The A/C Tune-up:

How to Evaluate and Optimize Peak Performance

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&
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TruTech Tools

- Experienced professionals delivering CEU training to the HVAC and related trades
- 45+ years combined experience
- Practical, related and hands-on training
- Earn while you Learn
  - BPI Recognized CEUs

“Quality comes not from inspection but from improvement of the process.”
W. Edwards Deming

There are no theories in HVAC/R!

- Air conditioning founded on scientific facts
  - Repeatable
  - Universal
  - Well proven
  - Understandable
  - Provable
  - And you can do it!
- Measurements are made to prove facts

Science

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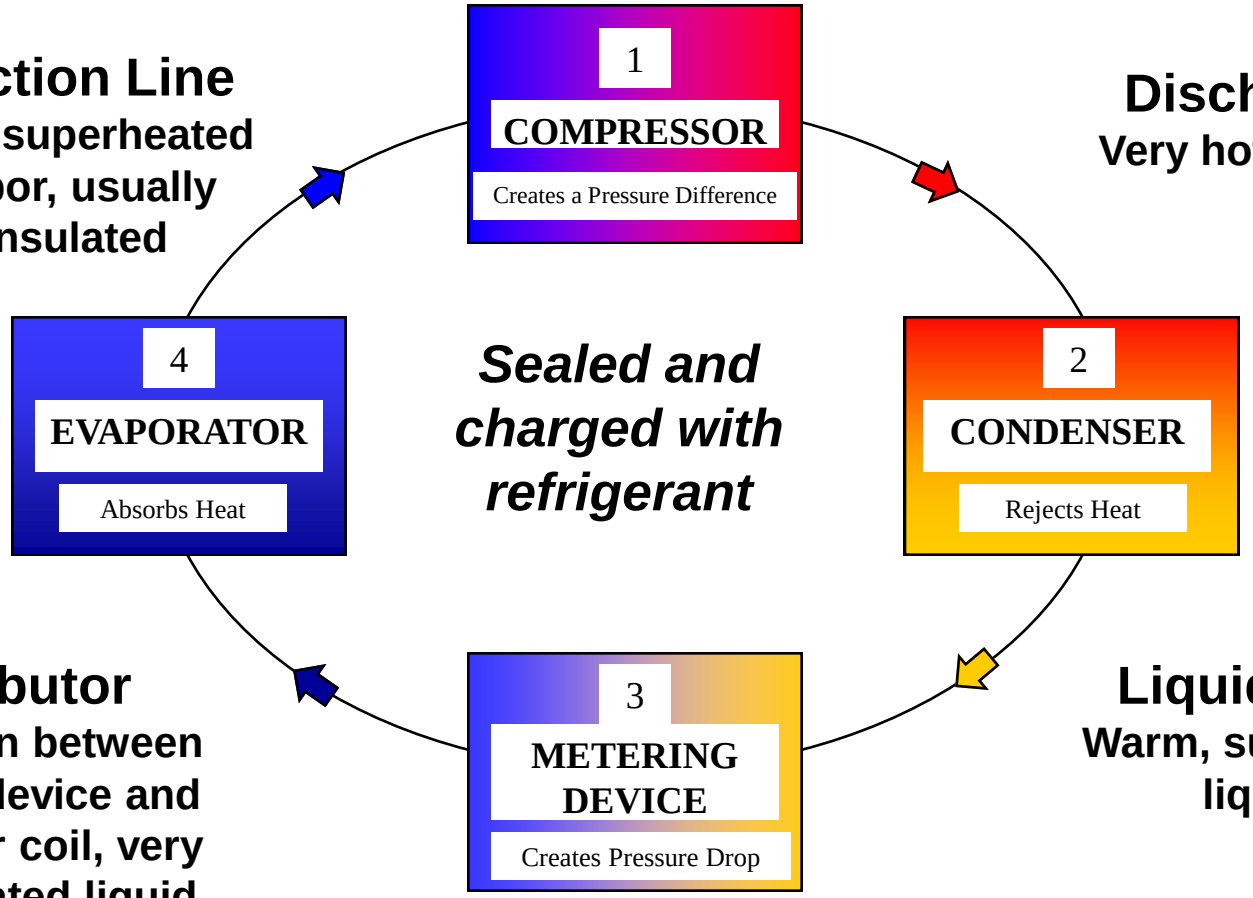
The only two problems with air conditioning systems

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.

