

# Energy Efficiency Policy and Research Trends towards a Global Clean Energy Economy

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Won Young Park

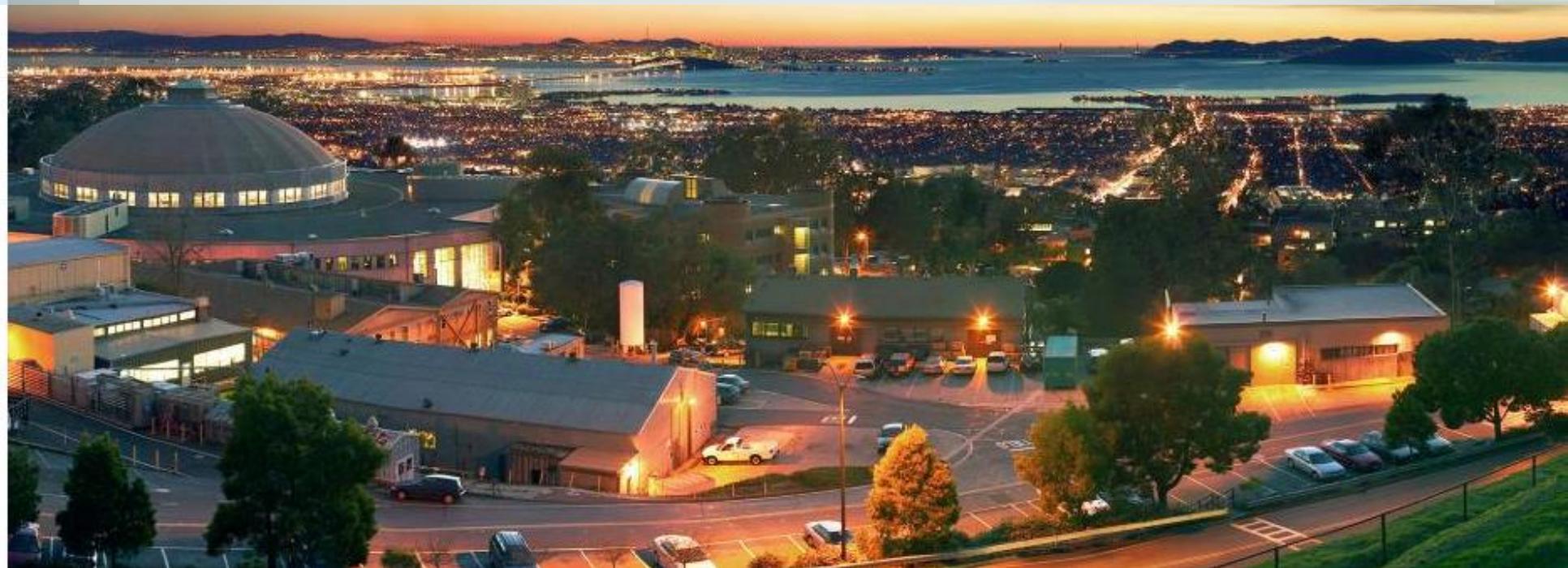
International Energy Analysis Department | Energy Analysis and Environmental Impacts Division  
Lawrence Berkeley National Laboratory



INTERNATIONAL  
ENERGY ANALYSIS  
DEPARTMENT

# Lawrence Berkeley National Laboratory

- A US DOE National Lab operated by University of California
- Founded in 1931
- 13 Nobel Prizes
- > 3,000 Employees
- > 1500 IP licenses for software and inventions in last 10 years:
- > 50 Startups based on Berkeley Lab technology
- > 200 UC faculty on staff at LBNL
- Annual operating cost \$872M (FY 2018)



Managed by the University of California  
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**Energy Analysis &  
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Electricity Markets and Policy; Energy  
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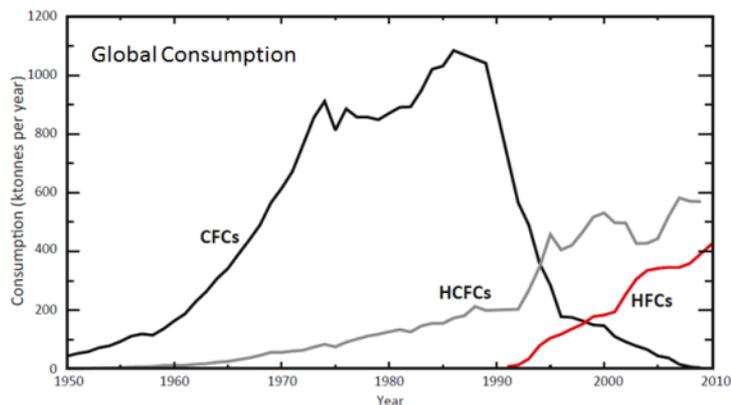
**Energy Storage &  
Distributed Resources**

