Best Practices for Small HVAC

June 8, 2017

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National Grid is a leader in energy efficiency. Our goal is to help professionals like you adopt better energy efficiency practices.

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*Depending on your location for in-person education and training workshops, there may be a nominal cost to meet regulatory requirements.

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That’s business on the grid.

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Safety Minute: Dig Safe

National Grid is reminding the public to call Dig Safe at 811 before undertaking any digging projects or excavations. **A call to Dig Safe to mark underground utilities is not only the safe thing to do – it's the law!** For more information visit [Dig Safe](http://call811.com/before-you-dig).
New Buildings Institute
Provider # 50111235

Best Practices for Small HVAC
NG201702

Alexi Miller
June 8, 2017
Topics

• **Background:** Small HVAC in Commercial Buildings

• **The Rooftop Unit Efficiency Framework:** Repair, Retrofit, Replace

• **Thinking Strategically** about Small HVAC Energy Efficiency
  • Preventative Maintenance and Systems Lifecycles

• **Non-Energy Benefits**

• **Q&A**

• **Coming Attractions:** Preview of Upcoming Webinars
Unitary Heating and Cooling System aka Rooftop Unit (RTU)
Some RTU Basics

- RTUs feature one or a combination of:
  - Air Conditioning (Direct Expansion: DX) for cooling
  - Heat Pumps (DX) for cooling and heating
  - Gas Furnaces for heating
  - Electric Resistance (“Strip Heat”) for heating

- RTU Cooling Capacity is measured in *Tons of cooling*
  - One ton = 12,000 BTU/hour
  - One ton = Heat required to melt 2,000 lbs. of ice in 1 hour

- RTU technology is well-established, affordable, and time-tested… therefore very common.
RTUs: A Very Common Strategy

• Nearly half (46%) of commercial buildings use RTUs!
• Most total commercial space (60%) is conditioned by RTUs!
• Common in Small to Medium Buildings (<50,000 ft²)
• Common in larger one-floor buildings
  • Big box retail
  • Warehouses

RTUs: A Very Common Strategy
Poll Question

1. Where does your company primarily offer its products / services?
   - a) Metro NYC
   - b) Long Island
   - c) Upstate NY
   - d) MA
   - e) RI

2. What kind of products / services does your company offer?
   - a) Architecture/Engineering
   - b) Equipment Sales / Distribution
   - c) Energy Consulting
   - d) Lighting Design and Consulting
   - e) HVACR
   - f) Other
RTUs: An Aging Fleet

51% of RTUs have been on the roof for over a decade!

Source: NWPCC 6th Power Plan
RTUs: Suffering in Silence

- Aging units begin to malfunction
- Efficiency degrades over time
- Performance degrades over time
- Maintenance is often only complaint-driven
  - Occasional filter changes are not enough
  - Many problems occur that do not jeopardize comfort; these often don’t get fixed
  - Example: condenser and cooling coils get dirty
- Cost of operation increases over time:
  - Can waste $1,000 - $3,700 annually (DOE)
Most RTUs Operate Inefficiently and Have Equipment Problems

Common Causes:

• Outside air/economizer dampers malfunctioning/broken
• The refrigerant system is improperly calibrated
• The control system is incapable of optimizing operation
•Leaks and broken equipment allow too much outside air to enter the building
• Over-ventilation

• Common root cause: Lack of Proper Maintenance
Many RTUs Operate Unnecessarily

Common Causes:
• Thermostat settings are not correct or monitored
• Sensors are out of calibration
• Controls are too simple
• Zoning problems
• Poor duct design
Most Common RTU Problem Areas

Source: Four studies of ~500 RTUs in CA and the NW
Poll Question

3. What sort of RTU projects have you done?
   a) New Installation (New Construction)
   b) Repairs to existing unit(s)
   c) Retrofits or Upgrades to existing unit(s)
   d) Replacements of unit(s)
   e) Ongoing Maintenance (on a schedule)
   f) Other
   g) None or N/A
The Rooftop Unit HVAC Efficiency Guide
## The RTU Efficiency Framework: The Three Rs

