# J∆S Engineering Suite

## Comprehensive Guide: Report Generation

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JS Engineering Solutions

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# 1. Overview

The Report Generator is the primary tool within the JΔS Engineering Suite for producing professional, submission-ready PDF calculation reports. It wraps the full ASHRAE CLTD/CLF load calculation engine together with equipment sizing, ventilation analysis, psychrometric analysis, controls sequences, code compliance checks, energy analysis, and plumbing calculations into a single, cohesive document that can be handed directly to a plan checker, building department, or owner for review.

## Why Professional Reports Matter

• Building departments and plan review agencies require organized, traceable calculation packages before issuing mechanical permits.

• Owners, architects, and contractors rely on these reports to confirm that the HVAC system is correctly sized and code-compliant.

• Engineering firms use them as part of the permanent project record, defending design decisions during construction and post-occupancy.

• Reports that match the format and rigor of tools such as EnergyPro, Trane TRACE 3D Plus, and Carrier HAP give the submitting engineer greater credibility during peer review.

## What the Report Generator Produces

The Report Generator creates a complete calculation package in a single PDF, typically ranging from 40 to 200+ pages depending on the number of rooms and which sections you select. Every page includes branded headers with the project name, job number, and date, plus professional footers with page numbering and confidentiality notices.

The underlying engine uses ReportLab to construct the PDF page by page, drawing tables, charts, and formatted text with a color scheme matching EnergyPro-style engineering reports (navy headers, gold accent rules, alternating row shading).

## Key Features

• 15 individually selectable report sections

• Two-pass PDF rendering for accurate Table of Contents page numbers

• Per-room detail pages with fully traceable calculation formulas

• ASHRAE 90.1-2022 and California Title 24-2022 compliance analysis

• Equipment schedules for AHUs, chillers, boilers, pumps, VAV boxes, and exhaust fans

• Full ASHRAE Guideline 36-2021 sequences of operations

- 12-month energy consumption analysis with utility cost estimates
- Complete plumbing system design (6 sub-sections)
- 80+ engineering abbreviations and 10 code references
- Background thread generation with real-time progress tracking
- Both standalone CLI and GUI modes

# 2. Report Types Available

The J∆S Engineering Suite provides multiple report generation pathways. Each is designed for a different use case.

## 2.1 Project Report (PDF) -- Primary Report

**Module:** `project_report_app.py` (GUI) + `generate_project_report.py` (engine)

This is the flagship report. It produces a complete mechanical design calculation package including load calculations, equipment schedules, controls sequences, compliance checks, energy analysis, and plumbing. It is the report most commonly submitted to building departments for plan review.

- **Typical output:** 40-200+ pages (depending on room count and section

selection)

- **Format:** PDF (letter size, 8.5" x 11")
- **Access:** Sidebar > HVAC Load Calculations > Project Report (PDF)

## 2.2 Report Engine -- Template-Based Reports

**Module:** `report_engine_app.py` (GUI)

The Report Engine is a separate module under Enterprise Tools that produces template-based narrative reports. It is designed for generating standard report formats that can be reused across projects, including load calculation summaries, equipment reports, compliance reports, cost estimates, and narrative design reports.

- **Access:** Sidebar > Enterprise Tools > Report Engine

## 2.3 Reports and Diagrams -- General Reporting

**Module:** `reports_app.py` (GUI)

This module provides additional reporting and diagramming capabilities including system diagrams, flow diagrams, and summary reports. It is accessible from the sidebar under HVAC Load Calculations.

- **Access:** Sidebar > HVAC Load Calculations > Reports and Diagrams

## 2.4 Load Calculation Reports

Load calculation reports are generated as part of the Project Report and include the Load Calculation Summary section, Floor Detail Load Breakdowns, and Room Detail Pages. These can also be generated independently by selecting only those sections in the Report Sections tab.

## 2.5 Equipment Schedule Reports

Equipment schedules are generated as part of the Project Report and include AHU schedules, chiller schedules, boiler schedules, pump schedules, VAV terminal unit schedules, and exhaust fan schedules. Select only the Equipment Schedules section to produce a standalone equipment report.

## 2.6 Compliance Reports

Compliance reports are generated as part of the Project Report and include ASHRAE 90.1-2022 prescriptive compliance checks and California Title 24-2022 prescriptive compliance analysis. Select only the Energy Code Compliance section to produce a standalone compliance report.

## 2.7 Energy Analysis Reports

Energy analysis reports follow the ECON-1 format and include monthly energy consumption breakdowns, annual energy performance summaries, utility cost estimates, and benchmarking against ASHRAE 90.1, ENERGY STAR, CBECS, and Title 24 baselines. Select only the Energy Analysis Summary section for a standalone energy report.

## 2.8 Cost Estimate Reports

Cost estimates are generated through the Report Engine module and include mechanical system cost breakdowns, equipment costs, installation labor, and lifecycle cost analysis projections.

# 3. Architecture and Components

## 3.1 File Structure

```
Root/
generate_project_report.py -- Standalone PDF generation engine (3,534 lines)
project_report_app.py -- PyQt6 GUI wrapper (586 lines)
launcher.py -- Main application entry point (launches both)
output/ -- Default output directory for generated PDFs
guides/ -- User guides (including this file)
```

## 3.2 Module Relationships

```
launcher.py
|
+-- launch_project_report()
| |
| +-- project_report_app.py :: ProjectReportApp (QMainWindow)
| |
| +-- generate_project_report.py :: ReportPDF (PDF engine)
```

```
| +-- generate_project_report.py :: compute_all_loads()
| +-- generate_project_report.py :: size_equipment()
|
+-- launch_report_engine()
| |
| +-- report_engine_app.py :: ReportEngineApp
|
+-- launch_reports()
|
+-- reports_app.py :: ReportsApp
```

## 3.3 Data Flow

**1.** User configures project parameters in the GUI (project info, building geometry, design conditions, section selection).

**2.** GUI pushes values into `generate_project_report.py` module globals (PROJECT, DESIGN_CONDITIONS, BUILDING dictionaries).

**3.** `compute_all_loads()` creates ZoneLoads for every VAV zone on every floor.

**4.** `size_equipment()` sizes AHUs, VAV boxes, chiller, boiler, and pumps from the calculated loads.

**5.** `ReportPDF.generate()` performs two-pass rendering:

• Pass 1: Draws all content to a throwaway BytesIO canvas, collecting Table of Contents entries with real page numbers.

• Pass 2: Re-draws all content to the actual output file with correct TOC page numbers.

**6.** The PDF is saved to the specified output path.

## 3.4 Color Scheme

The PDF uses a professional color scheme matching EnergyPro-style engineering reports:

| Element | Color Code | Description |
|---|---|---|
| Header Background | #1B365D | Navy blue |
| Header Accent | #B8860B | Dark goldenrod |
| Table Header BG | #1B365D | Navy blue (matches header) |
| Table Header FG | #FFFFFF | White text |
| Table Alternating | #F5F5F5 | Very light gray |
| Table Border | #666666 | Medium gray |
| Accent Green (PASS) | #228B22 | Forest green |
| Accent Red (FAIL) | #CC0000 | Dark red |

| Element | Color Code | Description |
|---|---|---|
| Body Text | #333333 | Dark charcoal |
| Secondary Text | #666666 | Medium gray |

### 3.5 Page Layout

| Parameter | Value |
|---|---|
| Page Size | Letter (8.5" x 11", 612 x 792 points) |
| Left Margin | 0.6 inches |
| Right Margin | 0.6 inches |
| Top Content Start | 1.1 inches from top |
| Bottom Margin | 1.0 inches |
| Header Height | 0.75 inches |
| Footer Position | 0.55 inches from bottom |

# 4. Opening the Report Generator

## 4.1 From the Launcher Dashboard

**1.** Launch the application by running `python launcher.py` or opening the compiled `Design_Suite.exe`.

**2.** After logging in and reaching the dashboard, locate the sidebar on the left side of the window.

**3.** Navigate to the **HVAC Load Calculations** section in the sidebar tool categories.

**4.** Click **Project Report (PDF)** to open the Report Generator window.

The dashboard also includes a quick-action **Reports** button that opens the general Reports and Diagrams module.

## 4.2 Standalone Launch

The Report Generator can also be run independently outside the launcher:

```
python project_report_app.py
```

This opens the same `ProjectReportApp` window with all four tabs and the generation controls. No login is required for standalone operation.

## 4.3 Command-Line Report Generation

For automated or batch operations, you can generate reports directly from the command line without the GUI:

```
python generate_project_report.py
```

This runs the `main()` function which computes loads, sizes equipment, and generates a PDF to the default output location (`output/San_Diego_Office_100K_SF_Report.pdf`). Console output shows progress through all 15 sections with load summaries printed to stdout.

## 4.4 The 4-Tab Interface

When the Report Generator opens, you will see:

• A **header** reading "Project Report Generator" with the subtitle "Generate

comprehensive HVAC + Plumbing calculation reports (PDF)".

• A **tab bar** with four tabs: **Project Info**, **Building**, **Design

Conditions**, and** Report Sections**.

• A **bottom bar** containing a progress bar (scaled 0 to 15 sections), a

status label, a **Generate Report** button, and an **Open PDF** button.

The dark theme matches the rest of the application, with cyan accent color (`#00d4ff`) for active tabs, focused fields, and the primary action button.

# 5. The GUI Report Builder

The `ProjectReportApp` class in `project_report_app.py` provides a full PyQt6 graphical interface for configuring and generating reports. It is a `QMainWindow` subclass that can operate either as a standalone window or as a child window launched from the main application.

## 5.1 Window Properties

| Property | Value |
|---|---|
| Title | Project Report Generator -- JΔS Engineering Suite |
| Minimum Size | 900 x 700 pixels |
| Theme | Dark (#0a0a0f background, #00d4ff primary accent) |
| Tab Count | 4 (Project Info, Building, Design Conditions, Report Sections) |

## 5.2 Signal Architecture

The report generation thread communicates back to the main GUI through `GeneratorSignals`, a `QObject` subclass with three signals:

| Signal | Parameters | Description |
|---|---|---|
| `progress(int, str)` | Step, message | Updates the progress bar and status |
| `finished(str)` | Completion msg | Called when PDF is saved successfully |
| `error(str)` | Error message | Called if an exception occurs |

## 5.3 Settings Application

When the user clicks **Generate Report**, the GUI calls `_apply_settings()` which pushes all GUI field values into the `generate_project_report` module's global dictionaries:

- `PROJECT` dictionary: project name, address, client, engineer, company, company address, phone, job number, and date.
- `DESIGN_CONDITIONS` dictionary: location, climate zones, elevation, outdoor design temps, indoor setpoints.
- `BUILDING` dictionary: total area, floors, floor area, heights, envelope construction, glazing properties, HVAC system type.

# 6. Project Info Tab

The Project Info tab captures the identifying information that appears on the cover page, headers, and throughout the report.

## 6.1 Project Information Group

| Field | Description | Default Value |
|---|---|---|
| Project Name | Full name of the project | San Diego Corporate Office Tower |
| Project Address | Street address, city, state, ZIP | 4500 La Jolla Village Drive, San Diego, CA 92122 |
| Client | Owner or developer name | Pacific Coast Development Group |
| Engineer | Engineer of Record with credentials | Michael R. Torres, PE, LEED AP |
| Company | Engineering firm name | SC Engineers |
| Company Address | Firm street address | 1250 Sixth Avenue, Suite 500, San Diego, CA 92101 |
| Phone | Firm phone number | (619) 555-0142 |
| Job Number | Internal project/job tracking number | SD-2026-0147 |

The **Date** field is auto-populated with the current date at the time of report generation (formatted as "Month DD, YYYY"). You do not need to enter it manually.

The company email is stored in the module globals as `PROJECT["company_email"]` and defaults to `info@scengineers.com`. It appears on the cover page in the "Prepared By" section.

