Removing Barriers to Energy Efficiency Improvement in MP Sectors in Article 5 Countries

Montreal Protocol Operations – World Bank

Thailand AC Conversion to R-32

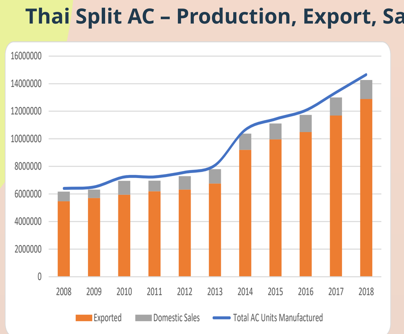
Under Thailand's Stage I HCFC Phaseout Management Plan – critical to convert from HCFC-22 to avoid build up servicing demand

AC conversion was to R-32 (fixed speed AC) to avoid high-GWP R-410A in a global market where R-32 AC was limited and non-existent in Thailand among multi-nationals.

Barriers to Deployment of Lower-GWP Refrigerant AC

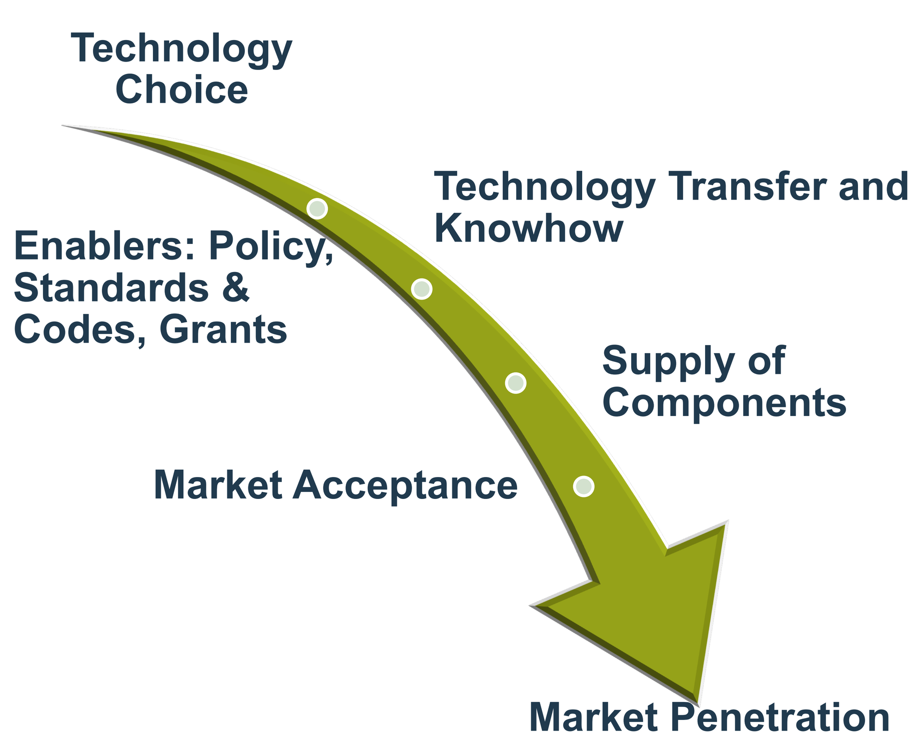
- Market acceptability of R-32 refrigerant which is mildly flammable a question;
- No technical and human capacity to manage flammable, higher pressure gas in manufacturing;
- Regulatory hurdles for installing R-32 units in buildings;
- R-32 Proprietary technology and "know-how" was not openly available.

Thai Split AC – Production, Export, Sales



Approach

Required synchronized action on several fronts. Critical mass, leadership and coordinated efforts needed to convince component suppliers to fill gap and produce R-32 compressors in larger size range.



Results

- Energy performance of R-32 AC is better than R-22 & R-410 units and Thai market quickly transitioned to R-32 based AC for fixed speed residential AC, allowing R-22 to be banned in 2017.
- Lessons on importance of guaranteeing compressor supply led to a grant to assist a Thai reciprocating compressor manufacturer design & develop R-32-based compressors for hi-ambient temp.
- Positive experience (new markets, more sales) of Thai AC manufacturers motivated them to engage in future EE activities.
- Tech transfer and TA served as a model for others (Vietnam etc.).
- Treatment of A2L refrigerant in building codes replicable

Context

Global scale: Est. 100 m unitary AC manufactured annually (15-16 m in Thailand alone). Per IEA, energy use for AC has increased 7.5x over 30 yrs in ASEAN while AC ownership averages at 15%, leaving potential for growth. More heat, wealth & people = demand.
Economic importance: Thailand, split AC market est. to be $2.8 billion (CLASP, 2018)
Energy consumption avoided: More EE AC would permit ASEAN countries to save 110 TWh of electricity by 2040 (IEA).
Climate imperative: Majority AC installed were fixed speed w/either of R-22, R-410A or R-32. Hi energy consumption & leakage = significant CO_2 eq. emissions.
Window of opportunity to build on the AC sector R-32 transition - greening *the same* MLF-supported AC industry thru open-access inverter tech., public-private sector partnership & policy reform.
•**Leveraging Kigali:** potential to align HFC phase-down (in CO_2eq) from high-GWP refrigerant (R-410A) with transformation of the AC sector to more efficient AC.