The Basic Refrigeration System



Suction Line
Cool superheated vapor, usually insulated

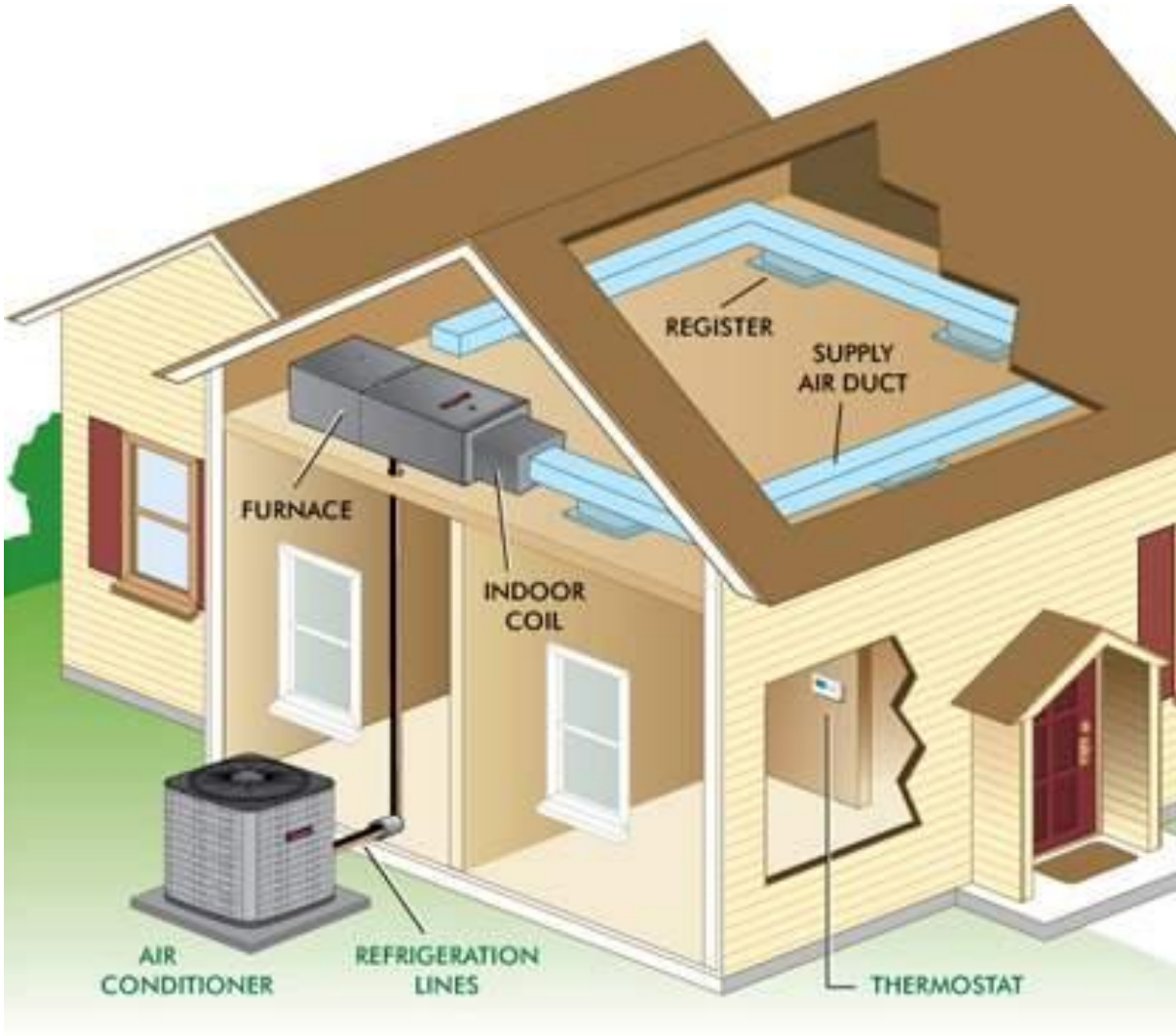
Discharge Line
Very hot superheated vapor

Distributor
Connection between metering device and evaporator coil, very cold saturated liquid.

Liquid Line
Warm, subcooled liquid

A/C SYSTEM

- Condenser
- Evaporator
- Refrigerant lines (split systems, not package unit)
- Air handler (furnace or indoor blower)
- Entire duct system from return to supply registers
- Building/loads



Air Conditioning

When was the last time you quantified how much you *conditioned* the air?

- Temperature drop won't tell you……
- Electrical measurements won't tell you…..
- Gauge pressures won't tell you……
- Superheat and sub-cooling won't tell you….

Yet that is what technicians measure to quantify performance!

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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.

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Energy Star on proper charge.

Refrigerant Charge

- **Essential to maintain capacity**
  - **Improper charge can lead to premature compressor failure**
  - **– Up to 41% systems undercharged, 33% overcharged**
  - **– Average savings of 12.1% with proper charge**
  - **Charge is adjusted by the technician in accordance with manufacturer's instructions**
  - **Systems with more than ±3° deviation in subcooling or manufacturer's spec would not qualify**

74% of systems have improper charge

Up to 41% systems undercharged, 33% overcharged

Energy Star on Air Flow

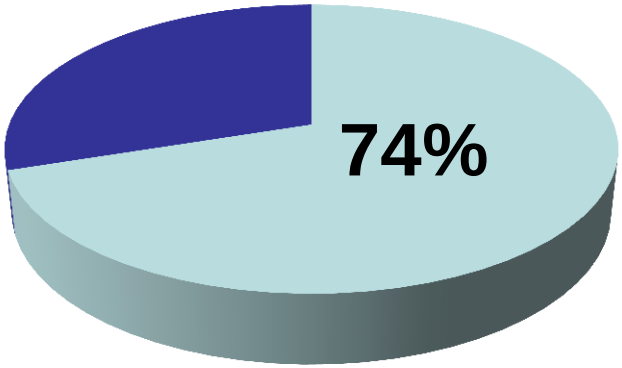
- Essential for comfort
  - 70% of systems tested are operating at less than 350 cfm/ton (ideal is 400 cfm/ton)
  - Annual savings of 8% possible
- Technician verifies system is flowing at 400 cfm/ton (or cfm specified by manufacturer) during full-speed testing
  - Systems incapable of 350 cfm/ton or greater must be corrected by improving ducts or would not qualify

70% of systems have improper airflow

California PUC analysis of 13,000 residential and commercial units

- Most off by ½ to 5 pounds of refrigerant
- A/C units off by more than 8 ounces will potentially fail within 5 years
- In cap tube or short orifice systems even one or two ounces can have a serious impact on performance

Units incorrectly charged



74% of systems are improperly charged

Causes
- Improperly calibrated measurement equipment
- Human errors during commissioning

SOURCE: The California refrigerant and airflow verification program

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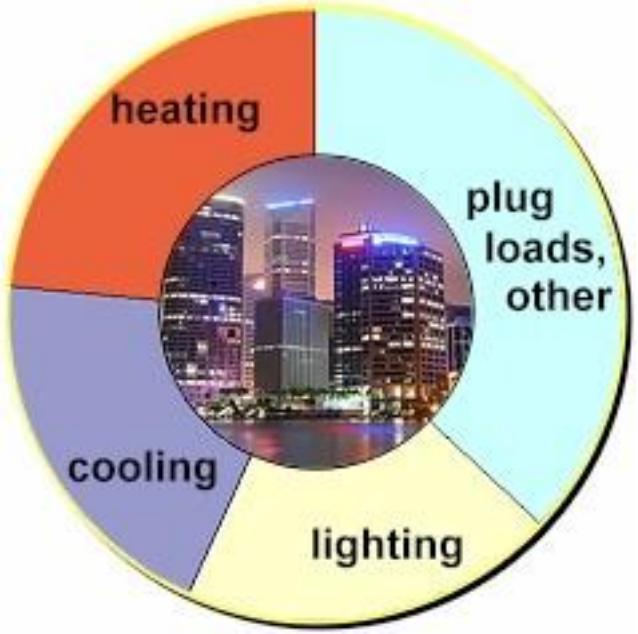
Advanced Energy of North Carolina Study On New Heating & Cooling Units