## 6.2 Output Settings Group

| Field | Description |
|---|---|
| Output Folder | Directory where the PDF will be saved. Click **Browse...** to pick a folder. Defaults to the `output/` subdirectory next to the application. |
| File Name | Name of the generated PDF file. Defaults to `San_Diego_Office_100K_SF_Report.pdf`. Change this to match your project. |

**Tip:** Use a descriptive filename that includes the project name and building area so the file is easy to identify later. For example: `ProjectName_LoadCalcReport_100KSF.pdf`.

## 6.3 Where Project Info Appears in the Report

• **Cover Page:** Project name (large title), address, client, job number,

date, engineer, company name, company address, phone, and email.

• **Page Headers:** Every page header includes the project name (right side),

job number, date, and company name (left side below section title).

• **Page Footers:** "JΔS Engineering Suite" branding, confidentiality

notice, page number, and copyright with company name.

• **Executive Summary:** Project name and address in the building info box.

# 7. Building Tab

The Building tab defines the physical characteristics of the building that drive the load calculations.

## 7.1 Building Geometry Group

| Field | Range | Default | Description |
|---|---|---|---|
| Total Area | 1,000 - 10,000,000 SF | 100,000 SF | Gross conditioned floor area of the entire building. |
| Number of Floors | 1 - 100 | 4 | Total number of above-grade floors. |
| Floor-to-Floor Height | 8.0 - 30.0 ft | 13.0 ft | Distance from one floor slab to the next. Controls plenum and wall area calculations. |

| Field | Range | Default | Description |
|---|---|---|---|
| Ceiling Height | 7.0 - 25.0 ft | 9.5 ft | Height of the occupied zone below the ceiling grid. The plenum height is computed automatically as (Floor-to-Floor minus Ceiling Height). |
| Window-to-Wall Ratio | 0.00 - 1.00 | 0.40 | Fraction of gross exterior wall area that is glazing. A value of 0.40 means 40% glass. |

The floor area per floor is automatically calculated as Total Area divided by Number of Floors. For the default values, each floor is 25,000 SF.

The building footprint dimensions default to 250 ft x 100 ft (25,000 SF footprint), giving a perimeter of 700 linear feet. These values are stored in the BUILDING dictionary and used in the project description narrative.

## 7.2 Envelope Construction Group

| Field | Options | Default |
|---|---|---|
| Wall Construction | Steel Frame R-19, Steel Frame R-13, CMU R-11, Precast R-15 | Steel Frame R-19 |
| Roof Construction | Metal Deck R-30, Metal Deck R-25, Concrete R-20, Wood Deck R-38 | Metal Deck R-30 |
| Glazing Type | Double Low-E Argon (U-0.29, SHGC 0.38), Double Clear (U-0.47, SHGC 0.70), Triple Low-E (U-0.20, SHGC 0.27), Single Clear (U-1.04, SHGC 0.86) | Double Low-E Argon (U-0.29, SHGC 0.38) |

The U-values and SHGC values shown in parentheses for glazing are used directly in the conduction and solar gain calculations. Selecting a different glazing type automatically updates the thermal properties used in every zone load calculation.

### Wall U-Values (from Module Globals)

| Construction | U-Value (BTU/hr-sf-F) | Effective R-Value |
|---|---|---|
| Steel Frame R-19 | 0.089 | R-11.2 |
| Steel Frame R-13 | 0.124 | R-8.1 |
| CMU R-11 | 0.148 | R-6.8 |
| Precast R-15 | 0.110 | R-9.1 |

### Roof U-Values

| Construction | U-Value (BTU/hr-sf-F) | Effective R-Value |
|---|---|---|
| Metal Deck R-30 | 0.039 | R-25.6 |
| Metal Deck R-25 | 0.048 | R-20.8 |

| Construction | U-Value (BTU/hr-sf-F) | Effective R-Value |
|---|---|---|
| Concrete R-20 | 0.058 | R-17.2 |
| Wood Deck R-38 | 0.031 | R-32.3 |

## 7.3 HVAC System Group

| Field | Options | Default |
|---|---|---|
| System Type | VAV with CHW/HW Reheat, VAV with Electric Reheat, Rooftop VAV (DX), Fan Coil Units (4-Pipe), WSHP (Water-Source Heat Pump), VRF (Variable Refrigerant Flow), DOAS + Radiant | VAV with CHW/HW Reheat |
| Supply Air Temp | 48.0 - 65.0 F | 55.0 F |

The supply air temperature determines the delta-T used for supply airflow sizing. The standard calculation is:

```
Supply CFM = Total Sensible Load / (1.08 x (Room Temp - Supply Air Temp))
```

With a 75 F room setpoint and 55 F supply air, the delta-T is 20 F. The 1.08 factor represents `60 min/hr x 0.075 lb/ft3 x 0.24 BTU/lb-F` at sea level standard conditions.

# 8. Design Conditions Tab

The Design Conditions tab sets the climate data and indoor setpoints that govern every load calculation in the report.

## 8.1 Location and Climate Group

| Field | Range / Options | Default |
|---|---|---|
| Location | Free text (city, state) | San Diego, CA |
| ASHRAE Climate Zone | 1A through 8 | 3B |
| Title 24 Climate Zone | CZ1 through CZ16 | CZ7 |
| Elevation | 0 - 15,000 ft | 62 ft |

The ASHRAE climate zone is used for ASHRAE 90.1-2022 compliance checks (envelope U-value limits, HVAC efficiency minimums). The Title 24 climate zone is used for California Title 24-2022 compliance. If the project is outside California, the Title 24 zone can be left at any value -- the compliance section will still generate but can be excluded via the Report Sections tab.

When passed to the engine, the ASHRAE climate zone is appended with "(Warm-Dry)" for zones like 3B. This annotation appears throughout the report wherever the climate zone is referenced.

## 8.2 Outdoor Design Conditions Group

| Field | Range | Default | Description |
|---|---|---|---|
| Cooling DB (0.4%) | 60.0 - 130.0 F | 89.0 F | ASHRAE 0.4% cooling dry-bulb design temperature |
| Cooling WB (0.4%) | 50.0 - 90.0 F | 69.0 F | ASHRAE 0.4% coincident wet-bulb temperature |
| Heating DB (99.6%) | -40.0 - 60.0 F | 44.0 F | ASHRAE 99.6% heating dry-bulb design temperature |
| Daily Range | 5.0 - 40.0 F | 12.0 F | Mean daily temperature range, used for CLTD correction |

These values come from the ASHRAE Fundamentals Handbook climatic design conditions tables (Chapter 14). The 0.4% cooling value means the outdoor temperature exceeds this value only 0.4% of the annual hours (roughly 35 hours per year). The 99.6% heating value means the outdoor temperature falls below this value only 0.4% of the year.

The daily range is critical for the CLTD correction factor. The corrected CLTD for walls is calculated as:

```
CLTD_corrected = CLTD_base + (78 - T_indoor) + (T_outdoor - DailyRange/2 - 85)
```

Where:

- `CLTD_base` = 13.0 F for steel frame walls (medium color, west orientation)
- `T_indoor` = indoor cooling setpoint (default 75 F)
- `T_outdoor` = outdoor cooling dry-bulb (default 89 F)
- `DailyRange` = mean daily range (default 12 F)

The module also stores latitude (32.73), longitude (-117.17), summer wind speed (7.5 mph), and winter wind speed (8.0 mph) in the DESIGN_CONDITIONS dictionary. These are used in narrative descriptions but do not affect the primary CLTD/CLF calculations.

## 8.3 Indoor Design Conditions Group

| Field | Range | Default |
|---|---|---|
| Cooling Setpoint | 68.0 - 82.0 F | 75.0 F |
| Heating Setpoint | 60.0 - 75.0 F | 70.0 F |
| Indoor RH | 30.0 - 65.0 % | 50.0 % |

These setpoints are used throughout the report:

- The **cooling setpoint** drives the cooling delta-T for envelope conduction,

ventilation sensible load, and supply air sizing. It also affects the CLTD correction factor.

- The **heating setpoint** drives the heating delta-T for all heating load

components. The heating delta-T = Indoor Heating DB - Outdoor Heating DB.

- The **indoor relative humidity** is reported in the psychrometric analysis,

design criteria sections, and determines the return air wet-bulb temperature used in mixed air calculations.

# 9. Report Sections Tab

The Report Sections tab provides 16 individually selectable sections. Each section has a checkbox that can be toggled on or off. By default, all 16 sections are enabled.

## 9.1 Section Checkboxes

| Key | Section Name | Default | Category |
|---|---|---|---|
| cover | Cover Page | On | Front Matter |
| toc | Table of Contents | On | Front Matter |
| exec_summary | Executive Summary | On | Front Matter |
| project_desc | Project Description & Design Criteria | On | Front Matter |
| load_calcs | Load Calculation Summary | On | Calculation Results |
| airflow | Airflow Summary (ASHRAE 62.1) | On | Calculation Results |
| psychrometric | Psychrometric Analysis | On | Calculation Results |
| equipment | Equipment Schedules | On | Calculation Results |
| controls | Controls & Sequences of Operations | On | Calculation Results |
| compliance | Energy Code Compliance | On | Calculation Results |
| energy | Energy Analysis Summary | On | Calculation Results |
| floor_details | Floor Detail Load Breakdowns | On | Detailed Breakdowns |
| room_details | Room Detail Pages (1 Page per Room) | On | Detailed Breakdowns |
| plumbing | Plumbing Calculations | On | Detailed Breakdowns |
| appendix_a | Appendix A - Design Assumptions | On | Appendices |
| appendix_b | Appendix B - Abbreviations & References | On | Appendices |

The checkboxes are arranged in a two-column grid layout for compact viewing.

## 9.2 Select All / Deselect All

Two buttons appear below the checkbox grid:

- **Select All** -- checks every section checkbox.
- **Deselect All** -- unchecks every section checkbox.

This is useful when you want to generate only one or two sections (for example, just the equipment schedules) without manually unchecking 14 other boxes.

## 9.3 Information Box

Below the section checkboxes, an information panel summarizes the calculation methodologies used:

- **Load Calculations:** ASHRAE CLTD/CLF methodology
- **Ventilation:** ASHRAE 62.1-2022
- **Controls:** ASHRAE Guideline 36-2021
- **Compliance:** ASHRAE 90.1-2022 and California Title 24-2022
- **Plumbing:** UPC/CPC 2022 using Hunter's curve for fixture unit demand
- **Room Details:** EnergyPro-style per-room breakdown (envelope, cooling, heating, ventilation, VAV sizing)
- **Typical Output:** 100-200 pages with room details enabled

## 9.4 Page Count Estimates by Section

| Section | Typical Pages | Notes |
|---|---|---|
| Cover Page | 1 | Always exactly 1 page |
| Table of Contents | 1-2 | May span 2 pages for large TOC |
| Executive Summary | 1-2 | Key metrics and findings |
| Project Description | 2-3 | Design criteria tables |
| Load Calculation Summary | 2-3 | Component breakdowns and floor summary |
| Airflow Summary | 2-4 | Zone-by-zone ventilation table |
| Psychrometric Analysis | 2-3 | State points, coil analysis, economizer |
| Equipment Schedules | 4-8 | Depends on zone count for VAV schedule |
| Controls & Sequences | 4-6 | Full Guideline 36 sequences |
| Energy Code Compliance | 3-5 | ASHRAE 90.1 + Title 24 |
| Energy Analysis | 1-2 | Monthly energy table + EUI |
| Floor Detail Breakdowns | 4-8 per floor | 7 sub-tables per floor |
| Room Detail Pages | 1 per room | 128 pages for 4-floor/32-room building |
| Plumbing Calculations | 3-4 | 6 sub-sections |
| Appendix A | 1-2 | 17 design assumptions |
| Appendix B | 2-3 | 80+ abbreviations, 10 references |

# 10. Generating the Report

## 10.1 Starting Generation

1. Review all four tabs to confirm your project settings are correct.
2. Click the **Generate Report** button in the bottom-right corner of the window. The button is styled with a cyan background for high visibility.

## 10.2 Progress Tracking

Once generation begins:

- The **Generate Report** button is disabled to prevent duplicate runs.
- The **progress bar** at the bottom advances from 0 to 15 as each major section is drawn.
- The **status label** displays real-time updates showing which step is active:
- "Computing building loads..."
- "Sizing equipment..."
- "Initializing PDF..."
- "Generating report (pass 1 - collecting pages)..."

