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Low Carbon Scenario Analysis and Climate Change in Energy Planning

Some actionable items in past and current work

EPIC Workshop

Sacramento, CA

March 16, 2017

Max Wei
Lawrence Berkeley National Laboratory

Dan Kammen
University of California, Berkeley

Brian Tarroja
University of California, Irvine

Outline

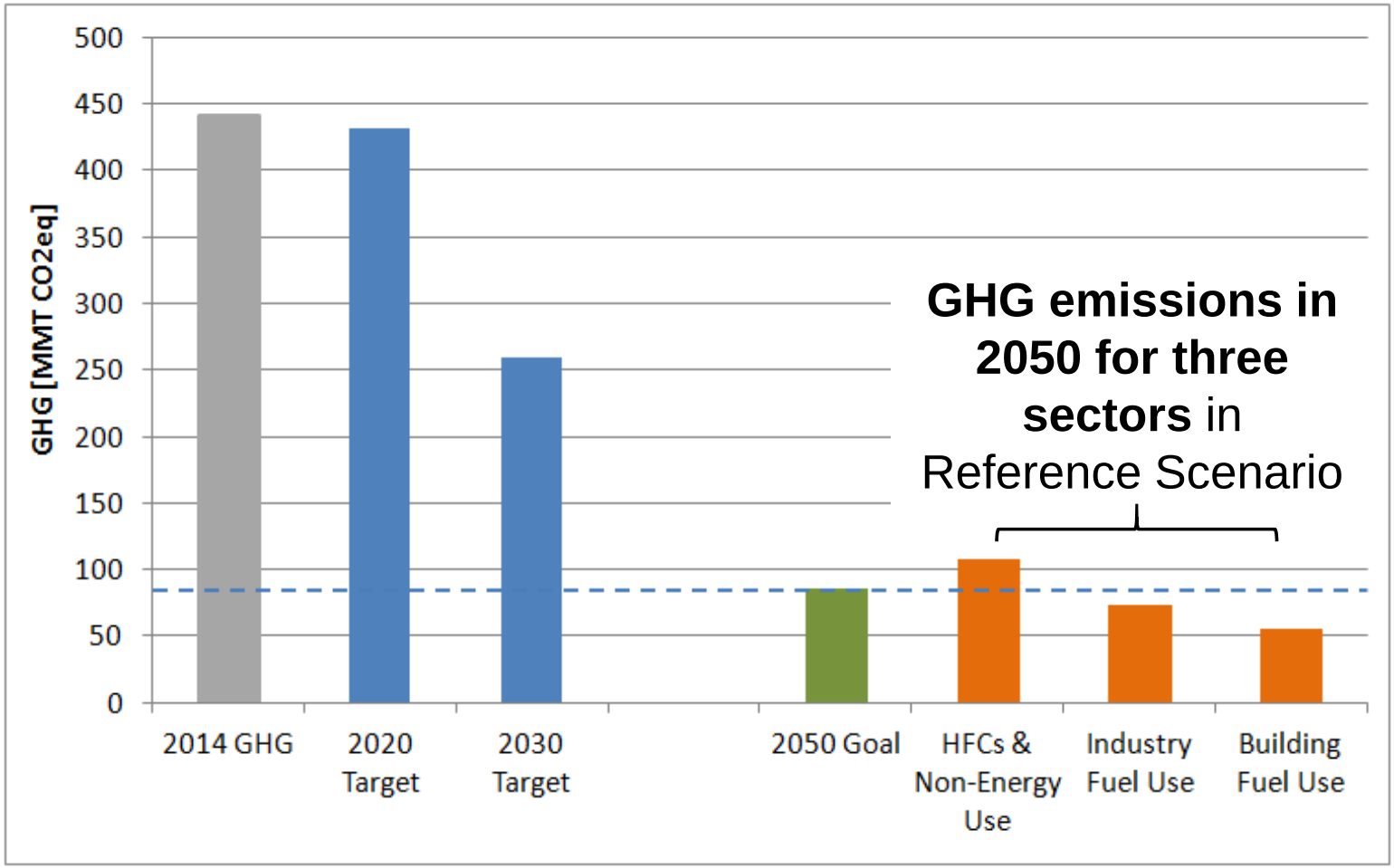
I Earlier work on decarbonization pathways and some key Actionable findings

II Current work and some key Actionable findings

- Climate change impact to load shapes
- Climate change impacts to hydropower
- Interaction of electrification, increased air conditioning demand and high GWP refrigerants (HFCs)

