

# Voltage Stabilization Using Synchronous Condensers

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Western Mine Electrical  
Association

November 15,2001

## The Players

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- ✍ Jim VanEmmerik – visionary
    - ✍ TBCC -> Grand Eagle -> Kennecott Energy
  - ✍ Rick Scherer - designer
    - ✍ TBCC -> DCS -> Grand Eagle -> Kennecott Energy (abbreviated to save space)
  - ✍ Gary Sorenson – trying to take the credit
    - ✍ Kennecott Energy -> DCS
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## Background & History

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### Black Thunder Mine 1999

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- ✍ Large surface mine in powder river basin
  - ✍ 3 draglines
  - ✍ 6 shovels
  - ✍ Overland conveyor
  - ✍ Acquired by arch minerals who intended to grow the operation
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## Black Thunder Mine- Growth Plans

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- ✍ Thundercloud lease
    - ✍ Additional 8750 dragline
    - ✍ Two BE 495 shovels
    - ✍ Overland conveyor and crusher
  - ✍ Concern about growth at neighboring mines.
    - ✍ North Rochelle - new mine
    - ✍ Jacobs Ranch Mine – proposed dragline
    - ✍ North Antelope / Rochelle – dragline and shovels
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## Black Thunder Mine- Problems

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- ✍ Experiencing 8% voltage drops.
    - ✍ Due to VAR deficiency on 2570 dragline.
    - ✍ Heavy load on 69kv line shared by 4 mines and a large gas plant.
    - ✍ Under voltage trips on 2570 swing inverter.
    - ✍ Over voltage problems with static drive shovels.
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## Model Results With Projected Additional Loads

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- ✘ Power system modeling predicted problems with projected loads.
    - ✘ Voltage dips in excess of 17%.
    - ✘ Under voltage trips at utility substation.
    - ✘ Voltage flicker outside of new utility standards.
    - ✘ Problems at neighboring mines.
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## Options Considered / Design

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## Solutions Investigated

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- ✍ Static VAR compensator.
  - ✍ Dedicated substation and power line from utility.
  - ✍ Synchronous condenser.
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## Static VAR Compensation

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### ✍ Advantages

- ✍ Very fast
- ✍ Industry standard on arc furnace applications
- ✍ Slightly more energy efficient than synchronous condenser

### ✍ Disadvantages

- ✍ Expensive
  - ✍ Harmonics issues
  - ✍ Maintenance learning curve with unfamiliar equipment
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## Utility Upgrades

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### ⌘ Advantages

- ⌘ Isolates mine from other customers
- ⌘ Allows for more growth
- ⌘ Easy to maintain

### ⌘ Disadvantages

- ⌘ Utility was initially reluctant
  - ⌘ Cost is high
  - ⌘ “Band-aid” approach for underlying VAR deficiency
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## Synchronous Condenser

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### ⌘ Advantages

- ⌘ Customer had 7 synchronous motors available
- ⌘ No harmonics
- ⌘ Cost
- ⌘ Scaleable
- ⌘ Short-circuit capacity

### ⌘ Disadvantages

- ⌘ Operating cost
  - ⌘ Rotating machinery maintenance
  - ⌘ Reaction speed
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## Synchronous Condensers Were Selected

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- ✍ System was modeled with proposed condensers.
    - ✍ Model indicated that voltage control was most effective control method over power factor or demand level.
    - ✍ Up to 20 MVAR would be required for proper regulation.
  - ✍ An equipment specification was developed for the mine.
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## Synchronous Condensers Solution

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- ✍ 3 units planned
    - ✍ Unit #1: three 3500 HP- 900 RPM sync motors
    - ✍ Units #2 & #3: two 3000 HP-1200 RPM sync motor each. (Unit 3 was never built)
  - ✍ Total capacity 23.5 MVAR (17.5 MVAR installed)
  - ✍ Utilized 15MVA pit substations to save money
  - ✍ Controlled by radio link from main meter or under local voltage regulator control
  - ✍ Semi-portable design
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## Control Hardware

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- ✍ Allen-Bradley SLC 5/05 Ethernet PLC
  - ✍ PanelView user interface
  - ✍ Power meters networked to PLC through Ethernet
  - ✍ Remote Ethernet link to mine network
  - ✍ Firing-Circuits static field exciter
  - ✍ Vacuum contactors
  - ✍ Pilot ground monitor
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## Safety Considerations

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- ✍ Safety
    - ✍ MSHA checks
    - ✍ Start console
    - ✍ Ground check
    - ✍ Hardwired pilot wire from substation to start console for emergency stop
    - ✍ Communications watchdog
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## Machinery Protection

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- ✍ RTD's on every bearing
  - ✍ Rotor over current- RMS and instantaneous
  - ✍ Stator over current- RMS and instantaneous
  - ✍ Multiple start lockout
  - ✍ Cooling fan control
  - ✍ Vibration transducers
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## The Final Result

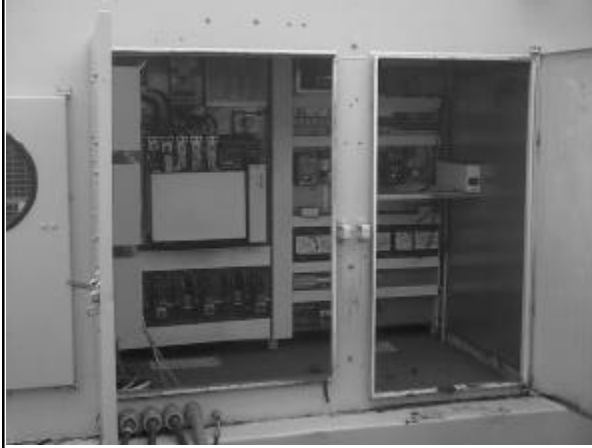
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Gary Sorenson



