MFVI Energy Efficiency Audit Training Module 3.1: Cooling Systems

Gokul Paranjothi, Jonathan Morgenstein, and Hallie Lucas
National Renewable Energy Laboratory
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Introduction to MFVI

MiPyMEs Futuros Verdes Initiative (MFVI) advances clean, reliable, and affordable energy solutions for micro-, small-, and medium-sized businesses (Spanish acronym “MiPyMEs”) in the Yucatan Peninsula through targeted technical training and affordable finance support. MFVI aims to increase financial inclusion, maximize the energy cost savings available to MiPyMEs, empower business owners to make strategic energy investments, and catalyze economic growth within the MiPyMEs sector.

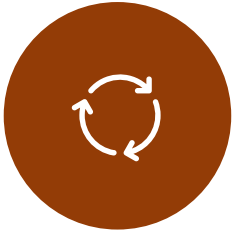
The following modules were developed as part of a two-part targeted training series to equip university students with the skills and expertise needed to conduct Level-2 energy audits for local MiPyMEs. This module was designed for undergraduate students from different backgrounds to perform audits for small and micro business buildings. The energy savings measures will reflect this overall purpose.

What Is the Purpose of MFVI?

Help MiPyMEs implement energy efficiency

Determine simple energy conservation measure (ECM) savings through targeted energy efficiency audits

Enable MiPyMEs to qualify for affordable “green” loans



Begin a cyclical process of building green credit

MFVI Two-Part Training Process

Phase 1 Training

- Understand and measure energy efficiency via on-site audits

Phase 2 Training

- Conduct analysis of data collected during audits, and recommend ECMs

Training Breakdown

Module 1: Lighting

1.1 Introduction to Efficient Lighting

1.2 Lighting Analysis

Module 2: Plug Loads

2.1 Introduction to Plug Loads

2.2 Plug Load Analysis

Module 3: HVAC

3.1 Introduction to Cooling Systems

3.2 HVAC Analysis

What You'll Need For the Audit

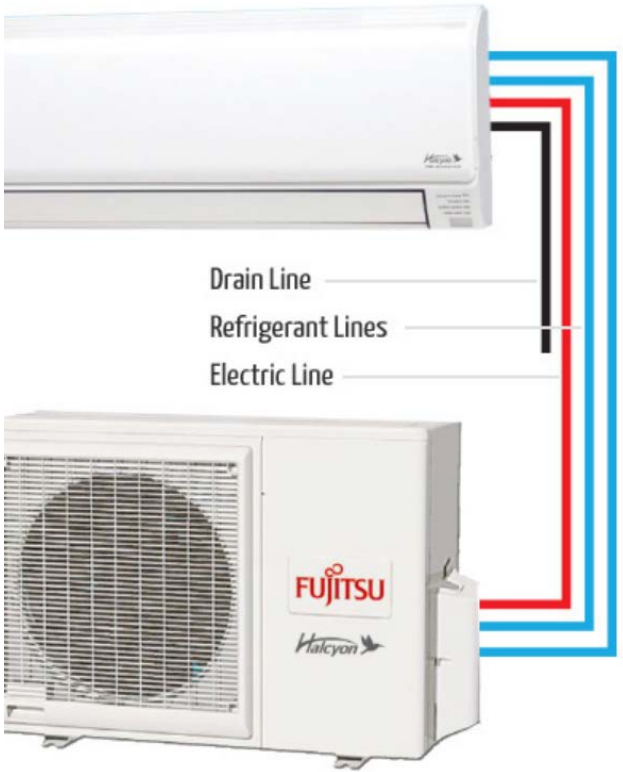
- A copy of your field tool sheet
- Pen, pad, and extra sheets of paper.

Introduction to Cooling Systems

Training Module 3.1

What Systems Does This Module Cover?

