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Planning, Design, and Operation Based on Conductor Ampacity

Did you know the ampacity assigned to a conductor is not based on its catalog rating? Rather, it must be determined based on local weather conditions and the design used to install the conductor. Once believed to only be a problem relating to transmission lines, it also applies to distribution systems. The system planner who defines a conductor ampacity in a planning study needs to coordinate this rating with the designer/staking technician and the SCADA/system operator who monitors the loading on the conductors.

As with most electrical components, the conductor is rated based on heat. The ability of an overhead conductor to dissipate the heat generated from the flow of electrons through the strands of the conductor is an important element in rating the conductor. If the ambient temperature is low, as in the winter, heat from the wire will readily dissipate into the cold air. However, in the summer months with ambient temperatures approaching 100 F (38 C), it is more difficult to cool the conductor. The ability of a conductor to cool itself is referred to as the emissitivity. Another major factor is the ability of wind to cool the conductor. In some parts of the country, electric utilities have weather stations to monitor wind speed and direction to help predict the changing ampacity of critical conductors.

The heat generated from current flow is a squared function of current or I^2R. So, as the current doubles, the heat generated increases by a factor of four. Another characteristic changed by heat in the conductor is its length. A conductor will elongate as its temperature increases. The problem for a line designer is that as the conductor elongates, the amount of sag increases. For a typical distribution line (336 ACSR with a 300 foot ruling span), the elongation caused from heating a conductor from 95 F (35 C) to 122 F (50 C) is 1.16 inches. This elongation results in an increased sag of 3.29 feet. Using the same conductor and increasing the temperature from 122 F (50 C) to 167 F (75 C), the elongation is 1.93 inches and the increase in sag is 4.25 feet. The elongation results in additional slack in the span. For this conductor the increase in sag as a function of slack is:

$$D = \sqrt{\frac{3 \times S \times (L - S)}{8}}$$

Where: $D = Sag$
$S = Span\ Length$
$L = Length\ of\ Conductor$
$(L - S) = Slack$

The National Electrical Safety Code (NESC) throughout their text requires utilities to design for the largest final sag of a conductor. The largest final sag is defined as the conductor operating at 120 F (50 C) or its highest operating temperature or the sag caused by ice loading (reference Rule 232A). **However, for a line that is built in an area that is a summer peaking system, with ambient summer temperatures of 95 F or higher, the amount of current necessary to cause a temperature rise to 120 F is approximately 231 amps in a 336 ACSR conductor.** This value is determined using IEEE Standard 738

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based on the ambient temperature and final operating temperature of the conductor. Yet most utility planning engineers will rate this same 336 ACSR conductor at 519 amps. This rating is often based on the catalog rating provided by the manufacturers. Closer inspection of the data provided by the manufacturers will note that the ampacity is based on an ambient temperature of 77 F (25 C) and a conductor operating temperature of 167 F (75 C). The following table provides a comparison of ampacities for common conductors.

Ampacity Ratings for Overhead Conductors

Source	IEEE 738	Catalog
Ambient temp	95 F	77 F
Conductor temp	120 F	167 F
2 ACSR	87	184
1/0 ACSR	112	242
2/0 ACSR	125	276
3/0 ACSR	141	315
4/0 ACSR	157	357
336 ACSR	220	519
477 ACSR	258	646
795 ACSR	343	884

When an electric utility installs large conductors, it intends to fully utilize the capacity at some point in the future. To be able to use this capacity, the designer of the line will need to design the line for operation at 167 F (75 C). The increase in sag at 167 F (75 C) is generally not a problem when considering clearance above roadways (although it must be verified by the designer). But this increase in sag will create a problem when considering mid-span clearance between conductors as required by NESC Rule 235C2b. This rule requires a specified distance between the phase conductor and its reduced neutral. To meet this rule, a common design technique is to increase the phase to neutral separation at the pole. Normally this separation is four feet, but it can be increased up to six feet. For RUS borrowers this increase is provided for in CFR 1724.

Distribution lines must be assigned an ampacity rating based on ambient temperatures and on design parameters. To get higher ampacity levels, it is suggested that large conductors be designed to operate at 167 F (75 C). **To simply ignore the NESC rule of designing for the highest operating temperature and loading the conductor as high as possible can only lead to future litigation.** The SCADA/system operator must know the ampacity rating of a line and the designer must know if the line is to be rated based on 120 F (50C) or 167 F (75C). These ratings also are used in the planning and economic justifications of system improvements.

For more information on how to apply IEEE standard 738 and how to design lines for higher operating temperatures contact:

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This article is an excerpt from the training seminars presented by Hi-Line Engineering, LLC throughout the United States. For more information regarding training seminars or to schedule a seminar at your utility contact Kevin Mara.

