TACKLING ENERGY EFFICIENCY WITH CLEVER CABLING

EXPERT'S WEBINAR

Energy Efficiency: Cables and Wiring

Voltimum ANZ

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Expert Introduction - Presenter 1

voltimum

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Established reasons for considering energy efficiency in buildings:

- Meet specification requirements
- Greenstar ratings
- Nabers requirements
- Save money!

41% of energy consumption is attributed to buildings

- When considering energy efficiency we immediately look to traditional automation techniques
  - Lighting control, brightness control and daylight harvesting
  - Sun shading through shutters and blinds
  - Heating, ventilation and cooling control
  - Energy monitoring and management
- These traditional automation measures can provide savings from 15% to more than 50% of a building's energy footprint.
- In a greenfield site or a refurbishment, additional techniques beyond what is "traditional" can be utilized.

Tackling energy efficiency -the basics……and more

- Lighting control and regulation
- Heating, ventilation, cooling
- Blinds and shutter control
- Security and monitoring
- Energy and load management
- Visualisation and operation
- Central automatic control
- Remote control / maintenance
- Interface to other control systems
  - DALI
  - BacNet

The worldwide STANDARD for home and building control

IEC 14543-3

The advantages of standardisation

- A platform such as KNX has multiple approvals for global markets.
- Compliance to an IEC standard ensures backward and forward compatibility.
- Multi vendor open protocol allows maximum competition for product costs.

Beyond building automation control ….

A different method to tackle energy efficiency and energy savings ….

Clever cabling

Expert Introduction - Presenter 2

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Established cable sizing methods

- Continuous current rating
    - Phase conductor resistance and cable thermal environment
- Voltage drop
    - Phase conductor resistance and cable length
- Earth fault loop impedance
    - Phase and earth conductor resistance and cable length
- Short circuit rating
    - Phase conductor resistance and thermal properties

Established cable sizing methods

- Based on safety, protect persons, livestock and property from
  - Electrical shock
  - Fire
  - Physical injury hazards

Current rating

- Prevent cable overheating, cable premature failure and possibility of fire

Voltage drop

- Ensure electrical appliances continue to operate correctly

Earth fault loop impedance

- Ensure circuit protective devices operate correctly under fault conditions, reducing risk of fire and/or electrical shock

Short circuit rating

- Prevent cable overheating by ensuring cable is sized to carry maximum fault current capability of electrical system. Reduce risk of fire and/or electrical shock.

Tackling Energy Efficiency with Clever Cabling

- **Established cable sizing methods**
  - Defined in standards and mandated by law

  - **AS/NZS 3000 (The Wiring Rules)**
    - Called up by law in each states’ electrical installation rules
  - **AS/NZS 3008.1.1 (Cable selection guide)**
    - Referenced in AS/NZS 3000
  - **Results in smallest cable size**
    - Lowest installation cost
    - No consideration of operating costs, ie cost of losses

Total lifetime cost of an electrical installation

- Initial cable installation cost + operating costs

Energy efficient cable selection

- Lowest lifetime cost
- Optimum in energy efficiency

Installation contractors

- Only interested in installation cost

Owners of electrical installations

- Interested in total lifetime cost

Installation designers

- Interested in both of above

Tackling energy efficiency with clever cabling?

- Can only be applied when cable size is selected based on current rating
  - Because current rating is based on thermal considerations where loss calculation is key
  - Current rating calculation is an energy balance equation, ie heat generated by conductor vs heat that can be carried away from conductor
    - Well established and covered by IEC 60287
    - Used to calculate current ratings in AS/NZS 3008

$$I = \sqrt{\frac{\Delta\theta - W_d\left[\frac{1}{2}T_1 + (T_2 + T_3 + T_4)\right]}{RT_1 + R(1+\lambda_1)T_2 + R(1+\lambda_1+\lambda_2)(T_3 + T_4)}}$$

Consider the following example

- 400 V 3 Phase system requiring 250 A over 75 m
- Single core copper XLPE/PVC in trefoil configuration laid on cable ladder tray, unenclosed, in free air, protected from direct sunlight

- Initial solution 95 mm^2 – ref column 9, table 8, AS/NZS 3008.1.1 (298 A)

- Voltage drop check to ensure compliance with AS/NZS 3000
  - V_d = 250 A x 75 m x 0.457 mV/A.m (ref column 8, table 40 AS/NZS 3008.1.1)
  - V_d = 8.6 V or 2.1 %

Step 1: Calculate losses and cost of losses for initial solution

- Losses = I^2 x R x L x N
  - I = required cable loading in A
  - R = cable AC resistance at load temperature in Ω/km (ref column 5, Table 34 AS/NZS 3008.1.1)
  - L= circuit route length in km
  - N = number of phases (loaded conductors)

- Losses = 250^2 x 0.247 x 0.075 x 3 = 3473 W
- Assume cost of losses charged at nominal rate of 0.15 c/kWhr
- However cable circuits are unlikely to operate at full load continuously – utilisation factor

Step 1 (cont'd): Calculate losses and cost of losses for initial solution

- Utilisation factor for supply mains – 80%
- Cost of losses over one year
  - Losses x Utlisation^2 x c/kWhr x 24 x 365
  - 3.473 x 0.8^2 x 0.15 x 24 x 365 = $2921

