Working Paper 03-04

Methodology Used for Determining Transit Revenue Hours and Energy Consumption for all Modes of Travel for the 2030 RTP

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1.0 Introduction

The purpose of this paper is to provide insight into the methodology that was used to calculate revenue hours (transit) and energy consumption (all modes) for the 2030 Regional Transportation Plan (RTP). In addition, it was deemed important to document (to the greatest extent possible) data input sources. This paper examines both revenue hours and energy consumption because energy consumption is inextricably linked to revenue hours since transit revenue hours were the primary data used to calculate energy consumption by transit. Gasoline consumption rates were used to determine the amount of energy used by automobiles and trucks.

When developing the methodology that was used, an important consideration was that it would need to be applied equally to each of the 6 scenarios being evaluated -- A (1199), B (2430), C (3430), D (4430), E (5430) and F (6430). This is important because one of our objectives was to understand and represent differences between various scenarios based on their inherent differences, as opposed to differences caused by changes in methodology. Thus, the methodology to be used had to be the same for each scenario. Practically speaking, this meant that any macros applied to one scenario had to be applied to all scenarios.

Another important consideration was the need to develop a methodology that could use data currently stored in a typical EMME/2 databank, as EMME/2 databanks are created when scenarios are being developed. After examining the various data attributes in an EMME/2 databank it was determined that calculating revenue hours would be one way to compare scenarios. Each of the six scenarios is represented by an EMME/2 databank. Starting with scenario A and proceeding to scenario F, each of the scenarios had more and more projects, project additions and project enhancements built into them. Revenue hours for transit were calculated first. The revenue hours were then entered into an equation that was used to calculate the amount of energy consumed by transit. Results for cars and trucks were added at this point, and the total amount of energy consumed was calculated.

This paper is roughly divided into two sections. The first section addresses issues pertaining to calculating revenue hours, while the second examines calculations pertaining to energy consumption. Revenue hours are calculated only for transit. In the current transit EMME/2 network databank only one (period 3) of the eight time periods has been fully coded. This created additional challenges. Not only did the methodology need to address each scenario equally, but it also had to incorporate a mechanism to capture data for the other seven time periods, and for weekends, when none existed. Automobile and truck EMME/2 network databanks are coded for all eight periods during the week; however, those databanks also lacked weekend-specific data. Other challenges included data collection, model testing and making data comparisons. In sum, the methodology that was developed, used and presented in this paper is not meant to be presented as the best possible methodology, merely the best option for us given our available resources, time and staff. Other methods that may enhance the accuracy of results could be developed in the future. However, more data or a completed coded network would do more to enhance the accuracy of the results than any methodological improvements would.

2.0 Revenue Hour Calculations

The procedures that were used for calculating the revenue hours during a 24-hour weekday period for CTA buses, PACE, CTA rail and METRA are explained in this section. There are three basic steps to calculating revenue hours:

1. Establishing an average headway for CTA Bus, CTA Rail and PACE for each time period.
2. Applying a macro to the EMME/2 databank to extract revenue hours for each mode for each time period for each scenario.
3. Creating an Excel spreadsheet to store, analyze and display the revenue hours extracted from EMME/2.

In general, the procedure worked in the following manner. Each transit mode had been assigned a code in the EMME/2 network (table 1 & appendix B pg.23 of the 2020 TIP). An EMME/2 databank was created for each of the five scenarios (b-f). A series of macros (appendix A), one for each time period, was also developed. The macros were applied to the EMME/2 databank for each scenario. The result was the number of revenue hours by mode for each of the eight periods (table 2) during a 24-hour weekday -- for each of the five scenarios. The EMME/2 results were then entered into an Excel spreadsheet and any necessary adjustments were made. The spreadsheet was then used to display the final results for each scenario in a table.

Creating the macros to run in EMME/2 is a crucial element in determining the revenue hours. Each macro has four parts, one for each of the four transit lines. The independent variable in each macro corresponding to CTA Bus, CTA Rail and PACE is the average headway for each transit line during each time period. The method for determining the average headway is explained in detail later in this document. There is no independent variable for METRA. Instead, the results from period 3 have a formula applied to them, which results in the revenue hours for the other seven time periods. The specific procedure that is used is explained in detail in the METRA portion of this memo.

Period 3 will always be the one exception for all four transit lines. Period 3 has the data for each transit line already coded into the network, which negates the need to apply a headway-based macro to this period. What follows in the remainder of the memo is a more detailed explanation of the methodology that was used for each transit line, followed by an example of the results from scenario B (2430). In addition, most of the raw data is available in an Excel spreadsheet located at:

M\Planning\PlanDevelopment\transit assignment\ transit_revenue_hrs_allscenarios.xls

Table 1

Mode	Description
B	CTA regular bus lines
E	CTA express bus lines
C	CTA rail transit
P	PACE regular bus lines
Q	PACE express bus lines
L	PACE local bus lines
M	METRA commuter rail lines

Table 2

Period	Time of Day	# of Hours
1	8 P.M. – 6 A.M.	10
2	6 A.M. – 7 A.M.	1
3	7 A.M. – 9 A.M.	2
4	9 A.M. – 10 A.M.	1
5	10 A.M. – 2 P.M.	4
6	2 P.M. – 4 P.M.	2
7	4 P.M. – 6 P. M.	2
8	6 P.M. – 8 P.M.	2

2.1 CTA Bus: (Mode = B, E)

The procedure that was used to determine the headways for CTA buses is as follows: A random sample of bus routes (1, 3, 7, 8, 20, 62, 81, 91, 92, 108, 111, 126, 127 and 155) was examined to determine the average headway for each route during each time period. An average headway was then established for all routes in each time period (Table 3). The headway corresponding with each time period was then entered into an equation and run as a macro in EMME/2, using the transit databank for each scenario. After the revenue hours for all eight time periods had been established for a scenario, a multiplier was applied. The multiplier is used to adjust the base year results (scenario A1199) so they would be more closely aligned with the 2000 annual revenue hours reported to the federal government on form 406 by the CTA.

