MEPS for Appliances and Equipment: A Roadmap for APEC Economies

Dr. Zhuolun Chen

Senior Advisor on Energy Efficiency & Finance

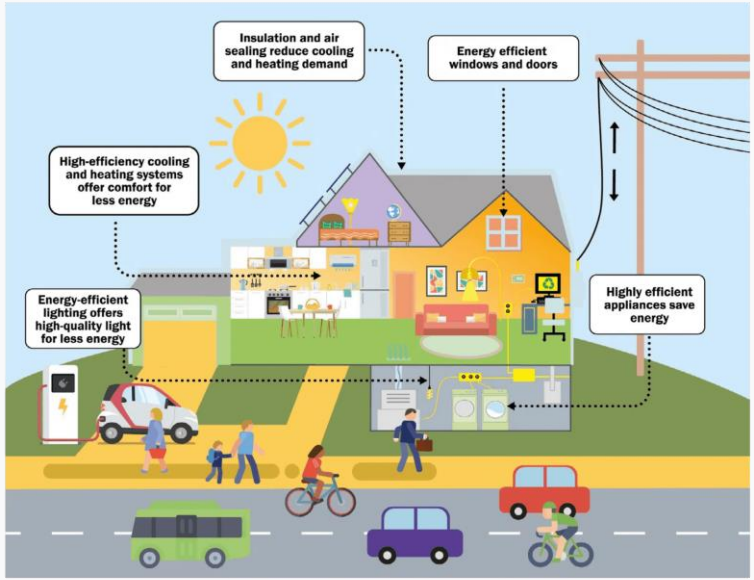
LEED AP, CMVP, CFA & CFA-Sustainable Investment

2025.11.18. Capacity Building Workshop on Energy Efficiency and Conservation Policy

UN environment programme | copenhagen climate centre

UN environment programme

APEC's Energy Challenge Demands Urgent Action on Efficiency



56%

Global Energy Demand

60%

Global CO_2 Emissions

1.9% per year

Energy intensity improvement since 2005

THE CHALLENGE

Absolute energy consumption continues to rise despite efficiency gains due to economic growth, demographic shifts, and urbanization. This underscores the urgent need for **scalable, enforceable policy instruments** that can deliver immediate and lasting energy savings across the region.

MEPS Deliver Multiple Benefits Beyond Energy Savings

ECONOMIC

Consumer savings: Lower electricity bills

Deferred infrastructure: Avoided generation costs

Innovation: Market creation for efficient tech

ENVIRONMENTAL

Climate: Reduced CO_2 emissions

Air quality: Lower power plant emissions

Resources: Water conservation

SOCIAL

Affordability: Reduced energy poverty

Health: Improved air quality benefits

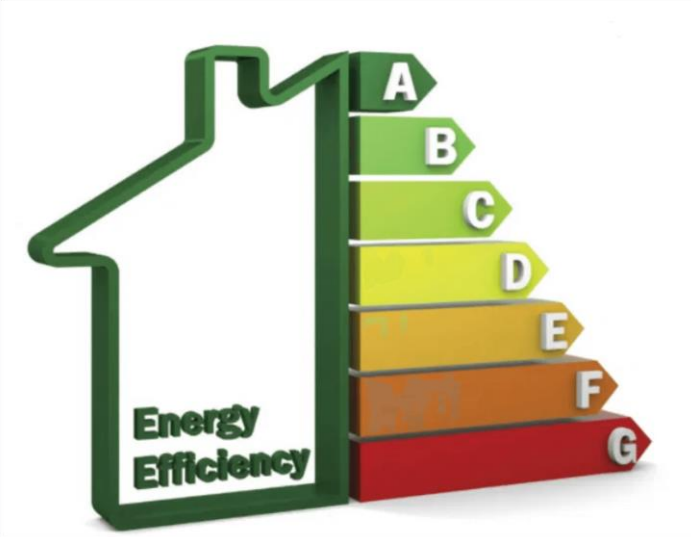
Security: Lower import dependence

TRADE

Harmonization: Reduced technical barriers

Markets: Expanded opportunities

Standards: Level playing field



MEPS represent one of the most cost-effective policy instruments available to governments, delivering immediate savings while incentivizing continuous innovation.

