ENERGY EFFICIENCY IMPROVEMENT AND REFRIGERANT REPLACEMENT

Understanding the Complementarities and the Potential in Practice
Energy Efficiency Can Bring Great Value to Countries

- Enormous EE potential in all sectors in all countries
- EE is a financially attractive “energy resource”
  - Most EE “negawatts” are cheaper than supply costs
  - EE could also help countries tap into concessional climate finance

- Multiple benefits of EE help countries meet objectives alongside meeting energy demand sustainably, e.g.:
  - Reduces consumer energy bills, facilitates tariff reform
  - Eases pressures on national budgets
  - Increases competitiveness of industries and services, creates jobs
  - Improves system reliability by reducing energy demand, peak load
  - Quicker to implement than many supply options
  - Contributes to reductions in GHG and local pollutant emissions
  - Cross-sectoral benefits (urban, education/health, transport, water, etc.)
Benefits of Energy Efficiency Improvements

1) GHG emissions reduction
   • For India alone (according to U4E analysis) almost $17 billion can be saved cumulatively for consumers through 2030 by improving air conditioner energy efficiency policies
   • Improve energy productivity of the economy thereby reducing emissions (60 – 70%)

2) National Benefits
   • Peak Demand reductions
   • Reduced Energy Demand
   • Meeting international obligations
   • Creation of additional jobs
   • Affordable access to cooling

3) Market opportunities
   • The most efficient air conditioners are over 50 per cent more efficient than average products on the global market
   • HAT conditions prevalent in the developing countries provide opportunity for efficient Acs in these countries.
   • Profitability & Market expansion for industries

New Delhi: The soaring mercury level has pushed Delhi’s power demand to an all-time high. The capital’s peak consumption demand at 3.06pm on Monday touched 6,361MW, the highest ever recorded in any city of India. The last time Delhi set an all-time record was on June 30, 2016 when the electricity demand shot up to 6,261MW.

Source: Times of India, 06 June 2017
Potential Areas for EE Improvements

**Equipment efficiency (60-70%)**
- High Efficiency Heat exchangers
- Motors with variable speed drives
- High Efficiency Compressors
- Electronic controls for reduced standby loads

**Servicing, Management and Behaviour change (10-20%)**
- Managing Existing Stock
- Pre-paid metering
- Timely servicing

**Building Codes (50%)**
- MEPS
- Building design
- Shading
- Cool-roofs

4) **Refrigerant change (5-10%)**
- Transitioning to low-GWP refrigerants
Price Sensitivity Plays a Major Role

What matters the most…

• Price Sensitivity
• Consumer Attractiveness
• Implementation Models

All of this has to be done through an integrated approach
WBG & Linked Agendas of Energy, Climate, Ozone

**SDGs**
- 7, 9, 11, 13
- SE4All

**Country Challenges**
- Energy Security and Affordability
- Barriers to Access EE Low Hanging Fruit
- Rapid Urbanization Demand for Cooling
- Scale-up and Crowd-in Private Sector
- Cold Chain: Food Safety and Security, Health
- HCFC Phase-out HFC Phase Down

**Country Support**
- **WBG EE Pipeline about US$1.9 billion**
  - India EE Scale-up Program: US$300 m
  - Vietnam Energy Efficiency for Industrial Enterprises: US$100 m WB loan
  - Metropolitan Buenos Aires: Efficient & Sustainable Urban Settlements: US$200m

- **WBG Commitment**
  - Invest US$1 billion in funding for EE in urban areas by 2020 that can include support for the development and deployment of high efficiency cooling technologies that also use climate-friendly refrigerants.

