

eQUEST Project QC: a Step-by-Step Procedure, M.S. Addison, May 2011



Things to obtain before starting:

To enable a review of the eQUEST project files, you'll need/want the following.

1) **eQUEST input files:**

- a. PD2 files for each case — may be separate files for ASHRAE baseline and LEED proposed case.
- b. INP files — obtain all INP files. There will be one INP file whose file name exactly matches each PD2 file. If the consultant also ran parametric runs, there will be one INP file for each parametric run. Obtain all INP files for possible use in a detailed comparison of runs.
- c. PRD file — this file is available only if parametric runs were conducted.
- d. Custom weather or custom library files, if any — obtain any custom weather files (prepared as part of a model calibration) or custom library files.

2) **eQUEST output files** — the following output files are necessary to conduct the review steps listed below. Note: it is optional whether they are obtained directly from the contractor that prepared the input files. In any case, it is best if they are reproduced by re-running the project using the eQUEST input files listed above. The reproduced output files can then be compared to the output files submitted by the contractor.

- a. **SIM files** for each case — The SIM file contains detailed eQUEST (DOE2) results reports. It is a large text file viewable using any text editor (including MS Word), however, eQUEST comes with *D2SIMViewer* that is normally used to view eQUEST SIM files. If the consultant made parametric runs, there will be one SIM file for each parametric run. Obtain all SIM files for possible use in a detailed comparison of runs. Note: these are large files; however, they zip down by a ratio of ~10 to 1 (or better for some compression utilities).
- b. **'parms.csv'** file — If the consultant made parametric runs, there will be one '- parms.csv' file for each batch of parametric runs. Obtain the '- parms.csv' file for possible use in a detailed comparison of runs. Use the '- parms.csv' file to construct (or reconstruct) a spreadsheet table of results containing incremental savings by enduse. See the spreadsheet 'eQUEST Detailed Results (2009).xls' (and linked spreadsheet 'eQUEST Detailed LCC (2009).xls') to use as a template.
- c. **'HVAC Summary.csv'** file — produced only if the following flag has been added anywhere in the '[preferences]' section of the eQUEST.INI (in the eQUEST Data folder): `StoreResults_HVAC_Summary=1`
This file provides a convenient summary of key HVAC data including: equipment capacities, flow rates, pressure drops, motor kW, etc.
- d. **'Space Loads Report (CSV)'** — this is a CSV file that contains selected information for each space in the model (one row per space). It is an 'optional' report in that it is not automatically produced by eQUEST. Rather, it must be manually exported each time one is desired. To export the Space Loads Report

(a CSV file) and open it into Excel, within eQUEST's Detailed Interface (DI), select the 'File' menu, then 'Export File', then 'Space Loads Report (CSV)'. It is not necessary to run the simulations first. Note that the Space Loads Report CSV file can only be produced for the 'base case', i.e., it is not directly available for parametric run cases. If the consultant made parametric runs, they can also produce one 'Space Loads Report (CSV)' file for each parametric run by first manually loading the INP file from each parametric directly into the DI, then following the export procedure described above.

- e. **QC report** — this is a report that documents the results of a series of QC checks (e.g., range checks) that are automatically conducted by eQUEST. It is an 'optional' report in that it is not automatically produced by eQUEST. Rather, it must be manually 'run' each time one is desired. Prior to producing the QC report, it is necessary to run the simulations. To produce the QC report, within eQUEST's Detailed Interface (DI), select the 'Tools' menu, then 'Quality Control Reporting'. Note that the QC Report can only be produced for the 'base case', i.e., it is not directly available for parametric run cases. If the consultant made parametric runs, they can also produce one QC report for each parametric run by first manually loading the INP file from each parametric directly into the DI, running the simulation for that one run, then following the procedure described above.
- 3) **Energy analysis report** — Obtain the energy analysis project report, if any. Ideally, this energy analysis report has been prepared to your specification to include the necessary detail (see item 10 below).
 - 4) **Project plans** — HVAC narrative, plans, specs, TAB report, etc., if available

Resources to review before starting:

