Adaptive measures for homes, buildings, and cities in California

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Impacts of Climate Change

- Extreme heat
- Flooding
- Sea level rise/storm surge
- Intense storms (including wind storms)
- Decreased water resources
- Wildfire
- Disease vector distribution
- Heat-related pollution impacts (e.g. ground-level ozone)
- Ocean/coastal changes

Homes

Water Conservation

- Low-water landscaping
- Tiered water pricing
  - Both total-use and dual (outdoor/indoor) metering strategies
- Rainwater harvesting
- Greywater systems
- High-efficiency fixtures and fixing household leaks
- Current California Water Plan goal is to reduce urban water use by 20% by 2020
- "If California had the same residential water use rates as Australia, it could have reduced gross urban water use by 2,600 GL (2.1 million acre-feet) in 2009 and potentially saved 1,800 GL (1.5 million acre-feet) for consumptive use by others." (Cahill and Lund, 2012)
- Also a mitigation option: can save energy/emissions

High Heat

- Air conditioning
  - (CEC 2004) found that 30% of peak load was due to air conditioning demand
  - Expected to increase, particularly in areas without A/C (e.g. coastal zones) (Lu et al., 2008)
  - Distributed renewable energy can help meet this demand
- Urban Heat Island mitigation efforts
- Improved housing design
- Improved insulation/weatherization
  - Also a mitigation option: can save energy/emissions
- Individual adaptive behaviors
  - Going outside, changing clothes, bathing
  - Correlate with indoor temperature, increased in multi-family housing (White-Newsome et al., 2011)

Other Impacts

- Wildfire (CEC, 2009)
  - Don't build in fire-prone areas
  - Improved emergency response
  - Vegetation clearances around homes, fire zone buffers/breaks
- Disease vector prevention
  - Empty swimming pools are a primary site of mosquito breeding, predicted by things like foreclosed homes (Harrigan et al., 2010)
- Sea-level rise
  - Coastal erosion prevention
  - Relocation (subject to local and state laws and policies)

Buildings

Cool Roofs

- Energy consumption can be reduced significantly through cool roofs, green roofs, and related high-reflectance building materials (Levinson and Akbari, 2010; Akbari and Rosenfeld 2009)
  - Essentially mitigating the Urban Heat Island Effect
- Cool roofs (including green roofs, and low-albedo roofs) are most effective in older buildings, those with good insulation see smaller improvements in energy performance (Castleton et al., 2010)
- Though UHI contributes ca. 2-4% of global warming, increasing the albedo of urban surfaces is unlikely to reduce global temperatures (Jacobson and Ten Hoeve, 2012)
  - See response from LBNL Heat Island Group – numbers are highly uncertain and mitigating the UHI can reduce energy demand and CO2 emissions significantly
- Also a mitigation option: can save energy/emissions

Additional Cooling Methods

- Managing building heat (e.g. from air conditioners)
- Optimizing building materials
- Geothermal heat pumps
  - Possibility for significant GHG emissions reductions and energy savings relative to mechanical cooling (up 78%; NREL, 1998)
  - Performance dependent on local climate, ground temperatures, and seasonal demand
- Passive structural cooling
  - Ventilation shafts can improve comfort and reduce energy consumption in high-rise buildings (Prajongsan, 2012)
  - Passive solar cooling
- Building Code Changes
  - Wider temperature tolerance
    - May result in economic cost associated with business preferences for cooler facilities during the hottest months

Trees

- Can reduce locally-experienced temperatures and the urban heat island effect
- Evapotranspiration provides a local cooling effect but increases water consumption with increasing temperatures
- Energy consumption can be reduced in buildings by reducing air-conditioning demand through shade
  - Location (West), height of building (to be shaded), local climate, and type of tree (shade tree, evapotranspiration rates) all affect the energy savings for cooling purposes
    - Nikoofard et al, 2011; Mochida et al, 2006;

Water Resources

- Rainwater harvesting
- Grey water systems
- Recycled water
- Improved industrial processes/ industry shifts
- May be a successful strategy for commercial/industrial water uses
- Also a mitigation option: can save energy/emissions

Cities

Cool Centers

- A central location with air-conditioning for local residents to use on high heat days.
- Can be located in local government-run facilities such as senior centers, community centers, fairgrounds, libraries, and other public facilities.
- Should be located in areas accessible by vulnerable populations (e.g. seniors, those without adequate insulation, etc.)
- Should be located in areas likely to experience greater rates of extremely hot days, areas where loss of power due to demand stress is high, or other vulnerable communities
- Should be accompanied by a transportation plan for at-risk individuals

