MAG Meeting 1

Intro
CPUC: Patrick Young and Forest Kaser

Four main parts to the IRP Implementation Work
1. developing a portfolio
2. guidance to individual LSEs
3. how PUC would be evaluating compliance with IRPs
4. approach to procurement authorization and process alignment

3 steps to develop the System Portfolio (step 1 above):
1. Assumptions development
2. Development of scenarios
3. Specifics of modeling tools being used

Effort is on developing the reference system plan. Presentation lists current modeling tools and how they will be used.

Results of survey on how the modeling advisory group should be run:

1. Concern of record development and getting work done in MAG on the record.

   Response: Our goal is to develop best proposal before it reaches the proceeding record.

2. Theme of dissenting views, asking for dissenting proposals we can enter into the record.

   Response: Notes are being taken to track dissenting views. And we invite everyone with specific concerns to contact staff directly. Informal written comments can be provided each week after the webinar, if topics in comments are within the MAG charter scope.

Today's focus is an introduction to RESOLVE.
This is the model proposed for the modeling exercise this year.
Plan is to use RESOLVE in the short term, CPUC is not committing to it over the long run.

Q&A on introductory slides:

-Kevin Woodruff, consultant for TURN
Q: When is the next opportunity to go over RESOLVE because we'd like to get more into the weeds of the model?
A: We are having 3 webinars focused on RESOLVE and each will get into more and more detail on the specifics of how the model runs.

- Carrie Bentley (ARem)
Q: Are the two different workplans going to operate completely independently? Will you need to attend both to keep track of what's going on?
A: Inevitably the two workplans will eventually converge. More technical specific issues will be addressed here (MAG). The more high level will be addressed in the scenario development webinars.

-Paul Klapka, SCE
Q: Where do you expect to be developing assumptions? Is the resolve model commercially available?
A: RESOLVE is not commercially available but we'll provide an update on its public availability at the next webinars.
In regard to assumptions, we're planning to circulate a document tomorrow or early next week indicating proposed assumption sources for the modeling we intend to do. In one month we'll release all the specific values. Process for discussing values has not been decided. We're looking at best way of providing transparency for the values.

<u>Resolve</u>
E3: Nick Schlag
With Arne Olson and Jimmy Nelson

RESOLVE is the product of work that's been done to look at grid integration issues and flexibility.

- Planning paradigm has shifted with the increased integration of renewables.
- Purpose of the model is to find the optimal mix of resources for a system with a high penetration of renewables.
- There is a tendency of high renewable penetration systems to require a higher degree of renewable curtailment. A lot of interest and work has shifted to consider other investments besides renewable.

There are three scenarios that help to simplify the starting point for logic trying to be captured with RESOLVE.
1. Overbuild of renewables = higher cost on ratepayers
3. Entirely eliminate curtailment and integrate completely with storage, for example
2. Sweet spot between the two is the optimal portfolio in which the need to curtail renewables and the cost of curtailing is balanced by other resource like storage.

RESOLVE is trying to find the balance point within the two extremes.

RESOLVE overview:
- It is fundamentally a capacity expansion model.

- Has capability to select any combination of resources. And finds the cost of a wide range of renewable integration solutions.
- Model produces a portfolio with renewable integration solutions that meet various constraints.
- Objective functions are fixed costs of new investment made, as well as fixed cost of new transmission, and alongside that system operating costs.
- There's quite a bit of uncertainty over the next 10-20 years…RESOLVE is intentionally designed to be flexible so it can easily be seen how a portfolio adjusts to changes in assumptions.
- Assumptions for key uncertainties can be easily adjusted to allow for the analysis of future risks.

How uncertainty will be dealt with will be discussed in scenario development.

Q&A on RESOLVE intro:

- Kathy Treleven, LSA
Q: On Slide 9 curtailment was mentioned as a geometric increase. Please explain.
A: Reference to a geometric increase refers to the cost of curtailment as a dollar per MWh metric. Whether geometric of exponential, the shape of curve is semantics.

