The 1,000 Power Plant Question: Cooling the Planet Sustainably

Dr. Nikit Abhyankar
Lawrence Berkeley National Laboratory

Jakarta
September 2018
Introduction to Lawrence Berkeley National Laboratory

• Dedicated to solving the most pressing scientific problems facing humankind
  – Basic science for a secure energy future
  – Science of living systems to improve the environment and energy supply
  – Understanding and control of matter and energy in the universe
  – Translation to applied energy programs

• Build and safely operate world-class scientific facilities
• Train the next generation of scientists and engineers

Managed by the University of California for the United States Department of Energy

13 — Nobel Prizes
13 — National Medal of Science recipients
4,200 — Employees
200 — Site acreage
Indonesian cities are hot and populous

Compared to other regions, Indonesia has higher cooling requirements

Over the next 15-20 years, globally, 1000-1500 new power plants will be needed just to meet the additional AC load

Data Source: Sivak et al (2009)
Room AC Penetration in China Grew from <5% to 100% in 15 yrs

China added ~200 million new ACs in 15 years

⇒ Equivalent to ~250 GW of peak load or ~500 power plants

- AC ownership is largely driven by income and structure of the economy
- In emerging economies, as incomes rise, AC ownership will increase rapidly
In Indonesia, Space Cooling Efficiency is Crucial for Peak Load Management and Investment Planning

Indonesia plans to add 56GW of capacity by 2027 (~$100 billion)

Appliance EE can save over 10 GW by 2025 (avoiding ~$20 bn)

LBNL and Government of Indonesia are working together to identify the essential strategies to achieve the 10 GW reduction target and collaborate on technical analysis and capacity building to achieve this.
## Key technology options for improving AC efficiency

<table>
<thead>
<tr>
<th>Component</th>
<th>Technology Option</th>
<th>Improvement in AC efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor</td>
<td>More efficient compressor</td>
<td>~10-20%</td>
</tr>
<tr>
<td>Compressor</td>
<td>Variable speed drive (inverter AC)</td>
<td>~20-25%</td>
</tr>
<tr>
<td>Heat Exchanger</td>
<td>Enhance thermal transmittance (U) and area (A)</td>
<td>~10-25%</td>
</tr>
<tr>
<td>Expansion valve</td>
<td>Thermostatic or electrostatic valves</td>
<td>~5-8%</td>
</tr>
<tr>
<td>Standby power</td>
<td>Lower standby power</td>
<td>~1-2%</td>
</tr>
</tbody>
</table>

In addition, refrigerant transition can lead to ~5-10% improvement in AC efficiency.
Can Policy Drive Accelerated Efficiency Improvement?

- Between 1995 and 2005, room AC efficiency in Japan improved by ~100%, while inflation adjusted prices declined by over 80% (Top runner program)
- Evidence from other major markets such as Korea, EU, US, India, China also show that enhancing efficiency does not imply increasing prices
Key Strategies for Enhancing the AC Efficiency

• Revise the metric and test procedures so AC efficiency can be measured more accurately

• Aggressive revision of MEPS (*Market Push Policies*)
  o Long-term and ambitious targets
  o Link the targets to commercial availability of the technology to ensure manufacturing at scale

• Incentives / Bulk Procurement (*Market Pull*)
  o Incentives / bulk procurement can pull the top of the market
  o Encourage “smart” / “DR” capabilities

• Complementary Programs
  o Building codes and design to reduce cooling demand
  o Coordinate with refrigerant transition to design-in efficiency
Thank You

Dr. Nikit Abhyankar
NAbhyankar@lbl.gov
+1-510-486-5681
Additional Material
Accelerated Efficiency Improvement Driven by Policy: Korea’s Energy Frontier Program

- Energy Frontier Program (2011) sets the energy efficiency criteria for key appliances to be 30-50% more efficient than Grade 1 (most efficient label)
- Between 2008 and 2015, Grade 1 efficiency criteria increased efficiency requirements by over 100% (~12% per year); Energy Frontier is 30-50% above the Grade 1 level
  - Most new models by LG and Samsung meet either the Grade 1 or the Energy Frontier criteria
  - Most efficient room AC model (meets the energy frontier criteria) has CSPF of 9.4
- During this period, inflation-adjusted room AC prices (CPI) continued to decline
- Since 2008, Korea has offered financial incentives for purchase of efficient appliances e.g.
  - Carbon Cashbag program (financial incentives for consumers and advertising etc incentives for manufacturers)
  - Feebates (tax on certain appliances to subsidize purchase of efficient appliances for low-income households)
Space cooling load is making the load shape peakier

Load Curves on a Summer and Winter Day (Average) in Mumbai and Delhi

**Southern California**
- Summer: ~8500 MW (45%)
- Winter: ~8500 MW (45%)

**New Delhi**
- Summer: ~2200 MW (40%)
- Winter: ~1600 MW (60%)