Introduction

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Automatic Wobbe Index Control for Peak Shaving Plants

Keywords

- Natural Gas
- Propane / Air; LP / Air
- Synthetic Natural Gas (SNG)
- Propane / Air / Natural Gas (PANG)
- Interchangeability
- Calorific Value
- Specific Gravity
- Wobbe Index
- Ratio Control
- Gravitometer
- Calorimeter
- Applied Engineering
- Algas / Sam Dick Industries
- Algas-SDI
- Alternate Energy Systems
- Ely Energy
- Ransome
- Ranarex (Chandler Eng.)
- Cosa Instruments
- Delta Instrument
- Hobre Instruments
- Reineke Fuchs
- Union Apparatebau

Industry Situation

- Most Existing Peak Shaving and Base Load Plants are from “the 70s” (built by Applied Engineering)
- Most are Flow-Controlled (manually)
- Most adjust the mixture by manually changing the Air Flow
- Most are strictly Specific Gravity controlled (manually)
- Most use 30s Technology to measure Specific Gravity (Ranarex Gravitometer)

Typical Existing Peak Shaving Plants

- Most existing Systems only have 2 upper and 2 lower SG Alarm Contacts
- First (upper or lower) Alarm is for Operator Notification only
- Operator is supposed to make Manual Adjustments
- Second (upper or lower) Alarm Shuts System Down

Typical Mixed Gas Settings

SG_{SNG}	=	1.28 to 1.32
CV_{SNG}	=	1292 BTU/cuft @ 1.28
	to	1476 BTU/cuft @ 1.32
$Ratio_{SNG}$	=	51/49 Vapor/Air @ 1.28
	to	58/42 Vapor/Air @ 1.32

SNG = Synthetic Natural Gas

Which Setting is the "right" Setting?

1.28 ?

1.30 ?

1.32 ?

1.xx ?

Which Setting is the "right" Setting?

That's where the Wobbe Index comes in.

Who was Mr. Wobbe?

Goffredo Wobbe

Physicist

Bologna, Italy

In 1927 he had these thoughts:

Mr. Wobbe's Thoughts

1.

The heat output of a burner
at constant gas pressure
at constant orifice size
is proportional to
the flow volume per time.

(The longer you run the burner, the more heat is being put out.)

Mr. Wobbe's Thoughts

2.

The flow velocity through a given orifice size
at constant pressure
is proportional to
the specific gravity (SG) of a gas.

(The lighter a gas molecule is, the more molecules can pass through a fixed-size orifice.)

Mr. Wobbe's Thoughts

3.

The calorific value (CV) of a gas
is proportional to its specific gravity (SG).

NG	1000 BTU/ft^3	SG=0.61	→	1640
C_3	2516 BTU/ft^3	SG=1.53	→	1644
C_4	3280 BTU/ft^3	SG=2.00	→	1640

Mr. Wobbe's Conclusion

If we combine the three thoughts, we can come up with a formula that allows us to compare the flow characteristics of two gasses.

If we know their CVs or SGs, we can determine whether they produce similar heat outputs when used with the same orifice.

Mr. Wobbe's Formula

$$\text{Wobbe Index} = \frac{\text{Calorific Value}}{\sqrt{SG}}$$

He decided to keep the number dimension-less to avoid confusion with CV.

Wobbe Index

Wobbe Index Explanation

(from American Gas Association Bulletin No. 36)

The Wobbe number, or Wobbe index, of a fuel gas is found by dividing the high heating value of the gas in Btu per standard cubic foot by the square root of its specific gravity with respect to air. The higher a gases' Wobbe number, the greater the heating value of the quantity of gas that will flow though a hole of a given size in a given amount of time. It is customary to give a Wobbe number without units–even though it has the dimensions Btu per scf–because to do so would lead to confusion with the volumetric heating value of the gas.

In almost all gas appliances, the flow of gas is regulated by making it pass through a hole or orifice. **The usefulness of the Wobbe number is that for any given orifice, all gas mixtures that have the same Wobbe number will deliver the same amount of heat.** Pure methane has a Wobbe number of 1363; natural gas as piped to homes in the United States typically has a Wobbe number between 1310 and 1390.