As you move up the curve its important to note that marginal cost of

- Jim Baak, First solar
Q: Descriptions of cost-effective solutions. How do you treat distributed resources in the evaluation? How are those intended to be treated in RESOLVE now?
A: Things like distributed generation resources are currently represented relatively coarsely. Just like we have central solar. We also have distributed solar. The model does not have any very specific locational value that distributed resources could get based on where they're located. However, if that data is made available it can be easily integrated into RESOLVE.

Additionally, we've been doing is working with Lawrence Berkeley Lab to add capabilities to model loads and being able to move around shift DR to take advantage of different market pricing.

Q: Will there be an opportunity to provide input for the 2017 data?
A: Yes, it would happen in the assumptions development process.

-Greg Morris, Green Power Institute:
Q: Is this a linear planning model? Does it run on excel?
A: Core engine is written in PYTHON. And Excel is tacked onto the front end.
Q: Optimal solution on slide 6 assumes a single RPS portfolio, all solar. You'd get different curves if you go to other mixes of renewables.

A: This is illustrative. The renewable portfolio that comes out of RESOLVE is a result of the optimal portfolio. Other renewables available that are cost effective will be included in the renewable portfolio.
Note that the same staff working on IRP is also working on LCBF effort on RPS. Very close coordination going on.

-Jan Reid
Q: What kind of run time are we looking at? Can parties get access to RESOLVE?
A: Working with E3 to provide access to the model itself and welcome party feedback on how to do that. Run time depends on the complexity of the inputs and how much detail you go into. A couple of hours: 1-2 or 3-4.
We do not currently have a timeframe for access. Next four weeks we'll have more information on that.

-Dave Smith, TransWest Express
Q: With regard to the optimization of the renewable portfolio, is selection of renewable portfolio all done in 1 step?
A: RESOLVE is not sequential. Integration solutions are considered at same time renewable resources are considered. The optimization will tend to steer portfolio away from cost.

- One of the objectives is minimizing the total cost of all of these factors. Not minimizing the flexibility need.
- System operating cost is one of the components of the optimization problem.

- Carrie Bentley, ARem
Q: How many years does it optimize across? Are investments made in multiple periods/ blocks of 5 periods?
A: The investment and optimization are long term. The objective function is an NPV of 20 years. Each investment period is a year and each year you can make a different decision on what you're investing in that year while minimizing the cost for that entire 20 years. The values and cash flows represent each year of the model horizon.

-Eric Woods:
Q: Regarding model integration, does RESOLVE get to transmission constraints and is it locational at the grid area? When integrating the resources you're also integrating transmission costs. Does model consider transmission constraints at the grid level that are locational?
A: This is a zonal model. CAISO is represented as a single zone assumed to have no internal transmission constraints. It links to LADWP, Southwest, and Northwest.

Q: Is RESOLVE linear or multipart?
A: Just a linear program.

-Mike Jaske, CEC

Q: Slide 10, how does RESOLVE deal with existing assets and their retirement overtime? What is that based on, assumptions?
A: In RESOLVE existing resources are sunk investments and no costs are shown. It does not have the granularity to make specific resource decisions of whether to keep or retire certain assets. Model is entirely assumption driven.

Mike, Q follow up: So solution is dependent on assumptions. Given local capacity issues there will need to be alternative scenarios with what is happening with existing system and what is happening to it across time. When we think about cases we choose to run- should be discussed in scenario development.
A: Agreed. Thank you for bringing up.

- Sae Sarwate?, CLECA

Q: As far as renewable solutions shown what are some of the other renewable solutions in the model right now. Besides storage?
A: We'll discuss that in the next section.

- Bob Fagan from Synapse?

Q: Presume model will have the ability to change the parameters of investments and storage changes over time? That's reflected?
A: Yes, for each investment period with whatever granularity you'll have a different cost assumptions for each candidate resource. Optimization will take into account that cost trajectory looks like over time.

<u>Candidate Resources in RESOLVE</u>

- Various candidate resources are included in the model see Slide 13.

Second characteristic is performance:
Functionality of resources depends on their

Representation of CAISO thermal fleet used in the model:
- We have 7 categories of thermal resources used.
- RESOLVE has grouped resources into these resource categories. E.g. Types of CCGTs, types of peakers. Instead of 100 different units we have 100 units characterized with 7 operating characteristics.