Time Will Tell…
Capital Availability in the Energy Market

Recent conditions in the energy market have created concerns about the availability of capital for investing in energy-related assets such as new generation. These concerns prompted the Federal Energy Regulatory Commission (FERC) to hold a conference on January 16, 2003, to provide a forum to informally discuss problems that currently exist, potential solutions to such problems, and actions that can be taken by FERC to improve the current market situation. Speakers at this conference included representatives from investment banks, commercial banks, insurance companies, hedge funds, credit rating agencies, as well as market participants and customers. In addition to FERC, representatives from other relevant agencies attended.

The dialogue at the conference focused mainly on investor-owned energy companies, their currently limited access to capital, the condition they are in today, and the reasons for this condition. Energy companies obtain capital through various sources, and the availability of this capital, both debt and equity, has diminished over the last year. Banks, the largest provider of liquidity to market participants, have been receiving pressure from their stockholders and executive management to reduce exposure to the energy industry. Credit downgrades and the resulting effect that downgrades have had on liquidity positions have exacerbated the risk exposure to banks, prompting banks to further limit capital.

Given banks' reluctance to provide capital, market participants are forced to access other sources of capital, such as public and private debt and equity markets. However, investors in these other markets are also apprehensive toward investing capital into the energy markets. In fact, some investors are actually disinvesting, favoring companies either exiting the energy trading business or investing in other industries all together. Lack of investor confidence in market participants, as well as the energy market in general, are the primary reasons for this investor apprehensiveness.

On the market participant level, investors are concerned that market models do not correspond to the business risk associated with that of a commodity's market. For example, current capital structures of market participants, typically 60% debt/40% equity or even higher, are too highly leveraged and are not appropriate for such a commodity's market. In addition, in light of the Enron debacle and subsequent investigations of questionable behavior of other market participants, investors are also concerned with the ethical behavior of management. Both of these concerns are well-placed considering the recent market performance of the energy stocks. For example, the market capitalization for the top 25 energy companies in 2001 was nearly $370 billion. In 2002, the market capitalization dropped nearly $160 billion to approximately $210 billion. This loss of real money has only solidified investors' diminishing confidence in energy companies over the last year.

The lack of investor confidence with respect to the general energy market can be largely attributed to regulatory uncertainty. At both the federal and state level, neither clarity nor consistency among rules and regulations are present. This regulatory uncertainty adds to investors concern with the ambiguity associated with the future market structure. The question can be raised, how can investors appropriately determine and measure risk, and therefore obtain a reasonable return, without a stable market structure in place. Granted, investors will invest in risky and unstable markets, but an inflated return will be demanded as compensation for taking on such risks.

What are possible solutions to eliminating problems associated with limited capital availability in energy markets? First and foremost, regulatory uncertainty must be substantially eliminated because future investment will rely on a stable regulatory framework. Due to the overlap of federal and state government jurisdictions, both levels of government must work together toward a common goal - workable competitive markets with a standard set of market rules that provide transparency, clarity, and consistency across the board. Both federal and state regulatory agencies need to be more expeditious in their proceedings and determinations. Unlike market participants, the capital market does not abide by or adhere to, governmental timeframes.

Contracts are another area that will play a key role in affecting future availability of capital in energy markets. Liquidity concerns of market participants have caused contracts to become smaller in volume and shorter in term. Investors are hesitant to invest in such an environment. Long-term contracts are needed to satisfy investors and to insure an appropriate return on their investment. In addition, the integrity of these contracts must be enforced. In the eyes of an investor, long-term contracts are worthless unless their integrity can be upheld.

Having a standard set of disclosures and accounting guidelines will also play a huge role in increasing investor confidence. Investors need transparency, especially in light of the recent ethical behavior of many market participants. This transparency needs to materialize through better disclosure by market participants and a universal and standardized set of accounting guidelines and procedures.

Many industry experts agree that, at some point, capital will flow back into energy markets at the levels that are needed. Market participants need **time** to mend their weakened balance sheets. Regulatory agencies need **time** to develop a consistent set of rules and regulations and to develop a market structure that has transparency and clarity. It will take **time** for the debt overhang of the industry to dwindle down and for investor confidence to increase, but eventually capital will flow back into the industry. **Time will tell…**

For more information or to comment on this article, contact Brian Lawson at 770.425.8100 or email: brian.lawson@gdsassociates.com

Perspective: Stop Picking At It

(Reprint from the *Arizona Statewide CURRENTS* publication, May 2003)

I have always led with my head - usually with my eyes closed. As a child, this meant I was often hurt. Usually it was minor cuts, scrapes, or bruises – like every kid has growing up. My mother would clean me up and then she would paint the wounds with this yellow antiseptic called, Mercurachrome, that stung so much you just knew it must be really working. And then, mom would send me back to play with the warning, **"Don't pick at it. If you don't leave it alone it will never heal."**

I am starting to feel this way about retail electric deregulation and competition. Not the burning and stinging part - that has passed after all these years. I mean the part about healing. We just can't stop picking at it and it doesn't seem to be getting better.

