Addressing Standby Power Needs of Science Buildings: How Much is Enough?

*I2SL Conference – Session F5 - 2019

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LEARNING OBJECTIVES

• Challenging the “Rules of Thumb” to Deliver Cost Effective Solutions.

• Understanding the Implications of Under or Over Sizing Equipment.

• Questioning the Solutions.

• Using Available Data to make Informed Decisions

“Those who cannot learn from history are doomed to repeat it”

George Santaya
PROJECT SEQUENCE

- Code Mandates
- Owner’s Brief
- Right Sizing
- Design Time
- Case Studies
APPLICABLE MANDATED CODES & GUIDELINES

**NFPA |** 101 – Life Safety Code  
110 – Standard for Emergency and Standby Power Systems  
99 – Health Care Facilities Code

**NEC |** Article 700 – Emergency Systems  
Article 701 – Legally Required Standby Systems  
Article 702 – Optional Standby Systems

**International Building Code |** Chapter 27

**Local Building & Electrical Amendments |** In conjunction with AHJ

## Code Definitions

**National Electrical Code | NFPA 70**

### Art. 700 – Emergency Systems
- Provide Lighting & Controls Essential for Human Life Safety – within **10 seconds**.
- IBC Chapter 27:
  - Exit & Egress Lighting
  - Elevator Car Lighting
  - Emergency Voice/Alarm Communications Systems
  - Automatic Fire Detection & Alarm Systems
  - Electric Fire Pumps
  - Smoke Venting or Control Systems
  - Stair Pressurization
  - At least 3 elevators in a building at 1 time with a transfer to other elevators.

### Art. 701- Legally Required
- Systems or Equipment required to aid people responding to rescue or firefighting operations:
- Loads can include:
  - Mechanical Systems
  - Communications Systems
  - Ventilation and Smoke Removal Systems
  - Sewage Disposal Systems
  - Lighting Systems
  - Industrial Processes

### Art. 702 – Optional Standby
- Systems protecting facilities where Life Safety doesn’t depend on the performance of the System. Not required for rescue operations:
  - Maintaining Critical Business Operations
- Real life examples include:
  - Lab/Office Power & Lighting
  - Critical HVAC Equipment
  - Freezers/Refrigerators
  - Vivariums
  - Environmental Chambers
  - Technology / Smart
National Electrical Code | NFPA 70


- Most Stringent of the NEC 700 sections;
- Preparation of a Risk Assessment;
- Additional levels of protection for electrical equipment & wiring in the event of Natural or Human created Disasters – The Facility Must stay Operational;
- Mandates a minimum of 72 hours of continuous alternate power source;
- Requires SPD;
- Above 100 Year Flood Elevation;
- References NFPA 1600 – Standard on Disaster/Emergency Management and Business Continuity Programs.
PROJECT SEQUENCE

Code Mandates  Owner’s Brief  Right Sizing  Design Time  Case Studies
OWNER’S BRIEF / VISION – LOOK THROUGH THEIR LENSES

Create an Exemplar of Integrated Infrastructure

- Action plan for Flexibility & Growth
- Integrate Latest Technologies
- Promote Maintainability - Beyond Oil Changes
- Environmental Leader & Socially Responsible in the Community
- Constructability!

Meet Functionality Goals

- Improve Building Operations
- Increased Reliability and Resiliencies – Hardening Approach
- Staying on Budget and Schedule
- Minimized Shutdowns / Phasing / Noise

Enhanced Occupant Satisfaction / Protection

- Maintaining Research Integrity
- Stakeholder Coordination

Innovative Solutions – The Big Ideas

- Risk Mitigation
- Open Possibilities
THE ENGINEER’S CHALLENGES

Communication
• Understanding the Loads & Profiles
• Staying Focused – Managing the Decision Process
• The Shutdowns!
• No compromise in the Program

Balancing Information
• Phased / Scalable Approach
• Budget & Schedule
• Environmental / Sustainable Considerations

Design Excellence
• Performance with Purpose
• Being Innovative in the Space Crunch Battle

Creative Solutions
• The Obvious Solution may not be the Obvious Solution!
• Bring the Concepts to Reality
• Short vs. Long Term
PROJECT SEQUENCE

Code Mandates  Owner’s Brief  Right Sizing  Design Time  Case Studies
Existing Conditions

- Gather the Right Information;
- Use the Data;
- Identifying the Peak Loading over a 24 month period - Ideal;
- Assists in establishing Base Load and allocation for future / spare loading.
New Installations

- Full vs. Partial Loading Impact
- Know the Baseline Anticipated Requirements
- Single vs. Multiple Units – Modular Approach
- Right Amount of Spare Capacity
- Impact to Oversizing
  - Capital and Operating Costs – Takes Away Funds from Core Business - Research
  - Footprint
  - Fuel Storage
  - Operational Inefficiencies
THE EQUIPMENT

How **Much** Space do you need?