TABLE 3

Time Period	Average Headway
1 (8 P.M. – 6 A.M.)	20 minutes
2 (6 A.M. – 7 A.M.)	10 minutes
3 (7 A.M. – 9 A.M.)	use actual data
4 (9 A.M. – 10 A.M.)	12 minutes
5 (10 A.M. – 2 P.M.)	12 minutes
6 (2 P.M. – 4 P.M.)	10 minutes
7 (4 P.M. – 6 P. M.)	8 minutes
8 (6 P.M. – 8 P.M.)	12 minutes

The headways for each time period were then entered into the formula listed below:

Variables:
Revenue hours by Time Period = (P*n*)
@ltime = line time in minutes (This is a coded variable in the emme/2 databank).
tpmin = Minutes in Time Period
hdwy = Headway
min = 60 minutes
P*n* = (@ltime * (tpmin/hdwy) / min)
Time Periods:

Period 1=P1	Period 5=P5	24-Hour Day = P24
Period 2=P2	Period 6=P6	
Period 3=P3	Period 7=P7	
Period 4=P4	Period 8=P8	

The formula for CTA buses in each Time Period is as follows:

P1 = (@ltime * (360/20)/60) *note: although this time period is 10 hours, only 6 are used in the equation since most buses only operate for 6 of the 10 hours in this Time Period.
P2 = (@ltime * (60/10)/60)
P3 = (@ltime * (120/hdwy)/60)
P4 = (@ltime * (60/12)/60)
P5 = (@ltime * (240/12)/60)
P6 = (@ltime * (120/10)/60)
P7 = (@ltime * (120/8)/60)
P8 = (@ltime * (120/12)/60)
P24 = P1+P2+P3+P4+P5+P6+P7+P8

Each of the time periods was multiplied by 1.2 to adjust the total so that it would more closely correspond to the 2000 annual revenue hours reported to the federal government on form 406 by the CTA.

Scenario A (1199) Unadjusted	**Scenario A (1199) Adjusted**	**CTA form 406**
15,825	18,990	19,301

2.2 CTA Rail: (Mode = C)

The procedure for CTA Rail is based on determining the headways for each rail line during each of the time periods. The first step was to choose a station for each CTA rail line as a point of reference, since schedules are germane only for a particular station. The Clark/LaSalle Street Station was chosen for all but the Red Line, for which the Washington/State stop was used. The Clark/LaSalle schedules for each rail line were then used to determine the headways. The time interval between train arrivals during each of the eight time periods was then recorded. Then, the headway was calculated for each time period by determining the *median* value of the time interval between trains during a given time period. The median was chosen to reduce the influence of extreme headways that may occur infrequently during any given time period. The equation used, as well as an example (Table 4) of how this procedure was carried out, are provided below:

X_n = number of observations of a given time interval
Md = median for a time period

$Md = X_n/2$

Example: Brown Line Headway Observations during Time Period 1.

$Md = (X_1+X_2+X_3+X_4+X_5+X_6+X_7+X_8+X_9)/2$
$14.5 = (2+0+3+5+0+12+0+6+1)/2$

Table 4: Brown Line Period 1

Time Interval between Trains	Variable	Period 1: Observations
5	X_1	2
6	X_2	0
7	X_3	3
8	X_4	5
9	X_5	0
10	X_6	12
11	X_7	0
12	X_8	6
13	X_9	1
Total		29
Median		14.5 (10 minutes)

The median equals 15 (14.5 rounded up). The 15th observation occurs at the10-minute interval, thus the median headway for the Brown line during period one is 10 minutes. This procedure is applied to each time period for each rail line. Once the headway has been established for each CTA rail line, they are then combined and the same procedure described above is applied to the rail system as a whole. The result is a median headway for each time period. The headway corresponding with each time period was then entered into an equation and run as a macro in EMME/2 using the transit databank for each scenario.

Variables:
Revenue hours by Time Period = (P*n*)
@ltime= line time in minutes (This number is taken from Period 3 and applied to all periods).
Mp = Minutes in Time Period
Hdw = Headway
Min = 60 minutes
P*n* = (@ltime * (Mp/Hdw) / Min)

Period 1=P1	Period 5=P5	24-Hour Day = P24
Period 2=P2	Period 6=P6	
Period 3=P3	Period 7=P7	
Period 4=P4	Period 8=P8	

Equation:
P1 = (@ltime * (420/15)/60) *Note: Although this time period is 10 hours, only 7 are used in the equation since most buses only operate for 6 of the 10 hours in this Time Period.
P2 = (@ltime * (60/9)/60)
P3 = (@ltime * (120/hdwy)/60)
P4 = (@ltime * (60/12)/60)
P5 = (@ltime * (240/12)/60)
P6 = (@ltime * (120/11)/60)
P7 = (@ltime * (120/8/60)
P8 = (@ltime * (120/9)/60)
P24 = P1+P2+P3+P4+P5+P6+P7+P8

Comparison between CTA report (form 406) and Scenario A(1199):

Scenario A (1199)	**CTA form 406**	**Percentage Over/Under**
1,559	1,465	+6.41%

2.3 METRA: (Mode = M)

METRA is calculated in a different manner than the other transit lines. Headways are not used; instead, the amount of minutes for *each* train in *each* time period for *each* METRA line is determined, thus establishing the revenue hours for the base year, 2000 (scenario A1199). Each time period is summed to get a total for that time period for that METRA line. An example of how this was done, using the Milwaukee District West line, is shown in Appendix B.