- 5) Any easy-to-use **file comparison utility**, i.e., part of your text editor suite (e.g., Boxer, UltraEdit/UltraCompare, ~\$60 each) or stand-alone (e.g., Winmerge, ExamDiff, freeware versions). Google search the product names above or phrases such as "free file compare utilities" or similar.
- 6) The **Detailed Simulation Reports Summary** — This is a PDF file that helps eQUEST users become familiar with eQUEST's detailed SIM file and some recommended high level QC suggestions. In eQUEST's DI, it is available from the 'Help' menu. Select 'Tutorials and Reference', then 'Detailed Simulation Reports Summary'. It provides the following helpful resources:
 - a. "10 Minute DOE2 Output QC Checklist" — a brief set of suggested items to check on selected SIM file reports (see an updated version of this list on pg 4).
 - b. 'Table of Contents' to the SIM files (see pgs 15-18) — one table for each of the four types of SIM file reports: Loads (space loads), System (air-side coil loads and energy requirements), Plant (water-side plant loads and energy requirements), and Economics (utility bills).
 - c. Annotated listing of all SIM file reports — starting on page 19, provides an annotations listing of the SIM file reports that explain how to interpret the SIM file reports.

- 7) **SIM file ‘Delta’ Reporting Utility** — this is a DOS utility used to compare two SIM files by producing a third SIM which contains the differences or ‘deltas’ between all of the numeric results contained in the two SIM files being compared. See ‘Del22.exe’.

Recommended modeling and reporting practices:

- 8) In the eQUEST model, use **recognizable names for all floors, spaces, zones, and HVAC equipment**. Names found on the plans and in the project analysis report.
- 9) Use **meaningful names for other model components**, e.g., constructions, glass types, schedules, global parameters.
- 10) In the energy analysis project report, require **parametric run reporting** of incremental results by enduse for **‘small’ packages of measure**. Do not group together too many measures per run, otherwise, it will not be possible to assess the reasonableness of specific measures. Include the original Excel file containing any parametric results tables (to facilitate additional review/QC calculations you may wish to add to the Excel file/table).

eQUEST Project review steps for reviewing *single run cases*

The following steps are provided from the perspective of reviewing inputs and outputs for a single run, e.g., the base case run, both to become familiar with the project (if you are reviewing someone else’s work) and to assess the reasonableness of the base case input assumptions, energy use, hours of operations, etc. Suggestions for the review of parametric (ECM) run results are provided in a subsequent section.

- 0) **Prior to opening eQUEST project**: Confirm which version of eQUEST was used to create the project files. This is found in any of the PD2 files. In Windows Explorer, right click on the PD2 file to open with NotePad (or any text editor). The eQUEST version number will be the second item listed in the PD2 file. Use the same version of eQUEST or later version to open the project.

High level checks

- 1) **Air-side Summary Report** — after running the currently loaded project, in eQUEST’s DI, go to the Air-Side HVAC module and click on the Summary tab. The items displayed on this tab will depend on which item is selected on the component tree at the left side of the screen. Selecting an individual system or zone in the component tree displays summary data for only that system and its zones in the Air-side Summary Report. Selecting the Project (top most item in the component tree) displays summary data for all system and zones plus a project-wide summary at the bottom of the Air-side Summary Report. Use the Air-side Summary Report to check system and zone supply CFM/sqft, Min Flow %, OSA (%, cfm/sf, cfm/person), and Design Capacity (tons, sf/ton, cfm/ton, Btuh/sf) and hours outside throttling range.
- 2) **QC Report** — To obtain the QC Report, see item 2e above from the list of things to obtain before starting. Review warning and error level items on the QC Report.
- 3) **Utility Calibration Workbook** — if a calibration was conducted, an Excel calibration workbook (‘EG_MoEU Utility Calibration Worksheet.xls’) is available which graphs utility history versus eQUEST-predicted energy and demand. It is set

up to allow single run results from the 'EG_MoEU_ED.csv' file to be pasted directly into the calibration workbook.

