Instructions_for_use_of_**RPM**_Conservation_P03_120924.docx

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There is strong interest in the Council's conservation targets among the regional stakeholders. Many stakeholders would like to better understand the assumptions and methods behind these targets. One way to gain some understanding is to examine the Regional Portfolio Model's (**RPM**) simulations.

One of the strengths of the **RPM** – in fact, one of its design criteria – is the transparency of its calculations. All calculations are performed with Microsoft Excel formulas and Visual Basic for Applications/Excel, both of which are in of the skill set of most power industry analysts.

The attached Excel workbook contains the extracted energy efficiency calculations from the version of the **RPM** that produced the final Council Sixth Power Plan resource strategy recommendations. This workbook simulator, in turn, is fed by the 750 **futures** that the final **RPM** model used for the Sixth Plan. The attached workbook replicates the cost and energy produced by the energy efficiency **supply curves** over each of the plans **futures**. The workbook results have been verified to the precision reported by Excel.

By modifying the formulas and input data, you can explore the relationship between the model's assumptions and results. This note provides some basic orientation to that process. At the end of this note, there appear references to the extensive documentation for the **supply curve** logic, which is largely unchanged from the Fifth Power Plan. What may be lacking in the documentation, you can explore on your own with the attached workbook. All formulas and VBA code are visible. Of course, users are always welcome to contact Council staff for assistance with this or any other Council work products.

Using the Workbook

Perhaps the quickest way to become familiar with the model is to run it. The workbook will open to the worksheet "Comments". On that worksheet are a couple of options that facilitate calculation speed and the exploration of **futures**. For the time being, we will disregard those. Simply hit the "Run Games" button.

The simulation will begin, and the worksheet "Conservation_Calc" containing the conservation **supply curve** calculations is activated. You can watch the status of the calculation in the status bar at the bottom of the workbook.

When the simulation of the 750 **futures** is complete, the application activates worksheet "Output". This worksheet captures key results for each of the 750 **futures**. The description of the "Output" worksheet also appears in the subsequent section of this note.

Returning to the run options for the application on the "Comments" worksheet, you can suppress the screen updating and obtain slightly faster execution. If you want to see the calculation for a specific **future**, you can cause the application to stop at any one of the 750 **futures** by specifying that **future** with the dropdown control on the worksheet. To make the workbook produce all the **futures**, simply return the value in the dropdown to "**Futures**," which is located at the top of the dropdown list.

Comments appear in columns Q and R of the worksheet "Conservation_Calc." These comments described the values in each row and provide some background about any formulas that appear in the row. This will be especially useful to those wishing to modify the workbook. There are also comments in the aqua blue "output" cells. The values in the output cells are preserved and reported in the "Output" worksheet.

You will be able to edit only particular cells in this workbook without changing the protection status of the workbook. The cells which ***can*** be edited appear in **dark blue, bold font on a lighter blue background.** The workbook refers to these as "input data cells." You will also be prevented from inserting or copying worksheets. Unfortunately, the "formula trace" feature of Excel is also disabled when a worksheet is protected.

The purpose of restricting the default scope of edits is to reduce the chance that a user might inadvertently break the workbook. If you want to edit a formula, you can do so by removing workbook and worksheet protection. There is no password. If you do not know how protection works and how to remove the protection, you may want to reconsider doing so.

As with all Excel workbooks, you will need to have macros enabled, the VBA entrusted to run, and the workbook in a Trusted Location in order for the workbook's subroutines to function. You may need administrative rights to your computer. If the workbook refuses to run and you are unfamiliar with these concepts, please contact your IT support staff to make the appropriate arrangements.

Understanding the Workbook Results

This section describes the data appearing in the columns of the worksheet "Output". It briefly describes the layout of the calculations in the worksheet "Conservation_Calc." It then identifies the location in the worksheet "Conservation_Calc" from which the application takes values for the worksheet "Output".

