GREEN COKE DISTRIBUTION

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1. Introduction

Green coke is a byproduct in the manufacturing process of oil. Once useless, green coke has become a very important component of the aluminum industry. Green Coke, after calcination, is used to make filters for the production process of aluminum. Although the filter making process was once done by the aluminum companies themselves, calcined coke is now produced by third party companies. One such company is CII Carbon. The purpose of this paper is to explain how AIMMS and Excel can improve CII Carbon's business practices. The paper will show how the two programs can work together to create a solver based on a model that can minimize business cost for the company. Finally, we hope that CII Carbon can use this solver to improve their business and that the model is flexible enough to account for real world changes.

In order to take on this task, we will first have to create a model that will describe the world distribution of green coke. Taking this model, we can expand it, and account for the specific needs of CII Carbon. This will allow CII Carbon to see the overall trend of market and improve business practices to cater those trends. The fundamental ideas behind the Worldwide model and the CII Carbon model are the same. Also by creating the model, our hope is that a CII Carbon employee will learn how Excel and AIMMS work together.

2. Worldwide Green Coke Model

2.1. **Basic Model Description.** We model how green coke is distributed worldwide. We do this with a set number of suppliers, calciners (where the green coke is processed), and customers. This model gives us the fundamental ideas both for the CII Carbon model and the Worldwide model. Once Excel and AIMMS are used in conjunction, the model will also allow us to see the world trends in this market. With this model, all parameters are constant functions. Through these numbers, we then computed our variable ***TotalCost*** which was the

total cost of running the business. Once we have our model in place and our variable easily computed, using the AIMMS interface we can easily manipulate the model which in turn change the value of ***Total-Cost***. AIMMS tracks how much of the green coke is at each location at any given time through the variable ***X***. In making this model, we first give have to have our sets:

(1) ***Sources*** - This set is indexed with ***i***. For this particular model, we have five suppliers.

(2) ***Calciners*** - This set is indexed with ***j***. For this particular model, we have three calciners.

(3) ***Customers*** - This set is indexed with ***L***. For this particular model, we have six customers.

(4) ***Qualities*** - This set is indexed with ***m***. For this particular model, we have two qualities.

We then create our parameters. Below is a list of the parameters used in this model and description of each:

(1) ***maxsupply(i)*** - This parameter stands for the max supply from source ***i***.

(2) ***Tput(j)*** - This parameter stands for the max amount of green coke a Calciner ***j*** can take.

(3) ***Demand(L)*** - This parameter stands for the demand from customer ***L***.

(4) ***freight1(i,j)*** - This parameter stands for the shipping cost from supplier ***i*** to calciner ***j***.

(5) ***freight2(j,L)*** - This parameter stands for the shipping cost from calciner ***j*** to customer ***L***.

(6) ***GreenCokeCost(i)*** - This parameter stands for the cost of green coke from source ***i***.

(7) ***InCustomerMaxQual(m,L)*** - This parameter stands for the max quality of Sulfur and Vanadium demanded by customer ***L***.

(8) ***InCustomerMinQual(m,L)*** - This parameter stands for the minimum quality of Sulfur and Vanadium demanded by customer ***L***.

(9) ***InSourceQual(m,i)*** - This parameter stands for the quality of Sulfur and Vanadium that the green coke supplied by the source ***i***.

(10) ***OutActualQual(m,L)*** - This parameter stands for the actual quality of Sulfur and Vanadium received by customer ***L***.

There are also two variables:

(1) ***X(i,j,L)*** - This variable stands for the amount of green coke at each given location based on all the parameters.

(2) ***TotalCost*** - This variable stands for the total cost to run the business. This is the variable that is trying to be minimized using this program. The variable is modeled by the following equation:

$$\sum_{i,j,L} [X(i,j,L) * (GreenCokeCost(i) + freight1(i,j) + freight2(j,L))] \tag{2.1}$$

Finally, there are also five constraints in this model:

(1) ***SupplyRestriction(i)*** - This constraint tells us the max supply the company can take in. If supply exceeds demand then the business will not profit. For this reason this constraint is modeled by the following equation:

$$\sum_{j,L} X(i,j,L) \leq maxsupply(i)$$

(2) ***TputRestriction(i)*** - This constraint tells us the max amount of greencoke (X) that the calciners can take in. It is modeled by the following equation:

$$\sum_{i,L} X(i,j,L) \leq Tput(j)$$

(3) ***DemandRestriction(i)*** - This constraint tells us the max amount of greencoke (X) that the customers want. It is modeled

by the following equation:

$$\sum_{i,j} X(i,j,L) = Demand(L)$$

(4) ***MaxQualRestriction(m,L)*** - This constraint tells us the max quality of Sulfur and Vanadium that the customers want. it is modeled by the following equation:

$$\sum_{i,j} X(i,j,L) * InCalcinerQual(m,i) \leq InCustomerMaxQual(m,L) * Demand(L)$$

(5) ***MinQualRestriction(m,L)*** - This constraint tells us the minimum quality of Sulfur and Vanadium that the customers want. it is modeled by the following equation:

$$\sum_{i,j} X(i,j,L) * InCalcinerQual(m,i) \geq InCustomerMinQual(m,L) * Demand(L)$$

2.2. **Using Excel.** Next we must input our data. We do this through Excel macros. Using AIMMS to input data would be a long cumbersome process. However, using Excel can make the task very easy and actually organize the data so that we can look at the final results of the project either in AIMMS or in Excel. The data in Excel will come in the form of charts, while the data in AIMMS will for the most part be in the form of bar graphs that can easily be manipulated.

Excel macros will allow the user to change input data values very easily and those data values will then be organized with a click of a button. Excel will lay out the data in a clear and easily understandable way. The huge benefit to Excel is the fact that CII Carbon already has all input data for both models in Excel spreadsheets. Because of this, a simple copy and paste into the Excel spreadsheet will allow CII Carbon to see their data in an organized fashion. Once this data is inputed into Excel, the data will be transfered to AIMMS where optimization calculations will be made. At this point, the user will have a choice to view the data in AIMMS or view the final data in Excel. In essence, Excel can use data from AIMMS and present it to the user.

2.3. **Using AIMMS.** Once all of this has been completed, our next job is to create a mathematical problem. We call our problem ***LeastCostTransport*** and we tell it to minimize the ***TotalCost*** variable using a linear programming algorithm. A linear programming model, essentially says that our answer comes from a linear equation. Notice equation (2.1), the value is in fact a linear variable that could easily be defined with matrices instead of sums. Finally, we use AIMMS

page manager which has a very friendly user interface to create a nice way to output the data. Our final product might look something like /refworldcokepage2.

We note that with this interface we can easily manipulate areas of data. For example, if we wanted to change the cost of green coke from supplier one, we can simply drag the bar graph from supplier one up or down and quickly recalculate the cost by clicking the "Total Cost" button. This simple interface gives us a way to calculate real world changes very quickly.

Now that we have shown a simple example of the problem it is time to get into the much more complex CII Carbon model.

3. CII Carbon Model

CII carbon is one of the leading producers in green coke. They have factories in the United States as well as China. Through our AIMMs model, our goal is to minimize the cost it takes to run their business. We will do this by using the model described in section one and expanding it to meet the needs of CII Carbon. Also, because the data is so complex for this model, we will be using Excel to organize the data which before was simply inputed into AIMMS itself. Our final goal is to have a user interface so that a CII Employee can easily use it. This paper in many ways will be a description of the AIMMs project as well as the Excel macros. After reading this paper, we hope that a CII Carbon employee will be able to understand the work done here as well know how to make changes to the model if necessary.

4. Final

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5. Final

5.1. **Current Work for CII Carbon Excel.** The CII Carbon Model has already been completed on AIMMS and Excel. Zachary and Steven have been working on the CII Carbon Excel sheet over the last two weeks. We have been cleaning up the macros and adding some new ones. Througout our work, some formating errors have been our biggest worries. We have mangaged to take care of most of these errors. Without the errors, the program can run multiple times with different number of sets. Also, we have been adding comments to the macros so that editors to macros can easily go back and change exactly what needs to be changed.

5.2. **Current Work for AIMMS.** The CII Carbon Model has already been completed on AIMMS and Excel. Zachary and Steven have been working on the CII Carbon Excel sheet over the last two weeks. We have been cleaning up the macros and adding some new ones. Throughout our work, some formating errors have been our biggest worries. We have managed to take care of most of these errors. Without the errors, the program can run multiple times with different number of sets. Also, we have been adding comments to the macros so that editors to macros can easily go back and change exactly what needs to be changed. Check macros have also been added to the project.