4) **“10 Minute” Checklist**

- a. Percent of hours outside throttling range — eQUEST DI: Air-side Summary Report; SIM file: BEPU (or BEPS), SS-R, SS-F, and SS-O. High number of hours outside throttling range will typically invalidate ECM savings estimates.
- b. Energy use & cost intensity — SIM file: Btu/sqft/year from BEPS, kWh and therms per sqft/year from BEPU, \$/sqft/year from ES-D. Note available in eQUEST's DI.
- c. Energy use by end use category (annual and monthly) — eQUEST DI: see the first two Single-Run reports, Monthly and Annual Energy Use by Enduse. SIM file: similar info is available in the PS-E report, monthly & annual by enduse for ALL electric meters and ALL fuel meters (two versions of the PS-E report) and PS-F report, same as the PS-E report except available for each utility-level meter defined in the project.
- d. Peak coil loads (DX + CHW) on the building — eQUEST DI: not reported; SIM file: SS-D report.
- e. Peak plant loads on hydronic loops — eQUEST DI: not reported; SIM file: PS-D
- f. HVAC equipment sizes — for plant equipment sizes: eQUEST DI: not reported; SIM file: Compare peak loop loads on PS-D and peak plant equipment load on PS-C with equipment sizes reported on PV-A. — for package equipment sizes: eQUEST DI: see the Project Totals at the bottom of the Air-side Summary Report; SIM file: Compare peak loop loads on SS-A with equipment sizes reported on SV-A report. See also the 'HVAC Summary.CSV' file.
- g. Plant equipment part-loads — eQUEST DI: not reported; SIM file: review hours at part load levels on PS-C (annual) and PS-H (monthly, one PS-H report for each piece of plant equipment).
- h. Equipment efficiencies (must be calculated) — eQUEST DI: not reported; SIM file: for plant equipment, PS-C load met reported in MBtu ($\text{Btu} \times 10^6$) divided by energy used (reported on PS-C in kWh for electric and MBtu for fuel) — for package equipment, SS-A load met (reported in MBtu) divided by SS-H energy used (reported in kWh for electric and MBtu for fuel). For packaged heat pumps, see also SS-P and SS-Q.
- i. Annual equipment operating hours — eQUEST DI: not reported; SIM file: for plant equipment, see the right most column of PS-C — for package equipment, see SS-C — for all air handlers (CHW & DX), see SS-E. Compare with Equivalent Full Load Hours (see item 8 on page 6).
- j. Weather file used — Confirm that the correct weather file was used. eQUEST DI: not reported; SIM file: the name of the weather file is reported at top right corner of most SIM file reports

Detailed checks

Any review of results will benefit greatly if the reviewer begins the review process having as much insight into the project details as possible, i.e., design details for the actual building and eQUEST model input assumptions. The following detailed steps are provided from the perspective of reviewing inputs and outputs for a single run, e.g., the base case run or any ECM run, both to become familiar with the project (if you are reviewing someone else's work) and to assess the reasonableness of the base case input assumptions, energy use, hours of operations, etc. The following detailed checks DO NOT include or replicate the high level checks listed above. See page 8 for reviewing parametric (ECM) run results.

- 1) Confirm **total conditioned area** — SIM file, see the upper left area of the LS-C report. This is total conditioned area (excludes unconditioned and plenum zones).
- 2) Check **HVAC air-side system types** — Compare what was simulated in the eQUEST project with what is on the building HVAC plans (if any) or from any walk-through. In eQUEST's DI, go to the Air-Side HVAC screen and in the Component tree (left side of screen), left click on each air handler (one at a time) and see the Zone Locations panel (lower left side of screen) for a view of the portion of the building served by the selected system (the area served by the selected system is shown in grey and red). Alternately, left click on a selected area of the building footprint (i.e., directly in the Zone Locations panel) to see the HVAC system serving the selected area (highlighted in the component tree). If the Zone Locations panel is not displayed (does not automatically display when using 1024x768 screen resolution), click the 'Show Zone Locations' button in the center/lower right area of main screen.
- 3) Check **HVAC system primary equipment** — Compare what was simulated in the eQUEST project with what was on the plans (i.e., mechanical equipment schedule) or documented from the walk-through.
- 4) Confirm **lighting power density (LPD)** (kW or W/sqft).
 - a. Space-by-Space Spreadsheet Method: Space Loads Report: this is the only eQUEST report that automatically compiles LPD info into a single table, i.e., one row per space. Note: column N reports ambient lighting power (installed lighting kW) while column P reports ambient lighting peak use (installed lighting kW multiplied by the lighting schedule). For a quick estimate of whole-building peak lighting load, sum column P from the Space Loads Report.
 - b. Quick One Space-at-a-time Method: eQUEST DI: go to the Internal Loads module, double click on any preferred space to display the Space properties dialog. Click on the Lighting tab. See the Power Summary (lower right corner of Space properties dialog) for kW and W/sqft for lighting and plug loads. After selecting a preferred space (on the Currently Active selection list), use the up & down arrows to quickly review the Power Summary of the other spaces.
 - c. Whole-Building Method: eQUEST DI: not available; Space Loads Report: sum column P. SIM file: PS-E report, see the last rows of the PS-E electric meters report (first of two PS-E reports, second PS-E report page) for annual results. 'MAX KW' on the PS-E report represents peak load (reported by end use, including indoor lighting). 'PEAK ENDUSE' on the PS-E report represents peak

load coincident with the whole building peak load. kW is reported. To calculate whole building W/sqft: 'MAX KW' * 1000 / conditioned area (from LS-C, see step #1 above) / maximum schedule value (available in the 'Space Loads Report (CSV)' report).

