# RPM Phase 1 Scope and Functionality Assessment

October 3, 2014

At the request of Council staff, I reviewed the scope and functionality of the Phase 1 deliverable. I started with the Approach document by Navigant from July 31, 2014, and created a checklist of the major components and key details specified therein. I also reviewed an earlier checklist that I created for myself in the course of reviewing the Approach document prior to July 31, in case there was anything here that was still missing from the July 31 version of the Approach. There wasn't anything missing, since my concerns were all adequately covered in the July 31 document, except for some items that I had flagged for verification in testing.

I then went down my latest checklist to verify the presence of each item in the Phase 1 deliverable. Whenever an item was present and appeared to be functional, I wrote "Yes" in a column in the checklist for Phase 1 compliance. I also indicated where I found an item in the model. If an item was not found and was identified in the Approach as scheduled for a subsequent phase, I wrote "n.a." I marked "No" or "?" under compliance for all other items. I made notes in the checklist indicating my concern for each item marked "No" or "?". In such cases, either I could not find an item, I was unsure about whether what I found would actually serve its intended function, or had a question. In each case I made a comment in the Comments column.

The first version of this assessment was provided to Council staff on September 26, 2014, who forwarded it on to Navigant, together with an extract of this assessment that included only the items not marked "Yes" or "n.a." in the first document. Navigant provided written comments on this extract. These comments provided the locations of elements that I had not been able to find in my initial assessment and clarification of some elements of the logic. These were discussed in a conference call including Navigant, Council staff, and me on October 1. I have subsequently verified these comments.

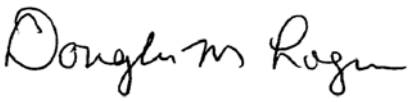
The table that begins after this introduction is an update of my initial assessment, reflecting the comments from Navigant that I have verified.

Please note that "Enhancement" in the right-hand column indicates a feature that is an enhancement relative to the previously existing RPM. "Originally in Phase 1" denotes features showing as included in Phase 1 in the Approach, but not in the current Phase 1 deliverable. Some were postponed by agreement with the Council staff; others were apparently overlooked by Navigant. The overlooked features will be undertaken in a subsequence phase. The current phase for these items in indicated in the third column.

The overlooked features are all minor. All major components required for Phase 1 are present.

I should say that I have only spot-checked a few equations and numbers. I am currently in the process of reviewing aspects of the macro behavior of the Phase 1 model for consistency with key features of RPM

identified in the RPM review panel's report of December 2012. These features are listed at the end of the table. I expect to conclude this review in about two weeks.