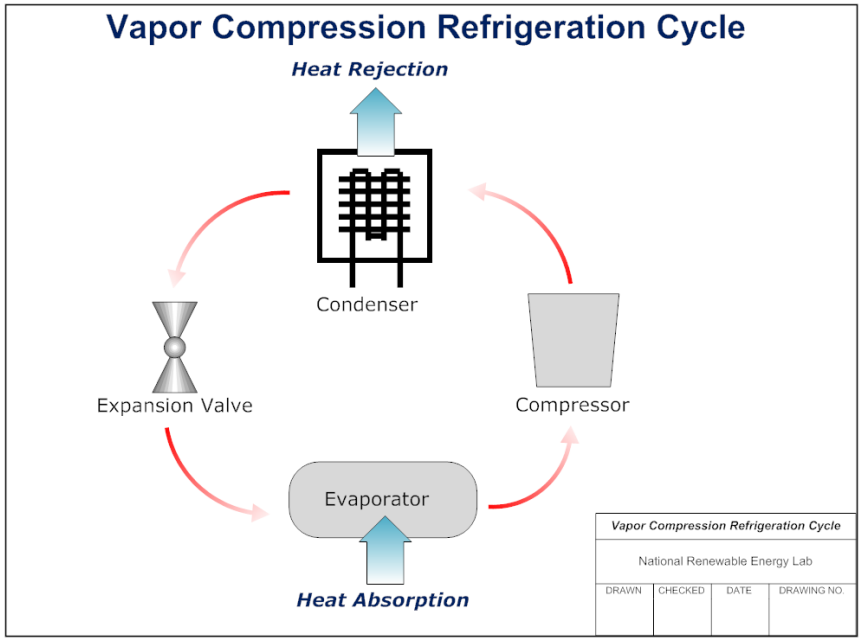
- Window air conditioners
- Split-system air conditioners.



Photo/Image credit:
- Window AC
- Mini Split

Before We Start: Refrigeration Basics: Vapor Compression Cycle

- Air conditioning systems cool air using a **vapor compression refrigeration cycle.**
- **Heat is removed** from conditioned air or water in the **evaporator.**
- **The refrigerant is compressed** in **the compressor** (increase pressure/temp).
- **Condenser rejects heat** to air or water.
- **Refrigerant flows through an expansion device** (reduces temp/pressure).



Photo/Image credit: NREL presentation, Energy Assessment Training, Cooling Systems

Before We Start: Refrigeration Basics: How Air Conditioners Work

1. Warm air from the space/room is absorbed by the units.
2. The refrigerant acts on the warm air, facilitating heat exchange
3. The warm air is then transferred out to the outside unit and exhausted. The cold air is recirculated back to the room.

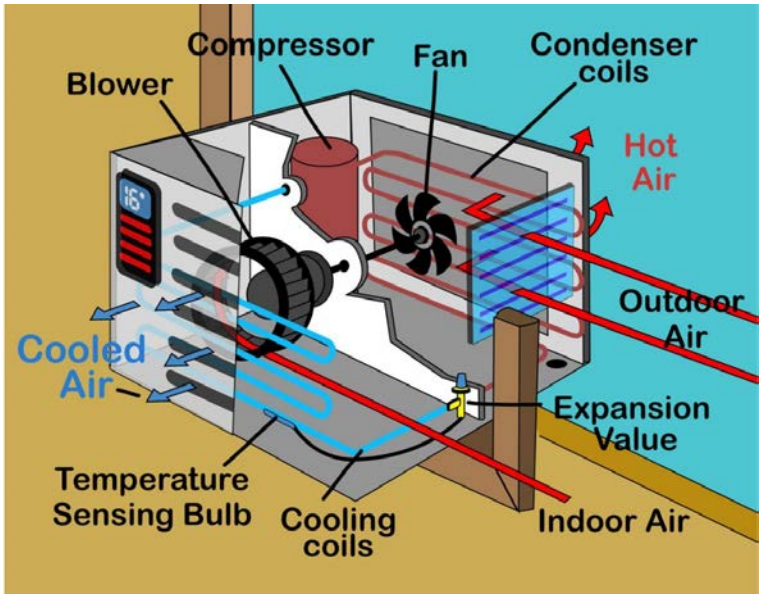


Image by researchgate.net

Key Terms and Definitions

- Cooling equipment is sized based on maximum internal cooling loads.
- Equipment performance ratings dictate efficiency of equipment.
  - Coefficient of Performance (COP) is the ratio of heat output over electrical work input.
  - Energy Efficiency Ratio (EER) is a second measure of efficiency.
  - The Seasonal Energy Efficiency Ratio (SEER) is the EER of a system calculated at specific performance conditions.
  - The higher the COP, EER and SEER, the more efficient the unit is.

Conversions

1kW (kilowatt) = 1/3412.142 Btu/hr

1 ton of cooling = 12,000 Btu/hr

$$EER = COP \times 3.413$$

$$COP = \frac{Q_{cooling}}{W_{elec.}}$$

Key Terms and Definitions (cont.)