- 5) Confirm **equipment power density (EPD)** (kW or W/sqft). Use the same procedures described in step 4 above for lighting power density.
- 6) Confirm **glass properties** (SHGC or SC, U-Factor) and **window properties** (area, window-wall ratio – 'WWR') against plans or specs.
 - a. **Glass/Window transmission properties:** eQUEST DI: use the spreadsheet view to review glass type properties (glass types from the glass library do not report glass properties in the spreadsheet view); SIM file: window (i.e., glass + frames) area and U-value for whole building and by orientation from LV-D report (see the last page of LV-D). Glass SC by window from LV-H. Note: there is no report that provides glass SC by glass type, only by window from LV-H.
 - b. **Glass Type assignments:** eQUEST DI: in the Building Shell module, 3-D geometry screen, right click and select Windows, by Glass Type. This displays a color-coded view of glass types assigned by surface.
 - c. **Window area & WWR:** eQUEST DI: not available; SIM file: use the LV-D report to obtain whole build window area (glass + frame) and gross wall area (window + opaque wall area) (also available by orientation). Use these values to calculate gross (floor-to-floor) WWR.
- 7) Confirm **wall and roof properties** (U-Factor and area) against plans or specs. Use similar procedures as described in step 6 above, i.e., LV-D for opaque & total wall area and color coded construction assignments in 3-D geometry screen. LV-I provides a list of U-values for all constructions. The equivalent for glass types does not exist. Note: when skylights are included in areas with drop ceilings, it is common to use 'dummy' roofs to host the skylights. This common eQUEST modeling 'trick' will cause the roof areas shown on the LV-D report to be misleading (i.e., too large).
- 8) If utility histories are available, calculate **equivalent full load hours (EFLH)** for whole premise meter(s). SIM file: from PS-E, EFLH = monthly (or annual) energy use divided by monthly (or annual) peak demand. EFLH should be less than the eQUEST model's scheduled hours, else, the building actual operating hours exceeds the original estimate operating hours. Compare the EFLHs from the whole premise meter(s) with EFLHs for lights and plugs obtained from the 'Space Loads Report (CSV)' and with fan hours from SS-E and/or SS-C.
- 9) Review and **confirm important schedules** (e.g., for occupancy, lights, equipment, t-stats and fans).
 - a. **Quick Method:** eQUEST DI: not available; Space Loads Report: EFLHs and schedule min and max values are written to the 'Space Loads Report (CSV)' file for **lights** (columns AC - AE), **equipment** (columns AI - AK), and **occupancy** (columns AF – AH are for task lighting but this often uses occupancy schedules). SIM file: For **fan hours**, see the SS-E (whole building) and SS-C (one for each AHU) reports in the SIM file. Note: fan hours on SS-C and SS-E are hours when fans were enabled to run. They are not EFLHs.