Case Study: SE4ALL- Sustainable Cooling and the Role of MEPS

Sustainable Energy for All's Cooling for All programme advocates for sustainable cooling solutions that are affordable, reliable, and use environment-friendly technologies. The programme addresses three critical cooling needs: human comfort and safety, food preservation and agriculture, and healthcare cold chains.

THE CHALLENGE

1.12 billion

people at high risk due to lack of cooling access

MEPS IMPACT

1.07 billion

appliances compatible with household electricity through MEPS

EFFICIENCY TARGET

4× lower

energy consumption with international best practice MEPS

SE4ALL KEY FINDINGS ON MEPS FOR COOLING

Refrigerators-Freezers: MEPS make an additional **133 million efficient units** viable, reaching 470 million total units compatible for 71% of households at medium and low risk. Market shift extends viability for **75 million additional poor households** in 40 countries.

Air Conditioners: Introduction of MEPS increases compatibility by an additional **15 million energy-efficient AC units** (+16% compared to business-as-usual), critical for households with limited electricity access.

Fans: Even with baseline efficiency, **490 million units** viable in 2030. MEPS aligned with international best practices reduce energy demand and free up household resources (electricity capacity and disposable income).

Equity Impact: MEPS expand cooling access for vulnerable populations by reducing appliance energy consumption, making cooling affordable for low-income households with limited electricity access.

SE4ALL'S THREE COOLING NEEDS FRAMEWORK

HUMAN COMFORT & SAFETY

Air conditioners and fans for thermal comfort, heat stress prevention, and climate adaptation

FOOD & AGRICULTURE

Refrigerators and cold chains for food preservation, reduced waste, farmer income, and nutrition

HEALTHCARE

Medical cold chains for vaccine storage, medicine preservation, and healthcare facility cooling

Pathways for Advancement: Scaling Up MEPS Ambition

PHASED IMPLEMENTATION APPROACH

PHASE 1
Year 1

Foundation Building: Market data collection, baseline assessment, institutional coordination mechanisms, stakeholder engagement, define roles and responsibilities

PHASE 2
Year 1-2

Standard Development & Capacity Building: Adopt international test methods (ISO 16358), establish accredited testing labs, develop draft standards, pilot testing

PHASE 3
Year 2-3

Implementation & Market Transformation: Adopt and publish standards, implement energy labeling, launch awareness campaigns, begin market surveillance and enforcement

PHASE 4
Year 3-5

Monitoring & Revision: Track market transformation, evaluate impacts, assess compliance rates, plan standard revisions based on technology advancement and market readiness

TECHNOLOGY ROADMAPS

Air Conditioner Efficiency Progression

Fixed-speed (EER 2.5-3.0) → Variable-speed inverter (CSPF 5.0-6.1) → Advanced optimization (CSPF 6.5+)

Key Technology Drivers

→ Variable-speed compressors: 25-60% energy savings

→ Low-GWP refrigerants (R-32): 10-15% efficiency gain + 68% GWP reduction

→ Enhanced heat exchangers, ECM fans, smart controls

→ Seasonal metrics (CSPF) capture real-world performance

REGIONAL ALIGNMENT STRATEGIES

ASEAN Harmonization Model

Common test method (ISO 16358) + minimum performance level (CSPF 5.0) + "floor not ceiling" approach allowing individual countries to adopt more stringent standards

