Contributing to Competitiveness with the Cheapest Industrial Energy: Energy Saved

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ABSTRACT

Domestic industrial plants face considerable competition from foreign firms, and improvements in energy efficiency aid these firms in the global marketplace. Small and medium-sized plants generally cannot afford in-house energy efficiency expertise to identify potential energy savings. Assessments performed by the Industrial Assessment Center (IAC) activity in the Industrial Technologies Program of the Department of Energy's Energy Efficiency and Renewable Energy office attempt to fill that void and improve industrial efficiency and reduce associated greenhouse gas emissions.

This paper compares the prices of energy consumed in the industrial and other sectors to a price of (in terms of funds expended to identify) conserved industrial energy. How little can be paid for energy? Very conservative estimates of the identified energy savings in the database for the IAC activity are examined. The total costs for the audits (free to the plants) for 1999 through 2004 are then compared to the projected energy savings from only the recommendations that would also be cost-free to the plants to derive a "price" for conserved energy. Finally, brief analyses are done of the difference between all recommendations in the data base and no-cost recommendations in terms of their implementation rates, the relationship between implementation rates and identified pay-back periods, and differences in implementation rates by plant size and industry

Introduction

Energy's Role in Industrial Competitiveness

The excess of goods imported into the U.S. over exported goods continues to grow, multiplying more than four times from $162 billion in inflation-adjusted year 2000 dollars in 1994 to $667.8 billion in 2004 (GPO 2007), the equivalent of 20.5 percent of the total of almost $3.3 trillion in goods consumed in the U.S. in 2004. With petroleum imports removed, the growth figures are even more striking: a seven-fold increase from $74.1 billion in 1994 to $522.9 billion in 2004 (Census 2007a). To remain competitive, U.S. manufacturers must improve the efficiency of all of their inputs, including energy.

Previous research has decomposed the change in energy's role in international trade (Policy 1989) into the effects of final demand, input-output structure, and energy intensity changes. Government intervention in the form of research, development, and deployment can directly affect the energy intensity component and associated greenhouse gas emissions.

Energy consumption in the industrial sector of the economy, including manufacturing, construction, agriculture, and mining, accounted for almost a third of total energy consumption (EIA 2006c) in 2005 (32.308 quadrillion British thermal units of the total of 100.358). Of that industrial total, over 80 percent of the energy is used for manufacturing (EIA 2006b).

[1] The views expressed here are not necessarily those of the Department of Energy.

Small and Medium-Sized Plants

Most manufacturing plants are small or medium-sized, and they are not likely to employ energy managers. Excluding the over three-quarters of U.S. firms that have no payroll, mostly self-employed persons operating unincorporated businesses (Census 2007b), there were 5.9 million firms in 2004. Of the almost 300,000 manufacturing firms, 74.1 percent fewer than 20 employees and only 1.4 percent had more than 500 employees.

According to a Resources for the Future study in 2002 (Anderson & Newell 2002), 42 percent of total manufacturing energy consumption comes from these small and medium-sized firms facing considerable global competition. For all manufactured goods, the import share of domestic supply increased from 19.9 in 2003 to 22.1 percent in 2005, with the export share only increasing from 8.7 to 9 percent during that period (BEA 2006).

So there's a large opportunity for energy savings to promote competitiveness in small and medium-sized firms. How much does it cost to save energy in these plants?

The Industrial Assessment Centers Activity

Background

The Industrial Assessment Centers (IAC) activity at the Department of Energy (DOE) targets the energy-saving opportunities at these small and medium-sized firms, offering them free energy, waste minimization, and productivity assessments (ITP 2007). Government-funded disclosure of energy-efficiency information, such as that provided through IAC assessments, helps to correct the problem of imperfect information creating market failures and the sub-optimal allocation of resources that contributes to losses in global market share.

The IAC activity has its origins in a small pilot program begun in the Department of Commerce Office of Energy Programs in 1976 with the faculty and students of 4 universities conducting free energy audits for industrial plants. DOE has been funding the program since it came to DOE with the founding of the Department in 1977. Known then as the Energy Analysis and Diagnostic Centers (EADC) program, the number of centers at accredited engineering schools grew to a peak of 30 in 1999 (Glaser 2006) and currently 26 centers are operating. Waste minimization assessments were added to the energy savings audits in 1993, and productivity improvement assessments in 1994, and the name of the program was changed to Industrial Assessment Centers to reflect these additions. The activity is managed by the Industrial Technologies Program within the Department of Energy's Office of Energy Efficiency and Renewable Energy whose mission includes accelerating advanced technologies and best practices to improve U.S. competitiveness (ITP 2007).