5.3. **World Coke Work for AIMMS.** Kristine and Brent have been working with AIMMS.

Our main World Coke page shows our input, which is the green coke cost, maximum supply, and customer demand. It also shows our output data, which is green coke transported from each supplier and the total cost which can be seen in Figure 1.

Our shipping page shown, in Figure 2, displays the total shipping cost, which is the cost from the sources to the calciners and the shipping cost from the calciners to the customers. It also shows the amount of green coke shipped from source to calciner, calciner to customer, and source to customer.

Shown in Figure 3, our capacity used page, we created a stacked bar chart to show the amount used by the source versus the maximum supply. We also have a chart showing the amount used by the calciner versus the throughput.

On our qualities received page, we have charts displaying the maximum and minimum qualities expected by each customer and the quality actually received of both sulfur and vanadium which is displayed in

Figure 4.

On each page, there is a working button that solves the model. When input is adjusted on any page, the relative output is adjusted accordingly.

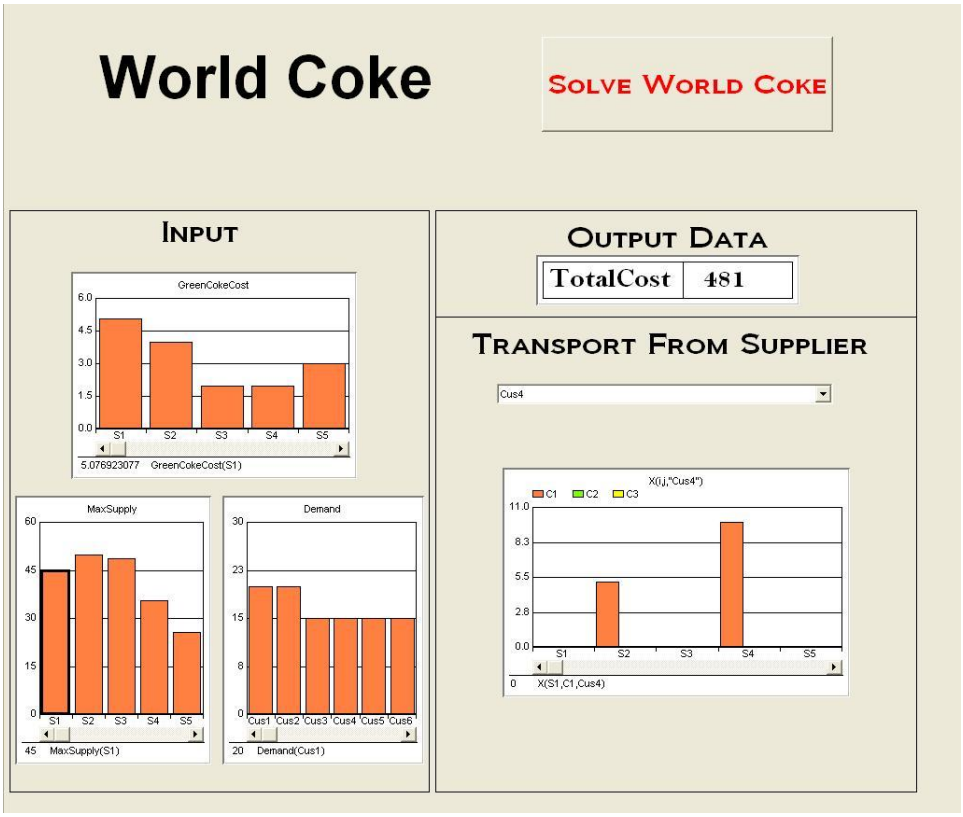

FIGURE 1. World Coke Page

The AIMMS world coke model was finished and work began on the CIICarbon model. A page format was created so that all pages contained a working "Run MP" button and displayed the total cost. This format can been seen in Figure 5.

5.4. **CII Carbon Work for AIIMS.** Plenty of time was spent organizing and optimizing previously created pages. A page format was created so that every page now contains a working "Run MP" button and displays the "Total Cost."' This format can be seen in the Shipping Page in Figure 5.

FIGURE 2. Shipping Page

5.5. **Current Work for world coke Excel.** Stephen and Jimbo are working with creating macros in Microsoft Excel. We created a Setup worksheet and an Input worksheet. The User enters data onto the setup worksheet like suppliers, calciners, and customers. The Input worksheet is linked to the setup worksheet. On the input worksheet are tables which include the data that was entered into the setup sheet. Now the user can enter the data into these tables. The biggest problem that we are facing is getting the macros' coding to work correctly. It is a very time consuming process that takes trial and error to get right.