After creating the equivalent of Appendix B for each train line, the total revenue hours for each time period (by METRA line) are then combined and put into a separate spreadsheet (Table 5). By summing all the revenue hours from all the METRA lines from each time period, the total number of revenue hours by time period is determined. The next step is to calculate the percentage of the total that each period equates to. This is important since it enables period three (the only period coded in EMME/2) to be used to determine all the other time periods for each scenario. As seen at the bottom of Table 6, each period had the per hour average calculated by dividing the total, by the weight (# of

hours in the time period). The weighted averages per hour were then summed. The percentage total of the day that each period equated to was then calculated by dividing the weighted total for a particular period by the sum weighted total. This method was chosen in order to minimize the effect that period one would have. Since this period encompasses 10 hours, even though there is not a lot of service, the cumulative effect of a 10-hour time period is that the total number of revenue hours are disproportionately high compared to the other time periods. Once the percentage for each period has been calculated, a formula can be used to convert period 3 EMME/2 results into revenue hours for the seven other periods. The first step is to convert period 3 into a total for the day. This is done by taking the period 3 EMME/2 results and multiplying them by 100, then dividing them by the percentage of the day that corresponds to period 3:

Total = (p3 * 100)/p3%
The next step was to compare the total revenue hours between what was calculated using METRA schedules (scenario A (1199)) and what was published in form 406.

Scenario A(1199)	**METRA form 406**	**Percentage Over/Under**
823	717	+15%

Scenario A had 15% more revenue hours than METRA had published in form 406. In order to create a base number so that future scenarios might be more accurate, the revenue hours for scenario A (1199) were adjusted by a factor of .87.

Adjusted Scenario A (1199) = Scenario A (1199) x .87
716.01 = 823 x .87

Now the base year, scenario A (1199) roughly equates to METRA's published revenue hours. To ensure consistency, the total revenue hours for all future scenarios were adjusted by the same factor (87).

Once the total revenue hours have been calculated, the revenue hours for each time period can be determined by multiplying the total revenue hours by the percentage of the day that corresponds to each time period. The following equations were used to calculate the revenue hours by time period for each scenario:

T = total revenue hours
Tadj = total adjusted revenue hours
P3n = Period 3 METRA total derived from the EMME/2 network.
P3% = Percentage of the day that Period 3 equates to (calculated using Metra schedules).
P*n* = Revenue hours by Specific Time Period
T = (P3n * 100)/P3%
Tadj = T * .87 (weighted number)

P1 = Tadj * .053876628
P2 = Tadj * .086822452
P3 = Tadj * .222263503
P4 = Tadj * .079730322
P5 = Tadj * .059336182
P6 = Tadj * .086822452

P7 = Tadj * .202172834
P8 = Tadj * .132119016
P24 = P1+P2+P3+P4+P5+P6+P7+P8

Table 5
Revenue Hours per Period

Railroad	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8	*Total*
HC	0.83	0.83	1.58	0.00	0.00	0.00	1.62	1.48	6.35
MDN	13.22	5.10	15.05	2.77	11.05	5.45	11.53	11.35	75.52
MDW	12.72	5.03	10.75	2.90	9.85	5.12	11.65	7.57	65.58
ME	20.68	6.62	26.93	5.37	16.17	9.25	25.78	12.42	123.22
NCS	0.55	2.30	3.30	0.00	0.58	1.38	3.57	3.03	14.72
BNSF	14.55	7.65	19.10	2.33	6.40	6.60	18.62	10.90	86.15
RI	12.28	5.60	14.22	2.80	5.40	8.97	11.63	8.30	69.20
SWS	1.67	1.12	3.40	0.92	0.38	2.68	4.07	2.20	16.43
UPN	15.22	4.97	16.17	3.02	8.08	5.63	13.35	6.45	72.88
UPNW	15.97	7.22	18.00	3.05	10.25	5.52	15.77	12.67	88.43
UPW	11.52	5.30	12.00	2.05	6.85	4.28	10.22	7.15	59.37
Total	119.20	51.73	140.50	25.20	75.02	54.88	127.80	83.52	677.85
Weight	7.00	1.00	2.00	1.00	4.00	2.00	2.00	2.00	
Weighted Total	17.03	51.73	70.25	25.20	18.75	27.44	63.90	41.76	316.07
Percentage	5%	16.4%	22.3%	8%	6%	9%	20%	13.2%	

2.4 PACE BUS: (Mode = P, Q, L)

Headways for Pace bus were determined by using the same procedures used to determine headways for CTA bus and rail. The first step was to determine the median headway (see CTA Rail) for each time period. This was accomplished by choosing a random sample of bus routes (318, 320, 350, 359, 366, 616, 626, 668, 669, 806, 824, 825, 882) and determining the time between buses on each route, examining information provide by PACE, and reviewing form 406. Once the headways are determined they could be easily plugged into the equations listed below, which are then entered into a macro to be used in EMME/2. Each equation is a macro that takes the coded period (period 3) and, by changing the headways, adjusts the revenue hours.