- ❑ Researchers perform analysis, research, and development in a wide range of topics to improve energy infrastructure and maximize socio-economic benefits –from buildings and batteries, to indoor air quality, electricity grid, transportation, and environmental impacts.
- ❑ Researchers have been providing technical support to U.S., China, India, Mexico, Brazil, and other developing economies to improve energy policies and programs.

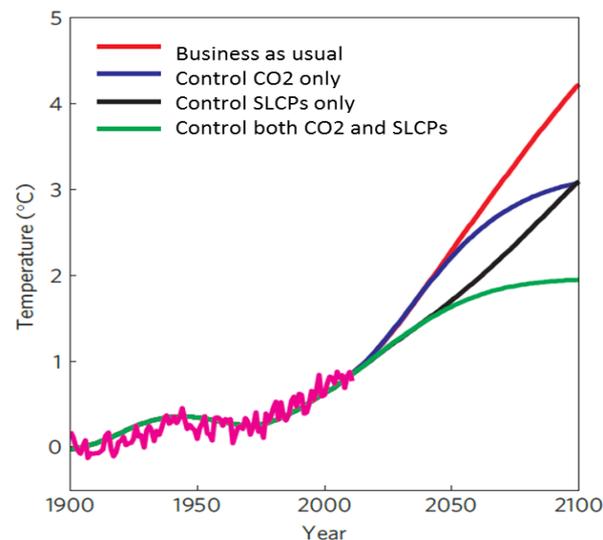


# Low GWP Refrigerants

Under the Kigali Amendment to the Montreal Protocol, 197 countries committed to cut the production and consumption of hydrofluorocarbons (HFCs) – potent greenhouse gases (GHGs) used in refrigeration and air conditioning – by more than 80 percent over the next 30 years.



