StaticCapPlan with Water Equations Quick Guide

By Bryan Palmintier, Aug 18,2011

# Overview

StaticCapPlan is a modular, highly configurable GAMS based electricity capacity expansion planning model. This configurability comes from a combination of a rich set of command-line options, and the ability to adjust the data and model include files.

The model consists of the core model file, helper utilities, and a collection of “shared” (by other similar models, such as OpsLp) model pieces. Of interest here is the WaterEquation family of model pieces that add information and controls for water usage, pricing, and caps. In addition to the core model and associated model pieces, StaticCapPlan also uses a set of data files for system parameters, demand timeseries, generator data, fuel parameters, and generator availability (including wind output).

# Basic Use & Useful Options

By default, StaticCapPlan uses a very simplistic capacity expansion model. Additional features are enabled by command-line options. A complete list of command-line options is included in the text at the top of the StaticCapPlan.gms file. The table below highlights options that will likely be helpful for this analysis. The default configuration for StaticCapPlan features:

* *Integer build decisions:* That is investments must be made in multiples of the notional plant\_size parameter. This makes for a simple Mixed-Integer problem (MIP)[for continuous build decisions use the ‑‑ignore\_integer=1 option]
* *Allowed non-served energy:* When operational costs are too high, or constraints are too strict, load is shed for a price, specified by pPriceNonServed in the system definition file. [Use ‑‑no\_nse=1 disable non-served energy and force supply to equal demand]
* *Allowed wind/renewable shedding:* If/when cost effective, excess wind is shed (not used). This setting typically has no effect unless reserves or p\_min are used. [Use ‑‑force\_renewables=1 to disable shedding. This only works for lower quantities of renewables]
* *Automatic anualization of capital costs:* The capital cost, c\_cap, is specified in actual total capital cost and automatically annualized by the model using the capital recovery factor based on the system weighted average cost of capital (WACC) and the plant’s life.

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| GAMS call/option[[1]](#footnote-1) | Description |
| gams StaticCapPlan | Simplest model run. Output in …/capplan/out. Uses the default sys.inc, gen.inc, fuel.inc, and avail.inc files, which are configured for a 20 block load duration curve and do not include water data. |
| … ‑ermsg=1 | Puts description of error codes inline with any errors in the \*.lst file for easier debugging. |
| … ‑‑sys=ercot\_water\_sys.inc | Use the ercot\_water collection of data files. This file automatically setsup the use of ercot\_water\_gens and ercot\_water\_avail. These files are all included in …/models/data and may be freely edited as needed for this project. |
| … ‑‑plan\_margin=1 | [Recommended] Enable use of planning margin. This ensures adequate supply at peak under simplistic uncertainties, by requiring sufficient firm capacity (based on cap\_credit) to meet the peak demand plus the margin specifed by pPlanReserve in the system data file. This is standard practice for simple capacity planning models. |
| … ‑‑derate=1 | [Strongly consider] Enable simple derating of capacity to approximate outages, reserves, and maintenance. This is standard practice for simple capacity planning models. *Important Note: The maximum power available (for power and reserves) for any generator during any period is given by the* ***minimum*** *of the derate constant and time varying availability. The default availability for thermal plants has only been reduced by the unplanned (forced) outage rate, which is appropriate for use with more sophisticated operating reserves. When these reserves are not used, the more conservative derate values are recommended.* |
| … ‑‑basic\_pmin=1 | [Optional] Forces generators to always output at least p\_min. Useful for simplistic handling of baseload generation. |
| … ‑‑calc\_water=1 | Enables the calculation of water usage (withdrawl), costs, and limits. Only works if the active generator data file contains water usage information. If not you will get errors |
| … ‑‑update=change\_stuff.inc | After loading the data files, load the specified update file from the .../models/capplan directory. Settings in the update file override those from the data files. |
| … ‑‑update=../data/change\_stuff.inc | Same as above, but load the update file from …/models/data Look at ieee2011\_update.inc for an example. Recommended method for sensitivity analysis. |
| … ‑‑rps=0.20 | Use a 20% renewable portfolio standard |
| … ‑‑demscale=1.2 | (linearly) scale demand up by 20% |
| … ‑‑co2cost=100 | Set the carbon cost to $100/ton CO2e. Note: command line options override both data and update settings. |
| … ‑‑co2cap=30000 | Set the annual carbon emissions cap to 30000 Kt CO2e. (Kt = 1e3 metric tons) |
| … ‑‑h2o\_limit=120 | Limit system-wide water withdrawals to 120Ggal/yr |
| … ‑‑h2o\_cost=10 | Set a system-wide water cost of $10/kgal (kgal = 1e3 gallons) |
| … ‑‑fix\_cap=1 | Do not make plant investment decisions. Instead only compute operations for the current plant capacities |
| … ‑‑from\_scratch=1 | Ignore the current capacity specified in the generator data file and re-build the generation mix from scratch. *Warning: Be sure to set non-zero costs for all generator types when using this option. For example, in the main ERCOT data (ERCOT2007), the capital costs for existing technologies are set to zero, which will result in a stupid mix from scratch.* |
| … ‑‑min\_plant\_size=250 | Specifies the minimum plant-size for integer investment decision should be 250MW. This is useful to reduce the search space when investing in lots of renewables, since these technologies tend to have small plant sizes (e.g. 50-100MW for wind) |
| … ‑‑force\_plant\_size=2000 | Ignore the representative sizes specifed by plant\_size and force all generation to use 2GW plant sizes. |