Benefits of Regional Coordination

→ Reduced compliance costs for manufacturers

→ Economies of scale in testing and certification

→ Enhanced market surveillance through information sharing

→ Accelerated technology diffusion across markets

Residential Cooling Demand Presents Both Challenge and Opportunity

CHALLENGE

~1/3 of electricity growth

from cooling in Asia-Pacific

OPPORTUNITY

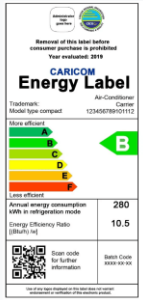
25-60% savings

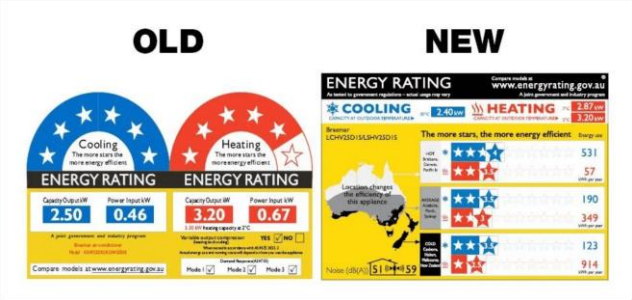
variable-speed vs. fixed-speed ACs

SOLUTION

ISO 16358

Seasonal performance metric





ASEAN SUCCESS STORY: Estimated Savings by 2040

144 TWh	**101M**	**$16B**	**66**
Electricity saved	**Tonnes CO_2 avoided**	**Consumer savings (USD)**	**500-MW power stations avoided**

Metrics for Measuring MEPS Impact

ENERGY SAVINGS

Unit-level: Annual electricity consumption (kWh/year) per appliance, baseline vs. actual performance

Aggregate: Total demand reduction (TWh), peak load reduction (MW), stock turnover modeling

Climate-adjusted: Cooling degree days, usage patterns, real-world performance factors

EMISSIONS REDUCTIONS

GHG emissions: CO_2 reductions using grid emission factors (average or marginal), NDC contribution

Co-pollutants: SO_2, NOx, PM2.5 from reduced power generation, health impact assessment

Direct emissions: Low-GWP refrigerant adoption, HFC phasedown contribution

ECONOMIC BENEFITS

Consumer savings: Reduced electricity bills, life-cycle cost analysis, payback periods

Avoided infrastructure: Generation capacity ($/kW), transmission and distribution, fuel costs

Employment: Testing and certification services, manufacturing, efficiency program jobs

EQUITY IMPACTS

Access expansion: Number of households for whom efficient appliances become viable

Affordability: Percentage of households that can afford cooling services, freed-up resources

Vulnerable populations: High-risk individuals gaining cooling access (gender-disaggregated)

MEASUREMENT APPROACHES

Bottom-Up Engineering

Unit energy savings × number of compliant units. Uses technical reference manuals, product testing data, stock turnover models. Provides detailed product-specific estimates.

Top-Down Econometric

Time-series or panel data analysis of aggregate consumption. Controls for economic growth, weather, prices, other policies. Captures market transformation effects.

Hybrid Validation

Engineering calculations as primary method, econometric analysis for validation. Addresses uncertainty, bias (free ridership, rebound, spillover). DOE EM&V best practice.

Key Principle: Establish clear baselines and counterfactual scenarios that isolate MEPS impacts from other market trends. Include uncertainty ranges and address potential sources of bias transparently.

Evaluation Frameworks and Best Practices

EVALUATION PLANNING (DOE EM&V FRAMEWORK)

OBJECTIVES & METRICS

Define clear evaluation objectives aligned with program goals. Specify metrics for impact, process, and market effects evaluation. Address stakeholder information needs.

TIMING & FREQUENCY

Process evaluation: 6-12 months post-implementation. Impact evaluation: 2-3 years when sufficient data available. Periodic updates: every 3-5 years for standard revision.

STAKEHOLDER NEEDS

Policymakers: aggregate impacts. Administrators: compliance data. Industry: clear requirements. Public: transparent benefit reporting. Budget 3-5% for evaluation.

DATA COLLECTION AND MANAGEMENT SYSTEMS

PRODUCT REGISTRATION

Mandatory database of all models offered for sale. Includes technical specifications, energy performance ratings, test reports from accredited labs. Enables market surveillance and compliance tracking.

