Assessment Techniques for Evaluating Black Boxes Technologies

Techniques for Evaluating Vendor Claims

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October 1, 2012

What is a “Black Box”

A device whose inner workings or capabilities are

- difficult to explain
- complicated, or
- otherwise not obvious

Example: Airplane data recorders

Example: Communications technologies

BLACK BOX®
NETWORK SERVICES

Why the "black box" moniker for some Retrofit Energy Saving Devices?

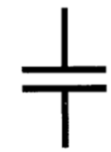
- The reasons vary:
  - Multiple technologies: Rather than just one of the passive one of the passive technologies, these devices often contain two or more
  - Unique configurations: The electrical configuration of these components is often unique or even patented
  - Unique packaging: The technologies are often contained in sealed (or even potted) packages.
  - Unique claims: Performance claims can be extraordinary, and often beyond those made by manufacturers of similar technologies
  - Source of performance: The performance of the device is often attributed not to the individual components, but to the *special* configuration
  - Unexplained performance: "We don't really know how the technology works."

Common Claims for Energy Saving Black Boxes

- Improved power factor
- Reduced harmonics
- Improved voltage imbalance
- Reduced electrical current levels
- Cooler device operation
- Prolonged motor and other device life
- Improved voltage level (higher or lower)
- Improved energy efficiency, often at extraordinary levels:
  - 10%
  - 20%
  - Even 30% or more

Retrofit Energy-Saving Devices
What are they?

- Typically incorporate common, passive electrical sub-devices
  - Capacitors (Var support, power factor correction)



  - Inductors/chokes/reactors (Dampening of fast current pulses)

  - TVSS: Metal-Oxide Varistors (MOVs, lightning/transient protection)
  - TVSS: Gas tubes (lightning/transient protection)

- A few devices, such as PF Controllers and motor soft starters, are “active”
- Most often pre-packaged, modular systems that are easily added to existing facility electrical systems (i.e. low installation cost, minimal down time)
- Other devices are as simple as a magnet, rectifier, or even a piece of metal

These technologies are common in Industry
Inductors / Chokes / Reactors

MTE® CORPORATION

Guard-Ac PLUS

Guard-AC™ PLUS combines the benefits of reactor and MOV (metal-oxide varistor) technology to provide enhanced surge/spike protection for variable speed drive/inverter applications.

Use this product on the input side of variable speed controllers to offer protection from power line spikes, voltage transients and even to help reduce the effects of lightning.

Guard-AC™ PLUS is factory assembled and prewired. Simply connect three incoming and three outgoing conductors, and make connection to ground.

The reactor portion of this network absorbs current surges, while the MOV portion clamps voltage spikes to acceptable levels. They combine to offer the optimum in electronic controller circuit protection. The reactor even helps to extend MOV life by reducing the energy content of spikes prior to reaching the MOV module.

Three phase MOV modules contain high energy rated MOV's offering protection from the most common transient voltage spikes. Module life is extended due to additional protection offered by reactor.

Typical Applications Include:

- Adjustable Speed Drives
- SCR Controllers
- Rectifier Circuits
- Elevator Drive Systems

Three Phase Reactor with Surge Arrestor

600 Volts AC max., 50/60 Hz

Guard-AC™ PLUS reactors with surge arrestors offer enhanced protection of diodes, transistors, SCR's, thyristors, etc. from dangerous voltage spikes and current surges. They can reduce overall system operating costs by reducing equipment down time and increasing system reliability and efficiency.

Little or no energy savings claims

Power factor correction Capacitors

Power Capacitors

COOPER Power Systems

Electrical Apparatus

230-10

McGraw-Edison® Type EX-7L™ Single-Phase Units and Accessories

McGraw-Edison Type EX-7L all-film capacitors (Figure 1) feature the latest Cooper Power Systems design innovation—extended foil/solderless connection* and laser-cut foil—with a high stacking factor. Designed, manufactured, and tested to meet or exceed the requirements of applicable NEMA, ANSI/IEEE, IEC and CSA standards, their low cost per kvar makes these capacitors a simple, economical reliable source of reactive power on electric power systems for:

- Improving power factor.
- Reducing line losses.
- Decreasing voltage drop.