Step 2: Calculate total cost – cable plus losses over life of asset

- Cost of cable from typical list pricing ($12/m)
- Total cost = 75 x 3 x 12 + 20 x $2921
- Total cost = $61,120

- Observation – cost of losses major component of system cost for this size of cable

Step 3: Repeat for next and subsequent cable size/s and tabulate

Conductor Size	Voltage Drop Factor	Voltage Drop	Voltage Drop	AC Resistance	Cable Losses	Cost of Losses	Cable Cost	Total Cable Cost	Total Cost Cable + Losses (20yr)
mm^2	mV/A.m	V	%	ohm/km	kW	$/yr	$/100m	$	$
95	0.457	8.569	2.14	0.247	3.473	$2,921.02	$1,212.65	$2,728.46	$61,148.90
120	0.373	6.994	1.75	0.197	2.770	$2,329.72	$1,457.03	$3,278.32	$49,872.76
150	0.316	5.925	1.48	0.16	2.250	$1,892.16	$1,812.18	$4,077.41	$41,920.61
185	0.269	5.044	1.26	0.129	1.814	$1,525.55	$2,216.42	$4,986.95	$35,498.03
240	0.227	4.256	1.06	0.0991	1.394	$1,171.96	$2,958.03	$6,655.57	$30,094.70
300	0.202	3.788	0.95	0.0803	1.129	$949.63	$3,660.30	$8,235.68	$27,228.23
400	0.183	3.431	0.86	0.0646	0.908	$763.96	$4,835.82	$10,880.60	$26,159.79
500	0.17	3.188	0.80	0.0525	0.738	$620.87	$6,072.56	$13,663.26	**$26,080.56**
630	0.159	2.981	0.75	0.0432	0.608	$510.88	$7,829.43	$17,616.22	$27,833.88

Step 3 (cont'd): Observations

- Total cost drops rapidly when choosing only one or two sizes larger than the minimum size
- Optimum size is many times larger than minimum size, but approaches law of diminishing returns
- Optimum size 500 mm^2 but may not practically be the best option as this study does not take into account:
  - Extra space required to install larger cable
  - Extra effort (and cost) required to install larger cable
  - Additional money earned (interest) by virtue of the dollars saved by paying less for losses

  - Need to use financial function: Net Present Value (NPV) to determine optimum cable size

Step 4: Add NPV to previous table

- Net Present Value represents the difference between the present value of savings in the cost of losses over the time period and the increase in capital expenditure required to purchase a larger cable size

$$NPV = \frac{Y(1-(1+r)^{-n})}{r} - cc$$

- Y = savings in cost of losses in $/yr
- r = discount rate, typically 7% (the expected rate of return that those paying for the energy losses could earn in financial markets)
- n = time period in years, typically 20 years for an electrical asset
- cc = increase in capital expenditure ($) as a result of using a larger cable in todays value (cable + other upfront costs)

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Step 4: Add NPV to previous table

Conductor Size	Cable Losses	Cost of Losses	Cable Cost	Total Cable Cost	Total Cost Cable + Losses (20yr)	Savings in Cost of Losses	Increase in Capital Expenditure	Net Present Value over Max Payback Year
mm^2	kW	$/yr	$/100m	$	$	$/yr	$	$
95	3.473	$2,921.02	$1,212.65	$2,728.46	$61,148.90	$0.00	$0.00	$0.00
120	2.770	$2,329.72	$1,457.03	$3,278.32	$49,872.76	$591.30	$549.86	$5,714.39
150	2.250	$1,892.16	$1,812.18	$4,077.41	$41,920.61	$1,028.86	$1,348.94	$9,550.84
185	1.814	$1,525.55	$2,216.42	$4,986.95	$35,498.03	$1,395.47	$2,258.48	$12,525.13
240	1.394	$1,171.96	$2,958.03	$6,655.57	$30,094.70	$1,749.07	$3,927.11	$14,602.52
300	1.129	$949.63	$3,660.30	$8,235.68	$27,228.23	$1,971.39	$5,507.21	**$15,377.77**
400	0.908	$763.96	$4,835.82	$10,880.60	$26,159.79	$2,157.06	$8,152.13	$14,699.82
500	0.738	$620.87	$6,072.56	$13,663.26	**$26,080.56**	$2,300.16	$10,934.80	$13,433.10
630	0.608	$510.88	$7,829.43	$17,616.22	$27,833.88	$2,410.14	$14,887.76	$10,645.29

- **Step 4 (cont'd): Observations**
  - Optimum cable size has highest NPV
  - Highest NPV not necessarily the cable size that has lowest total cost (cable and losses)
- **Where to from here?**
  - Continuing education of the industry via forums such as Voltimum
  - Addition of a worked example into AS/NZS 3008.1.1
    - Currently in progress

Further reading

- IEC standard 60287-3-2: Electric cables – Calculation of current rating – Part 3: Sections on operating conditions – Section 2: Economic optimization of power cable size
    - Replaces IEC 1059 first published in 1991
- Technical article titled “Principles of Economic and Energy Efficient Cable Sizing” by Auseng, download from the ICAA website at the link

http://www.copper.com.au/copper/wcms/en/home/Principles-of-Economic-and-Energy-Efficient-Cable-Sizing-AusEng-Sep-.pdf

Do you have questions?

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