Nationally, we are into the second decade of this movement to deregulate electric service. Today, the Congress is writing major energy legislation that includes provisions to move the country farther along the path of retail electric competition while adding more regulation and higher costs for electric cooperatives and their consumer-members.

In Arizona and California the forces of change in the electric industry have been at work for nearly 10 years. The California experiment with retail electric choice was nothing short of a disaster in every way. Supplies were short, prices were high, customers experienced forced outages called blackouts and some of the largest and most stable electric utilities in the Nation either went bankrupt or were close to bankruptcy. California may not be out of the woods yet.

Arizona has weathered the movement better than most but only because of timing and the fact that we were able to see first-hand the problems experienced by California and other states who were early adopters of electric choice legislation and regulation. We led with our heads too, but we had at least one eye open most of the time.

Today, the Arizona Corporation Commission is about to launch into a full blown review of its own retail electric competition rules. Not one competitive game has been played yet – the other teams left town – and we are already looking to change the rules.

The movement toward retail electric choice has become a game on its own played by politicians, regulators, speculators, large commercial power users and utilities. There is so much invested – time, money, and ideology – and so much at stake – money – that it is impossible to declare this a bad idea whose time came and went.

So, we keep picking at it. Which means it may never heal.

Tom Jones
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GDS Associates, Inc.
Engineers and Consultants

Mission Statement:

To help our clients succeed by anticipating and understanding their needs, and by efficiently delivering quality services with confidence and integrity.

GDS Associates, Inc. is a multi-service consulting and engineering firm formed in 1986 and now employs a staff of over 100 in five locations across the U.S. Our broad range of expertise focuses on clients associated with, or affected by, electric, gas, and water utilities. In addition, we offer information technology, market research, and statistical services to a diverse client base. The size and depth of our firm permits us to offer clients multiple sources of assistance, ensuring complete, competent, and timely service. Some of the consulting areas in which GDS has specialized skills are:

1. Power Supply Planning Services
2. Financial Analysis and Rate Services
3. Generation Services
4. Regulatory and Restructuring Services
5. Renewable Energy Resources, Distributed Generation, and Combined Heat and Power Services
6. Energy Efficiency and Demand-Side Management Services
7. Electric Planning and Design Services (Hi-Line Engineering, LLC)
8. Environmental Management Services (GreenLine Environmental)
9. Deregulation and Retail Energy Procurement Services
10. Utility Privatization Services
11. Water and Wastewater Utility Consulting Services
12. Natural Gas Consulting Services
13. Statistics and Market Research Services
14. Information Technology Services

GDS consultants are recognized leaders in their respective fields, dedicated to their clients, innovative in their approach to meeting unique challenges, and known for consistently being available when needed. GDS strives to develop long-term client relationships. Our goal is to be a wise investment in consulting services for our clients.

Hi-Line Engineering, LLC is a wholly owned subsidiary of GDS Associates, Inc. Hi-Line specializes in providing safe, reliable, and efficient planning and design for electric cooperatives, investor owned utilities, municipal electric systems, and the military in all types of terrain and all three NESC loading districts. Hi-Line's areas of expertise include:

1. Overhead Distribution Line Design and Staking
2. Underground Distribution System Design
3. Inspection and Inventory
4. Contract Administration
5. System Planning and Analysis
6. Right-of-Way Vegetation Management
7. GIS/GPS Mapping
8. Training Services
9. Specialized Design Services

Hi-Line uses the latest technology to increase efficiency and accuracy. Our commitment to client satisfaction and diversity of expertise ensures that we provide the highest quality of service.

GreenLine Environmental, a division of Hi-Line Engineering, LLC, provides environmental services specially geared to the electric utility industry. GreenLine's staff is composed of registered foresters and ISA certified arborists. Our experience in both power line design and operation complement our expertise in vegetation management on right-of-ways. GreenLine offers the following services to utilities, municipals, developers, industry, and the military:

1. Right-of-Way Vegetation Management
2. GPS and GIS Mapping and Inventory
3. Environmental Assessments
4. Urban Forestry Consulting

Our goal is to use our technology and experience to provide efficient long-term control of trees and brush in harmony with the biological ecosystem.

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