A/C System Best Practices
How to Evaluate and Optimize Peak Performance

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More technical session….

- AIR FLOW SESSION
- Bill Spohn
- Thursday, February 28
- 8:30 AM
- Grand Ballroom 11
- Airflow Measurement Techniques

This Session:

Contractors currently using this system in utility-sponsored programs are

- Achieving higher customer satisfaction
- Closing new maintenance agreements, re-engaging cancellations
- Realizing increased sales opportunities
- Minimizing call-backs
- Establishing a “Technician accountability” process
- Commissioning new installs and verifying capacity, EER
- Receiving utility incentives toward tool purchase, completed tune-ups and commissionings

This Session:

- The tools used allow techs to
  - “See the science"
  - Test quickly and accurately
  - Better understand what corrective measures are necessary
  - Gather the evidence needed to present to the owner/get authorization for repairs
- Important to realize NONE of this is necessary
  - If systems get designed, installed, commissioned and serviced correctly, until it needs a major repair
  - Ok…….

What's all the fuss about?

- Some estimates show that 55% of the capacity of the electrical grid is used for ACR.
- 10% is used for the 33,000 supermarkets alone
- Some estimates show that the efficiency of energy delivery is only 19%
  - from energy input to end use
- Therefore for every KW saved – 4-5 times the power plant output is saved
  - Reduces the need for more power plants ($, ROI)
  - Impacts the consumption of fuel (for non-nuclear plants)
  - Impacts the stack emissions

"facts" Courtesy Dave Boyd, Appion, Inc.

What's that got to do with you?

- Estimates show that ~37% of ACR energy used is wasted due to improper service procedures!
- A California a study showed ~60% of 4000 homes were incorrectly charged and impacted efficiency by 25% or more

What's the future?

- Power usage is expected to increase 46% increase by 2030
- The grid was developed decades ago (1935-1949)
- Since development grid usage is up 1315%
- Capital expenditures to maintain the grid have dropped 22% (1979 to 1999)
- In 1999 an estimated 1 billion dollars lost in productivity due to power outages
- In 2004 power outages cost approximately $ 20 billion
- In 2008 it rose to approximately $ 80 billion

Why are utilities interested in AC?

- Why are utilities interested in this?
  - Demand side reduction for peak load times
  - Increasing customer satisfaction
  - PUCs are forcing the hands of utilities
- Benefits to peak load reduction:
  - if all A/Cs are running due to weather
  - fewer are running simultaneously since individual A/C system operations & delivery are more efficient and matched to load
  - This helps to “shave the peaks”

What are the alternatives?

- What is the alternative to best practices?
  - More power plants.
  - NIMBY!

Broader applications

- Not just residential: commercial customers and contractors can benefit too.
- The physics basically scales up

TODAY: Often referred to as a "Pre-season checkup"

May merely confirm that:

- System is running and cooling somewhat
- Operating within reasonable voltage ranges
- Thermostat is functioning and unit is responding
- Condenser is somewhat clean and free of debris
- Contactors are clean and functioning
- Refrigerant pressures are within "expected range"
- Wiring and connections are OK, safe

In addition, some technicians may:

- Inspect filter for condition
- Clean and flush condensate drain line
- Remove debris from overflow pan, check pitch
- Inspect blower for cleanliness
- Check temperature drop across evaporator
- Inspect/repair vapor line insulation
- Confirm operation of reversing valve (heat pump)

The Air Conditioner is a “SYSTEM”

Traditionally thought of as only 4 main parts, there really are 7!

- Compressor
- Condenser
- Metering device (eg piston or TXV)
- Evaporator
- Refrigerant lines (for split systems)
- Air handler (furnace or indoor blower)
- Entire duct system from return to supply registers

THE PROBLEM WITH AIR CONDITIONING

1. It has to be installed.
   - That's where it starts to fall apart.
2. It has to be serviced.
   - That's where it gets even worse.

What might be skipped?

- Measuring airflow?
- Cleaning dirty evaporator coils and blowers?
- Inspecting the duct system for breaks & leaks?
- Measuring static pressure?
- Verifying actual delivered capacity & efficiency?
- Measuring refrigerant charge with digital accuracy?
- Adjusting charge to Superheat or Subcool?

THE ONLY TWO THINGS
You can adjust to make an
Air Conditioner PERFORM

1. **Refrigerant charge**
2. **Airflow**

…assuming it has been sized correctly

Unfortunately

50% of that equation gets ignored 99% of the time!