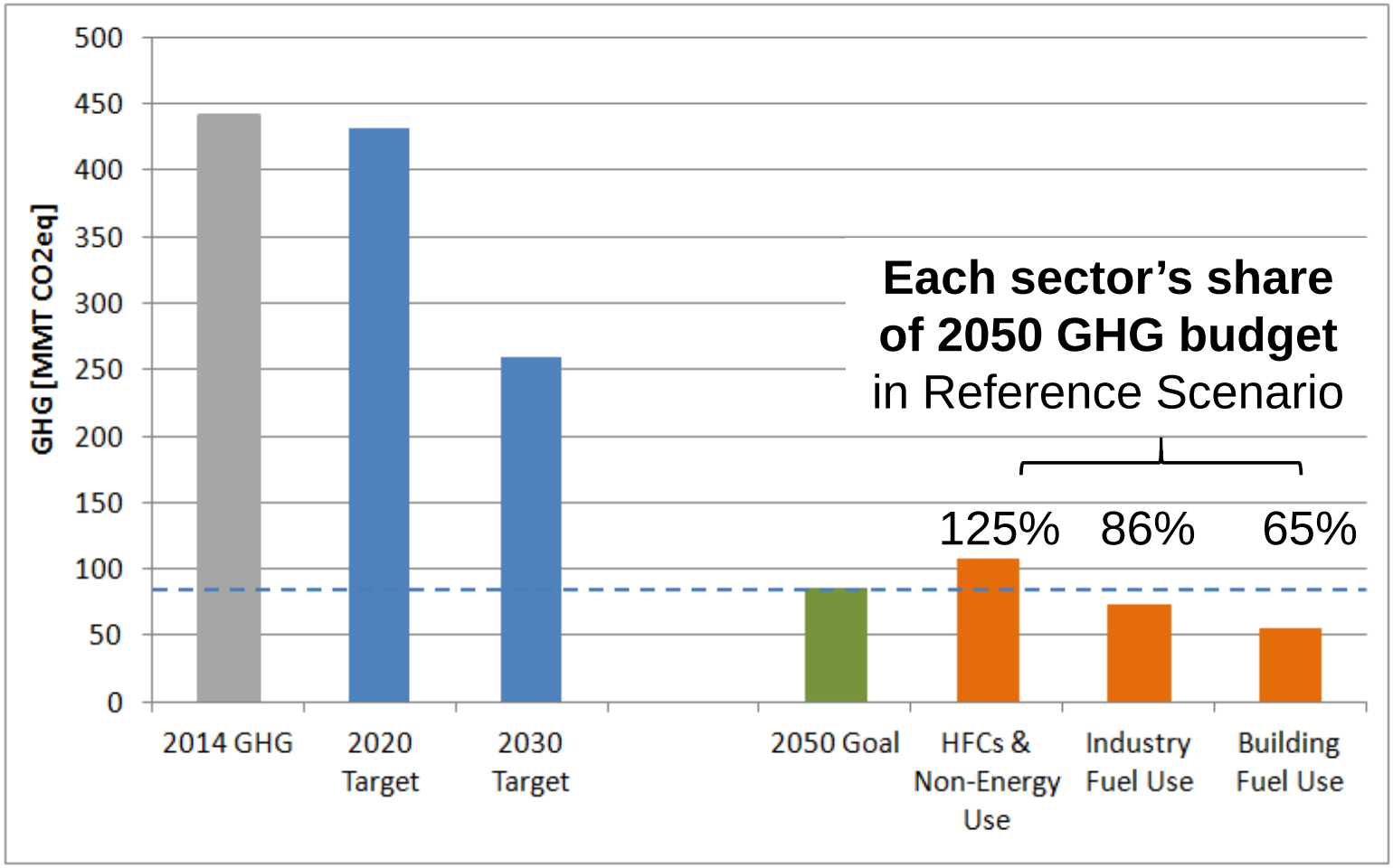
III Conclusions

Earlier work for CEC – Deep Carbon Reductions for 80% reduction in 2050



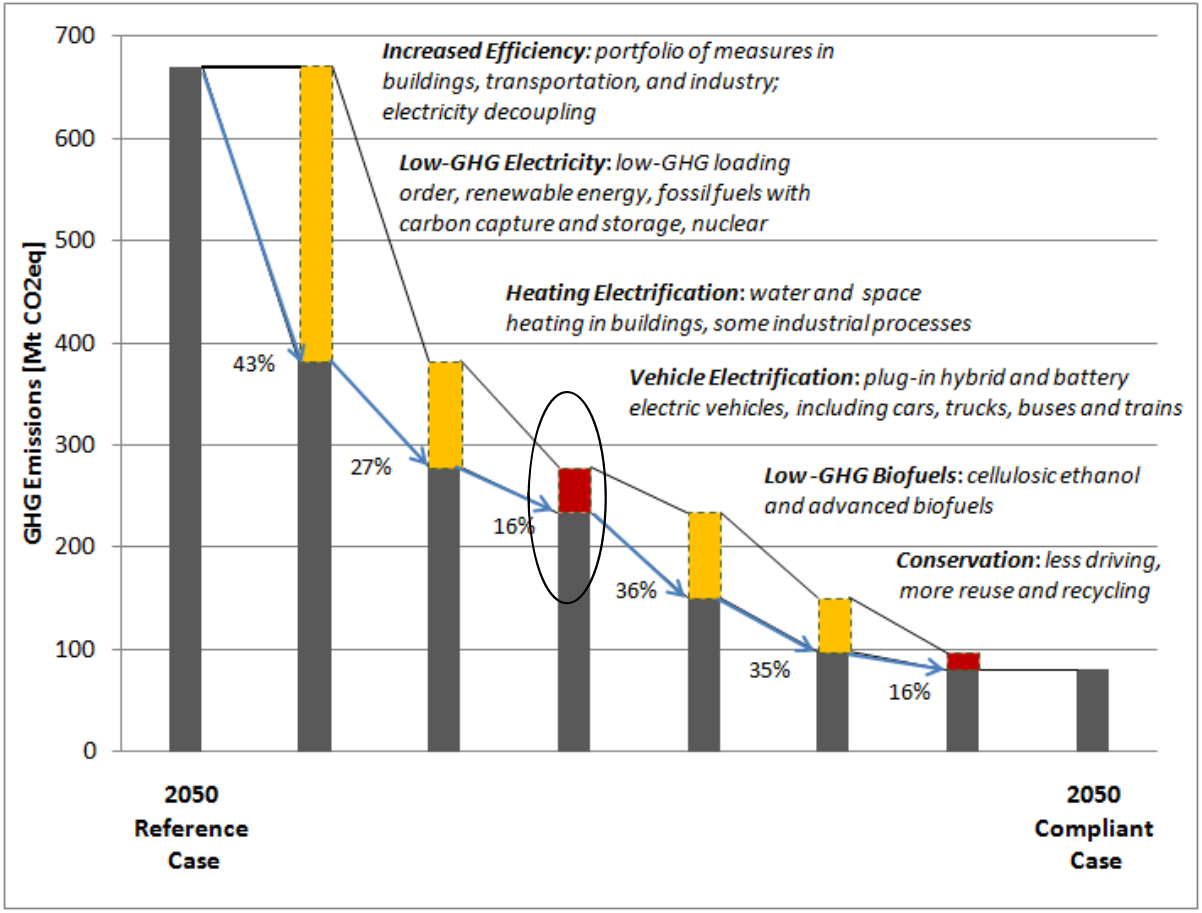
M. Wei, J.H. Nelson, J.B. Greenblatt, A. Mileva, J. Johnston, M. Ting, C. Yang, C. Jones, J.E. McMahon, D.M. Kammen, "Deep Carbon Reductions in California Require Electrification and Integration Across Economic Sectors," Environmental Research Letters, 2013; 8:014038.