Power capacitors can be installed singly or in factory-assembled switched or unswitched banks in:

- Pole mounting racks.
- Substation banks.
- Metal enclosures.

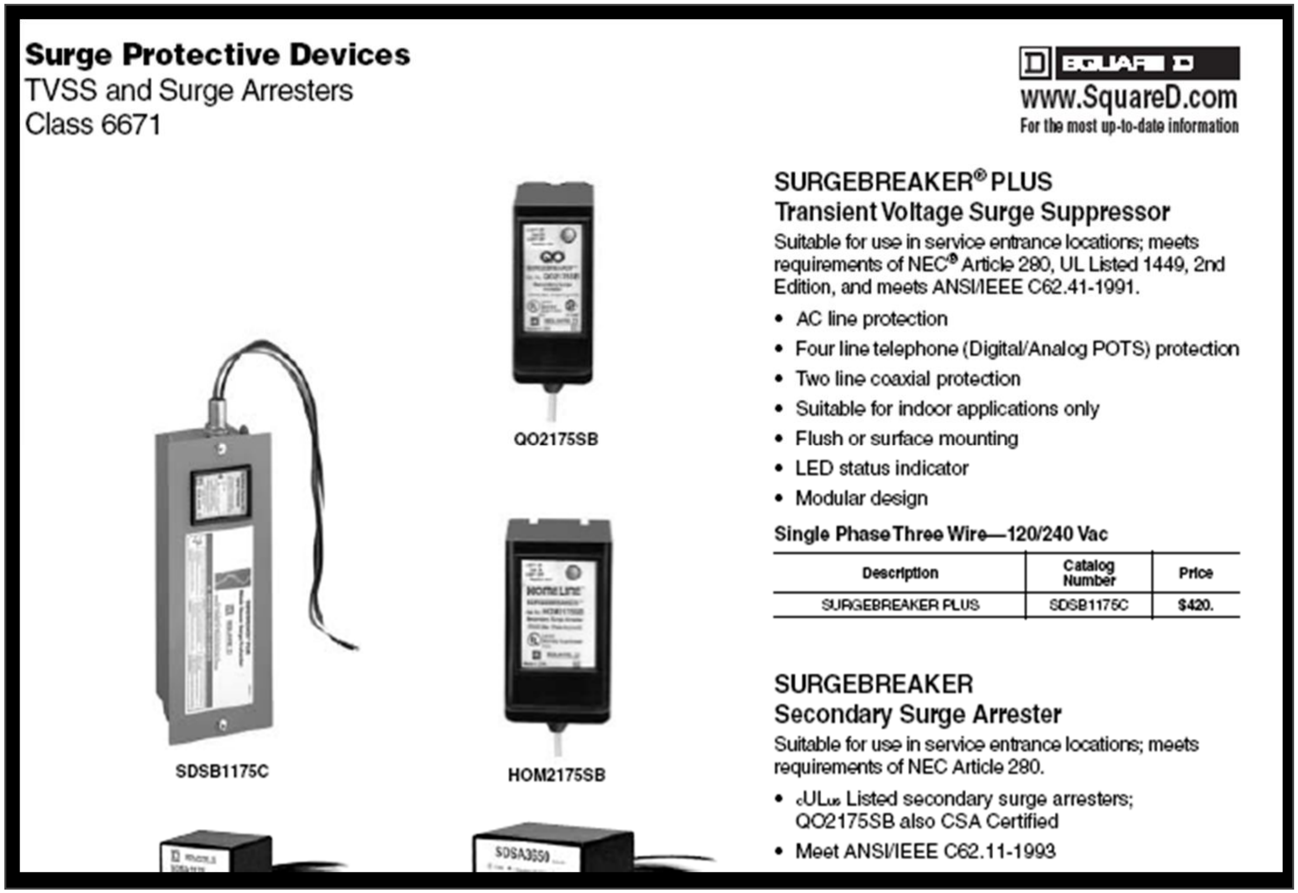
Figure 1.
The family of McGraw-Edison single phase, all film capacitors.

- The kvar needs.