The worksheet "Output" is cleared and rewritten for each simulation run. The first column is column B, which identifies the **future** the row of data represents among the 750 **futures**. The next four columns (column C – F) identify the energy and average cost for **lost opportunity** and **discretionary** conservation at the end of the 20-year study. These energies are added and the costs are averaged by energy in the next two columns (column G – H).

The next two columns (column I – J) contain the gross and net cost of energy efficiency over the 20 years in millions of 2006 constant dollars. The gross cost represents a net present value of associated real levelized streams for each of the periods back to the beginning of the study.

Subsequent description of the layout of the calculations in worksheet "Conservation_Calc" will make this rather abstract description a bit more concrete. The net cost of energy efficiency subtracts, from the gross cost, the value of this energy priced in the wholesale energy market. This will of course depend on the on- and off-peak electricity price within each **future**.

The remaining columns in the worksheet "Output" contain snapshots of cumulative energy and average cost for **lost opportunity** and **discretionary** conservation at particular periods in the study. These snapshots are intended to inform the user about the values of cost and energy within the **Action Plan** time period, as this note will now explain.

The five-year **Action Plan** targets may be calculated from two different base points. To a certain extent this arises from the Bonneville Power Administration (BPA) fiscal year convention. The BPA, of course, is tasked with implementing the Council's energy efficiency targets, and it does this on a fiscal year basis. For this purpose, the Council uses the first 60 months of the study, from September 2009 to August 2014. (August 2014 corresponds to the end of the June -- August three-month period in the **RPM**.) Because the accounting for energy conservation begins at zero at the beginning of September 2009 in the **RPM**, the balance at the end of the 20th hydro quarter, June -- August 2014, is the relevant value. These values appear in columns O – R of the worksheet "Output" and are highlighted in pale green.

Many utilities, however, will take as their beginning point the start of the calendar year 2010, a couple of months before the final plan was adopted. All of the conservation targets were fairly well established by that point. If we want to determine the five-year target based on that starting point, however, we need to shift both the beginning and ending of the accounting window forward six months. For this reason, the worksheet "Output" contains the balances at the end of the second (columns K – N) and 22nd (columns S – V) hydro quarters. These hydro quarters end at the 6-month and 66-month periods and corresponding results are in highlighted in pale blue on the worksheet "Output." The differences between the 6-month and 66-month may be taken as the five-year target.

When the **supply curves** were being developed, it was anticipated that the 2007 Energy Independence and Security Act (EISA) would compel the adoption of compact fluorescent lights within the **Action Plan** time period. When such measures are adopted in standards and codes, however, they are no longer optional resources for the **supply curves**. Instead, they are reflected in the underlying load forecast. During the development of the Council's power plan, however, the Council agreed to give utilities credit for the remaining compact fluorescent light conversion potential. To reconcile these perspectives, that potential was therefore added to the regional targets. The five-year target of 1200 average megawatts therefore reflects the sum of the values from the **supply curves** produced by the **RPM** (and this simulation workbook) and the 100 average megawatts of energy efficiency adopted in code.

The layout of the calculations in "Conservation_Calc" resembles closely the layout in the **RPM** as implemented for the Sixth Power Plan final resource strategy[1] and for the Fifth Power Plan.

[1] . The Sixth Power Plan RPM model itself and the spinner graphs of output results have been posted to the Council's website since the release of the Plan.

The relevance of the Fifth Power Plan model is that there is a row-by-row description of the formulas and functions of that model appearing on pages L-36 to L-48 of the Fifth Power Plan Appendix L.[2] There are also descriptions there of the **supply curve** specification, the concepts, and the calculation strategy for **supply curve** energy and cost. The only logic enhancements made for the Six Power Plan (and the only digression from that narrative) pertain to features that provide for the modeling of conservation cost and availability uncertainty. These features, however, were turned off for the development of the Six Power Plan resource strategy and are turned off in this workbook simulation.

