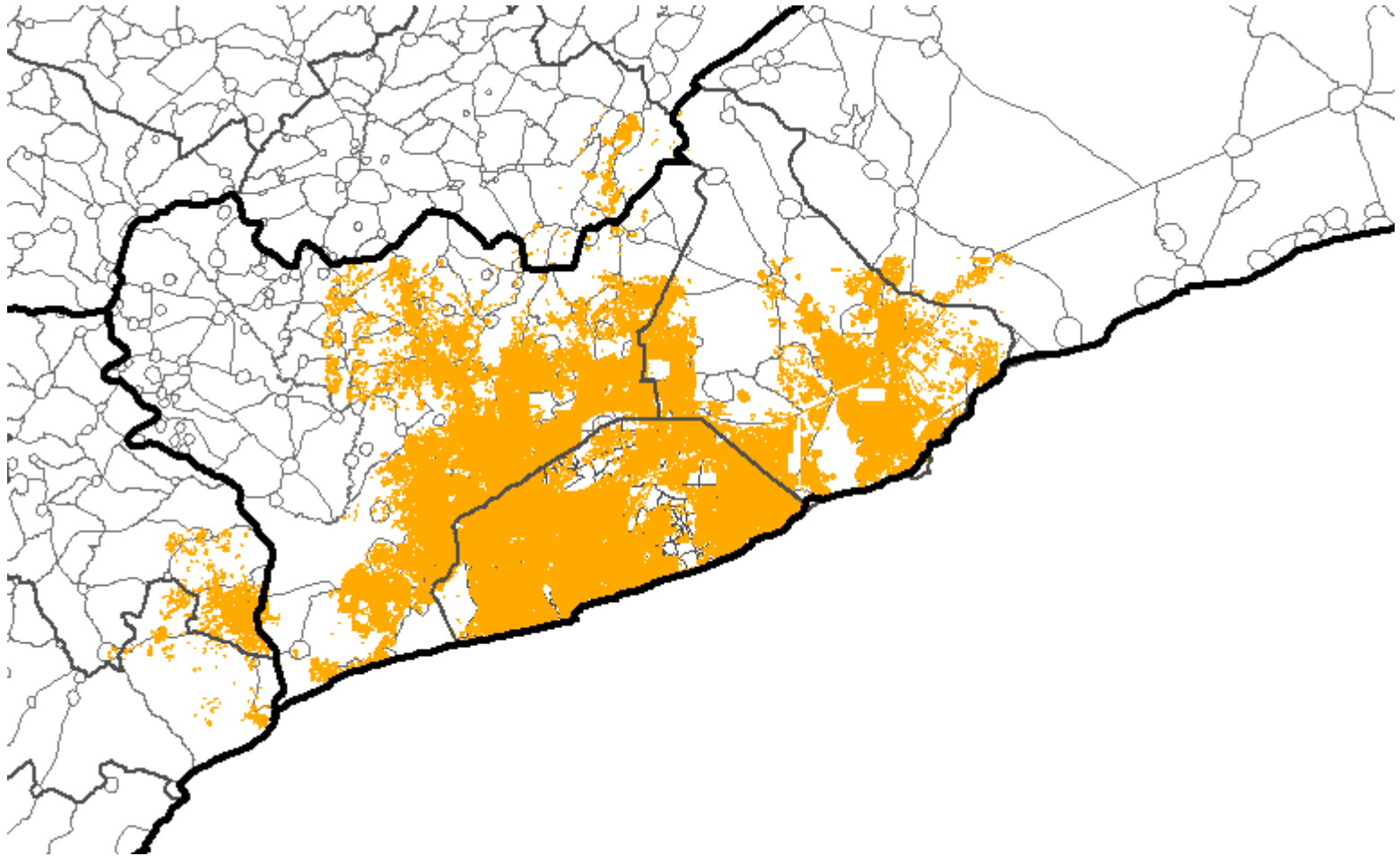


recent estimates have nearly 1 in 4 Ghanians living in the Accra Metropolitan Region

In 2000, the Greater Accra Metropolitan Region had 3 million+ inhabitants, about 625,000 households and about 1,350,000 structures