500-kvar capacitors will operate safely at 135% of kvar rating. The

Little or no energy savings claims

Transient Voltage Surge Suppression (TVSS)



Surge Protective Devices
TVSS and Surge Arresters
Class 6671

www.SquareD.com
For the most up-to-date information

QO2175SB

SDSB1175C

HOM2175SB

SURGEBREAKER® PLUS
Transient Voltage Surge Suppressor

Suitable for use in service entrance locations; meets requirements of NEC® Article 280, UL Listed 1449, 2nd Edition, and meets ANSI/IEEE C62.41-1991.

- AC line protection
- Four line telephone (Digital/Analog POTS) protection
- Two line coaxial protection
- Suitable for indoor applications only
- Flush or surface mounting
- LED status indicator
- Modular design

Single Phase Three Wire—120/240 Vac

Description	Catalog Number	Price
SURGEBREAKER PLUS	SDSB1175C	$420.

SURGEBREAKER
Secondary Surge Arrester

Suitable for use in service entrance locations; meets requirements of NEC Article 280.

- cULus Listed secondary surge arresters; QO2175SB also CSA Certified
- Meet ANSI/IEEE C62.11-1993

Little or no energy savings claims

Marketing Approach

There are huge opportunities for easy energy savings in most facilities

↓

The proposed technology is unique and revolutionary

↓

There are many, many satisfied customers

↓

Energy savings are guaranteed and technology warranted

↓

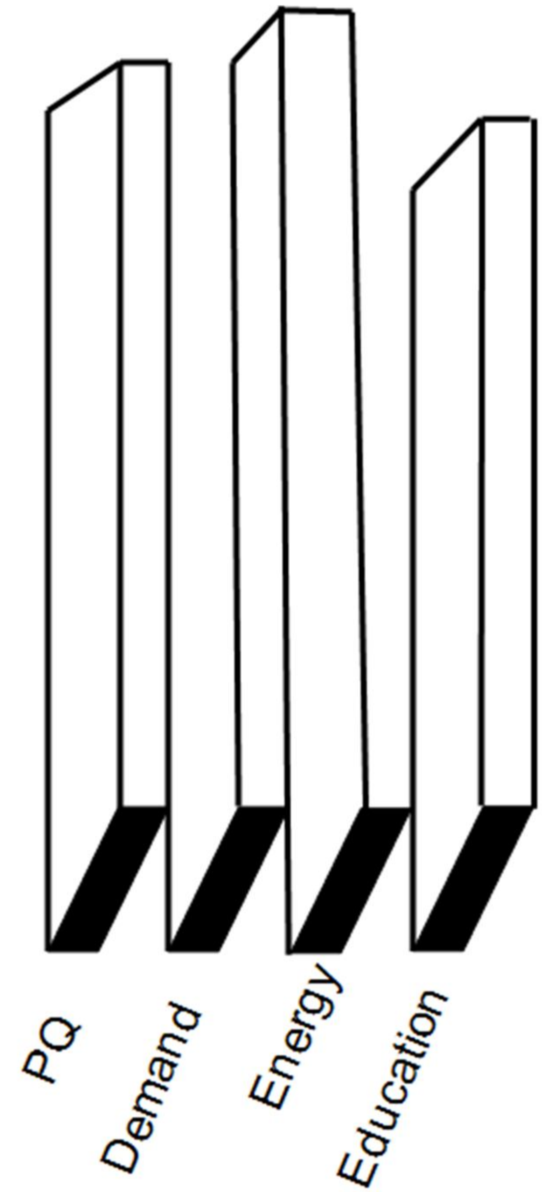
The vendor will verify savings levels

Our Role as Energy Industry Professionals

- Provide useful insights on the realities of saving energy and on the capabilities of different PQ technologies
- To educate and empower the consumer to make informed decisions
- Provide methods and resources for making informed decisions
- When appropriate, evaluate and test technologies to help inform the marketplace.