Eligible Plants

Small and medium-sized manufacturing (defined as Standard Industrial Classification codes from 20 through 39) plants that meet the requirements of having no designated energy manager, 500 employees or fewer, annual sales under $100 million, energy bills between $100 thousand and $2 million per year, and who are within 150 miles of an IAC apply to receive an assessment. Faculty and students at the centers conduct 1-2 day site visits at the plants, and prepare detailed analyses with recommendations for changes with accompanying cost and performance information. The assessment results are stored in the IAC database, accessible on-line to provide quick information for similar firms. The plant managers of the plants assessed receive follow-up telephone calls to determine the implementation of the recommendations.

We've all seen headlines about growing energy prices. So we know what it currently costs to purchase energy. But how much does it cost to become more energy-efficient and save energy? This paper will discuss the cost of the IAC activity in relation to the energy savings recommendations identified in that activity which are cost-free to the plant getting the free energy audit.

Identifying the Energy Savings

While the IAC activity tracks waste minimization and productivity improvements in addition to energy savings, the focus here will be exclusively on energy savings benefits from the assessment recommendations. Benefits from replications of recommendations to other plants, the training of about 140 students per year in recent years in energy engineering, and database use will also not be considered. Costs and assessment recommendations from 1999 through 2004 will be considered, providing a large database with sufficient time for recommendations to be implemented.

Compilation of the data from the assessments in a central location began in 1981 at the University City Science Center which was the program manager form 1976 to 1992. With the division of the program into Eastern and Western regions in 1992, database management was moved to Rutgers University. The data became available for download, and then available on-line in 2000, with a rebuilt database rolled out in 2004 (ITP 2007).

Assessments

The IAC database contained the results of almost 13,000 assessments performed in every state but Hawaii between 1981 and the data collection efforts for this paper in the spring of 2006. In addition to some 16,000 waste minimization, pollution prevention, and productivity recommendations not included in this analysis, over 82,000 energy management recommendations were identified, and over 39,000, or almost 48 percent, of these were implemented. The number of plants assessed in any given year is a function of Congressional program funding. The assessed plants averaged a little more than $31 million (nominal) per year in sales, had an average of 169 employees, and an average energy bill of a little over $550,000 (nominal) per year.[2]

For this effort, the sample was limited to the 3,862 assessments conducted from 1999 through 2004. The total number of energy management recommendations made was 23,735, with 10,515 or 44 percent of them implemented. The assessed plants averaged a little more than $39 million (nominal) per year in sales, had an average of 172 employees, and an average energy bill of a little over $750,000 (nominal) per year.

The most common industry affiliation for this sample of 3,862 assessments was Standard Industrial Classification (SIC) code 34 (Fabricated Metal Products), followed by SIC code 30

[2]Since the IAC activity requirements were in nominal dollar terms, comparisons to those requirements will be presented in this and the following paragraph in nominal dollar terms. Program costs and implementation costs and savings presented later in the analysis will be in inflation-adjusted dollar terms.

(Rubber and Miscellaneous Plastics Products), SIC code 20 (Food and Kindred Products), and SIC code 35 (Industrial Machinery and Equipment). An analysis of assessments performed between 1980 and 1992 also found these four industries to be the most frequently assessed (DOE 1996).

Firms in these industries are only slightly more likely to be small (as defined as having less than 500 employees), with percentages ranging from 94.7 to 98.6 compared to the manufacturing total percentage in 2004 of 98.6 percent (SBA 2007). They are also less energy-intensive than the manufacturing average, ranging from 1.4 to 6.0 thousand British thermal units (Btus) of energy consumption per dollar of value-added, compared to the manufacturing average of 8.9 (EIA 2005b).

To get some sense of the competitive position of these industries, according to the Census Bureau the 2005 excess of imports of goods over exports was $782.7 billion (BEA 2007b). Food products and fabricated metals contributed to this trade deficit, but both rubber and plastic products and industrial machinery ran trade surpluses in that year.