- 90% of all units tested exhibited some sort of energy waste problem
- 50% of all installations had an improper refrigerant charge
- 40% failed to meet the minimum requirements for air flow standards
- A 20% reduction in air flow will reduce SEER about 17% (12/9, 14/9, 18/14)
- A 15% return air leak from 120 degree attic will easily reduce a 12 SEER TO 6 SEER



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APS

Arizona Public Service Company

- Improvements to duct leakage and insulation can save 16% on cooling cost
- Properly insulated ducts and efficient units can reduce cooling usage by 42%
- 64% of units tested had air flow less than 350 CFM per ton (Ideal CFM is 400)
- 82% were improperly charged (average improper charge reduces efficiency 31%)
- Installation technicians frequently do not evacuate a system properly with Micron Gauges *(and proper technique, etc.)*
- 53% of units tested were oversized causing wear and tear, and thus higher energy costs

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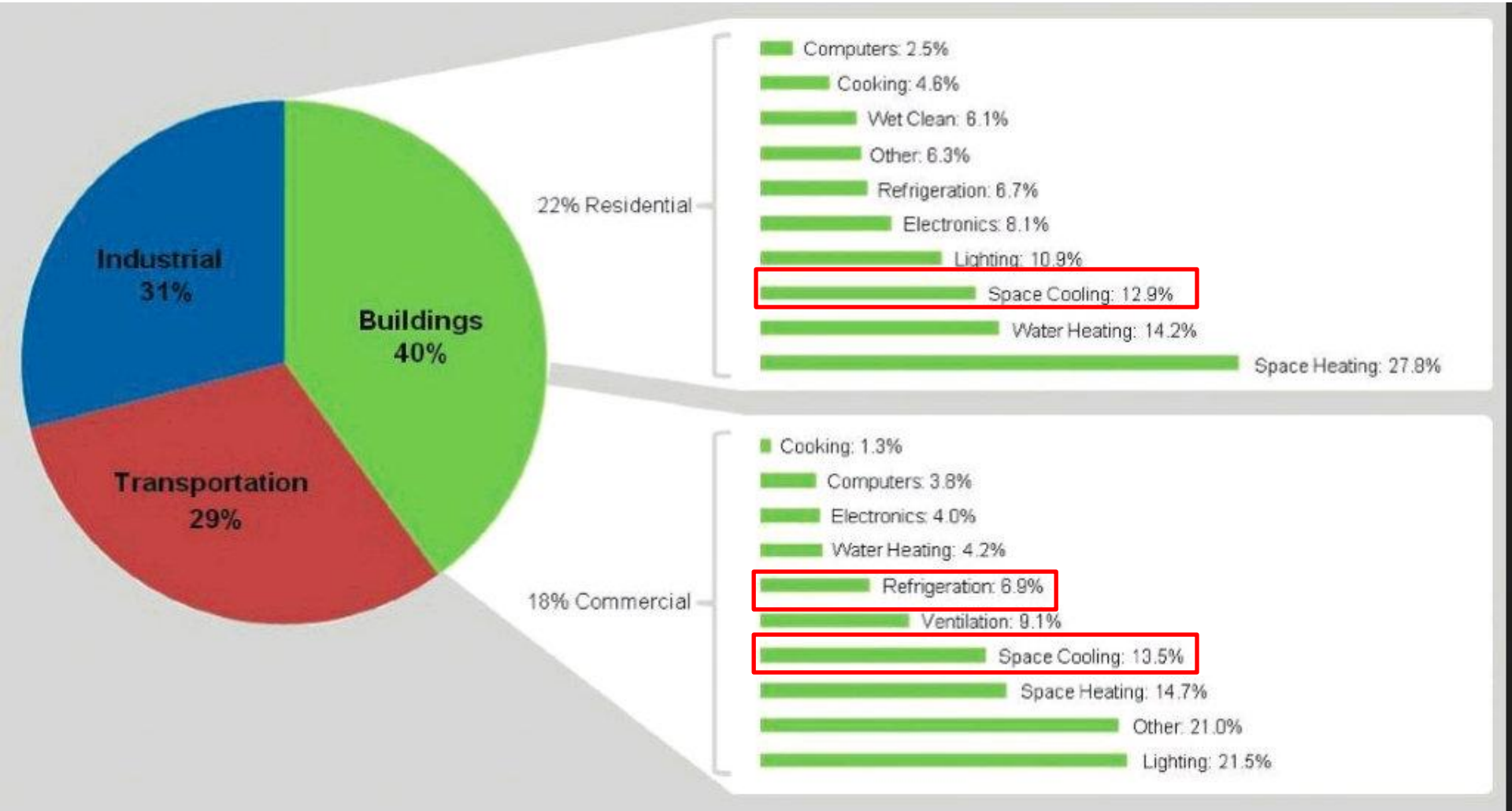
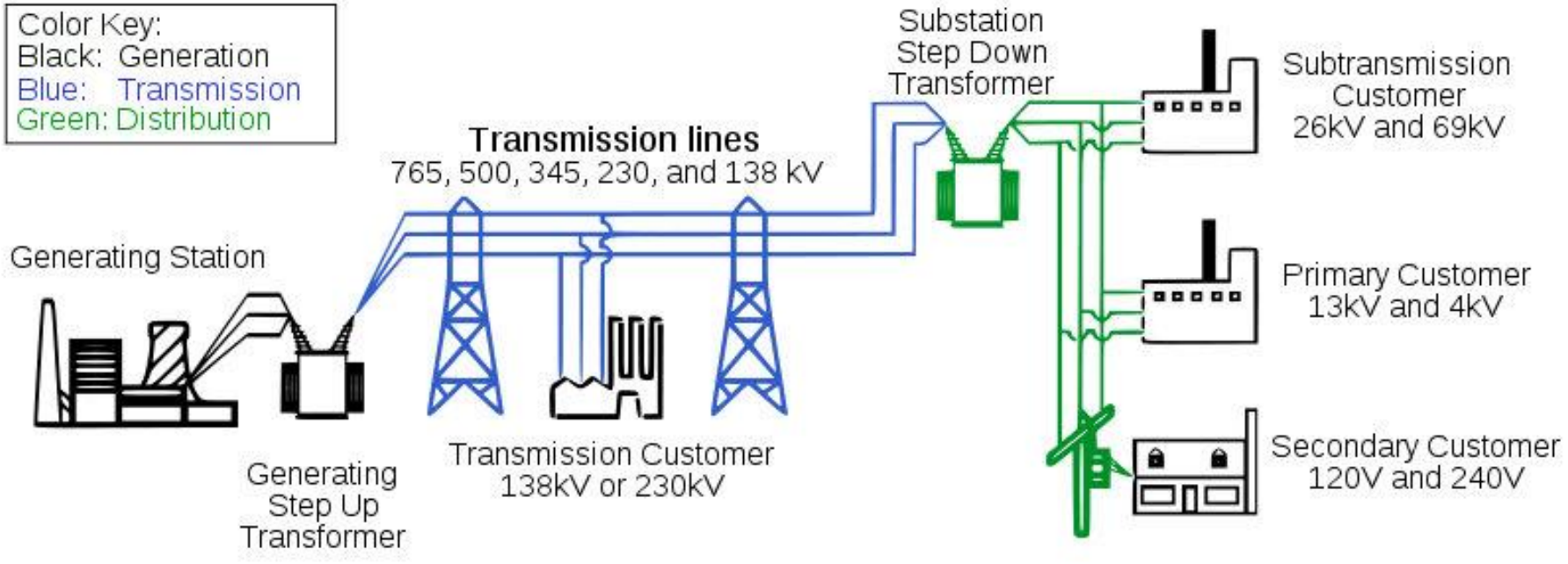
WHY????