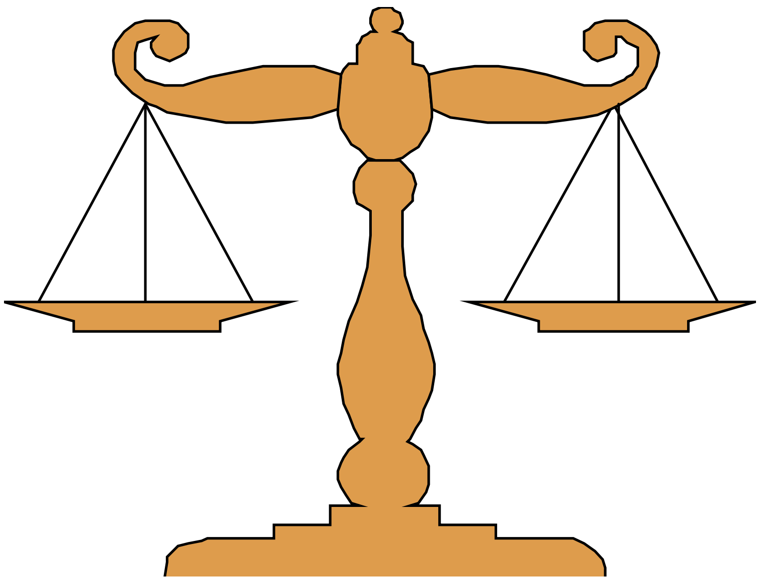
Unhelpful Responses

- "It's nothing but snake oil"
- "It doesn't work"
- "The company/vendor are crooks"
- "Only an Idiot would buy one of these"



Helpful Responses

- Describe what the technology can probably do well based on its components
- Identify claims that, based on experience, seem extraordinary
- Calibrate expectations on energy savings: Anything greater than 1-2% is extraordinary
- Provide hard data when possible, i.e. test reports, etc.
- Recommend Independent performance verification
- Recommend ignoring warrantees and guarantees
- Support testing where appropriate
- Give the consumer a methodology to make informed decisions

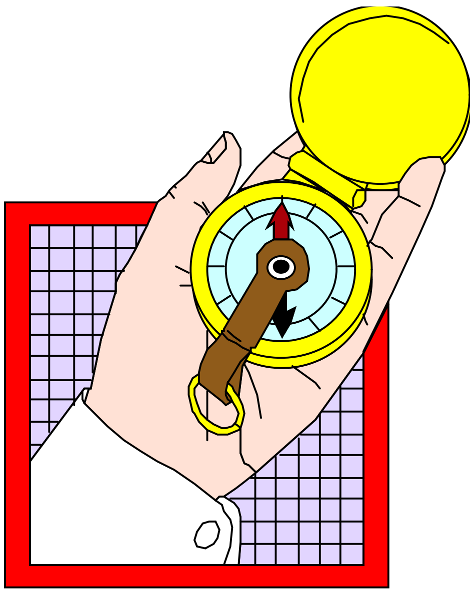


After providing this information, back away … the purchase decision is the consumer’s to make.

Evaluating Claims for Black Box Technologies

A Recommended 4-Step Approach for End Users

Require the <u>Vendor</u> to prove:



1) That an energy-savings opportunity exists
2) That there is a clear means available to save the energy identified in (1)
3) That the technology offered by the Vendor effectively implements the means identified in (2)
4) That the Vendor's proposal is cost effective compared to competing solutions

Example: The justification given for saving energy with transient voltage surge suppression (TVSS)

Progression of justification put forward by a vendor:

1. Facilities are subjected to multiple incidents of over-voltages each day
2. Being subjected to these over-voltages causes end-use equipment to over-heat
3. Over-heated equipment operates less efficiently
4. Installing TVSS will attenuate the over-voltages
5. This will result in double-digit percentage energy cost savings

Example: Logic for saving energy with TVSS

Step 1: Quantify the Energy-saving opportunity

Progression of justification put forward by a vendor:

1. Facilities are subjected to multiple incidents of over-voltages each day
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- **What data shows that end use equipment is operating at elevated temperatures?**
- **What lab or field results quantify the link between operating temperature and device efficiency?**

Example: Logic for saving energy with TVSS

Step 2: Proving that a clear means or mechanism exists to save the "wasted" energy

Progression of justification put forward by a vendor:

1. Facilities are subjected to multiple incidents of over-voltages each day
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- **Show me rigorous test data quantifying the number and magnitude of over-voltages for typical facilities**
- **Prove to me that brief over-voltages can cause heating in devices?**
- **Quantify the correlation between over-voltages and level of temperature rise**

Example: Logic for saving energy with TVSS

Step 3: Does the technology implement the means or mechanism to save the “wasted” energy

Progression of justification put forward by a vendor:

1. Facilities are subjected to multiple incidents of over-voltages each day
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- **To what extent will the vendors TVSS technology reduce the over-voltages previously identified?**

Example: Logic for saving energy with TVSS

Step 4: Is the technology cost effective compared with alternatives?

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- **If all else is satisfied, how do I *know* that I have the most cost-effective solution?**
- **What other vendors offer TVSS, and is their offering less expensive, regardless of energy-savings claims?**
- **Is there another, more cost-effective way to lower equipment operating temperatures?**

Example: The justification given for saving energy with power factor correction

Progression of justification put forward by a vendor:

1. Facilities have many inductive loads that draw significant amounts of reactive power and drawing reactive current
2. Reducing reactive current can produce profound reductions in overall current levels and real power levels
3. Installing PF correction will reduce reactive current levels
4. This will result in double-digit percentage energy cost savings

Example: Logic for saving energy with PF Correction

Step 1: Quantify the Energy-saving opportunity

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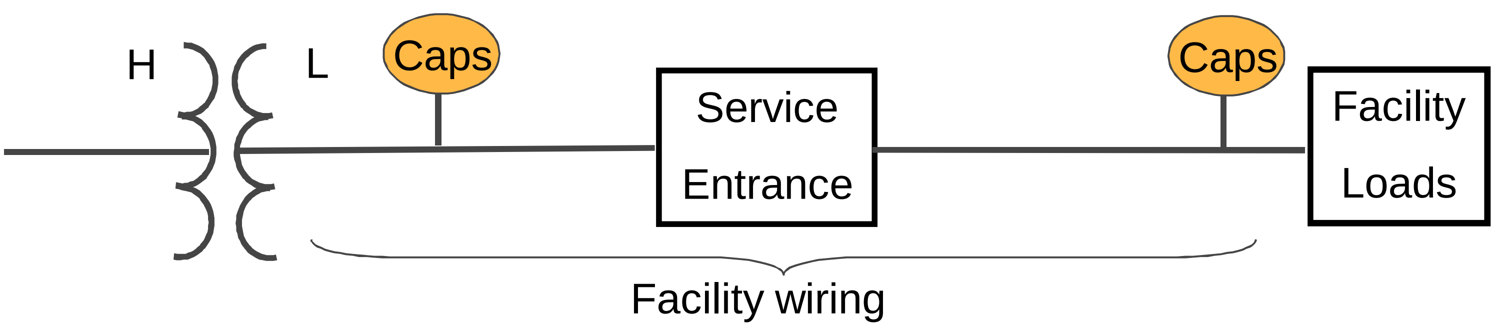
- **Quantify the level of reactive current in typical facilities and identify their source**
- **Quantify the amount of energy being lost due to reactive current and specify exactly where the energy is being wasted**
  - **What wires**
  - **What devices**
  - **Etc.**

Where is energy lost due to reactive currents?

Location of utility electrical meter	Percent energy savings for different capacitor locations: Bank capacitors at transformer	Distributed capacitors near motors
Low side of transformer	Negligible	0.0–0.5%
High side of transformer	0.4–1.0%	0.6–1.4%



Note: The National Electric Code *requires* wiring to be designed to operate at moderate temperatures to prevent fire hazards

End-Use Equipment
Transformer Efficiency

- Example: 25 kVA distribution transformer
- Even “standard” transformers are often over 98% efficient
- Proposals are common that show 10% or greater savings in transformers that are already well over 90% efficient

