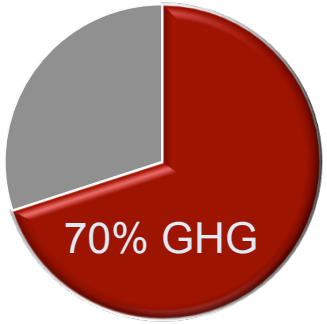
Urban Systems Science & Engineering:
Toward Smart, Low Carbon, High-Performance Cities

Charlie Catlett (ANL), Mary Ann Piette (LBL), Bhaduri Budhendra (ORNL),
Ramesh Ramamoorthy (LBL), Nancy Carlisle (NREL), Thom Dunning (PNNL)
(on behalf of 10 labs)

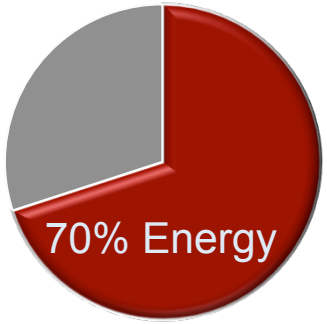
Briefing for
National Research Council study -
Pathways to Urban Sustainability: Challenges and Opportunities

Charlie Catlett
Senior Computer Scientist, Argonne National Laboratory
Senior Fellow, Computation Institute of the University of Chicago and Argonne National Laboratory
Senior Fellow, Harris School of Public Policy
Director, Urban Center for Computation and Data

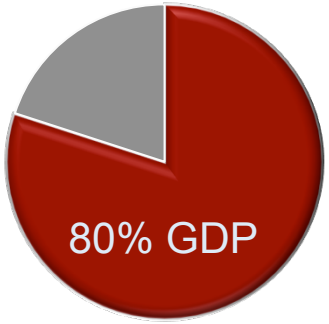
Cities are Central Drivers of:



Climate Change



Energy Security



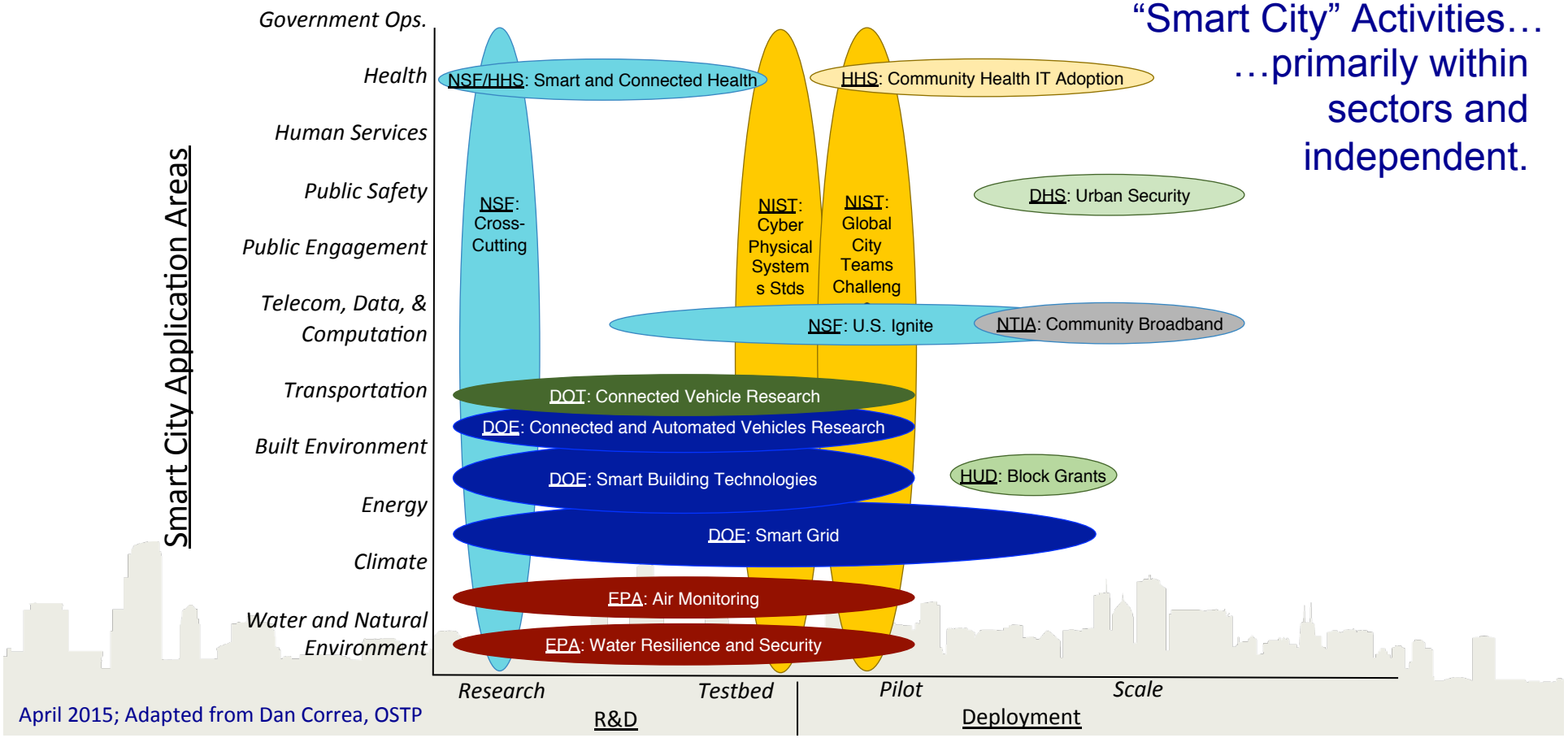
Economic Vitality

To address Climate Change and Energy Security while maintaining Economic Vitality will require understanding cities as multiscale, complex, dynamic, interconnected systems.

catlett@anl.gov

Federal "Smart City" Programs

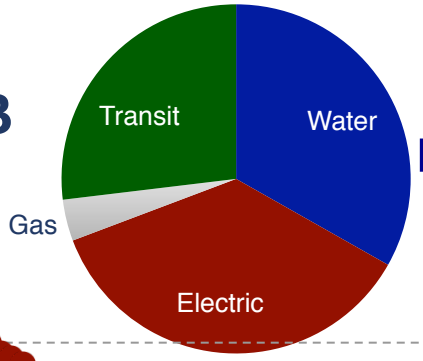
There Are Many Federal "Smart City" Activities…
…primarily within sectors and independent.

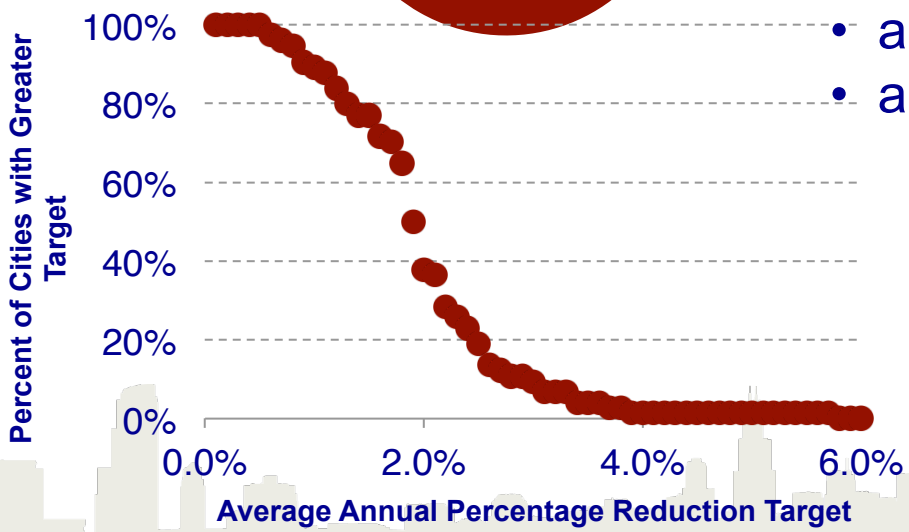


April 2015; Adapted from Dan Correa, OSTP

Urban Energy and Emissions

$183B





Achieving the emissions and energy reduction goals of U.S. cities will require:

- **data driven understanding**
- of the **interactions**,
- across **spatial and temporal scales**,
- among **integrated** urban
  - energy (buildings, storage, generation, grid),
  - emissions,
  - water,
  - environment, and
  - mobility.

