RESEARCH REGARDING THE CURRENT STATE AND THE LATEST TRENDS IN CONSTRUCTION AND EXPLOITATION OF MINING POWER SUPPLY SYSTEMS

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ABSTRACT: *This paper analyses the current state of mining power systems along with the ever increasing necessity in power quality improvement, studying a set of measurements on a 400V/230V mine transformer. The data collected is presented and interpreted with the necessary upgrade suggestion. Also this paper presents the idea of integrating renewable energy in mines that have a weak or no possibility for grid connection, in mines that want to harvest free energy decreasing carbon and green-house emissions and also reduce energy costs. It is shown that renewable energy can also be integrated in abandoned mine lands.*

KEYWORDS: mine power supply systems, renewable energy in mine industry, power quality in mining industry

1.INTRODUCTION

Underground mining machines are among the mostcompact and rugged equipment over designed, and individualunits can have up to 1,000 total horsepower. Miningequipment is usually mobile and self-propelled; most ispowered electrically through portable cables and, for safety,must be part of an elaborate grounding system. The machinesand power-distribution equipment are seldom stationary,must be adapted to continuous cyclic operation, andmust resist daunting levels of dust and vibration.

Surface mining can involve the largest earth-movingequipment built, where one piece can have 12,000 or moreconnected horsepower-the largest today is over 30,000 hp.The electrical loads created by this machinery are cyclicand extremely dynamic: the largest excavator, for example,can require electrical loads that range from 200%motoring to 100% generating every 50 to 60 s, under themost exacting physical conditions. In the ever-moving miningoperation where distribution of power must be constantlyextended and relocated, subjected to abuse bymachine and worker alike, the potential for safety hazardsis always present.

Engineering and maintaining such an electrical systemis demanding and challenging. It requires a specialist withknowledge of both mining and electrical engineering. Yetconversely, the effective management of a mine requiresthat anyone responsible for production and safety also beconversant with the mine electrical system.

Managementshould understand the advantages and disadvantages of onesystem over another, for if the power system is poorly designed,not only will safety be compromised but the mineoperator will pay for the resulting conditions with highpower bills, high-cost maintenance, and loss of production.

The main target in designing and operating a mine power system is safety for the electrical machines and workers, with an increasing tendency in increasing the power quality.

1.1 Power quality

Power quality is defined by IEEE asThe concept of powering and grounding electronic equipment in a manner that issuitable to the operation of that equipment and compatible with the premisewiring system and other connected equipment. The parameters monitored in order to improve power quality are:

- supplier dependent: frequency (must be 50Hz±1% in 95% of 1 week and 50Hz+4% to 50Hz-6% in 100% of 1 week), voltage (±10% in 95% of 1 week), and all voltage related shortages and dips
- consumer dependent: harmonics, voltage fluctuations and voltage unbalances

In modern power systems non-linear consumers have an increasing participation; using adjustable alternative current drives with first stage diode rectifiers, and adjustable continuous current drives based on thyristors increase the harmonics of the supplied current. The disadvantages of the harmonics are: power dissipation in power lines, transformers, electric machines and capacitors. In three phased systems increase in harmonics creates current in the neutral cable in some cases reaching unacceptable values. Electrical current harmonics create a distortion effect on supply tensions, affecting not only non-linear consumers but linear consumers that do not generate harmonics.

Another power quality parameter is the reactive power.Reactive power required by inductive loads increases the amount of apparent power(measured in kVA) in the distribution system. The increase in reactive and apparentpower causes the power factor to decrease. The smaller the power factor, the larger the kVA rating of equipments, the greater the conductor sizes required, large copper losses, poor voltage regulation, reduced handling capacity of the system. Causes of low power factor are: induction type a.c. motors (0.2 to 0.3 power factor on light load and 0.8 to 0.9 on full load), arc lamps, electric discharge lamps and industrial heating furnaces, high load on the power system during morning and evening and low atother times. During low load period, supply voltage is increased which increases themagnetization current. This results in the decreased power factor.

2. POWER QUALITY MEASUREMENT USING FLUKE 434

2.1. Description of the Fluke 434 three phase energy and power quality analyzer

The Fluke 434 (Fig.1) is the ideal tool for energy logging. It has Energy Loss Calculator function which measures the cost of energy wasted due to poor power quality.

