New Developments in Energy Efficiency Technology, Policy & Investments

Stanford University Energy Seminar
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In Memory of Dr. Arthur H. Rosenfeld
(June 22, 1926-January 27, 2017)
The Founder of Energy Efficiency
Special Thanks To:

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Today’s Seminar

• The Big Picture - Energy Efficiency Accomplishments
• The Levers of Technologies, Policy, and Investment
• Five Key Challenges Ahead
• New Developments – Six Examples
Energy Savings from Efficiency Improvements Globally

Source: IEA 2017 Energy Efficiency Report, p. 21
Global Emissions Avoided from Efficiency Improvements

Source: IEA 2017 Energy Efficiency Report, p. 27
2016 ACEEE International EE Scorecard

Source, 2016 ACEEE International EE Scorecard, p. 12
Buildings & Construction Are Major Drivers of Energy Demand and Global CO2 Emissions

Global final energy consumption by sector, 2015

- Transport: 28%
- Buildings: 30%
- Construction industry: 6%
- Other industry: 31%
- Other: 5%

Global energy-related CO2 emissions by sector, 2015

- Transport: 22%
- Buildings: 28%
- Other industry: 30%
- Other: 9%
- Construction industry: 11%

Source: Global Alliance for Buildings and Construction, 2017 Global Status Report
Energy Efficiency – Three Levers

• **Technology** – components, systems, and data
• **Policy** – international, national, subnational
• **Investment** – public and private
Why Do We Need All Three Levers? Because **Multiple Barriers** to EE

**Market/Availability**
- First cost bias
- Product availability

**Structural/Institutional**
- Distortionary regulatory and fiscal policies (e.g., obsolete building codes)
- Fragmented structure of construction industry

**Behavioral/Saliency**
- Low salience of energy issues
- Poor information about electricity prices & equipment use
Technology Levers: System Level & Component Approaches

- **Thermal Comfort & Air Quality**
  - Building Envelope
  - Ventilation & Air Quality
  - Space Conditioning
- **Lighting**
  - Windows, day-lighting & lighting controls
  - Lighting devices
- **Appliances**
  - Hot water heaters
  - Refrigerators
  - Clothes dryers
Global Incremental EE Investment (2016)

$4.6 trillion spent on buildings & construction
$460 billion on energy-related products
$134 billion on incremental EE investment

Policy Levers

- Energy Efficiency Obligations (EEOs)/EE Resource Standards (EERS)
- Building codes
- Appliance standards
- Labels and consumer information
- Incentives, both financial (tax credits, grants) and non-financial (expedited permitting for efficient buildings)
- Utility programs, decoupling, and shareholder incentives
- Research and development (R&D)

IEA Efficiency Policy Progress Index with and without China

EEOs in Europe – from 5 to 15 Member States

- 15 countries

58% of the EU final energy consumption (2012 data)

Source: Regulatory Assistance Project, April 2018.
Europe Uses Mixture of Policy Tools

- EEOs = 1/3 of savings
- “Alternative measures” finance, taxes, energy regulations, etc. = 2/3rds of required savings

BUT Nearly 2/3 of Buildings Lack Mandatory Energy Codes
Five Major Challenges Ahead

• Dramatically increase the **magnitude** of savings
• **Diversify** the sources of savings
• Measure and ensure the **persistence** of energy efficiency savings
• Integrate energy efficiency savings within a **GHG emission reduction** framework
• Understand and value energy efficiency as part of an **evolving grid**

Need for Shift to Highly-Efficient and Net-Zero Carbon Pathway in the Global Buildings Sector

Source: UN 2017 Environment Global Status Report, p. 21
U.S. Electricity Load, by Use

Residential

- space heating: 9%
- space cooling: 18%
- lighting: 9%
- water heating: 9%
- refrigerators & freezers: 9%
- TVs & related equipment: 6%
- all other uses: 40%

Commercial

- space heating: 3%
- ventilation: 11%
- space cooling: 12%
- lighting: 11%
- refrigeration: 14%
- all other uses: 37%

- Adapted from EIA, 2017
Challenge #5: EE In a Changing Grid

Source: SCE’s Preferred Resources Pilot (PRP) Annual Progress Update

Average Hourly CFL Usage Pattern

Source: NEEP, Energy Efficiency as a T&D Resource, 2015 p. 10
New Tools to Get Us There

• **Intelligent efficiency** (smart meter data, advanced analytics, sensors, etc.)
• **New technologies** (lighting, cooling, space and water heating, and plug loads)
• **Behavior interventions and information** to drive demand and deliver savings
• **Localized and grid-focused EE** (developing hourly/geographic EE supply curves)
• **New policies** to encourage and value all of the above
• **New investment tools** (PACE, Pay for Performance programs)
Six Examples of New Developments

• U.S. –
  - Operational Savings (more savings)
  - Avoiding/Deferring T&D Investment (grid)
  - Building Electrification (for carbon emissions)

• European Union – Smart Buildings

• India – LEDs

• China – Reinventing Fire
Example #1: New CA Law (AB 802) Taps Operational Savings – Thanks to New Technology (Smart Meters & Analytics)
Example # 2: EE Used to Address Evolving Grid Problems

- Smart meters & data analytics
- EE savings curves identified and targeted to the substation level
- Defer/delay transmission and distribution upgrades

Graphic provided by FirstFuel Software
Example #3: Building Electrification (EE for Carbon Goals)

• Traditional EE – values energy savings only
• Advanced EE – focuses on building GHG emission reductions (*Zero Emission Buildings – ZEBs*)
  ➢ **Technology**: heat pumps for water heaters and space heating and cooling
  ➢ **Policy**: CA Bill AB 3232 (ZEB goals and roadmap)
  ➢ **Investment**: CA Bill SB 1477 (incentive program for ZEB technologies)
Example #4: EU Smart Buildings

  - Countries must develop long-term renovation roadmaps – goal of near Net Zero Emission Buildings by 2050
  - EC must prepare “Smart Readiness Indicator” – ties building efficiency with ability of building to integrate flexibly and provide services to energy system; persistence of EE performance and operations also measured; focus on building systems, sensors, controls
Example #5: India – National Public ESCO

- **Energy Efficiency Services Limited (EESL)**
  - Implements projects at State level and nationally
  - Goal of replacing 700 million incandescent bulbs with LEDs by 2019; Almost 300 million distributed to date; www.ujala.gov.in
  - No upfront costs to end users or distribution companies; financed through pay-as-you-save
  - National motor replacement program, agricultural pumps, smart meters, EVs, etc.
Example #6: China Reinventing Fire

![Graph showing carbon dioxide emissions from different sectors and the reduction targets for 2050. The graph indicates a significant decrease in emissions, with a target of -74% for the 2050 Reinventing Fire Scenario.]
Final Thoughts

• Basics matter
  – Standards, codes, obligations, labels, etc.
  – Great technology exists but barriers remain

• For the future – what we need:
  – More technology, cheaper, and ubiquitous
  – New investment vehicles, large scale and accessible
  – Policies that measure emissions performance and support innovation in technology and investments
Thank You!

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