**Montreal Protocol**

**UNFCCC NDCs**

**Montreal Protocol**

**UNFCCC NDCs**

**MLF GEF**

**WBG EE commitments over last 5 yrs: US$6.4 b**
Tapping into the Triple Win

1. **Old system being replaced**
   - Refrigerant: R-22
   - Poor efficiency
   - Leakage levels high

2. **Less optimal win-lose-lose example**
   - Refrigerant: R-404A
   - Poor efficiency
   - Leakage levels high

3. **The optimal win-win-win example**
   - Refrigerant: R-717
   - High efficiency
   - Leakage levels low

**ODS emissions:** Zero

**Direct GHG emissions:** Zero

**Indirect GHG emissions:** 30% reduction through improved efficiency

**ODS emissions:** Zero

**Direct GHG emissions:** Higher than old equipment (GWP of R-404A is higher than R-22)

**Indirect GHG emissions:** No change
Case Study Approach - MP EE Nexus

- **Purpose of this Exercise**: To demonstrate the opportunities and implementation approaches to take advantage of synergies (the triple win).

- **Montreal Protocol agenda has**:
  - A specific focus: Refrigeration and AC
  - Specific comparative advantages
    - Relationship with & access to manufacturers
    - Experience with government regulation and supply side interventions, institutional basis
    - Capital for conversions
    - Combined refrigerant replacement with other co-benefits (MP-EE nexus)

- **Stocktaking of previous EE interventions can inform the MP community on**:
  - Types of EE interventions and instruments
  - Target points of intervention along the value chain
  - Effectiveness and conditions of success under real-live conditions
  - Ex post cost-benefit information of EE interventions
  - Defining the space where combining the two leads to the most effective and efficient solutions
  - Document and share results and lessons learned
<table>
<thead>
<tr>
<th>Target</th>
<th>Manufacturing</th>
<th>Demand Side</th>
</tr>
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<tbody>
<tr>
<td>Type of intervention</td>
<td></td>
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<tr>
<td>Financial Instruments</td>
<td>Financing: Concession loans, Grants, Subsidies, financial incentives, Production: Production taxes, fees, quotas, subsidies, Trade (import/export): Green tariffs, export/import fees/subsidies</td>
<td>Financing: Loans/grants, preferential terms, installment plans, leasing, ESCOs, Acquisition (by end user): Purchase tax, deposit schemes, subsidy, Use: Usage fee/subsidy, on-bill payment for equipment, energy pricing, RECs/EECs, ESCOs, Maintenance: Codes and permits, operating standards, Disposal: Take-back, disposal fees, deposit schemes</td>
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<tr>
<td>Policy and Regulations</td>
<td>Financing: Tax policy, industrial policy, Standards, prohibitions, testing, labelling, Trade restrictions, quotas</td>
<td>Financing: Financial disclosure rules (life cycle costs), Acquisition (by end user): Publicprocurement, proc. rules, guarantees, Use: Codes and permits, operating standards, Maintenance: Codes &amp; standards, inspections, licensing, training, Disposal: Disposal system, obligations</td>
</tr>
<tr>
<td>Information</td>
<td>Financing: Access to information, Market coordination</td>
<td>Financing: Product info, labeling, samples, Use: Env./energy audit, consumer awareness, Maintenance: Codes &amp; standards, inspections, licensing, training, Disposal: Labeling</td>
</tr>
<tr>
<td>Technical Capacity</td>
<td>Financing: Public education programs, Technical assistance, technician training</td>
<td>Financing: ESCO training, Bidding documents, Audit training, env./energy management systems, Use: Trade organizations, technician training, Maintenance: Codes &amp; standards, inspections, licensing, training, Disposal: Waste management system</td>
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<tr>
<td>Type of Intervention</td>
<td>Target</td>
<td>Manufacturing</td>
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<tr>
<td><strong>Type of intervention</strong></td>
<td><strong>Financing</strong></td>
<td><strong>R&amp;D</strong></td>
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<td>Financial Instruments</td>
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<td>Policy and Regulations</td>
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<tr>
<td>Information</td>
<td>TH AC: Sharing of experience with regulators</td>
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<tr>
<td>Institutions (public, private)</td>
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Demand Side (financial incentives + ESCO model): Philippines Chiller Replacement Project

**Challenge:** to lower chiller owner’s opportunity cost and up-front capital costs in an effort to accelerate the replacement of inefficient chillers, prior to the end of their useful life, with energy efficient chillers so as to promote market, economic and technological barrier removal.

