

# Web-Based Implementation of Energy Assessment Service

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## Abstract

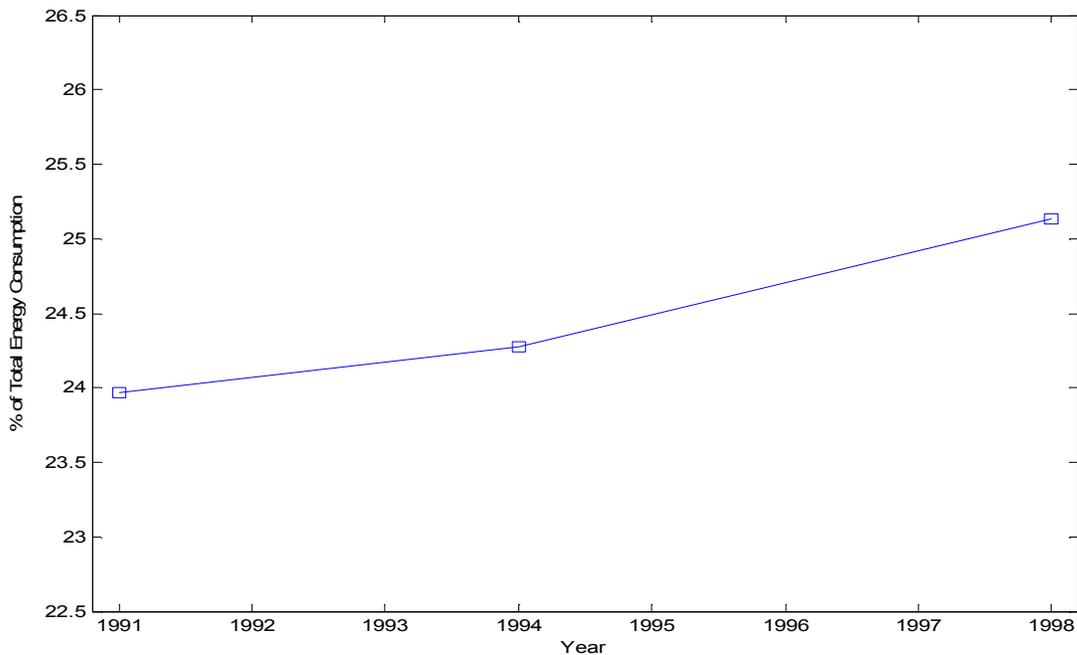
The continuing emphasis on environmental conservation hits hard on the industrial sector, since their energy use accounts for the majority of the nation's consumption. Contrary to popular belief, however, it is not the few major manufacturing institutions that have the most energy-management problems, but rather the many small manufacturers who do not spend enough money on utilities to be assigned an efficiency expert from the energy service companies they buy from. In addition to this, small companies typically do not have the resources to scrutinize and, if needed, revamp their current energy practices.

To help solve this problem, the Instrumentation Research Laboratory at the University of Maine, working with the U.S. Department of Energy and the Maine Department of Economic and Community Development, has created a web-based implementation of Rutgers University's *Self-Assessment Workbook for Small Manufacturers*. The initial application was completed using Java applets, but further consideration of the issues of scalability, ease of maintenance, and system compatibility resulted in implementing the final application in PHP (which recursively stands for PHP: Hypertext Preprocessor).

**Keywords:** web site management/development tools, knowledge management applications, client/server systems, middleware

## 1.0 The Problem

Energy use and energy efficiency have become hot topics in recent years as environmental awareness and concern grow. The industrial sector in particular has been targeted, since its energy use comprises roughly 1/4 of the national energy consumption [1], and that figure has been growing, according to the latest statistics from the Energy Information Administration (EIA) [2]. Figure 1 shows the rising trend of industrial energy consumption from data taken from the EIA's Manufacturing Energy Consumption Survey (MECS), for report years 1991, 1994, and 1998; as of the writing of this paper, the 2002 survey had just been mailed out.



**Figure 1.** Industrial Energy Consumption (1991-1998)

As a result of these concerns, many leading manufacturers have introduced internal energy efficiency operations to decrease their environmental impact; these major industrial companies, who spend millions of dollars on utilities and energy services, often also have the benefit of personalized assistance from the energy service companies that supply them.