UNEP (2011). HFCs: A Critical Link in Protecting Climate and the Ozone Layer

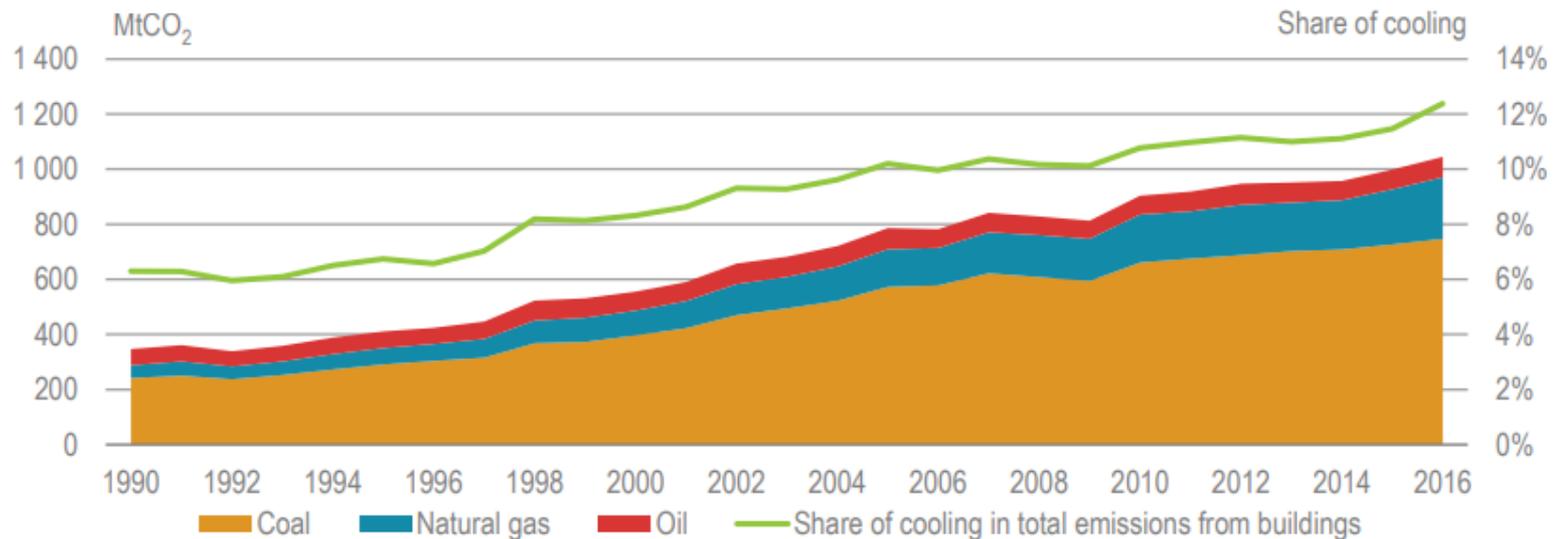


SLCP: short lived climate pollutants  
Hu et al. (2013). Mitigation of short-lived climate pollutants slows sea-level rise. Nature Climate Change

# Space Cooling Energy Use

GHG emissions related to the use of energy for space cooling hinge primarily on the fuel mix in power generation - fossil fuels accounted for 65% of globally total power generation in 2016.

## CO<sub>2</sub> emissions associated with space cooling energy use

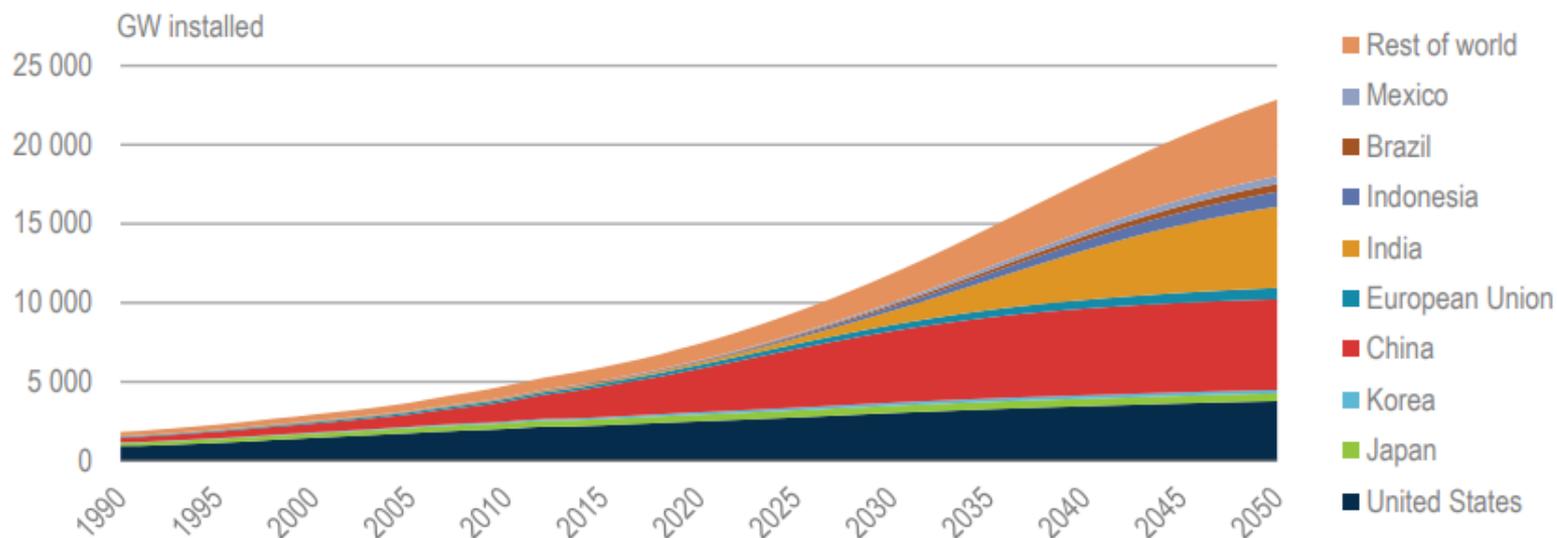


Source: IEA (2018). The Future of Cooling.