Fig.1

Other functions are:

-Energy loss calculator: active and reactive power measurements, unbalance and harmonic power, fiscal cost of energy loss

-Real-time troubleshoot

-600V Cat IV / 1000V Cat III rated for use at service entrance

-Measure at three phases and neutral

-Automatic trending

-System-monitor

-Logger function: up to 600 parameters at user defined intervals

-View graphs and generate reports with included analysis software

2.2 Graphs and measurement results

Using this Fluke 434 Series II Energy Analyzer power quality measurements were conducted at a low voltage 400/230 transformer and the most relevant graphs are the phase tensions screenshots, the harmonics graphs and the power factor graphs.

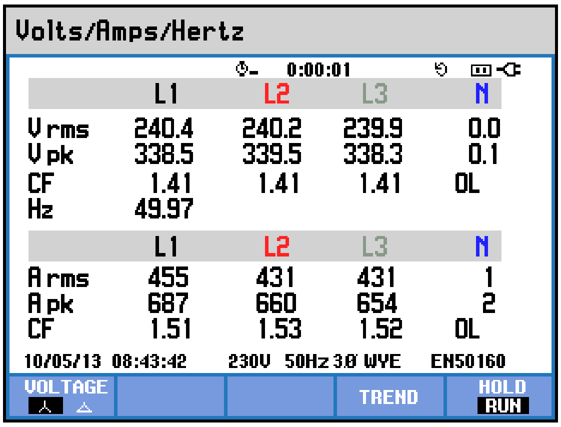


Fig.2

From Fig.2 it can be seen that the voltage differences are very small, under 0.2% in the 230v secondary of the transformer.

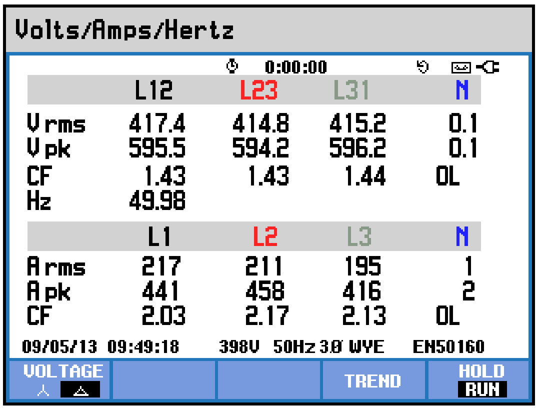


Fig.3

The 400V primary (Fig.3) shows a difference of 0.6%. In both primary and the secondary along with the 0A current going through the neutral (Fig.4) show a perfectly balanced system.

Summary

From	5/9/2013 09:54:52
To	5/10/2013 08:42:52
Maximum value	0 A
At	5/9/2013 09:54:52
Minimum value	0 A
At	5/9/2013 09:54:52
μ	0 A
s	0 A

Fig.4

The harmonics tables(Fig.5, Fig.6, Fig.7) show that there is no need for filtering, total harmonic distorsion being under 1% for all three phases, well under the maximum recommended value of 5%.