In contrast there are the small manufacturers, also part of the industrial sector, who typically employ fewer than 1000 people [3]. Their electric bill ranges from \$100,000 to about \$1 million, but since their energy expenditure is relatively small compared to that of the energy companies' "key accounts," these firms do not receive specialized attention or discounted rates [3]. In addition, due to the relatively small number of employees hired, these companies ordinarily do not have the manpower or the knowledge needed to evaluate their existing operations and improve their energy consumption costs and

production practices.

## 2.0 A Solution

In response, the Rutgers University Industrial Assessment Center (IAC), sponsored by the U.S. Department of Energy, has created the *Self-Assessment Workbook for Small Manufacturers*. This workbook is designed to “permit the owner of a small manufacturing operation to perform a self assessment to identify and calculate energy savings, waste reduction opportunities, and production enhancements frequently available only to larger companies” [4].

The *Workbook* is available online in portable document format (PDF) at <http://iac.rutgers.edu/selfassessment/workbook.php>. The 104-page manual is meant to be read in its entirety by a single person. The aim of the *Workbook* is to guide the reader in taking a very comprehensive look at all aspects of the manufacturing facility to evaluate areas where energy costs can be decreased and productivity can be increased. This document contains not only often-overlooked tips and general recommendations on efficient facility operations, but also numerous formulas that can be applied to existing data gathered from the plant to calculate potential savings.

However, for one person already in charge of such a manufacturing facility, who oversees plant operations and employees, and deals with customers, it would be a tedious, if not impossible, task to use the *Workbook*. This is because accurate recommendations can only be obtained through reading the document, collecting plant data, performing calculations, and referring to the recommendations for the resulting data set.

## 2.1 A Web-Based Solution

Despite these difficulties, the savings outlined in the workbook could prove to be considerable for the business; in addition, lowering energy consumption, increasing efficiency, and minimizing waste would benefit not only the company, but also the nation and future generations.

With these time, money, and manpower constraints in mind, the Instrumentation Research Laboratory at the University of Maine, in cooperation with the U.S. Department of Energy and the Maine Department of Economic and Community Development, decided to lighten the burden of reading the *Self-Assessment Workbook*, figuring out which recommendations to take, and looking up and calculating the associated formulas to realize these energy-saving suggestions by implementing the *Workbook* on the web as a simple, easy-to-use service. The only requirements for using the program would be access to the yearly utility bills of the plant, and knowledge of the overall layout and working operation of the plant; again, this means that a single person (most likely the owner or the chief supervisor, as suggested in the *Workbook*) will be able to accomplish this.

In addition, this web-based implementation of the *Self-Assessment Workbook* would prove invaluable in the state of Maine since the closest U.S. Department of Energy Industrial Assessment Center is in Amherst, Massachusetts; no participating universities exist in the state, which virtually eliminates the chances of evaluating the operations of small manufacturing facilities. It was the goal of the University of Maine Instrumentation Research Laboratory, with support from the U.S. Department of Energy and the Maine Department of Economic and Community Development, to enable small manufacturers in Maine the chance to increase productivity and decrease cost by making the *Workbook* accessible online.

## 2.2 Choice of Implementation

Porting the *Electronic Self-Assessment Workbook for Small Manufacturers* to the web was a given; but what implementation would best suit the needs of the projected users? The final product would have to be:

- simple enough to navigate even for users who might not necessarily be “computer literate”;
- platform- and browser-independent, as well as compact, to take into account the variety of systems used;
- integrable with a database application, so that users may save and review their information at will;
- easy to create and maintain, so that future versions of the *Workbook* will be easy to port from their original (written) format

### 2.3.1 Original Implementation

To achieve these goals, Java applets were originally chosen (in 2003) to develop the web version of the *Workbook* [5]. The database then used was Microsoft Access, which already existed on the Windows system planned as the web server. This seemed to be the most logical choice at the time since multiple simultaneous requests to the server were anticipated. By using applets, which run entirely on the client machine, the processing power of the server would not be needed to perform the calculations required in processing user data; processing would be done on the client computer. This also made the program platform- and browser-independent, since all that was needed was a Java-enabled browser.