## Space Cooling Energy Use

Increasing incomes and urbanization – as well as a warming climate – are driving up the global stock of ACs, particularly in emerging economies with hot climates. Accordingly AC energy consumption and related GHG emissions are expected to increase substantially as the stock of ACs rises.

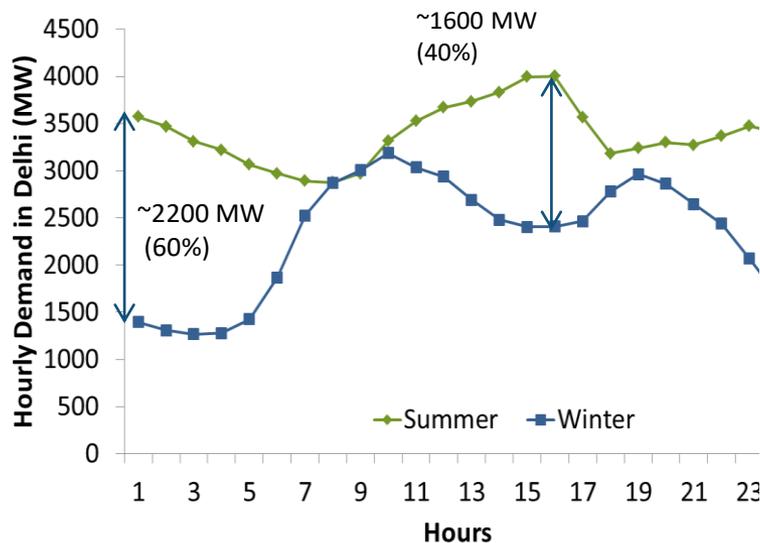
### Energy use forecast in air-conditioners



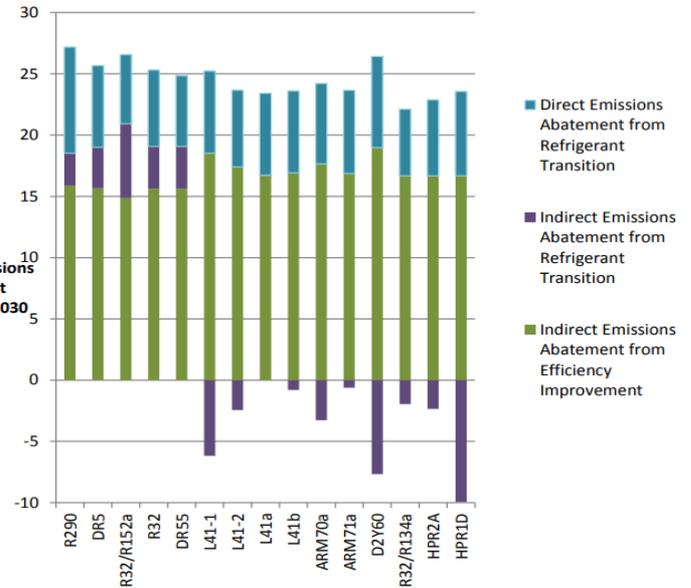
Source: IEA (2018) The Future of Cooling

# Low-GWP Refrigerant and Energy Efficiency

LBNL studies find that it is highly beneficial to pursue high energy-efficiency in concert with the transition to lower global warming potential (GWP) refrigerants to achieve maximal GHG reductions with the least amount of equipment re-design and replacement.



Abhyankar et al. (2017) Accelerating Energy Efficiency Improvements in Room Air Conditioners in India: Potential, Costs-Benefits, and Policies. LBNL report.



Shah et al. (2019) Benefits of Energy Efficient and Low-Global Warming Potential Refrigerant Cooling Equipment. LBNL report.