The FORTY PERCENTERS



Electrical generation efficiency ~ 30%

- ~ 3 times savings upstream
  - Fewer power plants ($, ROI)
  - Lower fuel consumption (non-nuclear)
  - Lower stack emissions



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!

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!

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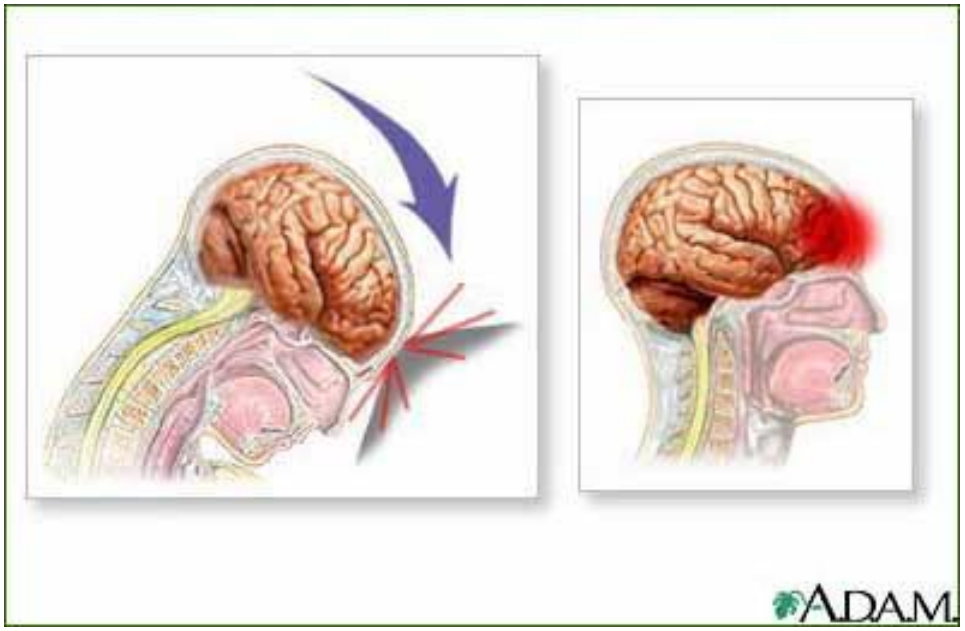
Insanity: Doing the same thing over and over, each time expecting a different result.



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Why do we keep missing the mark???

- Our test instruments and techniques do not measure up
  - We can't get "factory accurate" results.
  - We cannot trust our tools

Tech after tech should get the same measurements and results….

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So, what can we do?

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

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THEN…

Using the information to diagnose problems and make wise choices

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POP Quiz

What are the ONLY adjustable parameters or settings in a standard air conditioning system?

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Answer!!!

1. **Airflow**
2. **Refrigerant Charge**

You cannot adjust

- Voltage
- Amperage
- Temperature drop
- Temperature rise
- Pressure drops across filters or coils
- Capacity
- Efficiency

These are all a function of the load

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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 his visit

The $1,000,000 Question is…

WHY????

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04/20/2006

Wake-up call

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

What might be skipped?

- Measuring airflow?
- Cleaning dirty e-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 correct Superheat or Subcooling?

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Matched components:

–Systems must be listed in the ARI directory

Increased importance of charging:

–Proper charge is imperative to get guaranteed energy efficiency, capacity, and system reliability.

–A few ounces of refrigerant changes everything!!!!!

Critical airflows:

–Airflow directly effects efficiency, capacity, and creature comfort.

–Proper airflow across the evaporator is critical to achieve efficiency ratings.