You can’t HANDLE the truth!! Son, we live in a world that has CHILLERS, BOILERS AND SWITCHGAR.
And those pieces of equipment have to be located in rooms. Who’s going to design them? You, Mr.
Architect with your wild hair and cutting edge fashion?
I have a greater responsibility than you can ever fathom – you WEB for lost parking spaces and you
CURSE the size of my generator. You have that luxury. You have the luxury of not knowing what I
know. That those M&E systems, while tragic, probably saved lives. And my existence, while grotesque
and incomprehensible to you, saved lives. You don’t want the truth, because deep down, in places you
don’t talk about at parties – you WANT me on the design team. You NEED me on the design team.
We use words like Design, Code, Analysis…we use those words as the backbone to a life spent
providing owner comfort and energy efficiency. You use them as a punch line.
I have neither the time nor the inclination to explain my design to a man who rises and sleeps under
the blanket of the very environment I provide, then questions the manner in which I provide it?
I’d rather you just said thank you and went on your way. Otherwise, I suggest you pick up a dactilometer
and DESIGN A BUILDING SYSTEM.
EITHER WAY, I DON’T GIVE A DAMN WHAT I THINK YOU’RE ENTITLED TO!

Did you oversize the plant rooms?!!

I did the job you hired me to do.

**DID YOU OVERSIZE THE M&E PLANTROOMS!!!!!!**

**YOU’RE DAMN RIGHT I DID!!**
THE EQUIPMENT

Not the Right Answer!

Did you oversize the plant rooms??

I did the job you hired me to do

DID YOU OVERSIZE THE M&E PLANTROOMS?!?!!?!

YOU'RE DAMN RIGHT I DID!!
PROJECT SEQUENCE

- Code Mandates
- Owner's Brief
- Right Sizing
- Design Time
- Case Studies
THE DESIGN CHECKLIST

- Redundancy
- Demand Response Opportunities
- Emission Controls
- Fuel
- Load Bank
- Location
- Risk Mitigation
- Sizing & Systems Selection
- Operational Considerations
- Budget
Approaches to Improve Reliability and Availability of a System

- Adding Redundancy = Increased Complexity + Increased Cost
- Cost of Failure = Much Higher Cost = Unacceptable

What is Plan ‘B’?

- Cam-lock / Portable Generator Connection
- Multiple Generators in Parallel – ‘N+1’, ‘2N’, ‘2(N+1)’
- Planned Modular – Future Proofing
- Distributed vs. Centralized Systems
- Compartmentalization of Equipment
- Load Shedding Schemes
DEMAND RESPONSE PROGRAMS

Roadmap to Compliance – Varies Across the Country

- **Incentives** – Increasingly Attractive to Building Owners;
  - Generating Cash from Your Backup Generator;
  - Participation – Guarantee a Minimum kW;
  - Alternative Utility Rates & Tariffs;
  - Know the Program prior to Entry.
- **Eases Owner Concerns about potential utility outages**;
- **Owners need to be Ready when called upon**;
- **Appropriate Emissions Controls**;
- **Exit Fees**;
- **Obtaining necessary permits**.

“Peak Shaving” is running a generator to offset a utility bill demand charge; “Load Shaving” is running a generator that operates for other than an emergency condition.

**Peak Shaving is Load Shaving**
EMISSION CONTROLS – GETTING TO TIER 4F

INTEGRATION OF SYSTEMS

- Turbo After-Cooler (CAC) for NOx reduction;
- Selective Catalytic Reduction System (SCR) with Exhaust Stream Heaters for NOx reduction;
- Regenerating Diesel Particulate Filter (DPF) for PM reduction.
The Conversions & Considerations

- Increases Capital and Operating Costs;
- Locating, Storing, and Refilling Chemicals (i.e. DEF);
- Space and Power Requirements;
  o Compressors, control panels, and heaters
- Increased System Air Flow Requirements.
# FUEL SOURCES – THE DEBATE

<table>
<thead>
<tr>
<th><strong>PROS</strong></th>
<th><strong>CONS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diesel</strong></td>
<td><strong>Dirty Emissions / Higher GHG</strong></td>
</tr>
<tr>
<td>Smaller Dimensions / Footprint</td>
<td><strong>Higher Fuel Costs &amp; Maintenance</strong></td>
</tr>
<tr>
<td>Meets most AHJ Life Safety requirements</td>
<td><strong>Fuel Treatments needed</strong></td>
</tr>
<tr>
<td>Fuel storage is on site</td>
<td><strong>Fuel Containment Concerns</strong></td>
</tr>
<tr>
<td>Can be more sturdy &amp; reliable</td>
<td><strong>Cold Weather / Heaters</strong></td>
</tr>
<tr>
<td>Less Flammable Fuel Source</td>
<td><strong>Various Limitations on Storage Capacity</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Natural Gas</strong></th>
<th><strong>Larger Physical Size</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaner Burning Fuel</td>
<td><strong>Extremely Explosive</strong></td>
</tr>
<tr>
<td>More Economical Fuel</td>
<td><strong>Reduced Life Span</strong></td>
</tr>
<tr>
<td>Does not require regular fuel testing</td>
<td><strong>Does not meet many AHJ life safety requirements</strong></td>
</tr>
<tr>
<td>Eliminates diesel spill &amp; odor concerns</td>
<td>o Fuel Source Disruption</td>
</tr>
<tr>
<td>Readily available in urban cities</td>
<td>o Start up time may be greater than 10 sec.</td>
</tr>
</tbody>
</table>