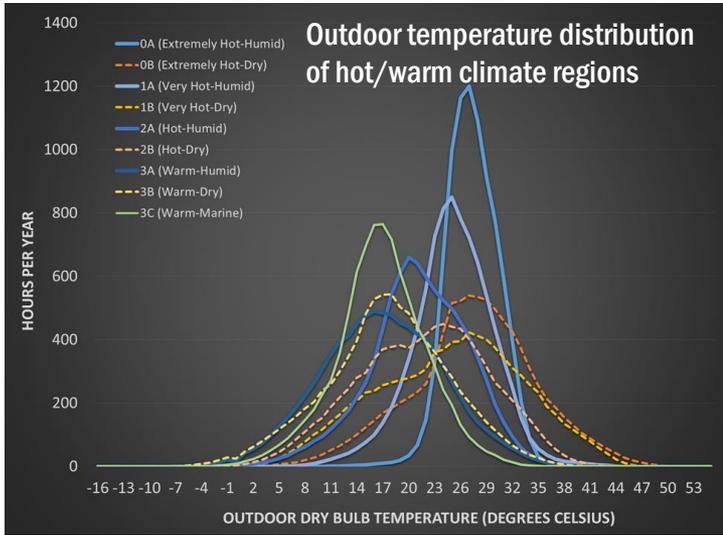
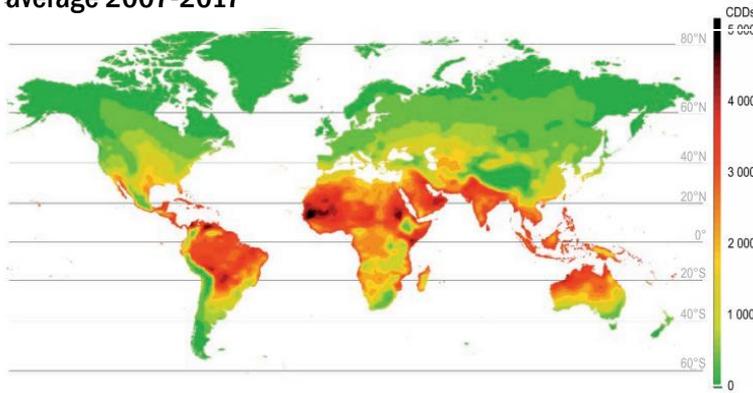
### Simultaneous Efficiency Improvement and Refrigerant Transition

- Air-conditioners and refrigeration appliances are often first products regulated for energy efficiency and will also undergo refrigerant transition under Kigali Amendment or current Montreal Protocol obligations.
- Refrigerant transition and efficiency improvement both typically require redesign of appliances and re-tooling of manufacturing lines.
- Coordinated efficiency improvement with refrigerant transition can keep costs low for consumers, manufacturers, utilities and governments.

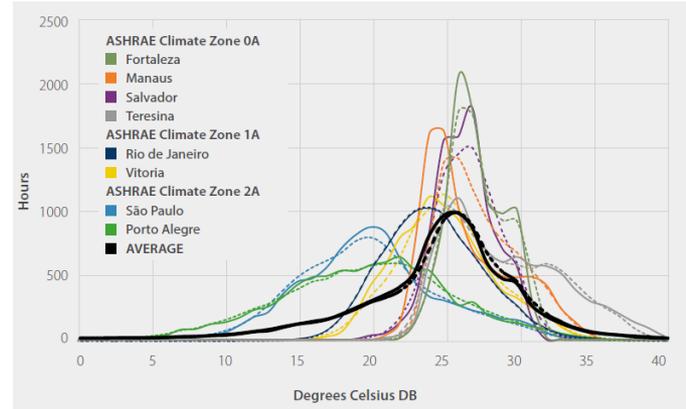
# Climate Region and Cooling Energy Efficiency

Policy action can be regionally developed/adopted, as well as harmonized with other regions.

Cooling-degree days (CDDs) across the world, mean annual average 2007-2017



Outdoor temperature distribution of eight regions in Brazil

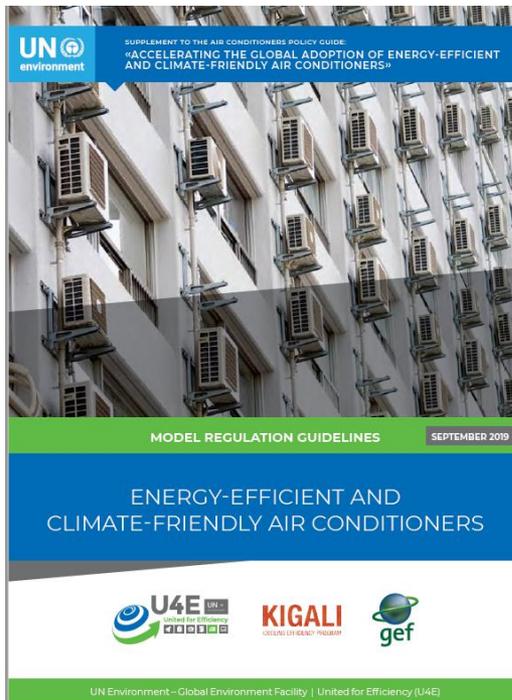


Efficiency of room AC models by different temperature bin hours in Brazil



# Policy and Market Transformation

Policy action and market transformation can be accelerated and effectively harmonized with international effort.