By doing so, the technician gives up 50% of his power to control the outcome of am A/C service call

An often overlooked fact

- It is not possible to correctly charge a system with refrigerant unless the airflow is first within range of accuracy
- Checking and adjusting the refrigerant charge of a system before verifying adequate airflow is pointless

Common enemies of airflow

- Improper duct design and construction (undersized return grills, chases, & ducts; undersized supply duct system, kinked flex duct or excess flex length)
- **Restrictive filters**
- **Closed dampers, blocked supply grills**
- **Clogged or dirty filters, coils, blowers**
- **Improper blower speed setting**

Filtration or strangulation?

Look for dumb and obvious stuff

Obstructed returns (furniture, boxes)

Squashed supply grills, covered w/ rugs

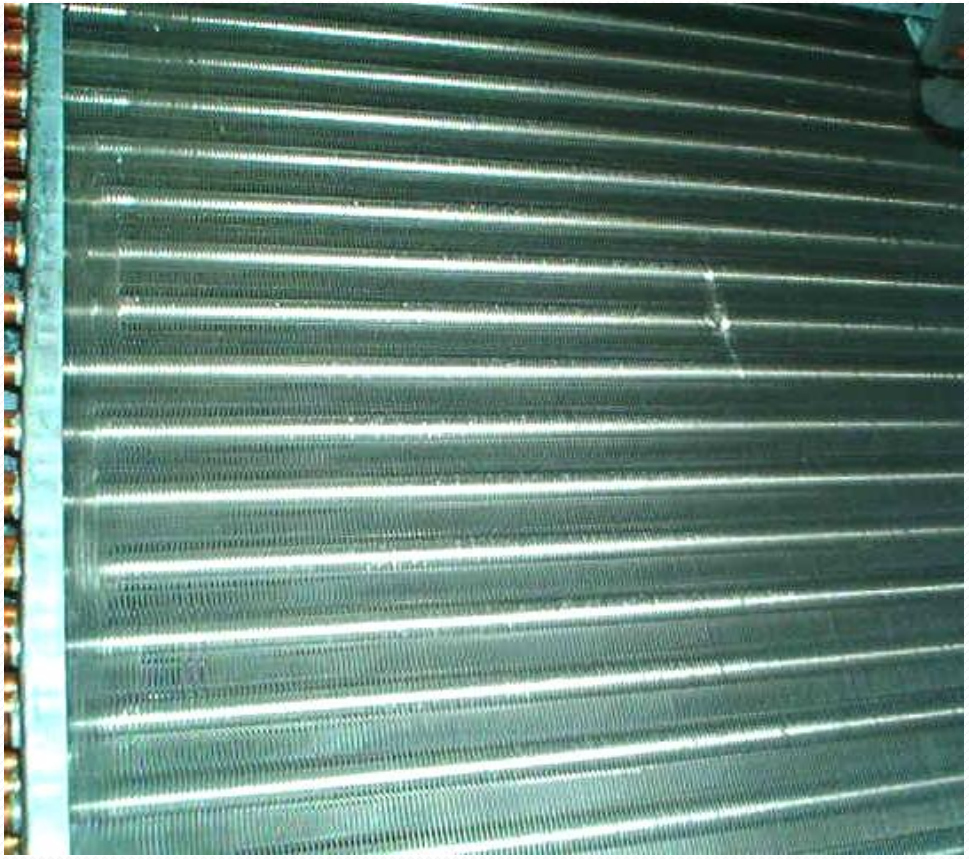
What's lurking behind that grill? Obstruction AND Indoor Air Quality issues

Coils that have not been cleaned in years (if ever)

Clean Those Coils!

Before

After



Distribution problems can defeat even the best equipment!

- Check for duct leaks, disconnects, insulation, damage
- Under-sized or restricted returns
- Restrictive, high-static filters (electrostatic or some pleated types, “permanent” filters)
- Static pressure measurements can point you in the next direction

Restricted return chase

Undersized filter grills, return chases and ducts

The “REAL” rules of thumb (Manual D condensed)

- Filter grills: 1.0 to 1.5 **sq. ft.**/ton
- Return ducts and chases: 85 to 100 **sq. in.**/ton

The Kinked Hose Syndrome

No airflow?

Gee, your ducts must be getting tired!

Have a seat and take a load off!

Aaaah! That's better!

Visual duct leakage inspection

- You can spot many serious duct leakage problems without doing a test
- “If you don’t go, you don’t know!”
- Physical damage (crushed, broken, etc.)