Zonal topology:
- Optimizing within the CAISO footprint. All of which impacts the bottom line.
- Only the CAISO resources and resources coming into CAISO and any resources outside of CALISO that might be contracted.

Hourly dispatch model:
- Daily profiles for load.
- RESOLVE doesn't model an entire year. Instead it's a smart sampling exercise where we've picked 37 days that represent a long run distribution of what

you'd expect to see in terms of net load, wind and solar performance. These 37 days give us a good approximation of the year.
- Fewer days than 8760. But more freedom.

Note: Comments on transparency and the MAG. We can change format if parties feel it is not long enough or have preference for another format.

Q&A on Candidate Resources in RESOLVE:

Jim Baak Vote-solar:
Q: How do local resources get optimized in transmission?
A: This entire problem is solved all at once. The model is not sequential.
Q: Regarding how distributed resources fall into the model, if there is distributed solar selected in these zones it comes with no transmission costs associated to it?
A: If you have something that needs new transmission there is no local specific transmission of distribution value in RESOLVE. Could be done if data is available to do so.

Q: What about existing CSP plants. Storage associated with CSP plans?
A: Existing solar thermal plants are treated as part of the existing portfolio taken as fixed inputs into the optimization problem.

- Matt Barmack, Calpine

Q: Operational model relies on linear hourly dispatch and it sounds like you're aggregating similar units, how are CCGT represented in the operational model?
A: We have linearized this problem. If you have 50 CCGTs modeled it's not a mixed integer program and can commit fractions of units. The nature of the simplification is based on a necessity to keep scope of this problem manageable.

Q: One goal is to enable intelligent trade-offs between different sources. What about EE as an input? Represent as a resource choice or as a determinant that's determined internally?
A: EE is something we're still grappling with. What can we do in this cycle is to provide information on the interactions between efficiency and renewables. Stay tuned. Data availability is a challenge because existing potential and goals study is not designed to feed into IRP. We'll be revisiting EE in more detail.

Q: Is this a case where uncertainty isn't really represented within the model? No uncertainty about load growth?
A: The investment takes account of the fact that investment may occur too early or too late. Each run of the model is more deterministic.

- Kevin Woodruff, TURN

Q: Does linear mean it's not mixed integer?
A: Yes, that's right.
Q: How is pumped storage characterized? 24 hour? Or 12 hour?

A: Resources are characterized by the duration of their charging and discharging.

-Jimmy Nelson , E3
Q: RE: slide 2, how are sub hourly constraints captured in the model?
A: Flexibility reserve requirement is on an hourly level. The flexibility reserve requirement evolves to carry a quantity of reserve to meet the flexibility requirement. We've internalized a relationship between the contribution of renewables. We do lose resolution/granularity going to an hourly model. There is a path somewhere down the road to run side by side with a more granular model. We have experience running PLEXOS at the 5 minutes level as a complement to RESOLVE.

-Antonio Alvarez, PG&E
Q: With respect to the optimization, are emissions a limit?
A: In our past work we've never had an emissions constraint in the model. It is an area of development. That functionality will be available in the model.
Q: Regarding modeling of resource alternatives for flexibility: At the hourly level, definitely a factor taken into account in the model. The cost attributed to that curtailment is a result of the model.
Re: BTM PV. Always treated as a static assumption in the model. RPS PV is treated as a resource.

Q: With respect to flexibility reserves, you mentioned units in an aggregated fashion. Do you represent ramping limitations? For the aggregated units?
A: See Slide 22. We look at a stack of thermal units. The pmins and pmaxs of the units even though we've linearized the unit commitment program.

Q: When you look at the benefits of the resource you are considering do you adjust for a change as you add resources? Or do you assume those prices are constant given at the beginning of the simulation?
A: Key distinction: RESOLVE is going to add resource with lowest net cost. And based on the impact on prices get a different result. RESOLVE is not converging until you get a result.
The model performs a true optimization. It's a different algorithm leading the model to the solution. If resource doesn't meet capacity then it doesn't add anything or add any value.

Q: Is there a way of reporting resulting energy capacity prices?
A: It can report all energy capacity prices.