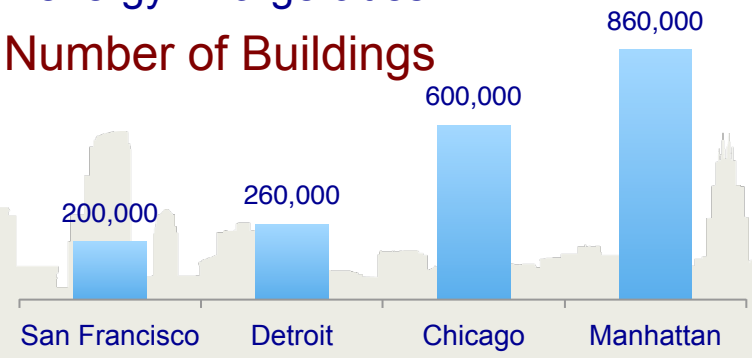
Used with permission: L. Doris (NREL), B. Kiger (NREL), O. Ma, A. Brown (NREL), S. Capanna, J. Dowd

catlett@anl.gov

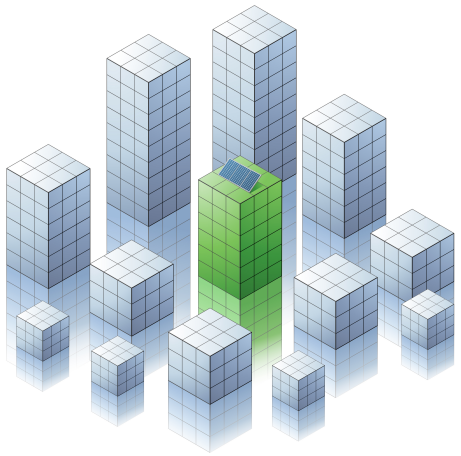
Imagine a City…

…that consumes 50% less total energy per capita, without compromising economic vitality or quality of life.

- Cities emit 80% of global CO_2
- Buildings consume more than 50% of energy in large cities



- Research Challenges: What are the "emergent behaviors" of cities as a whole (buildings, power grid, transportation, socio-economic choices, human activities) that can be leveraged to reduce energy consumption?

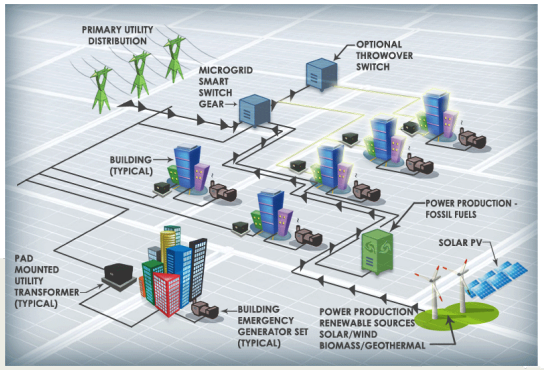


catlett@anl.gov

Imagine a City…

…that is designed to be resilient to disruptions and can rapidly respond to events and changing conditions by harnessing computational models linked to real-time data.

- Research Challenges: How can a city be designed or modified to be as resilient as possible, balancing redundancy and efficiency? How can a city use high performance integrated computational models, predictive analytics, and real-time data to optimize response to disruptive events and conditions and to minimize operational impact?