Mashed & Disconnected

Never been sealed with ANYTHING!

Ducts in poor condition

“Failure to communicate”

Read the signs: dirty insulation indicates return leaks Undersized return duct increases pressure on leaks.

Return leaks to attic at top plate of chase

“Gross” return chase leakage to crawl

Duct insulation inadequacies (outside of conditioned space)

- Gaps, missing, damaged
- Vapor barrier (white vinyl and paper are NOT good vapor barriers)
- Condensation damage

Possible airflow corrective measures

- Clean Blower
- Clean E-coil
- Install less restrictive filter(s)
- Clean return & supply grills
- Install larger or additional return grills
- Install larger or additional return ducts
- Repair kinked, crushed ducts
- Remove excess flex length
- Install larger or additional supply ducts & grills
- Install turning vanes
- Open dampers
- Install new E-coil
- Replace transition to coil
- Increase blower speed
- Perform duct leakage tests
- Seal return duct leaks
- Seal supply duct leaks

Verify *then* check!

- Verify that total system airflow is within + or – 10% of design (nominally 400 cfm/ton)
- THEN check refrigerant charge
- What results might we expect?
- What changes in performance, efficiency, and comfort might we expect?

Results

- **Average increase in Delivered Cooling:**

27.2%!

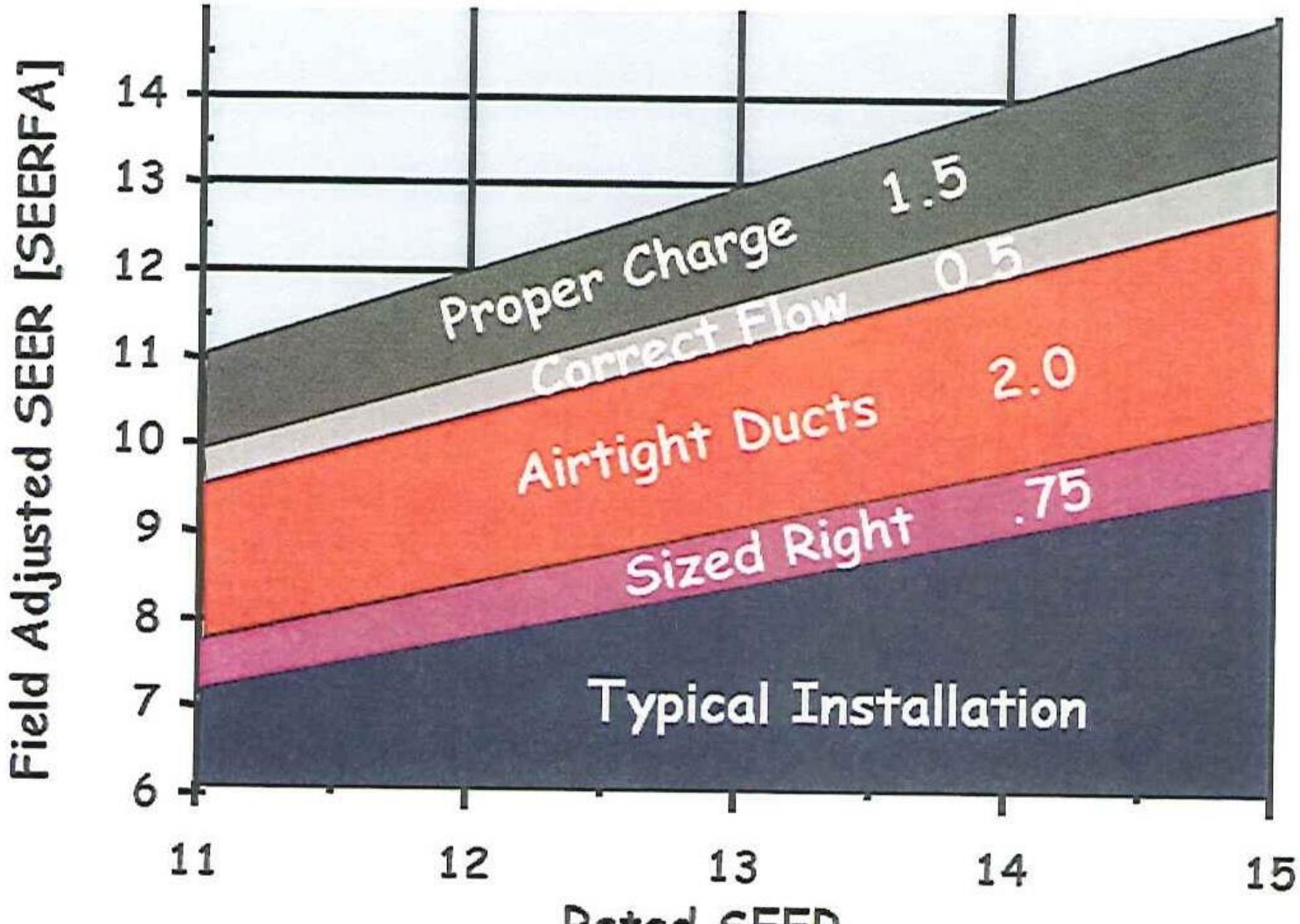
- **Hundreds of $ savings per system**
- **Often less than a 1- year payback per system**
- **Less trouble-calls and maintenance costs**
- **Fewer replaced parts**
- **Less “Guessing;” Get it right the first time!**