The application was built and installed on an internal server, then tested in accordance with the goals outlined above. Figure 2 below is a screen shot of one of the recommendations from the *Workbook*:

[Home](#)  
[Login](#)  
[Register](#)  
[Original Workbook](#)  
[Email Developer](#)

**Rec 1: Replace Drive Belts on Large Motors with High Torque Drive Belts or Energy Efficient Cog Belts.**

**Recommendation # 1**

<b>Total estimated Horse Power for V-Belts:</b>	232.5
<b>Average Efficiencies of the motors (%):</b>	85.0
<b>Average Load Factor (%):</b>	75.0
<b>Annual Operating Time (Hrs/Yr):</b>	2080.0

**Select any of the radio buttons to get estimate**

Cog Belts (estimated energy savings 2%)  
 HTD Belts (estimated energy savings 6%)

The anticipated reduction in power is 0.0
The anticipated energy savings is 0.0
Consumption savings = \$0.0
Demand savings is \$0.0
Total Annual Savings = \$0.0

<b>No. of HTD belt drives required:</b>	19.0
<b>Cost of each belt drive (\$):</b>	200.0
<b>Total Implementation cost of HTDs (\$):</b>	0.0
<b>Simple payback(Yrs):</b>	0.0

\*COG Belts installation is recommended due to its inherent safety.

[Go to Report Page](#)

**Figure 2.** Screen Shot of Java Applet Implementation of a *Workbook* Recommendation

Unfortunately, testing revealed unexpected drawbacks:

- limited acceptance--the existence of hostile Java applets [6], which are applets that “break out” of the Java virtual machine they run on to access parts of the user’s system has prompted security-conscious users to disable Java in their browsers; and cookies (which are required to send information to and from the server) are now rejected by most users because of tracking issues;
- slow response time--applet loading and information sending times are sluggish, especially if the data is being sent through dial-up Internet access, which is a possibility at some workplaces

The limitations discovered were inherent in programming using Java applets, so another approach needed to be taken. The goals set for the service had not changed, but the implementation of the application would have to be altered.

### 2.3.2 The Alternative: PHP

After an assessment of the needs and goals of the undertaking, PHP (PHP: Hypertext Processor) was chosen to reconstruct the web-based *Electronic Self-Assessment Workbook for Small Manufacturers*, because of its excellent fit with the project.

PHP was originally developed in late 1994 by Rasmus Lerdorf to keep track of viewers of his online resumé. The first public version was released in early 1995 under the name Personal Home Page Tools, and was merely a simple parser that recognized a few commands [7]. Today (early 2005) it is estimated that PHP is used in over 18 million domains and in over 1 million IP addresses [8].

This popularity is evidenced by characteristics that make PHP a superb implementation of the project at hand. First, PHP commands are parsed on the server, so all the data that is sent to the browser is in the form of HTML (HyperText Markup Language). This means that browser compatibility is not an issue, since neither Java nor cookies are used in the page the browser sees. The application will also work on all platforms with no special requirements since the PHP interpreter only needs to be installed on the server.

PHP is also quite easily integrated with database servers, since it has various built-in modules to support a number of databases. Because of this freedom, MySQL (where SQL stands for Structured Query Language) was chosen as the database application, supplanting Microsoft Access; not only is it platform-independent, but as full-featured open-source software, it solves the problem of buying and licensing for any and all platforms that the server may support.

Finally, PHP, being a C-like language, is easy to code; little time is needed to adjust to its syntax. Take an example between the “Hello World” code for PHP and that for Java:

#### PHP

```
<?php
    echo "Hello World";
?>
```

#### Java (from Sun website [9])

```
import java.applet.Applet;
import java.awt.Graphics;

public class HelloWorld extends Applet {
    public void paint(Graphics g) {
        g.drawString("Hello world!", 50, 25);
    }
}
```

This straightforwardness does not mean that PHP has limited use; it is a powerful language with many built-in functions, and is more than adequate for this task. In fact, because of the simplicity and clarity of the language, future changes that may have to be made to the application will be easy to undertake.