- **Temperature**: A measurement of heat intensity; controlled by heating and cooling equipment within a building. Measured in “dry bulb” temperature, or Tdb.
- **Humidity**: A measure of moisture content within air. Measured in relative humidity, absolute humidity, and “wet bulb” temperature, or Twb.
  - When Twb = Tdb, humidity = 100%.
- **Filtration**: Serves as a means of reducing particulate matter from conditioned air.
- **Circulation**: Involves the movement of air within a building.
- **Ventilation**: The process of introducing and removing excess air from a building.

Pause and Recap

Questions?

Introduction to Cooling Systems

Identify common cooling systems*

*Common cooling systems here refer to the cooling systems usually found in Yucatan, Mexico, where this training initially took place

Window Air Conditioners

- Window air conditioners have both the evaporator and the condenser as one unit.
- They are typically installed through a hole in the wall.

Image by thecoldwire.com

Split or Mini-Split System Air Conditioners

- Split systems have two separate units:
  - The indoor unit or evaporator is located inside the space.
  - The outdoor unit or condenser is located externally, typically at the ground level.
  - They are connected through refrigerant lines and wiring.
- They don't require any holes in the insulation to be installed.

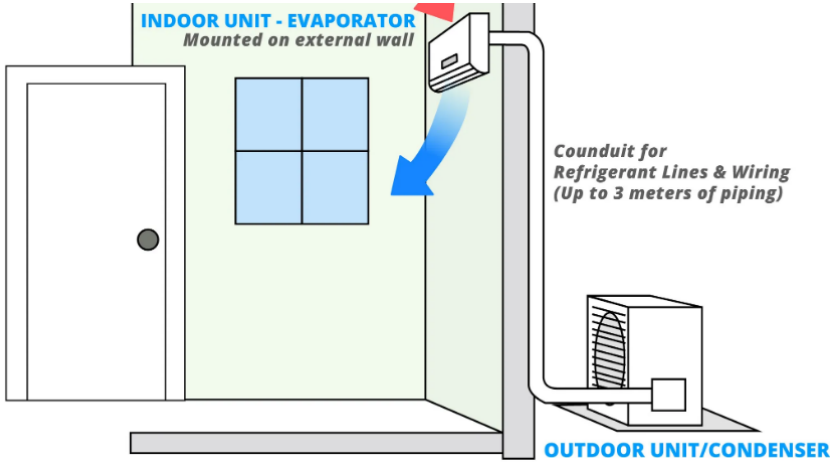


Image by fujistugeneral.com

Step 1: Collect Nameplate Information

- Look for a nameplate on both the indoor and outdoor units of the air conditioner
- Although they vary with models, nameplates are typically located on the side of the units.
- Note:
  - Manufacturer
  - Model number (M/N)
  - Capacity (kW, Btu/h, tonnes)
  - EER, SEER, or COP.
- Take a photo of the nameplate
- Take a photo of the unit.