Wake-up call

- **Many of these have been regularly "maintained" by the industry!**
- **How can this happen?**

ENERGY STAR INDOOR AIR PACKAGE

HVAC BEST PRACTICE INSTALLATION



BENEFITS TO YOU AND YOUR CUSTOMER

- Enhanced **customer services**
- Additional **revenue stream**
- Additional **work for Off-peak seasons**
- **Identify problems** that can bite you!
- **Fewer callbacks**
- **Differentiation** in the Marketplace
- **Become a** “Participating Contractor”
- Offer Utility Coupons to **help them buy it!**

So, what can we do?

1. **Verify airflow:** digital vane anemometer or other airflow measurement device
2. **Verify static pressure** is within range
3. **Visual inspection of duct inadequacies**
4. **Measure** return and supply wet-bulb and dry-bulb, **calculate delivered capacity,** compare to rated capacity
5. **Recommend corrective actions**
6. **Recommend digital refrigerant gauges** be used for better accuracy

Necessary Toolkit

1. **Large Vane Anemometer for system air flow**
2. **Pocket manometer for static pressure**
3. **Video scope to check ducts and coils**
4. **Humidity sticks to calculate delivered capacity**
5. **Digital refrigerant gauges** to adjust charge as needed
6. Assorted hoses and probes to “get ‘er done”
7. Advanced testing: Electric Current

- Issues:
  - Lousy tools
  - Lack of target measurements
  - Lack of understanding of what is being ,measured and how to measure

Digital Vane Anemometer for measuring airflow in CFM

Traverse of return grill

Digital Manometer for measuring Static Pressure / estimate airflow

Digital RSA

- **Digital refrigeration system analyzer**
  - Plus- or Minus 0.5% accuracy
  - Measures to 0.1 Psig and 0.1 degree Fahrenheit
  - Calculates Superheat, Subcool to 0.1 degree
  - Programmed-in charts for 30 refrigerants
  - Displays Evaporator and Condenser saturation temperatures

Checking static pressure

Videoscopes

for inspecting coils and blowers

The “Humidity Stick”

- Dry-bulb & wet-bulb temps of Return & Supply Air
- Also fast response for OutDoor Air Temperature
- Used in capacity calculation

Advanced- Checking volts and amps

Best Practices

- **3 step process**
  - **Test in**
  - **ID problems & repair**
  - **Test out**

Calculating Equipment Capacity

1. Measure
   - CFM
   - Entering and leaving wet bulb
2. Find change in enthalpy (Δh)
3. Capacity calculation
   - BTUh = 4.5 x CFM x Δh***
   - Tons = BTUh/12,000