## Control Skid

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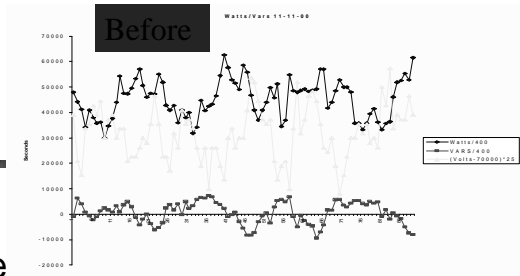
## Rotating Skid

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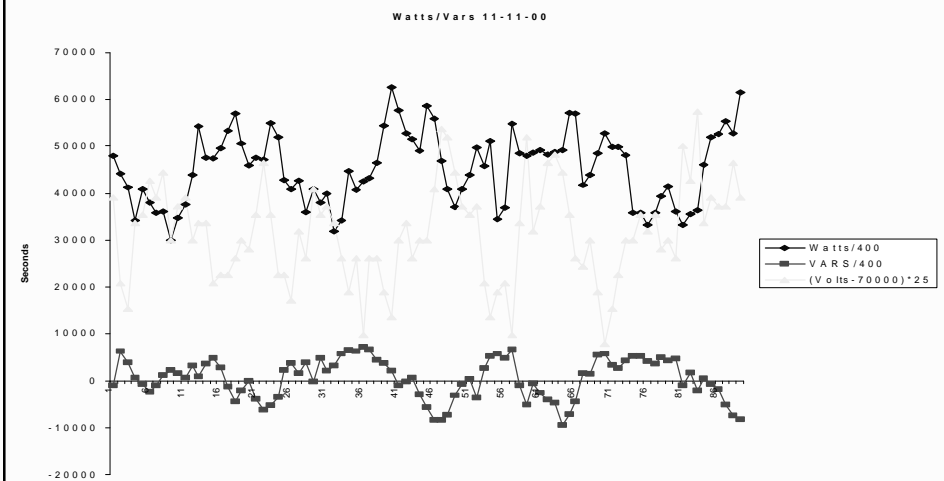


# Results

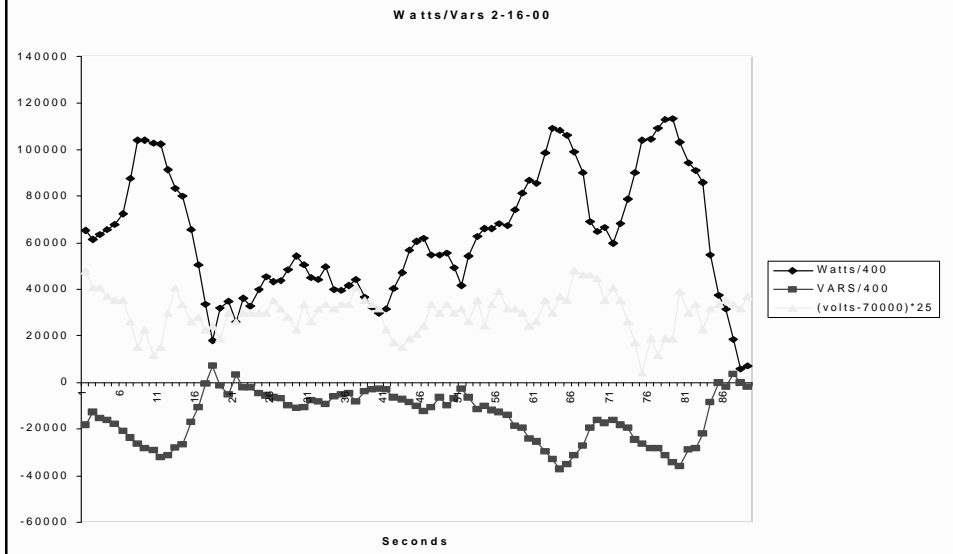
- ⚡ Voltage dips reduced from 9% to 4% before utility upgrade occurred
- ⚡ Reduced fuse loss on 2570 dragline substantially



# Watts/VARS/volts Before Upgrade



## Watts/VARS/volts After Upgrade



## Black Thunder 2001

- ✍ Overland conveyor and plant upgrades did not occur.
- ✍ Only 2 of the 3 planned condensers were commissioned.
- ✍ Operating 4 draglines and 8 shovels.
- ✍ Utility eventually provided dedicated substation and power line to mine due to growth in area.

## Problems Encountered

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- ✍ Regulating from main metering point created unacceptable voltage swings on secondary of pit substation due to transformer impedance. This caused problems for shovels sharing the substation.
    - ✍ Operating on local voltage regulation mode.
  - ✍ System response on unit #1.
    - ✍ Complemented well with unit #2.
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## Additional Credits

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- ✍ Tony Strgar- TBCC Electrical Superintendent during project.
  - ✍ Tom Walker/Dale Wilgers- TBCC -helped with wireless network
  - ✍ Donald Jean- DCS Panel Shop
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