STATEMENT OF RESEARCH

Elliot Cohen | elliot.cohen@columbia.edu | github | Earth Institute | SEL | QMSS

Research Philosophy

The best descriptor for my area of expertise is Sustainable Energy Systems. It is truly interdisciplinary -- part environmental engineering, part mechanical engineering, part sustainability science, part data analysis and part statistics. My research calls upon:

- **Impact-oriented research design** from the sustainable engineering lab (Current, Columbia)
- Fluency with quantitative methods in **environmental engineering** (Ph.D. 2014, Colorado Denver)
- Extensive **fieldwork** (Fulbright Scholar to India, 2013)
- Interdisciplinary training in **sustainable urban infrastructure** (M.S. 2011, Colorado Denver)
- Solid foundation in **mechanical engineering** (B.S. 2009, University of Maryland)

In terms of impact, my research extends beyond peer-reviewed journals and onto the desks of policy-makers. Notably, I have contributed research and analysis to:

- World Bank Cities and Climate Change: Responding to an Urgent Agenda
- National Renewable Energy Laboratory Life Cycle Assessment Harmonization Project
- IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation
- Presidential Climate Action Project Addressing Climate Change Under Executive Authority

Current Research

Continuing in the tradition of policy-relevant and impactful externally-funded research, I am currently working with the United Nations Industrial Development Organization (UNIDO) to train energy professionals in West Africa in data analytics and grid-integration of renewable energy.

I am currently lead author, principle investigator and/or project-lead for six research initiatives:

- Spatial Analysis of Energy Access, Consumption and Reliability in Emerging Megacities
  with Sou Min Sonia Lee (Columbia)
- Global Trends in Urban Energy Use
  with Vijay Modi, Henri Torbey, Michael Piccirelli and Yu-Tian (Columbia)
- Temporal Downscaling of Global Energy Demand Forecasts
  with Vijay Modi, Henri Torbey and Yu-Tian (Columbia)
- The Water Footprint of Urban Energy Systems
  with Anu Ramaswami (Minnesota)
- The Effect of Climate on Grid-Scale Electricity Supply Reliability (see Ch. 6)
  with Anu Ramaswami and Balaji Rajagopalan (Minnesota; Colorado)
- Weather Data Pipeline for R
  with Michael Piccirilli and James McCreight (Columbia, NCAR)

To keep within a two-page limit, I will describe just one of six current projects. Links are provided (above) for further details.

Global Trends in Urban Energy Use

Many of the world's largest and fastest-growing cities--from Karachi to Delhi, Dhaka, Jakarta, Bangkok, Lagos and Kinshasa--are located in South Asia and Sub-Saharan Africa with tropical to sub-tropical climates unlike those of most OECD-member cities in the global North. As the tropics/sub-tropics become increasingly urban, industrial and affluent, it is important to consider how energy demand--particularly for thermal comfort--will evolve differently in these places than it has historically across the OECD.

To illustrate the potential for vast differences in energy demand for thermal comfort between cities in the global North and cities in the Tropics/Sub-Tropics, consider Delhi, India. Delhi with its massive population and very hot climate is an outlier compared to most OECD cities but typical of South Asia: Peak summer temperatures routinely exceed 40 deg C. (104 F.), and intense heatwaves can approach 50 deg C. (122 F.). Given the huge temperature differential between outdoor (say 104 F.) and desired indoor air temperature (say 72 F), and the thermodynamic fact that energy for cooling scales linearly with the temperature differential, cooling a building in Delhi requires twice as much energy as cooling a building in New York where the summer indoor-outdoor temperature differential is typically half that.

In addition to higher temperatures, the summer season is also much longer: in the past year, Delhi had over six times as many cooling-degree days as New York City (again assuming a desired indoor air temperature of 72 deg F). Compounded by leaky building envelopes in developing world cities (designed for natural ventilation, not air conditioning), intense heat-island effects (typically less green space), and massive population growth, peak electricity demand in cities throughout the developing world could one day surpass that of their neighbors to the north--not just in aggregate terms because of their size, but also *per-capita* due to climate, building design and thermodynamics.

This will have huge implications for capacity expansion, technology deployment, grid planning, demand-side management, pricing mechanisms, and overall system reliability. More broadly, it will influence the global transition to renewable energy given the limitations of meeting such large and 'peaky' demand with non-dispatchable resources such as wind and solar.

To address this issue, I am compiling a global database of high-resolution electricity demand data for a large number of cities in the tropics/sub-tropics. Using this database (which will be the first of its kind), I am analyzing demand elasticity, climate effects, cooling/heating thresholds, and how all of these evolve over time along the development spectrum.