*Dual Fuel not a great option in the larger size units.*
How Much Fuel to Store?

- Code Restrictions and Considerations
- Examples below:

<table>
<thead>
<tr>
<th>Equipment Ratings</th>
<th>Storage Capacity (Gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24 Hours</td>
</tr>
<tr>
<td>750kW Generator</td>
<td>1,500</td>
</tr>
<tr>
<td>1000kW Generator</td>
<td>2,000</td>
</tr>
<tr>
<td>1500kW Generator</td>
<td>3,000</td>
</tr>
<tr>
<td>2000kW Generator</td>
<td>4,000</td>
</tr>
</tbody>
</table>
SITE PARAMETERS

Roadmap to Compliance

• **Considerations to Natural or Human created Disasters**
  o Flooding – External & Internal
  o Physical Attack
  o Wind Blown Debris
  o Lightning Strikes
  o Snow Drifts

• **Fundamentals**
  o Safety - EHS
  o Fuel Oil Storage Location & Protection of Tanks
  o Exhaust Re-entrainment
  o Bollard Protection
SPACE PLANNING CONSIDERATIONS

**Indoors:**
- 2-Hour Fire Resistance Rating;
- Significant Combustion & Exhaust Air Volumes;
- Vibration Control & Acoustical Treatment;
- Indoor Fuel Piping Distribution System.

**Outdoors:**
- Weatherproof & Acoustically Treated Enclosure;
- Simplified Fuel Storage & Delivery;
- Easier to deal with Exhaust and Emissions;
- Security.
THE BIG QUESTION – WHAT SIZE IS THE GENERATOR?

Crunching the Numbers

• Today
  o Listing of all Loads, including dependencies;
  o Questionnaire – Listening;
  o What loads are important?
  o How do the loads interact?
  o Utilization Factor.

• Tomorrow (Future - Spare Capacity)
  o Anticipated Growth;
  o Upcoming Lab Renovations;
  o Demand Response Participation;
  o Modular Approach.
Think of the Facilities Engineers

- Strongly Encourage Commissioning, including a full “Pull the Plug” test;
- Verification of Performance & Redundancies;
- Addition of Metering;
- As-Built and ‘O&M’ Documents – a must;
- SOP – Preparation of Unplanned Power Outages & Restoration
- Staff Training
COST: MANAGING & FITTING THE BUDGET

• **Prioritize:** Each upgrade/feature needs to be carefully evaluated (Introduce Alternates).

• **Existing Occupancy:** Noise and Vibration reductions.

• **Swing Space:** Infrastructure & move implications.

• **Down Time:** General Conditions & Temporary Generator rental costs.

• **Program & User Changes:** Need to minimize these – I know its Hard!

• **Economic Cycle:** Timing of material and labor costs.

• **Escalation:** Look at Pre-Purchase.
PROJECT SEQUENCE

- Code Mandates
- Owner's Brief
- Right Sizing
- Design Time
- Case Studies
CASE STUDIES – A TALE OF 3 LABORATORIES:

Stand-Alone R & D Facility
• In Construction

Multi-Building R & D Campus
• Completed & Operational

Lab Tenant in Multi-Tenant Building
• Recently Completed
CASE STUDY #1 – STAND-ALONE ‘R & D’ FACILITY

Back of the Baseball Card | The Stats

<table>
<thead>
<tr>
<th>Project Status:</th>
<th>In Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Type:</td>
<td>Food + Beverage - R &amp; D</td>
</tr>
<tr>
<td>Project Area (ft²):</td>
<td>110,000</td>
</tr>
<tr>
<td>Project Type:</td>
<td>New Construction</td>
</tr>
<tr>
<td>Number &amp; Ratings:</td>
<td>1 @ 1000kW – Tier 2</td>
</tr>
<tr>
<td>Location:</td>
<td>Outdoors</td>
</tr>
<tr>
<td>Fuel Source:</td>
<td>Diesel - 5 day Supply</td>
</tr>
<tr>
<td>Loads Served:</td>
<td>Partial Loading - Life Safety + Business Critical</td>
</tr>
<tr>
<td>Right Sizing:</td>
<td>Yes</td>
</tr>
<tr>
<td>Spare Capacity %:</td>
<td>21%</td>
</tr>
<tr>
<td>Load Bank:</td>
<td>Yes</td>
</tr>
<tr>
<td>Demand Response Program:</td>
<td>No</td>
</tr>
<tr>
<td>Acoustical Treatment:</td>
<td>60dBA @ 5 feet</td>
</tr>
</tbody>
</table>

