IEQ Roadmap Update
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Introduction/overview

Hal Levin
Building Ecology Research Group
hlevin6@gmail.com
http://buildingecology.com

Outline of Presentation

- Links between Energy and IEQ:
  - Which changes will bring about needs for IEQ research (regulatory and non-regulatory)?
- Outline of Input Needs
  - Scenarios: what are major changes in California's buildings (2011-2021) to move towards low energy – regulatory and product driven (early adopters important)?
  - Research Priorities: What are IEQ research topics that will need to be addressed?

ZEBs – Possible Links to Energy and IAQ and Health – 1

Process	Link to Energy	Link to IAQ- Health
Outside air ventilation	Energy used to transport and thermally condition air	Dilutes indoor-generated pollutants Associated with symptoms, respiratory illness, perceived air quality, and work performance Brings outdoor pollutants and moisture into building In some climates: inadequate ventilation leads to increased humidity, condensation, and mold in houses
Heating	Energy used to heat and transport air	Affects thermal comfort Risk of combustion product entry to indoor air
Air conditioning	Energy to cool, dehumidify and transport air	Affects thermal comfort Risk of microbiological contamination of wetted surfaces. Risk of condensation on occupied space surfaces when warm air enters cooled interior. Associated dehumidification may help prevent moisture problems and microbiological contamination Associated with increased health symptoms Can be a source of unwanted noise
Humidification	Energy to evaporate water	Affects comfort Potential source of microbiological and chemical pollutants in the HVAC system May lead to condensation and microbiological growth on occupied space surfaces. Linked to respiratory illnesses from humidifier contaminants Possible link to person-to-person respiratory illnesses transmission

(Adapted from 2002 IEQ Roadmap)

ZEBs – Possible Links to Energy and IAQ and Health – 2

Process	Link to Energy	Link to IAQ- Health
Particle filtration	Energy used to overcome airflow resistance May save energy by preventing fouling and obstruction of heating and cooling coils and ductwork	Reduces indoor particle concentrations with indoor or outdoor origin Reduces soiling of surfaces Filters can be odor sources Filters, if wet, can be contaminated microbiologically
Air recirculation	Energy used to transport air	Enables filtration of recirculated air Causes dispersion of indoor pollutants Reduces concentrations of indoor pollutants near sources Potential source of noise in occupied space
Building pressure control	Energy used to transport air Sealing moisture pathways	Affects pollutant and moisture transport through building envelope and among rooms May prevent or cause moisture problems in building envelope Prevents or causes infiltration-related drafts and comfort problems Back drafting
HVAC maintenance	Improves HVAC system operation, expected to normally save energy	May improve ventilation, air distribution, thermal comfort, humidity control, and pressure control Lack of maintenance may lead to microbial contamination Combustion safety problems

(Adapted from 2002 IEQ Roadmap)

ZEBs – Possible Links to Energy and IAQ and Health – 3

Process	Link to Energy	Link to IAQ- Health
HVAC Cleaning	Cleaning of coils reduces airflow pressure drops and improves heat transfer, potentially reducing HVAC energy use	May reduce, or temporarily increase, pollutant emissions from HVAC systems Debris, microbiological contamination, and poor draining from cooling coil drain pans are associated with increased respiratory symptoms
Space cleaning	Minor energy use for cleaning	May reduce indoor odors and resuspended particles Cleaning compounds can be indoor pollutant sources Workstation cleanliness has been associated with reduced symptom reports and with lower dust fungal loads.
Water leaks	Degrades thermal performance of building envelopes May increase dehumidification energy	Increases indoor microbiological contamination including fungi and bacteria. Affects presence, survival and pathogenicity of viruses. Linked to increase in respiratory symptoms and asthma and other allergy symptoms.
Indoor pollutant source exclusion or isolation	Often energy neutral; except when source or its replacement consumes energy or affects heat transfer from indoors to outdoors. May reduce ventilation requirements	Reduces indoor pollutant concentrations May reduce loading on air filters, air cleaners, and interior surfaces

(Adapted from 2002 IEQ Roadmap)