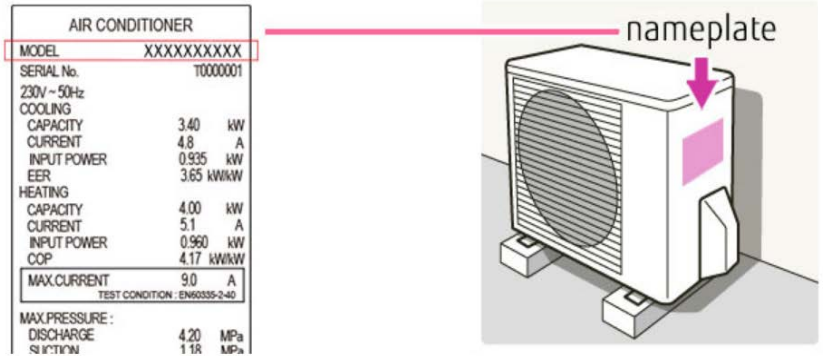
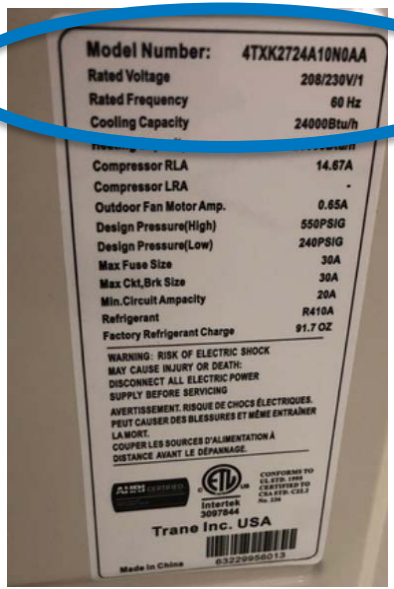
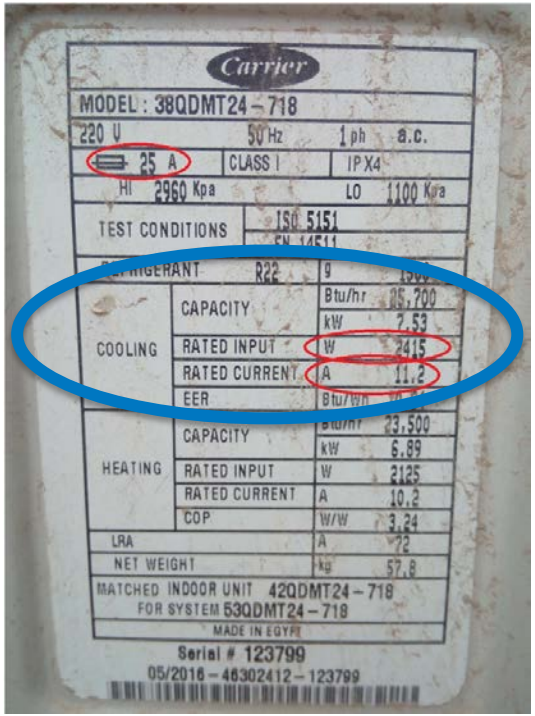
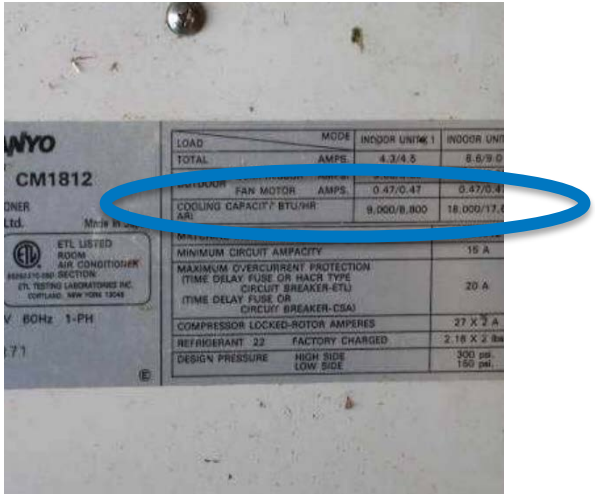


Image by fujitsu-general.com

Typical Nameplates







Photo/Image credit (From the left):

- surpluscityliquidators.com
- diy.stackexchange.com
- inspectapedia.com

Step 2: Remove the Front Panel of the Indoor Wall Unit: Window Air Conditioners

For window air conditioners, either pull the front panel out or remove screws attached to front panel, depending on the model type.

Refer to this video between 1:30 to 1:45 for a video tutorial.

Image by youtube.com

Step 2: Remove the Front Panel of the Indoor Wall Unit: Split and Mini-Split Air Conditioners

- For split-system air conditioners, lift the wall unit up and remove them from the hinges.
- Refer to this video between 0:26 to 0:36 for a video tutorial.

Image by youtube.com

Step 3: Check Air Filter and Collect Related Information

- Removing the front panels exposes the cooling system's air filter.
- Most modern air filters are made of rigid plastic. However, some systems may have a foam or fiber air filter as well.

Image by pioneerminisplit.com

Step 3: Check Air Filter and Collect Related Information

- Note whether the air filter is clean.
- If dirt isn't obviously visible, run your finger over the filter to see if a layer of dust collects on the finger.
- Find out how often the systems are maintained by talking to employees. Typically, this should be every 2 months.

Step 4: Collect System Control Information

For each system, note how the system is controlled. Is there a thermostat in the system that turns it on/off to maintain the temperature specified?

- If so, what are the temperature setpoints?
- If not, is there an outlet timer that turns the system on/off at certain intervals?
- Is the system switched on/off manually or automatically?
- If manually, who controls it? What are typical times of operation?
- If automatically, when do they come on and turn off?

