October 18, 2013

MEMO

TO: California Energy Commission
Email: docket@energy.ca.gov

FROM: Lorenz V. Schoff, PE
Energy Efficient Solutions

SUBJECT: Docket No. 13-CCEJA-1 – Comments and recommendations for the Draft Proposition 39 Program Implementation Guidelines

As a member of the committee, writing the Grid Neutral: Electrical Independence for California Schools and Community Colleges, introduced in December 2008, I am commenting on these guidelines that will implement Proposition 39. My comments sight the Grid Neutral document and the ASHRAE Advanced Energy Design Guide (AEDG) for K-12 Schools both (30% and 50% reduction) as the basis for these comments.

BACKGROUND: Electrical loads in educational facilities have over the past third of a century, changed from linear to non-linear in nature in all areas: classroom, administrative, lighting, and HVAC. The surge from linear to non-linear began in the 90's with the introduction of computers in all areas of education. This impact is found on those electrical circuits providing 120/208 V throughout the building. The energy for these circuits originates from the dry distribution transformer reducing incoming electrical power from 480/277V to 120/208V. These transformers in the past 1/3 of a century have been designed, sized and installed when opaque or slide or overhead or 16mm projectors, and Tube Type TV's were in use and the norm; not today's, computers, LCD projectors or smart boards, DVD or Tape recorders, LCD/LED TV's and computer monitors. The capacity remains but the load is significant less, resulting in reducing the efficiency of the transformers and increasing the waste of electrical energy.

The U.S. Department of Energy realized distribution transformers were a major source of energy waste and energy inefficiency in buildings and began to studying, testing and making recommendations in the late 90's. The results were published in the Federal Register in July 2004. The recommendation for low voltage distribution transformers was based on lowest Life Cycle Cost and is known as CSL-3 or C-3. This transformer is 30% more efficient than the EPACT 2005 minimum allowable as TP-1 or C-1. C-3 design will handle up to 100% non-linear load while the TP-1 is UL approved for 5%. Non-linear loading in most schools ranges from 50 to 75%. Today, transformer loading in schools ranges from 5 to 18% significantly less than the 35-50% for TP-1 needed for maximum efficiency and in line for max efficiency of 10-20% for a C-3. Back in 2004, DOE estimated "IF" all distribution transformers were replaced with C-3 transformers, the amount of energy saved would be equal to 9 days of U.S. electricity generation annually (-2.5%). That is from one gray box requiring, behind closed doors, no maintenance and failure does not occur due to low loading. The following is provided as an example of the potential energy savings based on the original DOE information. Based on population figures in 2004, California had about 12.1% of the US population. Based on this information and the 9 days of electrical generation, projected to be saved annually with the C-3 transformer installation either new/replaced/upgraded, then approximately 26 hours of electrical generation and purchases could be saved annually in California with the installation of C-3 transformers. Educational facilities have a significant number of these transformers and thus would account for a significant portion of the 26 hours.

In the ASHRAE K-12 AEDG (-30%) on page 151-152 and in the K-12 AEDG (-50%) Section: Electrical Distribution, the C-3 transformer is recommended for additional savings and the California Grid Neutral Document on page 17 encourages the installation of C-3 transformers for establishing a foundation for sustainable grid neutral design and operations.

RECOMMENDATIONS:

1. **Add the following to the Exhibit B:** Typical Cost Effective K-12 School Energy Projects – Upgrade existing or install new Dry Low Voltage Distribution Transformers meeting the requirements of DOE CSL-3 (C3) design capable of handling current non-linear loading while maintaining a high efficiency rating for all loads during the day.

Priority	*Project Example*	*Climate Zone (CZ) Recommendations*
1	Implement automatic shutdown software on all computers.	Custom audit required
1	Install occupancy controls on all vending machines.	Custom audit required
1	**Upgrade existing or install new Dry Low Voltage Distribution Transformers meeting the requirements of DOE CSL-3 (C3) design capable of handling current non-linear loading while maintaining a high efficiency rating for all loads during the day.**	**Custom audit required**

2. **Add the following to the Exhibit F:** Effective Useful Life of Measures in Years – Add C3 Distribution Transformers with a useful life of 32+ years.