During the two-pass rendering, the console also shows detailed progress:

```
Pass 1: Collecting page numbers for TOC...
[1/15] Drawing cover page...
[2/15] Drawing table of contents...
[3/15] Drawing executive summary...
[4/15] Drawing project description...
[5/15] Drawing load calculations...
[6/15] Drawing airflow summary...
[7/15] Drawing psychrometric analysis...
[8/15] Drawing equipment schedules...
[9/15] Drawing controls & interlocks...
[10/15] Drawing compliance analysis...
[11/15] Drawing energy analysis...
[12/15] Drawing floor detail pages...
[13/15] Drawing room detail pages (1 page per room)...
[14/15] Drawing plumbing calculations...
[15/15] Drawing appendices...
Pass 2: Rendering final PDF with correct TOC...
(same 15 steps repeated)
Report saved: output/San_Diego_Office_100K_SF_Report.pdf
Total pages: 185
```

## 10.3 Threaded Generation

Report generation runs in a separate background thread (`threading.Thread` with `daemon=True`) so that the GUI remains responsive. You can continue to view (but not modify) the tabs while the report is being built. The thread communicates back to the main GUI through Qt signals.

## 10.4 Two-Pass Rendering

The report uses two-pass rendering to produce an accurate Table of Contents:

- **Pass 1:** All content is rendered to a throwaway `BytesIO` canvas. As

each section starts a new page, the section title and page number are recorded in `self.toc_entries`. This pass is discarded after collecting page numbers.

- **Pass 2:** All content is rendered again to the actual output file. The

Table of Contents page now uses the page numbers collected in Pass 1 to produce correct cross-references.

This means the report generation takes approximately twice as long as a single pass, but ensures that all TOC page numbers are accurate.

## 10.5 Completion Dialog

When generation finishes successfully, a message box appears showing:

- The full file path where the report was saved.
- The total page count of the generated PDF.

The status label changes to "Complete!" in green (`#10b981`), and the **Open PDF** button becomes enabled.

## 10.6 Error Handling

If an error occurs during generation, the error signal is emitted with the exception message. The GUI:

- Re-enables the **Generate Report** button.
- Resets the progress bar to 0.
- Changes the status label to "Error!" in red (`#ef4444`).
- Displays a critical message box with the error details.

## 10.7 Opening the Report

Click **Open PDF** to launch the report in your system's default PDF viewer (e.g., Adobe Acrobat, Foxit Reader, or the built-in Windows PDF viewer). The application calls `os.startfile()` on the output path.

# 11. The Standalone Report Generator

The standalone report generator (`generate_project_report.py`) is a 3,534-line Python module that can be run independently from the command line. It contains all calculation logic, data structures, and PDF generation code.

## 11.1 Running Standalone

```
python generate_project_report.py
```

Output:

```
======================================================================
J∆S Engineering Suite - Project Report Generator
100,000 SF Office Building - San Diego, CA
======================================================================

[1/3] Computing building loads...
Total Cooling: 271 tons (3,249,000 BTU/hr)
Total Heating: 89 MBH (89,000 BTU/hr)
Total Supply Air: 148,500 CFM
Total Outdoor Air: 32,400 CFM
Load Intensity: 32.5 BTU/sf
SF per Ton: 369

[2/3] Sizing equipment...
AHU-1: 66,825 CFM, 136 tons cooling, 45 MBH heating
AHU-2: 66,825 CFM, 136 tons cooling, 45 MBH heating
CH-1: 300 tons (Air-Cooled Screw)
B-1: 107 MBH (Condensing, Natural Gas)
VAV Boxes: 128

[3/3] Generating PDF report...
(pass 1 and pass 2 messages)
Report saved: output/San_Diego_Office_100K_SF_Report.pdf
Total pages: 185
```

## 11.2 Module Structure

The module is organized into these major sections:

**1. Color Scheme Constants** (lines 28-44): ReportLab color definitions matching EnergyPro style.

**2. Project Data Dictionaries** (lines 51-101): PROJECT, DESIGN_CONDITIONS, and BUILDING dictionaries with default values.

**3. Zone Definitions** (lines 107-155): `ZoneDef` dataclass and `ZONE_TEMPLATES` list defining 9 zone types per floor.

**4. Load Calculation Functions** (lines 162-231): Individual functions for each load component (wall, roof, glazing, lighting, equipment, people, ventilation, infiltration, heating).

**5. Zone Load Computation** (lines 237-409): `ZoneLoads` dataclass, `compute_zone_loads()`, and `compute_all_loads()`.

**6. Equipment Sizing** (lines 416-586): `AHUData`, `VAVData`, `PlantData` dataclasses and `size_equipment()` function.

**7. ReportPDF Class** (lines 593-3483): The main PDF generation class with all 15 section drawing methods.

**8. Main Function** (lines 3489-3534): CLI entry point.

## 11.3 Zone Templates

The module defines 9 zone types that are replicated on each floor. Each zone type can have multiple VAV boxes, with loads and areas divided proportionally:

| Zone Type | Area/Floor | Occupants | LPD (W/sf) | EPD (W/sf) | VAV Boxes | Exterior |
|---|---|---|---|---|---|---|
| Open Office | 15,000 SF | 75 | 0.98 | 1.0 | 12 | Yes |
| Private Office | 2,000 SF | 10 | 1.11 | 1.0 | 10 | Yes |
| Conference Room | 2,400 SF | 36 | 1.23 | 0.5 | 3 | Yes |
| Break Room | 1,200 SF | 20 | 0.60 | 0.5 | 1 | Yes |
| Lobby/Reception | 1,500 SF | 10 | 0.90 | 0.5 | 1 | Yes |
| Corridor | 1,800 SF | 0 | 0.41 | 0.0 | 2 | No |
| Restrooms | 600 SF | 0 | 0.98 | 0.0 | 1 | No |
| Elec/IDF Room | 300 SF | 0 | 0.82 | 5.0 | 1 | No |
| Server/MDF Room | 200 SF | 0 | 0.82 | 40.0 | 1 | No |

**Total per floor:** 25,000 SF, 32 VAV zones (when individual boxes are counted)

**Total building (4 floors):** 100,000 SF, 128 VAV zones

## 11.4 All 15 Report Sections

The `_draw_all_content()` method calls these 15 drawing methods in order:

1. `draw_cover_page()` -- Cover page with project and firm information
2. `draw_toc_page()` -- Table of contents with page references
3. `draw_executive_summary()` -- Key metrics and engineering check table
4. `draw_project_description()` -- Building description and design criteria
5. `draw_load_summary()` -- Building peak loads and component breakdown
6. `draw_airflow_summary()` -- ASHRAE 62.1 ventilation calculations
7. `draw_psychrometric()` -- AHU air process state points
8. `draw_equipment_schedules()` -- All equipment schedules
9. `draw_sequences()` -- ASHRAE Guideline 36 controls sequences
10. `draw_compliance()` -- ASHRAE 90.1 and Title 24 compliance
11. `draw_energy_analysis()` -- Monthly energy consumption and benchmarks
12. `draw_floor_details()` -- Per-floor load breakdown tables
13. `draw_room_detail_pages()` -- One full page per room
14. `draw_plumbing_calcs()` -- Complete plumbing system design
15. `draw_appendices()` -- Design assumptions and abbreviations

# 12. Report Section 1: Cover Page

The cover page (`draw_cover_page()`) features a professional layout with the following elements:

## 12.1 Title Banner

A full navy-blue banner spanning the top 2.8 inches of the page contains:

- "HVAC DESIGN REPORT" in 24pt bold white text, centered.
- "Mechanical System Design & Analysis" in 16pt light gray text.
- "100,000 SF Corporate Office Building" in 13pt text.
- Company name in gold accent text.

A gold horizontal rule (3pt line weight) separates the banner from the body.

## 12.2 Project Information Box

A light gray (#F8F8F8) bordered box containing:

- **Left column:** Project name, address, client, and building description

(area, floors, system type).

- **Right column:** Job number, date, and engineer of record.

## 12.3 Prepared By Box

A blue-tinted (#F0F4F8) bordered box containing:

- Company name
- Company address
- Phone and email

## 12.4 Applicable Codes Box

A light gray bordered box listing the applicable codes and standards:

- ASHRAE 90.1-2022 | ASHRAE 62.1-2022 | ASHRAE Guideline 36-2021
- California Title 24-2022 | California Plumbing Code 2022 | California

Mechanical Code 2022

## 12.5 Footer

- "Generated using JΔS Engineering Suite" in italic gray text
- Disclaimer about design purposes and engineer responsibility
- Copyright notice with current year and company name

# 13. Report Section 2: Table of Contents

The Table of Contents (`draw_toc_page()`) lists all 15 major sections with page numbers collected during the first rendering pass.

## 13.1 TOC Structure

```
Cover Page ..... 1
Table of Contents ..... 2
1. Executive Summary ..... 3
2. Project Description & Design Criteria ..... 5
3. Load Calculation Summary ..... 8
4. Airflow Summary ..... 11
5. Psychrometric Analysis ..... 14
6. Equipment Schedules ..... 17
7. Controls & Sequences of Operations ..... 23
8. Energy Code Compliance ..... 29
9. Energy Analysis Summary ..... 34
10. Floor Detail Breakdowns (Floors 1-4) ..... 36
11. Room Detail Pages (1 Page per Room) ..... 52
12. Plumbing Calculations ..... 180
A. Appendix A - Design Assumptions ..... 184
B. Appendix B - Abbreviations & References ..... 186
```

## 13.2 Formatting

- Major sections (numbered 1-12) are displayed in 10pt bold navy text.
- Front matter entries (Cover Page, TOC) use 9pt regular text.
- Appendix entries use letter prefixes (A, B) in bold navy text.
- Page numbers are right-aligned with dot leaders.
- If the TOC exceeds one page, it continues onto additional pages.

## 13.3 Page Number Accuracy

Page numbers are populated from `self.toc_entries`, which stores (title, page_number) tuples collected during Pass 1. The `_pg()` helper method performs case-insensitive substring matching to find the correct page number for each TOC entry.

# 14. Report Section 3: Executive Summary

The Executive Summary (`draw_executive_summary()`) presents key project metrics at a glance.

## 14.1 Project Overview Box

A light blue (#F0F4F8) bordered box summarizing:

- Project name and location with climate zone

- Building area, floors, and system type
- Central plant description (chiller type/tonnage + boiler type/capacity)
- Air system count, VAV zone count, total supply CFM, and total outdoor air

## 14.2 Engineering Check Metrics Table

A detailed metrics table with benchmark ranges and pass/fail status:

| Metric | Example Value | Benchmark Range | Status |
|---|---|---|---|
| Total Cooling Load | 271 Tons | - | - |
| Total Heating Load | 89 MBH | - | - |
| SF per Ton | 369 | 250-400 (Office) | PASS |
| CFM per SF | 1.49 | 0.7-1.2 (Office) | REVIEW |
| CFM per Ton | 548 | 350-450 | REVIEW |
| BTU/SF Cooling | 32.5 | 15-25 (Office) | REVIEW |
| BTU/SF Heating | 0.9 | 5-15 (Office) | REVIEW |
| Outdoor Air % | 21.8% | 15-25% | PASS |
| Sensible Heat Ratio | 0.812 | 0.70-0.85 | PASS |
| Total Supply Air | 148,500 CFM | - | - |
| Total Outdoor Air | 32,400 CFM | - | - |

Metrics are evaluated using the `check_range()` function which returns "PASS" when the value falls within the benchmark range and "REVIEW" when it falls outside.

## 14.3 Key Findings and Notes

A numbered list of engineering findings covering:

1. Building peak cooling load assessment relative to expected range
2. Ventilation outdoor air compliance with ASHRAE 62.1-2022
3. Sensible heat ratio interpretation for the climate zone
4. Envelope performance notes (wall U-value, glazing SHGC compliance)
5. Energy recommendations (EUI estimate, rooftop PV recommendation)

# 15. Report Section 4: Project Description and Design Criteria

The Project Description (`draw_project_description()`) provides the narrative context and design basis for the report.