ZEBs – Possible Links to Energy and IAQ and Health – 4

Process	Link to Energy	Link to IAQ- Health
Envelope insulation and tightness	Reduce heat gain and loss	Reduces moisture intrusion (tightness) Changes dew point location Reduces infiltration that provides air exchange where proper means are not in use and Reduces intrusion of vapor and pollutants Garage vapor intrusion
Crawl space or slab seals	Reduce heat gain and loss Vapor intrusion .	Reduces moisture intrusion Changes dew point location Reduces infiltration that provides air exchange where proper means are not in use and Reduces intrusion of pollutants Reduce vapor intrusion
Windows and skylights: ventilation, lighting	Reduces unwanted heat loss/gain, air leakage Reduces need for electric illumination Can be source of unwanted air leakage Can be source of desirable ventilation Replace or Back up for mech'l systems	Dilutes indoor-generated pollutants Associated with symptoms, respiratory illness, perceived air quality, and work performance Brings outdoor pollutants and moisture into building In some climates: inadequate ventilation leads to increased humidity, condensation, mold in houses Can provide natural lighting, beneficial views Can be source of noise intrusion.
Gaseous air cleaning	Energy used to overcome airflow resistance Reduced energy when indoor air is recirculated	Reduces indoor gas concentrations with indoor or outdoor origin Reduces volatile and semi-volatile organic compounds Filters can be odor sources Wet filters can be contaminated microbiologically Chemical reactions on filters can be sources of cleaner or fouler air

(Adapted from 2002 IEQ Roadmap)

Questions to focus comments on…..

1. What are the most important linkages between energy use and indoor environmental quality?
2. Most important IEQ effects in terms of health
3. Measures most likely to improve energy and IEQ
4. Other linkages not included here

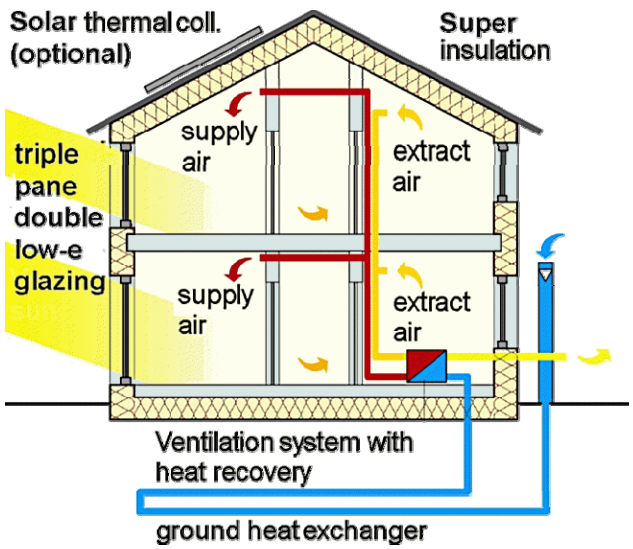
Draft Scenarios: Trends in Achieving ZEBs (New and Retrofits) that Might Affect IEQ