A Closer Look at the Wobbe Index !

Wobbe Index of Natural Gas

$$\text{Wobbe Index} = \frac{\text{Calorific Value}}{\sqrt{SG}}$$

$$\text{Wobbe Index} = \frac{1000\ [BTU/cuft]}{\sqrt{0.61}} = \frac{1000}{0.781}$$

Wobbe Index of Natural Gas = **1280**

A Closer Look at the Wobbe Index !

Wobbe Index of Natural Gas

SG	0.59	0.6	0.61	0.62
Sqrt(SG)	0.7681	0.7746	0.7810	0.7874
CV	Wobbe Index			
950	1237	1226	1216	1207
980	1276	1265	1255	1245
1000	1302	1291	1280	1270
1050	1367	1356	1344	1334

Back to our earlier Question

Which Setting is the “right” Setting?

1.28 ?

1.30 ?

1.32 ?

1.xx ?

Wobbe Index of LPG/Air Mix

SG_{SNG}	=	1.28 to 1.32
$\sqrt{1.28}$	=	1.1313
$\sqrt{1.32}$	=	1.1489
CV_{SNG}	=	1292 BTU/cuft @ 1.28
	to	1476 BTU/cuft @ 1.32
$Wobbe_{SNG}$	=	1142 @ 1.28
	to	1284 @ 1.32

Consider the Wobbe Index !

$Wobbe_{SNG}$ = 1142 @ 1.28
to 1284 @ 1.32

CV_{NG} = 1000 BTU/cuft

SG_{NG} = 0.61

$Wobbe_{NG}$ = 1280

Wobbe Index Changes

Natural Gas:

- Seasonal Changes
- Source may change

LPG:

- Propane/Butane Composition

How much Wobbe Change is Acceptable

- Less than 5% deviation is desired
- Depending on how much SNG you have in your PANG*, the $Wobbe_{SNG}$ should be maintained at better than +/- 10%

*PANG = Propane Air Natural Gas

Typical max. LP/Air is 50% of total to maintain the SG_{PANG} lighter than Air.

How do we measure WOBBE

- Wobbe Analyzers offered by several manufacturers (CV, SG, O_2, …)
- AES uses the SG-based method
- Since we know the LP properties (HD-5), SG gives us accurate SNG properties
- AES Gravitometer is GraviBlend™-3

PeakShaving Control Concepts

- Almost all Equipment Manufacturers* have their own Control Concepts
- There is probably more than one “right” solution

* US Manufacturers

Algas-SDI	www.algas-sdi.com
Alternate Energy Systems	www.altenergy.com
Ely Energy	www.elyenergysystems.com
Ransome Manufacturing	www.meeder.com/ransome_mfg_.htm

AES PeakShaving System (1)

- Consists of two main components
  - LP/Air Blender with Gravitometer (GraviBlend™-3) and Automatic Gas Properties Control (AccuBlend™)
  - Peak Shaving Controller

AES PeakShaving System (2-1)

LPG/Air Blender (POM Series)

- Sizes from 20 to 2000 MMBTU/h
- Turndown better than 50:1
- Sendout Pressures 10 to 200 psi
- AccuBlend™ Gas Properties Control
- GraviBlend™ Gravitometer with Wobbe Display
- Option: SG/CV/Wobbe Analyzer

AES PeakShaving System (2-2)

LPG/Air Blender (POM Series)

- Allen-Bradley PLC
- Rosemount Transmitters
- Color Touch Screen
- Local Trend Recording with Date/Time
- NFPA 58/59, FM, UL 508-A
- Skid Mounted

AES PeakShaving System (3-1)