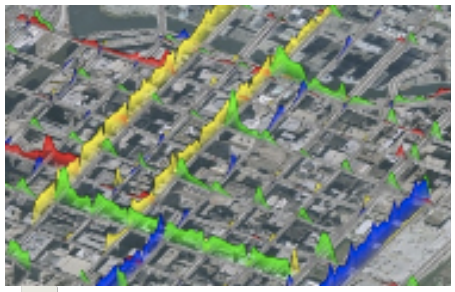


catlett@anl.gov

Imagine a City…

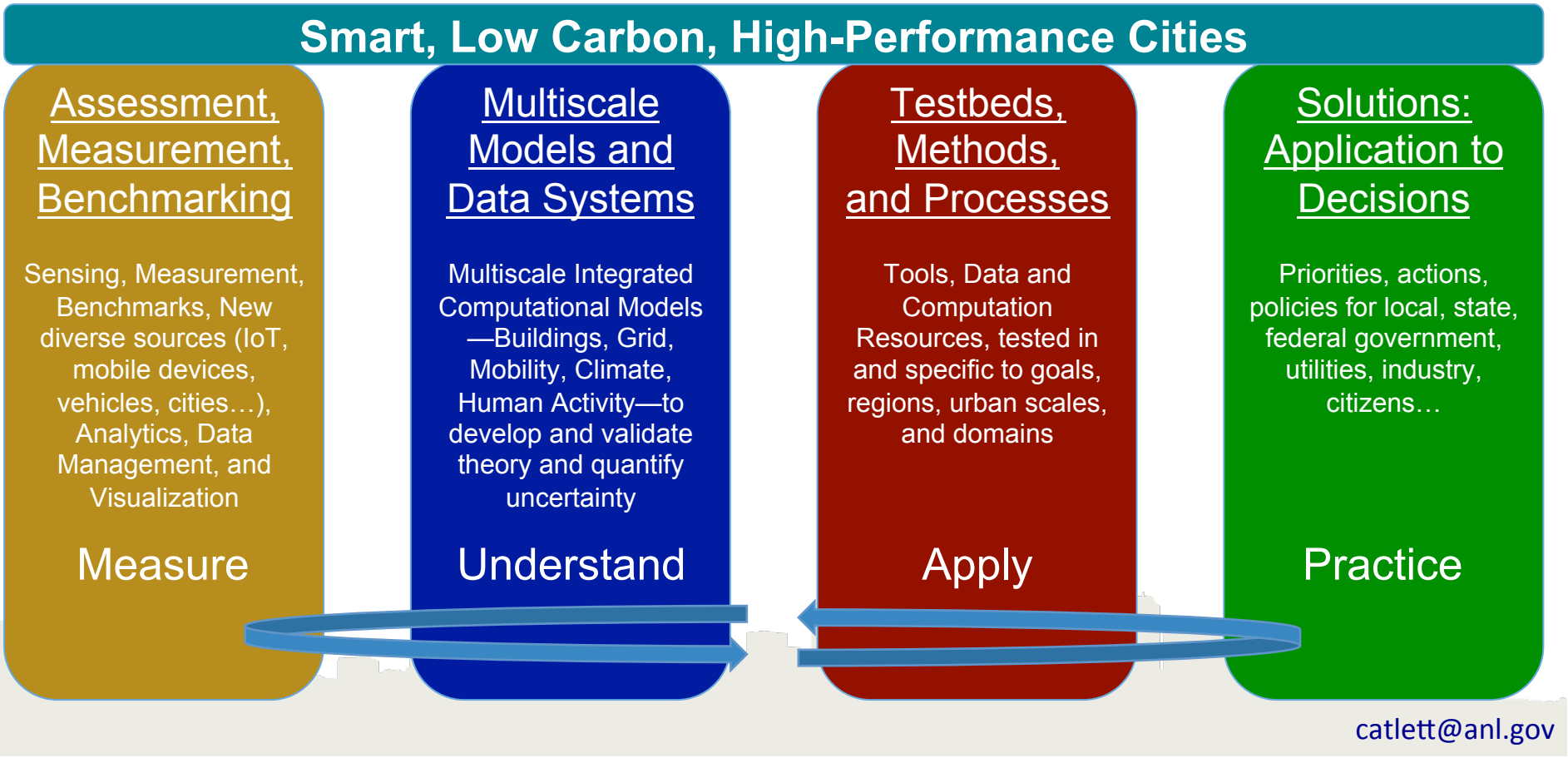
…where travel is unimpeded, no matter the location or time of day, reducing transit fuel costs and GHG emissions and congestion-related delays by 50%.

- Research Challenges: Reliable assessment of potential solutions for traffic congestion; delivering real-time routing plans, exploiting autonomous vehicle capabilities such as platooning and vehicle-to-infrastructure communications.