Recommendations

For the IAC audits, total and average implementation costs and annual savings (all in inflation-adjusted year 2000 dollars), as well as average payback-periods, for all recommendations identified in the named year and for the total period are shown in Table 1 below. The costs of the recommendations varied widely. One-eighth of them, over 3,000, had zero cost. Another 1,532 had costs between $1 and $100. So, while the mean for the implementation cost was $26,185, the median was $1,000. The 23,735 recommendations identified potential annual savings of over $402 million with an average payback period of 1.5 years. Recommendations ranged from reducing the pressure of compressed air to the minimum required to right-sizing motors and pumps, with the most common recommendations being in the areas of buildings and grounds, motor systems, and thermal systems.

Table 1. All IAC Recommendations, 1999 to 2004 - - Year 2000 dollars

Year	Total Implementation Costs	Total Annual Energy Cost Savings	Average Implementation Costs	Average Annual Energy Cost Savings	Average Pay-Back Period
1999	$ 62,892,234	$ 38,262,149	$ 17,587	$ 10,700	1.6
2000	$ 78,766,392	$ 43,874,228	$ 21,562	$ 12,010	1.8
2001	$ 86,261,856	$ 77,665,994	$ 24,265	$ 21,847	1.1
2002	$ 192,568,383	$ 87,775,495	$ 50,783	$ 23,148	2.2
2003	$ 112,162,693	$ 102,632,130	$ 25,445	$ 23,283	1.1
2004	$ 88,849,924	$ 52,383,575	$ 18,701	$ 11,026	1.7
Total Period	$ 621,501,482	$ 402,593,571	$ 26,185	$ 16,962	1.5

Source: ITP 2007

Implemented Recommendations

Table 2 below shows the same information for the 10,515, or 44 percent, of the recommendations actually implemented. Average implementation costs were less than one-third that of the total population of recommendations. Annual savings of almost $100 million were associated with the implemented recommendations, but at a cost of over $80 million. The average payback period was 0.8 years, a little more than half that of all of the recommendations. Smaller investments that would pay back sooner were being made. Excluding for the moment the no-cost recommendations, implemented recommendations with associated costs of $80.4 million would be associated with total annual energy cost savings of almost $85 million (savings from implemented recommendations with and without costs of $99.8 million less savings from implemented no-cost recommendations of $15.4 million), a payback of 0.95 years.

Table 2. Implemented IAC Recommendations, 1999 to 2004 - - Year 2000 dollars

Year	Total Implementation Costs	Total Annual Energy Cost Savings	Average Implementation Costs	Average Annual Energy Cost Savings	Average Pay-Back Period
1999	$ 8,055,381	$ 9,885,447	$ 5,338	$ 6,551	0.8
2000	$ 9,552,121	$ 9,606,992	$ 6,123	$ 6,158	1.0
2001	$ 7,654,039	$ 14,744,387	$ 4,932	$ 9,500	0.5
2002	$ 17,578,518	$ 22,406,207	$ 10,091	$ 12,862	0.8
2003	$ 18,497312	$ 22,381,384	$ 9,855	$ 11,924	0.8
2004	$ 19,072,637	$ 20,776,137	$ 8,384	$ 9,132	0.9
Total period	$ 80,410,008	$ 99,800,554	$ 7,647	$ 9,491	0.8

Source: ITP 2007

No-Cost Recommendations

The 3,013 no-cost recommendations were associated with annual savings of a little more than $25 million. Pay-backs were, by definition, immediate. The average annual cost savings for the no-cost recommendations were about one-half that of the total of the 23,735 recommendations made.

Table 3. No-Cost Recommendations, 1999 to 2004 - - Year 2000 dollars

Year	Total Implementation Costs	Total Annual Energy Cost Savings	Average Implementation Costs	Average Annual Energy Cost Savings
1999	0	$ 2,326,107	0	$ 5,646
2000	0	$ 2,460402	0	$ 5,789
2001	0	$ 2,965,582	0	$ 6,605
2002	0	$ 8,417,228	0	$ 14,664
2003	0	$ 4,414,334	0	$ 7,248
2004	0	$ 4,772,847	0	$ 8,774
Total period		$ 25,356,500		$ 8,416

Source: ITP 2007

Implemented No-Cost Recommendations

Finally, 1,598 no-cost recommendations were actually implemented, amounting to just over half or 53 percent of them, compared to the 44 percent implemented of all recommendations. Surprisingly, the no-cost recommendations implemented had lower average annual cost savings than the total no-cost recommendations in four of the six years.