***Adjust the constant if outside of standard air!!!

Calculating Delivered Capacity from 3 measurements

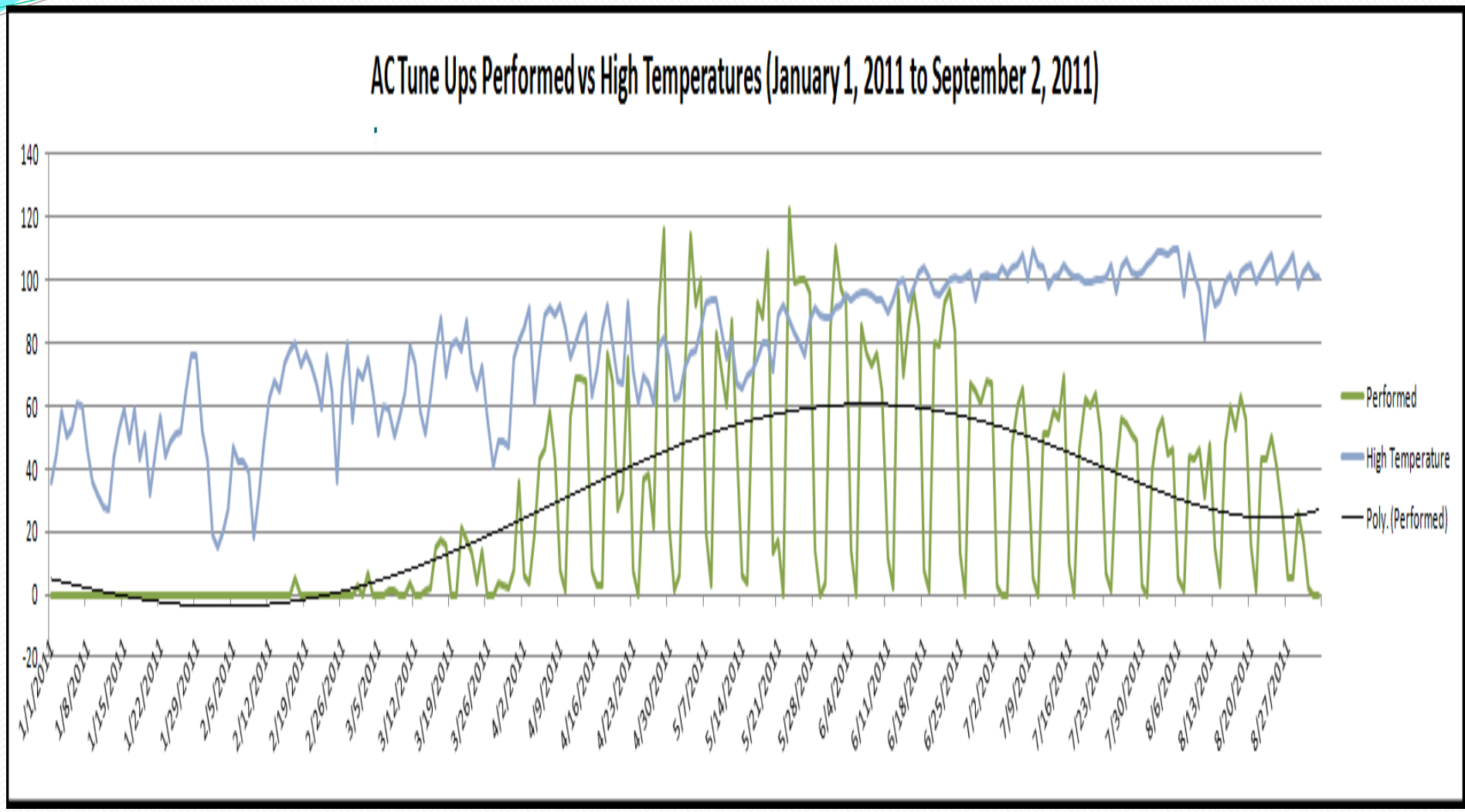
- Return: WB°F; look-up enthalpy (h) from chart.
- Return Enthalpy:_____
  Supply: WB°F; look-up enthalpy (h) from chart. Sup. Enthalpy: _____ Δh =_____
- BTUh output = 4.5 x measured CFM x Δh;
- BTUh = 4.5 x ____ CFM* x _____ Δh = _____
- Delivered Percentage of Rated Capacity:
- Delivered BTUh / Rated BTUh x 100 = _____ %

System Performance

- Performance cannot be assumed!!!
  - Performance varies with load conditions
  - Equipment performance does not assure delivered performance
  - Systems are field installed and require a field commissioning procedure
- Efficiency and performance go hand in hand
- Opportunity to improve system efficiency and capacity