- ✓ Clear scope and definitions
- ✓ Common efficiency metric
- ✓ Common testing standards

## Approach

- ✓ Catalyze **product innovation**, giving consumers more choice
- ✓ Harmonize requirements to **reduce trade barriers and unlock economies of scale** to make products more affordable
- ✓ Enable more **effective market enforcement** using proven test procedures and an easier exchange of compliance information

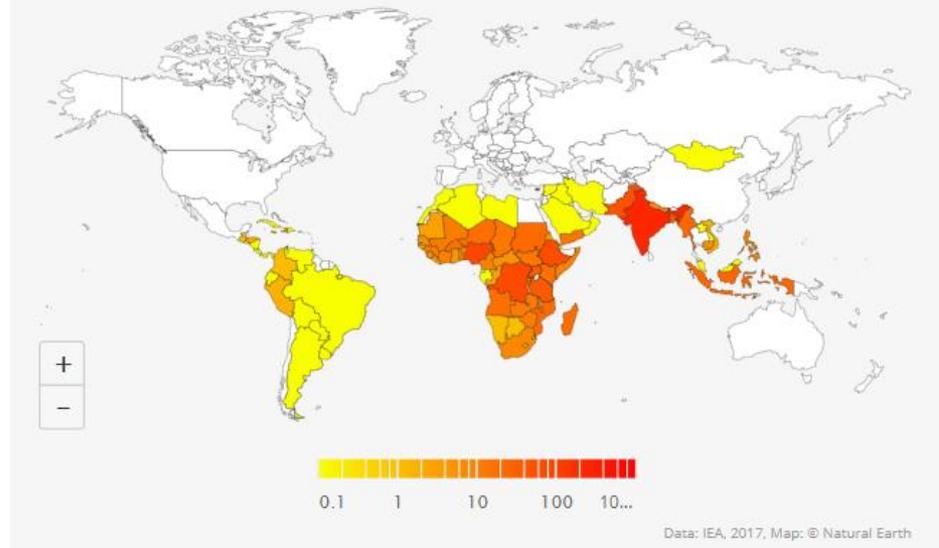
## Other Research

- **Efficiency for Energy Access**
- **Renewable Energy and Efficiency**
- **Distributed Energy Resources**
- **Building Energy Efficiency**

# Efficiency for Energy Access

- About 1.1 billion people in the world, largely in developing Asia and sub-Saharan Africa, do not have access to electricity.
- Energy efficiency supports increased clean energy access and improved service.

Population without access to electricity, 2016 (millions)



## IMPACT OF OFF-GRID SUPER-EFFICIENT APPLIANCES ON CLEAN ENERGY ACCESS

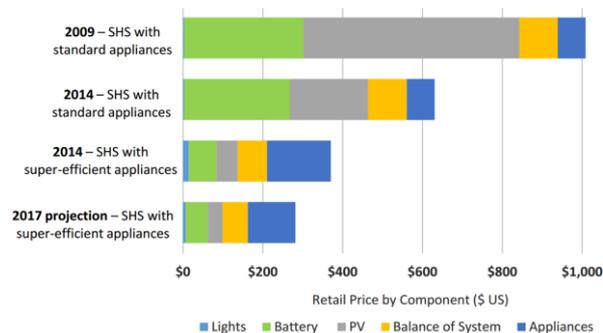
Energy efficiency supports increased clean energy access and improved service

The same system paired with super-efficient appliances provides greatly enhanced energy service:

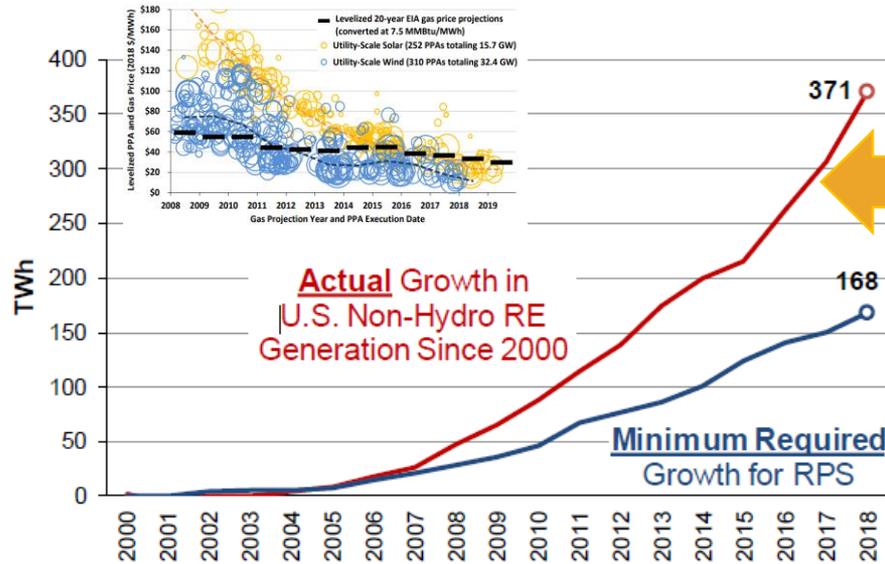


An **energy system** with a 40 Wp solar panel and 70 Ah battery will power:  
 ▶ a 25W Incandescent Light Bulb (250 – 400 lumens) for 5 hours/day

Appliance super-efficiency also enables much smaller and more affordable energy systems to provide equivalent, and even superior, service.



# Renewable Energy and Efficiency (U.S.)



Source: LBNL/NREL (2018). Wind Technologies Market Report

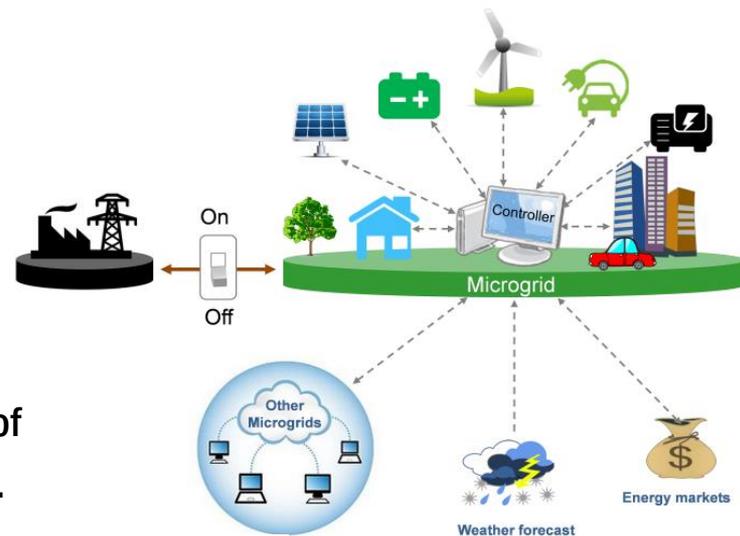
State clean energy policies are strengthening -- California's Senate Bill (SB) 100 established a landmark policy requiring renewable energy and zero-carbon resources supply 100% of electric retail sales to end-use customers by 2045.

RE additions continue at a robust pace.  
 Direct cost of wind and solar continues to decline and faces competition.