MARKET SALES DATA

Sales-weighted efficiency analysis tracks market transformation. Sources: manufacturer shipments, retailer point-of-sale, import/export statistics. Monitor units sold, revenue, market share by efficiency level.

ENERGY CONSUMPTION

Smart meter data for appliance-level consumption. Metering studies with sub-meters for detailed analysis. Surveys on usage patterns, maintenance, consumer satisfaction. Validate engineering estimates.

COMPLIANCE VERIFICATION

Check testing programs randomly purchase products from retail. Verify performance against declared ratings. Track non-compliance patterns by manufacturer/category. Penalties: recalls, fines 5-10% of annual sales.

EVALUATION BEST PRACTICES

Baseline Establishment

Use adjusted baselines that project pre-MEPS efficiency trends forward. Avoid historical baselines if efficiency was already improving. Consider comparison groups from non-MEPS markets.

Uncertainty Quantification

Include confidence intervals or uncertainty bands. Use Monte Carlo simulation or sensitivity analysis. Communicate precision of estimates to policymakers and stakeholders.

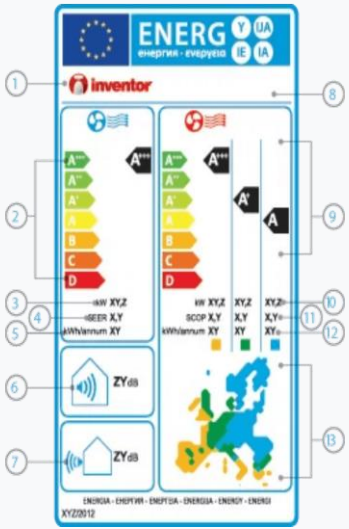
Addressing Bias

Account for free ridership, rebound effects, and spillover. Transparently discuss treatment of each factor. Use hybrid approaches combining engineering and econometric methods for validation.

Case Study: ASEAN Harmonization Shows Power of Regional Cooperation

ASEAN AC HARMONIZATION PROJECT

Regional harmonization of air conditioner efficiency standards based on ISO 16358 metric



Harmonized energy label example

KEY SUCCESS FACTORS

1. Regional harmonization reduces costs and complexity for manufacturers and regulators

2. ISO 16358 adoption aligns with international standards and best practices

3. Simplified testing protocols for both fixed-speed and variable-speed ACs lower compliance burden

4. Technical support from UNEP, Lawrence Berkeley Lab, and U4E provided expertise

5. Stakeholder engagement through Technical Working Group ensured buy-in

TRANSFERABLE LESSONS FOR APEC

→ Single set of temperature bin hours for entire region simplifies implementation

→ Combining fixed-speed and variable-speed under same metric enables consumer comparison

→ Phased implementation with capacity building supports gradual adoption

Case Study: EU Energy Label Demonstrates Impact of Complementary Policies

79% **of purchase decisions**

EU energy label influences nearly 4 out of 5 appliance purchase choices, driving continuous market transformation

KEY SUCCESS FACTORS

- → MEPS and labeling as complementary policies
- → Mandatory display online and in stores
- → Comprehensive stakeholder consultation
- → Product registration database (EPREL)
- → Regular revisions for technology improvements

CASE OVERVIEW

Policy: EU Energy Label with A-G comparative scale, color coding (green to red), mandatory display in-store and online

Timeline: Implemented since 1995 alongside MEPS. 2021 rescaling returned to simple A-G from A+++ scale

Integration: MEPS eliminate worst products (D-G rated), labeling drives market pull toward high efficiency (A-B rated)

GOVERNANCE LESSONS

Coordinate policy development across energy ministries, standards bodies, market surveillance, and customs

Invest in consumer research to improve label design and effectiveness

Anticipate need for revisions from the start with clear triggers and procedures

Manage consultation to prevent industry capture and delays

2014 evaluation and 2020 Court of Auditors report confirmed contribution to EU energy efficiency and climate goals