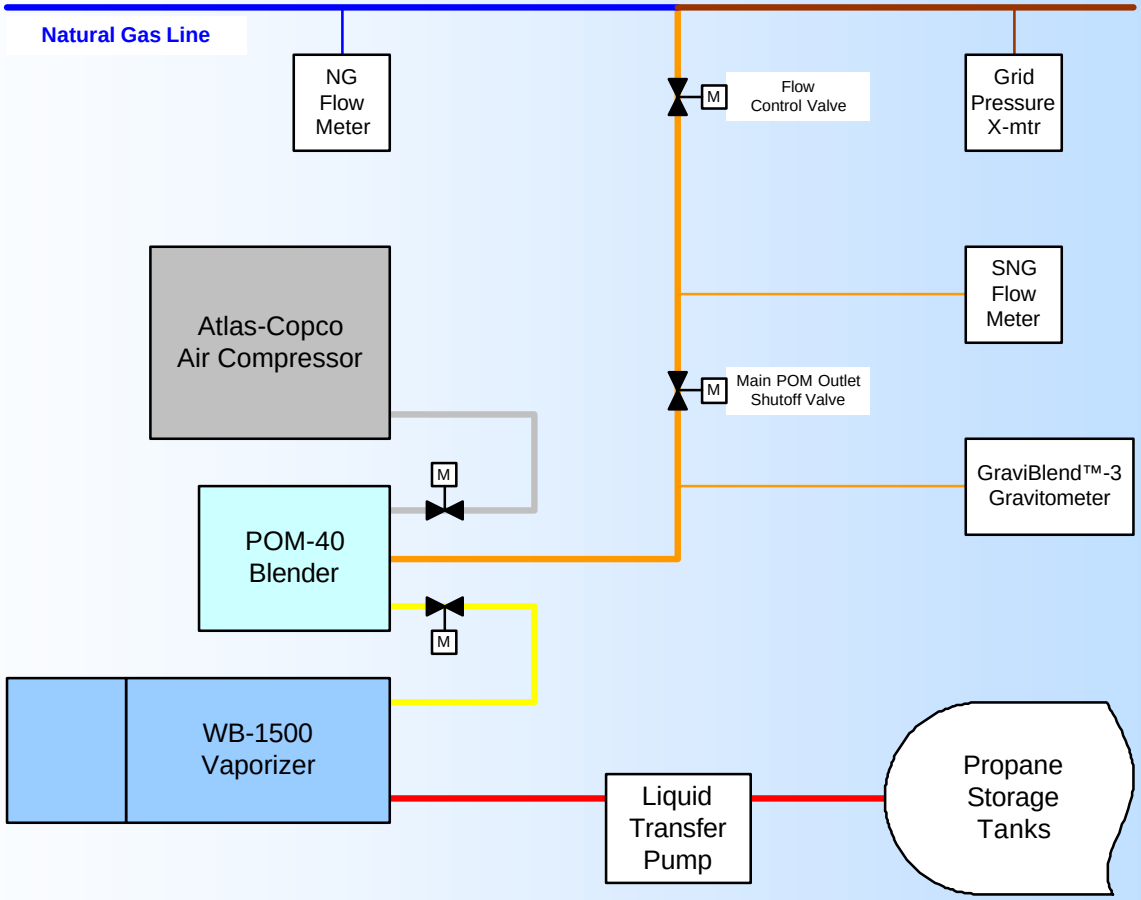
Peak Shaving Controller

- Flow Rate (SNG as % of PANG)
- Flow Rate (SNG in cuft/h)
- Pressure (maintain min. Grid Pressure)
- Minimum Flow Through System
- Maximum Flow Through System
- Module Sequencing (Blender 1 - 2 - 3 - ...)

AES PeakShaving System (3-2)

- Allen-Bradley PLC
- Rosemount Transmitters
- Color Touch Screen
- Local Trend Recording with Date/Time
- UL 508-A
- Remote Monitoring and Control
- Ethernet