There is a clear anomaly in the energy cost savings data in 2002. In that year, there were 9 no-cost energy management recommendations with annual savings of over $100,000. Of these

9 recommendations, 3 of them had annual savings of over $200,000. All three were implemented, for average annual savings of $1,436,311. There was a tie for the next highest number of no-cost recommendations made with annual savings of over $100,000, with 5 made for 2003 and for 2004. Only 2 of the 2004 recommendations had associated annual savings of over $200,000, and none of the 2003 recommendations. Both 2004 no-cost recommendations with annual savings over $200,000 were implemented, but the average annual savings were only $296,171.

One of the 2002 implemented no-cost recommendations saved over $2 million per year by eliminating a heating and drying cycle using natural gas in a Kaolin processing facility. Kaolin, a white alumina-silicate, is used in making paper, plastics, and paint. The purification process for the mined raw material requires multiple heating and drying cycles, and the recommendation proposed eliminating one of them. If this one observation is excluded, average annual energy cost savings for the six-year period would have been $8,274, more in line with succeeding years.

Table 4. No-cost Implemented Recommendations, 1999 to 2004 - - Year 2000 dollars

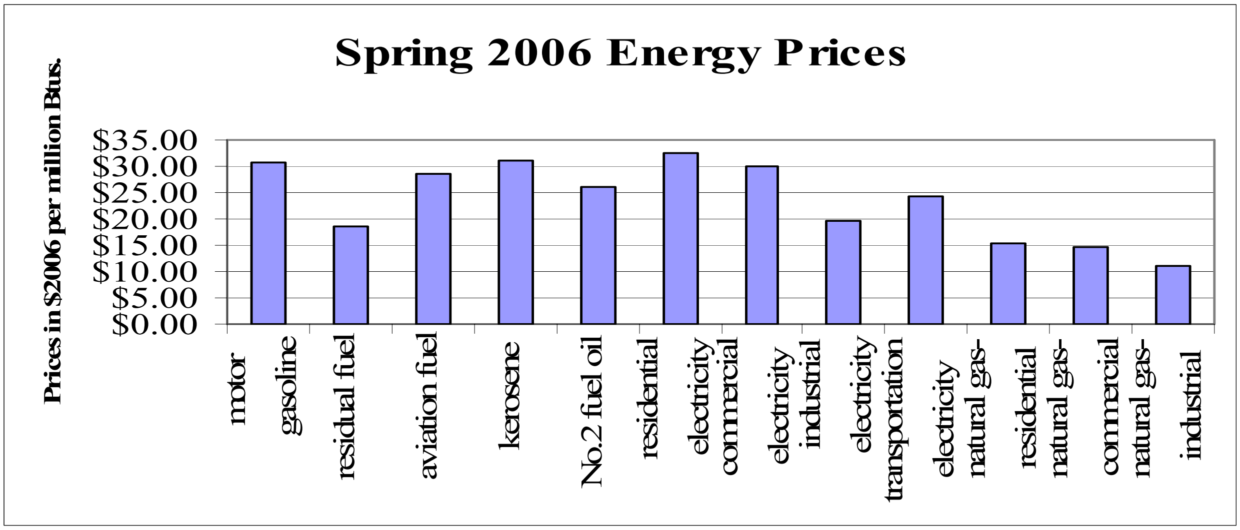
Year	Total Implementation Costs	Total Annual Energy Cost Savings	Average Implementation Costs	Average Annual Energy Cost Savings
1999	0	$ 1,035,772	0	$ 5,053
2000	0	$ 1,228,345	0	$ 5,508
2001	0	$ 1,365,171	0	$ 5,572
2002	0	$ 6,724,664	0	$ 21,281
2003	0	$ 2,031,530	0	$ 7,030
2004	0	$ 2,995,262	0	$ 9,360
Total period		$ 15,380,744		$ 9,625

Source: ITP 2007

Energy Prices in Context

At the end of March of 2006, prices in year 2006 dollars of delivered energy to all sectors of the economy ranged from $32.58 per million British thermal units (Btus) for electricity in the residential sector to $11.15 per million Btus for natural gas in the industrial sector (EIA 2006c and BEA 2007a). As seen in Figure 1 below, the industrial sector, with a greater proportion of longer-term and bulk energy contracts, generally has lower energy prices.