## 15.1 Building Description

A narrative paragraph describing the building including area, number of floors, address, footprint dimensions, floor-to-floor height, ceiling height, plenum height, wall construction, roof construction, and glazing properties with their thermal values.

## 15.2 Outdoor Design Conditions Table

| Parameter | Cooling | Heating |
|---|---|---|
| Dry Bulb (F) | 89.0 | 44.0 |
| Wet Bulb (F) | 69.0 | N/A |
| Daily Range (F) | 12.0 | N/A |
| Wind Speed (mph) | 7.5 | 8.0 |
| ASHRAE Climate Zone | 3B | 3B |
| Title 24 Climate Zone | CZ7 | CZ7 |
| Elevation (ft) | 62 | 62 |

## 15.3 Indoor Design Conditions Table

| Parameter | Cooling Season | Heating Season |
|---|---|---|
| Dry Bulb (F) | 75.0 | 70.0 |
| Relative Humidity (%) | 50 | 30 (min) |
| Supply Air Temp (F) | 55 | 95 (reheat) |
| Sound Criteria (NC) | 35-40 | 35-40 |

## 15.4 Ventilation Requirements (ASHRAE 62.1-2022)

A table showing ventilation rates by space type:

| Space Type | Rp (CFM/person) | Ra (CFM/sf) | Density (sf/person) |
|---|---|---|---|
| Office - Open Plan | 5 | 0.06 | 200 |
| Office - Enclosed | 5 | 0.06 | 150 |
| Conference/Meeting | 5 | 0.06 | 20 |
| Break Room/Lounge | 5 | 0.12 | 40 |
| Lobby | 5 | 0.06 | 100 |
| Corridor | 0 | 0.06 | N/A |
| Restrooms | 0 | Exhaust | N/A |
| Server Room | 0 | 0 | N/A |

## 15.5 Code References

A bulleted list of 8 applicable codes and standards including ASHRAE 90.1, 62.1, Guideline 36, Title 24, California Mechanical Code, California Plumbing Code, NFPA 90A, and SMACNA Duct Construction Standards.

# 16. Report Section 5: Load Calculation Summary

The Load Calculation Summary (`draw_load_summary()`) contains the building- level results.

## 16.1 Building Peak Load Summary Cards

Four summary metric cards displayed horizontally:

- **Total Cooling:** Tons and BTU/hr
- **Total Heating:** MBH and BTU/hr
- **Total Airflow:** CFM and CFM/sf
- **Load Intensity:** BTU/sf and Tons/1000 SF

## 16.2 Cooling Load Component Breakdown Table

Every cooling load component as both BTU/hr, Tons, and percentage of total:

| Component | BTU/hr | Tons | % of Total |
|---|---|---|---|
| Walls (Conduction) | calculated | - | - |
| Roof (Conduction) | calculated | - | - |
| Glazing (Solar) | calculated | - | - |
| Glazing (Conduction) | calculated | - | - |
| Lighting | calculated | - | - |
| Equipment/Plug Loads | calculated | - | - |
| People (Sensible) | calculated | - | - |
| People (Latent) | calculated | - | - |
| Ventilation (Sensible) | calculated | - | - |
| Ventilation (Latent) | calculated | - | - |
| Infiltration | calculated | - | - |
| **TOTAL** | calculated | - | 100.0% |

## 16.3 System-Level Load Summary

Loads grouped by AHU assignment:

| System | Cooling (Tons) | Heating (MBH) | Supply CFM | OA CFM |
|---|---|---|---|---|
| AHU-1 (Fl 1-2) | calculated | calculated | calculated | calculated |
| AHU-2 (Fl 3-4) | calculated | calculated | calculated | calculated |
| BUILDING TOTAL | calculated | calculated | calculated | calculated |

### 16.4 Floor-by-Floor Summary

One line per floor showing cooling tons, BTU/hr, heating MBH, and supply CFM.

## 17. Report Section 6: Airflow Summary

The Airflow Summary (`draw_airflow_summary()`) documents ASHRAE 62.1-2022 compliance.

### 17.1 Ventilation Calculations Table

A comprehensive table for every zone in the building:

| Floor | Zone | Pz | Rp*Pz | Ra*Az | Vbz (CFM) | Supply CFM | Ez |
|---|---|---|---|---|---|---|---|

Where:

- Pz = zone population (occupants)
- Rp*Pz = people-based outdoor air component
- Ra*Az = area-based outdoor air component
- Vbz = breathing zone outdoor air (Rp*Pz* + *Ra*Az)
- Ez = zone air distribution effectiveness (1.0 for ceiling supply, 0.8 for corridors)

### 17.2 Exhaust Air Requirements Table

Zones with exhaust air requirements:

| Floor | Zone | Exhaust CFM | Source |
|---|---|---|---|
| (filtered to zones with exhaust > 0) | | | |

Sources include "Toilet exhaust" for restrooms and "Equipment cooling" for server rooms.

### 17.3 Building Airflow Summary

Aggregate airflow metrics:

- Total Supply Air (CFM)
- Total Outdoor Air (CFM) with percentage of supply
- Total Exhaust Air (CFM)
- Net Return Air (CFM) = Supply - OA

# 18. Report Section 7: Psychrometric Analysis

The Psychrometric Analysis (`draw_psychrometric()`) contains four sub-sections covering all air-side heat transfer processes.

## 18.1 Cooling Design Day State Points

A table showing 6 state points through the AHU during peak summer cooling:

| State Point | DB (F) | WB (F) | RH (%) | W (gr/lb) | h (BTU/lb) | v (ft3/lb) |
|---|---|---|---|---|---|---|
| 1. Outdoor Air (OA) | 89.0 | 69.0 | 36 | 78.2 | 32.8 | 14.2 |
| 2. Return Air (RA) | 75.0 | 62.5 | 50 | 65.4 | 28.1 | 13.7 |
| 3. Mixed Air (OA%) | calc | calc | calc | calc | calc | calc |
| 4. Cooling Coil Leaving | 53.5 | 52.8 | 95 | 60.5 | 21.8 | 13.1 |
| 5. Fan Discharge (+2F) | 55.5 | 53.5 | 89 | 60.5 | 22.3 | 13.1 |
| 6. Supply Air (SA) | 55.0 | 53.0 | 90 | 60.2 | 22.1 | 13.1 |

Mixed air conditions are calculated dynamically from the actual outdoor air fraction. The mixed air RH is estimated using the Antoine equation for saturation pressure.

## 18.2 Cooling Coil Analysis

Detailed coil performance parameters:

| Parameter | Value |
|---|---|
| Entering Air (DB/WB) | Calculated from mixed air |
| Leaving Air (DB/WB) | 53.5F / 52.8F |
| Entering CHW Temperature | 44F |
| Leaving CHW Temperature | 54F |
| Apparatus Dew Point (ADP) | 51.0F |

| Parameter | Value |
|---|---|
| Bypass Factor (BPF) | Calculated |
| Contact Factor (1-BPF) | Calculated |
| Sensible Heat Ratio (SHR) | Calculated |
| Total Coil Capacity | Calculated BTU/hr + Tons |
| Sensible Capacity | Calculated BTU/hr |
| Latent Capacity | Calculated BTU/hr |
| CHW Flow (10F dT) | Calculated GPM |

## 18.3 Heating Design Day State Points

Six state points during peak winter heating at 44F outdoor air, including preheat coil and zone reheat processes.

## 18.4 Economizer Mode Analysis

Differential enthalpy economizer operation by outdoor air temperature range:

| OA Temp Range | Mode | OA Fraction | MAT | Action |
|---|---|---|---|---|
| < 55F | Full Economizer | 100% | = OAT | No mechanical cooling |
| 55F - 70F | Partial Econ. | Modulated | 55F SP | Dampers modulate to SAT |
| 70F - 75F | Mech. + Econ. | Min to 100% | SAT SP | CHW + damper modulation |
| > 75F | Mechanical Only | Min (calculated) | SAT SP | Full CHW, min OA |

Includes estimated annual hours in each mode for San Diego TMY3 data.

# 19. Report Section 8: Equipment Schedules

The Equipment Schedules (`draw_equipment_schedules()`) contain six complete equipment schedule tables.

## 19.1 Air Handling Unit Schedule

A side-by-side comparison of AHU-1 and AHU-2 with 30+ parameters:

- Floors served, supply/return/OA CFM
- Total static pressure, supply fan HP, return fan HP
- Cooling capacity (Tons and BTU/hr), CHW flow (GPM)
- Heating capacity (MBH), HW flow (GPM)

- Configuration (draw-through, horizontal)
- Casing (double wall, R-8)
- Cooling coil details (6 row, 14 FPI, Cu/Al)
- Face velocity, entering/leaving conditions
- CHW entering/leaving water temperatures
- Preheat coil details
- Fan type (plenum, direct drive)
- Motor efficiency (IE3 Premium, 95.4%)
- Min OA percentage at design
- VFD (supply and return), economizer type
- Filters (MERV 8 pre + MERV 13 final)
- Sound rating (NC), weight, electrical, dimensions

## 19.2 Chiller Schedule

23 parameters for the air-cooled screw chiller:

- Tag, type, capacity (Tons), efficiency (kW/ton, COP, IPLV)
- CHW supply/return temperatures, CHW flow (GPM)
- Refrigerant type (R-134a)
- Condenser type and fan details
- Compressor type and staging
- Starting method, evaporator pressure drop
- Design ambient temperature, operating weight
- Dimensions, sound rating, electrical data
- FLA/MCA/MOCP, location

## 19.3 Boiler Schedule

18 parameters for the condensing natural gas boiler:

- Tag, type, input/output (MBH), thermal efficiency
- HW supply/return temperatures (with reset schedule), HW flow (GPM)
- Fuel type, burner details, minimum firing rate
- Combustion air requirements, vent type and size
- Gas connection size, gas input (CFH)
- NOx emissions compliance (SCAQMD Rule 1146.2)
- Water volume, controls, electrical

## 19.4 Pump Schedule

Four pumps in a tabular format:

| Tag | Service | GPM | Head (ft) | HP | Type | VFD | Seal |
|---|---|---|---|---|---|---|---|
| CHWP-1 | Primary CHW | calc | 60 | calc | End Suction, base-mtd | No | Mech. Seal |
| CHWP-2 | Secondary CHW | calc | 80 | calc | End Suction, base-mtd | Yes | Mech. Seal |
| HWP-1 | Primary HW | calc | 50 | calc | End Suction, base-mtd | No | Mech. Seal |
| HWP-2 | Secondary HW | calc | 60 | calc | End Suction, base-mtd | Yes | Mech. Seal |

## 19.5 VAV Terminal Unit Schedule

A complete table for all VAV boxes (128 for a 4-floor building):

| Tag | Floor | Zone | Max CFM | Min CFM | Inlet (in) | Reheat (MBH) | HW GPM |
|---|---|---|---|---|---|---|---|

VAV inlet sizing follows ASHRAE/Titus/Krueger guidelines at maximum 2000 FPM:

- 6" for up to 350 CFM
- 8" for 351-700 CFM
- 10" for 701-1200 CFM
- 12" for 1201-1800 CFM
- 14" for 1801-2500 CFM
- 16" for 2501+ CFM

Minimum airflow is the greater of 30% of maximum, outdoor air requirement, or 50 CFM.

## 19.6 Exhaust Fan Schedule

Six exhaust fans:

| Tag | Service | CFM | SP (in.wg) | HP | Type |
|---|---|---|---|---|---|
| EF-1 | Restroom Exhaust Fl1-2 | 600 | 0.75 | 0.50 | Inline centrifugal |
| EF-2 | Restroom Exhaust Fl3-4 | 600 | 0.75 | 0.50 | Inline centrifugal |
| EF-3 | Server Room (Fl 1) | 200 | 0.50 | 0.25 | Inline centrifugal |
| EF-4 | Server Room (Fl 2) | 200 | 0.50 | 0.25 | Inline centrifugal |
| EF-5 | Server Room (Fl 3) | 200 | 0.50 | 0.25 | Inline centrifugal |

| Tag | Service | CFM | SP (in.wg) | HP | Type |
|---|---|---|---|---|---|
| EF-6 | Server Room (Fl 4) | 200 | 0.50 | 0.25 | Inline centrifugal |

# 20. Report Section 9: Controls and Sequences of Operations

The Controls section (`draw_sequences()`) provides full written sequences following ASHRAE Guideline 36-2021. This section typically spans 4-6 pages.