Exhibit F: Effective Useful Life for Measures in Years

Measure Category	Measure Type	Measure	Effective Useful Life
Other	Domestic Hot Water	DHW Boiler or Tank Water Heater	20
	Plug Load	LCD monitors	4
		Power Management	4
		Vending Machine Miser	5
	Motors and Drives	Efficient Motor	15
	Distribution Transformers	CSL-3 (C3) – Non Linear Load	32+
	Wastewater	VFD on water pumps	15

CURRENT EDUCATIONAL FACILITIES: Supporting Case Studys and other data

- Case Study – UC Merced (Attached)
- Case Study – Stanford University (Attached)
- % Peak loading Distribution in Schools for Various Size Transformers (Attached)

Case Study
University of California
Merced, CA
Transformer Retrofit
Lower Costs and CO_2 at UC Merced

THE CLIENT

Opened in September 2005, the University of California, Merced was the newest University of California campus at the time. In addition to its mission of providing excellence in education, the University is committed to setting the standard for sustainable use of energy and other resources. To that end, the University requires a minimum of LEED Gold Certification for all their on-campus buildings and enforces a program to design buildings that consume half the energy and peak demand of other university buildings in California.

UC Merced also maintains several off campus buildings. Off campus buildings include older buildings purchased or leased by the University to serve the interests of the wider San Joaquin Valley. As part of their sustainability mandate, the University's Facilities Management team undertakes improvements to upgrade the resource efficiency of the University's entire building stock including initiatives designed to bring older off campus buildings more in line with the University's high performance standards.

OPPORTUNITY

EPC program enables building owners and managers to undertake a no risk pilot project to identify the energy savings potential of replacing a building's standard transformers with higher efficiency C3 level transformers. The program is of particular interest to building owners looking for effective means to upgrade energy efficiency in existing buildings.

The role that transformers play in a building's overall energy efficiency is not widely understood. "We had not been aware that there were significant differences in transformer performance and efficiency. The EPC program gave us the opportunity to judge for ourselves whether replacing the transformers would be an effective energy saving strategy," noted John Elliott, the University's Assistant Director, Energy and Sustainability.

Mr. Elliott selected UC Merced's off campus building in Fresno, CA for the project. The facility provides space for university and regional community business, health and development offices. The buildings transformers supply plug load power for computers, printer and other office equipment.

THE STUDY

The first step of a program establishes the baseline performance of a building's existing installed transformers. For the purpose of this study, selected were 75 kVA and a 45 kVA transformers. Meters were setup to record actual loading, demand, consumption and losses at five minute intervals over a one week period. This data was then analyzed to identify the amount and cost of electricity lost by the older transformers.

THE STUDY (CONT'D)

Low loading contributed to the poor performance of the Fresno facility's existing transformers. Neither transformer averaged any more than 79% efficiency. To put this into perspective, for every dollar the University paid to power the building's plug load, only 79 cents was available for useful work. Furthermore, because transformer power losses are converted to heat, the existing transformers increased the building's cooling demand. By replacing the old and inefficient transformers, UC Merced could lower both direct energy losses and indirect losses associated with cooling.

Having established the baseline performance data, Powersmiths removed the old transformers and replaced them with C3 model "L" transformers. The C3 meets the US Department of Energy's Candidate Standard Level 3 (CSL 3) efficiency level the efficiency level deemed by the DOE to offer the lowest lifecycle cost. "L" models were installed, because they are specifically engineered to reach peak performance at low load levels.

To compare performance, the new transformers were measured over the same time intervals and timeframe used to measure the older transformers.

FINDINGS

C3 produced substantial performance improvements. Efficiency increased to an average of 96% compared to the 79% efficiency measured for the older transformers. The E Savers had effectively reduced losses by 85%. Over the course of a year, this efficiency gain will add up to a 15,434 kWh savings for these two transformers alone.

The increased power conversion efficiency also lowers the building's peak demand, in this case by 18% and 19.3% for 75 kVA and 45 kVA respectively. Based on the current rate of 15¢/kWh, UC Merced's upgrade to C3 transformers will save the university $ 3820/year in usage charges and gain additional demand charge savings. Over the course of their estimated thirty two year life cycle, the C3's are projected to save more than $200,000.

Electricity savings also reduce environmental costs. In this case, the retrofit will reduce the buildings carbon emissions by 5.59 tons annually. At UC Merced, installation of C3 transformers supports the University's sustainability mandate, while at the same time lowering operating costs to free up money for educational programs.