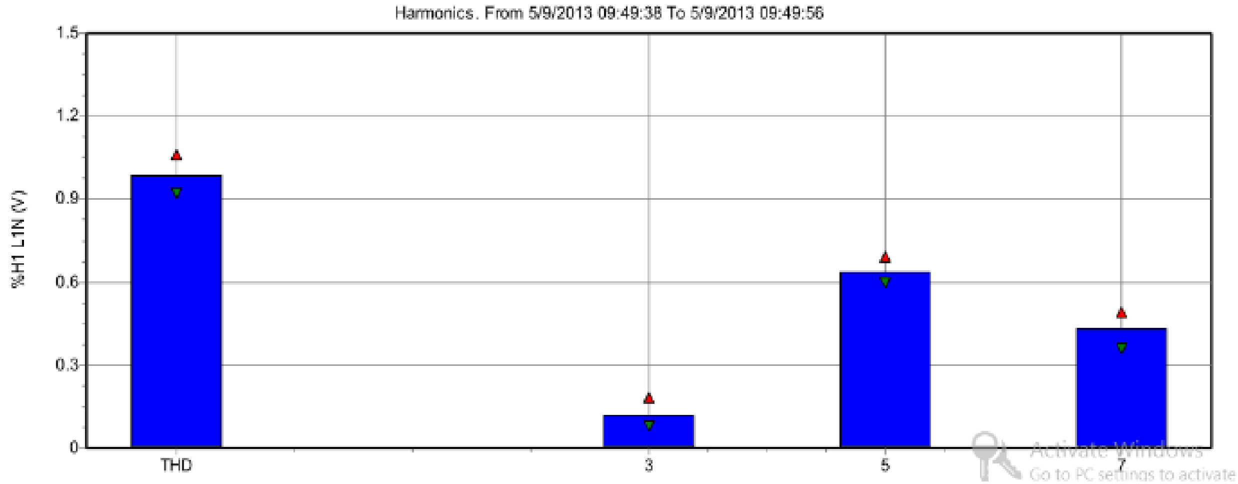


Fig. 5 (Harmonics between phase 1 and neutral)

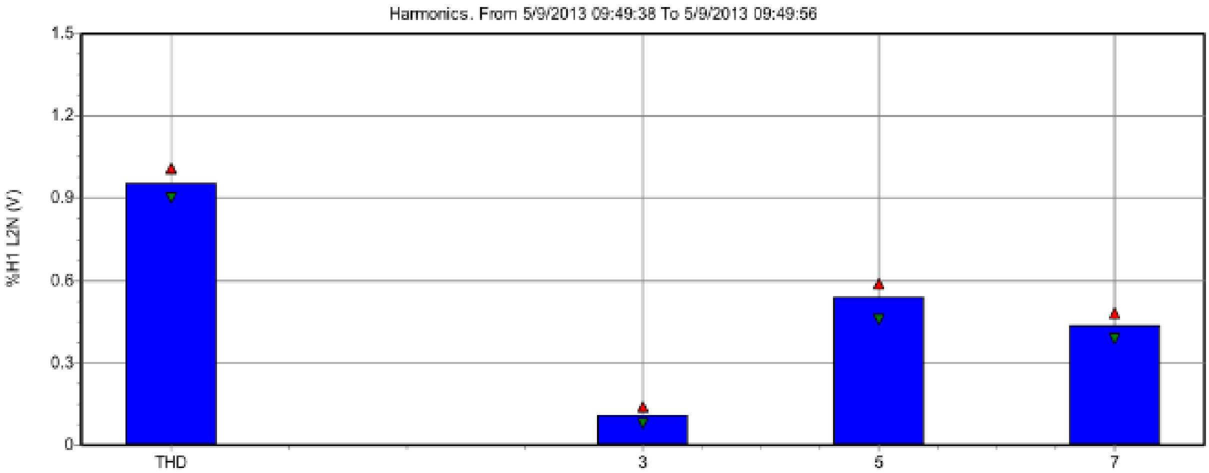


Fig. 6 (Harmonics between phase 2 and neutral)

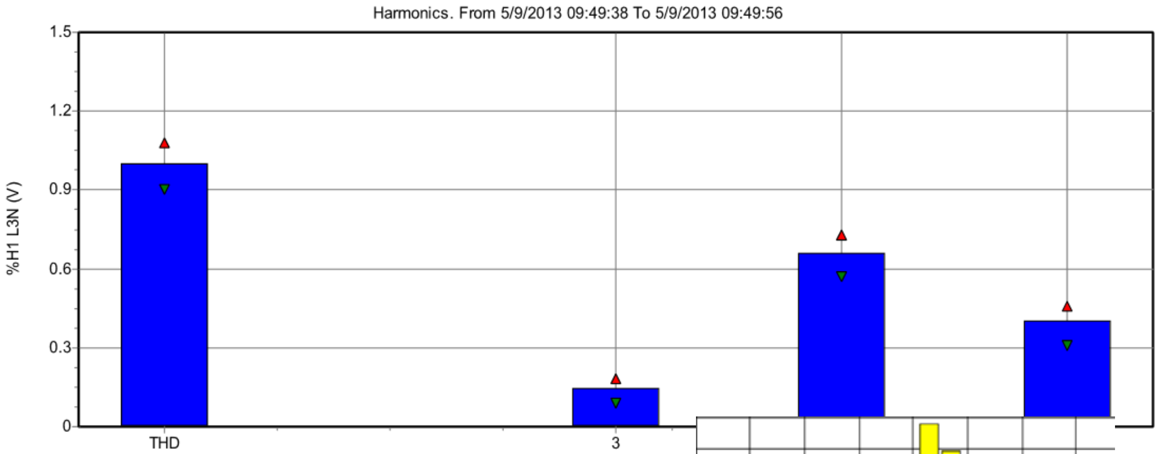


Fig. 7 (Harmonics between phase 3 and neutral)