The first 40 rows of calculations in "Conservation_Calc" are setting up the **decision criteria** for conservation and the supply availability of lost-opportunity conservation. The **decision criterion** may be thought of as the long-term view for conservation energy in the wholesale power market. That is, it ignores some short-term and seasonal variation in power prices and it takes the seasonal shape of energy efficiency contribution into account. Because it uses averages over recent history to construct a "persistence forecast" of future price, some knowledge of power prices prior to the beginning of the study is necessary. These appear, for example, in rows 19 and 28. The rationale for these particular **RPM decision criteria** is discussed in the Fifth Power Plan, Chapter 6, Risk and Assessment and Management (pages 6-24 ff), and in Appendices L (pages L-88 ff).

Because **lost opportunity** conservation is often tied to the addition of new homes and businesses, it is influenced by the load growth in the **future** under consideration. Factors that influence the amount of conservation potential in each period due to load variation appear in row 40.

The application writes the on- and off-peak wholesale power prices associated with each **future** into the worksheet at rows 14 and 15. The load energy requirement goes into row 12. Calculations are then performed left to right, in chronological order.

Based on these factors and on the **risk premium** associated with the plan under consideration, the amount and cost of new **lost opportunity** conservation is derived from the **supply curves** in rows 58 through 60. (The selection of the plan – that is, determination of the optimal values of the **risk premiums** – is beyond the scope of this note and is not discussed here.) The energies are then adjusted for seasonal variation, on-peak energy, and valued in the market in rows 53 through 55. The net present values of the gross cost and the net cost in the market are in columns CV and CW. The values highlighted in aqua blue are picked up by the simulator and reported on the worksheet "Output". A similar calculation for on-peak **discretionary** conservation energy takes place in rows 64 through 73. The off-peak calculations are in rows 76 or 93. The supporting reasoning for the particular **RPM supply curve** values is found primarily in Chapter 4 and Appendix E of the Sixth Power Plan. Some discussion of the coordination of energy efficiency with the Council's load forecast also appears in Chapter 3 of the Sixth Power Plan.

[2] http://www.nwcouncil.org/energy/powerplan/5/Appendix%20L%20(Portfolio%20Model).pdf

Some subtleties deserve highlighting. The **risk premium** for **lost opportunity** conservation is in cell R51. The risk premium for **discretionary** conservation is in cell R64. The limitation on the amount of **discretionary** conservation that can be added to each quarter is specified in cell J66. As you will see, this constraint on energy addition dominates the selection of **discretionary** conservation for the first decade of the study. Constraining the ramp rate for **discretionary** conservation is necessary to prevent the **RPM** from implementing almost all of the **discretionary** conservation measures in the first period of the study. You may also note that while there is only one **supply curve** for **discretionary** conservation (cell R65), the **supply curves** for **lost opportunity** conservation (row 52) change periodically to reflect the assumed change in potential for this source of energy efficiency. The reasoning for this arrangement is laid out in the **supply curve** reference in the previous paragraph.

Some Recommended Experiments

There are several factors that influence the results of these energy efficiency calculations. Some of the more obvious are the electricity price and load values, the **risk premiums**, the **discretionary** conservation ramp rate, and the history of electricity prices prior to the beginning of the study. These are all good candidates for experimentation, and the cells controlling these values may be edited without modifying the workbook protection.

You may notice that the history of electricity prices (row 19) is low compared to the values that were actually seen during this period. This was a conscious choice on the part of the staff, because high values for historical electricity price would tend to bias conservation acquisition upward. This choice is in keeping with the more conservative values that staff believes enhance the credibility of energy efficiency recommendations.