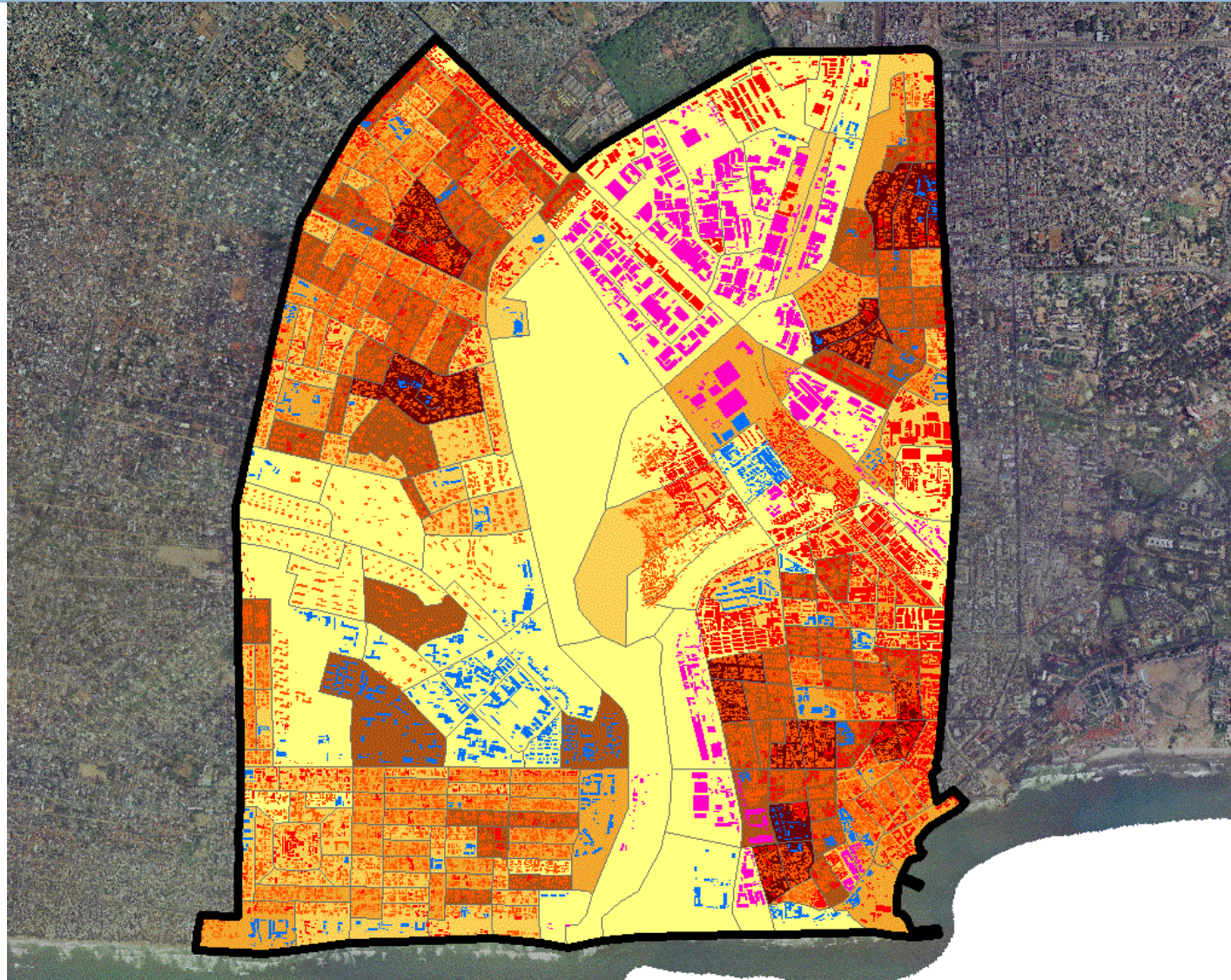
Most significant area for industrial and services sectors, together these account for nearly 75% of Ghana's GDP