Douglas M. Logan, PhD, PE
Independent Consultant

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| ***General Structure*** | | | | | |
| *Objective Function* | | | | | |
| To minimize expected 20-yr NPV of cost to serve region. | Nav-2 | 1 | Model Details \| Cost to Serve Region \| NPV of 20 year Cost to Serve | Yes | |
| Elements to include in cost to serve region: | Nav-2 | 1 | Model Details \| Cost to Serve Region \| ... | | |
| • Planning costs for new resources | | | Model Details \| Cost to Serve Region \| New Resource Acquisition Cost | Yes | |
| • Capital and fixed O&M costs for new resources | | | Model Details \| Cost to Serve Region \| New Resource Acquisition Cost<br>Model Details \| Cost to Serve Region \| Conservation Value | Yes | |
| • Variable O&M and variable dispatch costs for existing resources and new resources | | | Model Details \| Cost to Serve Region \| Generation Value<br>Model Details \| Dispatch \| Find Dispatch Value per Period MW<br>Model Details \| Cost to Serve Region \| Conservation Value | Yes | |
| • Cost to import or export electricity from outside the region | | | Model Details \| Market Balancing \| Imports, Exports<br>Model Details \| Market Balancing \| Net Supply<br>Model Details \| Cost to Serve Region \| Generation Value | Yes | Net change in generation cost owing to imports and exports, both contracted and market imports and exports. |
| • Cost to purchase power from resources not dedicated to the region, at equilibrium prices. | | | Model Details \| Cost to Serve Region \| Generation Value | Yes | |
| • CO2 emission costs | | | Model Details \| C02 Emissions | Yes | CO2 costs increase dispatch cost, reduces generation value, and thereby increases Cost Stream. |
| • Other emissions/regulatory costs (TBD) | | | | n.a. | |
| • Backstop cost of unserved energy | | | Model Details \| Cost to Serve Region \| Backstop & Curtailment Cost<br>Model Details \| Market Balancing \| Imports,Exports \| Load Shed | Yes | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| • Value of unneeded RECs | | | Model Details \| Cost to Serve Region \| REC Value Stream | Yes | Linkage to Cost Stream to be made visible in subsequent release. |
| | L-13 (2) | | Model Details \| Cost to Serve Region \| Market Cost to Serve Load | Yes | This is the the first term of the value formula. |
| Contracts will be valued at the equilibrium electricity price | Nav-2 | 1 | Model Details \| Market Balancing \| Imports, Exports<br>Model Details \| Market Balancing \| Net Supply<br>Model Details \| Cost to Serve Region \| Generation Value | Yes | Net change in generation cost owing to imports and exports. |
| *Decision Variables* | | | | | |
| • Option to Acquire Resources | Nav-3 | 1 | Key Input \| Resource Add'n Options<br>Model Details \| Cost to Serve Region \| New Resource Acquisition Cost | Yes | Full compliance to be verified after implementation of Optimization in Phase 2. |
| • Conservation Value Adder | Nav-4 | 1 | Key Input \| Lost Opp Market Adjustment and Discretionary Market Adjustment<br>Model Details \| Cost to Serve Region \| Conservation Value | Yes | |
| Retirements will be exogenously determined. | Nav-9, 12, 15 | 1 | Other Input \| Retirement Multiplier<br>Model Details \| Capacity and Generation | Yes | |
| Implement economic retirements. | Nav-12 | Later, optional | | n.a. | Enhancement |
| DR will be modeled as an exogenous input, initially. | Nav-14, 15 | Later | | n.a. | Originally in Phase 1, but postponed 1 by agreement with Council staff |
| Implement endogenous calculation of the addition of DR as a resource. | Nav-14, 15 | 2, optional | | n.a. | |
| *Constraints* | | | | | |
| • Resource adequacy | Nav-4 | 1 | Model Details \| New Construction Criteria \| Resource Adequacy | Yes | |
| • Renewable portfolio standards | Nav-4 | 1 | Model Details \| Renewable Portfolio Stds | Yes | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| • Risk metric | Nav-4 | 1 | Model Details \| Cost to Serve Region<br>Key Output \| CVaRxx | Yes | Is this really going to be a constraint?<br>Full compliance to be verified after implementation of Optimization in Phase 2. |
| Implement alternative risk measures/metrics. | Nav-9 | 3, optional | | n.a. | Enhancement |
| Implement peak demand capacity tracking and adequacy constraint. | Nav-15 | 3, optional | | n.a. | |
| *Decision Criteria* | | | | | |
| Decision criteria will determine whether to "realize" the capacity option. | Nav-7 | 1 | Model Details \| Capacity and Generation \| Crossover Within Lead Time [Resource Adequacy]<br>Model Details \| New Construction Criteria \| Resource Adequacy | Yes | |
| Allow a multi-phase construction cycle. | Nav-7, 9, 15 | Later, optional | | n.a. | |
| Apply decision criteria to enforce RPS mandates. | Nav-7, 9 | 1 | Model Details \| Renewable Portfolio Stds | Yes | |
| Redefine option to allow option cost to occur later. | Nav-8 | Later, optional | | n.a. | Enhancement |
| Apply market premium adder to generating resources. | Nav-9 | Later, optional | | n.a. | Enhancement |
