* This is the last webinar before workshop in mid-December

Today: Deeper understanding of engine behind RESOLVE and how it works

* RESOLVE is a linear program
* Has a single objective function that is an expression of the total cost of a given portfolio
* Total cost function is expressed as a function of a number of decision variables
* Each decision variable reflects a choice the model can make (e.g. how much wind and solar should I install, how much capacity of batteries do I want to install, how should I operate my CCGTs, etc etc)
* Objective function is constrained by a number of constraints (e.g. GHG target, PRM)
* 700,000 variables and 700,000 constraints are currently in the model

Q&A:

-Kevin Woodruff, TURN

Q: Slide 6. The 5% discount rate?

A: It’s what’s we’ve used to represent a real discount rate. In line with weighted average cost of capital that most utilities have. Resolve operates in real dollars.

Q: Workshop schedule?

A: Looking at the 16th.

-Deborah Behles, CEJA

Q: Has there been a decision made about what years to model?

A: no, What we showed on slide 5 is intended to be illustrative.

Q: For the SB 350 study did you do a similar type of interpolation?

A: Yes, SB 350 study used same methodology for interpolating costs. It modeled years 2016 2020 2025 and 2030.

-Michael Cohen, UCS

Q: On slide 6, The 0.8 discount factor isn’t applied to the last item in the column. Please clarify. Intended?

A: No, that’s a typo. 2022 cost should be discounted by the same discount factor.

-Bob Fagan, Synapse (22:50)

Q: Slide 5 end affects? End effects can have a huge impact. Can you talk more about options for dealing with end effects?

A: At the highest level the choice we have within Resolve is how many years we think are appropriate to include within the discounting factor. Assumption in Resolve is: if our last year of analysis is 2038 then the 2038 total cost is given additional weight to reflect that years beyond 2038 will look relatively similar in terms of their real cost over time. We can follow up offline on the weighting used.

-Gregg Morris, Green Power Institute

Q: Want to go back to issue of discount rates. Will be a key variable. There’s no such thing as a correct discount rate. We’re going to have to be very careful about it.

A: It’s not a parameter we haven’t tested too in depth. But you are right it is something very important. A point well taken.

- Sarita Sarvate, CLECA

Q: Question about end effects. Can’t comprehend mathematically what you exactly do there.

A: Take what’s on slide 6 as an example. It’s a way of approximating for the objective function. We are more interested in costs across the entire lifetime we’re investigating (not just the 20 years we’re explicitly modeling).

-Eric Woychik, Strategy Integration

Q: It looks to be like the objective function is a sum of total least NPV costs. I don’t see any real optimization in this. Normally the objective function itself has optimization itself built into it so it’s a loop. You’re not doing that. Is that right? It’s a mere summation not an optimization across resources.

A: That’s not a correct characterization of Resolve. What is being optimized is the NPV of total cost. RESOLVE is selecting from options of resources. None of that is established ahead of time. Resolve has the functionality as a linear program to choose among those.

It’s more nuanced than that. We’re modeling how the portfolio operates explicitly.

-Kevin Kitz, US Geothermal

Q: Slide 5. The lower the weighting that’s given to the final year the more the decisions in 2030 through 2038 are going to favor the lowest capital cost. It’s important to weigh 2038 with a 30-year present value of operating costs or the optimization program will inherently select the lowest capital cost resource.

A: Thanks Kevin.

-Antonio Alvarez, PG&E

Q: You’re only looking at the new cost (cost of new resource fixed and variable) as well as the variable cost of existing resources. Is that correct?

A: Yes that’s correct. It’s just the fixed cost of new resources plus the sum of all the variable costs to operate the grid.

Q: It would include e.g. the cost of the demand side resources, they are embedded in the load or fixed, they are different in different scenarios so you can compare the cost across different scenarios or plans?

A: Yes, that’s right.

-Alex Morris, California Energy Storage Alliance

Q: How the model looks at calculating the cost of operating the fleet that is picked for a particular year ... Have you crossed checked the cost of operating the fleets you’ve developed and how much that costs in RESOLVE vs in an 8760 production simulation. How accurate is RESOLVE?

A: We do have a section coming up that describes the constraints we put on the model to represent operations as accurately as possible. We haven’t gone through the process of benchmarking this directly to a Plexos production simulation model. Next step in spring or summer when the PUC comes together to evaluate approach taken here and options moving forward for IRP. At the pace we’re moving in this cycle not something we can develop with the timeframe we’re working in. Next section illustrates more.

Q: I have a concern that Resolve is making choices on the fleet based in part on expectations of operating costs across the years. So the accuracy of that is very important. Key sensitivity for focus on. The Plexos modeling looks at hourly solutions but may not accurately reflect intra-hour variability needed to run the grid. Do these models understate the need in the future or not. Important point of discussion.

