14.0 NEC Wire Sizing (Electrical Breadth)

14.1 Background Information

Like the chilled beam analysis, this analysis will also look at different building systems for energy efficiency improvements. Specifically, this analysis will research upsizing wire size beyond the minimum size requirement set by the National Electric Code for different loads. There are many different articles on the World Wide Web and talk in the building industry about the benefits to upsizing conductors. This notion is based upon the principle that even wire conductors have some amount of resistance.

14.2 Goal

The goal of this analysis is determine the feasibility of upsizing wire to save in energy costs. If it is in fact true that actual savings in energy are realized, a payback period will be calculated for the different areas studied. Also, this analysis will determine the areas of a building that this technique would be most beneficial to.

14.3 Method

- Conduct literature reviews and interviews of electrical engineers
- Consult with faculty members about the feasibility of upsizing wire to improve the energy efficiency of a building
- Refer to the National Electric Code
- Conduct calculations as necessary to determine energy efficiency gains and payback periods
- Determine areas of buildings or specific building types that would be most appropriate for wire upsizing

14.4 Resources

- Case studies
- Electrical faculty and L/E students
- Mike Prinkey, Penn State Electrical Engineer
- META Engineers
- National Electric Code
- R.S. Means

14.5 Expected Outcome

A guide to upsizing wire for energy efficiency gains will be established and payback periods will be determined. This analysis will determine the areas of buildings and/or specific building types that would be most appropriate for wire upsizing.

14.6 Findings

Speaking to several different electrical engineers has made it clear that upsizing wires beyond the NEC minimum has issues that are not typically addressed in articles on the subject. The main flaw in the theory of upsizing wires is the assumption that the current flowing on the conductor is the maximum allowable by the National Electric Code. The maximum allowable current for a particular conductor size is usually larger than average load on the circuit in most all cases. Mike Prinkey, an electrical engineer for Penn State's Office of Physical Plant, said the University finds that the main service energy capacities of the buildings on campus are often twice the peak loads and 3 to 4 times the average loads. When comparing the average load to the rated capacity, the wiring is usually already upsized several times.

Calculating the energy loss associated with the resistance of the wiring can be approached much in the same way as voltage drop calculations usually preformed to check wiring size. For this analysis, the No. 2 circuit for the lighting panel LP-H will be used as an example of how to calculate the power loss. Once the power loss is known for the actual circuit, the wire will be upsized one size and the calculations will be performed again for the larger wire size. The results summarized in energy savings and a payback period calculation will be performed.

Circuit No. 12 on the lighting panel LP-H provides power to 2'x4' parabolic troffer luminaire. The 277V circuit's connected Volt-Amps is 5,000VA. The circuit uses two #12 wires with a #12 wire for the ground. The current in the wires is 5,000VA/277V = 18.1 amps. The luminaire are approximately 100' from the panelboard.

The first step is to calculate the resistance of the wire:

For #12 THHN @ 75^oC (From NEC Chapter 9, Table 9):

$R = 2\Omega/kFT$

To correct resistance to 30^oC, use NEC Table 8 footnote:

$R_2 = 2\,[1+0.00323(30-75)] = 1.71\ \Omega/kFT$

The second step is to calculate the power loss:

Power Loss = $I^2 * R = (18.1)^2 * 1.71 * 0.1 = 56.0$ W

The third step is to calculate energy loss per year:

Energy Loss = 56.0 W / 1000W/kW * 12hrs/day * 365days/year = 245 kWh/yr

Now repeat the steps for the upsized wire:

For #10 THHN @ 75°C (From NEC Chapter 9, Table 9):

$R = 1.2\ \Omega/kFT$

To correct resistance to 30°C, use NEC Table 8 footnote:

$R_2 = 1.2\ [1+0.00323(30-75)] = 1.03\ \Omega/kFT$

Calculate the power loss:

Power Loss = $I^2*R = (18.1)^2*1.03*0.1 = 33.7$ W

Calculate the energy loss per year:

Energy Loss = 33.7 W / 1000W/kW * 12hrs/day * 365days/year = 147 kWh/yr

Savings due to upsizing the wiring:

245-147 = 98 kWh/yr

Dollar Savings at $0.09 per kWh:

$8.82/year

Dollar Savings at $0.14 per kWh:

$13.72/year

Initial Cost Increase:

Cost of #12 wire & conduit = $2.85LF*100' = $285

Cost of #10 wire = $3.03LF*100' = $303

Cost difference = $18

Discounted Payback Period (assume MARR=15%):

Period	Cash Flow	Cost of Funds (15%)	Cumulative Cash Flow
0	($18)	$0	($18)
1	$13	($3)	($8)
2	$13	($1)	$4

Payback period is within two years.

The above strategy may work for specific applications, but the wiring is already oversized for most applications, so there would be little efficiency gains and therefore payback.
Locations where this may work are locations with constant high loads. Data center equipment, large constant speed motors, and possibly HVAC chillers are all applications where this strategy may work.

14.7 Conclusion and Recommendation

The above calculations prove that upsizing wire from the NEC minimum can have a payback in efficiency saving within a few years. The savings for each circuit may not be drastic, but if you applied this principle to more building areas, overall operating savings could be substantial. One major flaw with the principle of upsizing the wire conductors is that most circuits never operate at their full design capacity. This would lead to the wires being oversized in most instances and not provide the calculated cost benefits.

Upsizing wires have the most potential for savings when used in conjunction with circuits that have large, constant loads. Data centers, large constant speed motors, and possibly even HVAC chillers are potential areas that would work well for upsizing wires beyond the NEC minimum.