| Improve decision criteria to eliminate non-real world requirements. | Nav-9 | Later, optional | | n.a. | Enhancement |
| Implement alternate resource and EE modeling approaches. | Nav-9 | 1, optional | | n.a. | Enhancement |
| Implement alternate "plan" definitions. | Nav-9 | 1, optional | | n.a. | Enhancement |
| Implement improved decision criteria. | Nav-9 | 1, optional | | n.a. | Enhancement |
| Implement additional resource adequacy (e.g., peak demand) constraints. | Nav-9 | 2, optional | | n.a. | Enhancement |
| Implement additional environmental/ emissions constraints. | Nav-9 | 2, optional | | n.a. | Enhancement |
| *Optimization* | | | | | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| Implement optimization. | Nav-9 | 2 | | n.a. | |
| The model will identify the "efficient frontier." | Nav-4, 9 | 3 | | n.a. | |
| The model will support a scenario based approach for generating "non optimal" plans. | Nav-6 | Later | | n.a. | May involve process rather than code |
| ***Uncertainty*** | | | | | |
| 750 future are to be provided by staff, initially. | Nav-10, 19, 20 | 1 | | Yes | |
| The futures are to be generated by model, later. | Nav-10, 11, 19 | 2 | | n.a. | |
| 6 variables are to be modeled stochastically, initially: | Nav-10 | 1 | | | |
| • Load | | | Other Input \| Non Normalized Loads | Yes | |
| • Gas Price | | | Other Input \| Fuel prices by Futures and Period | Yes | |
| • Electricity Price | | | Other Input \| Elec Price OnPeak and Elec Price OffPeak | Yes | |
| • Hydro Generation | | | Model Details \| Capacity and Generation \| Hydro Average MW by Run<br>Other Input \| Historical Period Map | Yes | Present, but not currently shown in an input screen; input screen to be included in subsequent release. |
| • CO2 Tax | | | Other Input \| CO2 Penalty | Yes | |
| • Production Tax Credits | | | Other Input \| Production Tax Credits | Yes | |
| Some of remaining 7 variables are to be modeled stochastically, later: | Nav-10, 15 | 2, optional | | n.a. | |
| • Conservation Performance | | | | | |
| • Green Tags | | | | | |
| • Forced Outage Rates | | | | | |
| • Capital Costs | | | | | |
| • Variable O&M | | | | | |
| • Fixed O&M | | | | | |
| • Commercial Availability | | | | | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| Loads and prices are input in quarterly and on/off-peak time periods, with distribution to represent variability | Nav-10 | 1 | Other Input \| Non Normalized Loads<br>Other Input \| Fuel prices by Futures and Period<br>Other Input \| Elec Price OnPeak and Elec Price OffPeak<br>Other Input \| Fuel Price Volatility<br>Other Input \| Electricity Price Volatility<br>Other Input \| Miscellaneous \| Miscellaneous \| Electricity / Load Correlation | Yes | |
| Hydro generation is input for each quarter for on/off peak periods | Nav-10 | 1 | Model Details \| Capacity and Generation \| Hydro Average MW by Run | Yes | |
| Correlations among the uncertain variables are input. | Nav-10 | 2 | | n.a. | The 750 futures provided for prices will already include any assumed correlation among these uncertain variables. |
| ***Resource Modeling*** | | | | | |
| Generators will be aggregated to a similar level as in the current RPM. | Nav-12 | 1 | Other Input \| Existing Plant Parameters and Existing Plant Capacity | Yes | |
| A resource may be specified as must-run. | Nav-12 | 1 | Other Input \| Existing Plant Parameters | Yes | |
| Forced outages and planned outages will be modeled as derations. | Nav-12 | 1 | Other Input \| Existing Plant Parameters<br>Model Details \| Dispatch \| Dispatch Value per Period per MW | Yes | |
| Generator operating and cost parameters to be included: | Nav-13 | | | | |
| • Heat rate | | 1 | Other Input \| Existing Plant Parameters | Yes | |
| • Forced outage rate & planned outage rate | | 1 | Other Input \| Existing Plant Parameters | Yes | |
| • Mean time to failure (for Phase 2 consideration) | | Later | | n.a. | Missing for existing units; but included for new units. |
| • Mean time to repair (for Phase 2 consideration) | | Later | Other Input \| Existing Plant Parameters | Yes | |
| • Fuel type | | 1 | Other Input \| Existing Plant Parameters | Yes | |
| • Nameplate capacity | | 1 | Other Input \| Existing Plant Capacity | Yes | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| • Firm capacity value (for intermittent generation) | | ? | Other Input \| Existing Plant Capacity | Yes | Must Run Capacity Factor |
| • Integration cost (for intermittent generation) | | Later | | n.a. | |
| • Variable O&M cost | | 1 | Other Input \| Existing Plant Parameters | Yes | |
| An input field will be provided for fixed O&M for each existing resource. | Nav-2 | 2 | | n.a. | Enhancement<br>Originally in Phase 1 |
| Variable integration costs will be added for intermittent resources. | Nav-13 | Later, optional | | n.a. | Enhancement |
| Additional parameters, as the need arises. | Nav-13 | Later, optional | | n.a. | Enhancement |