<table>
<thead>
<tr>
<th>Repair</th>
<th>Incentivizing maintenance personnel to visit a site and make standardized maintenance upgrades to a particular RTU and/or controls.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrofit</td>
<td>Adding a new component to an RTU, its components, or controls, to improve the thermodynamic operation, enable advanced or improved functionality or connectivity, or add diagnostic capability.</td>
</tr>
<tr>
<td>Replace</td>
<td>Completely remove existing RTU/controls and replace it with a higher efficiency unit or completely change the HVAC design approach.</td>
</tr>
</tbody>
</table>
### The RTU Efficiency Framework: Inside/Outside

<table>
<thead>
<tr>
<th>Inside</th>
<th>Inside the building, the RTU thermostat, duct work and additional sensors are designed to maintain comfort based on occupant work schedule. Measures to improve performance include repairing and recommissioning the controls, installing a remotely monitored thermostat system, addressing duct leakage and installing lockout controls for doors and windows.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside</td>
<td>The heating, cooling and ventilation unit itself is typically on the roof. This label refers to repairs and measures that improve this RTU so that it delivers requested cooling (or heating) more efficiently.</td>
</tr>
</tbody>
</table>
# Summary of Strategies

<table>
<thead>
<tr>
<th>Repair</th>
<th>Measure</th>
<th>More Info</th>
<th>Cost</th>
<th>Savings</th>
<th>Cost Effectiveness</th>
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</thead>
<tbody>
<tr>
<td>Outside</td>
<td>RTU Maintenance</td>
<td>Page 10</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
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<tr>
<td></td>
<td>Fault Detection and Diagnostics</td>
<td>Page 11</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Inside</td>
<td>Thermostats, Sensors, and Controls</td>
<td>Page 12</td>
<td>Low</td>
<td>Mixed</td>
<td>High</td>
</tr>
<tr>
<td>Retrofit</td>
<td>Advanced Variable Speed Controls</td>
<td>Page 14</td>
<td>Medium-High</td>
<td>High</td>
<td>Medium</td>
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<tr>
<td></td>
<td>ECM for Supply Fan Motor</td>
<td>Page 18</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium-Low</td>
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<tr>
<td></td>
<td>Air-Side Economizer</td>
<td>Page 18</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
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<tr>
<td></td>
<td>Evaporative ‘Side Car’ Unit</td>
<td>Page 19</td>
<td>Very High</td>
<td>High</td>
<td>Low*</td>
</tr>
<tr>
<td></td>
<td>Evaporative Condenser Pre-Cooling</td>
<td>Page 20</td>
<td>Very High</td>
<td>High</td>
<td>Medium-Low*</td>
</tr>
<tr>
<td>Inside</td>
<td>Advanced Wireless Controls and/or EMS</td>
<td>Page 18</td>
<td>Medium-Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Replace</td>
<td>High Efficiency RTU</td>
<td>Page 21</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>HVAC System Redesign</td>
<td>Page 22</td>
<td>N/A</td>
<td>N/A</td>
<td>Medium-Low</td>
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<tr>
<td></td>
<td>HVAC System Redesign</td>
<td>Page 22</td>
<td>N/A</td>
<td>N/A</td>
<td>Medium-Low</td>
</tr>
</tbody>
</table>
RTU Maintenance Programs

- Contractor confirms RTU is operating to manufacturer specs, makes minor repairs
- Comprehensive approach to optimize and maintain performance of equipment and system
- Major non-energy benefits
  - Avoid emergency repairs, downtime, reduced revenue

Fault Detection and Diagnostics (FDD)

- Automate alerts to tenants/vendors/contractors
- Helps to avoid longer-term performance degradation

<table>
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<tr>
<th>Cost Effectiveness</th>
<th>High</th>
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<tr>
<td>Cost</td>
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Fault Detection and Diagnostics (FDD)
• Automate alerts to tenants/vendors/contractors
• Helps to avoid longer-term performance degradation
Fixing Thermostats, Sensors, and Controls

- Reaffirm correct thermostat schedule settings and connect existing 2-stage controls.
- Calibrate CO$_2$ and temperature sensors
- Reaffirm or adjust sensor or thermostat placement
- With web-enabled thermostats, building owner/manager can do this remotely
Thermostat Upgrades: Metered Savings