Figure 3 below is a screen shot of one of the recommendations in the PHP implementation:

**Electronic Self-Assessment Workbook**

[Home](#)  
[Register](#)  
[Login](#)  
[Original Workbook](#)  
[Disclaimer](#)

**Recommendation 1 for Test**

**Replace Drive Belts on Large Motors with High Torque Drive Belts or Energy Efficient Cog Belts.**

Total Estimated Horse Power for V-Belts:	<input type="text" value="232.5"/>
Average Efficiencies of the motors (%):	<input type="text" value="85"/>
Average Load Factor (%):	<input type="text" value="75"/>
<a href="#">Annual Operating Time (hrs/yr):</a>	<input type="text" value="2080"/>

---

Select any of the radio buttons to get estimate

COG Belts (Estimated energy savings 2%)  
 HTD Belts (Estimated energy savings 6%)

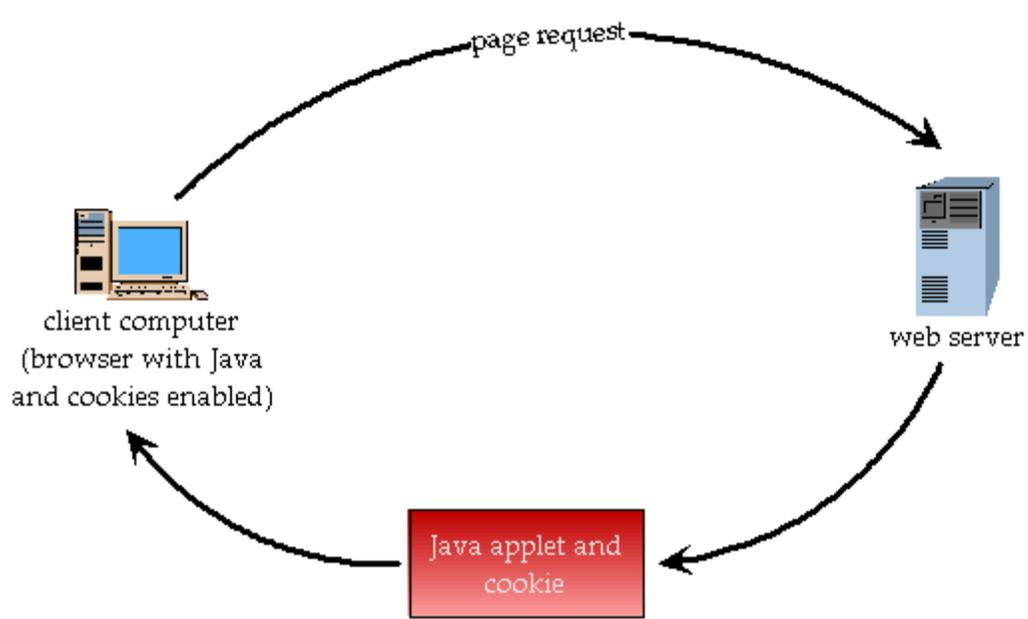
---

The anticipated reduction in power:	<b>3.06</b>
The anticipated energy savings:	<b>6365.6</b>
Consumption Savings:	<b>0</b>
Demands Savings:	<b>0</b>
Total Annual Savings:	<b>0</b>
Number of HTD belt drives required:	<input type="text"/>
Cost of each belt drive (\$):	<input type="text"/>
Total implementation cost of HTDs (\$):	<b>0</b>
Simple Payback:	<b>immediate</b>

**Figure 3.** Screen Shot of PHP Implementation of a *Workbook* Recommendation

## 2.4 Java Applet Processing Framework

The Java processing framework is shown in Figures 4, 6, and 7. When the client computer requests a page from the server (Figure 4), the server sends back a Java applet, which then runs on the client, and a cookie. The applet now controls all subsequent requests from the client to the server, while the cookie is used to keep track of user-selected recommendations (Figure 5).