	Standard	High efficiency			Premium efficiency	
Capital cost ($)	320	370	410	510	680	680
Core losses (W)	95	75	70	65	58	18
Copper losses (W) at full-load	300	200	170	150	130	150
Efficiency (%)	98.44	98.91	99.05	99.15	99.25	99.33
Core material	Silicon steel	Silicon steel	Silicon steel	Silicon steel	Silicon steel	Amorphous metal
kWh losses/year	2,768	1,927	1,682	1,507	1,318	1,177

It impossible to make devices more than 100% efficient

Savings Estimates for Transformers

Vendor proposal to a packaging plant

Energy Savings Benefits Summary

Transformer	Description	Projected Current Reduction (Amps)	Projected kVA Reduction	Projected kW Savings	Projected kVAR Reduction (kVA)
T1		206	118	49	250
T2		401	249	75	500
T1 & T2	Totals	607	367	124	750

- KVA reduction for T1 = sqrt(3) * V * I
  = 1.732 * 206 * 480
  = 171 kVA
- KVA reduction for T2 = sqrt(3) * V * I
  = 1.732 * 401 * 480
  = 333 kVA
- Finding errors of this type is common

- A 1000 kVA transformer operating at 97% efficiency has losses of 30 kW at full load
- Reducing these losses is extremely difficult
- Eliminating all losses is impossible
- Saving more energy than losses without fundamental changes to the load is impossible

Example: Logic for saving energy with PF Correction

Step 2: Proving that a clear means or mechanism exists to save the “wasted” energy

Progression of justification put forward by a vendor:

1. Facilities have many inductive loads that draw significant amounts of reactive power and drawing reactive current
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- **PF Caps are a well understood technology that can accomplish reductions in reactive current downstream of the capacitor connection point**

Example: Logic for saving energy with PF Correction

Step 3: Does the technology implement the means or mechanism to save the “wasted” energy

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- **Is there enough capacitance in the device to achieve near-unity power factor?**
- **Would the technology be located close enough to the loads to save I2R heating in most conductors**
- **Are the energy savings sufficient to offset losses added by the retrofit technology?**

The real world is more complicated than simple "Does it work?" questions and answers

Results from one detailed testing

Variable	Technology out of service	Technology in service	Percent difference in means
Kilowatts	320.48	319.45	-0.32%
kWh [per 15 minutes]	80.15	79.88	-0.34%
Power factor	0.872	0.946	7.82%
Voltage imbalance	1.70%	1.60%	-6.25%
Current (3-phase amps)	771.3	704.6	-9.46%
Voltage THD	2.8%	3.0%	6.67%
Current THD	8.3%	9.7%	14.43%

- Conspicuous power factor improvement
  - Reduced PF penalties a possibility
- Reduced current levels
  - Freed transformer capacity
- Improved voltage imbalance
- Slightly worse voltage harmonics levels
- Slightly worse current harmonics levels
- No statistically significant evidence of any energy savings

Example: Logic for saving energy with PF Correction

Step 4: Is the technology cost effective compared with alternatives?

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- **If all else is satisfied, how do I *know* that I have the most cost-effective solution?**
- **What other vendors offer PF correction technologies, and is their offering less expensive, regardless of energy-savings claims?**
- **Is there another, more cost-effective way to achieve the same energy savings?**

Regardless, always
Consider the Alternatives

Expenses	Retrofit Technology	Simple Caps (at Service Ent.)	Simple Caps (at Load)
Average cost per unit	$4,404	$2,290	$508
Number of units	7	1	7
Total installed cost	$30,825	$2,290	$3,556
Annual savings			
PF penalty savings	$2,370	$2,370	$2,370
Total annual savings	$2,370	$2,370	$2,370
Simple payback (years)	13.0	1.0	1.5

Favorite Quotes from over the years

- “The technology doesn’t work in the lab … it only works in the field.”
- “The technology works at very high frequencies, so normal instruments can’t be used to measure it’s benefits”
- “The technology converts reactive power to real power AND power factor is improved.”
- “The technology interacts with the whole system to make it more efficient.”
- “The technology ‘settles in’ over time, so efficiency just keeps getting better and better.”
- “We don’t really know how it works. Not even the inventor knows how it works.”
- “I hate talking to engineers … they ask too many difficult questions.”

For More Information

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"Extraordinary claims, require extraordinary evidence"

-- Carl Sagan