Loss Reduction	Before	After	% Loss Reduction
kW losses (75 kVA)	**1.1480**	**0.1331**	**88%**
kW losses (45 kVA)	**0.8690**	**0.1245**	**86%**

Efficiency Measurements	Before	After	Efficiency Increase
Avg. Efficiency (75	**78.59**	**96.75**	**18.16%**
Avg. Efficiency (45	**75.3**	**95.6**	**20.30%**

Annual Operating Cost Savings	Before	After	Saving
75kVA	**$2,491**	**$288**	**$2,203**
45kVA	**$1,888**	**$271**	**$1,617**
32 Year Lifecycle Saving*			**$200,561**

***Assumes 3% annual increase in the price of electricity**

Annual Reduction in Greenhouse Gases (per EPA)	Equivalence
5.59 tons of CO2	
8.18 lbs SO_2 emissions averted	**1.3 acres of trees**
9.57 lbs NO_X emissions averted	

Page 17 from Grid Neutral Doc with CSL-3 Side Bar`

Building

Designing the building envelope (walls and windows) with the following features can ensure higher energy efficiency for each building:

- Building insulation
- Weather strip openings
- Integrating walls into the building with thermal mass—a passive solar technique that uses the temperatures of the each day to heat or cool spaces
- Daylighting—bringing in natural light can reduce electrical lighting need
- Clerestory windows—a daylighting technique of locating windows above space with high ceilings

Tip for daylighting: To alleviate glare, allow sunlight to hit one surface before entering a space.

Furnishings, Fixtures and Equipment

Although your entire campus will be designed energy efficiently, targeting spaces that consume large amounts of electricity can significantly impact the success of a new grid neutral campus. This would include focusing in on the energy efficiency of the furnishings, fixtures and equipment of spaces like commercial kitchens, welding, woodworking, and auto shops, along with other areas that have combined uses such as multipurpose rooms, gymnasiums, and performing arts centers.

The electrical load where equipment is plugged in (plug loads) also plays a large role in energy inefficiencies. Computers and monitors can be equipped with programs to turn them off when not in use and can largely reduce energy losses. Installing Energy Star appliances and equipment is highly recommended.

Electrical transformers can be evaluated for opportunities for energy savings. Additionally, you can have an electrical engineer look into upgrading the minimum required transformer and replace it with one of higher efficiency, like the CSL-3 transformers.

Reducing electrical losses in the building when the buildings are not in use can significantly reduce the number of PV arrays required to achieve grid neutral. Making sure that all the photovoltaic (solar) equipment is compatible with the other systems will make a difference, too.

Systems

Lighting, heating and air conditioning (HVAC) systems can be targeted as the largest energy users in a new facility.

Incorporating automated controls on the energy-efficient lighting and HVAC systems can increase energy efficiency:

- Occupancy sensors can help turn off lights when areas are not in use.
- Occupancy sensors will also control the electricity used at electrical outlets to help manage plug loads and the electricity used when equipment or appliances are plugged in and not being used (called "phantom loads").
- Interlocking controls—turns HVAC off if doors, operable windows, or clerestory windows are opened.
- Daylight harvesting—dimming the light fixtures near windows to maximize the natural light when available.

Commissioning the systems with an outside agent that checks that the lights, HVAC and other systems are properly set at their optimum design helps to save a lot of energy. Sometimes fans are running or valves are open when not necessary, so they need to be reset to save electricity. Refer to CHPS' Best Practices Manual for more detailed information.

Electrical Transformers

- Transformers operate 24 hrs a day/7 days a week for the life of a building. Even at night when buildings are not in use, transformers have electrical losses (called no-load losses).
- CSL-3 Transformers reduce the no-load electrical losses by 50 percent or more compared to the regularly installed TP-1 transformer.
- Electrical loads must be matched to transformer size. Often transformers are oversized for future expansion, which will offset the intended energy efficiencies.
- Replacing existing transformers with CSL-3 transformers can realize more energy savings.
- The number of transformers at facilities varies from 1 or 2; sometimes even 20 depending on the campus.
- CSL-3 Transformers can significantly reduce the number of PV arrays required to achieve grid neutrality.
- Work with your comprehensive planning team and find out details for your campuses using a life cycle cost analysis.