Institutional Coordination is Critical for Effective Implementation

GOVERNMENT DEPARTMENTS

Energy/Environment Ministry

Policy development, performance targets, program oversight

Standards/Standardization Body

Technical specifications, international alignment, revision cycles

Market Surveillance Authority

Compliance enforcement, verification testing, enforcement actions

Customs/Trade Authority

Import controls, conformity verification, border enforcement

Consumer Protection Agency

Consumer interests, complaint handling, labeling accuracy

EXTERNAL ORGANIZATIONS

Accreditation Bodies

Laboratory accreditation (ISO/IEC 17025), quality assurance

Testing Laboratories

Conformity assessment, verification testing, certification

Industry Associations

Stakeholder representation, consultation facilitation, capacity building

International Organizations

Model regulations (U4E), research (IEA), technical assistance (CLASP)

COORDINATION MECHANISMS

Establish inter-ministerial working groups with regular coordination meetings, clear information sharing protocols, and defined escalation procedures for enforcement issues.

Aligning with International Standards Reduces Barriers and Costs

BENEFITS OF ALIGNMENT

✓ Reduces technical barriers to trade

✓ Leverages existing supply chains

✓ Simplifies compliance for manufacturers

✓ Enables technology transfer

U4E MODEL REGULATION GUIDELINES - KEY TARGETS

LIGHTING	90 lm/W (LED transition), advanced target 120 lm/W
ELECTRIC MOTORS	IE3 efficiency class (IEC 60034-30-1)
AIR CONDITIONERS	CSPF 5.1 Wh/Wh (ISO 16358 standard)
REFRIGERATORS	279 kWh/year (400L unit), intermediate target 223 kWh/year
WATER HEATERS	≥90% efficiency (gas), ≥100% efficiency (electric storage)
SPACE HEATING	≥90% efficiency (fossil fuel), 100% efficiency (electric)

Most appliances are manufactured in or source components from major economies like China, making it feasible for APEC economies to adopt similar standards and leverage global supply chains.

UN environment programme

Identifying and Communicating Co-Benefits Strengthens Policy Support

ECONOMIC

Consumer savings: Lower electricity bills, reduced total cost of ownership

Deferred infrastructure: Avoided power generation, transmission, distribution costs

Industrial competitiveness: Innovation stimulus, market creation

Job creation: Testing, certification, manufacturing, efficiency services

ENVIRONMENTAL

Climate mitigation: Direct CO_2 reduction, NDC contribution, net-zero support

Air quality: Reduced power plant emissions (SO_2, NOx, particulates)

Water conservation: Reduced cooling water for power plants

Resource conservation: Lower fuel consumption, reduced imports

SOCIAL

Energy affordability: Lower costs for low-income households, reduced energy poverty

Health benefits: Improved air quality, reduced respiratory disease

Energy security: Reduced import dependence, lower price volatility

Consumer protection: Minimum quality assurance, accurate information

BEST PRACTICES FOR CO-BENEFIT ASSESSMENT

✓ Use established methodologies (IEA Multiple Benefits framework)

✓ Conduct baseline and counterfactual analysis

✓ Engage multiple stakeholders in benefit identification

✓ Use conservative assumptions for credibility

✓ Monetize benefits where possible

✓ Update assessments as new data becomes available

Quantifying and communicating the full range of MEPS co-benefits is essential for building political support, securing sustained funding, and maintaining public acceptance beyond energy efficiency advocates.

Recommendations for APEC Member Economies

FOR ECONOMIES DEVELOPING INITIAL MEPS PROGRAMS

1. Adopt U4E Model Regulations: Use U4E guidelines for priority products (ACs, refrigerators, fans). Adopt ISO 16358 CSPF for air conditioners to capture seasonal performance and incentivize variable-speed technology.

2. Establish Institutional Coordination Early: Define clear roles across departments before launch. Create interagency working groups with written terms of reference. Learn from ASEAN's facilitated coordination model.