Reliability Standard in RESOLVE

* Resource Adequacy Program: system, local, and flexibility resource adequacy requirement.
* Within RESOLVE we have been working on refining these constraints.
* System RA will work in RESOLVE as a PRM (planning reserve margin)
* Each year RESOLVE models we’ve imposed a constraint on. Devil is the details on how much capacity we count on from each resource in order to meet the PRM. The way is gets factored for each resource is a little different for each resource to reflect the characteristics of each type of resource.

To represent ELCC in a ROBUST way: must capture two effects:

* Marginal ELCC declines with penetration
* Multiple variable technologies interact in terms of their marginal ELCCs. As you add more solar its marginal ELCC may decline but as you push net peak into evening then wind produces more in the evening and its marginal ELCC increases

We’ve developed the idea of an ELCC surface.

* Used an LOLP model to create a multi-dimensional ELCC surface.
* This is being incorporated in a two-dimensional surface with wind and solar.
* The two major drivers of ELCC on the surface.
* We may consider expanding this to incorporate new resources. Expanding this type of surface will be considered while considering expanded run-time.

We will look into differences in efficiency or differences in the load forecast. Because assumptions used in ISO studies do not align with assumptions we’re using in the IRP.

Internalizing these needs (local capacity needs) as constraints. The optimization we’re conducting may choose resources that meet local capacity need. It adds location specific value for certain resources on the grid.

Investment in new flexible resources is determined economically. Solved for in how it impacts actual system operations rather than as a reliability standard.

Q&A:

-Dave Smith, TransWest Express

Q: Slide 18, it doesn’t matter what resource portfolio comes up with regards to the flexibility requirement. It won’t impact the net present value. Is that correct?

A: Assuming you can curtail renewable resources at the system level. Will never be binding as a need for capacity at the system level. You can use renewable curtailment to soften the upward ramp in order to avoid problems.

Q: What’s driving the curtailment?

A: Over generation. But at that at the same softens the magnitude of the upward ramp. If you had a portfolio with all solar you would have a flexible RA requirement that would be material in the net present value.

Studying high renewable penetration systems commissioned by the major utilities. Your point is well taken about the concern about upward ramping. To ramp with their pmins and pmaxs. FRACMOO requirement has been able to ensure capacity in the market is able to dispatch flexibly. The way it shows up in operations is a combination of factors. You may actually end up curtailing or pre-curtailing certain renewables. Those are the important factors we’re trying to capture within RESOLVE.

We are trying to capture the effect you are mentioning.

-Deborah Behles, CEJA

Q: Slide 14. In the past transmission options have been another way to reduce local need. Is that considered at all in this modeling?

A: The local RA constraints are constraints we’re still working to develop in RESOLVE. To the extent we have information about potential transmission solutions that can be incorporated.

Q: Are you working with CAISO in their TPP to see what solutions they’re identifying in that process?

A: We will rely heavily on work ISO has already completed.

-Carrie Bentley, AReM consultant

Q: On ELCC surface topic, confirm it’s no generic wind but that you’re going to do an area specific value?

A: We don’t actually plan to do resource specific capacity values for wind or for solar. Every different resource you add to this surface is another dimension. That ultimately means we start to expand the problem dramatically. We can get a good enough approximation of the total ELCC as a portfolio with just a couple simple dimensions.

-There seem to be some benefits in considering certain areas (work in RETI).

Q: local RA slides note says “additional constraints on resource build-out”.

A: That note means for each of the areas with a deficiency each of those areas would factor into RESOLVE as a constraint on the resource buildout.

Q: Flex RA: it’s not binding. Once you start getting into individual LSEs that’s not true anymore. Are you going to include things like voltage or frequency? Something to make sure you are getting the other requirements that fall in line with the flex requirements.

A: Defer until later in presentation. If not clear, bring up again.

-Cindy Lee, ORA

Q: It looks like you guys have decided to use the recap model for ELCC whereas in the RA ED division hasn’t finished its ELCC work. How do you reconcile these different approaches for ELCC? Is it possible for you to use ED values once the Commission has a Decision?

A: This comes down to a challenge we have: RA program itself and the modeling we are trying to do here. They are actually very different in terms of the things we’re asking each model to do. The work we’re going here is much more expansive that what is the RA program’s goals. Their focus is on allocation or attribution.

* ED RA staff is also looking at more granularity on a local level. If their results show vast difference between inland and coastal. Would you consider that type of granularity in your model?
* Yes.

Q: Slide 13, The CAISO currently has different assumptions regarding DR. Only take in DR that can respond within 20 min. You should consider including all available demand response.

A: Thank you for recommendation.

-Phil Muller, ORMAT

Q: Slide 9, for the non variable renewables how are those included in the NQC list. Are they considered part of the thermal capacity for the NQC or do you use some other mechanism?

A: The way we approach that is a similar way to how we approach thermal resources. E.g. biomass and geothermal that operate in a base load capacity.

Q: Slide 15, integration solutions: if you’re using a MW of geothermal to replace 4 mw of solar is that going to show up in the assessment as far as the integration impact it’s going to have?

A: Yes it will. Will show up in how the system operates. Generally all else equal you’ll expect to see less renewable curtailment need.