- b. Detailed Method: There is no eQUEST or DOE-2 report that makes a detailed review of schedules a quick or easy process. The best available option is performed from within eQUEST's DI by examining each schedule (Annual, Week, and Day). Check that unoccupied schedule levels are reasonable (see 9a above). Confirm that start times for people, lights, equipment, and fans **schedules are well synchronized**. Check also to see if **night cycle control** is enabled: in eQUEST's DI, see Air-Side HVAC—System—Fans—Night Cycle Control. If night cycle control is enabled, confirm which hours are unoccupied in the fan schedule (= zero) and check t-stat set points (in t-stat schedules) for these same hours to confirm that the unoccupied set points are reasonable for night cycle operation. To confirm whether there are any hours when night cycle control resulted in fan operation, see the eighth column of hours reported on SS-E (whole building) and SS-C (one for each AHU).
- 10) Check overall **operations hours**:
- a. **Fan hours**: SS-E (for the whole building/project), and SS-C (for each AHU)
 - b. **Primary equipment hours**: PS-C (annual operating hours for each piece of plant equipment, only one PS-C report for all plant equipment), and PS-H (monthly operating hours for each piece of plant equipment, one PS-H report for each piece of plant equipment)
- 11) Check **part load hours** on air-side and primary equipment:
- a. Fans, SS-L (for each AHU, monthly and annual)
 - b. Primary equipment, PS-C (annual) and PS-H (monthly if necessary)
- 12) Check **minimum VAV flow rates** on VAV air-side equipment:
- a. Inputs at Air-Side Zone spreadsheet, Display Mode = 'Air Flow'. See 'Min Flow Ratio' or 'Min Flow/Area'.
 - b. SS-L (for each AHU, monthly and annual).
- 13) Check **design flows**, **minimum flows**, and **OA flows** using the Air-Side Summary: check CFM/sqft, Min Flow %, OSA (%), cfm/sf, cfm/person), and Design Capacity (tons, sf/ton, cfm/ton, Btuh/sf)
- 14) Confirm major **peak space load components** — LS-C (one report for the whole building/project)
- 15) Check **air-side equipment sizing**: eQUEST DI: Air-Side Summary report; SIM file: SV-A report (includes more detail than the Air-Side Summary report, e.g., fan motor kW). See also the 'HVAC Summary.CSV' file.
- 16) Check **water-side equipment sizing**. eQUEST DI: not available; SIM file: PV-A report. See especially loop and pump flow rates, pressure drop (feet of head) and kW. Compare PV-A with PS-C (plant equipment peak and annual loads) and PS-D (Peak and annual coil load, pipe loss — especially HW pipe loss, and plant load). See also the 'HVAC Summary.CSV' file. Compare with building plan equipment schedule if available.
- 17) Check **zone exhaust** used throughout the project. Check using either the Zone input spreadsheet (Display Mode = Outside Air & Exhaust) or the SV-A report (one report

per AHU). Check also that the zone exhaust air has not forced an increase amount of outside air as make-up air, i.e., zone exhaust air must be \leq zone OA on SV-A. Compare with building plan equipment schedule.

- 18) Check **hours outside throttling range**. eQUEST DI: Air-Side Summary Report. SIM file: BEPU and SS-R. For more detailed follow-up, check:
- SS-F (one for each zone) to determine problem hours by month
 - SS-O (one for each zone) to estimate hour of the day outside throttling range (hours logged on SS-O are during normal fan operations only, night cycle control hours are NOT reported on SS-O)
 - Check **T-Stat setpoints**: examine each thermostat schedule (Annual, Week, and Day). Confirm that the fan start times allow sufficient time prior to occupancy to overcome any pick up (or pull down) loads. Note that the wizard often defaults the fans to come on only one hour prior to occupancy.
- 19) Confirm **utility rate**:
- ES-D for an overall virtual rate (e.g., \$/kWh, \$/therm) per utility rate.
 - Review inputs at Utility & Economics module. Double click on each rate to review its inputs and its structure. Use the ES-F report for detailed auditing of utility tariff.
- 20) If **LCC** is included, confirm discount rate, energy price escalation rates, incremental costs and other costs.
- 21) Check **annual baseline energy use by enduses** —
- eQUEST Reports: Single Run Reports: Annual Energy Consumption by Enduse (pie charts)
 - SIM file: BEPU (kWh, Therms, etc.) or BEPS (MBtu, i.e., Btu $\times 10^6$)
- 22) Check **monthly baseline energy use by enduses** —
- eQUEST Reports: Single Run Reports: Monthly Energy Consumption by Enduse (stacked bar charts)
 - SIM file: PS-E (monthly & annual, one for all electric, one for all fuel) or PS-F (monthly & annual, one for each utility meter)

eQUEST Project review steps for reviewing parametric run results

The following steps are provided from the perspective of reviewing inputs and outputs for a series of parametric ECM runs.

- 23) Check **incremental (and cumulative) savings by end use** using the parametric reports (i.e., the Annual Enduse Summary). Using the Annual Enduse Summary report, in the incremental savings (i.e., middle) section, work row-by-row (one measure at a time) and column-by-column (for each end use) to confirm the sign and magnitude of benefits (savings) and penalties. In most cases, cascade the runs (each run on top of a previous run) to account for the **interactive effects** between measures. At least initially, keep each efficiency measure in separate runs. This will make it much easier to assess the reasonableness of the incremental impacts (benefits and penalties). Once the incremental results for separate measures are confirmed, measures may be grouped into larger aggregate packages of measures for final runs and presentation.
- 24) Identify **what measures and end uses were responsible for most of the savings** (Annual Enduse Summary and Annual Building Summary).