| Generating resources within the region but "not dedicated to serve the region" to be modeled consistent with the current RPM. | Nav-13 | 1 | Other Input \| Existing Plant Parameters \| Fraction Dedicated to Region<br>Model Details \| Generation Value | Yes | |
| New generating resource characteristics will include the same parameters as existing generating resources, and the following additional parameters: | Nav-14 | 1 | | | |
| • Fixed O&M costs | | | Other Input \| New Plant Parameters | Yes | |
| • Fixed integration costs | | | | n.a. | Missing |
| • Siting and permitting costs | | | Other Input \| New Plant Parameters \| Planning Costs | Yes | Include development costs |
| • Fixed capital costs | | | Other Input \| New Plant Parameters | Yes | |
| • Cancellation costs | | | Other Input \| New Plant Parameters \| Cancellation Costs | Yes | |
| • Etc. (TBD) | | | | n.a. | |
| • Earliest availability period | | | Other Input \| New Plant Parameters | Yes | |
| • Economic life | | | Other Input \| New Plant Parameters | Yes | |
| • Construction lead time | | | Other Input \| New Plant Parameters | Yes | |
| Each new generator type will give a new class of resources in the dispatch. | Nav-14 | 1 | Model Details \| Generation Value | Yes | The list of Resources includes new types as well as existing resources. |
| New resource characteristics will address the following technology types: | Nav-13, 14 | 1 | Other Input \| New Plant Parameters | Yes | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| • Combined-cycle combustion turbine<br>• Simple-cycle combustion turbine<br>• Wind<br>• Geothermal<br>• Woody biomass<br>• Advanced nuclear<br>• Supercritical pulverized coal<br>• Integrated gasified combined-cycle combustion with carbon capture and sequestration<br>• Montana wind with transmission<br>• Demand response | | | | | |
| Dispatch costs will be modeled on a $/MWh basis. | Nav-14<br>L-26-ff | 1 | Model Details \| Dispatch | Yes | |
| Include the capability to specify for each existing generating resource whether the cost of dispatch will be the market electricity price or the cost of service. | Nav-15 | 1 | Other Input \| Existing Plant Parameters \| Fraction Dedicated to Region<br>Model Details \| Generation Value | Yes | The fraction dedicated to region is the market price less cost of service.<br>The net value of the remainder is the cost of service less cost of service, which is zero. |
| Implement stochastic calculation of forced outage rates. | Nav-15 | 2, optional | | n.a. | |
| Allow multiple types of wind resources with differing costs and profiles. | Nav-15 | 2, optional | Other Input \| New Plant Parameters | n.a. | There are multiple new wind resource types, with different costs, but not different profiles. |
| Represent wind resource energy output as a distribution within the dispatch period. | Nav-15 | 2, optional | | n.a. | |
| Implement seasonal profiles for capacity and forced outages for all resources. | Nav-15 | 2, optional | | n.a. | |
| Implement tracking and/or additional constraints regarding other emissions. | Nav-15 | 2, optional | | n.a. | |
| ***Market Modeling*** | | | | | |
| The redeveloped model will model resource dispatch and northwest region prices by taking an exogenous market price, calculating regional supply based upon that price, and then adjusting the price as necessary to balance imports/exports and | Nav-16, 17 | 1 | Model Details \| Dispatch | Yes | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| resource dispatch, but perhaps with a different equilibrium algorithm. | | | | | |
| The redeveloped model will solve resource dispatch, etc. for on-peak and off-peak for each of the 80 periods (quarterly subperiods for 20 years). | Nav-16 | 1 | Model Details \| Dispatch | Yes | |
| The number of subperiods per year will be flexible. | Nav-16 | 1 | Model Details \| Miscellaneous | Yes | |
| A single equilibrated price for the northwest region will be calculated. | Nav-16 | 1 | Model Details \| Market Balancing \| East Equil Elect Price Iteration | Yes | |
| There is a shortage cost to provide a backstop and guarantee feasibility. | Nav-16 | 1 | Other Input \| Miscellaneous | Yes | |
| Thermal resources are dispatched given a function of spark spread, accounting for an assumed distribution for natural gas prices around the mean. | Nav-16 | 1 | Model Details \| Dispatch | Yes | |
| Hourly variations within subperiods will be represented by probability distributions. | Nav-16 | 1 | Model Details \| Dispatch | Yes | |
| Regional import and export limits are exogenously given and can vary over time. | Nav-16 | 1 | Other Input \| Transmission Capacity | Yes | |
| Only existing external contracts are modeled. Amounts are subtracted/added to the import/export limits. | Nav-16 | 1 | Other Input \| Contracts | Yes | |
| Consider using linear programming for market balancing. | Nav-17 | 1, optional | | n.a. | |
| Consider using the Analytica dispatch function. | Nav-17 | 1, optional | | n.a. | |