# Files of interest

Most of the time the best way to use these is to keep the same name and write over the old values. These files are all under version control so it is easy to go back to the old/original versions if/needed.

## Input data

These are all in …/models/data/ [Use ‑‑data\_dir=DIR to change, path relative to model file, so default is ../data/]

* **ercot\_water\_sys.inc:** Baseline system-wide configuration parameters such as WACC, planning reserves, etc. Also defines the inclusion of the other ercot\_water data files. [Specified with ‑‑sys=FILE as described above]
* **ercot\_water\_gens.inc:** Contains all of the generator cost and technical data, including water numbers. This is the primary place to look/edit for different technology categories and mixes. See below for the multiple places that need edits when new generators are added. [Change file name using ‑‑gens=FILE]
* **ercot\_water\_avail.inc:** Contains a time series for wind availability (maximum output) and your choice of either a timeseries or a single line constant value for thermal generators. [Change file name using ‑‑avail=FILE]
* **ercot2009\_demand.inc:** Contains the demand timeseries. [Use ‑‑demscale=1.2 to linearly scale up for 20% growth, or ‑‑demand=NEWFILE to specify an alternate file]
* **fuel.inc:** The humble, constant fuel data set. [Change file name using ‑‑fuel=FILE]
* **your update file:** Don’t forget this feature for easy sensitivity analysis. See above for how to include and remember you have to include ../data/ in the path. Values here over write data from the other files, however, values from the command line (such as ‑‑rps) are used instead of those from update if provided.

## Results

These show up in …/models/capplan/out/ after a successful model run [Use ‑‑out\_dir=DIR to change, path relative to model file, so default is out/]

* **SCP\_summary.csv:** This should contain all of the output data you need. Fieldnames and units should be self describing.
* **Other outputs:** The complete dispatch timeseries, unit commitment, reserves, build summary, capacity summary, and other files are also available [You can suppress printing these using the ‑‑summary\_only=1 option]

## Model related

The core model is in …/models/capplan/, but the water functions and related are in …/models/shared/

* **…/models/capplan/StaticCapPlan.gms:** The core gams model
* **.../models/shared/WaterEquations.gms:** Additional equations for water calculations
* **.../models/shared/writeSummary** and **calcSummary:** provide most of the calculations and output for the summary file. Look here to find out the source for output data
* **…/models/shared/WaterDataSetup** and **writeWaterSummary:**  provide additional input and output support for the water equations
* **…/models/capplan/Screening Curves.xlsx:** A simple graphical capacity planning model that includes support for carbon costs and renewable capacity credit. Makes nice pictures if you need them.

## Data helpers

These excel files include the raw data and intermediate calculations to create most of the data files described above. In most cases you can use these for simpler formatting and then copy and paste into the text files above. Typically located in the …/models/data directory

*IMPORTANT: If you make changes to these files, please save them using a new name. For all other files, please do not use a new name.*

* **ERCOT\_2009\_Hourly\_Wind&Load\_GAMS\_formatter.xlsx:** Contains the raw 2009 wind and load time series and a number of nifty page formatters to create block load duration curves, selected weeks, and 8760 series sorted by time, load, etc. All such pages are designed for easy copy and paste into GAMS data files
* **ERCOT2007 Plant Summary.xlsx:** Walks through the clustering approach I used to develop the ercot2009 generator data set of installed capacity and average heatrates by technology type.
* **Generator Data Formatter.xlsx:** Provides a table based interface for editing generator include data.

# To add new generation types

The new generation types must be added in multiple places:

1. The G set definition in ercot\_water\_gens.inc
2. The pGenData(G, GEN\_PARAMS) parameter table in ercot\_water\_gens.inc
3. The availability list in ercot\_water\_avail.inc

1. Assumes running the model from the …/models/capplan directory. When running using the Windoze IDE, setup a new project in this directory, open StaticCapPlan.gms and then place everything after gams StaticCapPlan into the command line option box near the top right of the IDE, just below the menu bar. The use of … before double dash options, implies the use of [↑](#footnote-ref-1)