Earlier work for CEC – Deep Carbon Reductions for 80% reduction in 2050



- Emissions from each these sectors can exceed or approach the total GHG goal for 2050

Earlier work for CEC – Deep Carbon Reductions for 80% reduction in 2050

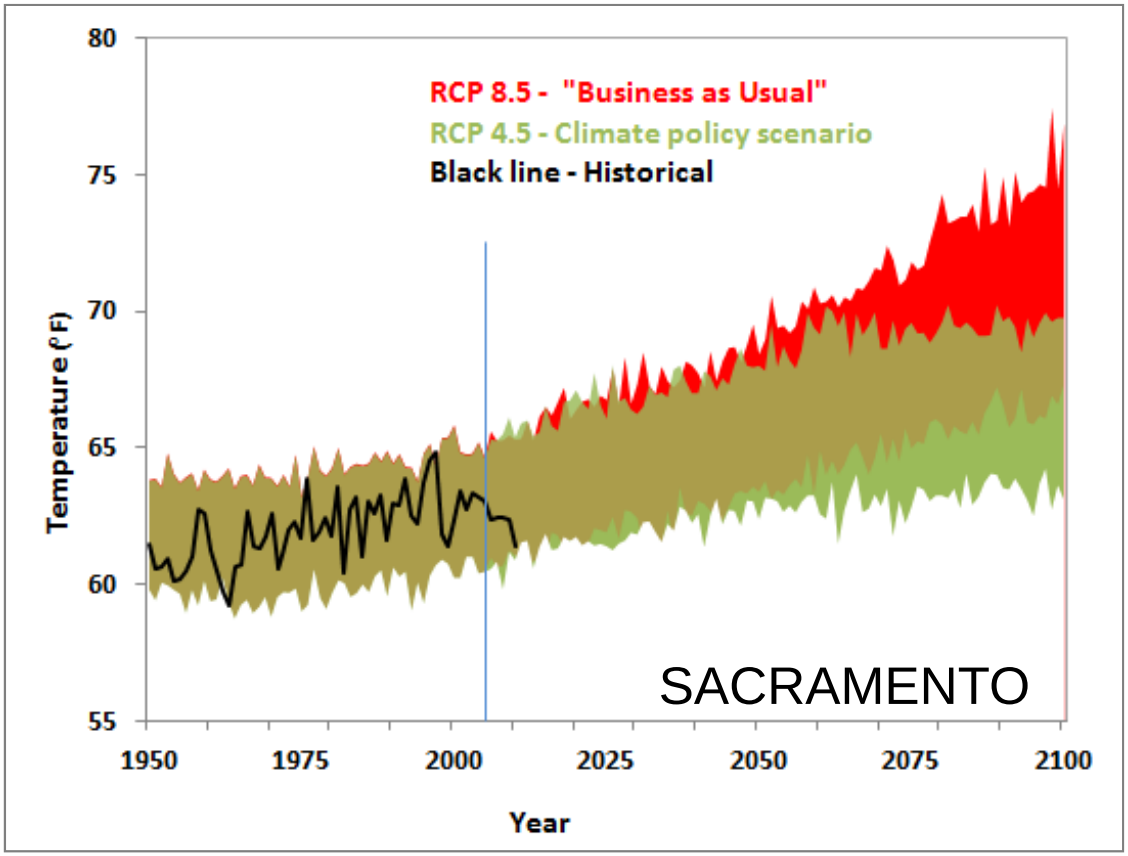


- Earlier work for CEC highlighted decarbonization pathways: Aggressive Energy Efficiency, Low Carbon Electricity and **Electrified End Uses**, Low-GHG Biofuels, & Conservation
- This work (2013) highlighted the need for **further techno-economic and societal analysis, technical demonstration and piloting** of electrified end uses

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“Probabilistic” Climate Scenarios

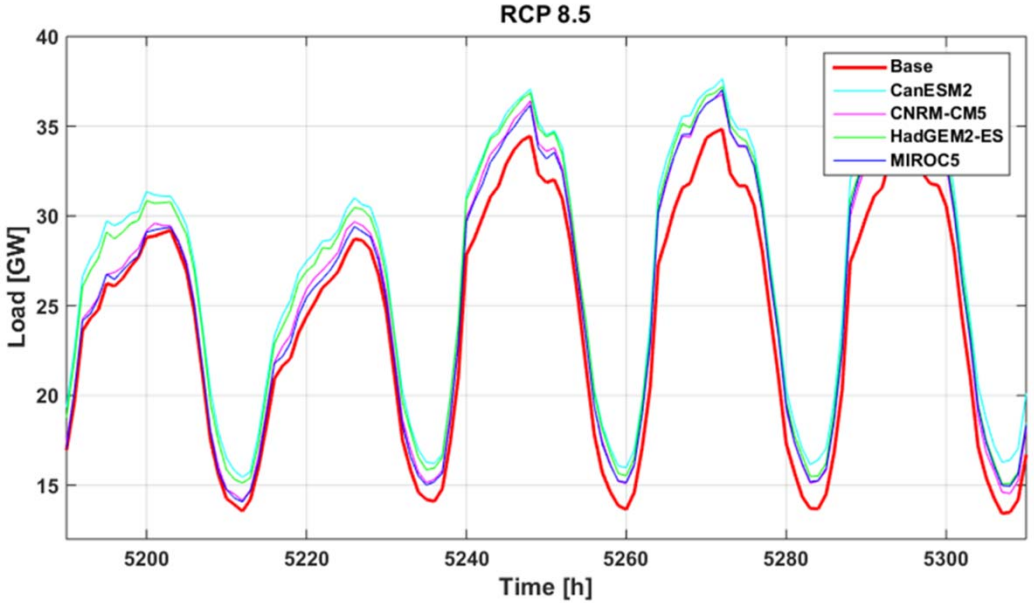
- Common set of “probabilistic” climate and sea level rise scenarios. The same scenarios that will be used for the California Fourth Climate Change Assessment.
- The climate projections developed by Scripps suggests that from the present to 2050 the scenarios are independent of global emission scenarios (RCPs).



Data from Pierce et al., 2015. Scripps Institution of Oceanography

Impacts on Electric Demand (Preliminary)

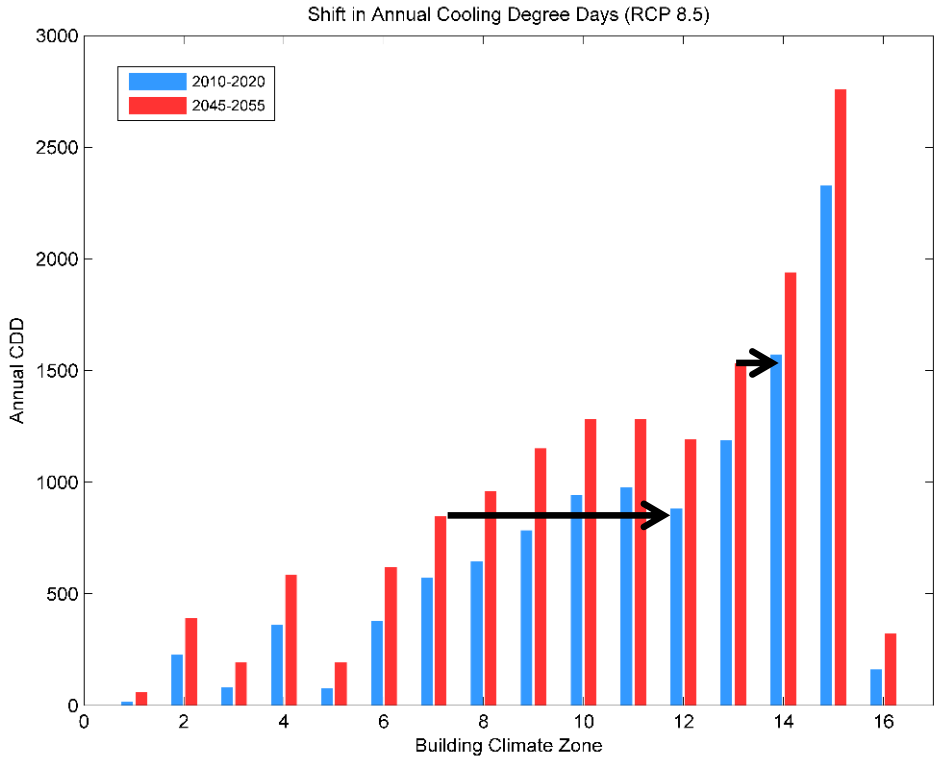
- **Impacts on Residential+Commercial Buildings (climate impacts only)**
  - **Increased temperatures cause increased cooling needs**