Critical Infrastructure

Major Impacts and Responses	Critical Infrastructure Elements

- Sea-level rise
  - Resilient infrastructure design
  - Rolling easements/managed retreat
  - Setbacks/buffer zones
  - Relocation of infrastructure elements
- Flooding
  - Expanded flood zones/improved flood maps
  - Improved flood channel design
- Wildfire
  - Increased wildland-urban interface buffer zones
- Heat
  - Mitigate Urban Heat Island Effect
  - Cool pavement, cool roofs
  - See Levinson et al., 2010

- Wastewater treatment facilities
- Sewage lines
- Ports/airports
- Electricity transmission
- Power plants
- Hospitals
- Communications infrastructure
- Transportation

Transportation Infrastructure

- Road surfaces
  - Heat can cause material damage
  - Flooding
- Critical transportation routes
  - For traffic circulation, critical routes should avoid high-risk zones (e.g. flood-zones and areas prone to coastal erosion)
  - For evacuation, critical routes should allow for movement from areas at risk from extreme events
- Rail tracks
  - Heat can cause buckling
  - Flooding
- Overhead electric lines
  - Light rail and other transit dependent on overhead electric lines are at risk to similar heat and storm-related stresses as exposed power transmission lines
- Bridges
  - Build for a consideration of sea-level rise and increases in storm surge or flood height
  - During routine maintenance, this can avoid a “retrofit penalty”


Emergency Response

- Coordinated regional emergency response planning associated with specific impacts
  - Address critical infrastructure first
  - Redundancy for energy systems in at-risk areas
  - Example: San Gabriel Valley Windstorm, Dec. 2012
    - 433,945 Southern California Edison customers affected; Outages lasted 13 to 187 hours; 300 poles replaced; 100 circuits repaired
    - 80 power technicians from PWP, mutual aid, and contractors 20,000+ man-hour; PWP and contract call center handled over 8,000 calls; Power restored to 95% of impacted customers 6 p.m.12/2
    - $50 million damage for all affected communities
    - Power outage: Slowed emergency response; Slowed traffic; Closed gas stations; Patients dependent on medical devices without battery backup required generator or relocation

- Community outreach protocol for specific impacts
  - Extreme heat events
  - Flooding and storm events
  - Wildfires

Water Resources

- Surface storage
  - Mitigate evaporation through capping or natural means
  - Tied to flood management
- Conjunctive use
  - Integrate floodplain management, groundwater banking, and surface storage
- Groundwater resources
  - Improve recharge and infiltration
  - Integrated with public works (streets, etc.)
  - Recharge with recycled water (also to forestall saltwater intrusion in coastal aquifers)
- Water curtailment strategies/drought management

Land Use Planning

- Should consider public health
- Should consider emergency response
  - Hazard mitigation plans
  - (e.g. coastal and wildfire evacuation methods)
- Could discourage development in high-risk areas
  - Limit floodplain development (e.g. through National Flood Insurance Program)
  - Limit development in the urban-wildland interface
- Mechanism for policy responses such as managed retreat, rolling easements, and disaster risk evaluation (e.g. flood zones)
  - General plan elements
  - Include hazard (flood, fire) information in general plans