Project Design Approach: Subsidy + ESCOs

- Partially funded with GEF and MLF grants.
- **Financial incentive to chiller owners:** Up-front grant subsidy of 15% of the cost of new chillers. The level of incentive was determined by aggregating opportunity costs using the model developed in the India Chiller Sector Strategy undertaken by the Bank in 2002.
- **Financial incentive to Energy service companies (ESCOs):** to ensure ESCOs participation in implementation they received a guarantee on the return on their investment generated by energy savings gained thru technical conversions.
- **Capacity Building:** technical training in the handling and management of alternative technologies & servicing.
- **Leveraging carbon finance** through the Clean Development Mechanism, to generate additional revenues, but was cancelled due to global carbon market downturn.

Results (2011 – 2016)

- 71 new chillers installed
- **Net GHG emission reduction:** 111.9 ktCO2eq
- **Reduced power demand** of 18.95 MW
- **Sustainable market transformation in the chiller sector:** Philippines' ESCO market grew from 2 to 4 companies and generated interest amongst chiller owners in undertaking further replacements to maximize space cooling energy consumption.

Key Findings

Small-scale financial subsidies for chiller replacement delivers major impact by:

- **building confidence** in technical advancements and energy savings potential
- **promoting commercialization** of EE products
- **accelerating private sector engagement** and fostering market transformation by promoting supporting market mechanisms, such as ESCOs.
Demand Side (ESCO + integrated model): India’s Super Efficient AC Programme

**Challenge:** Growing demand for AC (4.5 m unit sales in 2015...expected sales of 19 m in 2030) directly leads to increased electricity demand but there is high cost to supplying peak power. To meet future demand need to ratchet up efficiency standards at affordable costs.

**Project Design Approach: ESCO, Bulk Procurement, Warranty**

- Energy Efficiency Services Limited (EESL) fills the gap in the Indian EE market
- EESL acts as a “Super ESCO”
  - Aggregation of demand cost reduction affordability
  - High quality technical specs with 3 yrs warranty
  - Awareness creation
  - Strong Measurement and Verification
  - Integrating MP & EE (proposed WB support)

**Expected Results**

- Improvement of energy efficiency in AC by at least 30%.
- Affordable hi-efficient AC units made available by suppliers (500,000 units is the goal)

**ISEER 5.2 or more**

- Warranty - 3 year comprehensive warranty; 5 year on key components
- Dual Branding - Vendor brand/EESL owned new brand to convey super efficiency
- Institutional / Employee sales -- channels
- Installation & aftersales by Manufacturer (EESL oversight linked with bank guarantee)
Manufacturing Side (integrated model): Thailand R-22 AC Conversion

Challenge: Enabling market penetration of a new technology for room AC that is patented, mildly flammable and not yet used in developed country markets. New non-HCFC AC launched in Thailand by Thai manufacturers.

Results & Key Findings

**Results:**
- R-32 based AC introduced by multinationals and 3 Thai AC companies; 30,000 units sold (fixed speed)
- Ban of >50,000 Btu R-22 AC manufacturing for domestic market as of 1 Jan. 2017
- R-32 AC performance is better than similar R22, R410A units.

The project brokered solutions that work for all by:
- Building consensus among stakeholders by singling out the bottom line/interest of each
- Fostering confidence of policy-makers in new technology through information, particularly that from developed countries

**Project Design Approach: Manufacturing (integrated model)**

- **Market acceptability**
  - Create confidence and scale through involvement of a major player while assuring small enterprises they will not be shut out of the market
  - Dialogue with Daikin leads to agreement that it launches R-32 in the market
  - Continued dialogue with Thai industry eventually leads all companies to accept R-32 tech. partly in order to open new markets (EU).