| Monetize emissions that are not currently modeled. | Nav-17 | 3, optional | | n.a. | |
| Price elasticity of demand calculations will not be included in Phase 1. Rather, this interdependence is assumed to be included in the loads and prices in the 750 futures. | Nav-17 | 1 | | Yes | |
| Price elasticity of demand calculations may be included later. | Nav-17 | Later, optional | | n.a. | Enhancement |
| ***Model Boundary and Input Data*** | | | | | |
| The portions of RPM to be replicated start at the point where data are pasted into the RPM workbook, for Phase 1. | Nav-20 | 1 | | Yes | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| Data preparation functions may be added later. | Nav-20 | Later, optional | | n.a. | Enhancement |
| ***Real Levelized Costs*** | | | | | |
| All generating resource costs will be annualized. | Nav-21 | 1 | Other Input \| New Plant Parameters<br>Other Input \| Existing Plant Parameters | Yes | |
| Fixed capital and O&M costs for each new generating resource can vary depending on:<br>(1) the year of installation, and<br>(2) the trajectory of historic equilibrium prices in a given future.<br>But they are then constant over the entire operating life of the resource. | Nav-21 | 1 | Capital & Fixed O&M Multiplier | Partial | The Capital & Fixed O&M Multiplier allowed parameters to depend on year of installation.<br>The capability to vary by future could be implemented later. |
| Expectations are purely backward-looking. | Nav-21 | 1 | Model Details \| Price Expectations | Yes | |
| Variable costs will vary by time and future. | Nav-21 | 1 | Variable O&M Multiplier | Partial | The Variable Multiplier allowed parameters to depend on year of installation.<br>The capability to vary by future could be implemented later. |
| A perpetuity factor will be applied to all costs. | Nav-21 | 1 | Model Details \| Cost to Serve Region \| Perpetuity Calcs | Yes | |
| Include some upstream calculations for levelized fixed capital and fixed O&M costs. | Nav-21 | 2, optional | | n.a. | |
| Include uncertainty around fixed capital and O&M costs. | Nav-22 | 2, optional | | n.a. | |
| Make variable costs dependent on a trended real growth rate. | Nav-22 | 2, optional | | n.a. | |
| ***Hydro Generation*** | | | | | |
| Hydro generation by period will be provided by staff as an input. | Nav-23 | 1 | Model Details \| Capacity and Generation \| Hydro Average MW by Run | Yes | Where can input values be seen? |
| Implement shifting of generation between off-peak and on-peak on a quarterly basis. | Nav-23 | 2, optional | | n.a. | |
| ***EE/DSM*** | | | | | |
| The redeveloped RPM will include two types of | Nav-24 | 1 | Model Details \| Conservation | Yes | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| energy efficiency (EE) conservation: lost opportunity and discretionary. | | | | | |
| *Lost Opportunity EE* | | | | | |
| Each period will have its own lost opportunity supply curve, independent of prior period supply curves, represented by a 5-segment piecewise approximation, together with a subperiod x on-/off-peak shaping factor. | Nav-24 | 1 | Model Details \| Conservation \| Lost Op Curves<br>Model Details \| Conservation \| Cumulative Conservation \| Conservation Shape | Yes | |
| *Discretionary EE* | | | | | |
| A single discretionary supply curve (over the entire simulation horizon) will be used that represents the total "bucket" of potential from which efficiency could be acquired. | Nav-25 | 1 | Model Details \| Conservation \| Discretionary Curve | Yes | |
| The model will permit a user-defined constraint on the maximum EE that can be acquired per quarter, together with a subperiod x on-/off-peak shaping factor. | Nav-25 | 1 | Model Details \| Conservation \| Max Discr Conserve Rate | Yes | |
| Discretionary potential is "drawn down" from the single supply curve in each period. | Nav-25 | 1 | Model Details \| Conservation \| Discr Cons Acquisition | Yes | |
| The supply curve for Phase 1 already includes the effect of drawing down resources over a range of prices in each period. | Nav-25, 26 | 1 | Model Details \| Conservation \| Discretionary Curve | Yes | By assumption |
| Implement alternate formulations for endogenous sampling without replacement for conservation into the RPM model logic. | Nav-25, 26 | 1, optional | | n.a. | |
| *EE Acquisition* | | | | | |
| EE is acquired if its supply-curve cost is less than the moving average plus a "Long Term Value Adjustment". | Nav-24 | 1 | Model Details \| Conservation \| LO Market Price<br>Model Details \| Conservation \| Discr Market Price | Yes | |
| The "initial" moving average price will be a user input. | Nav-24 | 1 | Model Details \| Price Expectations \| Initial Expected Price | Yes | |
| The redeveloped RPM will include the "high water mark" concept, with a "switch". | Nav-24 | Later, optional | | n.a. | Originally in Phase, but postponed 1 by agreement with Council staff |
| There will be a Long-Term Value Adjustment | Nav-25 | 1 | Key Input \| Lost Opp Market | Yes | |