**Figure 4.** Java Processing Framework (Page Request)

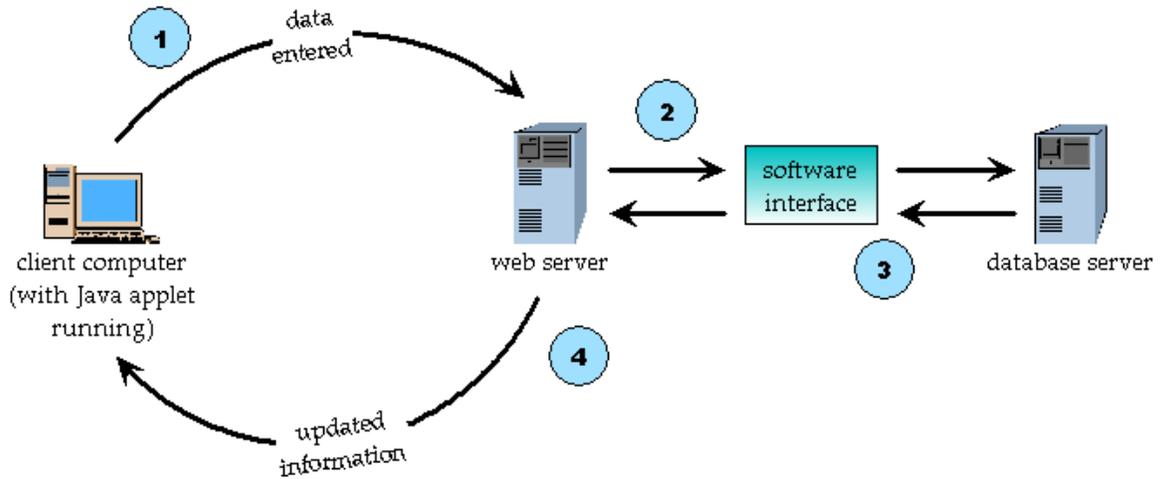
**Select the checkboxes next to the appropriate recommendations for your company.**

<b>Recommendation for energy savings through better utility selection</b>	
(1) Replace Drive Belts On Large Motors With High Torque Drive Belts or Energy Efficient Cog Belts.	<input type="checkbox"/>
(2) Use Synthetic lubricants.	<input type="checkbox"/>
(3) Begin a Practice of Monitoring Electrical Demand.	<input type="checkbox"/>
<b>Recommendation for Turning Off Equipment or Using Set-Back Timers.</b>	
(4) Turn Off Equipment When Not in Use.	<input type="checkbox"/>
(5) Install Set Back Timers on Thermostats Controlling Space Heating.	<input type="checkbox"/>
<b>Recommendation for Fuel Fired Boilers or Heaters.</b>	
(6) Implement Periodic Inspection and Adjustment of Combustion in a Natural Gas Fired Boiler.	<input type="checkbox"/>
(7) Implement Periodic Inspection and Adjustment of Combustion in a an Oil Fired Boiler.	<input type="checkbox"/>
(8) Preheat Boiler Combustion Air With Stack Waste Heat.	<input type="checkbox"/>
<b>Insulation Recommendations</b>	
(9) Insulate Condensate Return Tank.	<input type="checkbox"/>
(10) Insulate Plant Roof.	<input type="checkbox"/>
<b>Lighting Recommendations</b>	
(11) Replace Standard Fluorescent Lighting With Energy Efficient Tubes.	<input type="checkbox"/>
(12) Lower Lighting Levels.	<input type="checkbox"/>
<b>Air Compressor Recommendations</b>	
(13) Redirect Air Compressor Intake To Use Outside Air.	<input type="checkbox"/>
(14) Repair Compressed Air Leaks.	<input type="checkbox"/>
(15) Lower Air Pressure in Compressors.	<input type="checkbox"/>
<b>Waste Reduction Recommendations</b>	
(16) Minimize Waste of Tap Water.	<input type="checkbox"/>
(17) Implement Corrugated Cardboard Recycling Program.	<input type="checkbox"/>
(18) Replace Conventional Paint Spray Gun.	<input type="checkbox"/>
(19) Use a Solvent Recovery Unit.	<input type="checkbox"/>

**Figure 5.** Recommendation Selector Screen (Java Applet Implementation)

When the client wishes to save data for later calculations (Figure 6), the applet connects to the web server which sent it (1). The applet cannot store data locally, nor connect directly to the database server due to built-in security controls.