Hal Levin

Very Low Energy Buildings Commercial and Residential

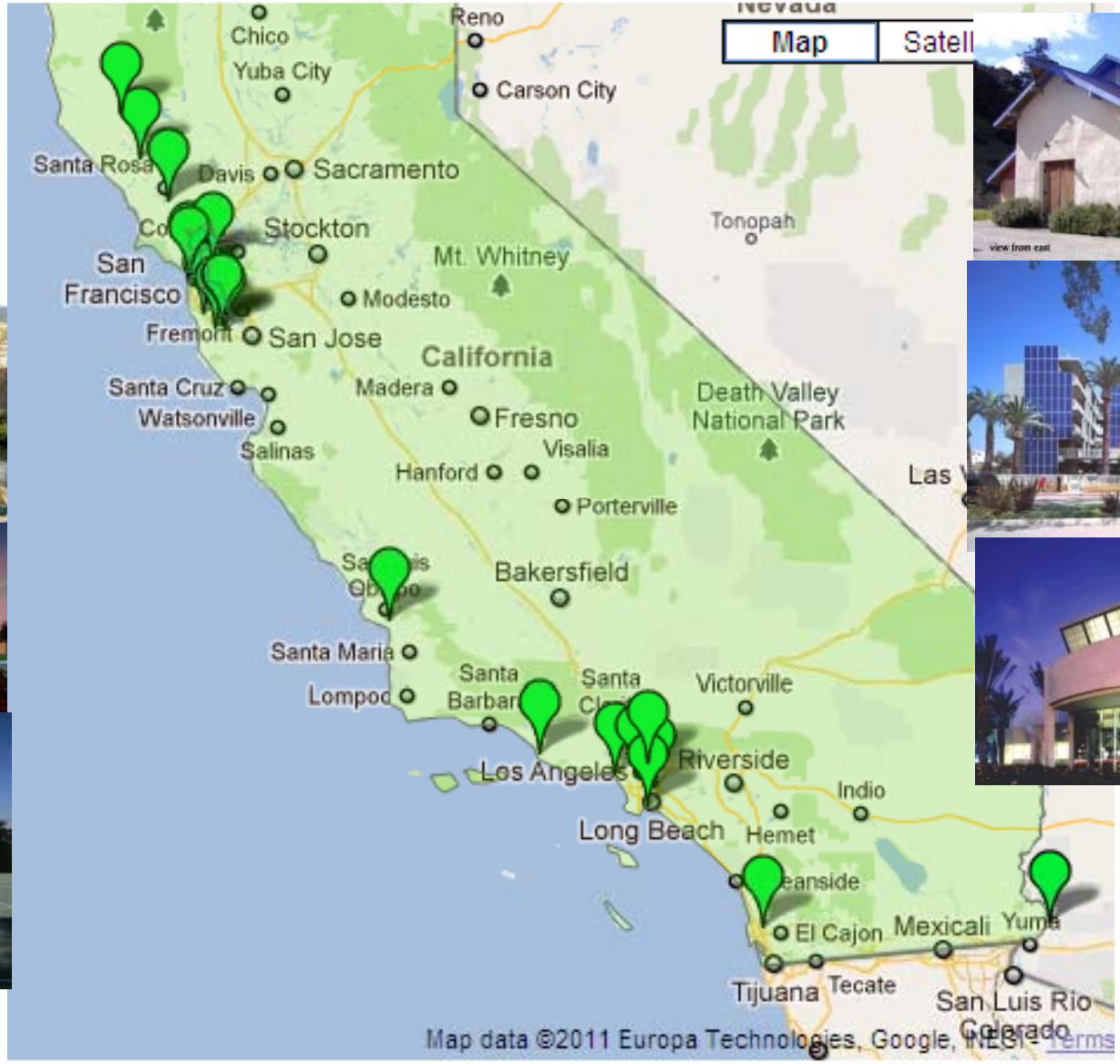
Examples of Low-Energy Technologies

- Tightly sealed, super insulated, tested to verify performance
- Mechanical ventilation with heat recovery
- Mini-split heat pump
- Low VOC materials, sealed combustion appliances
- Energy use
  - residential: ~ Primary Energy ≤ 38.1 kBtu/ft^2/yr
  - commercial ~12 kBtu/ft^2/yr
- Commissioning
- IAQ , ventilation and thermal comfort verified