Basic equation to determine the median headway:

X_n = number of observations
Md = median for a time period

$Md = X_n/2$

Time Periods

Period 1=P1	Period 5=P5
Period 2=P2	Period 6=P6
Period 3=P3	Period 7=P7
Period 4=P4	Period 8=P8

24 Hour Day = P24

Equation to determine the PACE revenue hours per time period:

Revenue hours by Time Period = (P*n*)
@ltime= line time in minutes (This number is taken from Period 3 and applied to all periods).
Mp = Minutes in Time Period
Hdw = Headway
Min = 60 minutes
P*n* = (@ltime * (Mp/Hdw) / Min)
P1 = (@ltime * (360/65)/60)
P2 = (@ltime * (60/35)/60)
P3 = (@ltime * (120/hdwy)/60)
P4 = (@ltime * (60/40)/60)
P5 = (@ltime * (240/60)/60)
P6 = (@ltime * (120/40)/60)
P7 = (@ltime * (120/32.5)/60)
P8 = (@ltime * (120/45)/60)

P24 = P1+P2+P3+P4+P5+P6+P7+P8

2.5 Results

Each of the five scenarios has a unique EMME/2 databank. The macros (appendix A) that were created were applied to each scenario's EMME/2 databank. The results for one such scenario, scenario B (2430), is shown below. All of the revenue hours for each mode of transit were compiled by time period and summed. The total is comprised of the revenue hours for each mode of transit during a 24-hour weekday.

Table 6
Scenario B(2430)
Revenue hours for a 24 Hour Weekday Period

Time Period	CTA BUS	PACE	CTA Rail	METRA
1 (Hrs.=*)	2,627.12	976.27	467.19	160.82
2 (Hrs. =1)	802.73	390.51	88.99	69.80
3 (Hrs.=2)	2,018.23	726.80	205.38	189.55
4 (Hrs.=1)	642.18	390.51	94.22	34.00
5 (Hrs.=4)	2,568.72	781.02	355.96	101.03
6 (Hrs.=2)	1,605.46	781.02	177.98	74.04
7 (Hrs.=2)	1,926.55	781.02	246.43	172.42
8 (Hrs.=2)	1,133.28	520.68	228.83	112.67
Totals	13,324.27	5,347.81	1,864.98	914.33

Per Period Hourly Average

Time Period	CTA BUS	PACE	CTA Rail	METRA
1 (Hrs.=*)	437.85	195.25	77.87	22.97
2 (Hrs. =1)	802.73	390.51	88.99	69.80
3 (Hrs.=2)	1,009.12	363.40	102.69	94.78
4 (Hrs.=1)	642.18	390.51	94.22	34.00
5 (Hrs.=4)	642.18	195.25	88.99	25.26
6 (Hrs.=2)	802.73	390.51	88.99	37.02
7 (Hrs.=2)	963.28	390.51	123.22	86.21
8 (Hrs.=2)	566.64	260.34	114.41	56.34
24 Hr. Average	733.34	322.03	97.42	53.30

* note period 1 was calculated using the following hours; cta bus = 6, pace = 5, cta rail = 7 & metra = 7

3.0 Energy Consumption Calculations

The procedures that were used for calculating the total energy consumption (fuel and electricity) for a year for each scenario (B – F) are explained in this section. Two separate procedures were used to calcuate energy consumption -- one for cars and trucks, another for transit. Both procedures were applied to an EMME/2 databank that had been created for each scenario. The chief difference between the two procedures is that calculations for cars and trucks are based on a rate of consumption value, while calculations for all transit modes are based on revenue hours. The Excel workbooks and spreadsheets that are mentioned throughout this section of this document can be found at:

M\Planning\PlanDevelopment\transit assignment\ transit_revenue_hrs_allscenarios.xls
M\Planning\PlanDevelopment\transit assignment\ energy_calculations.xls

3.1 Car and Truck Energy Calculations:

The calculations used to determine the amount of energy consumed (gallons of fuel) by cars and trucks is based on the same methodology that was used for the 2020 RTP. In the first part, a series of macros are applied to an EMME/2 databank for a given scenario. Macro 2 is the key macro. This macro is where all of the calculations are performed. The end result of the various calculations is the number of gallons of gasoline consumed by time period. After all eight time periods have been calculated, the results are exported into an Excel spreadsheet. There they are formatted and converted into year 2000 dollar amounts. The steps used in EMME/2 to calculate the amount of fuel consumed are listed below:

In EMME/2
1. Open up EMME/2 databank for a given network scenario.
2. Run macro (macro 1: Appendix C).
3. Run macro (macro 3: Appendix C) which runs another macro (macro 2: Appendix C) for each of the eight time periods.
4. Put EMME/2 results into an excel spreadsheet.

Macro 1:
This macro clears the temporary fields ul1, ul2 and ul3 for use in future calculations.

Macro 2:
As previously mentioned, this is the macro where all of the calculations are performed. The first calculation performed by this macro calculates the average miles per hour (mph) of a link by multiplying the link length by 60 and then dividing the results by the auto time (minutes) on a link. The results are placed in temporary field ul1. The next step is the if/then statement that assigns fuel consumption rates to a link. In the previous step each link was assigned an average mph. The average mph for each link is then used to place that link into a fuel consumption category from which a fuel consumption rate (Table 1) is assigned to each link and placed in temporary field ul2. The third temporary field is filled by multiplying ul2 by auto volume link (volad) by link length (len). The result is the gallons consumed by link. This macro is applied to all the links in the network except toll collection links (vdf=7).