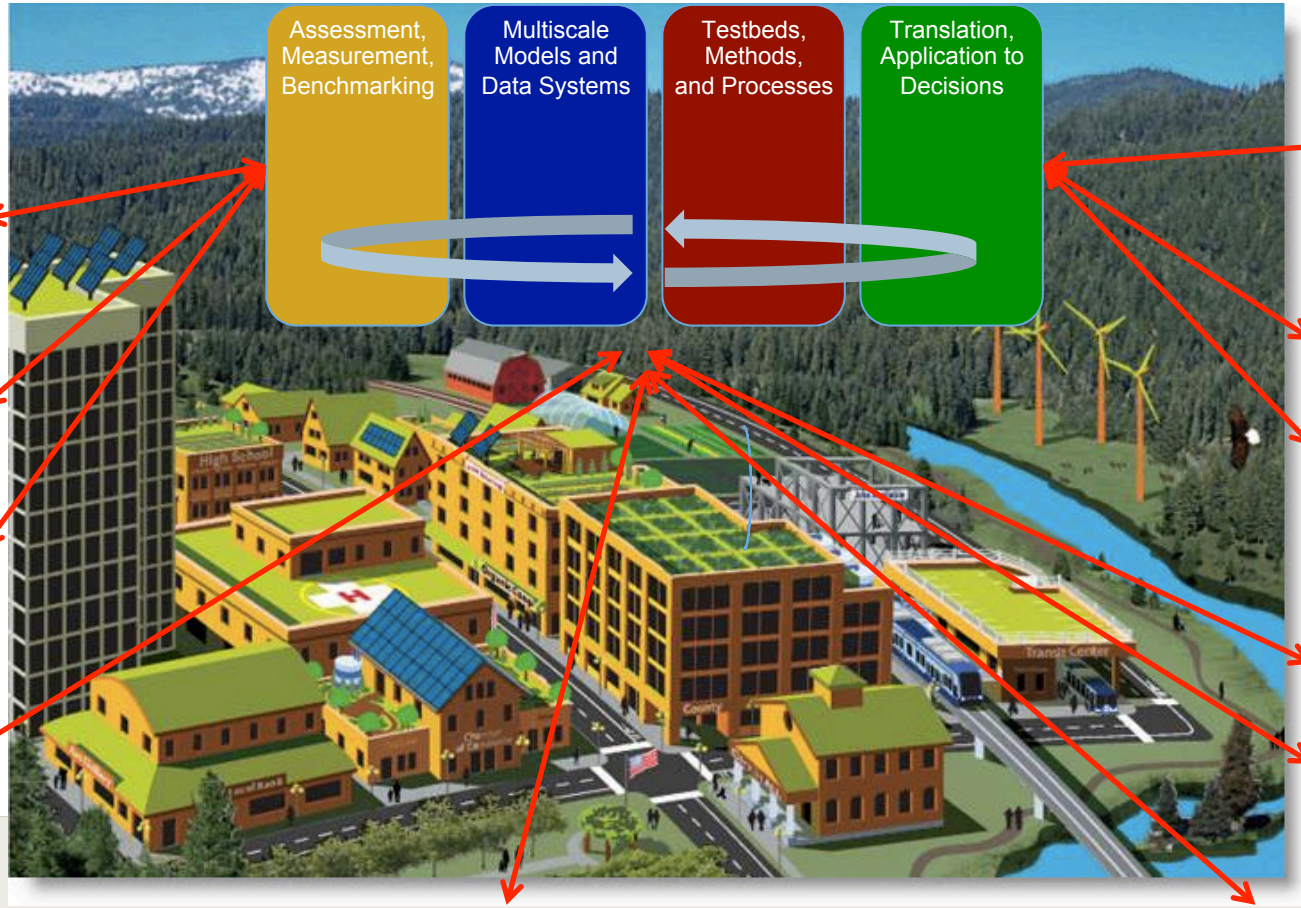
catlett@anl.gov

A Proposed DOE Urban Science and Engineering Initiative



catlett@anl.gov

DOE Smart, Resilient, Low-Carbon Cities



catlett@anl.gov

Example Research Questions

- How do individual urban systems (buildings, grid, transportation, water, …) behave, how do they interact, and what reductions (energy usage, GHGs) are possible if the system as a whole is optimized?
- How do urban areas impact regional and global climate? How will their future impact be affected by changes in fuel sources and technology? Climate? Social and Economic Factors?
- How will urban areas be impacted? How can cities respond to these impacts while maintaining sustainability, resilience and livability?
- What impact will connected vehicles, and eventually autonomous vehicles, have on traffic congestion? Energy usage? Urban sprawl? Air quality?
- How can urban renewable energy sources and distributed storage be integrated into building or district management systems to reduce energy usage?
- What is the impact and footprint of urban areas with respect to energy? Carbon and Climate? Water? Environment?

catlett@anl.gov

Urban Science and Engineering Initiative Executive and Leadership Team

Executive Team

Mark Peters (ANL), Associate Laboratory Director
Douglas Ray (PNNL), Associate Laboratory Director
Dana Christensen(NREL), Deputy Laboratory Director
Ramesh Ramamoorthy (LBL), Associate Laboratory Director
Al Sattelberger (ANL), Deputy Laboratory Director
Horst Simon (LBL), Deputy Laboratory Director

Scientific Leadership Team

Charlie Catlett (ANL)
Senior Computer Scientist, ANL;
Director, Urban Center for Computation and Data, Computation Institute of the University of Chicago and ANL
Mary Ann Piette (LBL)
Director, Building Technology and Urban Systems Division, LBL
Thom Dunning (PNNL)
Co-Director, Northwest Institute for Advanced Computing, PNL
Nancy Carlisle (NREL)
Director, Integrated Applications Center, NREL
Budhendra Bhaduri (ORNL)
Director, Geographic Information Science and Technology (GIST) group

catlett@anl.gov