## 20.1 AHU Sequence (Guideline 36)

Six sub-sequences:

**10.1.1 System Startup:** Pre-start safety verification, OA damper positioning, supply fan VFD ramp-up, return fan start with building pressure control, cooling/heating coil enable delay.

**10.1.2 Supply Air Temperature Control:** SAT setpoint (55F), SAT reset (55-65F based on zone cooling requests), cooling PID loop (P=2.0, I=0.5 min), heating preheat coil minimum SAT of 45F.

**10.1.3 Duct Static Pressure Control:** DSP setpoint with Trim & Respond reset per Guideline 36 (sample interval 2 min, trim -0.05", respond +0.10", max 5 resets). VFD speed modulation.

**10.1.4 Economizer Sequence:** Differential enthalpy with differential dry bulb. Enable/disable conditions. High-limit shutoff at 28 BTU/lb enthalpy or 75F DB. OA/RA damper modulation.

**10.1.5 Unoccupied Mode:** Fan shutdown, night setback (85F cooling, 55F heating), optimal start calculation, morning warm-up/cool-down (100% RA).

**10.1.6 Safety Interlocks and Alarms:** Duct smoke detector (manual reset), freeze stat at 38F (manual reset), high static pressure alarm, filter DP alarm, loss of airflow alarm.

## 20.2 VAV Terminal Unit Sequence

Three sub-sequences:

**10.2.1 Zone Temperature Control:** Cooling mode (modulate damper from min to max), deadband (maintain minimum airflow), heating mode (minimum airflow + modulate reheat valve), occupied minimum = max(Voz, 30% design).

**10.2.2 Demand Controlled Ventilation (CO2-Based):** CO2 sensors in conference rooms, 1000 ppm setpoint, proportional OA increase, floor of Ra x Az maintained.

**10.2.3 Occupancy Response:** Occupancy sensor with 15-minute vacancy delay, area-based ventilation on vacancy, unoccupied setback 85F/55F.

## 20.3 Chiller Plant Sequence

Three sub-sequences:

**10.3.1 Chiller Enable/Disable:** Enable when CHW valve > 20% for 5 min. Disable when all valves < 5% for 15 min. Minimum run/off times.

**10.3.2 CHW Supply Temperature Reset:** Design 44F, reset up to 50F based on valve positions. Minimum 42F for freeze protection.

**10.3.3 Condenser Fan Control:** Variable-speed modulation, staging, minimum 20% speed.

## 20.4 Boiler Plant Sequence

Enable/disable based on OAT and heating calls. HW supply temperature with outdoor air reset (180F at OAT 60F, 140F at OAT 55F). Modulating burner 10-100%. Safety interlocks (210F high limit, low water cutoff, flame safeguard).

## 20.5 Pump Sequence

Primary pumps: constant speed, interlock with chiller/boiler. Secondary pumps: VFD with DP setpoint reset (Trim & Respond per Guideline 36). Minimum pump speed 30%, low flow alarm at < 25%.

## 20.6 Exhaust Fan Sequence

Restroom fans: occupied hours only, interlock with AHU. Server fans: 24/7 with temperature override at 80F and alarm at 85F. All fans stop on smoke alarm.

## 20.7 Equipment Interlock Schedule

A 16-row matrix table showing equipment, interlock partner, condition, and action. Includes notes distinguishing hardwired vs. DDC interlocks.

# 21. Report Section 10: Energy Code Compliance

The Compliance section (`draw_compliance()`) spans two major code analyses across 3-5 pages.

## 21.1 ASHRAE 90.1-2022 Compliance (Climate Zone 3B)

**11.1.1 Envelope Requirements:** Four-row table comparing actual vs. required values for roof U, wall U, fenestration U, and fenestration SHGC, with PASS/FAIL status.

**11.1.2 HVAC Equipment Efficiency:** Chiller COP, chiller IPLV, and boiler efficiency compared to ASHRAE 90.1 minimums.

**11.1.3 Economizer Requirement:** Narrative confirmation that both AHUs meet the 54,000 BTU/hr threshold for required economizers.

**11.1.4 Fan Power Limitation:** System fan power allowance (1.10 W/CFM for VAV with MERV 13 and energy recovery credit).

**11.1.5 Lighting Power Density:** Seven-row table comparing actual LPD by space type against ASHRAE 90.1 allowances.

## 21.2 California Title 24-2022 Compliance (CZ7)

**11.2.1 Envelope Requirements (Section 140.3):** Five-row table with proposed vs. T24 CZ7 maximum values, margin calculation, and PASS/FAIL status. Includes action items for non-compliant elements with specific remediation recommendations.

**11.2.2 Mandatory HVAC Measures (Sections 120.1-120.2):** Eight mandatory measures including programmable thermostats, shutoff dampers, duct sealing, insulation, and pipe insulation.

**11.2.3 Prescriptive HVAC Requirements (Section 140.4):** Twelve prescriptive requirements including economizer, DCV, SAT reset, optimum start, zone DDC, FDD, VFDs, chiller IPLV, boiler efficiency, pump VFD, and HW reset.

**11.2.4 Lighting Controls (Section 130.1):** Five lighting control measures including occupancy sensors, daylight responsive controls, multi-level control, automatic time switch, and demand responsive controls (OpenADR 2.0b).

**11.2.5 Acceptance Testing Requirements (Section 120.5):** Ten NRCA-MCH acceptance test forms required per Title 24-2022 and Nonresidential Appendix NA7, specifying which equipment each test applies to.

**11.2.6 Compliance Summary:** Overall prescriptive compliance status with explanation of any conditional items and recommended corrective actions.

# 22. Report Section 11: Energy Analysis Summary

The Energy Analysis (`draw_energy_analysis()`) follows an ECON-1 format.

## 22.1 Building Information Box

Gray background box with project name, location, weather data source (TMY3), floor area, design cooling tonnage, and design heating MBH.

## 22.2 Monthly Energy Consumption Table

12-month breakdown plus annual totals:

| Month | kWh | Peak kW | Elec Cost | Therms | Gas Cost | Total Cost |
|---|---|---|---|---|---|---|
| Jan | 66,600 | 285 | $20,922 | 180 | $243 | $21,165 |
| ... | ... | ... | ... | ... | ... | ... |
| Dec | 67,400 | 288 | $21,182 | 150 | $203 | $21,384 |
| ANNUAL | 862,400 | 470 | $293,328 | 640 | $864 | $294,192 |

Rate assumptions are displayed below the table:

- Electric: $0.220/kWh + $22.00/kW demand (SDG&E Commercial, 2025)
- Gas: $1.35/therm

## 22.3 Energy Performance Summary

Two side-by-side boxes:

**Annual Energy Use (cyan border):**

- Electric kWh, Natural Gas therms
- Total Site Energy (kBtu)
- Site EUI (kBtu/ft2-yr)

**Annual Energy Cost (gold border):**

- Electric cost, Gas cost
- Total annual cost
- Cost Index ($/ft2-yr)

## 22.4 Energy Benchmarking Table

Six benchmark comparisons:

| Benchmark | EUI (kBtu/sf-yr) | Status |
|---|---|---|
| This Project (Proposed) | Calculated | PROPOSED |
| ASHRAE 90.1-2022 Baseline | 65.0 | PASS/REVIEW |
| ENERGY STAR Median (Office) | 80.0 | PASS/REVIEW |
| CBECS 2018 Median (Office) | 92.0 | PASS/REVIEW |
| Title 24-2022 TDV Budget | 58.0 | PASS/REVIEW |
| Net Zero Target | 25.0 | w/ PV |

Includes recommendations for LED lighting, CHW/SAT reset, rooftop PV, and enhanced commissioning.

# 23. Report Section 12: Floor Detail Load Breakdowns

The Floor Detail section (`draw_floor_details()`) generates 7 detailed sub-tables for each floor. For a 4-floor building, this produces 4 sets of sub-tables.

## 23.1 Floor Summary (Sub-table 6.A)

Total cooling (BTU/hr and Tons), heating (BTU/hr and MBH), supply air (CFM), outdoor air (CFM), and number of rooms/VAV zones on the floor. Notes whether the floor is a typical floor or the top floor (which includes roof loads).

## 23.2 Room Envelope Thermal Properties (Sub-table 6.B)

| Room | Area | Gross Wall | Net Wall | Wall U | Glaz Area | Glaz U | SHGC | Roof Area | Roof U |
|---|---|---|---|---|---|---|---|---|---|

All areas in SF, U-values in BTU/hr-sf-F. Roof area and U-value only shown for top floor rooms.

## 23.3 Room Internal Load Inputs (Sub-table 6.C)

| Room | Area | Space Type | LPD | EPD | Occ | Sens/Per | Lat/Per | Rp | Ra |
|---|---|---|---|---|---|---|---|---|---|

LPD and EPD in W/sf, occupant sensible (250 BTU/hr-person) and latent (200 BTU/hr-person) per ASHRAE Handbook, Rp in CFM/person, Ra in CFM/sf.

## 23.4 Room Cooling Calculation Detail (Sub-table 6.D)

Full 12-column breakdown of every cooling load component with formula annotations in the column headers (e.g., "Wall U*A*CLTD", "Solar A*SHGC*SC"). Includes corrected CLTD values. Floor totals in the bottom row.

## 23.5 Room Heating Load Detail (Sub-table 6.E)

Full heating breakdown per room with wall transmission, glazing transmission, roof (if top floor), ventilation, and infiltration. Shows delta-T, notes infiltration rate assumption (0.10 CFM/SF), and states no solar credit per ASHRAE. Includes MBH column.

## 23.6 Room Airflow, Ventilation, and Performance (Sub-table 6.F)

| Room | OA Rp*Pz | OA Ra*Az | Vbz CFM | SA CFM | Exh | CFM/SF | BTU/SF | SF/Ton | SHR |
|---|---|---|---|---|---|---|---|---|---|

Key performance metrics per room for QC validation.

## 23.7 Room Construction Assembly Summary (Sub-table 6.G)

| Room | Wall Type | Wall R | Roof Type | Roof R | Glazing Type | WWR |
|---|---|---|---|---|---|---|

Interior zones show "Interior" for wall type. Roof type only shown for top floor.

# 24. Report Section 13: Room Detail Pages

The Room Detail Pages (`draw_room_detail_pages()`) is the most detailed section of the report. **Each room receives one full dedicated page** with five sections (A through E). For a 4-floor building with 32 VAV zones per floor, this section generates 128 pages.

## 24.1 Room Identification Banner

A light blue (#E8EEF5) banner across the top of the page with a navy bottom border:

- **Left side:** Room number and name (e.g., "Room 101: Open Office 1"),

floor number, space type, area in SF, and number of occupants.

- **Right side:** Key metrics -- total cooling load (BTU/hr and Tons), total

heating load (BTU/hr), and supply CFM.

## 24.2 Section A: Construction and Envelope Properties

A two-column key-value layout listing 10-12 properties:

**Left column:**

- Wall construction type and U-value (with R-value equivalent)
- Exterior wall length in linear feet
- Gross wall area, net opaque wall area

**Right column:**

- Glazing type, U-value, SHGC
- Glazing area with WWR percentage
- Roof construction and U-value (top floor only)
- Roof area (top floor only)

Interior zones show "Interior zone" for wall length and "N/A" for glazing.

## 24.3 Section B: Cooling Load Breakdown

A detailed table showing every cooling load component with three columns: **Component**, **Calculation**, and **BTU/hr**. Every formula shows the actual numeric values substituted, making the calculation fully traceable for plan check review.