Figure 1. Energy Prices



Source: EIA 2006c

This is a picture of energy prices for energy consumed. Viewing price as the amount of funds that must be expended to procure an amount of energy for use, what is the price of energy conserved in the IAC activity? Using the very conservative energy quantity measures of only the identified no-cost recommendations and implemented no-cost recommendations, how would these prices compare to those above?

Quantifying the Price for Saved Energy

To examine the price for energy saved by the IAC activity, we examine how many federal dollars have been spent on the activity. As shown in Table 5, from 1999 through 2004, a total of $46.754 million (in year 2006 dollars) was spent for the IAC activity (ITP 2007).

Table 5. IAC Funding by Fiscal Year

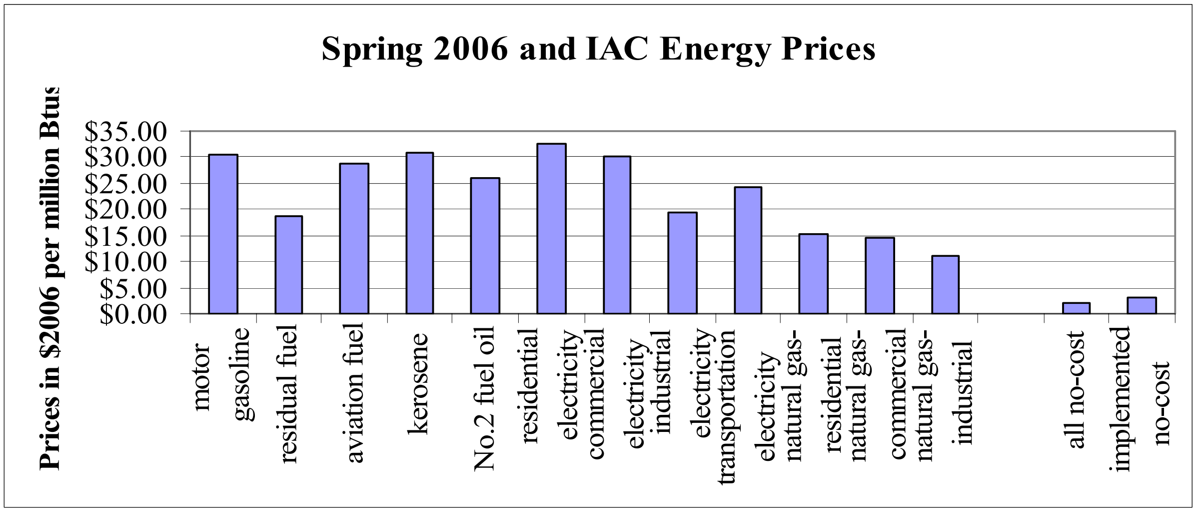
Fiscal Year	Funding in $2006 thousands
1999	$ 9,615
2000	9,270
2001	7,558
2002	6,343
2003	7,033
2004	6,936
Sum	$ 46,754

Source: ITP 2007

For this analysis, all identified no-cost recommendations will first be considered as energy savings benefits, followed by the implemented no-cost recommendations. Using the average industrial energy prices published in the Annual Energy Review (EIA 2005a) and

Annual Energy Outlook (EIA 2006b) for the study years, the identified total of $25.4 million per year in savings from no-cost recommendations corresponds to 3.377 trillion Btus per year.

Figure 2. Energy Prices with IAC Comparisons



Source: EIA 2006c, 2005a, 2006b, ITP 2007

On average, savings from these no-cost recommendations are expected to persist for 7 years (PBA 2007), for a total estimated savings of 23.64 trillion Btus from identified no-cost recommendations. The IAC price, by division, is $46.754 million divided by 23.64 trillion Btus, or roughly $1.98 per million Btus.

Similarly, for the no-cost recommendations actually implemented, the annual savings are 2.056 trillion Btus, or a total of 14.39 over the 7-year period. The corresponding price is roughly $3.25 per million Btus for implemented no-cost recommendations.

