

Direct Load Control Analysis and Stacking of Benefits in OMF Using VirtualBatteries

Key Highlights

- To support cooperatives goals of continually improving peak demand savings programs, NRECA is working with the Pacific Northwest National Laboratory (PNNL) on a demand response planning software application called the "VirtualBatteries" evaluation tool.
- In addition, NRECA and PNNL are implementing an application “vbatStacked” that uses the Virtual Battery algorithm to determine load control benefits for three simultaneous (stacked) applications.
- The new tool is available on NRECA’s Open Modeling Framework (OMF) website: omf.coop.

What has changed?

While representing only 12 percent of consumers, rural electric cooperatives account for 27 percent of all reported peak demand savings – more per consumer than any other utility class.¹ Nonetheless, co-ops are always interested in improving or expanding their existing programs. To help with this goal, NRECA was recently funded by the Pacific Northwest National Laboratory (PNNL) to work with them in building and testing a demand response planning software application called the "VirtualBatteries" evaluation tool. It uses detailed models of electricity loads for common appliances and equipment (water heaters, air conditioners, refrigerators, and resistance heaters) to determine the ability of a large group of these resources to store and release energy like a battery energy storage system, and hence, to manage energy consumption and peak load.

In addition to our dispatch tool, called “vbatDispatch,” PNNL and NRECA began implementing another application, called “vbatStacked,” which uses the Virtual Battery algorithm to determine the load control benefits for three simultaneous (stacked) applications: price structure, regulation, and deferral. These applications are described in detail below.

This evaluation tool simulates the economic impacts of dispatching a group of loads. The tool is now available to the co-ops, and in this advisory, we describe this tool and how it has been tested and can be used.

¹ Form EIA-861 Electric power sales, revenue, and energy efficiency. Can be found here: <https://www.eia.gov/electricity/data/eia861/>

What is the impact on cooperatives?

VirtualBatteries will allow co-ops to evaluate the potential of diverse direct load control programs to enhance revenue streams. The tool will enable its users to see the impact both on revenue and on demand. The tool can be used by co-ops without a demand response program and by co-ops who want to compare their existing program with NRECA's model.

Cooperatives are encouraged to try the tool, send NRECA and PNNL feedback via the email addresses listed at the bottom of this article, and consider using it when you plan your next demand response program expansion. Your feedback will provide us with useful insights with which to make updates to the tool to better serve cooperatives.

Cooperative Demonstrators

This simulation tool was tested and developed with the cooperation of Washington Electric Co-op, Blue Ridge Energy, Black Hills Electric Cooperative, Flathead Electric Cooperative, Oklahoma Electric Cooperative, Allegheny Electric Cooperative, and Central Alabama Electric Cooperative. With their help, we were able to validate results and improve our interface, as well as implement new features to better serve co-ops. In the benefits stacking analysis, we worked closely with Flathead Electric Cooperative and Oklahoma Electric Cooperative.

How the Model Works

The VirtualBatteries algorithm operates by comparing the outside temperature to a desired temperature threshold for the thermostatically controlled device to determine when the device is operating. By strategically operating these devices to "charge" them before the peak consumption of the day, it can then "discharge" them to shave the peak of the given day. This potential is calculated and treated like a battery, which is only dispatched on peak consumption days.

PNNL has developed a prioritization algorithm that will try to maximize profits across the revenue streams selected by the user. Those revenue streams are price structure, regulation, and deferral.

- **Price structure:** Either an annual "G&T Peak Charge," an annual demand charge applied to the distributor on the G&T's peak, or a "Peak Percentile Multiplier," an annual demand cost.
- **Regulation:** Up- and down- regulation ancillary service revenue provided by user in CSV (see below). This is a general model of bulk power system spinning reserve markets based on work by Argonne National Lab².
- **Deferral:** Deferral and annualized cost provided by user (see below).

² Argonne, Survey of U.S. Ancillary Services Markets, <https://publications.anl.gov/anlpubs/2016/01/124217.pdf>

What do cooperatives need to know or do about it?

The vbatStacked evaluation tool is hosted on NRECA's Open Modeling Framework (OMF) website. To access the OMF, go to omf.coop, log in (create a free account, if you do not have one), and select vbatStacked from the "New Model" drop down menu.