Step 4: Collect System Control Information

This information is collected to suggest better methods of control for the systems; we will look at it in more detail in the next section.

Photo/Image credit: (from the left):

- diy.stackexchange.com
- cielowigle.com
- hvachowto.com

Pause and Recap

Questions?

Analysis of Cooling Systems

Training Module 3.2: High-Efficiency Systems

Step 1: Lookup Model Number of the System and Search for Higher Efficiency Alternatives

- Search for the model number on the internet to get the capacity of the system and efficiency.
- Most efficiencies are expressed in EEF or SEER.
- Look at the ENERGY STAR® website fo higher efficiency alternatives at the same capacity.

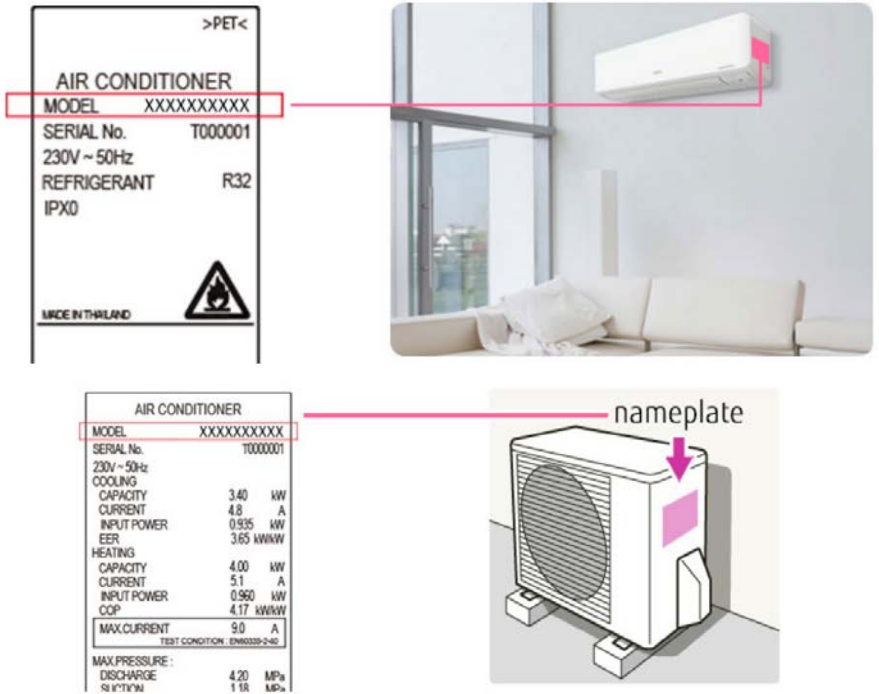


Image by fujitsu-general.com

Step 2: Energy Use Savings

Look at the ENERGY STAR website for higher efficiency alternatives at the same capacity

Costs of the system can also be obtained from there.

Notes:

- It is difficult to calculate annual energy savings for window and split-AC cooling systems without energy models.
- Savings will have to be estimated with manufacturer claims, which may not be the best estimates of performance.
- For context, upgrading a system from SEER 14 to SEER 19 can save anywhere between 26%-42% in heating and cooling energy.
- Typically, cooling system replacements have a payback of 8-12 years.

Analysis of Cooling Systems

Air filters

Cleaning Air Filters

- DOE estimates that cleaning air filters regularly will result in a savings of 15%-20% in your cooling energy use.
- It also improves overall health and well being, making sure you aren't breathing in dirty air.
- Air filters can be cleaned by using water to wash them, and then drying them with cloth or in the sun.
- Wet air filters SHOULD NOT be replaced back into the cooling system.
- Typically, air filters need to be cleaned every 2 months and replaced every 2-3 years.

Analysis of Cooling Systems

Thermostat control

Thermostat Control

- DOE estimates 10% annual savings on cooling energy use with effective thermostat control.
- It is recommended to keep thermostats at 24-25°C when cooling. During non-occupied hours, this number would increase to 30°C.
- For businesses, it is easiest to automate the control process, using a smart thermostat control through your mobile phone.

Notes

- All cooling system savings are hard to estimate without energy modeling.
- Generally, a payback of 8-12 years is expected for replacing HVAC with high-efficiency systems, 1-2 years for cleaning air filters, and 2-3 years for thermostat controls.

Questions?

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