Stephen and Jimbo have completed the Excel spreadsheets to display the AIMMS output data. The user will enter the number of sources, calciners, and customers involved in the distribution of the world coke. This information is entered into the setup worksheet and is displayed in 3 columns (See Figure 6).

The input worksheet displays the data that was inputed into the AIMMS program. This data is entered by the user into AIMMS and is displayed in Excel for easier viewing.The input worksheet data is displayed in tables and can be manipulated. Buttons were created for the user to quickly delete and rebuild the worksheet (See Figure 7).

Stephen and Jimbo have also created a check infeasibility button on

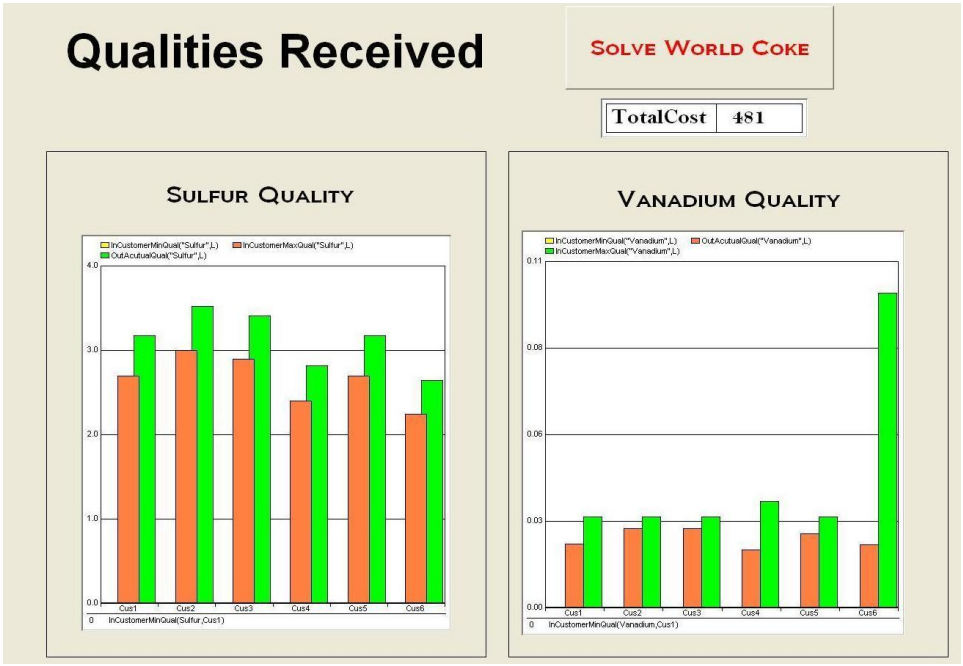

FIGURE 3. Qualities Received Page

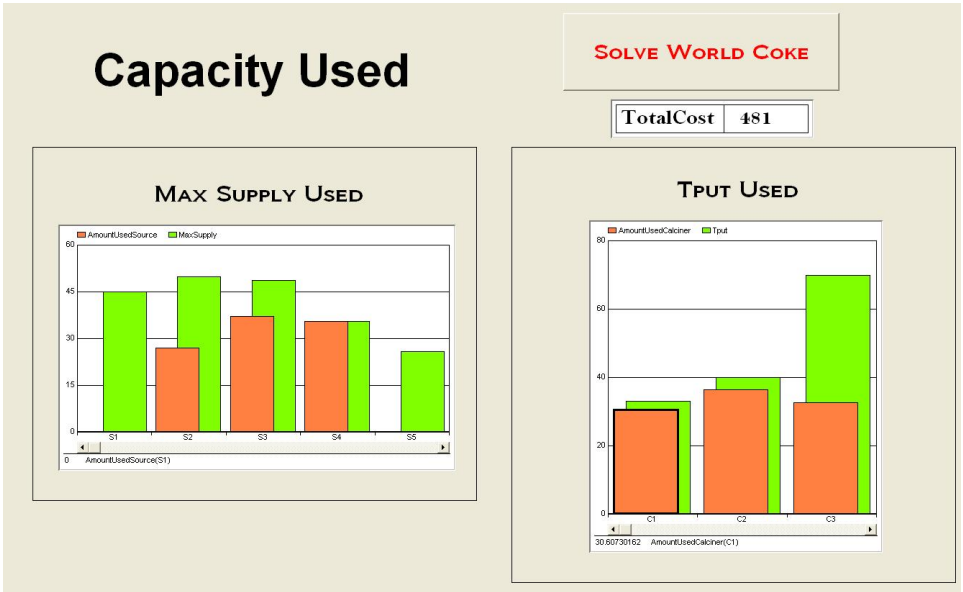

FIGURE 4. Capacity Used Page

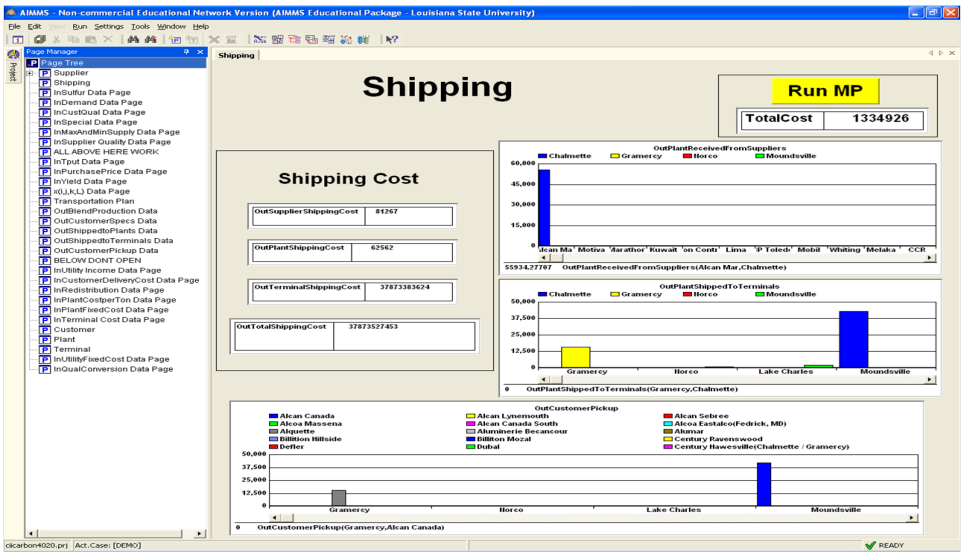

FIGURE 5. CII Carbon Shipping Page

	A	B	C	D	E	F	G	H	I	J	K	L	M
1													
2		4	<=Max Sources		Blank Setup			Delete Contents			Default Setup		
3		5	<=Max Calciners										
4		5	<=Max Customers										
5					Sources			Calciners			Customers		
6				1	Source 1		1	Calciner1		1	Customer1		
7				2	Source 2		2	Calciner2		2	Customer2		
8				3	Source 3		3	Calciner3		3	Customer3		
9				4	Source 4		4	Calciner4		4	Customer4		
10							5	Calciner5		5	Customer5		
11													

FIGURE 6. Excel Setup Worksheet

the input worksheet to make sure the user did not enter any data that would be infeasible. (i.e. Customer Demand > Max Supply, Customer Demand > Max Throughput, Minimum Quality > Maximum Quality) (See Figure 8). The last worksheet will display the output data received from AIMMS. AIMMS will calculate the optimal solution for minimizing cost with the given parameters. The Output Data worksheet in Excel gives the user an easier way to view the data computed from AIMMS (See Figure 9)

5.6. **Website.** A website was made with three different sections. The project summary page gives a basic view of the project and also links to a copy of the LaTeX file for a detailed look. The Excel and AIMMS parts of the project also have their own pages with summaries. Finally,