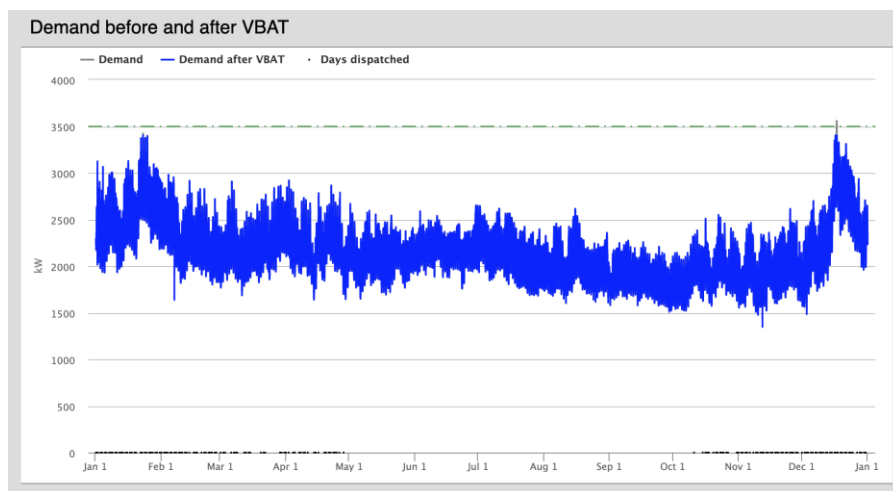
The OMF is a website developed by NRECA. It is comprised of a set of Python libraries for simulating power systems behavior with an emphasis on cost-benefit analysis of emerging technologies: distributed generation, storage, networked controls, etc.

To run a vbatStacked simulation, a few things are required:

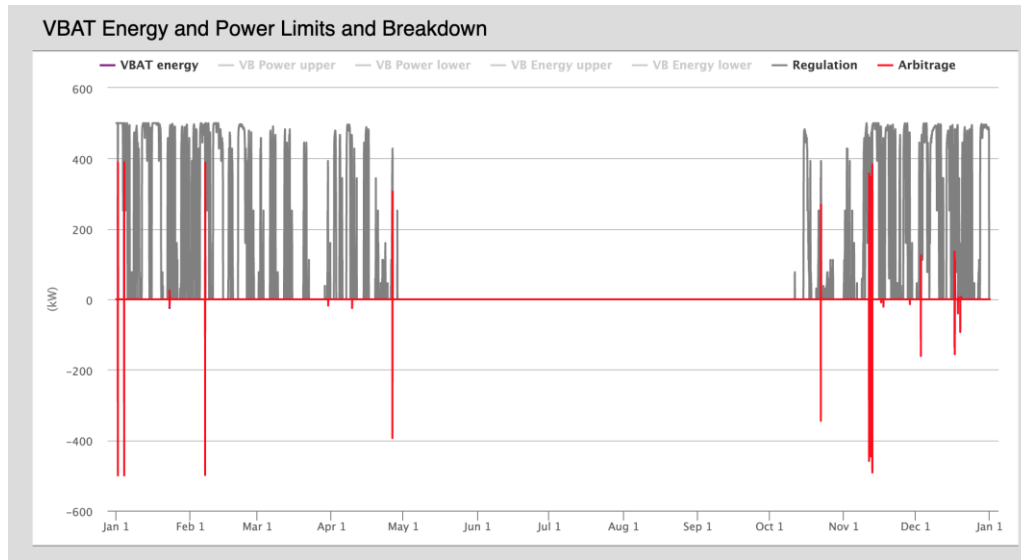
- 8,760 rows with the following columns (It is important to name the columns properly; they are case sensitive.)
 - "Load (kW)": Demand curve in kW
 - "Reg-dn Price (\$/MW)": Hourly regulation down pricing
 - "Reg-up Price (\$/MW)": Hourly regulation up pricing
- A .csv file with 8,760 hourly temperature measurements in Celsius in a single column of the same year as the demand data. (A good source of historical weather data is <https://mesonet.agron.iastate.edu/request/download.phtml>).
- The specifications of the devices to be modeled (common default values exist), including the rated power, thermal capacitance, thermal resistance, coefficient of power (COP).
- Maximum number of hours you are willing to implement controls.
- G&T Curve (Option: G&T Peak): An 8,760 demand curve of the utility's G&T.