✓ Biggest Challenge – Meeting Town Sound Ordinances
**CASE STUDY #2 – MULTI-BUILDING ‘R & D’ CAMPUS**

**Back of the Baseball Card | The Stats**

<table>
<thead>
<tr>
<th>Project Status:</th>
<th>Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Type:</td>
<td>R &amp; D Campus</td>
</tr>
<tr>
<td>Project Area (ft²):</td>
<td>900,000</td>
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<tr>
<td>Project Type:</td>
<td>Infrastructure Upgrade</td>
</tr>
<tr>
<td>Number &amp; Ratings:</td>
<td></td>
</tr>
<tr>
<td>1 @ 2500kW – Tier 4F (New)</td>
<td></td>
</tr>
<tr>
<td>2 @ 2000kW – Tier 4F (New)</td>
<td></td>
</tr>
<tr>
<td>2 @ 2000kW – Tier 4 Conversion</td>
<td></td>
</tr>
<tr>
<td>1 @ 1500kW – Tier 4 (Conversion)</td>
<td></td>
</tr>
<tr>
<td>2 @ 1000kW – Tier 4 (Conversion)</td>
<td></td>
</tr>
<tr>
<td>Location:</td>
<td>Outdoors</td>
</tr>
<tr>
<td>Fuel Source:</td>
<td>Diesel - 7 day Supply</td>
</tr>
<tr>
<td>Loads Served:</td>
<td>Full Building Back-up</td>
</tr>
<tr>
<td>Right Sizing:</td>
<td>Yes</td>
</tr>
<tr>
<td>Spare Capacity %:</td>
<td>20%</td>
</tr>
<tr>
<td>Load Bank:</td>
<td>Portable</td>
</tr>
<tr>
<td>Demand Response Program:</td>
<td>Yes</td>
</tr>
<tr>
<td>Acoustical Treatment:</td>
<td>60dBA @ 5 feet</td>
</tr>
</tbody>
</table>

- Biggest Challenge – Phasing & Routing New Feeders in Active Research Facilities
CASE STUDY #2 – MULTI-BUILDING ‘R & D’ CAMPUS

Back of the Baseball Card | Home Run

After 2 years in Operation:

• Utilized multiple times the Summer Peak Conditions;
• Under budget; and **ON** schedule;
• Projected 5 - 8 year payback.
CASE STUDY #3 – LAB IN A MULTI-TENANT BUILDING

Back of the Baseball Card | The Stats

<table>
<thead>
<tr>
<th>Project Status:</th>
<th>Recently Completed</th>
</tr>
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<tbody>
<tr>
<td>Research Type:</td>
<td>Core Lab</td>
</tr>
<tr>
<td>Project Area (ft²):</td>
<td>103,000</td>
</tr>
<tr>
<td>Project Type:</td>
<td>Fit-out Renovation</td>
</tr>
<tr>
<td>Number &amp; Ratings:</td>
<td>1 @ 2500kW – Tier 2</td>
</tr>
<tr>
<td>Location:</td>
<td>Outdoors</td>
</tr>
<tr>
<td>Fuel Source:</td>
<td>Diesel - 5 day Supply</td>
</tr>
<tr>
<td>Loads Served:</td>
<td>Full Tenant Backup</td>
</tr>
<tr>
<td>Right Sizing:</td>
<td>Yes</td>
</tr>
<tr>
<td>Spare Capacity %:</td>
<td>15%</td>
</tr>
<tr>
<td>Load Bank:</td>
<td>Portable</td>
</tr>
<tr>
<td>Demand Response Program:</td>
<td>No</td>
</tr>
<tr>
<td>Acoustical Treatment:</td>
<td>65dB @ 5 feet</td>
</tr>
</tbody>
</table>

✓ Biggest Challenge – Locating Unit on a Tight Site and Fuel Storage Quantity
LESSONS LEARNED: (‘N+1’ VERSION)

• The Obvious Solution may not be the Obvious Solution: Each project needs multiple options regardless of past performance. Avoid Complacency!

• Understand the implications of Under and Over Sizing.

• Use the Data Metrics to the Client’s Benefit: Use the Past to help Predict the Future with Informed Decisions.

• Bringing Concepts to Reality: Be Proud in Delivering a Great Product to the Client with an Integrated Design Approach.
THANK YOU FOR YOUR TIME!

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