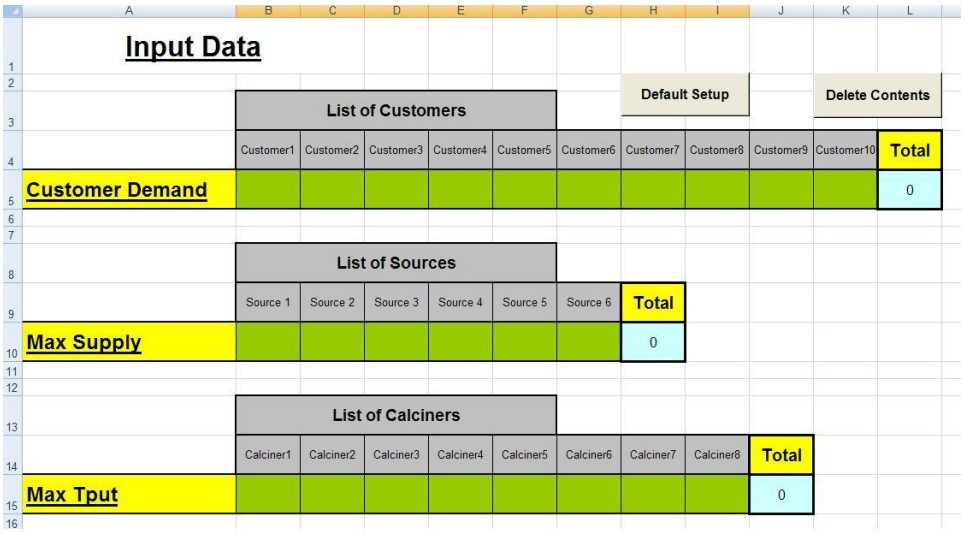

FIGURE 7. Excel Input Worksheet

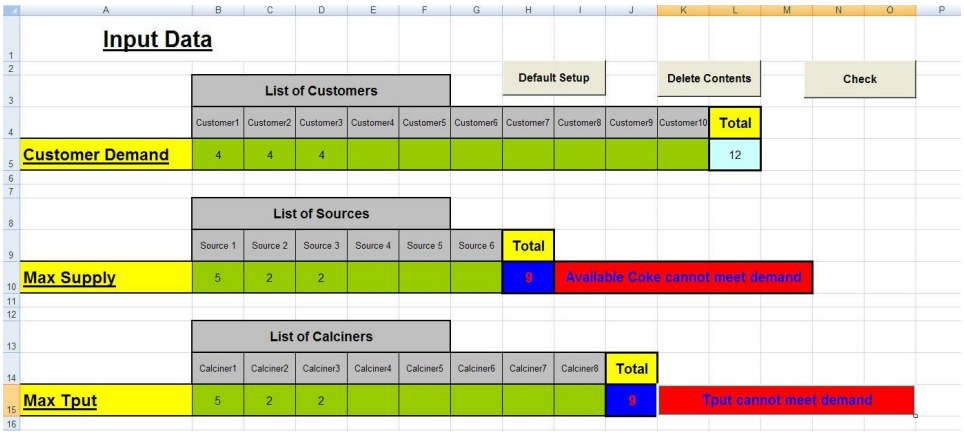

FIGURE 8. Excel Check Input

the website has a page about the group. This part contains in essence what we did for the project individually.

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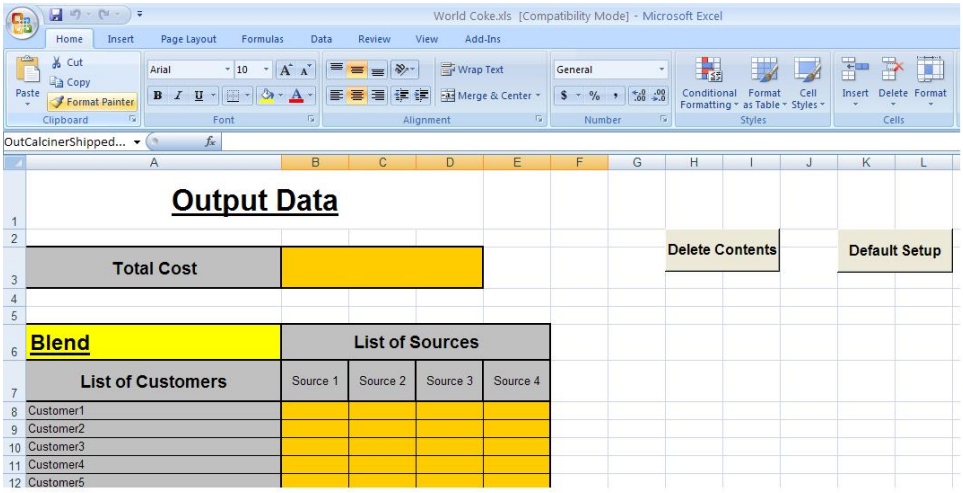

FIGURE 9. Excel Output