Source: Bonneville Power Administration
RETROFIT
Enhanced Economizer + Controllers

- Outside damper control controlled by dry-bulb temperature differential
- Simple Fault Detection & Diagnostics (FDD) helps maintain functional economizers
- Proper fan cycling for energy savings
Advanced RTU Controls (ARC)

- VFD control for fans
- Enthalpy controlled economizer
- Two-stage capacity control
- Demand controlled ventilation
- FDD for maintenance
Wireless Web-based Thermostats and Sensors

- WiFi thermostat allows for remote monitoring and control
- Integrated thermostats can use signals from occupancy, CO2, and other sensors for tighter control
- Advanced control algorithms can further optimize performance

<table>
<thead>
<tr>
<th>Inside Retrofit: Controls</th>
<th>Repair</th>
<th>Retrofit</th>
<th>Replace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside</td>
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<tr>
<td>Inside</td>
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Cost Effectiveness: Medium-Low

<table>
<thead>
<tr>
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<td>Cost</td>
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</tr>
<tr>
<td>Savings</td>
<td>Medium</td>
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</tbody>
</table>

Source: SiteSage by PowerhouseDynamics
RTU Upgrades: Adding Equipment (Outside)

- Air-Side Economizers
- Electrically Commutated Motors (ECMs)
- Evaporative ‘Sidecar’ Unit
- Evaporative Condenser Pre-Cooling Unit
High Efficiency RTUs

- Better performance “Out of the box”
- Replace end-of-life equipment
- Opportunity to adjust system capacity
- Savings: electric, gas, or both

Consider the opportunity cost of inaction:
- Ongoing $$ loss from existing inefficient unit
- Capital cost of new unit
Energy Recovery Ventilation:

- Recover energy (heating/cooling) from exhaust air
- Can significantly reduce RTU compressor and/or furnace run time

<table>
<thead>
<tr>
<th>Outside and Inside Replacement: System Redesign</th>
<th>Repair</th>
<th>Retrofit</th>
<th>Replace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside</td>
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<tr>
<td>Inside</td>
<td>⚫️</td>
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<td>⚫️</td>
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National Grid Resources:

- ERV User Guide
- ERV Calculator

Cost Effectiveness: Mixed
Cost: Very High
Savings: Very High
Radiant Heating/Cooling with Dedicated Outside Air Systems (DOAS):

- Panels or surface layer easier to install in existing buildings
- Increased thermal comfort
- Best suited for mild climates
Variable Refrigerant Flow (VRF)

- Relatively small equipment sizes
- Well suited to meet diverse zone heating and cooling needs
Poll Question

4. How many commercial or industrial energy saving projects have you worked with National Grid in the past?
   a) Zero
   b) 1-4
   c) 5-9
   d) 10+

5. Would you like to speak with a National Grid expert on a current HVAC opportunity that you are pursuing?
   Yes / No
Thinking Strategically about Small HVAC Energy Efficiency
Building System and Component Lifecycle Opportunities

System Redesign – 30-50 Years

http://www.loopnet.com/Listing/18577617/90-South-Swan-Street-Albany-NY/
Building System and Component Lifecycle Opportunities

HVAC Equipment Replacement – 15-20 Years

http://www.loopnet.com/Listing/18577617/90-South-Swan-Street-Albany-NY/
Building System and Component Lifecycle Opportunities

Major Repairs – 5-7 Years

http://www.loopnet.com/Listing/18577617/90-South-Swan-Street-Albany-NY/
Building System and Component Lifecycle Opportunities

Controls, Maintenance, Minor Repairs – 1-2 Years

http://www.loopnet.com/Listing/18577617/90-South-Swan-Street-Albany-NY/
NON-ENERGY BENEFITS
Non-Energy Benefits: Thermal Comfort

• Properly maintained and tuned RTUs are more responsive to space heating and cooling demands
• Calibrated sensors (Temp, RH) lead to more accurate control of the space conditions to expected parameters
• A system redesign gives an opportunity to adjust heating and cooling capacity to better match space loads in each zone
Non-Energy Benefits: Air Quality