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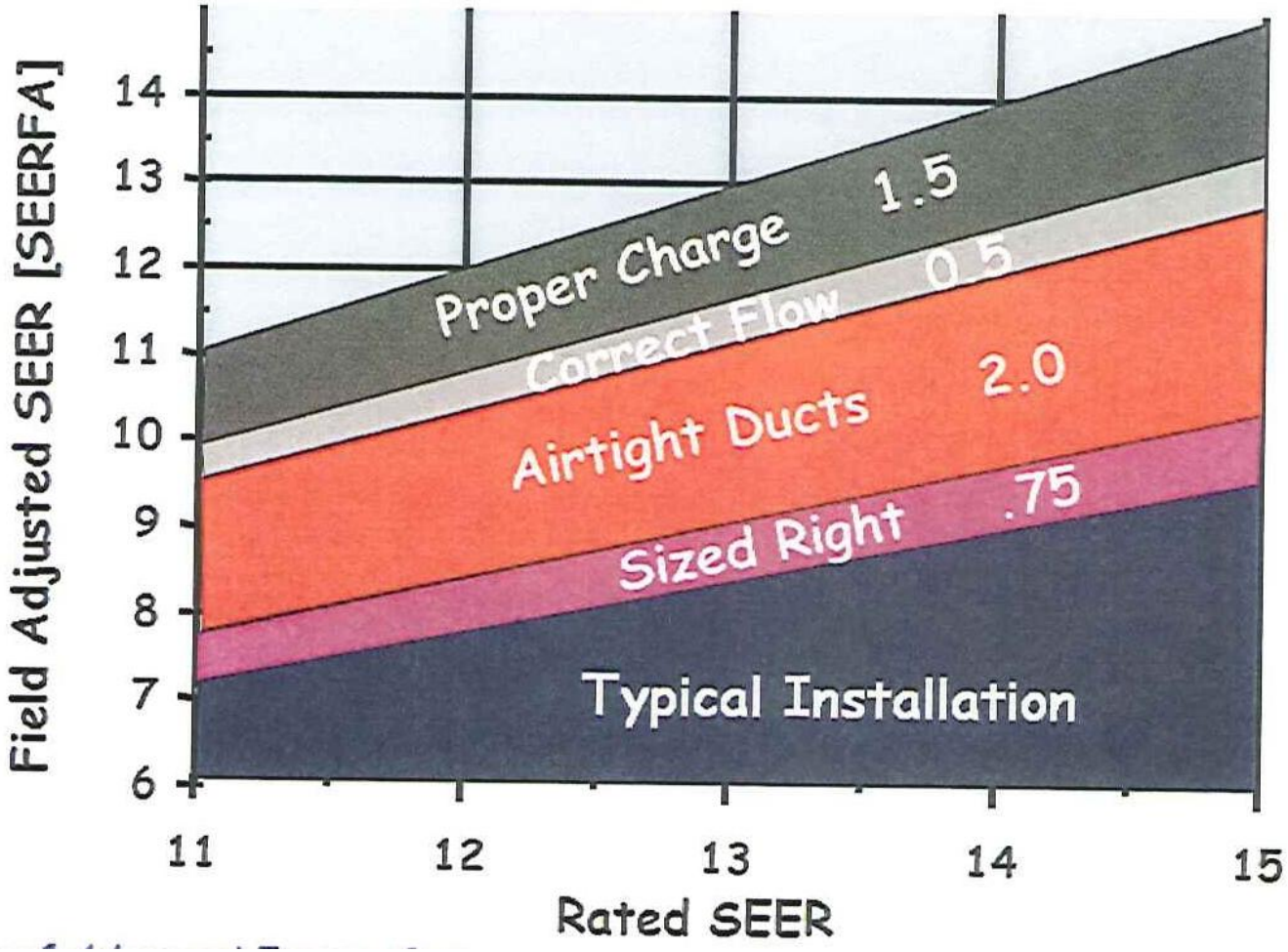
System Performance

- 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

ENERGY STAR INDOOR AIR PACKAGE

HVAC BEST PRACTICE INSTALLATION

ENERGY STAR



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"

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THE AC-TUNE-UP

- Includes the entire system
- Focusing on:
  - Proper airflow
  - Correct refrigerant charge
  - Delivering conditioned air
- Ultimately proper AIR CONDITIONING
  - By quantifying performance

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Sample of 59 Hi-Perf. tune-ups at Arkansas State University

- 50 tons of additional delivered capacity
- 28% average increase in delivered capacity from Pre- to Post
- Total increase of 21% of **rated** capacity
- Typical Actions taken:
  - Clean condenser
  - Clean evaporator coil and blower
  - Change filter as needed
  - Adjust refrigerant as needed

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Typical 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!**

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Results

- **Average reduction of 0.127 kW/ton in peak demand (res. & comm.)**
- **(99% confidence from a 7500-TU sample)**
- **Average of 500 – 1500 kwh savings annually (A/Cs only; Heat pumps higher)**

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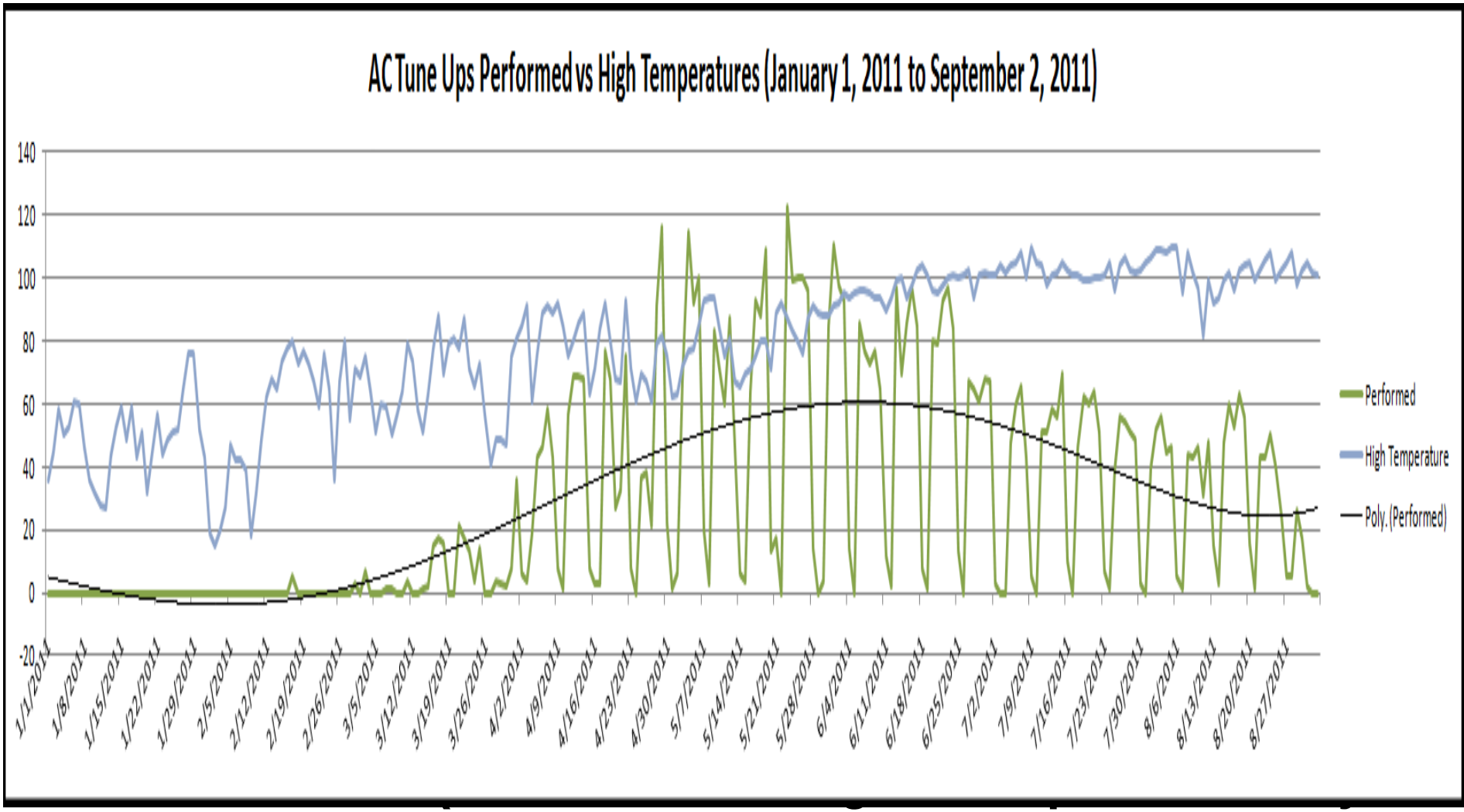
Understanding the Tune-Up