3. Invest in Testing Laboratory Capacity: Pursue ISO/IEC 17025 accreditation for relevant test methods. Consider regional cooperation through shared facilities or mutual recognition. Budget $500K-2M for comprehensive capability.

4. Implement MEPS and Labeling Together: Design as integrated policies from outset. Use comparative labels (A-G or star ratings) to drive consumer demand beyond regulatory minimums. Ensure online and in-store display.

FOR ECONOMIES SCALING UP EXISTING MEPS PROGRAMS

5. Develop Technology Roadmaps: Map pathways from current market performance to future efficiency potential. Establish triggers for standard updates: 25-30% high-efficiency market share, technology breakthroughs, or periodic reviews (3-5 years).

6. Strengthen Market Surveillance: Invest in check testing programs and non-compliance penalties. Allocate 10-15% of program resources to surveillance. Implement risk-based targeting of high-volume products and new entrants.

7. Quantify and Communicate Co-Benefits: Use IEA Multiple Benefits framework to assess economic, environmental, and social co-benefits beyond energy savings. Follow SE4ALL's model for equity-focused impact assessment.

8. Pursue Regional Alignment: Engage in APEC cooperation on test method harmonization, information sharing, and mutual recognition. Consider bilateral or plurilateral harmonization with neighbors or major trading partners.

CROSS-CUTTING PRIORITIES FOR ALL APEC ECONOMIES

Focus on Residential Cooling

Given SE4ALL findings that cooling drives 1/3 of electricity growth in Asia-Pacific and ASEAN's demonstrated impact (144 TWh savings, 101M tonnes CO_2 avoided, $16B consumer savings), prioritize residential cooling in MEPS programs.

Leverage External Organizations

Engage U4E for model regulations, CLASP for implementation assistance, IEA for research and best practices, SE4ALL for sustainable cooling frameworks. Participate in international networks and capacity building programs.

Invest in Data Systems

Establish product registration databases, market sales monitoring, energy consumption tracking, and compliance verification. Use DOE EM&V framework for evaluation planning. Budget 3-5% of implementation costs for evaluation.

Advancing MEPS Implementation: Key Takeaways

PATHWAYS FOR ADVANCEMENT

Systematic phased approach from foundation building through monitoring and revision. Technology roadmaps guide standard progression. Regional alignment (ASEAN model) delivers economies of scale and accelerates technology diffusion.

METRICS FOR IMPACT

Comprehensive measurement across energy savings, emissions reductions, economic benefits, and equity impacts. Bottom-up engineering calculations validated by top-down econometric analysis. SE4ALL framework for equity-focused assessment.

EVALUATION FRAMEWORKS

DOE EM&V framework provides comprehensive evaluation planning guidance. Robust data systems (product registration, market sales, consumption monitoring, compliance verification) enable evidence-based policy. Budget 3-5% for evaluation activities.

LESSONS FROM EXPERIENCE

ASEAN harmonization demonstrates value of international standards, facilitated coordination, and "floor not ceiling" approach. EU label evolution shows power of complementary policies and need for periodic rescaling. Both provide actionable guidance for APEC.

THE RESIDENTIAL COOLING OPPORTUNITY

Residential cooling presents both the greatest challenge and opportunity for APEC economies. SE4ALL's analysis demonstrates that MEPS aligned with international best practices could make **1.07 billion cooling appliances compatible** with household electricity services while reducing energy consumption by **4×**. ASEAN's harmonization projects **144 TWh of electricity savings, 101 million tonnes of CO_2 emissions avoided, and $16 billion in consumer savings** by 2040.

The time to act is now, as cooling demand continues its rapid growth trajectory and the window for cost-effective climate mitigation narrows. MEPS represent a proven, cost-effective policy instrument that APEC economies can deploy immediately to achieve energy security, economic, environmental, and equity objectives simultaneously.

Thank you very much!

Dr. Zhuolun Chen

email： zhuolun.chen@un.org

LinkedIn

UN environment programme | copenhagen climate centre

UN environment programme