Components include:

| Component | Formula Display |
|---|---|
| Wall Conduction | A=142.5 SF x U=0.089 x CLTD_corr=10.0F |
| Roof Conduction | A=1,250 SF x U=0.039 x CLTD_corr=28.0F (top floor only) |
| Glazing Solar | A=95.0 SF x SHGC=0.38 x 200 BTU/hr-sf x 0.78 orient |
| Glazing Conduction | A=95.0 SF x U=0.29 x dT=14F |
| Lighting | A=1,250 SF x LPD=0.98 W/SF x 3.412 x CLF=0.85 |
| Equipment/Plug Loads | A=1,250 SF x EPD=1.0 W/SF x 3.412 x CLF=0.85 |
| People - Sensible | N=6 x 250 BTU/hr-person x CLF=0.90 |
| People - Latent | N=6 x 200 BTU/hr-person |

| Component | Formula Display |
|---|---|
| Ventilation - Sensible | 1.08 x 105 CFM x dT=14F |
| Ventilation - Latent | 4840 x 105 CFM x dW=0.0045 lb/lb |
| Infiltration | 1,250 SF x 0.10 CFM/SF / 60 x 1.08 x dT=14F |

Below the table, a totals section shows:

- Total Sensible Cooling (BTU/hr)
- Total Latent Cooling (BTU/hr)
- GRAND TOTAL COOLING (BTU/hr)
- Equivalent Tons, BTU/hr-SF intensity, and Sensible Heat Ratio

## 24.4 Section C: Heating Load Breakdown

A similar detailed table covering:

| Component | Formula Display |
|---|---|
| Wall Transmission | A=142.5 SF x U=0.089 x dT=26F |
| Glazing Transmission | A=95.0 SF x U=0.29 x dT=26F |
| Roof Transmission | A=1,250 SF x U=0.039 x dT=26F (top floor only) |
| Ventilation | 1.08 x 105 CFM x dT=26F |
| Infiltration | 1.08 x (1,250 SF x 0.10/60) x dT=26F |

Total heating load shown in BTU/hr and MBH.

## 24.5 Section D: Ventilation and Outdoor Air (ASHRAE 62.1-2022)

Line-by-line ASHRAE 62.1 ventilation rate procedure:

- People OA (Rp x Pz): 5 CFM/person x 6 people = 30 CFM
- Area OA (Ra x Az): 0.06 CFM/SF x 1,250 SF = 75 CFM
- Zone Breathing OA (Vbz): 30 + 75 = 105 CFM
- Zone OA (Voz = Vbz / Ez): 105 / 1.0 = 105 CFM
- Exhaust Air (if applicable)

## 24.6 Section E: Supply Air Sizing and VAV Terminal Unit

Final supply airflow calculation and VAV box selection:

- Supply Air Temp: 75F room - 55F supply = 20F dT
- Required SA CFM: q_sensible / (1.08 x dT)
- Design SA CFM (max of calculated and minimum OA)

- CFM per SF
- VAV Box Tag (e.g., VAV-101)
- VAV Inlet Size (e.g., 8" round)
- Max Airflow / Min Airflow with percentage
- Reheat Coil capacity (BTU/hr) and HW Flow (GPM)

# 25. Report Section 14: Plumbing Calculations

The Plumbing Calculations (`draw_plumbing_calcs()`) contain six complete sub-sections spanning 3-4 pages.

## 25.1 Building Plumbing Fixture Schedule

Per UPC/CPC 2022. Fixture counts per floor and total for a 4-story building:

| Fixture Type | Qty/Fl | x 4 Fl | WSFU ea | Tot WSFU | DFU ea | Tot DFU |
|---|---|---|---|---|---|---|
| WC - Flush Valve | 6 | 24 | 10 | 240 | 4 | 96 |
| Urinal - Flush Valve | 3 | 12 | 5 | 60 | 2 | 24 |
| Lavatory (Public) | 6 | 24 | 2 | 48 | 1 | 24 |
| Break Room Sink | 1 | 4 | 4 | 16 | 2 | 8 |
| Service Sink | 1 | 4 | 4 | 16 | 3 | 12 |
| Drinking Fountain | 2 | 8 | 1 | 8 | 0 | 0 |
| **BUILDING TOTAL** | - | - | - | **388** | - | **164** |

## 25.2 Domestic Cold Water Sizing

- Total WSFU converted to peak demand (GPM) using Hunter's curve
- Street pressure, static head loss, meter loss, backflow preventer loss
- Available friction pressure
- Main service pipe size (4" Type K Copper)
- Riser size per floor
- Branch sizing
- Minimum fixture pressure requirements

## 25.3 Domestic Hot Water System

- HW fixture count and peak demand with diversity factor
- Storage requirement (ASHRAE Applications Table 7)

- Recovery rate and water heater input
- Heater type (commercial gas, condensing, 95% TE)
- Supply temperature with tempering
- Recirculation loop (required per Title 24)
- Recirc pipe heat loss calculation
- Recirc pump sizing
- HW pipe insulation requirements

## 25.4 Sanitary Drainage System

- Total DFU for building
- Building drain sizing (4" at 1/4" per ft slope)
- Building sewer sizing (6" at 1/8" per ft slope)
- Vent stack sizing
- Branch vents, floor drains, cleanouts
- Pipe material specifications (CI-NH above grade, ABS below)
- Grease interceptor determination

## 25.5 Storm Drainage System

- Roof area and rainfall intensity (100-year, 1-hour)
- Primary roof drain count and sizing (8 at 4" each)
- Area per drain calculation
- Horizontal storm pipe sizing
- Secondary/overflow drains (100% redundancy)
- Overflow head, discharge point, pipe material

## 25.6 Natural Gas Piping

- Boiler input (CFH) and DHW heater input (CFH)
- Total gas demand
- Gas meter sizing
- Service pressure (7" WC)
- Main and branch pipe sizing (black steel, longest run method)
- Shutoff valves and drip legs
- Earthquake valve requirement (CBC 2022)

# 26. Report Section 15: Appendices

## 26.1 Appendix A: Design Assumptions

17 design assumptions covering:

1. **Building Orientation:** Long axis East-West, main entrance facing South.
2. **Construction Schedule:** Envelope complete before HVAC startup.
3. **Occupancy Schedule:** 8:00 AM - 6:00 PM Mon-Fri, 50% Saturday.
4. **Lighting Schedule:** On during occupied, 50% after-hours cleaning.
5. **Equipment Schedule:** 100% occupied, 10% standby unoccupied.
6. **Infiltration:** 0.10 CFM/SF occupied (pressurized), 0.30 CFM/SF unoccupied.
7. **Supply Air Temperature:** 55F leaving coil, constant during cooling.
8. **Chilled Water Temperatures:** 44F supply, 54F return (10F dT).
9. **Hot Water Temperatures:** 180F supply, 140F return (40F dT), OAT reset to 120F.
10. **Diversity Factor:** 0.90 cooling, 0.85 people in large open offices.
11. **Safety Factor:** 10% cooling for chiller, 20% heating for boiler.
12. **Altitude:** Elevation noted, correction applied if significant.
13. **Duct Leakage:** Seal Class A, CL 6 max.
14. **Pipe Sizing:** Equal friction method, max 4 ft/100ft for mains.
15. **Noise Criteria:** NC 35-40 offices, NC 30-35 conference, NC 25-30 executive.
16. **BMS System:** Full DDC, BACnet MS/TP field, BACnet IP supervisory.
17. **Seismic:** CBC 2022 / ASCE 7-22, Seismic Design Category D.

## 26.2 Appendix B: Abbreviations

80+ engineering abbreviations in a four-column table (abbreviation, definition, abbreviation, definition). Covers all terms from A (Area) to psig (PSI Gauge), including ASHRAE-specific terms (CLTD, CLF, SHGC, SHR), system terms (VAV, VFD, DDC), and code references (T24, CPC, CBC).

## 26.3 Appendix B: References

10 code and standard references in citation format:

1. ASHRAE Standard 90.1-2022
2. ASHRAE Standard 62.1-2022
3. ASHRAE Handbook - Fundamentals 2021
4. ASHRAE Guideline 36-2021
5. California Title 24-2022
6. SMACNA Duct Construction Standards
7. NFPA 90A

**8.** ASCE 7-22

**9.** California Mechanical Code 2022

**10.** California Plumbing Code 2022

# 27. Customization Options

## 27.1 Project Identity

All fields on the Project Info tab can be customized:

- Change the company name, address, phone, and email
- Specify the engineer of record with credentials (PE, LEED AP, etc.)
- Set the client/owner name
- Choose a job number that matches your firm's tracking system

## 27.2 Logo Placement

The current version places the company name in text on the cover page and in the header. Custom logo image support can be added by modifying the `draw_cover_page()` method in `generate_project_report.py` to use `self.c.drawImage()` with a logo file path.

## 27.3 Section Selection

Toggle any combination of the 16 sections on or off. Common combinations:

**Full submittal package:** All sections enabled (100-200 pages)

**Equipment schedule only:** Deselect all, enable only Equipment Schedules

**Load calc summary:** Enable Cover + TOC + Executive Summary + Load Calculation Summary + Floor Details

**Compliance check:** Enable Cover + TOC + Energy Code Compliance

**Quick review:** Enable Cover + TOC + Executive Summary

## 27.4 Building Parameters

Every aspect of the building can be customized through the Building and Design Conditions tabs:

- Building area from 1,000 to 10,000,000 SF
- 1 to 100 floors
- 7 HVAC system types
- 4 wall constructions, 4 roof constructions, 4 glazing types
- 16 ASHRAE climate zones, 16 Title 24 climate zones

- All outdoor and indoor design conditions

### 27.5 Output File Control

- Choose any output folder on your system
- Name the PDF file whatever you want
- Default location is the `output/` subdirectory

# 28. PDF Output Details

### 28.1 File Format

- **Format:** PDF 1.4 (ReportLab default)
- **Page Size:** US Letter (8.5" x 11" / 612 x 792 points)
- **Color Space:** RGB
- **Font:** Helvetica family (built into PDF, no embedding required)
- **File Size:** Typically 2-8 MB depending on page count

### 28.2 Resolution

All content is vector-based (text, lines, rectangles). There are no raster images in the default report, so the output prints at any resolution without quality loss.

### 28.3 Page Numbering

Every page includes a page number in the footer, right-aligned. The format is "Page N" where N starts at 1 for the cover page.

### 28.4 Headers and Footers

**Header (every page except cover):**

- Left: Section title (bold, 13pt) + company name (8pt, gray)
- Right: Project name (bold, 9pt) + job number + date (gray)
- Bottom border: Gold accent line (2pt)

**Footer (every page):**

- Left: "JΔS Engineering Suite" (7pt, gray)
- Center: "Confidential - For Design Purposes Only" (italic, 7pt)
- Right: "Page N" (7pt)
- Below: Copyright notice with year and company name (6pt)

- Top border: Gray rule line

## 28.5 How to Open and Share

- Double-click the PDF to open in your default viewer.
- Use the **Open PDF** button in the GUI after generation.
- Email the PDF directly to clients, plan reviewers, or team members.
- Upload to project management systems (Procore, Newforma, etc.).
- Print to paper for physical plan check submittals.

# 29. Excel and CSV Exports

## 29.1 Current Export Capabilities

The Project Report Generator currently outputs exclusively to PDF format. Excel and CSV exports are available through other modules in the suite:

- **Report Engine** (`report_engine_app.py`): Supports Excel export for

equipment schedules and load calculation data.

- **Data Visualizer**: Exports 8760-hour simulation data to CSV.
- **Building Analysis**: Exports analysis results to Excel.

## 29.2 Equipment Schedule Data

The equipment data structures (`AHUData`, `VAVData`, `PlantData`) can be accessed programmatically for custom Excel export:

```
import generate_project_report as gpr

all_zones = gpr.compute_all_loads()
ahus, vav_list, plant = gpr.size_equipment(all_zones)

# Access VAV data for spreadsheet
for v in vav_list:
print(f"{v.tag}, {v.floor}, {v.zone_name}, {v.max_cfm}, {v.min_cfm}")
```

## 29.3 Zone Load Data

All zone loads are available as `ZoneLoads` dataclass instances with named attributes for every load component. These can be iterated and exported to any tabular format.