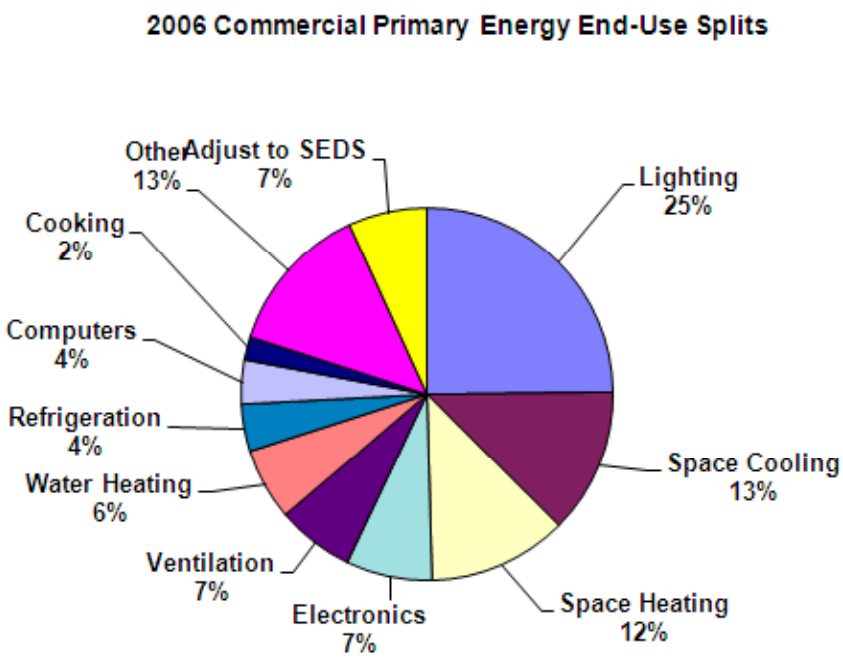


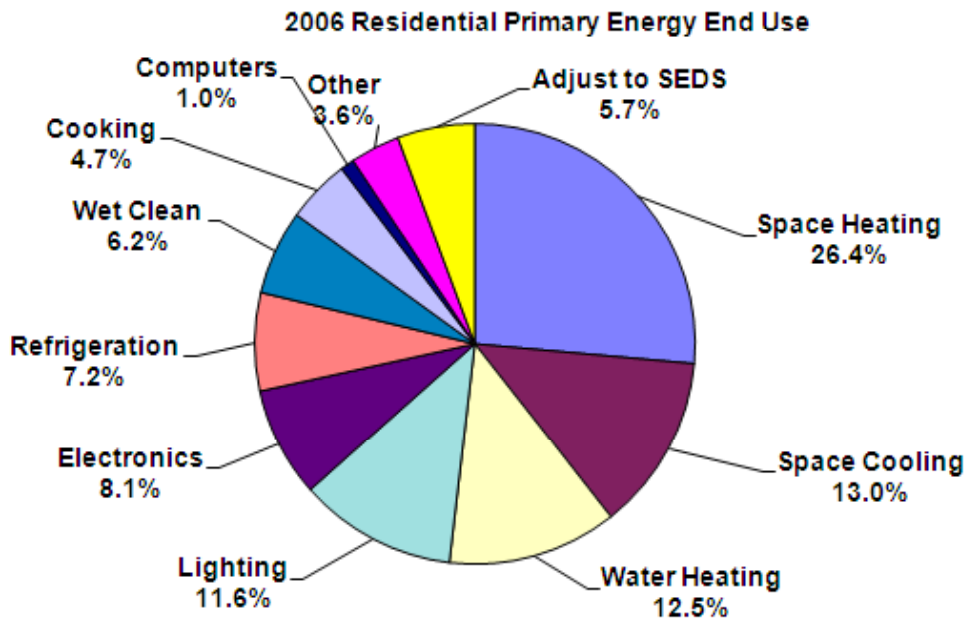
High Performance Building Database

http://eere.buildinggreen.com/searchby.cfm?search=location

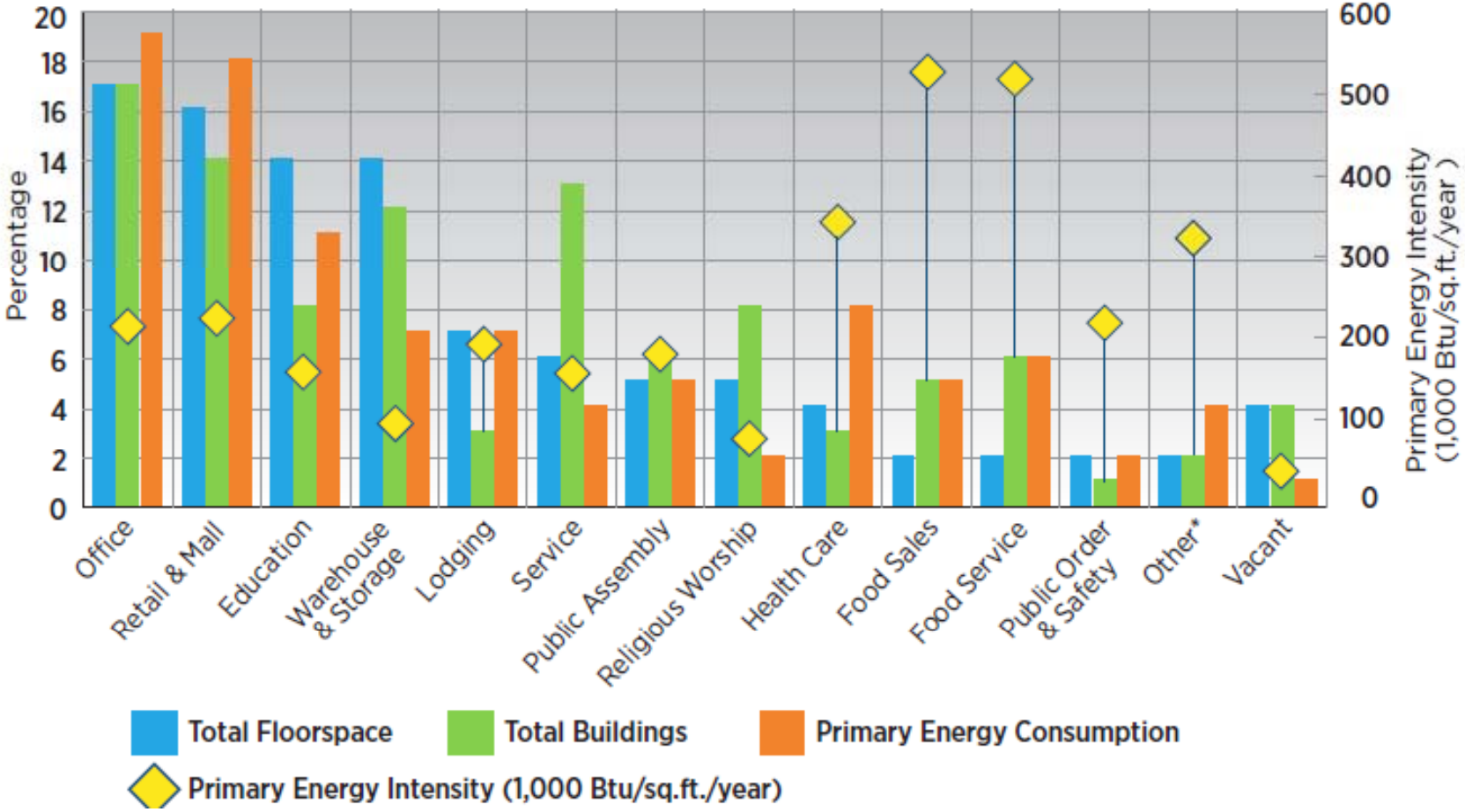


Primary Energy End-Use Splits
US DOE 2009 Building Energy Data Book





Commercial Buildings' Shares of floor area (sf) and primary energy consumption (Btu/sf-yr)



Adapted from US DOE 2009 Building Energy Data Book (2003 data)

Outline: Possible Scenarios New and Retrofit

- Ventilation
- Air cleaning and filtration
- Building shell
- Sources
- Climate change
- Commissioning, re-commissioning, fault diagnostics
- Operation and Maintenance
- Commercial role: Products, services

Ventilation – 1/2

- Reduced or minimized outdoor air ventilation
- ASHRAE IAQ Procedure (see big box study, CEC-funded LBNL vent study)
- Increased fault detection and diagnostics for HVAC (FDD)
- Increased reductions of OA ventilation by building operators to save costs
- Continuing non-enforcement of Cal OSHA Minimum Building Ventilation regulation
- More natural ventilation cooling (economizers, night cooling, hybrid natural ventilation)

Ventilation –2/2

- Personal ventilation - local ventilation air delivery and control
- Personal thermal comfort systems – local radiant devices
- Changing HVAC operational hours
- Improved air filtration systems
- Recirculation with or without filtration
- UVGI implementation in health care, home HVAC
- Increased use of portable HEPA air cleaners

Air Cleaning/Filtration

- Improved air filtration systems performance
  - Improved media
  - Higher performance specifications (higher MERV)
  - Better installation (avoid by-pass)
  - Appropriate replacement/renewal
- Recirculation with or without filtration
- UVGI implementation in health care, home HVAC
- Increased use of portable HEPA air cleaners