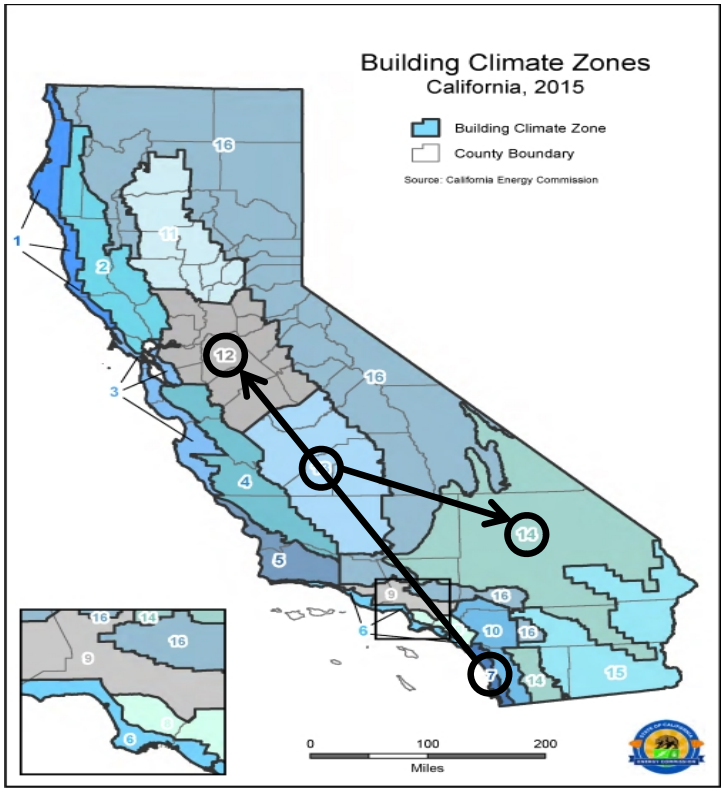


- Increased overall electricity demand
  - 1.1% to 4.3% increase over historical demand
- Increased typical peak electric demands
  - Representative typical increases of 3.2% to 8.3% over historical
- Electric demands increase, but overall energy demand at the building level actually decreases
  - Lower space heating demand
- Electrification of residential heating through heat pumps:
  - Reduced overall energy consumption – space heating and water heating

✓ **NEXT STEPS – Integration of climate-impacted load shapes into Electricity Supply Modeling (SWITCH)**

Future demand impact: More air conditioning equipment adoption (Preliminary)



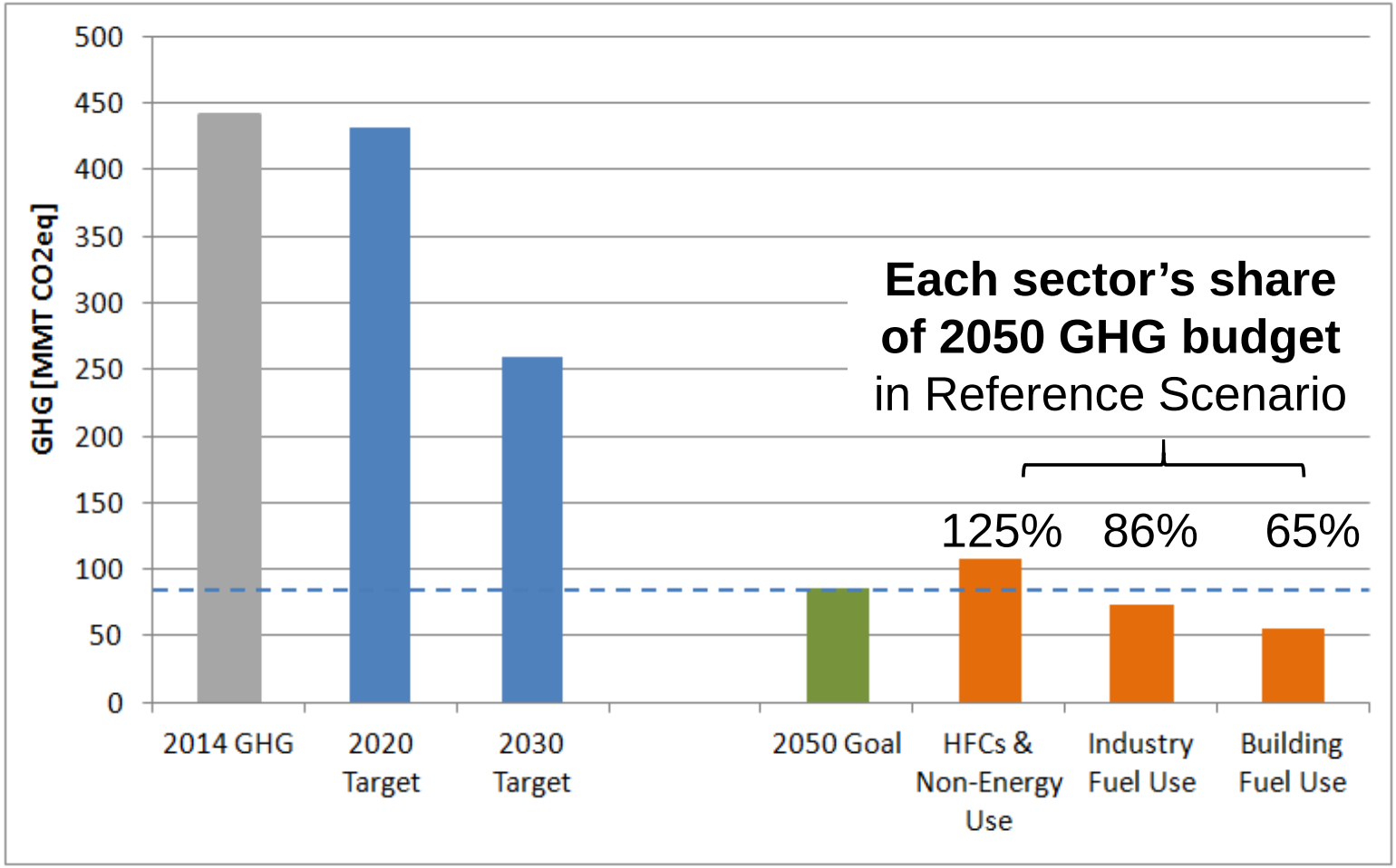


Shifts in Cooling Degree Days (CDD) by climate zone from 2015 to 2050

San Diego area becomes more like Central Valley, Central Valley becomes even hotter