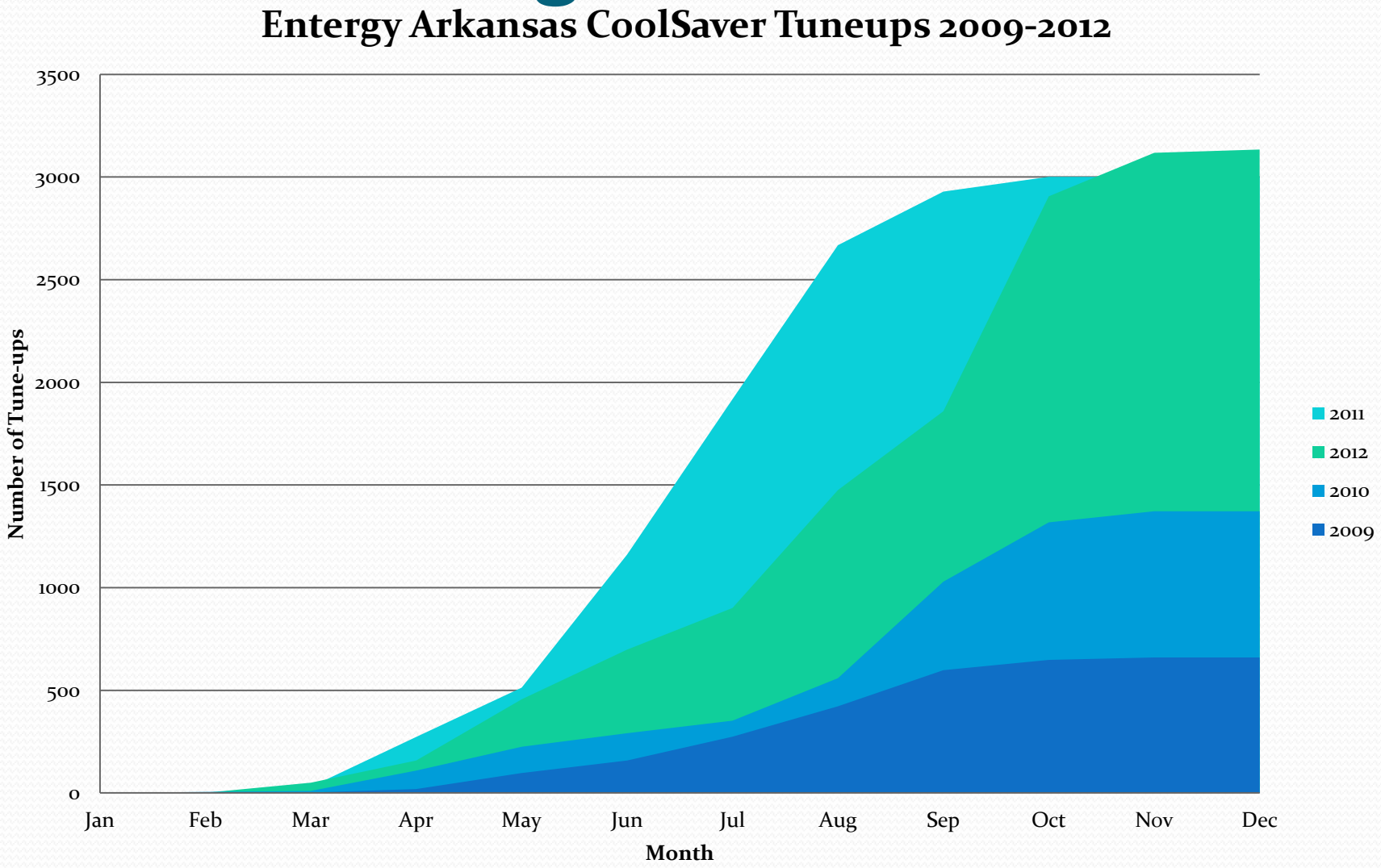
THEN…

Using the information to diagnose problems and make wise choices



Tune-ups (Green) decreased as daily high temps (Blue) increased (OG&E HEEP Program, implemented by CLEAResult; 2011)

