DTE Energy

Detroit Edison Distributed Resources Utility Applications & Case Studies

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Agenda

- DTE Energy Background
- Detroit Edison DG Distribution Solutions
  - Internal to the distribution circuit
  - At the substation
  - In an island mode to perform maintenance
- Getting it Done
- DG Operating Options

Company Overview - DTE Energy

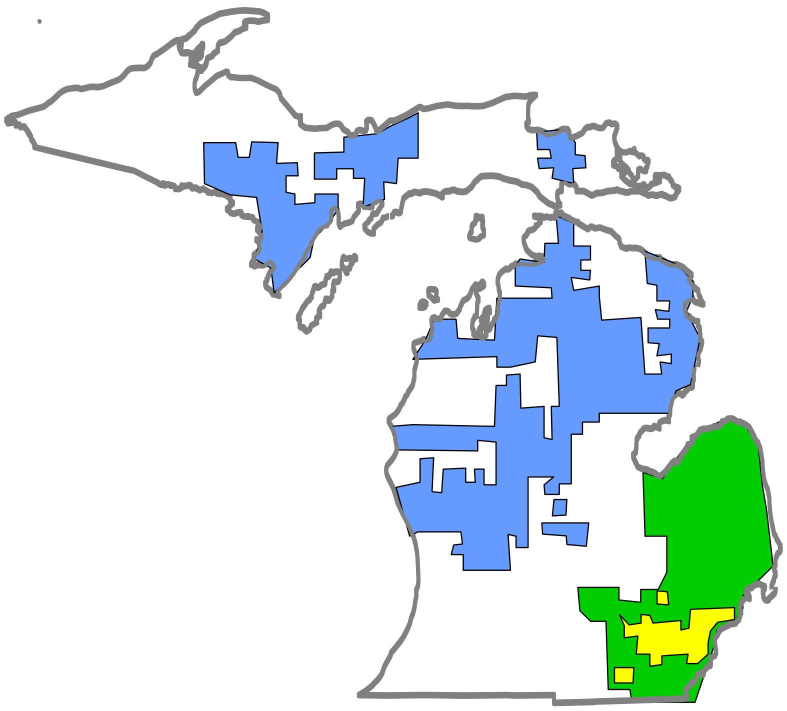
DTE Energy

Overall

- Full-spectrum regional energy provider
  - An electric and natural gas utility
  - Growing non-regulated energy related businesses
- Assets of $19 billion
- Annual revenues over $7 billion

Electric & Gas Utility

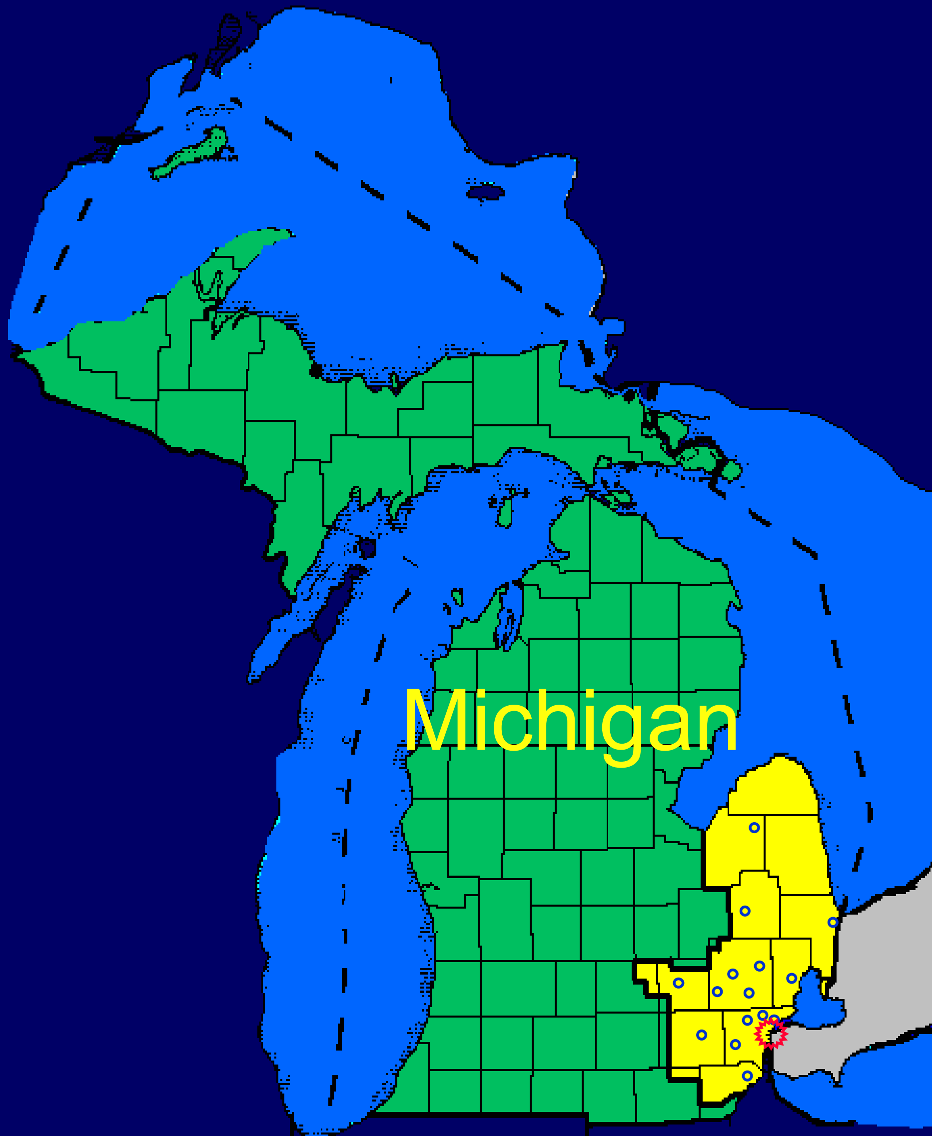
- 2.6 million customers
- 11,000 MW of generation
- 600 BCF natural gas delivery
- 11,500 employees