AC Household adoption can increase by 5-10% in 2050

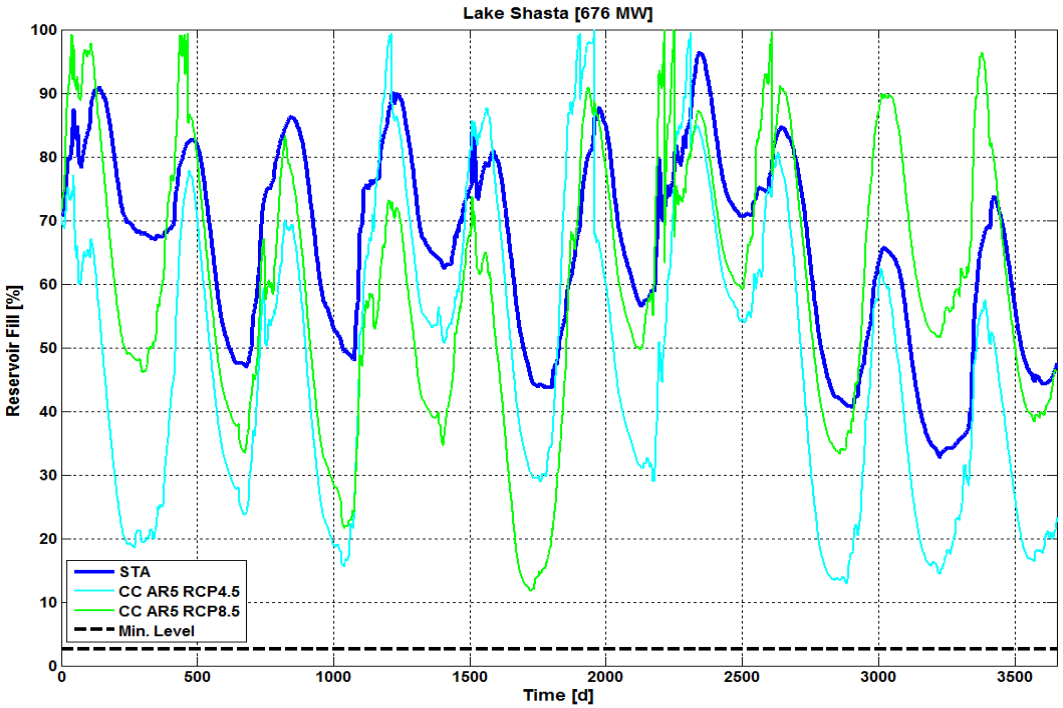
Earlier work for CEC revisited – Electrification AND increased AC demand will increase HFC GHGs



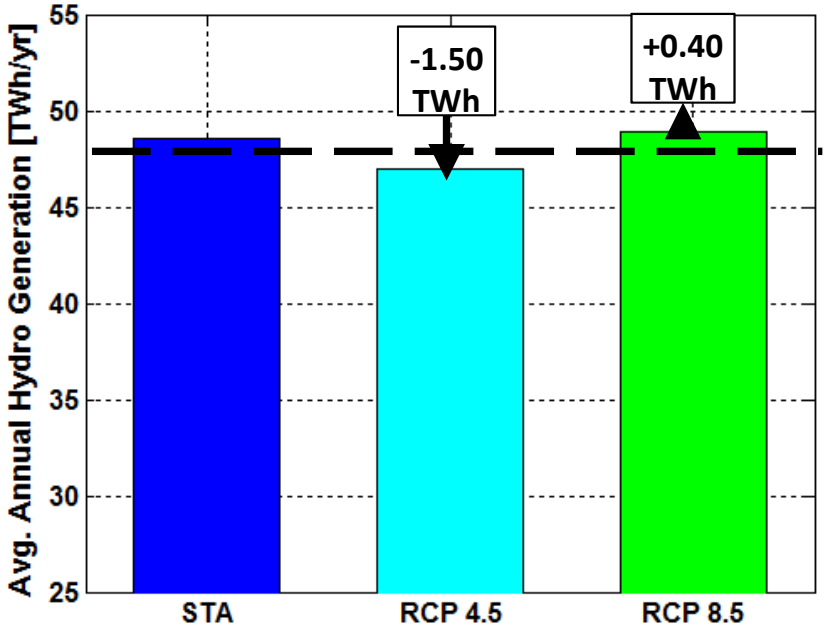
- **Electrification to HPs will increase HFC demand, as will more air conditioners** (HFC GHG here is without electrification and inc. AC)
- **Low GWP replacements are even more important with electrified end uses and increased AC demand**

Impacts on Hydropower (Preliminary)

Reservoir Behavior



Avg. Generation



- Increased reservoir inflow variability under climate change across all major water reservoirs
- Average annual generation is similar to current, but individual years will vary over a larger range, and increased extremes cause more spillage.