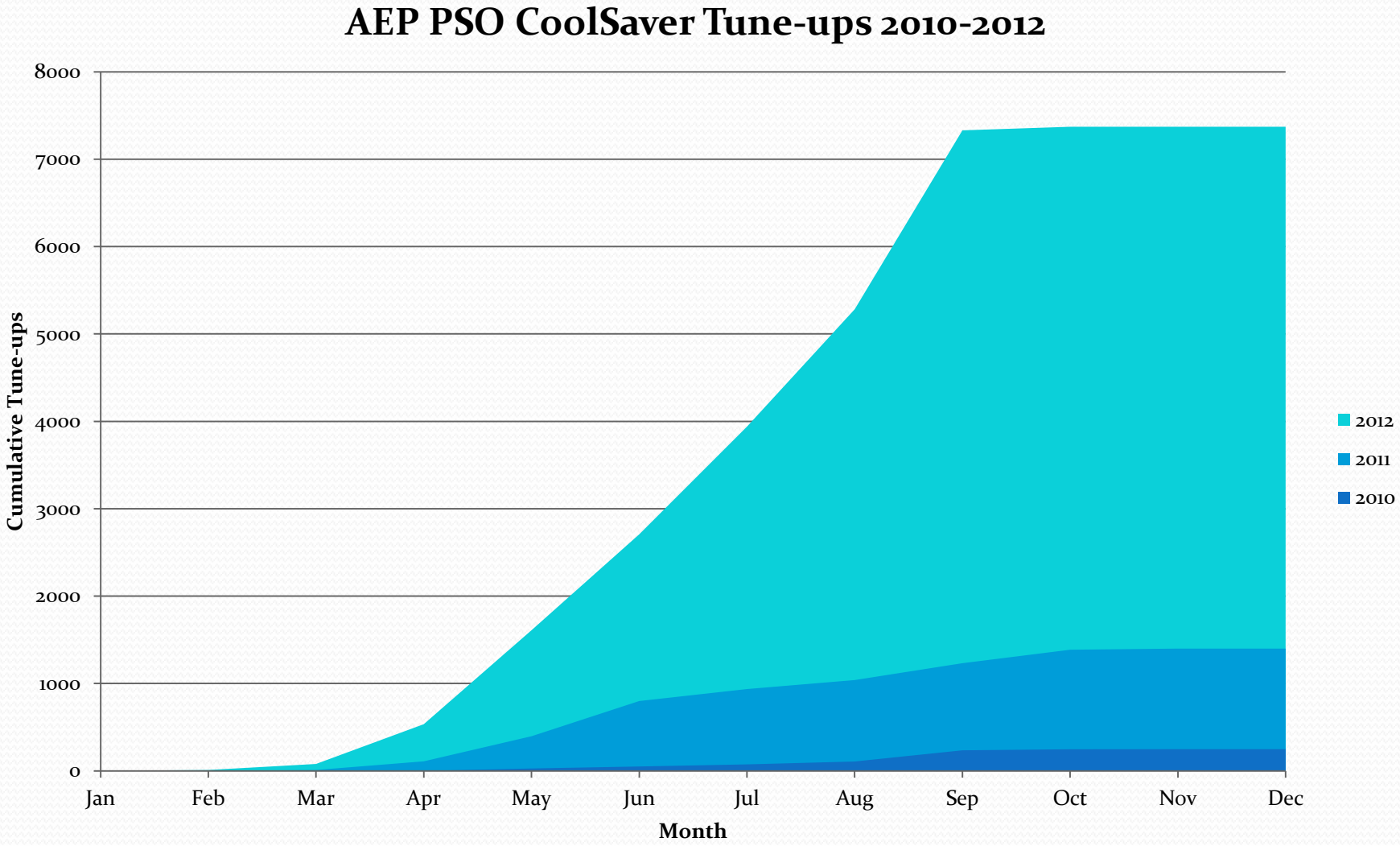
CoolSaver Program Growth - AR



Entergy Arkansas CoolSaver 2012 Results

- 3101 Tune-ups
- 1602 kW Peak reduction
- 3,339,776 kWh savings
- $453,820 incentives paid