PeakShaving System Components



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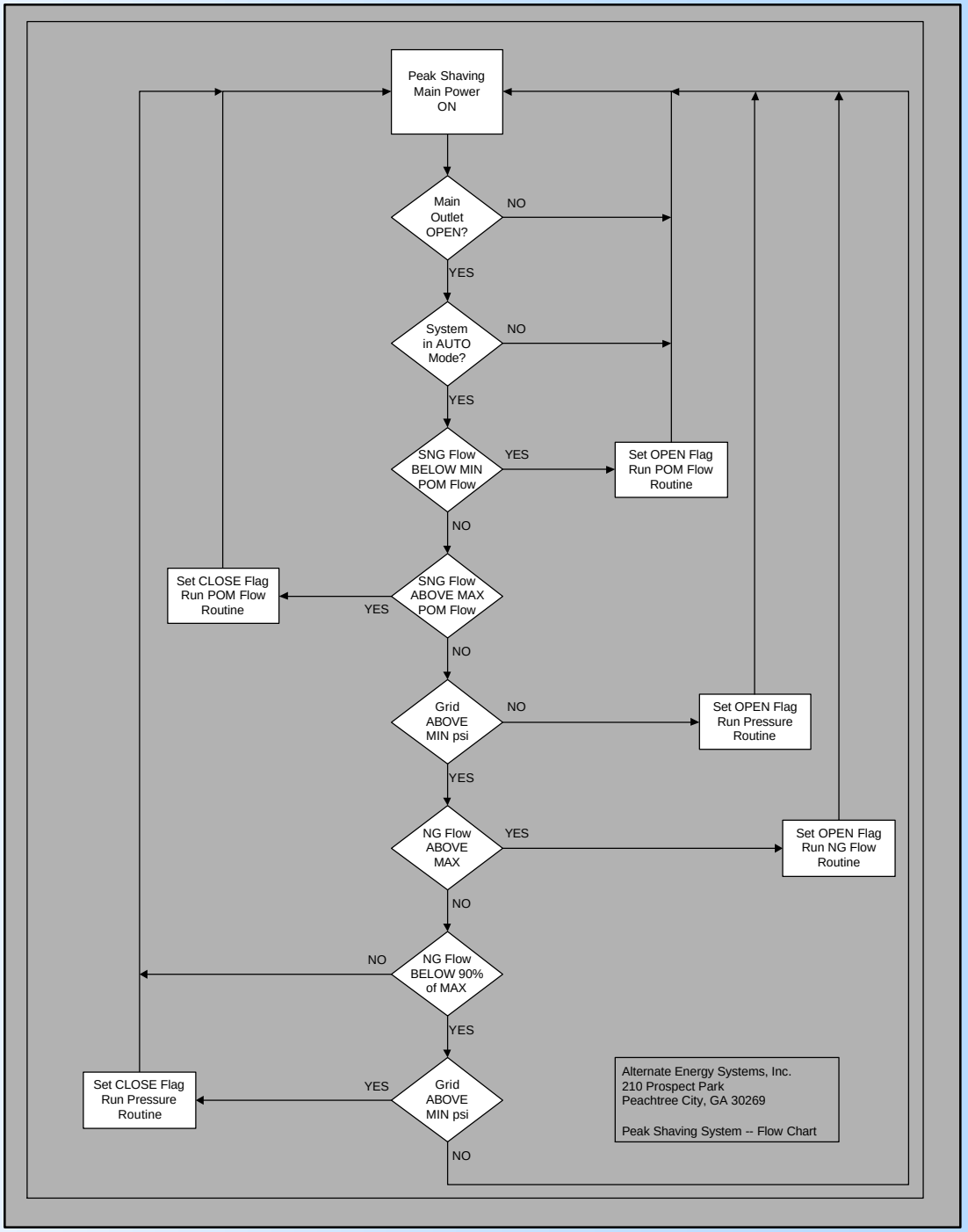
Flow Chart

AES PeakShaving Controller



How much does it cost

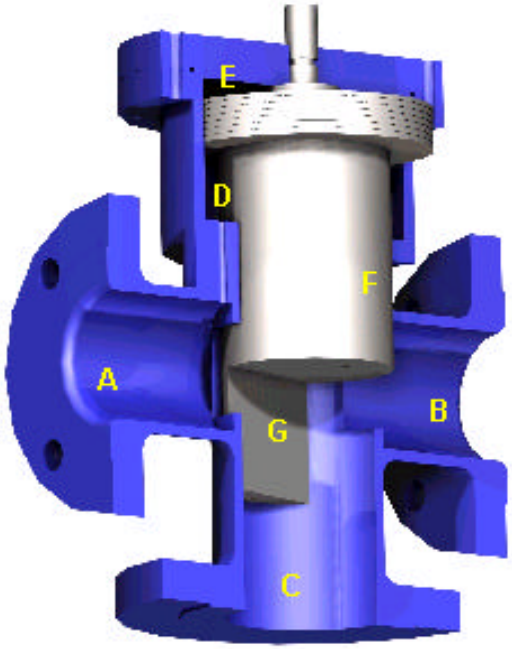
More than you like - Less than you think