If you wish to experiment with the effect of, say, natural gas prices on conservation acquisition, the way to do it would be through the electricity prices. The on-peak electricity prices for each hydro quarter (column) and each **future** (row) are in the worksheet “ELP_West_NP”; the corresponding off-peak prices are in the worksheet “ELP_West_FP”. One approach would be to simply take an average market heat rate of 6000 BTU/kWh and scale all these electricity prices to values corresponding to the new natural gas price. The natural gas prices, carbon penalties, and other factors used to produce the workbook’s electricity prices appear in the spinner graph for this resource strategy. You can use factors to create more sophisticated estimates of revised electricity price. The spinner graph is available for download from the Council’s website (http://www.nwcouncil.org/dropbox/Olivia_and_Portfolio_Model/Spinner_Graphs_6th_Pwr_Pln/Spinner_091220_2157_L813_2990_LR.zip)

Another issue to note is the control of calculations in this workbook. By default, all Excel calculations are placed in manual mode and are under the direct control of workbook VBA macros. If you place a value into a cell, such as for the **risk premium**, and want to see changes in formula values, you must press the key combination <CTRL>-I (that is "I" as in India). The key combination will force certain macros the fire that will refresh the values in Conservation_Calc.

Workbook Calculations and Structure

As mentioned at the beginning of this note, the conservation calculations were extracted from the **RPM** and placed into worksheet "Conservation_Calc". In order for the calculations to work outside of the **RPM**, the inputs to the calculations for each **future** are provided by additional logic in the workbook application. The additional logic also causes the calculations to be performed in the proper sequence. We will refer to this additional logic by the name "Reader." This Reader can take any number of worksheets containing data describing detailed **futures** and write the data into the calculation worksheet in a specific location. This enables the user to study particular questions and calculations without the burden of running the entire **RPM**. It also permits the user to find the net cost or value of the conservation in the wholesale energy market.[3]

You should note, however, some of the limitations of using this approach. The value of conservation is much more than the value of conservation energy in the wholesale market. This application will not permit you to evaluate capacity deferral or the value of defrayed Regional Portfolio Standard (RPS) resources, for example. Nevertheless, it should provide some insight into the basic operation of the conservation **supply curve** model and the sensitivity of results to assumptions.

Advisory

You may wish to replicate the energy efficiency values in the spinner graph or the **RPM**. If so, certain details will be useful.

First, the energy values appearing in the spinner graph are seasonal values. This means you'll have to pick up megawatt-hour values from rows 53, 66, 80, and 87. Be aware that these values represent megawatt-hours over "standard" periods and subperiods. The definition of and justification for standard periods can be found on pages L-11 ff of Appendix L, in the Fifth Power Plan.

Second, there is an error in the Sixth Power Plan version of the **RPM** that has been corrected in the simulation model. The **decision criterion** for **discretionary** conservation was inadvertently tied to the **decision criteria** for **lost opportunity** conservation. (The **lost opportunity** conservation calculation is correct.) This error results in 3 average megawatts less **discretionary** conservation by the end of the 20 year study on average (about 0.05 percent). While this is very small, it is quite evident at the high level of precision and reproducibility maintained by the **RPM**.

More References

Description of the **supply curves** and **supply curve** logic in the model was mentioned above, pages L-36 to L-48 of the Fifth Power Plan Appendix L. There is also a companion Fifth Power Plan Appendix P that describes the production of the electricity and load **futures**, among other

[3] Finding the value of energy in the wholesale energy market does ***not*** mean the energy is ***sold*** in the energy market. Instead, this value is a standard means of finding system cost or value irrespective of whether it serves load or is traded. Additional explanation appears in the Fifth Power Plan, Appendix L, pages L-13 ff.

things. The **supply curve** data used in the Sixth Power Plan final resource strategy model is discussed in Appendix E of that plan.[4] The spinner graph, feasibility space/efficient frontier, and model L813 are available from the Council's DropBox, as described on the previous page. A functioning version L813 with benchmark levels for each of the sources of uncertainties is in L813mini_P.xls . There is also a Windows setup executable that will install all of the requisite Council dlls on your machine.[5] None of these additional models or files is necessary for using the workbook application, however. The workbook is completely self-sufficient.

[4] http://www.nwcouncil.org/energy/powerplan/6/final/SixthPowerPlan_Appendix_E.pdf
[5] http://www.nwcouncil.org/dropbox/Olivia_and_Portfolio_Model/RPM_Setup/L813mini_P.xls