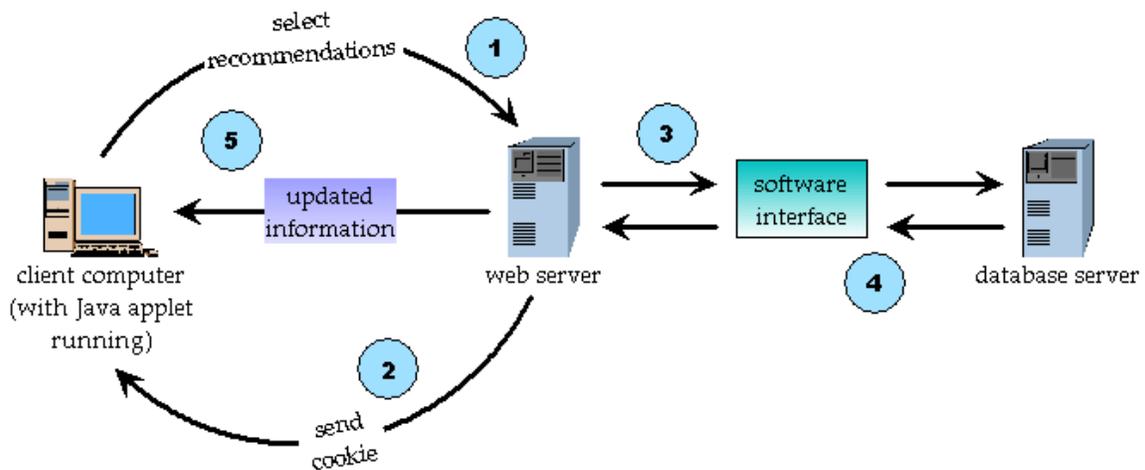
A software interface on the physical web server detects the applet connection and passes the data sent to the web server application to the database application (2). The database application then connects with the software interface to send the updated information back to the web server (3), which passes the information on to the applet on the client computer (4).



**Figure 6.** Java Processing Framework (Database Update)

When the client is ready to select recommendations (Figure 7), the applet connects to the web server (1). Since the web server needs to keep track of the recommendations selected by the user and display only those, the server sends a cookie to the client (2). The selected recommendations are then stored in the cookie, which the web server “consults” before selecting the appropriate page.

Once the proper page is selected, the web server communicates with the database server using the software interface (3). The database then sends the data required to the web server application (4), which transmits the data to the client computer (5). The applet can then use the data to perform calculations and display the requested recommendations.