- **Technology Transfer**
  - Daikin agreed to provide developing countries free access to 93 basic application patents
  - Daikin agrees to provide support to Thai companies to improve AC quality (“clean-dry-tight” manufacturing) during project implementation
  - Component manufacturer responds to demand from critical mass and starts making R-32 compressors.

- **Policy and Standards**
  - Regulatory agency needed more clarity on R-32 use in hi-rise buildings so WBG shared experiences of other countries with R-32 refrigerant
  - Based on tests and evidence, Thai Gov. decided to modify regulation to allow installation of split-type R-32 AC with capacity up to 36,000 Btu/hr in high-rises.
What would be the additional costs and benefits if the Thailand R-22 AC Conversion had gone from R-22 to R-32 plus hi-EE units?
## Incremental Costs

<table>
<thead>
<tr>
<th></th>
<th>R-22 to R-32 single-speed</th>
<th>R-22 single-speed to R-32 inverter technology</th>
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<tbody>
<tr>
<td><strong>Product Development</strong></td>
<td></td>
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<tr>
<td>Modification of R&amp;D and testing facilities for handling flammable refrigerant (A2L or A3)</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Improving calorimeter room for testing low load</td>
<td></td>
<td>$150,000</td>
</tr>
<tr>
<td>Product design and performance optimization</td>
<td>$3,000 (per model)</td>
<td>$3,000+ (per model)</td>
</tr>
<tr>
<td>Development of prototypes</td>
<td>$1,500 (per model)</td>
<td>$1,500+ (per model)</td>
</tr>
<tr>
<td>Field test: AC unit</td>
<td>$3,000 (per model)</td>
<td>$3,000 (per model)</td>
</tr>
<tr>
<td>Product certification</td>
<td>$1,000 (per model)</td>
<td>$1,500 (per model)</td>
</tr>
<tr>
<td>New refrigerant charging machine (ex-proof)</td>
<td>$75,000 (per unit)</td>
<td>$75,000 (per unit)</td>
</tr>
<tr>
<td><strong>Manufacturing Line Modification</strong></td>
<td></td>
<td></td>
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<tr>
<td>Replacement of vacuum pumps</td>
<td>$2,500 (per unit)</td>
<td>$2,500 (per unit)</td>
</tr>
<tr>
<td>Storage and transfer of flammable refrigerant</td>
<td>$30,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>Safety: leak detectors, ventilation, fire suppression system...</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>Modifications to heat exchanger production line to handle higher pressure (R-32)</td>
<td>$90,000</td>
<td>$90,000</td>
</tr>
<tr>
<td>Inverter control box assembly station</td>
<td></td>
<td>$15,000</td>
</tr>
<tr>
<td>Improvement of functional test on inverter in condensing unit assembly line</td>
<td></td>
<td>$3,000</td>
</tr>
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</table>
## Incremental Costs: Inverter Drive Development

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque Testing Machine to tune Inverter Driver with Compressor Motor Parameter</td>
<td>$150,000</td>
</tr>
<tr>
<td>Surge Test, Lightening Test for Inverter Driver</td>
<td>$50,000</td>
</tr>
<tr>
<td>AC source to simulate undervoltage, overvoltage</td>
<td>$50,000</td>
</tr>
<tr>
<td>Testing Chamber for inverter driver</td>
<td>$60,000</td>
</tr>
<tr>
<td>Field test inverter driver</td>
<td>$3,000 (per model)</td>
</tr>
</tbody>
</table>
Thailand: Potential Opportunities

- Stage I HPMP
  - $9 million for air-conditioning sector
  - 12 companies average ~$750,000

- Additional investment for increasing manufacturing and market penetration of low-GWP, inverter AC
  - Product development & manufacturing line modifications: additional $200,000 - 500,000
  - Manufacturing cost increases per unit: approximately 15-20% of single speed
    - 30% of cost increase related to mechanical components
    - 70% of cost increase related to electronic controllers

- Additional investment could provide energy efficiency gains of at least 30% while replacing R-410A with lower-GWP refrigerant in inverter AC.