• Routine air filter changes maintain low levels of particulate matter, allergens, and dust

• Regular cooling coil cleaning prevents mold propagation and reduces the needed maintenance frequency of downstream components

• Properly calibrated sensors (CO2) and functioning economizers help the RTU maintain proper fresh air delivery to the space
Non-Energy Benefits: Acoustics

- Fans and compressors in poorly maintained units work harder and more hours.
- RTU retrofit and replacement is a good time to switch to a quieter unit, install silencers or vibration isolation in the ducts or curb, or reposition the RTU over a less populated area.
Non-Energy Benefits: Maintenance Savings

• In the long run, proactive maintenance will increase the life of system components (fans, compressor, etc.)
  • Poorly maintained equipment may have a lower capacity and need to spend more time running to deliver heating or cooling
  • Proactive maintenance can reduce unnecessary operation

• Routine maintenance is easier to manage than urgent repairs triggered by tenant complaints
  • Reducing tenant problems = positive owner $$ impacts
Non-Energy Benefits: The 3-30-300 Principle

Typical office building example:

- Annual Energy Cost: $3/ft²
- Annual Rent Cost: $30/ft²
- Annual Payroll Cost: $300/ft²

Seemingly minor impacts on productivity can have major impacts on bottom line…
Poll Question

6. How valuable has this webinar been to you?

   a) Not valuable at all. The content was too technical and detailed for me to understand.
   b) Slightly valuable. It was worth attending, but I would not recommend it to anyone.
   c) Moderately valuable. Content was interesting and informative, but only increased my knowledge or comfort level a little.
   d) Very valuable. This was time well spent and I learned a lot.
   e) Extremely valuable. My knowledge of National Grid Small HVAC offerings and opportunity has increased considerably.
Services & Tools

Use the left-hand menu to discover energy saving services and rebates available to you.

Roof Top Unit (RTU) Optimization Worksheet for Massachusetts, Rhode Island and Upstate New York

Reduce your customers’ energy costs by optimizing the energy efficiency of their Rooftop Units (RTU). National Grid will work with you to implement energy-saving retrofit controls that can increase the efficiency of existing rooftop HVAC equipment by as much as 40%. Download our sample RTU Optimizer Tool for details.

Downloads: Tool (83.0 KB WWW)

Transformer Replacement Program

National Grid offers incentives to your customers to replace their low-voltage, dry-type transformers with premium energy-efficient models. Download our program tools to learn more about implementation, energy savings, the application process, and more.

Downloads: Manual (875.0 KB WWW) Calculator (4.0 MB WWW)
Technical Resources

New Construction (MA & RI):
• New Building Ground-Up Construction
• Major Code-Triggering Renovations
• Commercial Tenant Fit-Outs (including commercial office lighting)

Retrofit:
• Interior/Exterior Lighting
  • Lamps, Fixtures, Systems and Controls
• Heating, Ventilation and Air Conditioning
  • Chillers, Variable Speed Drives, Motors, umps, and Controls
• Energy Management Systems (EMS)
• Water Heating
• Refrigeration — Equipment and Controls
• Food Service — Cooking, Holding, and Dishwashing
• Process Heating and Cooling
  • Motors, Variable Speed Drives, and Compressors
• Combined Heat and Power Systems (MA & RI)
• Custom Engineered Projects

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From technical advice to financial incentives, we help architects, engineers, contractors, and other trade and energy professionals add value to their projects. Start here to find the resources you need to achieve your clients’ energy saving goals and grow your business.
# Upcoming Webinars

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<th>Tools and Design Strategies of Resilient Buildings</th>
<th>Thursday 7/13/2017 @ 1 pm ET</th>
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<tbody>
<tr>
<td>Office Worker Performance and the Indoor Environment</td>
<td>Thursday 8/31/2017 @ 1 pm ET</td>
</tr>
<tr>
<td>Benchmarking – 101</td>
<td>Thursday 9/28/2017 @ 1 pm ET</td>
</tr>
<tr>
<td>Benchmarking – 102</td>
<td>Thursday 10/12/2017 @ 1 pm ET</td>
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Thank You!

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