CoolSaver Program Growth - OK

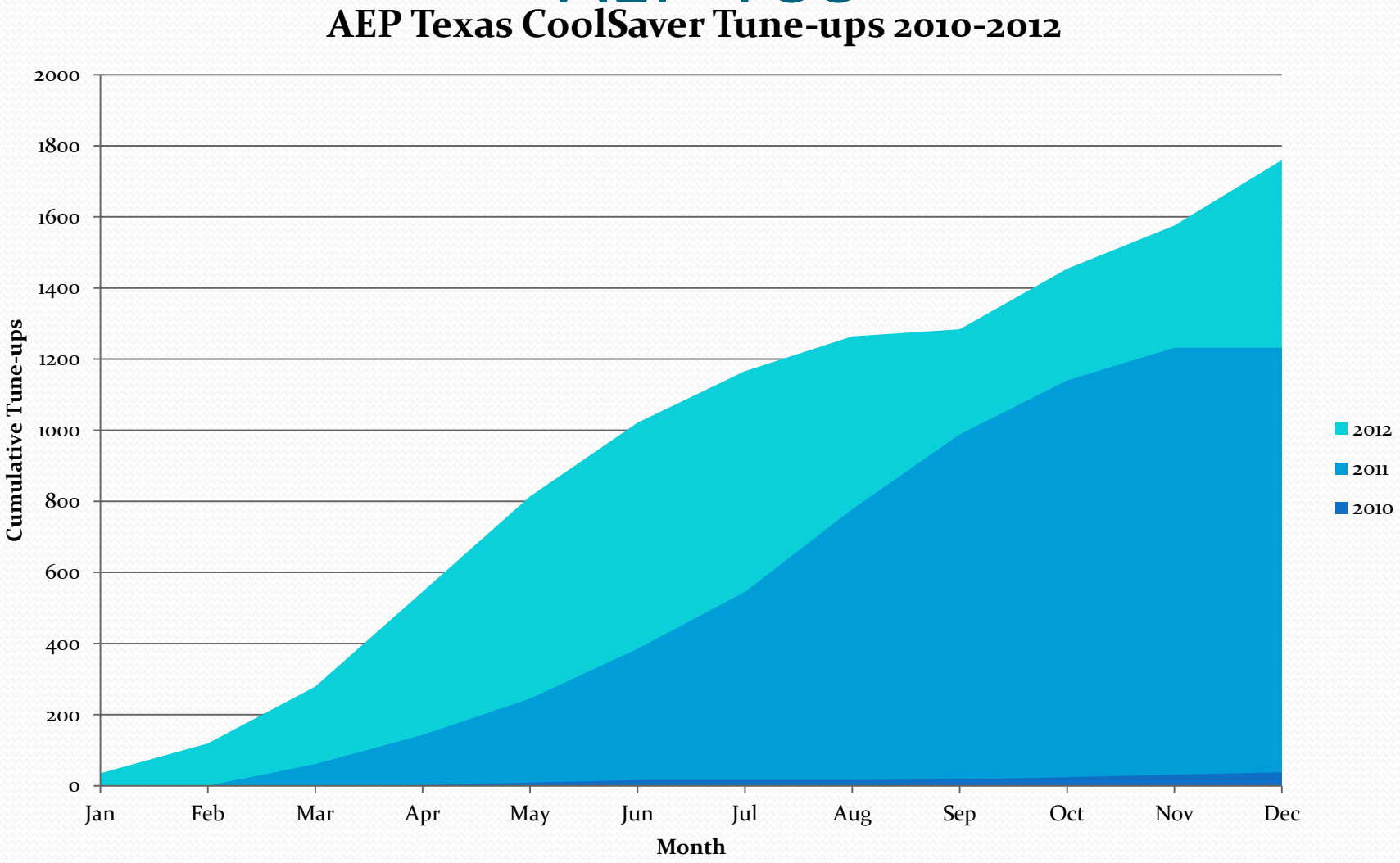


AEP-PSO CoolSaver 2011 Results

- 7371 Tuneups
- 2,986 kW Peak reduction
- 4,991,931 kWh savings
- $1,289,925 incentives paid

CoolSaver Program Growth Texas

AEP-TCC



AEP-TCC CoolSaver 2011 Results

- 1765 Tuneups
- 654 kW Peak reduction
- 1,025,345 kWh savings
- $245,600 incentives paid

Now…

How do you turn this into a new profit center in your business?

The Status Quo, Rights and Wrongs

- Historically measurements were not made due to expense and time
- Also, until the last 5 years, good measurements were hard to make, usually done in lab
- Bad measurements were made and did not yield results and measurements were abandoned
- A resurgence of good measurements, now in the field, is under way!

INGREDIENTS of a Successful program

- *AND– it doesn't happen by itself!*
- Interested customers
- Active program sponsor: Utility or state (or local) energy office (municipals, co-ops, etc.)
- Interested contractors
  - Business training
  - Mindset change
  - Technical Training
  - Proper tools

What makes the difference

- A standard tune-up procedure
- Training, mentoring, right tools
- A responsive support structure and process

Contractor Success stories

- Higher customer satisfaction
- Better profits
- Excited technicians
- Better reputation
- More confidence from equipment manufacturers
- More confidence from technicians
- Improved reputation
- Business Impact for contractors and Utilities
- Program feedback and business model changes

CONCLUSIONS:

- So Therefore….
- Training needed - contractors don’t know what they should know
- Business model changes

Consequences

- If you don't LOOK - MEASURE - ID the PROBLEM
- Manufacturers and distributors can avoid a black eye for poor quality that they are NOT responsible
- What would the world be like if 100,000 systems were improved, a million, 5 million, 100 million?