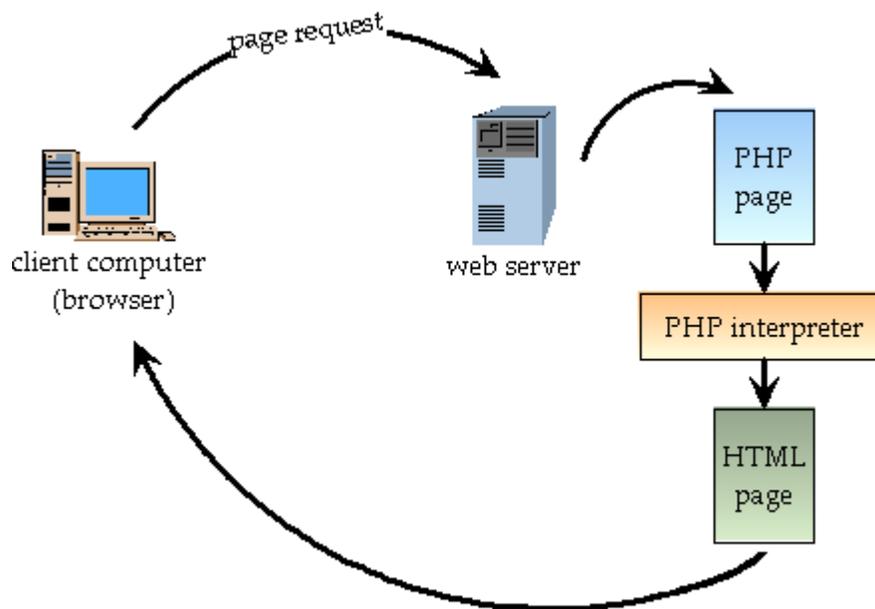


**Figure 7.** Java Processing Framework (Recommendation Selector)

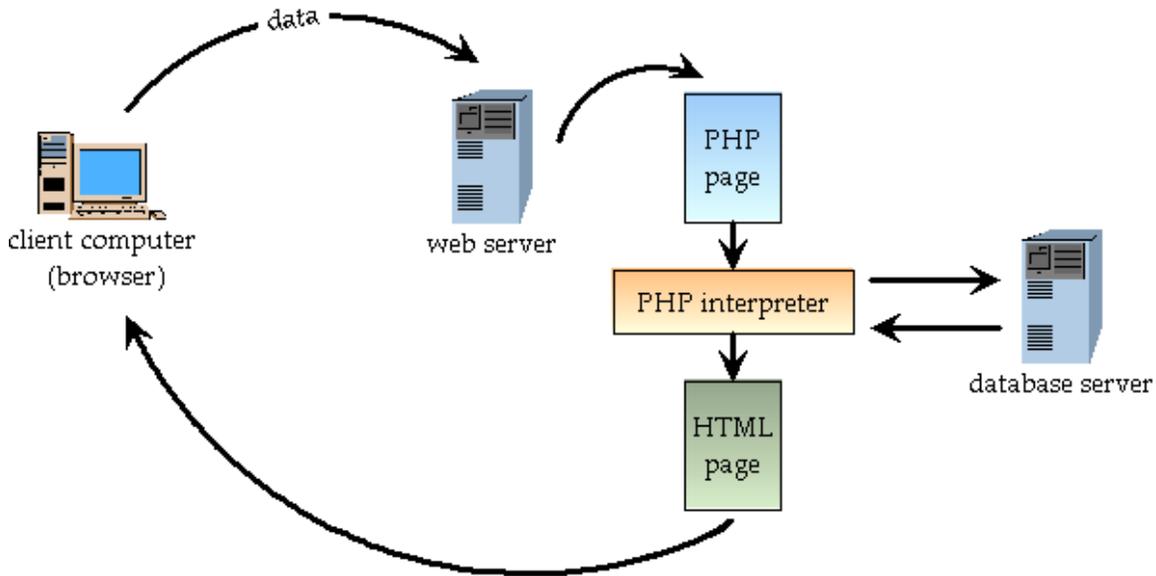
The framework reverts to the simple Java processing cycle shown in Figure 4 when the recommendations are being displayed; in this case, the cookie on the client machine is used by the server to keep track of the recommendations that need to be displayed.

## 2.5 PHP Processing Framework

The framework for the PHP implementation (Figures 8 and 9) on the other hand is simpler, with page requests and database updates kept separate. Each time the user requests a page, the PHP page is parsed by the PHP interpreter, then sent to the browser as HTML, as seen in Figure 8. When data is sent to the web server in the page, any needed database actions are controlled by PHP; the resulting page is again parsed by the interpreter and sent back to the client browser as HTML, as seen in Figure 9 below.



**Figure 8.** PHP Processing Framework (Page Requests)



**Figure 9.** PHP Processing Framework (Database Update)

### 3.0 Conclusion

Small manufacturers have historically faced a two-sided dilemma: their operations are large enough to influence the national energy consumption, yet they are individually too small to merit the assistance of their energy suppliers in conserving energy and increasing efficiency.

The *Workbook* was initially ported to the web using Java applets; however, testing of the package revealed serious drawbacks with this implementation, among them limited acceptance and slow response time.

The web-based, PHP-implemented incarnation of the *Electronic Self-Assessment Workbook for Small Manufacturers* was created to help guide small manufacturers in reducing costs and energy consumption and increasing productivity. In contrast to the print version of the *Workbook*, this web-based service greatly simplifies and reduces the work that the evaluator needs to accomplish this task.

Initial testing of the package satisfies all the goals set for the final product. In addition, a small installation package had been constructed to guide server administrators in installing the required components (web server, database application, PHP interpreter), as well as to set up the necessary database tables for the program.

The Maine Department of Economic and Community Development plans to install the application on one of their servers to enable small manufacturers in Maine to access the service. This application is clearly beneficial to the state since the closest U.S. Department of Energy Industrial Assessment Center is located in Amherst, Massachusetts.

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