PG&E's Renewable Integration Calculator
Responses to June 29, 2009 IEPR Workshop Questions
Electricity System Implications of 33 Percent Renewables

Q1. What is/was the purpose and principle research questions of the study?

A: PG&E developed a prototype model (The Renewable Integration Calculator or Calculator) to understand the operational impacts of higher levels of intermittent resources, the drivers of those impacts, and the resulting integration needs and costs of different renewable portfolios.

Planners and decision-makers need to know ahead of time, as they plan and before they make commitments for increased intermittent generation, what type and amount of resources are needed to integrate that intermittent generation. Rather than doing another 33% RPS study, whose results depend on the particular inputs used and become outdated before the study is completed, PG&E's current focus is:

- Understanding the key drivers of integration needs and costs;
- Facilitating communication and learning within the industry about the integration needs and costs of intermittent generation;
- Developing tools to capture the major drivers of integration and to quickly evaluate the integration needs for different portfolios with different penetration levels of intermittent resources.

The Calculator was built jointly by PG&E and The Brattle Group Inc.

PG&E is working with the CAISO, as part of its 33% RPS integration project, to calibrate the inputs to the model described below. After that, PG&E will make the Calculator publicly available along with a description of the methodology and user manual.

Q2. Brief description of methodology/links to documentation

A: The Calculator is an incremental model; that is, it assumes the existing system has just enough resources to cover both reliability and operating needs.[1]

To estimate ancillary service (A/S) requirements of intermittent resources, the Calculator uses statistical parameters of load and intermittent generation forecast errors for different time intervals.

- For regulation (reg-up and reg-down): based on the forecast error from the 5 minute ahead forecast to actual minute load/generation;
- For load following: based on the forecast error from hour-ahead forecast to 5-minute ahead forecast;

[1] The Calculator defines "reliability need" as the amount of resources needed to meet expected peak plus a planning reserve margin required by the CPUC to meet an adopted reliability criteria, typically a 1 day in 10 year chance of involuntary service interruption due to supply deficiencies. The Calculator defines "operating need" as the amount of resources needed to meet load less variable generation plus the required A/S needed to manage the variability and forecast uncertainty of load and variable generation.

- For day-ahead commitment: based on the forecast error from day-ahead forecast to hour-ahead forecast.

To estimate integration resource need, the Calculator:

- Estimates reliability need as incremental peak plus required planning reserve margin less intermittent resources' contribution to reliability or their net qualifying capacity (NQC);
- Estimates operating need as incremental hourly load less hourly intermittent generation plus ancillary services (A/S) needed for incremental load and intermittent resources;
- Integration resource need occurs when operating need exceeds reliability need. (The Calculator assumes that resources available to meet the system's reliability need are operationally flexible and can provide the incremental A/S for load and intermittent resources.)

The Calculator uses a cost-based (rather than market-based) approach to estimate the following integration costs:

- The fixed cost of the integration resources needed, net of expected energy profits; and
- The variable costs (fuel and variable O&M) of resources providing the incremental A/S.

Note that because of its cost-based model, the Calculator allocates to integration cost only a portion of the fixed cost of additional integration resources, and only to the extent those integration resources are needed over and above resources available to meet the reliability need. This may underestimate integration costs since the buyer of intermittent generation will have to buy or self-provide all of the additional A/S amounts required by the incremental intermittent generation.

Q3. Key drivers

A:

The key drivers of A/S need are:

- Load and intermittent generation forecast uncertainty at different time intervals from day-ahead to 5-minute ahead forecasts;
- Amount of variable generation in the portfolio.

The key drivers of integration cost are:

- A/S needed for load and intermittent generation;
- Availability of operational flexible resources already in the system that can provide incremental A/S;
- Fixed and variable operating costs of resources providing the integration services.

Q4. Findings and conclusions

A:

- Integrating intermittent resources requires flexible generation that can respond quickly to forecast deviations of intermittent generation;
- Resources available to meet reliability requirements may not be sufficient to satisfy operating requirements of additional intermittent resources;
- PRM evaluation is based on loss of load expectation which does not account for forecast uncertainty or operating needs of load or intermittent resources;
- Today's preferred resources (EE, DR, DG) do not help integrate intermittent resources;
- Integration needs are a function of the variability and forecast uncertainty of intermittent generation.

Q5. Uncertainties

A: The major uncertainties associated with intermittent generation integration are:

- Forecast uncertainty of intermittent generation;
- Unknown intermittent resource additions.

Although not addressed by PG&E's Calculator, additional uncertainties associated with the system implications of 33% renewables include:

- Impacts on the electric transmission system, both regarding the need for major transmission lines or system upgrades to access and integrate renewables;
- Impact on the natural gas system (pipeline, storage and operating procedures) needed to manage large amount of intermittent generation;
- Potential increases in over-generation (periods when must-run generation exceeds load) due to increase renewable resources;
- Potential impacts to the distribution system from large amounts of rooftop installations.

Q6. Lessons for implementing a higher level of renewable in California by 2020

A:

- Need tools to estimate the combined reliability/operational need of the system with increased levels of intermittent resources. Current reliability tools do not account for forecast uncertainty in operations.

- Need weather-specific generation profiles of intermittent resources. Typical profiles are not enough.
- Need to track progress made in reducing the forecast error for solar/PV generation.

Q7. Recommendations for further analysis

A: See response to Q 5 and 6.

Q8. Input assumptions: matrix for comparing studies

A: The comparison suggested by this question is useful only to the extent studies being compared measure the same effects under comparable assumptions. For example, the Calculator can be run to estimate the incremental A/S needs and integration costs associated with a given amount and type of intermittent resource additions. Its results can then be compared to estimates of A/S need and integration costs produced by other studies, to the extent other studies can measured those estimates.

Input assumptions	Used by Calculator
▪ Load forecast	Defined by user (e.g., CAISO 2006 hourly load plus 1% load growth to 2020)
▪ Additional renewables required for 33 percent renewable energy by 2020	Defined by user for desired scenario (e.g., 10,000 MW of wind 5000 MW of various solar technologies in different locations)
▪ RPS developments in the rest of WECC (How much fossil generation was added to replace OTC retirements and how much was added to "Back-up" intermittent renewable energy in California and the rest of the WECC?)	Model calculates amount of A/S needed for incremental intermittent resources given input assumptions, including type and amount of intermittent resources, generation forecast error, fixed and variable cost of integration resources
▪ Major transmission upgrades included	Not applicable