Why These Prices are Very Conservative Estimates

The 3,862 assessments that we've been examining resulted in 23,735 recommendations. This analysis only counted, at most, the benefits from the 3,013 that had zero costs. Of the 10,515 recommendations actually implemented, only 1,598 were no-cost recommendations.

Benefits from reduced greenhouse gas emissions were not quantified and considered in this analysis, nor were benefits from replications of recommendations to other plants, the training of about 140 students per year in recent years in energy engineering, and benefits derived from database use. Benefits for this analysis were also limited to energy savings, although the assessments also included recommendations for waste minimization, pollution prevention, and productivity improvements. For the analysis of implemented recommendations, any implementations that were not yet known to the program and thus did not appear in the data base as of the time of this writing in the spring of 2006 were not included.

Or Not

If a local energy price is higher than the national average, a plant is more likely to request an assessment. Using national prices to convert from dollar amounts of energy savings to Btus would then tend to overstate the energy savings and understate the implicit price.

Differences in No-Cost Recommendations and Implementation by Plant Size and Industry

As noted above, the most common industry affiliation for the sample of 3,862 assessments was Standard Industrial Classification (SIC) code 34 (Fabricated Metal Products), followed by SIC code 30 (Rubber and Miscellaneous Plastics Products), SIC code 20 (Food and Kindred Products), and SIC code 35 (Industrial Machinery and Equipment). In a sub-sample of 1,385 of these assessments, the top four most commonly assessed industries were the same.

Almost 12 percent of the sub-sample recommendations were no-cost recommendations, just slightly less than the 12.7 percent for the entire sample. The industries most likely to receive no-cost recommendations were also SIC code 20 (Food and Kindred Products), code 34 (Fabricated Metal Products), and code 30 (Rubber and Miscellaneous Plastics Products). The percentage of no-cost recommendations varied substantially by industry, from 20 percent for the Leather and Leather Products industry (albeit an industry with only 2 assessments in the sub-sample) followed by Miscellaneous Manufacturing Industries 18.7 percent to a low of 6.7 percent in the Petroleum and Coal Products industry.

Implementation rates for no-cost recommendations varied from 31 percent in SIC code 22 (Textile Mill Products) to almost 67 percent in code 25 (Furniture and Fixtures). The overall average for no-cost implementation rates for the sub-sample was 53 percent, the same as that for the sample.

Assessed plants in the sub-sample had slightly higher annual sales in nominal terms, $33 million versus $31 million for the entire sample, and roughly the same average employment, 167 for the sub-sample versus 172 for the sample. Using sales as the size metric, was size a predictor of no-cost recommendations or their implementation? Smaller plants were both more likely to receive no-cost recommendations and to implement them, with an implementation rate of 56 percent for plants with annual sales of under $20 million compared to the average of 53 percent. Using employment as the size metric, smaller plants were again more likely to receive no-cost recommendations and to implement them, with an implementation rate of 57 percent for plants with fewer than 100 employees compared to the average of 53 percent.

Conclusion and Suggestions for Future Analysis

Improvements in industrial energy efficiency improve the competitive position of U.S. industries. As shown in this paper, the IAC activity produces energy savings with a considerably lower "price" than industrial energy consumption, even if only the energy cost benefits of no-cost recommendations are included and emission abatement costs of various fuels are excluded. So, the audits are a good public investment, and the recommendations identify good private investments that can improve American industrial competitiveness.

The implementation rate for all 23,735 recommendations in the sample was 44 percent for recommendations with an average pay-back period of 1.5 years, with a 0.8-year average pay-back period for those implemented. No-cost recommendations, with immediate pay-back, were implemented at a rate of 53 percent. Smaller plants were more likely to implement no-cost recommendations than larger plants.

As the database used for this analysis continues to develop, future rounds of analysis involving the merging of the assessment and recommendation databases might include further analysis of the relationships between implementations of no-cost recommendations and the size and industrial classification of the plants assessed to form the basis for checklists, either on-line or for IAC assessment teams, to ensure the inclusion of these no-cost recommendations where appropriate.

The audits and database also provide guidance to energy-efficiency investments that do have costs, but have low average payback periods. Future analysis might include the refinement of the IAC-based price estimates to include the cost benefits of all recommendations.

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