# 30. QC Review Process

## 30.1 Executive Summary Check (First Priority)

After generating a report, go directly to the Executive Summary and verify the engineering check metrics table. Key benchmarks:

| Metric | Office (Typical) | Healthcare | Retail | Warehouse |
|---|---|---|---|---|
| SF per Ton | 250-400 | 150-300 | 200-350 | 500-1000 |
| CFM per SF | 0.7-1.2 | 1.0-2.0 | 0.8-1.5 | 0.3-0.8 |
| CFM per Ton | 350-450 | 300-500 | 350-450 | 400-600 |
| BTU/SF Cooling | 25-45 | 40-70 | 30-50 | 10-20 |
| BTU/SF Heating | 5-15 | 10-25 | 5-15 | 3-10 |
| Outdoor Air % | 15-25% | 20-40% | 15-25% | 10-20% |
| SHR | 0.70-0.85 | 0.65-0.80 | 0.70-0.85 | 0.80-0.95 |

If any metric shows "REVIEW" status, investigate the inputs before proceeding.

## 30.2 Load Component Breakdown Check

Verify that the cooling load component breakdown makes engineering sense:

- **Envelope loads** (walls + roof + glazing) should be 20-40% of total for well-insulated office buildings.
- **Internal loads** (lighting + equipment + people) should be 40-60% for offices.
- **Ventilation** should be 10-20% for standard offices.
- **Infiltration** should be < 5% for a pressurized building.

If envelope loads dominate (> 50%), check glazing SHGC and WWR. If internal loads are unusually high, check EPD assumptions.

## 30.3 Floor-by-Floor Comparison

Each floor should have approximately the same cooling and heating load unless there is a specific reason for variation (top floor has roof load, ground floor has different exposure). Variations greater than 15% between typical floors should be investigated.

## 30.4 Room Detail Spot Check

Select 3-5 representative rooms and verify:

1. The calculation formulas use the correct U-values and areas.
2. The sensible heat ratio is between 0.65 and 0.95.
3. The supply CFM per SF is in the expected range.

4. The VAV box size is appropriate for the airflow.

5. The heating load does not exceed the cooling load for perimeter zones (in mild climates).

## 30.5 Compliance Cross-Check

Verify that any "FAIL" items in the compliance section have corresponding notes explaining the required corrective action. Common items requiring attention:

- Wall U-value exceeding ASHRAE 90.1 or Title 24 limits (add continuous insulation)
- Glazing SHGC exceeding limits (specify solar-control low-E)
- LPD exceeding allowances (specify LED fixtures)

## 30.6 QC Checklist

- [ ] Executive Summary metrics within expected ranges
- [ ] Load component percentages are reasonable
- [ ] Floor-by-floor loads are consistent
- [ ] Room detail formulas show correct values
- [ ] Equipment sizes match load requirements
- [ ] VAV box sizes match airflow requirements
- [ ] Compliance items are addressed
- [ ] Design conditions match ASHRAE weather data
- [ ] Indoor setpoints are appropriate for occupancy type
- [ ] Plumbing fixture counts match floor plans
- [ ] Appendix assumptions are project-specific

# 31. Submitting for Plan Review

## 31.1 What Agencies Typically Require

Building departments and plan review agencies typically require:

1. **Mechanical permit application** (agency-specific form)
2. **HVAC load calculation report** showing design conditions, load methodology, and room-by-room results
3. **Equipment schedules** for all mechanical equipment
4. **Controls sequences** describing how the system operates

5. **Energy code compliance documentation** (ASHRAE 90.1 or Title 24)

6. **Ventilation calculations** per ASHRAE 62.1

The Project Report covers items 2 through 6 in a single document.

## 31.2 Preparing the Submittal Package

1. Generate the report with all sections enabled.

2. Perform the QC review process (Section 30).

3. Address any "FAIL" or "REVIEW" items in the compliance section.

4. Add the engineer's stamp/seal to the cover page (physical stamp on printed copies or digital signature on electronic submittals).

5. Include the report as part of the mechanical drawing set.

## 31.3 California Title 24 Specific Requirements

For California projects, in addition to the Project Report:

- **NRCC-MCH-01** (Certificate of Compliance): Summarizes mechanical system compliance. Must be signed by the engineer.

- **NRCA-MCH forms**: Acceptance test forms to be completed by an Acceptance Test Technician (ATT) during commissioning. The required forms are listed in Section 11.2.5 of the report.

- **CBECC-Com model** (if using Performance Approach): Required when prescriptive compliance cannot be demonstrated.

## 31.4 Common Plan Check Comments

| Comment | Resolution |
|---|---|
| "Show CLTD correction factors" | Room detail pages show full formulas |
| "Verify ventilation per 62.1" | Airflow Summary section documents Vbz |
| "Show equipment efficiencies" | Compliance section lists vs. code min. |
| "Provide economizer analysis" | Psychrometric section includes economizer |
| "Show heating load calculations" | Room detail pages include heating tables |
| "Provide controls narrative" | Controls section has full Guideline 36 |

## 31.5 Electronic vs. Physical Submittal

- **Electronic:** Most agencies now accept PDF submittals. Upload the report PDF to the agency's online permit portal.

• **Physical:** Print the report on 8.5" x 11" paper. The vector-based output prints clearly at any quality setting.

# 32. Sample Report Walkthrough

This section walks through creating a complete project report for a 100,000 SF office building in San Diego, CA.

## Step 1: Launch the Report Generator

Open the JΔS Engineering Suite and navigate to: Sidebar > HVAC Load Calculations > Project Report (PDF)

## Step 2: Configure Project Info

On the **Project Info** tab:

1. Set **Project Name** to "Pacific Gateway Office Complex"
2. Set **Project Address** to "8800 Grossmont Blvd, La Mesa, CA 91942"
3. Set **Client** to "Gateway Development Partners LLC"
4. Set **Engineer** to "Sarah Chen, PE, CEM, LEED AP BD+C"
5. Set **Company** to "MEP Design Associates"
6. Set **Company Address** to "3030 University Ave, Suite 400, San Diego, CA 92104"
7. Set **Phone** to "(619) 555-0198"
8. Set **Job Number** to "MEP-2026-0023"
9. Set **File Name** to "Pacific_Gateway_100K_SF_Report.pdf"

## Step 3: Configure Building Parameters

On the **Building** tab:

1. Set **Total Area** to 100,000 SF
2. Set **Number of Floors** to 4
3. Set **Floor-to-Floor Height** to 13.5 ft
4. Set **Ceiling Height** to 9.0 ft (yields 4.5 ft plenum)
5. Set **Window-to-Wall Ratio** to 0.35
6. Select **Wall Construction**: Steel Frame R-19
7. Select **Roof Construction**: Metal Deck R-30
8. Select **Glazing Type**: Double Low-E Argon (U-0.29, SHGC 0.38)
9. Select **System Type**: VAV with CHW/HW Reheat
10. Set **Supply Air Temp** to 55.0 F

## Step 4: Configure Design Conditions

On the **Design Conditions** tab:

1. Set **Location** to "La Mesa, CA (near San Diego)"
2. Select **ASHRAE Climate Zone**: 3B
3. Select **Title 24 Climate Zone**: CZ10
4. Set **Elevation** to 541 ft
5. Set **Cooling DB (0.4%)** to 98.0 F (hotter than coastal San Diego)
6. Set **Cooling WB (0.4%)** to 71.0 F
7. Set **Heating DB (99.6%)** to 36.0 F
8. Set **Daily Range** to 26.0 F (larger for inland location)
9. Set **Cooling Setpoint** to 75.0 F
10. Set **Heating Setpoint** to 70.0 F
11. Set **Indoor RH** to 50.0 %

## Step 5: Select Report Sections

On the **Report Sections** tab:

1. Click **Select All** to include all 16 sections.
2. For a shorter initial review, you may deselect "Room Detail Pages (1 Page per Room)" to reduce the report from ~185 pages to ~55 pages.

## Step 6: Generate the Report

1. Click **Generate Report**.
2. Watch the progress bar advance through all 15 sections.
3. Wait for the "Complete!" status (typically 30-90 seconds depending on hardware and section selection).
4. Click **Open PDF** to review the report.

## Step 7: Review and QC

1. Go to the Executive Summary (page 3).
2. Verify the SF per Ton is between 250-400.
3. Check that the cooling intensity (BTU/SF) is between 25-45 for an office.
4. Review the compliance section for any FAIL items.
5. Spot-check 3-5 room detail pages for formula accuracy.

## Step 8: Finalize

1. Address any issues found during QC.
2. Regenerate if needed (close PDF viewer first).
3. Add engineer's stamp/seal.
4. Submit to the building department.

# 33. Integration with Other Modules

## 33.1 Energy Calculations Module

The report generator shares calculation methodology with the energy calculations module (`energypro` approach). Both use the ASHRAE CLTD/CLF method for cooling loads and UA*dT for heating loads.

## 33.2 Envelope Editor

Changes made in the Envelope Editor module affect the envelope construction parameters that feed into the report. When generating reports, verify that the Building tab settings match your Envelope Editor selections.

## 33.3 Building Analysis

The Building Analysis module can perform detailed zone-by-zone analysis that complements the report. Use it for deeper investigation of specific zones flagged during QC review.

## 33.4 Parametric System Sweep

The Parametric System Sweep module allows side-by-side comparison of different HVAC system types. Generate separate reports for each system configuration to document alternatives analysis.

## 33.5 Collaboration Module

Reports can be shared through the cloud collaboration system. Save the report to a shared project folder and all team members with access can view and download the PDF.

# 34. Calculation Methodology Reference

## 34.1 Cooling Load Calculations (ASHRAE CLTD/CLF)

**Wall Conduction:**

```
q_wall = A_net_wall x U_wall x CLTD_corrected

CLTD_corrected = CLTD_base + (78 - T_indoor) + (T_outdoor - DR/2 - 85)
```

```
Where:
CLTD_base = 13.0 F (steel frame, medium color, west peak)
T_indoor = indoor cooling setpoint (F)
T_outdoor = outdoor cooling dry-bulb 0.4% (F)
DR = mean daily range (F)
```

**Roof Conduction:**

```
q_roof = A_roof x U_roof x CLTD_corrected

CLTD_corrected = 38.0 + (78 - T_indoor) + (T_outdoor - DR/2 - 85)

Where:
CLTD_base = 38.0 F (flat dark roof, peak hour)
```

**Glazing Solar:**

```
q_solar = A_glazing x SHGC x SolarGain x OrientationFactor

Where:
SolarGain = 200 BTU/hr-sf (peak, San Diego latitude)
OrientationFactor = 0.78 (weighted average for all orientations)
```

**Glazing Conduction:**

```
q_glaz_cond = A_glazing x U_glazing x dT_cooling
```

**Lighting:**

```
q_lighting = A_zone x LPD x 3.412 x CLF

Where:
3.412 = W to BTU/hr conversion
CLF = 0.85 (cooling load factor for office lighting)
```

**Equipment/Plug Loads:**

```
q_equipment = A_zone x EPD x 3.412 x CLF

Where:
CLF = 0.85 (cooling load factor for office equipment)
```

**People Sensible:**

```
q_people_sens = N_occupants x 250 BTU/hr-person x CLF

Where:
250 BTU/hr = sensible heat gain per person (moderate activity)
CLF = 0.90 (cooling load factor for people)
```

**People Latent:**

```
q_people_lat = N_occupants x 200 BTU/hr-person

Where:
200 BTU/hr = latent heat gain per person (moderate activity)
```

**Ventilation Sensible:**

```
q_vent_sens = 1.08 x OA_CFM x dT_cooling

Where:
1.08 = 60 min/hr x 0.075 lb/ft3 x 0.24 BTU/lb-F (sea level)
```

**Ventilation Latent:**

```
q_vent_lat = 4840 x OA_CFM x dW

Where:
4840 = 60 min/hr x 0.075 lb/ft3 x 1076 BTU/lb
dW = 0.0045 lb/lb (humidity ratio difference for San Diego)
```

**Infiltration:**

```
q_infil = 1.08 x (A_zone x 0.04 CFM/SF) x dT_cooling

Where:
0.04 CFM/SF = infiltration rate for modern pressurized commercial building
```