The only problem is with the power factor (Fig.8, Fig.9, Fig. 10, Fig.11) where there is room from improvement from a medium value of between 0.8 and 0.85 on all three phases. The system could benefit from adding power factor correction capacitors

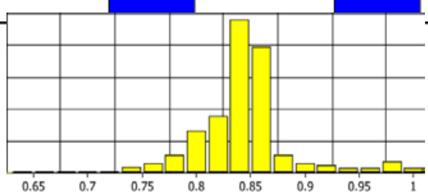


Fig.8

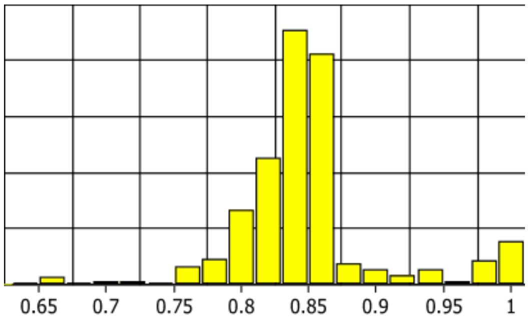


Fig. 9

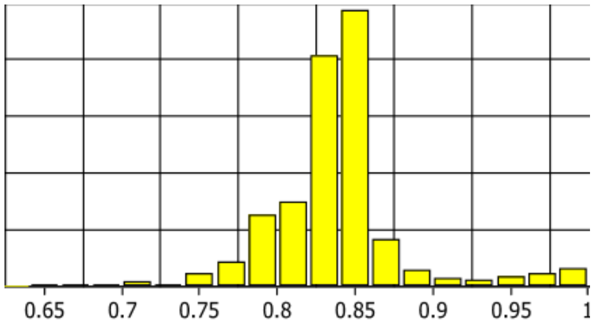


Fig.10

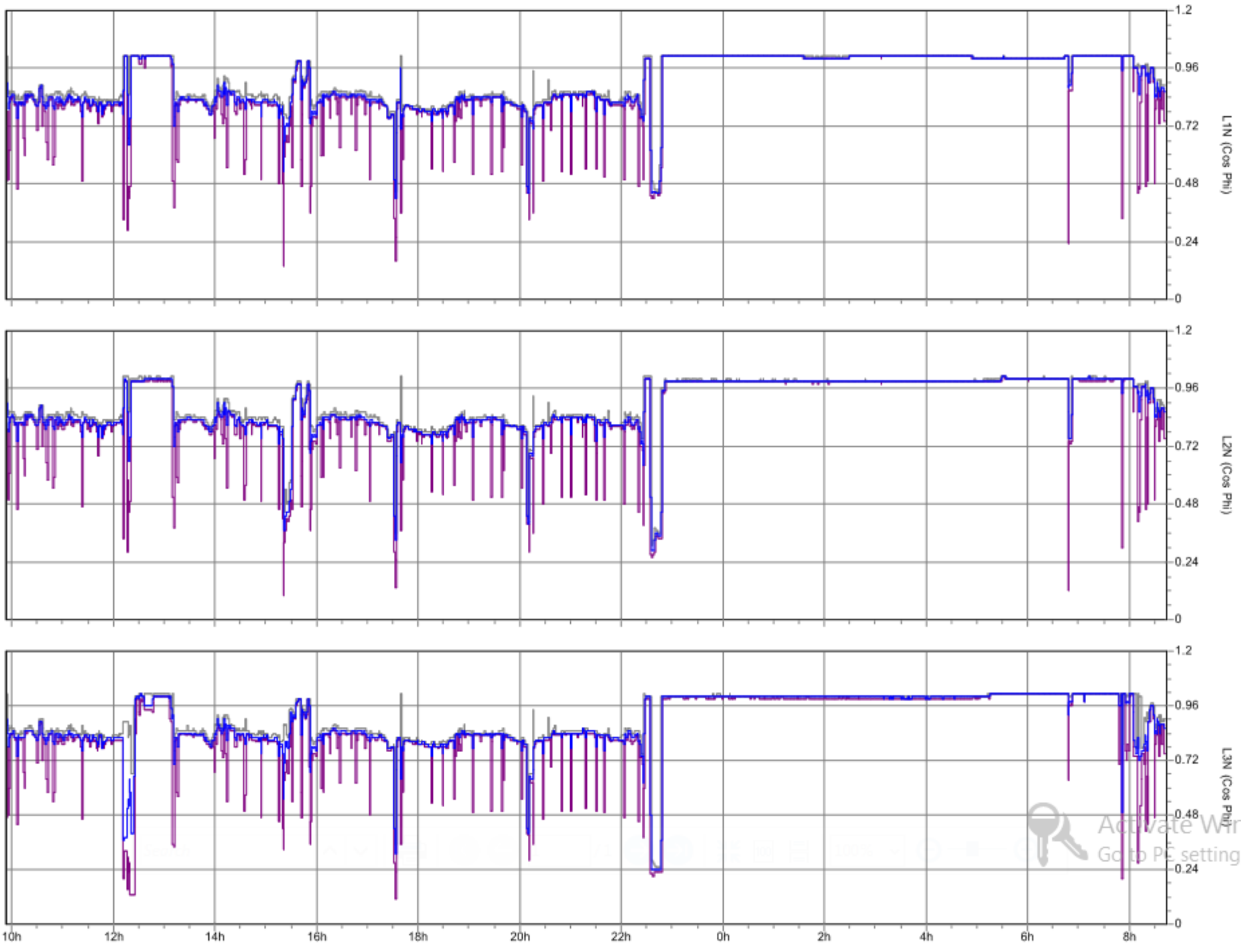


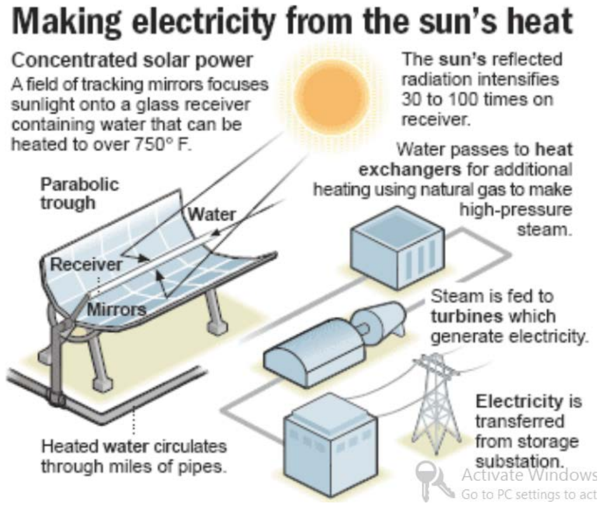
Fig. 11 Wind turbine generator to grid schematic

3. INCORPORATING RENEWABLE ENERGY IN MINING INDUSTRY

While mining companies´ interest in incorporating renewable technologies historically came from an environmental direction, market conditions have impelled many to switch to a more economic view. Renewable technologies are more likely to be implemented to mining projects with little or no access to a well-established electricity grid.

3.1. Use of wind energy in mining industry

Diavik diamond mine in northeast Canada installed four wind turbines(Fig.11) that generate between 8% and 9% of the project´s power needs. Without these



wind turbines the mine requires between 60 and 70 million liters of diesel fuel per year to fuel the generators.

Using renewable energy also reduces carbon and green houseemissions and the negative environmental impactsof their operations.

In Germany, RWE Innogy installed ten Repower Systems SE wind turbines(fig.11) near RWE´s Garzweiler open cast mine. The 150m high turbines have a combined capacity of 20.5 Mw.

3.2. Use of solar energy in mining industry

Jinko Solar from china together with Solea Renewables are building a 1 MW solar energy array(Fig.12) at a chromium mine in Limpopo, a South African province, and it is the first off-grid, utility-scale solar PV system in South Africa.