Building Shell: reduced heat losses and gains

- Tighter envelopes – less air leakage
- More insulation – less heat gain/loss
- Better glazing and orientation - less heat loss and solar gain, more comfortable surface temperatures
- Exterior shading – lower solar gain in summer
  - Fixed exterior shading
  - Movable exterior shading
  - Adjustable interior shading
- More efficient lighting (lower internal heat loads)

Sources:

- Materials
  - More testing and improved specification
  - Improved products
  - Regulatory elimination of “bad actors” (e.g., Comp Wood regs from CARB)
- Appliances and equipment
  - Required exhaust for all combustion devices including cooking?
  - Eliminate backdrafting
  - Exhaust moisture to the outside

Pollutant Sources 1/2

- Increased use of lower-VOC and low- or no-formaldehyde building materials and furnishings
- Increased use of anti-pest, anti-microbial agents
- Increased use of plastics and resulting emissions of phthalates
- Increased use of scented products
- Increased use of so-called green cleaning products (increased indoor air chemistry in presence of ozone or No_x)

Pollutant Sources – 2/2

- Probiotics (beneficial microbes) for buildings
- Indoor air cleaning plants
- Air cleaners that pollute
- Air quality (CONTAM model of home)
- Ventilation adequacy

Commissioning, re-commissioning, fault diagnostics Monitoring, Control and Feedback Systems

- Time of use meters
- Fault detection and diagnosis, constant feedback (see CEC staff re: Ti. 24 proposals)
- Economizer and damper malfunctions
- Maintenance indicators, warnings
- Monitor Based Commissioning : Retro and Continuous
  - Already happening; cost effective energy-wise, quick payback

State and local regulation and market forces – 1/2

- Total consumption per square foot of conditioned space, per building, or per occupant
- Permit requirements, real-time monitoring, annual accounting, etc.
- Maximum total end use (Marin County limits number of maximum sq ft in a Single Family dwelling before renewable requirement kicks in)
- Peak load limits (throttle control?, severe price penalty, total capacity limit?)

State and local regulation and market forces – 2/2

- Time of use meters with price incentives/penalties
- GHG regulations and carbon trading, credits (will they affect any buildings/owners other than large corporations? Will they be implemented through the utilities? On-site combustion?)
- Third party retrofits that are beyond health and safety regulations
- On-site electricity generation (PV, wind)
- Possible Property Assessed Clean Energy (PACE) retrofit subsidy

Resilience in heat waves, power outages, and climate change

- Conservative assumptions for climate change over building lifetimes (50-100 years):
- Integrate whole building and community design
- Making homes ready for PV and solar hot water
- Interconnection with neighborhood grids

Climate change – AB 32 and SB 375

- Heat waves
- Severe floods and snow storms
- Wildfires
- Increased attention to filtration, infiltration, maintenance and operation issues
- Land use
  - Changes in commute patterns
  - Telecommuting
  - Increased infill and urban density
  - Higher exposures to emissions from motor vehicles, roadway proximity, commercial/industrial activity

Ambient air quality changes:

- Improvements from regulation
  - Control of wood-burning
  - Lower emissions from power plants and automobiles
  - Reduced VOC sources
- Changes from climate change
  - Increased pollen generation
  - Possibly increased mold spores
  - Increased Ozone concentrations

Behavioral factors

Motivation: economic, comfort, duty, status, convenience

- Increased use of air conditioners as indoor climate modifiers (newer houses more likely to have central A/C systems ?? covered under Land Use below
- Neglect or deactivation of mechanical ventilation in all building sectors; include spot ventilation(??)
- Increased development and training in Retro and Continuous Cx
- Productivity and health (old Johnson Controls model)
- Occupant use patterns (Offermann study)
- Increased focus on occupant behavior and plug loads

Questions to focus on…

1. What are major changes in California's buildings (2011-2030) to move towards low energy that will have the greatest potential impact on occupant health and comfort?
   - Did we miss any?
   - What are most important?

2. What other major changes will impact the energy-IEQ relationship (e.g., building commissioning)?
   - Did we miss any?
   - What are most important?

3. Will people change their behavior? How?