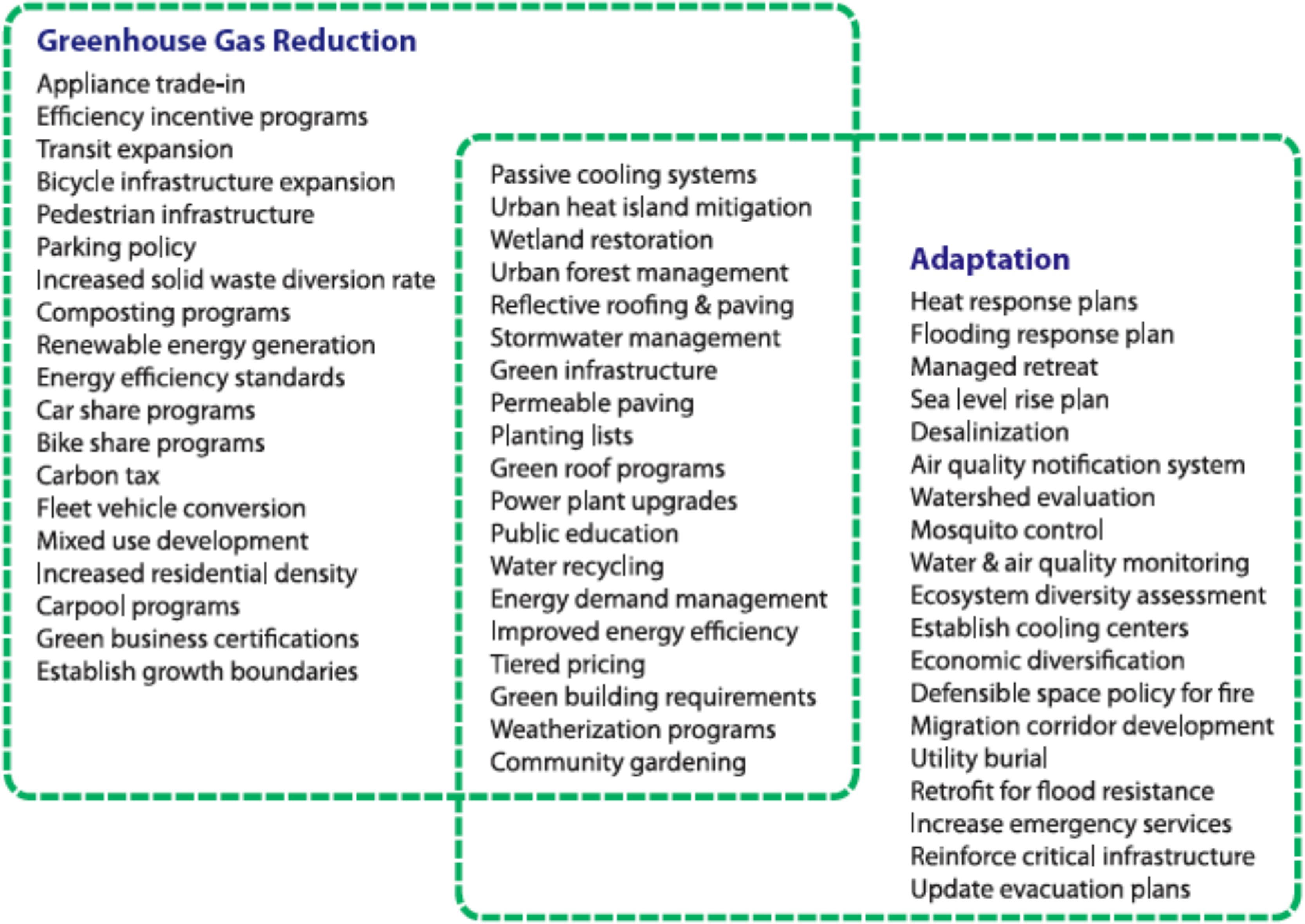

Figure 2. Illustration of the overlap between greenhouse gas emissions reduction measures and climate change adaptation strategies.
[Moser, 2012; Boswell, Greve, and Seale, 2012]

Open Questions and Issues

- The California Climate Adaptation Strategy is an excellent source for adaptation policy guidance. It could be expanded to address urban issues more thoroughly.
  - Further elucidation of the adaptation measures is warranted (e.g. those in the draft Climate Adaptation Policy Guide.
- A framework for evaluating long-term GHG mitigation benefits versus adaptation effectiveness should be developed
  - For example, air conditioning will be required at different rates in different parts of the state
- What is the effect of land use policies, particularly SB 375, on development in high-temperature regions?
  - Can SCS include land use strategies to reduce exposure to heat and related impacts (water) that drive energy consumption?
- The success of different strategies in different parts of California deserves further investigation
  - Adaptation measures will also have different levels of success in different communities
- In general, there is a lack of quantification of the impacts of adaptation strategies on energy or costs
  - Much of it is location-specific
  - Often the impacts are not well quantified enough to allow further risk quantification
    - Though CA, due to PIER research, is much further ahead on assessing the impacts
- Climate services would be useful
  - Monitoring, forecasting, decision support, and warning systems

Acknowledgements

- Walker Wells, Global Green USA
- Ted Bardacke, Global Green USA
- Cris Liban, LA County Metro
- Stephanie Pincetl, UCLA Institute of the Environment and Sustainability
- Sarah Potts, Clinton Climate Initiative
- John Penido, Los Angeles County