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Conclusions/ Summary

- Long Term Energy Scenarios teams are **building upon previous work** to quantify the impacts of climate change on energy supply and demand in California to 2050 and to investigate energy system resiliency
  - Previous scenario modeling **highlighted key sectors and key interactions**
- Preliminary conclusions:
  - **Shifts in climate** will lead to increased cooling demand and lower heating demand and need to plan for increased electricity demand and peak demands
  - **Water availability** can increase hydropower variability and GHG emissions and potentially limit solar thermal / geothermal supply
  - **2030 vs. 2050 planning** can have path dependency favoring longer term planning
- Follow up work to focus on:
  - **Health and environmental benefits** of cleaner transportation
  - Assessment of building greater **energy system preparedness and resilience** to climate change and other risks, using more probabilistic electricity supply modeling (stochastic SWITCH model)

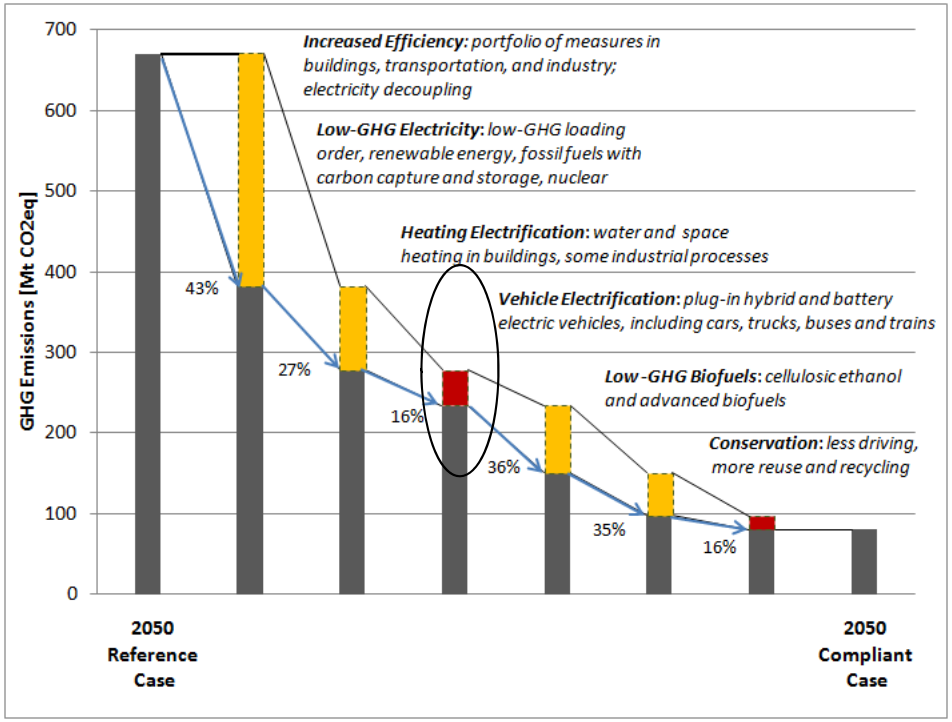
Acknowledgments

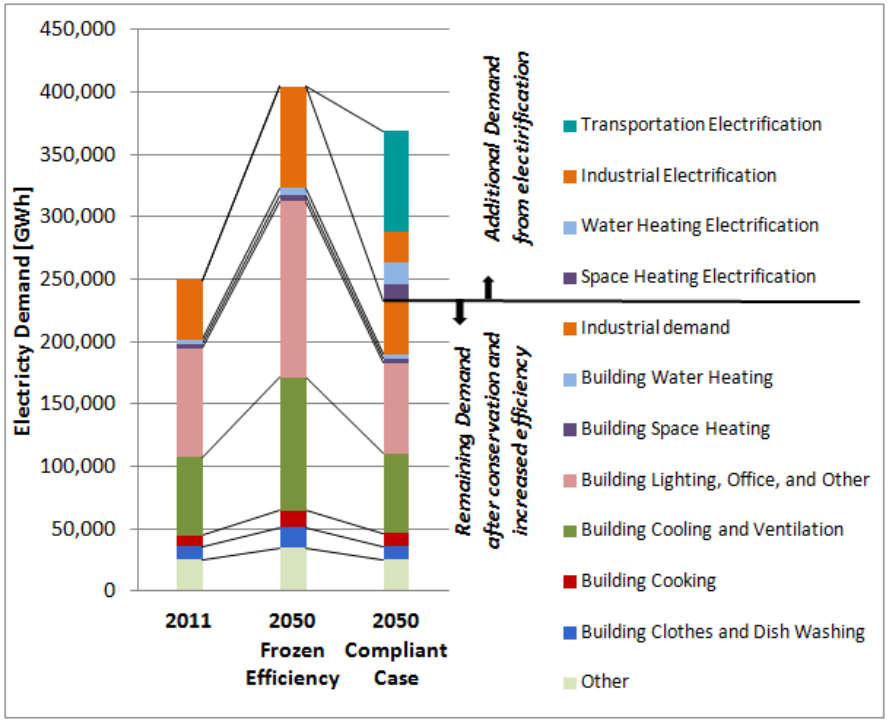
Funding and support of this work by the California Energy Commission is gratefully acknowledged.

Thank you

mwei@lbl.gov

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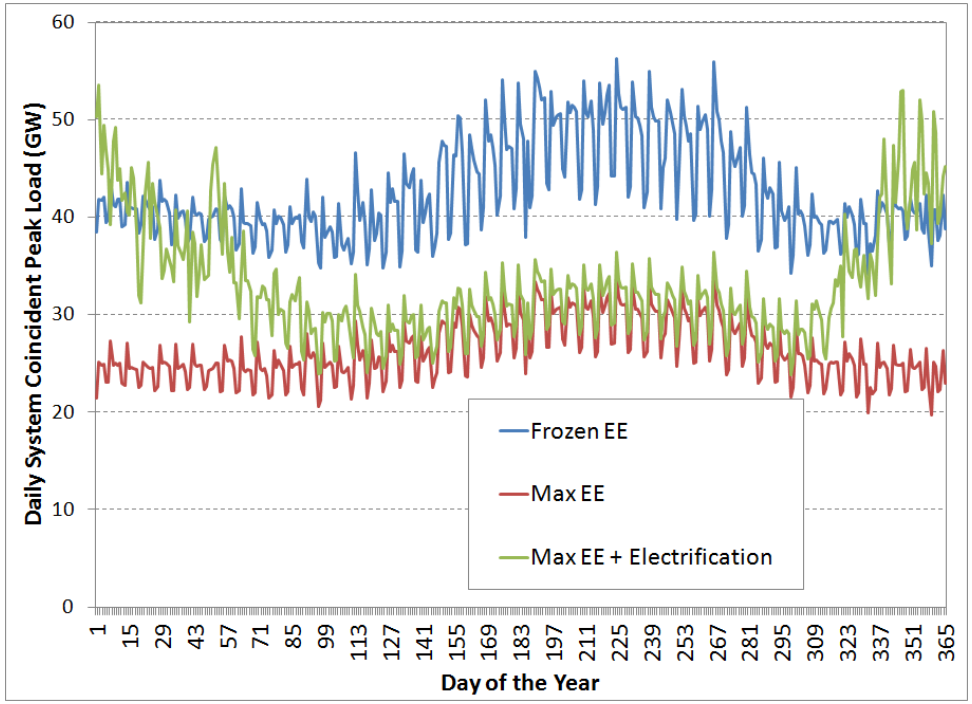