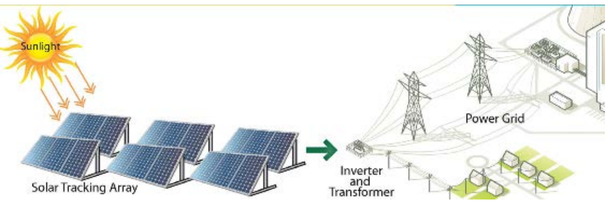


Fig.12. Photovoltaic system schematic

The solar PV system is expected to supply 1.8 GWh of clean, renewable electricity for the chromium mine´s operation per year, reducing the mine´s reliance on diesel fuel generators.

Another type of solar power generation is to use solar thermal power plants (Fig.13). Solar thermal collectors are used to concentrate the sun's energy by using mirrors to heat a fluid that produces steam that's used to power an engine or turbine. A solar thermal plant consists of two parts: one part that collects solar energy and converts it to heat and the other that converts this heat into electricity.

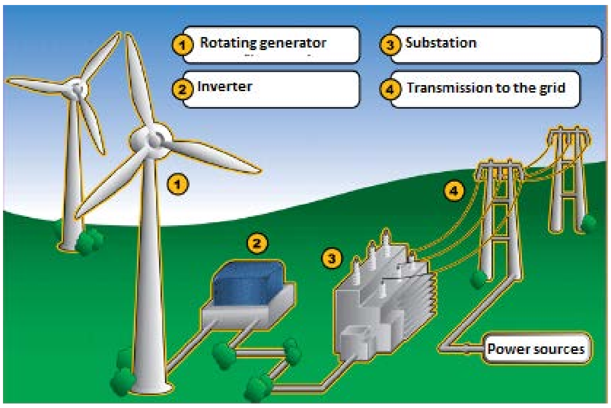


Fig. 13. Thermal power plant

Currently, concentrating solar power is the most efficient and cost effective way to generate electricity from the sun.

3.3 Using abandoned mine lands

Another application of renewable energy is using the abandoned mine lands that have never been considered for any type of reuse, and have remained idle. Abandoned mine land sites are generally located in areas that are not well suited for commercial or industrial reuse, however these sites can take advantage of local renewable resource attributes to generate electricity. Abandoned mine lands can serve as excellent locations for wind farms or solar energy plants depending of the characteristics of the land. Usualy abandoned mine lands are located near existing infrastructure including roads and power lines reducing the cost of initial investment, and the large size of the abandoned mine is adequate for accomodating on one location large-scale wind turbines or solar arrays.

Fig.14. PV system in Espenhain Germany

From 2004 on a former lignite-mine ash deposit in Espenhain Germany, a 5 MW photovoltaic power plant made up of 33500(fig.14) solar modules generate electricity that is fed directly into the German electricity grid. The project was initiated and developed by the energy company Geosol for € 20 million. In 2005 Geosol installed an aditional 3.4 MW PV array near Espenhain at the Borna Solar Plant. This plant was installed for €22 million on the site of a former lignite briquettes factory, and has an anual electricity output of 3.5 million kWh.

Another use of an abandoned mine site is the geothermal energy.

Since the ambient temperature of the Earth increases with depth, underground mine workings provide a convenient collection point for groundwater. This resource may be sufficiently warm to raise the starting temperature of the water used for heating and hot water in buildings and horticulture, often involving ground-source or water-source heat pumps. Mine and quarry sites can also offer opportunities for access to deep geothermal resources, involving hotter water or even superheated steam power generation via a turbine.

Geothermal Engineering Ltd is creating a 10 MW geothermal power plant at United Downs near Redruth that will generate sustainable electricity which can be fed into the national grid. As a by-product it will also produce 55MW of heat which can be used for the local community.

The first water power station opened in Heerlen in the Netherlands in 2008. It uses water at 32°C extracted from underground coal mine workings through boreholes in what was once the Netherlands' coal mining heartland. It heats 350 homes and businesses and is estimated to reduce CO_2 emissions by 55 percent compared to conventional water heating systems.

4.CONCLUSIONS:

In modern times all trends regarding power systems in general go towards improving quality of power delivered. Industrial power systems must be constantly supplied with energy, reducing at minimum power outages.

The use of renewable energy is more and more common in every industry mainly because of the cheap energy after the initial investment, and the decrease of carbon and green house emissions. Also renewable energy can be fed into the grid or made available to the local community.

In the future large investments will be made into renewable energy sources making it more accessible and more efficient.

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