Greater Accra Region

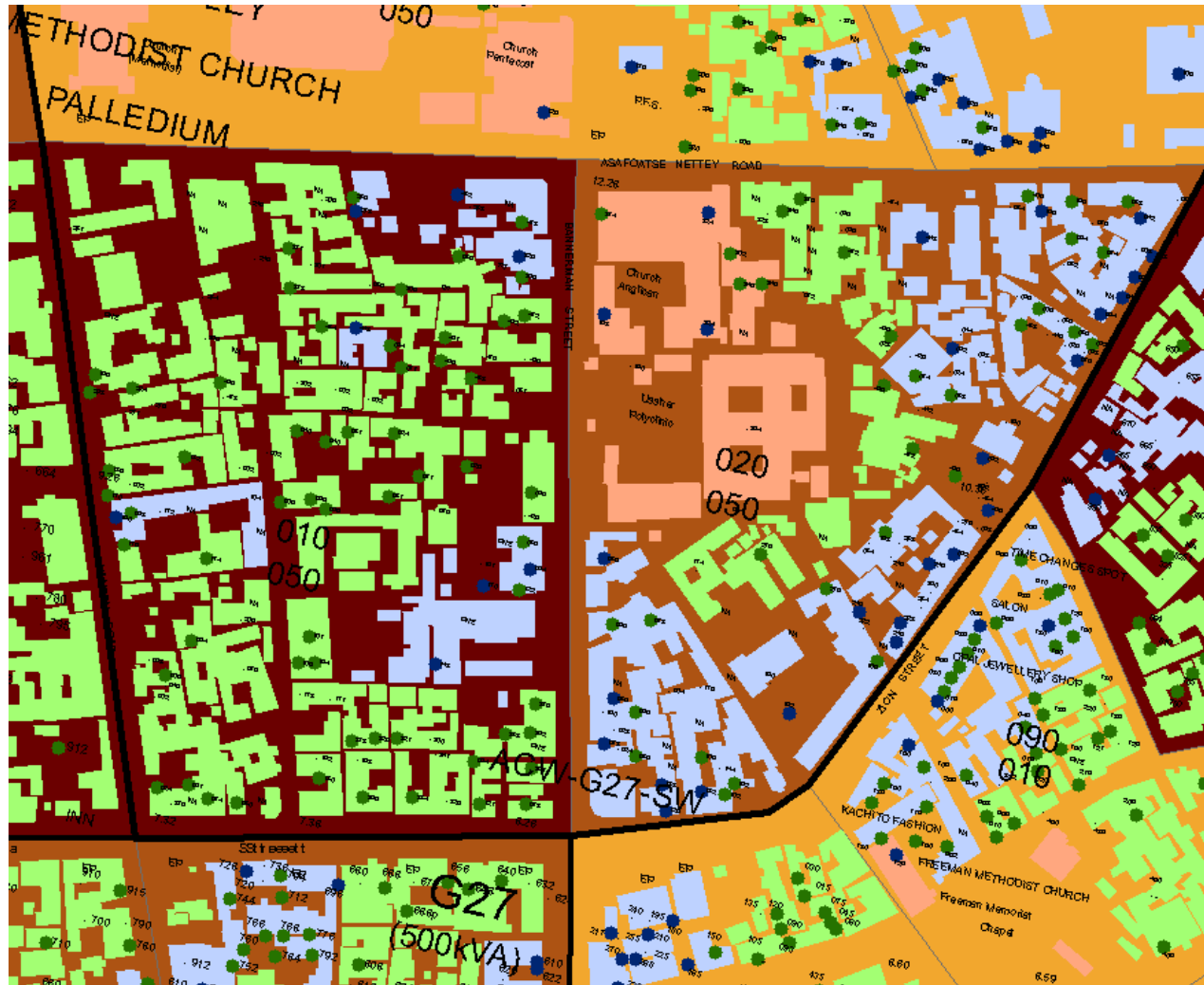


Korle Bu District

- District
 - 190,000 residents
- Blocks
- Rounds
- Plots
- Buildings
 - Com, Inst, Ind, Res
- Property Value
 - Commercial: 4 – 63 GHC/m²
- Demographics
 - HHs, Density, Age
 - Density- up to 120,000 persons/km²
- Energy Consumption
 - Residential
 - kWhours



James Town Block



Urbansim Zone Project

- Households
 - ▣ Cars, workers, persons, tribe, income, age_of_head, children
- Jobs
 - ▣ Building type, sector
- Pseudo buildings
 - ▣ Building type, avg value, residential units & capacity, commercial/industrial/government job spaces & capacity

Synthetic Population Generator

- Ghana Statistical Service – has released 5% microdata of Greater Accra, control totals from Census and other sources
- Iterative Proportionate Updating (IPU)
 - ▣ Work by Ram Pendyala at Arizona State
 - ▣ Next step to Incorporate exogenous variables through time
 - Unique to Ghana: tribal affiliation
 - Asante, Ga, Erweh, Fante, etc...
 - ▣ Location Choice Modeling
 - Statistical parameters from GLSS data

Electricity Demand Modeling

□ Linear Regression

- $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \dots + \varepsilon$

- $Y =$ residential energy demand (commercial, institutional, industrial)
- $X_1 \dots N =$ population, hhs, land value, density, presence of automobile, household appliances (television etc..)
- $\beta =$ regression coefficients
- $\varepsilon =$ residual term

□ Time Series Analysis

- Actual electricity consumption for about 300,000 meters
- 16 months (Oct 2006 – January 2008)
- Land use (commercial, industrial, institutional, residential)
- meters are spatially located

Scenarios

- Population Growth
 - ▣ High, medium, low
 - ▣ Control tables
- Economic Growth
 - ▣ High, medium, low
 - ▣ Control tables
- Conservation Consumption
 - ▣ Performance standard by Use
 - Commercial, Institutional, Industrial, Residential
 - NPV
- Decentralized Generation
 - ▣ Performance standard by Use
 - Commercial, Institutional, Industrial, Residential
 - NPV

		Energy Sustainability		
Land Use Sustainability	BAU/LG	BAU/MG	BAU/HG	
	WS/LG	WS/MG	WS/HG	
	SS/LG	SS/MG	SS/HG	

Americans, Germans & Ghanaians...

- Obtained datasets during field work
 - ▣ Working closely with the Ministry of Finance and Economic Planning, Electricity Company of Ghana, the Ministry of Lands, Forestry and Mines, Ministry of Road Transport, the Survey Department, Town & Country Planning, (Accra, Ghana)
- Development of urban simulation
 - ▣ Working closely with the Center for Urban Simulation and Policy Analysis at the University of Washington



Thank you...questions???