AC Manufacturing Readiness

Objective: equip local manufacturers with open-access tech. and know-how for designing, developing, and placing on the market more efficient AC, to complement MP-supported conversions and thereby support an increase in MEPS and accelerated AC market transformation in Thailand and Viet Nam by:

- Creating enabling environment for supply and demand of high EE RAC with lower GWP refrigerants in domestic markets.
- Improving local RAC industry's technical capacity to design EE AC using inverter technology, increasing confidence of regulatory bodies to raise product minimum standards.
- Identifying and addressing other technical barriers to the deployment of inverter AC.
- Opening the inverter AC market to local AC companies that collectively can help drive costs down.
- Catalyzing a market shift to more efficient AC with minimal increased costs to pave the way for an economically viable market.

Technical Barriers to Deployment of inverter AC

- Inverter AC highly competitive;
- Technology and know-how not in hands of small, local companies making them dependent on designs not in their control;
- Perception that inverter AC underperforms in certain applications;
- Lack of capacity for programming, repair and replacement of control box.

Target group: 14 Thai & Vietnamese-owned AC manufacturers.

Product: 1, 2, & 3-ton split AC with a focus on R-32 refrigerant in line with MLF-supported conversion projects.

Tech/know-how facilitator: Leading manufacturer of hermetic compressors (Kulthorn K.) + research facility at Purdue University.

Policy Target: increase ASEAN SHINE 2020 MEP target of CSPF 3.08 W/W by 20% in a timetable captured in AC cooling plan if 30% of enterprises assessed as capable to produce RAC using inverter technology and lower GWP refrigerant.

Results

- Results significantly impacted by COVID but also vary due to capacity starting points of enterprises (engineers, testing capability, etc.) & degree of capacity built is mixed based on latest readiness assessments (March 2022)
- Results underline the key barrier remaining for room AC suppliers in offering more and higher EE room AC is not having access to and autonomy over lower-cost inverter technology.
- Complexities involved in fully removing technological barriers reinforces need for an integrated sector approach that weaves in TA, market incentives, awareness raising and policy.
- Critical finding is that readying local AC companies for transitioning to more climate-friendly AC will be a process, requiring additional incentives depending on needs.
- Mixed results of the quick studies on barriers to inverter AC field performance across the two countries point to the need for additional research to substantiate respective assessments. Voltage impact review confirms inverter sensitivity that needs to be managed (as done by multinationals) by reliability testing protocols
  - Technical knowledge-base is available to the public at large.

- Network of industry and research experts built to continue building AC enterprise capacities including with inverter manufacturers, academia and gov. research institutes.
- Enterprises' negotiating powers expected to be enhanced to obtain cost-competitive components and RAC supplies. Component costs to enterprises will be tracked.

Enterprise capacity to integrate inverter tech and knowledge in business operations strengthened.

- As inverter technology is assimilated at beneficiary enterprises a medium-term goal could be development of business models and financing approaches for the demand-side.
- As an unconventional approach (focus on industry) towards increasing policy ambition on EE, outputs and results of open-access, inverter technology and know-how transfer to local AC manufacturers can contribute to the current dialogue on how to scale-up sustainable cooling and possible feasible models for transformative action.

Tools

- Instructional video series
- Training Presentations
- PID Loop Automated Software Tool
- User Manuals for Open Access Tech
- Inverter AC Design, HPDM Simulation
- AC Design Process Flowchart
- Inverter Electronic Components Guide
- Assessment Survey & Field Guide
- AC Readiness Checklist
- Reliability Test Program & Conditions

Training Module Examples:

RefProp –Training on open access design software:

https://www.youtube.com/watch?v=SFZE_EwJqYs

Introduction, Thermodynamics basics and training on refrigerants:

01 Intro
02 Thermo Review I
03 Thermo Review II
04 Refrigerants

Next Steps

- Expand the application of the approach to stand-alone **commercial refrigeration** manufacturing with natural refrigerants
  - Develop a methodology to accurately quantify additional climate benefits from energy efficiency improvement
  - Work with compressor, component manufacturers to offer technology options for local manufacturers to adopt variable speed technology
  - Support the transfer of open-access inverter technology
  - Market research for development of minimum energy performance standard for plug-in units

- Build-on ***AC Manufacturing Readiness*** work by targeting in on one local room AC manufacturer of R-32 units to:
  - Further support enterprise to master inverter technology to dictate terms with component and equipment suppliers.
  - Build internal capacity to fix circuit boards to prevent electronic waste while saving customers from costly replacement.
  - Avoid imports of R-410A inverter AC.

Acknowledgements

Piloting of R-32 refrigerant and inverter technology in AC was only possible through the strong leadership and in-country, inter-agency cooperation of the following:

- Departments of Industrial Works and of Alternative Energy Development and Efficiency, **Thailand**
- Departments of Climate Change and of Energy Efficiency and Sustainable Development, **Viet Nam**

- **Policy scenarios for increasing MEPS by 20% in both countries indicated significant direct and indirect GHG emissions savings are possible through the Kigali compliance period of 2045.**
- **Model exclusion analyses revealed the crux of the AC supply challenge - where most inefficient AC products are associated with local AC firms (manufacturers and importers).**
- **Comparison of S&L programs confirm that MEPS could be better aligned with the current situation of respective markets where the average performance rating of fixed speed models in the market is 10-22% higher.**