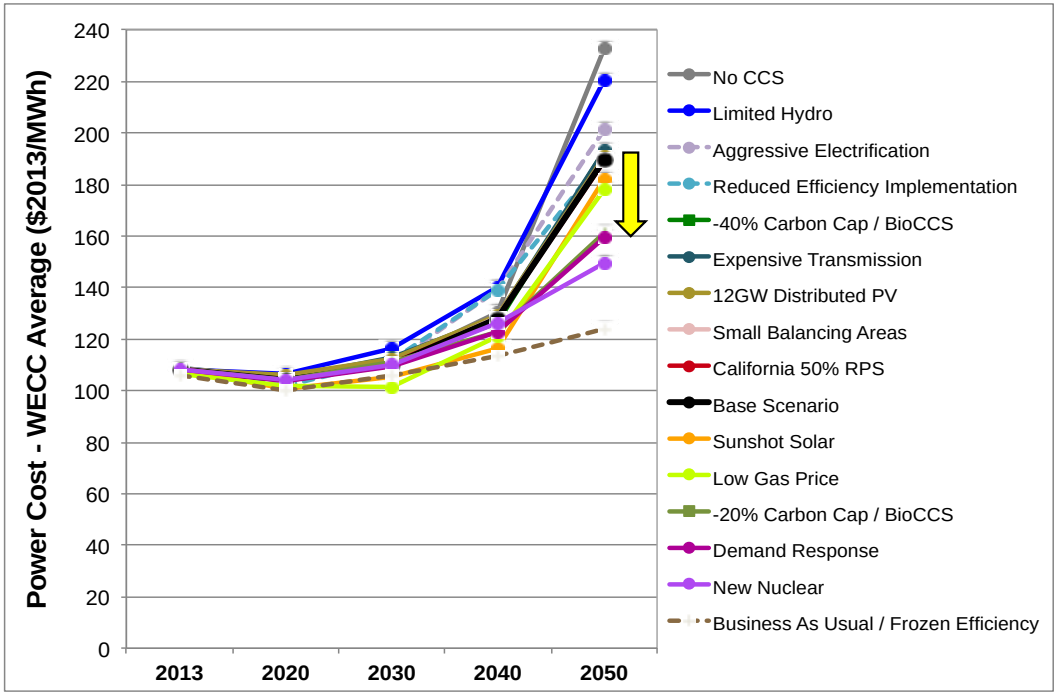


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Earlier work for CEC – Impacts to System Load Shapes and DR Opportunities





- **Combination of low carbon electricity and electrified end uses**
  - **Shift to Winter peaking system is predicted, similar to Northwest**
  - **Electrified end uses can expand the technology space/opportunities for demand shifting and grid support**

M. Wei, J.H. Nelson, J.B. Greenblatt, A. Mileva, J. Johnston, M. Ting, C. Yang, C. Jones, J.E. McMahon, D.M. Kammen, "Deep Carbon Reductions in California Require Electrification and Integration Across Economic Sectors," Environmental Research Letters, 2013; 8:014038. [left]

J. H. Nelson, A. Mileva, J. Johnston, D.M. Kammen, M. Wei, J.B. Greenblatt "Planning Power Systems with Deep Emission Reductions by 2050 using the SWITCH Model (Vol. II, California's Carbon Challenge Phase 2)," California Energy Commission PIER Report, November 2014. [right]

SWITCH Electricity Supply Model

SWITCH WECC model

- **Capacity expansion deterministic linear program**

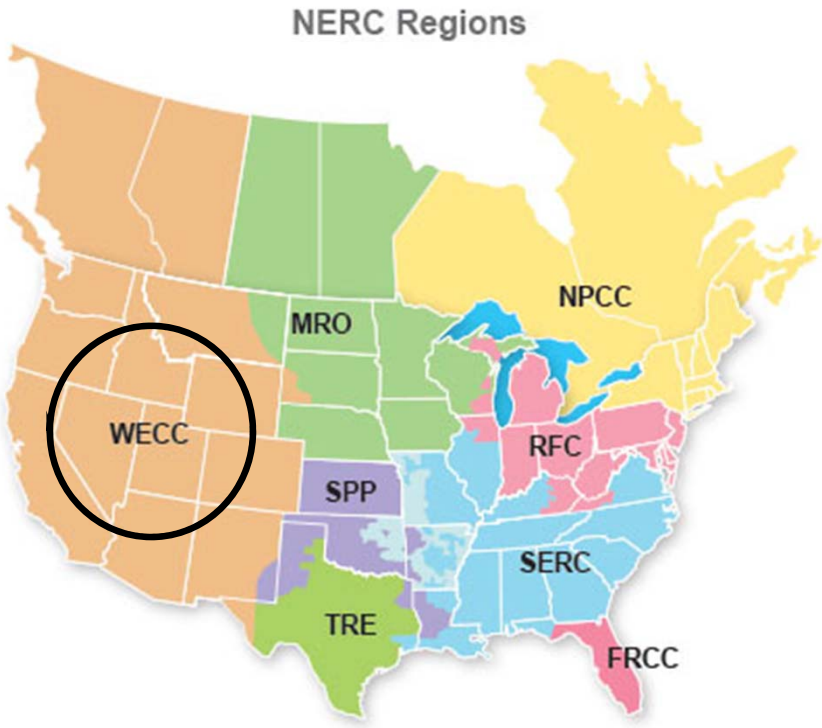
- **Minimizes total cost of the power system:**
  - **Generation investment and operation**
  - **Transmission investment and operation**

Geographic:

- Western Electricity Coordinating Council
- 50 load areas

Temporal:

- 4 investment periods: 2016-2025 (“2020”); 2026-2035 (“2030”); 2036-2045 (“2040”); 2046-2055 (“2050”);
- 72 distinct hours simulated per period
  - Dispatch simulated simultaneously with investment decisions



Current Work: 2030/2050 Path Dependency Using SWITCH

How to plan efficiently?

- Today until 2030 and then until 2050?
- Or today until 2050?