- Deborah Behles, CEJA:

Q: Will there be any work done to consider air quality?
A: RESOLVE doesn't have the locational information or resolution to deal with this.
Q: Has there been work to consider air emissions on a system wide bases?
A: We have things like fuel burn for the system. The portfolio then can be put into more detailed production simulation model that then looks at location of specific

resources and see if they're in DAC. The model can be complemented with a more detailed tool.
Where we would integrate air quality would be when LSEs file their plans and they are then integrated together. That's where we'd expect 1 option for evaluating those types of impacts. It's a technically challenging thing to come up, especially local impacts, but we're working on it.

- Pushkar Wagle, BAMX:
Q: Slide 15, the interaction between different super cresses.
A: No RESOLVE doesn't get down to the dynamic level. The way it's treated in RESOLVE is very comparable to the way it's taken in RESOLVE.
Q: If the ISO provides you numbers combined or provide more aggregated constrains of the zones of super creses you would be able to handle those in RESOLVE>

Q: When you talk about ISO footprint you take into account POUs?
A: That's right.

- Kathy Treleven , LSA
Q: On pg. 21needs clarification on solar graph.
A: X axis is not in fact the hours of the day. It's in MW and it's a histogram. Far left of x axis is zero. Showing that solar resources only produce when sun is shining. Large percentage of time solar is zero (when sun doesn't shine). Illustrates that there are periods throughout the year when you see different levels of solar.

-Paul Klapka from SCE
Q: Is optimization methodology similar to the methodology in other commercially available models?
A: limited knowledge of other models. E>G> model does iterative approach. Model calculates the prices. Resolve does it all in 1 scoop. Doesn't go back and forth. In plexus you can formulate and optimization in plexus. There are specific details that make resolve interesting in its functionality. The state picking has a lot to do with picking.

-Eric:
Q: Do you think DER can be represented as a virtual powerplant based on sub portfolios at transmission locations?
A: It would look at BTM vs in front of the meter resources. If e.g. in DER case there is amount dedicated to deferred distribution and that amount is subtracted from cost input into model does that seem like a way to reflect the difference between its use and its option value?
A: What you're pointing out is theoretical functionality. There are value streams not captured in the distribution model. It comes down to a data question. Somewhere we'd need to find a source.

Q: Mike Jaske

Slide 20: BTM solar. Evolving gross load curve over time and some kind of altered distribution of types progressively through time.

A: Naturally adjusting load shape over the time of the model. We don't have a profile that shows the load shape.

-?, CLECA
Q: Slide 15 wondering about the costs. Indicated that there is projection of cost. ISO provides to CPUC best predictions of transmission capability as well as cost of minor and major upgrades.

- What we're doing in RESOLVE takes into account operational needs for flexibility, and transforms that question into an economic question. There is investment cost associated with flexibility need.

- The output of RESOLVE will be will be xyz MW of different renewables and xyz of different integration solution. Doesn't imply that any of those are the need.

-Kevin Woodruff:
Q: Re: mechanics of running model. Does it produce more data than you produced in SB 350 studies?
A: Don't recall what we made public for the SB 350 studies. It is a very big set of information you could pull out. You can pull out the dispatch of the system and not all of that was published for the SB 350 study.

Q: Do you have to specify the data that you want to see?
A: Model produces a number of things routinely.

- Carrie Bentley (ARem)
Q: How does model relate to contracting? LSEs don't contract out 20 years. How will it relate to 3-4 year contracting? What output is going to come out of RESOLVE that will impact how LSEs will contract in the future?
A: In general focus is on bringing model on a long horizon so that plan would have resources selected over a 20 year period. There will be a plan for what resources get added to the system for each incremental year. Focus is on identifying investments that seem economical in the 3 to 5 year period. There are at this stage lots of questions regarding authorizing procurement. There's a series of issues we'll need to go through before we solidify what authorizing procurement will look like.

Q: What does it look like if you plan for the next 10 years or the next 20?

A: Our plan is to look at 20. Open to looking at shorter horizons and comparing them to other horizons. Resolve as a long term planning model. So much of what's guiding electric sector is a future that looks incredibly different from what we have today. Something may look good in the short term but in the long run we can identify a much better decision for the system. And translate these identifications into concrete actions.