CLEAResult; 2011)

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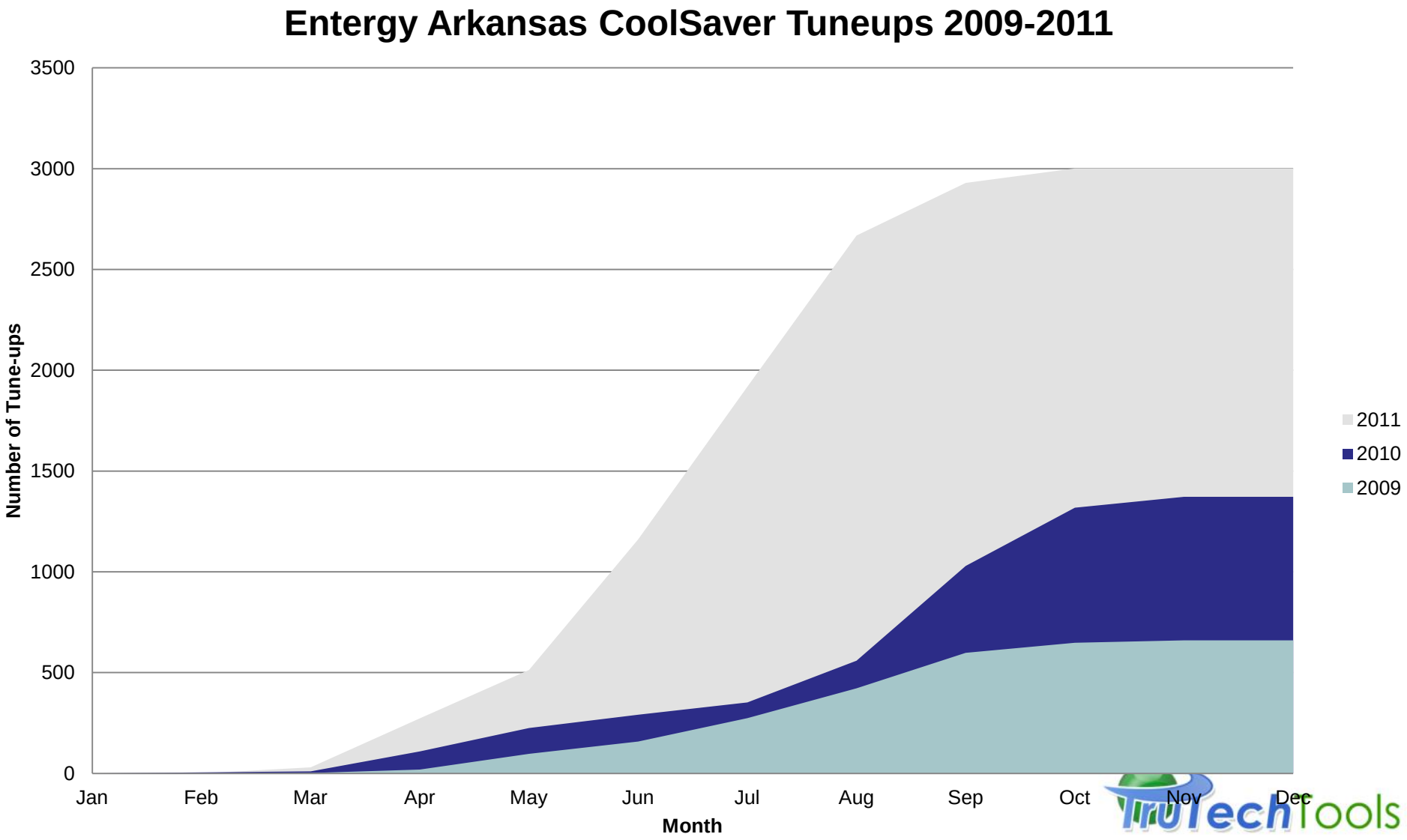
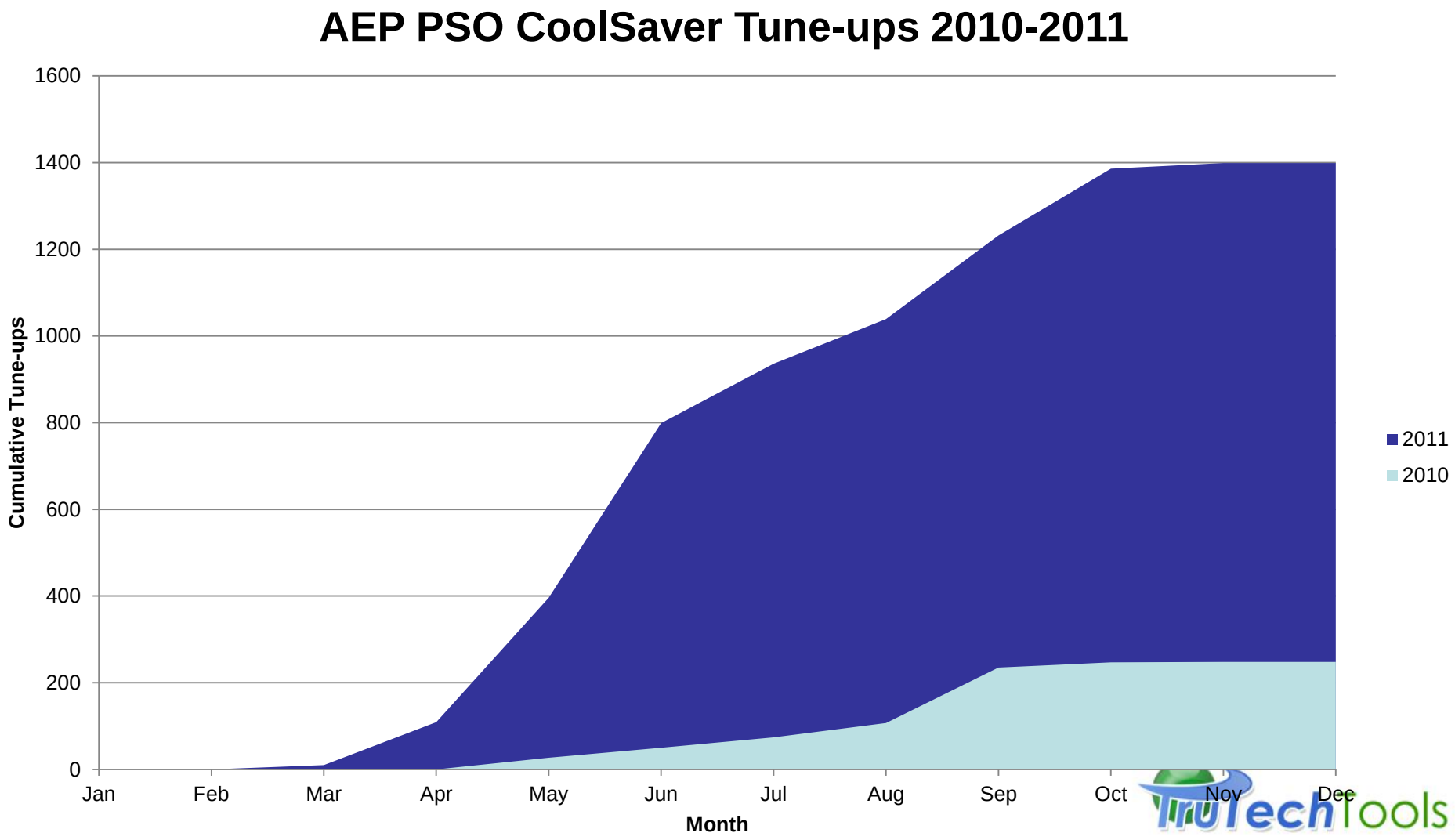
CoolSaver Program Growth - AR