Macro 3:
This macro automatically runs macro 2 for each of the eight time periods in a given scenario.

Running the macros results in the number of gallons consumed for all the links. Appendix D shows this process for scenario B (2430) in time period 1, as well as the results.

The EMME/2 results for each scenario are then entered into that scenario's worksheet in an Excel spreadsheet (table 8). The next step is to convert the results from a 24-hour weekday to a yearly total. Multiplying the results by 365 (days in a year) does this. The result may be on the high side, but there is no network data for a weekend or holiday. At this point, the yearly amount of gallons of fuel used by cars and trucks has been calculated. Using the AAA Chicago Monthly Fuel Gauge Report (Oct. 2002) $1.51 a gallon was determined to be the average cost per gallon in the Chicago area. This number was then applied to the yearly amount of gallons consumed to determine the total yearly cost of gasoline. (Note: Trucks were not calculated independently and diesel fuel was not factored-in.) In general, trucks are assigned as car equivalents in the EMME/2 databank in the following manner; trucks classified as B or L are assigned as one car, trucks classified as M are assigned as two cars; and trucks classified as H are considered the equivalent of three cars. There are other methods that may be used to calculate trucks independent of cars, but they require more time than was available when this task was undertaken.

Table 7

MILES PER HOUR (MPH)	FUEL CONSUMPTION
> 1	.592
1 - 5	.141
5 –10	.084
10 – 15	.066
15 – 20	.056
20 – 25	.051
25 – 30	.047
30 – 35	.045
35 – 40	.039
40 – 45	.039
45 – 50	.039
50 – 55	.041
55 – 60	.047
60 – 65	.052

Table 8

Scenario: B (2430)					
Revenue hours for a 24 Hour Weekday Period					
Time Period	**CTA BUS**	**PACE**	**CTA Rail**	**METRA**	**Cars/Trucks**
1 (Hrs.=*)	3,467.79	901.16	373.75	39.97	1,217,583.50
2 (Hrs. =1)	1,155.93	334.72	88.99	121.44	521,226.84
3 (Hrs.=2)	2,421.88	726.80	205.38	165.67	2,416,561.75
4 (Hrs.=1)	963.27	292.88	66.74	59.16	794,618.69
5 (Hrs.=4)	3,853.10	781.02	266.97	44.03	3,102,029.75
6 (Hrs.=2)	2,311.86	585.76	145.62	64.42	1,816,240.75
7 (Hrs.=2)	2,889.81	720.93	200.23	150.00	2,041,765.25
8 (Hrs.=2)	1,926.55	520.68	177.98	98.03	1,077,759.00
Totals	18,990.18	4,863.94	1,525.65	742.72	12,987,785.53

3.2 TRANSIT Calculations:

Transit calculations involve two main data components: revenue hours and data from either form 402 (from the national transit database) or a transit agency's annual budget. First, the base year is calculated. In this example, the base year is scenario A (1199) from the 2030 RTP. Once the base year has been established, various ratios and proportions can be determined which can then be applied to any future scenario. In future scenarios, the only input data that changes are revenue hours; everything else is calculated from this. All of the calculations are performed in an Excel spreadsheet. Following is a summary of the two-step process:

Step 1 (base scenario)

1. Calculate the revenue hours for an entire year for each transit agency.
2. Enter relevant data from form 402 or transit agency budget.
3. Calculate cost per revenue hour, cost per gallon of gasoline, cost per gallon of diesel, and cost per kilowatt.

Step 2 (all other scenarios)

1. Using the revenue hours for a 24-hour weekday, calculate the total revenue hours for each scenario for an entire year (using base year ratios).
2. Carryover the cost per revenue hour from the base year.
3. Calculate the cost of diesel fuel, gasoline and electricity.
4. Calculate the amount of diesel fuel, gasoline and electricity consumed.
5. Finish total calculations for the rest of the spreadsheet.

Table 9 shows the results for the base year, scenario A(1199).

Table: 9

Scenario: A (1199) Annual Amounts

Item	CTA BUS	PACE	CTA Rail	METRA	Transit Total
Gasoline (Gallons) [1]	11,673	N/A	N/A	N/A	N/A
Diesel (Gallons)	22,636,519	5,127,571	N/A	24,748,307	52,512,398
Electricity (Kilowatts)	N/A	N/A	350,807,562	125,599,805	476,407,367
Cost per Revenue Hour [2]	$3.86	$3.56	$40.63	$124.95	$9.30
Revenue Hours	6,033,371	1,370,152	506,258	219,043	8,128,823
Total Diesel Cost	$23,305,021	$4,882,554		$20,285,498	$48,473,073
Total Electricity Cost	N/A	N/A	$20,569,131	$7,084,676	27,653,807
Total Energy Cost by Mode	$23,305,021	$4,882,554	$20,569,131	$27,370,174	$76,126,880

Notes
* All dollar figures are expressed in year 2000 dollar amounts
[1] CTA includes ethanol; Cars/Trucks gasoline total includes all types of gasoline.
[2] Cost per revenue hour is from the base year, 2000 and does not change from one scenario to another.