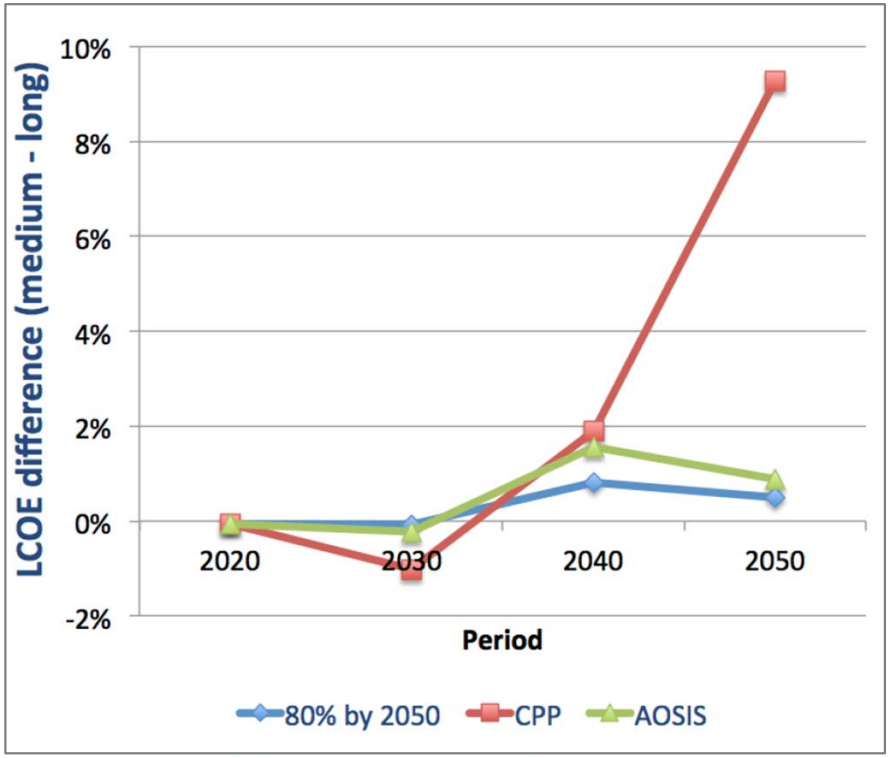
Carbon cap scenarios:

- 80% reduction by 2050
- 1.5°C
- SB350 (40% lower in 2030)
- Clean Power Plan

Preliminary Findings

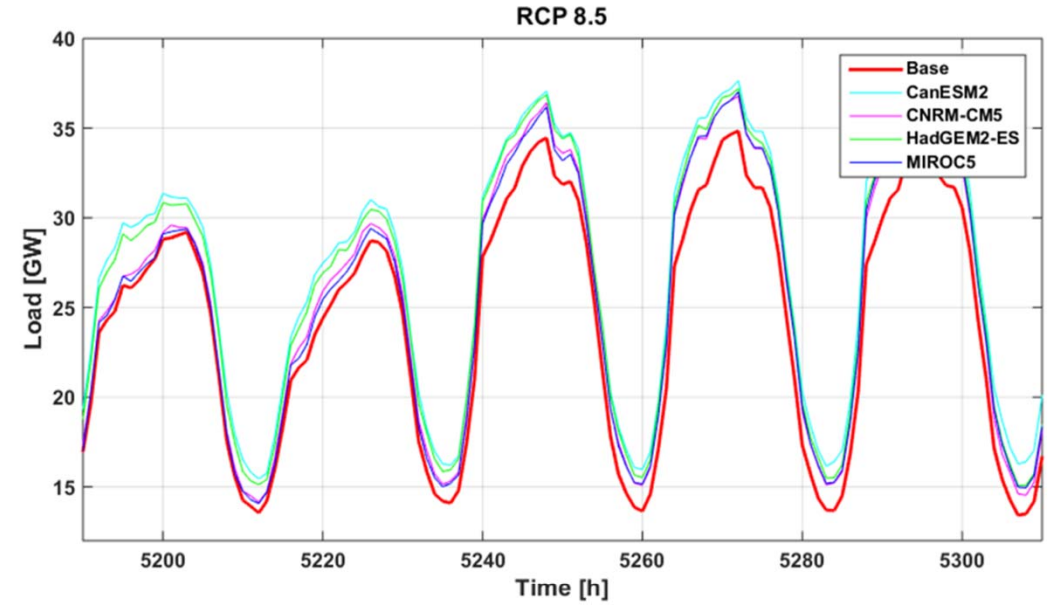
Planning until 2030 for CPP results in:

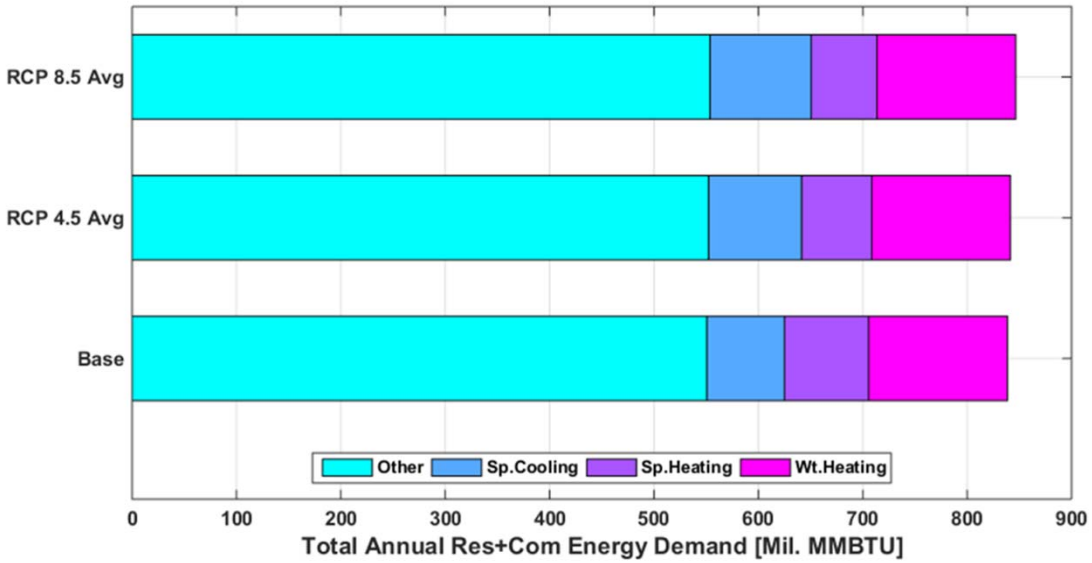
- Later coal retirements
- Minor/no savings in periods 2020 and 2030
- More costly in 2040 and 2050
- CPP 9% more expensive in 2050



Impacts on Electric Demand (Preliminary)

- **Impacts on Residential+Commercial Buildings (climate impacts only)**
  - **Increased temperatures cause increased cooling needs**





- Increased overall electricity demand
  - 1.1% to 4.3% increase over historical demand
- Increased typical peak electric demands
  - Representative typical increases of **3.2% to 8.3% over historical**
- **With thermal gen/Transmission line, reduced hydro+ extrinsic demand incl., expect ~10-15% peak demand hit**
- Electric demands increase, overall energy demand at the building level actually decreases
  - Lower space heating demand
- Electrification of residential heating through heat pumps:
  - **Reduced overall energy consumption – space heating and water heating**

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