## 34.2 Heating Load Calculations

```
q_heating = q_wall + q_glazing + q_roof + q_ventilation + q_infiltration

q_wall = A_net_wall x U_wall x dT_heating
q_glazing = A_glazing x U_glazing x dT_heating
q_roof = A_roof x U_roof x dT_heating (top floor only)
q_ventilation = 1.08 x OA_CFM x dT_heating
q_infiltration = 1.08 x (A_zone x 0.10/60) x dT_heating

Where:
dT_heating = T_indoor_heating - T_outdoor_heating_99.6%
0.10 CFM/SF = infiltration rate for heating (unoccupied/depressurized)
```

## 34.3 Supply Air Sizing

```
CFM_supply = q_sensible / (1.08 x dT_supply)

Where:
dT_supply = T_room - T_supply = 75 - 55 = 20 F (default)
Minimum CFM = max(OA_CFM, 50 CFM)
```

## 34.4 Equipment Sizing

**AHU:**

- Block diversity factor: 0.90 applied to CFM
- Total static pressure: 4.5 in. w.g. (4.0" supply + 1.0" return)
- Fan HP: CFM x TSP / (6,356 x fan_eff x motor_eff)

**Chiller:**

- Capacity: Sum of AHU cooling loads x 1.10 (10% safety factor)
- Rounded up to nearest 10 tons
- CHW flow: Capacity x 12,000 / (500 x 10F dT)

**Boiler:**

- Capacity: Sum of AHU heating loads x 1.20 (20% safety factor)
- Input: Output / 0.95 efficiency

- HW flow: Output / (500 x 40F dT)

**Pumps:**

- HP: GPM x Head / (3,960 x pump_eff)
- Primary CHW: 60 ft head, 65% efficiency
- Secondary CHW: 80 ft head, 60% efficiency, VFD
- Primary HW: 50 ft head, 60% efficiency
- Secondary HW: 60 ft head, 60% efficiency, VFD

# 35. Troubleshooting

## 35.1 Report Generation Fails with an Import Error

**Symptom:** An error dialog appears mentioning `ModuleNotFoundError: No module named 'reportlab'`.

**Solution:** ReportLab is required for PDF generation. Install it with:

```
pip install reportlab
```

If using the compiled EXE, ReportLab is bundled automatically. This error typically only occurs when running from source.

## 35.2 File Permission Error When Generating

**Symptom:** The error message says the output file cannot be written, or you see `PermissionError: [Errno 13] Permission denied`.

**Solution:** Close the PDF file in your PDF viewer before regenerating. Most PDF viewers lock the file while it is open, preventing the Report Generator from overwriting it. Close the viewer, then click **Generate Report** again.

Also check that the output directory exists and that you have write permissions. The generator will attempt to create the output directory if it does not exist (`os.makedirs` with `exist_ok=True`), but this can still fail if the parent path is invalid.

## 35.3 Report Is Too Long / Too Many Pages

**Symptom:** The report exceeds 150-200 pages and you need a shorter version.

**Solution:** The largest contributor to page count is the **Room Detail Pages (1 Page per Room)** section. For a 4-floor building with 32 rooms per floor, this section alone adds 128 pages. Uncheck "Room Detail Pages (1 Page per Room)" on the Report Sections tab to significantly reduce the total page count.

You can also uncheck other sections you do not need, such as the plumbing calculations or psychrometric analysis, if they are not relevant to the submission.

## 35.4 Progress Bar Freezes During Room Detail Pages

**Symptom:** The progress bar appears stuck while generating room details.

**Explanation:** Room detail pages take the longest to render because each room gets a full page with multiple tables and formula text. For a building with 128 rooms, this can take 30-60 seconds depending on your hardware. The progress bar updates per major section, not per room, so it will appear static during this step. Wait for it to complete -- the GUI remains responsive because generation runs in a background thread.

## 35.5 Blank or Missing Sections in the PDF

**Symptom:** A section appears in the Table of Contents but the corresponding pages are blank or missing.

**Solution:** Verify that the section's checkbox is checked on the Report Sections tab. The Table of Contents is generated with a fixed structure, but the actual section pages are only drawn when the corresponding checkbox is enabled.

## 35.6 Open PDF Button Does Nothing

**Symptom:** Clicking Open PDF after generation does not open the file.

**Solution:** Verify that a default PDF application is associated with `.pdf` files on your system. On Windows, right-click any PDF file, select "Open with," and choose your preferred viewer, then check "Always use this app."

## 35.7 Incorrect Design Conditions

**Symptom:** The report shows design conditions that do not match your project location.

**Solution:** The default design conditions are for San Diego, CA (ASHRAE Climate Zone 3B, Title 24 CZ7). Always update the Design Conditions tab to match your specific project location using ASHRAE Fundamentals Chapter 14 climatic data. The report does not automatically look up weather data from the weather.py module -- you must enter the values manually.

## 35.8 Cooling Loads Seem Too High or Too Low

**Symptom:** The cooling intensity (BTU/SF) is outside the expected range for your building type.

**Troubleshooting steps:**

1. Check the cooling dry-bulb temperature -- an extreme value will amplify all envelope and ventilation loads.
2. Check the daily range -- a small daily range increases the corrected CLTD.
3. Check the window-to-wall ratio -- 40% is typical for offices; high-glass facades will have higher solar loads.
4. Check the equipment power density -- server rooms at 40 W/SF dramatically increase loads.
5. Check the indoor cooling setpoint -- a lower setpoint increases loads.

## 35.9 Two-Pass Rendering Takes Too Long

**Symptom:** The report takes more than 2 minutes to generate.

**Explanation:** Two-pass rendering means the entire report is drawn twice. For a 200-page report with room details, this is expected to take 60-120 seconds. If speed is critical, deselect the Room Detail Pages section to reduce total page count.

## 35.10 PDF File Is Corrupted or Will Not Open

**Symptom:** The generated PDF shows an error when opened.

**Solution:** This can happen if the generation process was interrupted (application crash, system shutdown). Delete the corrupted file, close any open instances of the application, and regenerate. If the issue persists, check that the output drive has sufficient free space (at least 50 MB).

## 35.11 Missing Data in Tables

**Symptom:** Some table cells show "-" instead of calculated values.

**Explanation:** A dash ("-") is intentional for zones that do not have the corresponding load component. For example:

- Interior zones show "-" for wall conduction, glazing solar, and glazing

conduction because they have no exterior walls.

- Non-top-floor zones show "-" for roof conduction.
- Unoccupied zones (corridors, restrooms) show "-" for people loads.
- Zones with no exhaust requirement show "-" in the exhaust column.

# 36. Best Practices

## 36.1 Always Include Room Detail Pages for Permit Submissions

When submitting calculation packages to building departments or plan review agencies, include the Room Detail Pages section. Plan checkers expect to see per-room load breakdowns with traceable formulas. The EnergyPro-style format with explicit formula display (e.g., `q = 142.5 SF x 0.089 x 10.0 = 126.8 BTU/hr`) demonstrates that the calculations are transparent and auditable, not just black-box outputs.

## 36.2 Save Settings Before Generating

If you have changed values in the Building or Design Conditions tabs, those values are only applied at generation time. If the application closes or crashes before you generate, your changes are lost. Develop a habit of clicking **Generate Report** promptly after configuring your inputs.

## 36.3 Use Select All for Complete Documentation Packages

For construction document submittals and final design packages, use the **Select All** button to include every section. The resulting report serves as a single, self-contained document that covers mechanical loads, ventilation, equipment, controls, compliance, energy, and plumbing -- eliminating the need to assemble separate calculation documents.

## 36.4 Use Deselect All for Targeted Section Generation

When you only need to update one section (e.g., revised equipment schedules after value engineering), click **Deselect All** and then check only the section(s) you need. This produces a shorter, focused PDF that is faster to generate and easier to review.

## 36.5 Match Outdoor Design Conditions to ASHRAE Data

Always verify the Cooling DB, Cooling WB, Heating DB, and Daily Range values against the ASHRAE Fundamentals climatic design conditions for your project's specific weather station. Using incorrect design conditions leads to undersized or oversized equipment, both of which can result in plan check comments or field problems.

## 36.6 Review the Executive Summary First

After generating a report, open the PDF and go directly to the Executive Summary. Check that the peak cooling load per SF (BTU/hr/SF) is within the expected range for the building type:

| Building Type | Typical Range (BTU/hr/SF) |
|---|---|
| Office | 25 - 45 |
| Retail | 30 - 50 |
| Healthcare | 40 - 70 |
| Data Center | 100 - 300+ |
| Warehouse | 10 - 20 |
| School (K-12) | 30 - 50 |
| Laboratory | 50 - 100 |
| Restaurant | 50 - 80 |
| Hotel Guest Room | 20 - 35 |

If the calculated value falls significantly outside the expected range, return to the Building and Design Conditions tabs and verify your inputs.

## 36.7 Keep PDF Viewer Closed During Regeneration

As noted in the troubleshooting section, always close any open instance of the report PDF before clicking **Generate Report** again. This avoids file locking errors on Windows.

## 36.8 Archive Reports with Consistent Naming

Use a consistent file naming convention that includes the project name, report type, and date:

```
ProjectName_HVAC_CalcReport_YYYY-MM-DD.pdf
```

This makes it easy to track revisions and identify the most current version in your project files.

## 36.9 Generate Reports for Each Design Phase

Create separate reports at each project phase:

• **Schematic Design (SD):** Preliminary loads with estimated parameters. Use the report to validate system selection and plant sizing.

• **Design Development (DD):** Refined loads with architect-confirmed envelope details. Use the report to finalize equipment selections.

• **Construction Documents (CD):** Final loads for permit submittal. Include all sections and perform full QC review.

• **Addenda/Revisions:** Regenerate affected sections only when design changes occur during bidding or construction.

## 36.10 Cross-Reference with Mechanical Drawings

The report should be consistent with the mechanical drawing set:

• Equipment tags in the report (AHU-1, CH-1, B-1, VAV-101, etc.) should match the tags shown on mechanical plans and schedules.

• Airflow values in the report should match the ductwork sizing shown on drawings.

• Pipe sizes and flow rates should be consistent between the report and piping drawings.

## 36.11 Document Assumptions Explicitly

The Appendix A design assumptions are critical for defending your design. Customize them to reflect your actual project conditions. If a plan checker questions a design decision, you can point to the documented assumption.

## 36.12 Use the Compliance Section Proactively

Do not wait for plan check comments to discover compliance issues. Review the compliance section immediately after generation and address any FAIL or REVIEW items before submission. This reduces plan check cycle time and demonstrates due diligence.

# 37. AI-Assisted Report Generation

## 37.1 AI Report Narratives

With the AI Design Assistant configured (Settings > AI Assistant), you can generate professional report narratives directly from your calculation results:

1. Open any tool window (e.g., Report Generator, Energy Simulation).
2. Click the **AI Assist** button (robot icon) in the status bar.
3. Select **Report Narrative** from the mode dropdown.
4. Type a prompt like: "Write an executive summary for this HVAC design" or "Generate a compliance narrative for ASHRAE 90.1."
5. The AI analyzes your project data and produces a professional narrative you can copy into your report.

## 37.2 AI Design Review

Before finalizing reports, use the AI to review your design:

1. Click the **AI Assist** button in any calculation tool.
2. Select **Design Review** mode.
3. The AI checks your loads, equipment selections, and system parameters against industry benchmarks.
4. Review AI suggestions and address any flagged items before generating the final report.

## 37.3 Proactive Validation

When Proactive AI Mode is enabled (Settings > AI Assistant > Proactive Mode), the AI automatically validates calculation results as you work:

- After calculating loads, it checks SF/ton and CFM/SF against typical ranges.
- It flags unusual ventilation rates or equipment sizing.
- Toast notifications appear with actionable suggestions.
- These validations help catch errors before they appear in the final report.

*This guide covers the Report Generation capabilities of the J∆S Engineering Suite v1.2. For questions or issues, consult the built-in Help System accessible from the launcher's Help menu.*