Once these parameters and files are loaded, the simulation can be run and will return the results as follows:

- The demand curve before and after dispatching the virtual battery algorithm. Days dispatched are represented by black points on the x-axis. In this chart, the user has selected the "deferral" option as well, represented by the dotted line at 3500kW.



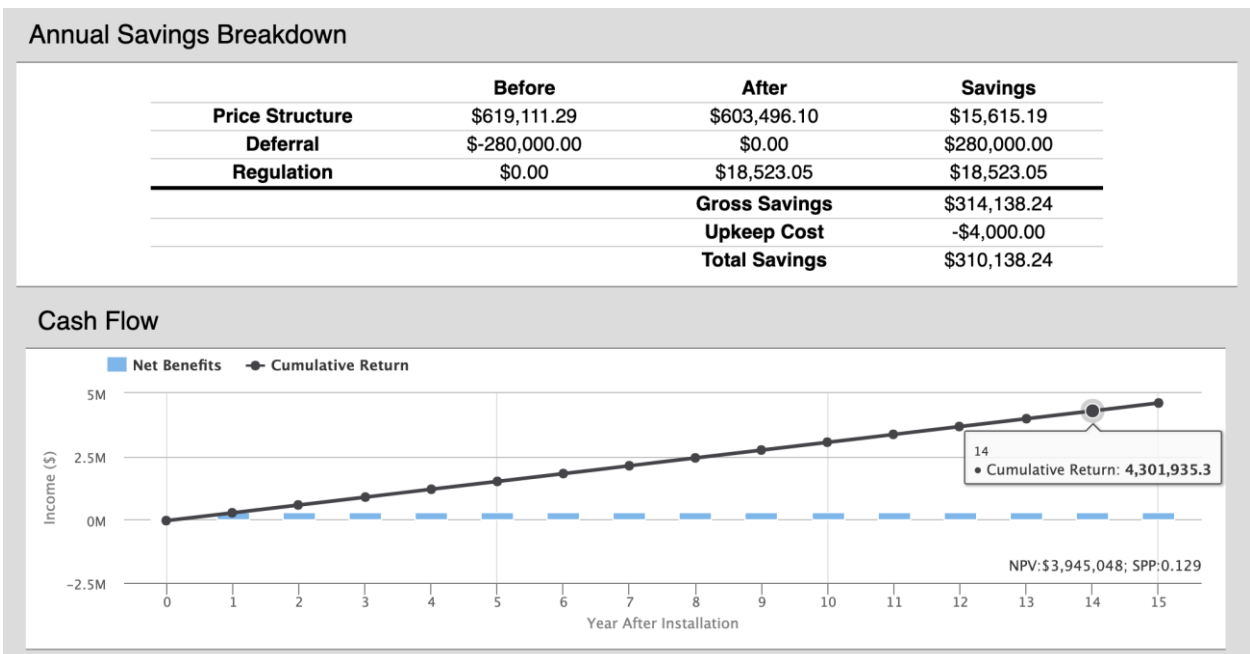
- The limits and dispatch of the virtual battery system, and how it is distributed across revenue streams over time;



- A breakdown of how many days there were water heater / air conditioner / etc. controls sent out; and

There were 165 daily dispatches.

- A financial breakdown, considering each revenue stream.



Additional details about the model can be found at <https://github.com/dpinney/omf/wiki/Models---vbatStacked>.

Related model

For cooperatives interested in how Virtual Batteries can help their bottom line in a more straightforward way, consider looking at the OMF's other model vbatDispatch. Link: <https://www.omf.coop/newModel/vbatDispatch/vbatDispatchDemo>. The full documentation is available at: <https://github.com/dpinney/omf/wiki/Models---vbatDispatch>.

Additional Resources

- Try out the model: <https://www.omf.coop/newModel/vbatStacked/vbatStackedDemo>
- Documentation for the model: <https://github.com/dpinney/omf/wiki/Models---vbatStacked>
- Open Modeling Framework (OMF): <https://www.omf.coop>
- More information about the OMF: <https://www.cooperative.com/programs-services/bts/open-modeling-framework/Pages/default.aspx>

Contacts for Questions

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