GRID Neutral Schools

DIVISION OF THE
STATE ARCHITECT
DEPARTMENT OF GENERAL SERVICES

FACT SHEET: TRANSFORMING ENERGY USE

HIGH EFFICIENCY TRANSFORMERS AT STANFORD

Using energy from efficient sources while reducing overall energy usage is central to creating a sustainable campus. Stanford is building on a decades-long commitment to energy conservation and efficiency, as well as benefiting from a temperate climate and strong state energy codes. Current energy-saving strategies are expected to push energy consumption down through 2011, but by 2012 additional use from new buildings is likely to require further conservation efforts. High efficiency power transformers are being used at Stanford for new construction and building retrofits to help accomplish this goal.

REDUCING ENERGY DEMAND THROUGH INCREASED EFFICIENCY

Importance of efficient transformers

Transformers are used to convert the 480 Volt power delivered at the building entrance to the lower 120 Volt power supplied at the building's electrical outlets.   A typical building may have as many as half-a-dozen distribution transformers installed in various electrical rooms. Transformers lose power in the conversion process. The extent of these losses is a measure of a transformer's efficiency. Efficiency increases can have a substantial impact on total building electrical consumption because transformers operate continuously whether plug load electricity is being used or not. Furthermore, because transformers emit wasted electricity as heat, inefficient transformers place a higher burden on a building's cooling system. Powersmiths' transformers operate more efficiently than standard transformers. Designed to meet the U.S. Department of Energy's Candidate Standard Level Three (CSL-3) efficiency,these transformers exceed the mandatory TP-1 efficiency standard to lower electricity losses and reduce cooling burden.

Table 1. Comparative Energy Savings

kVA	30	45	75	112.5	150	225	300	500
TP1 (current standard)	97.5	97.7	98.0	98.2	98.3	98.5	98.6	98.7
CSL3	98.1	98.3	98.6	98.8	98.9	98.9	99	99.1
Saved Energy (W)	180	270	450	675	900	900	1200	2000

KEY PERFORMANCE METRICS

- Using the per unit watt values above, the electrical savings per year are approximately 450,000 kWh. This is equivalent to about 235,800 lbs of CO_2 per year. This estimate is based on use of approximately 75 transformers.
- At $0.11 per kWh, the annual savings in avoided costs is approximately $50,300. When combined with the additional savings associated with reduced cooling costs, the annual total savings exceed $92,000 per year.
- These transformers offer a 5 year or less simple payback on the price difference between high efficiency CSL-3 transformers and minimum efficiency TP-1 transformers. The higher cost is a reflection of the increased labor and material costs required to achieve higher efficiency. Over their 30+ year life cycle, the cost difference is returned many times over through electricity savings.

MORE INFORMATION

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SUSTAINABLE STANFORD

% Peak loading Distribution in Schools for Various Size Transformers

Transformers were tested in school facilities in the early 2000's in schools in the Phoenix AZ area

XFMR Size in KVA	30	45	75	112.5	150	225	500		
	5.6	14.1	3.2	9.07	10.1	18.3	7		
	4.4	8.9	6.6	5.8	3.5	9.4			
		7.7	11.6	8.1	3.5				
		14.5	11.1	4.1	17.6				
		7.1	1	3.4	11.5				
			7.7	15.4	2.4			Percent	High Peak load = 18.3
			3.3	7.8				Percent	Average Peak Load = 8.2
			9.1					Percent	Low Peak Load = 1
			3.6						Number of transformers = 41
			11.2						Number of Schools = 15
			10.2						
			16.5					NEMA Premium Performance Based on 35% L	
			16.2					Real Life Loading ranges from 1 to 18.3 which	
			7.9					NEMA Premium performance Curve is based l	
			1.3					Today's School loading is between 60 to 80% r	
			4.9					NEMA Premium transformer is not approved l	
			4.3					NEMA Premium Transformer performance (ef	
			6.8						
	10	52.3	136.5	53.67	48.6	27.7	7	335.77	
	5	10.46	7.583333	7.667143	8.1	13.35	7		
	2	5	18	7	6	2	1	41	
								8.189512	

oading and Linear Loading
is about 3% to 52.2% of the NEMA Performance Standard
inear loading which existed in schools in the 70's and 80's
non-linear loads --
by UL for use in a predominate non-linear load environment
ficiency) is reduced in a non-linear load environment