Example:

- 1,300 MMBTU/h @ 200 psi (30,000 dTh/day)
- 2 skids (2 x 650 MMBTU/h) (15,000 dTh/day)
- AccuBlend™ (Automatic Gas Properties Control)
- GraviBlend™-3E (ex-proof)
- Ethernet
- On-Site Commissioning and Training
- < $200k
- 10 Weeks Lead Time

Thank You.

What Does It Look Like

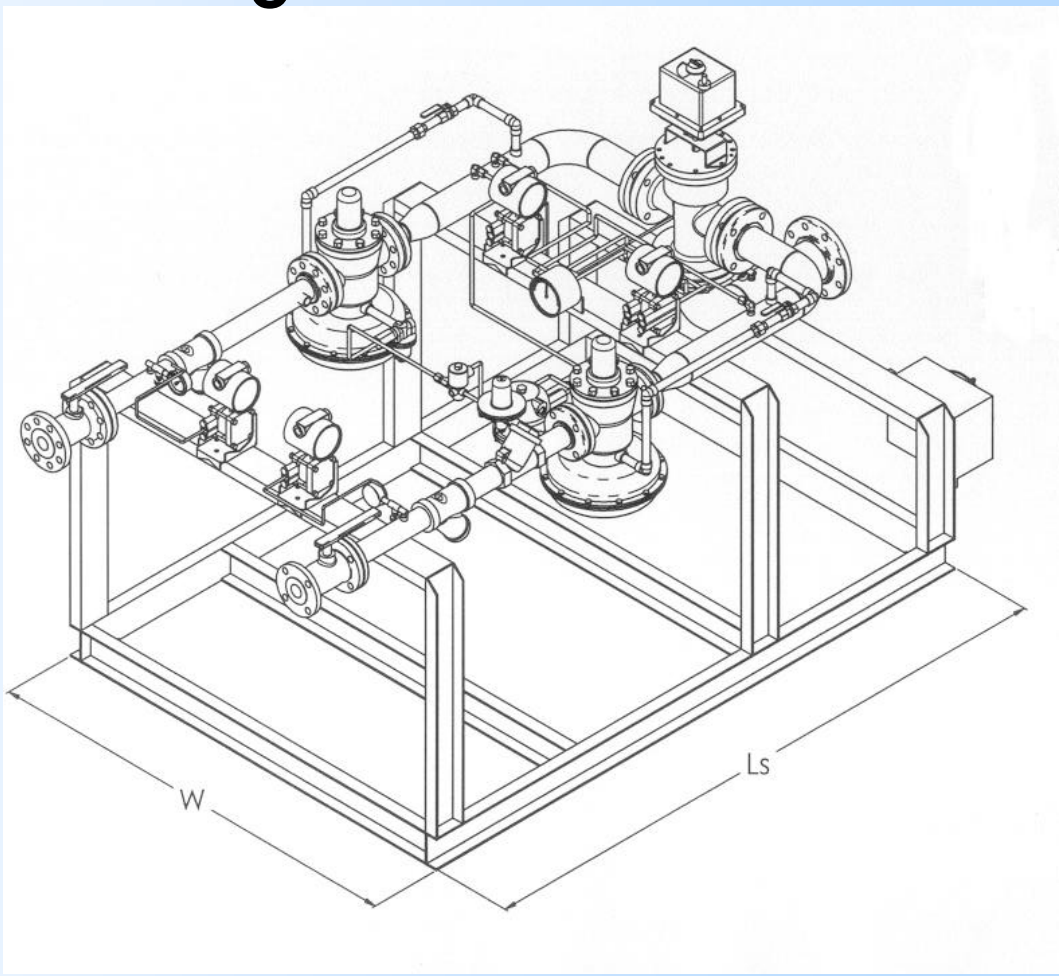


Mixing Valve Cut-Away

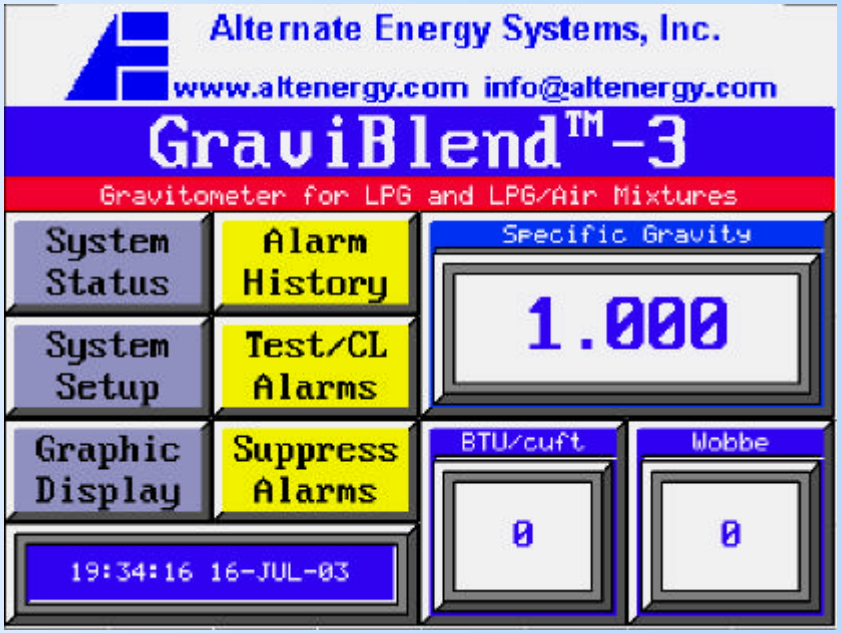
POM-40 Blending Skid

How Big Is It

Dimensions in inches Dimensions in mm				
	W_S	L_S	L_T	H
POM-30	54 1372	72 1829	92 2337	53 1346
POM-40	54 1372	76 1930	96 2438	57 1448
POM-60	54 1372	84 2134	103 2616	64 1626



GraviBlend™ Gravitometer



Does it really work ? (1)

- Between 20 and 40 systems per year
- Industrial Customers
  - Automotive
  - Chemical
  - Metal
  - Food
  - Glass/Ceramic/Brick

Does it really work ? (2)

- Institutional Customers
  - Schools/Colleges
  - Hospitals
  - Prisons
  - Offices

Does it really work ? (3)

- Government
  - Military Bases
  - Demilitarization Processes

Does it really work ? (4)

- Export (Example: China)
  - Primary Fuel Supply
  - Peak Shaving
  - Backup / Standby
  - Approximately Systems per Year
  - Unreliable LP Quality
  - Wide Variety of Customers and Appliances
  - All Systems are Wobbe-controlled

Who Is Alternate Energy Systems

After working for other manufacturers of LPG vaporizers and LPG / air systems for several years, John E. Hallberg founded Alternate Energy Systems, Inc. in 1974 in Peachtree City, located just 20 minutes south-west of the Atlanta airport. He successfully set out to design and manufacture products which were superior to those of his competitors. As a result, AES became very quickly known as the innovative manufacturer of quality products. Soon, the customer list included a representative cross-section of the Fortune 500 companies in the U.S

Through the years, AES has constantly added new products, and has further improved the design of existing products, keeping us ahead of the competition. Several designs, including those for LPG/Air mixing systems, were awarded national and international patents.

Today, AES is owned by Wolfgang Driftmeier. With his manufacturing background and his experience in sales and marketing, the company focus is clearly on "... offering the best product design, combined with quality workmanship, at a competitive price, to the full satisfaction of our customers, at all times ...".

AES is committed to serve customers in the U.S. through a network of sales specialists, technical support personnel, distributors and installers, and international customers in selected countries through qualified representatives.

Thank You.

Thank You.

Really.