* Antonio, PG&E

Q: how demand side resources are considered towards system or local reliability constraints. Is BTM PV treated as a supply or demand adjustment? How is adjustment calculated? And for EE?

A: EE would enter into the constraint on each of these requirements. EE would reduce the 1 in 2 peak. For BTM PV that’s something we consider as part of the ELCC surface. SO the solar penetration access you can think about as representing not just the central station solar procured by utilites for RPS, it’s the sum of that and the BTM PV.

Q: for local reliability do you use same approach? Meaning e.g. BTM PV are you using the NQC to satisfy local reliability to the extent you have BTM PV in the constrained area.

A: for the local areas this idea of the surface we have at the system level doesn’t apply at the local level. We don’t know it’s the same dynamic we have at the local level. Our current plan is to use the NQC rules. We would be happy to hear recommendation because it’s a major challenge. We’ll have to make some simplifying assumptions.

* Nancy Brown
* Q: Re: existing fleet. How do you handle retirements? Do you just assume they’re going to hit 40 years and then they are retired? Do you have anything that handles pre-mature retirement risk because resource wasn’t picked back up for a commercial reason?

A: Something we’ve talking a little bit about. The current plan is to deal with this question of pre-mature retirement as a sensitivity case where the assumptions is made that a certain portion of the fleet retires for commercial reasons.

Q: Over time for the various resources. Are those values (NQC and ELCC) assumed to be static over entire modeling period?

A: For something like a gas power plant? Yes, that’s assumed to be static. For something like renewables, those end up being more complex by nature of the ELCC approach.

Q: This is more interaction of the load forecast. Is there a max hour of curtailment assumed? Or do you assume you can curtail whenever it’s needed? Load growth tied to residential building…Are net zero energy structures baked into the load forecast?

A: In operations model is allowed to curtail as much as it needs to operate reliably. The model tried to steer itself away from it to avoid building additional renewables.

As far as profiles go, we have separate profiles for the system load shape and the forecasted impact on the shape of EE.

-David Howard, MRW

Q: When you’re constructing your ELCC surface are you looking at a single load profile? does that change over time so you have different surfaces for different periods? If you were to look at a future where there were changes in load profiles would that be captured.

A: A single surface is a function of a single load profile. We’ve taken historical system loads from the past 5 or so years. The way this is implemented we have to make a single assumption about a static load shape. Something where we could re-run the surface to construct an alternative surface that reflects future conditions more than today. But we have to make a single assessment of what the load shape looks like.

-Sarita Sarvate, CLECA

Q: discussion of flexible RA: You assume certain must offer obligation contracts are in place. What kind of assumptions you can make for the future?

A: It’s not that we’re assuming these contracts will be in place. We’re making an assumption that if you have a flexible resources that has the physical capability to ramp between its pmin and pmax that resource is available to provide its flexibility to the grid. The ultimate assurance or resolution or contracting that’s needed isn’t something that this model considers.

* Jan Reid

Q: ELCC: has the commission ever adopted ELCC?

A: The RA proceeding has not adopted the ELCC framework yet but we are required to implement it. Q: How do you know that your methodology will be consistent whatever the Commission finally decides. What do you do if they decide to authorize some different methodology than what you’ve used?

A: If different from RECAP we would try to line up with the Commissions or reconcile it. The preliminary results have been consistent.

Note that the Commission has independently been using E3’s RECAP model in DR and other proceedings.

-Jamie Fine, Environmental Defense Fund.

Q: How are you reflecting the social cost associated methane leakage from production of natural gas for our generators?

A: The idea of a GHG constraint on a portfolio has been built into RESOLVE as a functionality. We are incorporating a constraint on electric sector emissions. Will be a rich topic of discussion at the December workshop.

Q: When will we be able to discuss different approaches to reflecting those costs?

A: We are closely coordinating with ARB. Social cost of carbon and leakage issues crosses different agency as well as within agency boundaries that is a challenging issue we are aligning on. The next opportunity to discuss in the IRP context will be at the Dec workshop.

Next section:

RESOLVE simulates dispatch of resources on an hourly basis throughout the year accounting for a variety of different constraints of resources available to the grid.

Frequency response constraint: implemented on operations.

Only taking one question. If you have unanswered questions please email it to [Forest.Kaser@cpuc.ca.gov](mailto:Forest.Kaser@cpuc.ca.gov)

- Kathy Treleven

Q: Question on the previous section on the system reserve margin. Is that an annual calculation?

A: Yes.

Q: And the distributed solar PV do you mean PV restricted to the area of local capacity concern?

A: right.

Q: Could you go over again the level of detail you plan to release on the inputs, the outputs, and the formulas on the model?

A: We are working through the appropriate level of documentation of assumptions. We will have a comprehensive set of inputs for parties to review around the time of the December workshop.

-Kevin Woodruff, TURN

Q: General procedural question: will there be a way to comment on these assumptions? Is there anything else you’re going to want us to comment on in the next couple of weeks?

A: Yes. We don’t have an assignment yet but something we’re thinking about. We’ll send something out to the service list if something comes up.