Entergy Arkansas CoolSaver 2011 Results

- 3011 Tuneups
- 1112 kW Peak reduction
- 1,750,000 kWh savings
- $426,575 incentives paid

CoolSaver Program Growth - OK

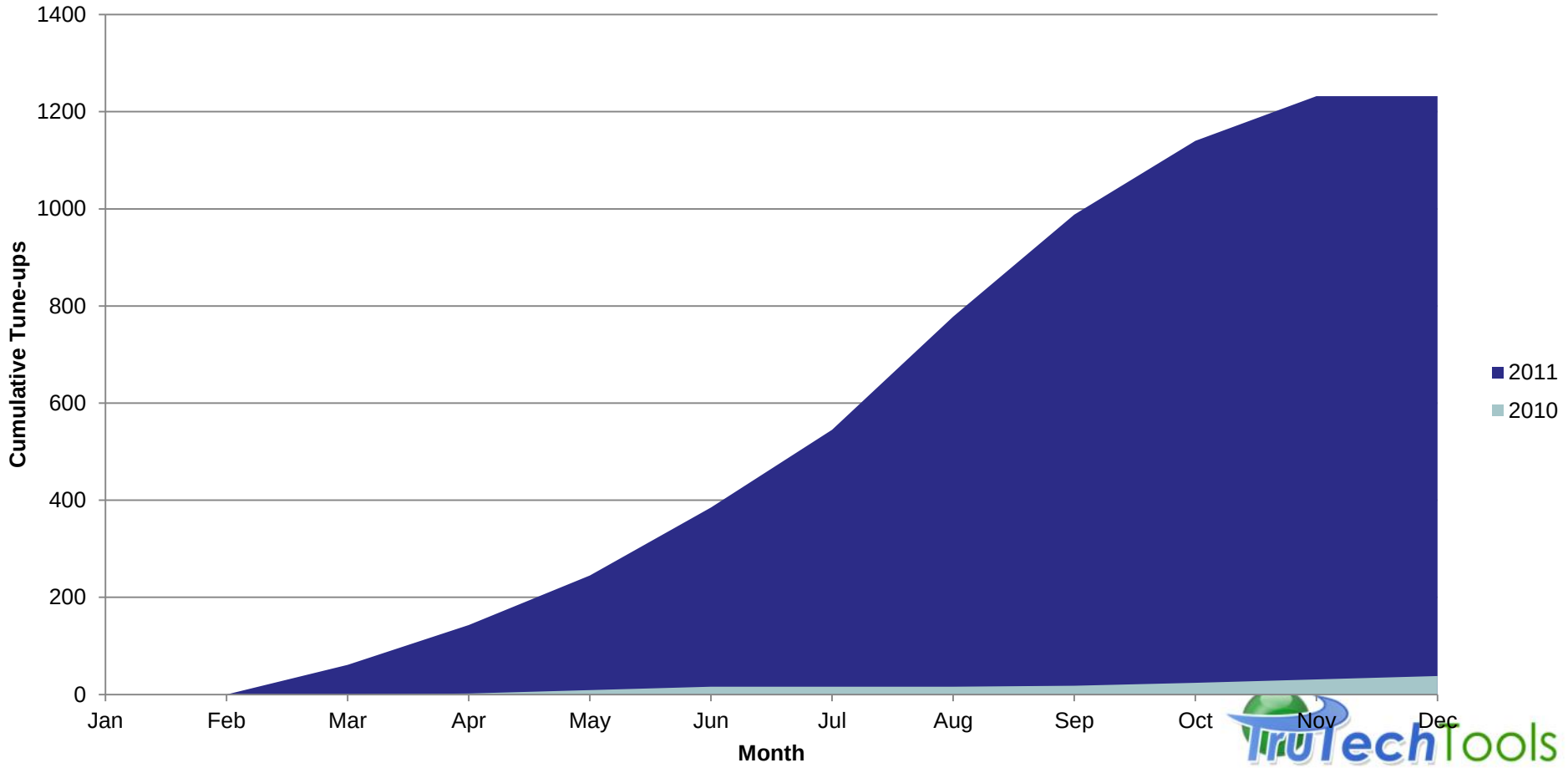


AEP-PSO CoolSaver 2011 Results

- 1417 Tuneups
- 820 kW Peak reduction
- 1,219,755 kWh savings
- $185,825 incentives paid

CoolSaver Program Growth
Texas
AEP-TCC

CoolSaver



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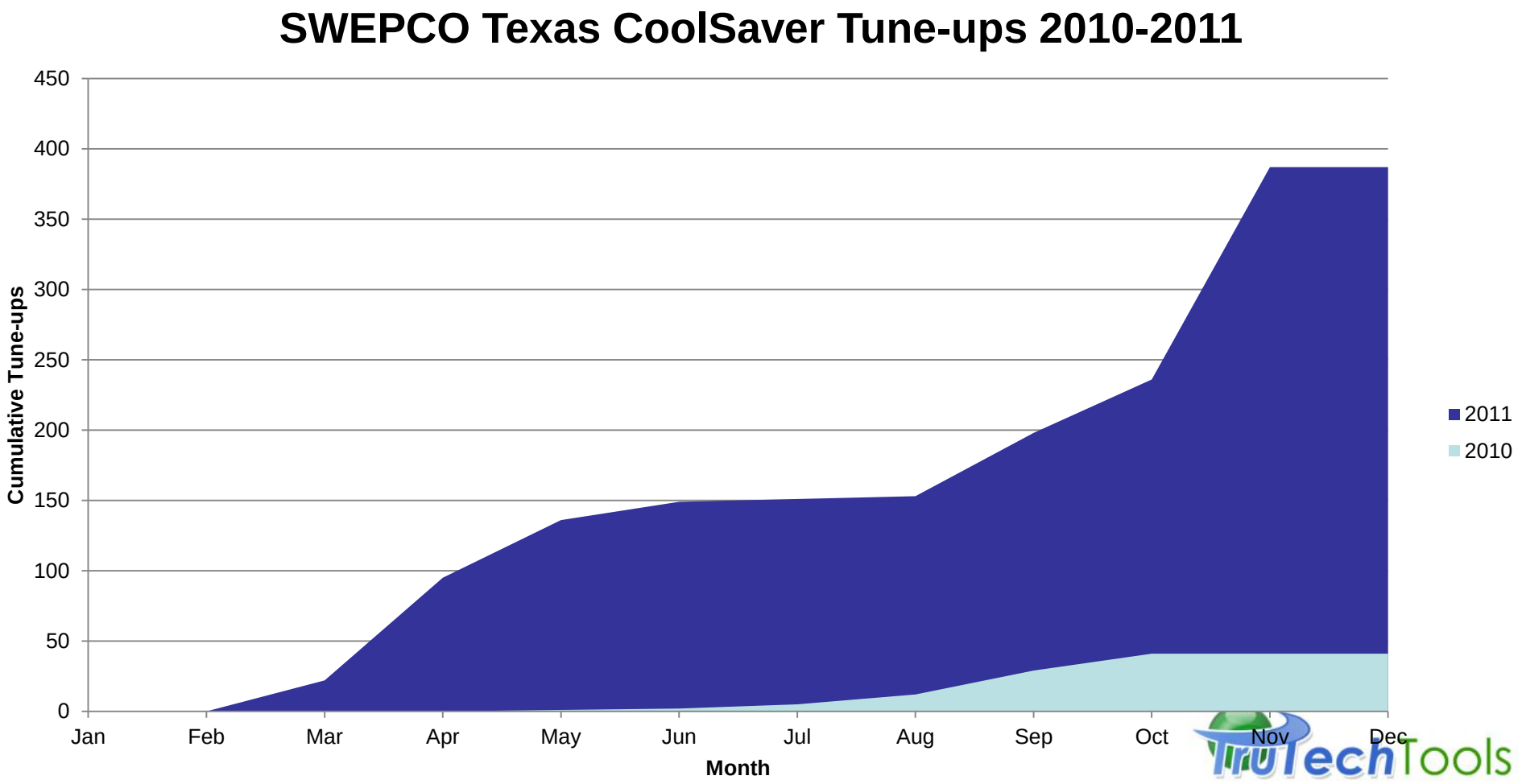
AEP-TCC CoolSaver 2011 Results

- 1247 Tuneups
- 570 kW Peak reduction
- 1,431,018 kWh savings
- $173,175 incentives paid

CoolSaver Program Growth
SWEPCO-TX



CoolSaver

AEP-SWEPCO-TX CoolSaver 2011 Results

- 392 Tuneups
- 152 kW Peak reduction
- 305,859 kWh savings
- $46,875 incentives paid

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CoolSaver

Total results for all 4 programs (2011)

- 6,067 Tuneups
- 2.67 MW Peak reduction
- 2,969,755 kWh savings
- $832,450 incentives paid

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Now…

How do we turn this into a new profit center in our business?

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

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What makes the difference

- Experienced Energy Services Company (ESCO)
  - A thorough, customized process
  - The glue that holds it all together and makes the program happen
  - A responsive support structure and process

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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

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CONCLUSIONS:

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

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Consequences

- If you don't LOOK - MEASURE - ID PROBLEM
  - You might as well leave the scene before you commit a crime!
- Manufacturers and distributors can avoid a black eye for poor quality that they are NOT responsible for
- What would the world be like if systems were improved, a mill million, 100 million?

Resources & Contacts

www.TruTechTools.com/Training

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