Detailed process:

The process begins with and is based on revenue hours for each scenario. In a previous memo (M\Planning\PlanDevelopment\transit assignment\ energy.doc), the process for determining the revenue hours for a 24-hour weekday was documented. Using the revenue hours for a 24-hour weekday for each transit agency is the beginning point for all the transit agencies. Each transit agency uses the following formula to determine the yearly amount of revenue hours:

Variables:
R = 24-hour Weekday Period Revenue Hours (derived from emme/2)
D = Weekdays in a year
SD = Saturdays in a year
Sn = Sundays and Holidays in a year.
Sat = % of Saturday relative to a weekday.
Sun = % of Sunday relative to a weekday.
ARH = Annual Revenue Hours
ARH = (r*d)+((r*sat)*sd)+((r*sun)*sn)

Base Year Sources:
Form 402:
Gasoline (CTA Bus), Diesel (CTA Bus, PACE, CTA Rail, METRA), Electricity (CTA Rail, METRA)

CTA Annual Budget Summary (2003):

Total Fuel Cost (CTA Bus), Total Electricity Cost (CTA Rail)

PACE 2003 Operating and Capital Program Budget
Total Fuel Cost (PACE)

EMME/2:
Annual Revenue hours (CTA Bus, PACE, CTA Rail, METRA)

METRA 2001 Program and Budget:
Total Fuel Cost (METRA), Total Electricity Cost (METRA)

Equations:
Cost Per Revenue Hour = Total Energy Cost by Mode/Annual Revenue hours

Annual Revenue hours: (Examples of annual revenue hours calculations are from scenario B (2430))
CTA Bus = Revenue hours = 18,990
= (18,990.18 *255)+((18,990.18*0.65)*52)+((18,990.18*0.49)*59)
CTA Bus Annual Revenue hours = 6,033,371

PACE = Revenue hours = 1,370,152
= (1,370,152*255)+((1,370,152*0.35)*52)+((1,370,152*0.144)*59)
PACE Annual Revenue hours = 1,370,152

CTA Rail = Revenue hours = 517,399
= (517,399*255)+((517,399*0.74)*52)+((517,399*0.65)*59)
CTA Bus Annual Revenue hours = 517,399

METRA = Revenue hours = 211,385
= (211,385*255)+((211,385*.47)*52)+((211,385*.26)*59)
METRA Annual Revenue hours = 211,385

Total Energy Cost by Mode = Total Fuel Cost + Total Electricity Cost
Total Transit = Sum of each row

Each scenario is calculated using the same methodology. First, the revenue hours for that scenario are calculated in EMME/2 and exported into an Excel spreadsheet. Next, the annual revenue hours are multiplied by the cost per Revenue Hour to determine the Total Energy Cost by Mode. Then, using ratios calculated from the base year (scenario A (1199), the total costs of fuel and electricity are calculated, along with the amount of gasoline, diesel and electricity consumed. The ratios are listed below:

CTA Bus: Total Diesel Cost = Annual Revenue hours * Cost Per Revenue Hour
Gasoline = Annual Revenue hours * % of fuel that is gasoline (0.001934739)
Diesel = Annual Revenue hours * % of fuel that is diesel (0.97131511)

PACE: Total Diesel Cost = Annual Revenue hours * Cost Per Revenue Hour

Diesel = Annual Revenue hours * cost per gallon ($.95 scenario A(1199) gallons/ total fuel cost).

CTA Rail: Total Electricity Cost = Annual Revenue hours * Cost Per Revenue Hr.
Electricity = Annual Revenue hours * Cost Per Kilowatt ($17.06 scenario A(1199) kilowatts/ total kilowatt cost).

METRA: Total Diesel Cost = Annual Revenue hours * Cost Per Revenue Hour
Diesel = Annual Revenue hours * cost per gallon ($1.22 scenario A(1199) gallons/ total cost).
Total Electricity Cost = Annual Revenue hours * Cost Per Revenue Hr.
Electricity = Annual Revenue hours * cost per kilowatt ($14.73 scenario A(1199) kilowatts/ total kilowatt cost).

3.3 Results

Once all the various calculations have been obtained for the transit related variables and the auto/truck variables, the total energy costs by mode are summed, resulting in the total energy cost for all modes. The above process is repeated for each scenario. The results for scenario B (2430) are shown below (Table 10).

Table 10

Scenario: B(2430) Annual Amounts						
Item	**CTA BUS**	**PACE**	**CTA Rail**	**METRA**	**Transit Total**	**Cars/Trucks**
Gasoline (Gallons) [1]	11,673	n/a	n/a	n/a	11,673	4,740,541,719
Diesel (Gallons)	22,636,519	5,127,571	n/a	24,748,307	52,512,398	n/a
Electricity (Kilowatts)	n/a	n/a	350,807,562	125,599,805	476,407,367	n/a
Cost per Revenue Hour [2]	$3.86	$3.56	$40.63	$124.95	$9.30	n/a
Revenue Hours	6,033,371	1,370,152	506,258	219,043	8,128,823	n/a
Total Diesel Cost	$23,305,021	$4,882,554	n/a	$20,285,498	$48,473,073	n/a
Total Electricity Cost	n/a	n/a	$20,569,131	$7,084,676	$27,653,807	n/a
Total Energy Cost by Mode [3]	$23,305,021	$4,882,554	$20,569,131	$27,370,174	$76,126,880	$7,158,217,996
Total all Modes						$7,234,344,876

Notes

* All dollar figures are in year 2000 dollar amounts

[1] CTA includes ethanol and Cars/Trucks gasoline total includes all types of gasoline.