| Item | References | Phase | Location | Phase 1 Compliance | Comments |
|---|---|---|---|---|---|
| decision variable for each of lost opportunity and discretionary EE | | | Adjustment and Discretionary Market Adjustment<br>Model Details \| Cost to Serve Region \| Conservation Value | | |
| There will be a "switch" to disable the Long-Term Value Adjustment capability | Nav-25 | 2 | | n.a. | Adjustment, including zero value, can be entered manually in Phase 1.<br>Switch will eliminate Adjustment as a decision variable. |
| Don't tie the amount of EE to the actual future's load forecast. | Nav-26 | 1 | | Yes | |
| Tie the amount of EE to the actual future's load forecast. | Nav-26 | 2, optional | | n.a. | |
| Implement alternate approaches to simulate inertia in EE programs, such as optimization constraints. | Nav-24, 26 | 1, optional | | n.a. | |
| Implement alternate treatments of EE, including decision variables. | Nav-26 | 1, optional | | n.a. | |
| ***Model Behavior*** | | | | | |
| The model output should exhibit business cycle behavior. | | | | TBD | |
| The model output should show normal returns to new generation over the time horizon. | | | | TBD | |
| The model output should show reasonable implicit heat rates. | | | | TBD | |

Notes:

[1] Items are listed generally in the order they appear in the approach document. The order is adjusted to keep related items together.

[2] Reference key:

Nav-nn indicates page nn in the Navigant approach document, July 31, 2014.

J-nn is page nn of Appendix J, and similarly for other appendices.