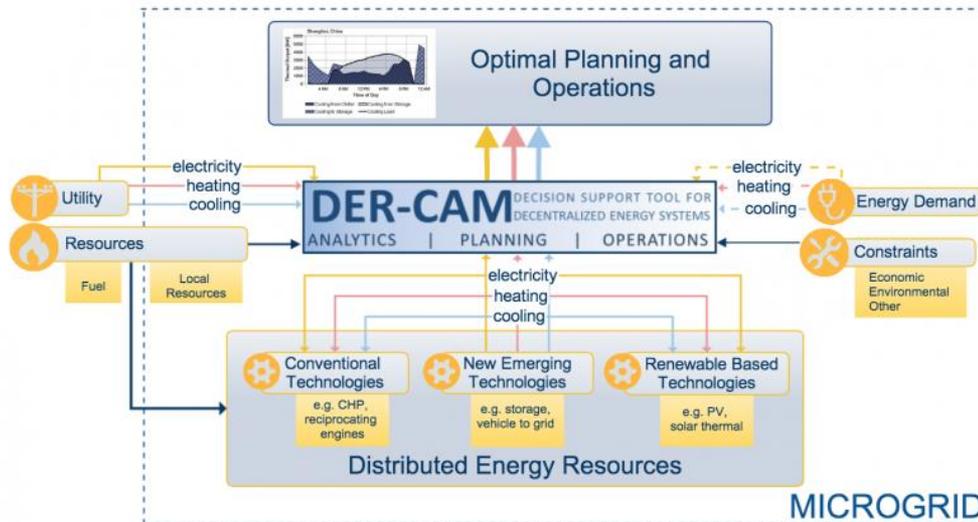


# Distributed Energy Resources

■ **LBNL's Distributed Energy Resources Customer Adoption Model (DER-CAM)** is a comprehensive decision support tool that help users find optimal distributed energy resource (DER) investments in the context of either buildings or multi-energy microgrids.



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A microgrid is a localized solution of electricity sources and loads that typically operates connected to and synchronous with the traditional centralized grid, but can disconnect and maintain operation autonomously as physical and/or economic conditions dictate.

Source: LBNL Energy Storage and Distributed Resources Division

# City Building Energy Saver (CityBES)

LBNL's CityBES a web-based computing platform, specialized on energy modeling, benchmarking and performance visualization of a city's building stock to support district or city-scale energy efficiency programs.

The screenshot displays the CityBES web interface with several key components:

- Navigation Bar:** CityBES, Introduction, Start, District Buildings, Retrofit Scenarios, Simulate, Team.
- Filtering Buildings:** A sidebar with filters for Properties (Building Type, Year Built, Total Floor Area, Energy Use Intensity, Peak Electricity Load per Area) and Building Coloring Options (Color buildings by: Site Energy Use Intensity, Result options: Retrofit Savings - ECM Package 1).
- 3D + GIS + Color Coding:** A central 3D visualization of a city block with buildings color-coded by energy use intensity.
- Building Highlight:** A detailed view of a specific building (Sanfran\_Orig\_0725) showing baseline results and retrofit results for an ECM Package 1.
 

Sanfran_Orig_0725	
Name	Sanfran_Orig_0725
Building Type	Large Office
Year Built	1971
Number of Stories	37
Total Floor Area	85174 m <sup>2</sup>
Compliance Status	
EnergyStar Score	
Asset Score	
<b>Baseline Results</b>	
Site Energy Use Intensity	251 kWh/m <sup>2</sup>
Source Energy Use Intensity	748 kWh/m <sup>2</sup>
CO2 Emission per Area	167 lbs/m <sup>2</sup>
Peak Electricity Load per Area	65 W/m <sup>2</sup>
Electricity Use Intensity	232 kWh/m <sup>2</sup>
Natural Gas Use Intensity	19 kWh/m <sup>2</sup>
<b>Retrofit Result for ECM Package 1</b>	
Site Energy Use Intensity Reduction	40 kWh/m <sup>2</sup>
Source Energy Use Intensity Reduction	141 kWh/m <sup>2</sup>
CO2 Emission per Area Reduction	29 lbs/m <sup>2</sup>
Peak Electricity Load per Area Reduction	13 W/m <sup>2</sup>
Electricity Use Intensity Reduction	48 kWh/m <sup>2</sup>
Natural Gas Use Intensity Reduction	-8 kWh/m <sup>2</sup>
- Aggregated Retrofit Results:** Three pie charts showing the distribution of results across building types.
 

Building Type	Floor Area (m <sup>2</sup> )	Energy Use (kWh)	Energy Savings (kWh)
Small Office	21.6%	21%	18.5%
Medium Office	8.6%	9.4%	12.6%
Large Office	66.7%	66.4%	64.9%
Small Retail			
Medium Retail			
Others			
<b>Total</b>	<b>9,400,077 m<sup>2</sup></b>	<b>2,299.5 GWh</b>	<b>330.7 GWh</b>
- Color Legend:** A vertical legend for Site Energy Use Intensity Reduction, ranging from 7 kWh/m<sup>2</sup> (blue) to >108 kWh/m<sup>2</sup> (orange).

Acknowledgment: Dr. Tianzhen Hong, LBNL Building Technology & Urban Systems Division



# Thank you.

Won Young Park (wypark@lbl.gov)