[2] Cost per revenue hour is from the base year, 2000 and does not change from one scenario to another.

[3] Cars/Trucks are calculated using $1.51 per gallon as the unit cost

Appendix A

EMME/2 Macros used to calculate revenue hours (all are applied to period three)

PD1: ~+;1;n;(@ltime*(360/20)/60); ;mod=BE; ;all;2;2
~+;1;n;(@ltime*(300/65)/60); ;mod=PQL; ;all;2;2
~+;1;n;(@ltime*(420/15)/60); ;mod=C; ;all;2;2
~/+;1;n;(@ltime/60); ;mod=M; ;all;2;2;

PD2: ~+;1;n;(@ltime*(60/10)/60); ;mod=BE; ;all;2;2
~+;1;n;(@ltime*(60/35)/60); ;mod=PQL; ;all;2;2
~+;1;n;(@ltime*(60/9)/60); ;mod=C; ;all;2;2
~/+;1;n;(@ltime/60); ;mod=M; ;all;2;2;

PD3: ~+;1;n;(@ltime*(120/hdwy)/60); ;mod=BE; ;all;2;2
~+;1;n;(@ltime*(120/hdwy)/60); ;mod=PQL; ;all;2;2
~+;1;n;(@ltime*(120/hdwy)/60); ;mod=C; ;all;2;2
~+;1;n;(@ltime/60); ;mod=M; ;all;2;2;q

PD4: ~+;1;n;(@ltime*(60/12)/60); ;mod=BE; ;all;2;2
~+;1;n;(@ltime*(60/40)/60); ;mod=PQL; ;all;2;2
~+;1;n;(@ltime*(60/12)/60); ;mod=C; ;all;2;2
~/+;1;n;(@ltime/60); ;mod=M; ;all;2;2;

PD5: ~+;1;n;(@ltime*(240/12)/60); ;mod=BE; ;all;2;2
~+;1;n;(@ltime*(240/60)/60); ;mod=PQL; ;all;2;2
~+;1;n;(@ltime*(240/12)/60); ;mod=C; ;all;2;2
~/+;1;n;(@ltime/60); ;mod=M; ;all;2;2;

PD6: ~+;1;n;(@ltime*(120/10)/60); ;mod=BE; ;all;2;2
~+;1;n;(@ltime*(120/40)/60); ;mod=PQL; ;all;2;2
~+;1;n;(@ltime*(120/11)/60); ;mod=C; ;all;2;2
~/+;1;n;(@ltime/60); ;mod=M; ;all;2;2;

PD7: ~+;1;n;(@ltime*(120/8)/60); ;mod=BE; ;all;2;2
~+;1;n;(@ltime*(120/32.5)/60); ;mod=PQL; ;all;2;2
~+;1;n;(@ltime*(120/8)/60); ;mod=C; ;all;2;2
~/+;1;n;(@ltime/60); ;mod=M; ;all;2;2;

PD8: ~+;1;n;(@ltime*(120/12)/60); ;mod=BE; ;all;2;2
~+;1;n;(@ltime*(120/45)/60); ;mod=PQL; ;all;2;2
~+;1;n;(@ltime*(120/9)/60); ;mod=C; ;all;2;2
~/+;1;n;(@ltime/60); ;mod=M; ;all;2;2;

Appendix B
METRA Coding Example

Time Periods: To Chicago Milwaukee District West (MDW)								
Train/minutes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2200	70							
2202	60	15						
2204	30	42						
2206	10	60	3					
2208		31	18					
2210		48	34					
2212		3	49					
2214			52					
2216		8						
2218			61					
2220			42					
2222			55					
2224			35					
2226			69					
2228			24	51				
2230				33	42			
2232					75			
2234					74			
2236					74			
2238					38	36		
2240						79		
2242						38	41	
2244							79	
2246							50	30
2248								74
2250	16							58
2252	74							
2254	74							
2256	74							
Total Minutes per Period	408	207	442	84	303	153	170	162
Time Periods: From Chicago (MDW)								
Train/minutes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2201	15	60	3					
2203		35	35					
2205			73					
2207			62	16				
2209			30	44				
2211				30	45			
2213					74			
2215					74			
2217					75			

2219					20	54		
2221						75		
2223						25	62	
2225							33	
2227							79	
2229							34	
2231							70	
2233							63	
2235							55	7
Time Periods: From Chicago (MDW) continued								
Train/minutes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2237							43	25
2239							37	5
2241							33	22
2243							20	54
2245								72
2247								77
2249	44							30
2251	74							
2253	74							
2255	74							
2257	74							
Total Minutes per Period	355	95	203	90	288	154	529	292
Total	763	302	645	174	591	307	699	454

Appendix C

Macros for calculating automobile and truck fuel consumption in EMME/2

Marco 1: *Cleaning:* Clears temporary fields ul1, ul2, and ul3.

```
reports=cleaning
2.41
~<;1;y;ul1;0; ;*;2;2;6
2.41
~<;1;y;ul2;0; ;*;2;2;6
2.41
~<;1;y;ul3;0; ;*;2;2;6
```

Macro 2: *Speed*: Calculates an average mph for a link, assigns the link a fuel consumption value based on the average mph, calculates the amount of gallons consumed over the link, and sums all the links, resulting in the number of gallons consumed over the network for a given time period.

```
~/calculate gallons used by truck and cars
~!rm speed.%1%
reports=speed.%2%.%1%
s=%2%%1%
2.41
~/calculate miles per hour
~+;1;y;ul1;(len*60)/timau; ;*;2;2;q
2.41
~/input fuel consumption rates by speed
 1
 y
 ul2
(.592*(ul1.lt.1))+
(.141*((ul1.ge.1).and.(ul1.lt.5)))+
(.084*((ul1.ge.5).and.(ul1.lt.10)))+
(.066*((ul1.ge.10).and.(ul1.lt.15)))+
(.056*((ul1.ge.15).and.(ul1.lt.20)))+
(.051*((ul1.ge.20).and.(ul1.lt.25)))+
(.047*((ul1.ge.25).and.(ul1.lt.30)))+
(.045*((ul1.ge.30).and.(ul1.lt.35)))+
(.039*((ul1.ge.35).and.(ul1.lt.40)))+
(.039*((ul1.ge.40).and.(ul1.lt.45)))+
(.039*((ul1.ge.45).and.(ul1.lt.50)))+
(.041*((ul1.ge.50).and.(ul1.lt.55)))+
(.047*((ul1.ge.55).and.(ul1.lt.60)))+
(.052*((ul1.ge.60).and.(ul1.lt.65)))
vdf=1,6
vdf=8
2
2
```

```
q
2.41
~/calculate fuel consumption
1
y
ul3
ul2*volau*len
vdf=1,6
vdf=8
2
2
q
reports=reports
```

Macro 3: *Runall*: This macro runs macro three for all eight time periods.

```
~/ENTER THE SCENARIO NUMBER LIKE RUNALL 2340
~<speed 1 %1%
~<speed 2 %1%
~<speed 3 %1%
~<speed 4 %1%
~<speed 5 %1%
~<speed 6 %1%
~<speed 7 %1%
~<speed 8 %1%
```

Appendix D: Scenario B(2430) Results

```
_ EMME/2 Module:   2.41          Date: 03-02-24  12:58          User: E170/CATS.....rjp
Page:56097
 Project:       s02 scenario b30 (2430) highway analysis
 Scenario 24301: period 1.  8 pm to  6 am
-------------------------------------------------------------------------------
 NETWORK CALCULATIONS
  ul1      =   (len * 60) / timau

 Selected links: all

 Result summary:

 Allocated memory buffer space:    117777 (max.  816000)
 Number of expression evaluations:  39259 (link)
 Number of result values obtained:  39259 (link)
 Number of attr. values changed:        0
 Minimum result value:           0.14286  at link   3238   3239
 Maximum result value:           74.32417  at link  10960   8280
 Sum of result values:      1140803.75000
 Average result value:           29.05840

_ EMME/2 Module:   2.41          Date: 03-02-24  12:58          User: E170/CATS.....rjp
Page:56098
 Project:       s02 scenario b30 (2430) highway analysis
 Scenario 24301: period 1.  8 pm to  6 am
-------------------------------------------------------------------------------
 NETWORK CALCULATIONS

 ul2      =   (.592 * (ul1 .lt. 1)) + (.141 * ((ul1 .ge. 1) .and. (ul1
               .lt. 5))) + (.084 * ((ul1 .ge. 5) .and. (ul1 .lt. 10))) + (
              .066 * ((ul1 .ge. 10) .and. (ul1 .lt. 15))) + (.056 * ((ul1
              .ge. 15) .and. (ul1 .lt. 20))) + (.051 * ((ul1 .ge. 20)
               .and. (ul1 .lt. 25))) + (.047 * ((ul1 .ge. 25) .and. (ul1
               .lt. 30))) + (.045 * ((ul1 .ge. 30) .and. (ul1 .lt. 35))) +
              (.039 * ((ul1 .ge. 35) .and. (ul1 .lt. 40))) + (.039 * ((
              ul1 .ge. 40) .and. (ul1 .lt. 45))) + (.039 * ((ul1 .ge. 45)
              .and. (ul1 .lt. 50))) + (.041 * ((ul1 .ge. 50) .and. (ul1
              .lt. 55))) + (.047 * ((ul1 .ge. 55) .and. (ul1 .lt. 60))) +
              (.052 * ((ul1 .ge. 60) .and. (ul1 .lt. 65)))

 Selected links:   vdf=1,6
                 | vdf=8

 Result summary:

 Allocated memory buffer space:     78518 (max.  816000)
 Number of expression evaluations:  39150 (link)
 Number of result values obtained:  39150 (link)
```

Number of attr. values changed: 0
Minimum result value: 0.00000 at link 1779 12031
Maximum result value: 0.59200 at link 22136 22138
Sum of result values: 1901.70911
Average result value: 0.04857

_ EMME/2 Module: 2.41 Date: 03-02-24 12:58 User: E170/CATS.....rjp Page:56099
Project: s02 scenario b30 (2430) highway analysis
Scenario 24301: period 1. 8 pm to 6 am

NETWORK CALCULATIONS
ul3 = ul2 * volau * len
Selected links: vdf=1,6
| vdf=8

Appendix B
Result summary:

Allocated memory buffer space: 157036 (max. 816000)
Number of expression evaluations: 39150 (link)
Number of result values obtained: 39150 (link)
Number of attr. values changed: 0
Minimum result value: 0.00000 at link 457 20397
Maximum result value: 2261.34546 at link 10978 1757
Sum of result values: 1217583.50000
Average result value: 31.10047