Utility Service Territory

Detroit Edison Service Territory

DTE Energy



Service Area: 7,600 Sq. Miles

Customers: 2.1 million

System Peak Load: 12,132 MW
Annual Sales: 56,000 GWH
37% Commercial
29% Residential
29% Industrial
5% Wholesale & Interconnection

Distributed Generation: 1,427 MW
or 12 % of Peak Load
(Does not include < 100kW units)

Distribution Substations		662
Distribution Circuits		2,808
	1,876 @ 4.8kV	
	932 @ 13.2kV	
Distribution Circuit Miles		38,939
	20,184 @ 4.8kV	
	18,755 @ 13.2kV	
Subtransmission	2,664 @ 24 kV	
	797 @ 41.6kV	

DTE Energy's DG Commitment

" Several years ago, the leadership at DTE tried to envision what the electric utility business would look like in a decade. One of our conclusions was that this industry would go through the same transformation that the computer business has experienced. There, mainframe computers gave way to desktops which gave way to laptops.

In the electric industry, the day of large central station power plants has already given way to modular, combined cycle gas powered plants. We envisioned a day when the next step, distributed (or personal) generation would play a major role. In fact utilities may be among the first real-world, large scale users of distributed generation. Distributed generation will increasingly become a cost-effective alternative to the expansion and reinforcement of T&D infrastructure."

Anthony F. Earley, Jr.
Chairman & CEO, DTE Energy

DTE's Vision for Distributed Generation (DG)

DTE Energy

Traditional Electric System

Traditional Electric System
+
Personalized Power through Distributed Resources (DR)

Just another tool
a 3% solution

The Utility Today

- Many utilities' capital budgets are decreasing as their customer's expectations are increasing
- Utilities must balance the need for new distribution and caring for existing distribution
- We can't afford to solve every 1MVA problem with traditional T&D 30MVA solution
  - Problems that may only exist for a few hours per year
  - Capacity that may not be fully utilized for several years.
- DG is one way of delivering just-in-time and "right-sized" capacity to resolve smaller short falls while minimizing the initial capital outlay
- Freeing dollars for reliability and maintenance

What Have We Done

- We have installed DG as distribution solutions,
  - Internal to the distribution circuit.
  - At the substation.
  - In an island mode to perform maintenance.
- We are partnering with customers on overloaded circuits sharing the cost and the benefits of DG through a premium power rate.
- We have formally included DG analysis into our capital budget process as an alternative to traditional T&D solutions.
- We are using & developing tools, such as EPRI's distribution engineering workstation (DEW), to quantify the impacts of DG on the distribution system, particularly the protection concerns.

Detroit Edison's Distributed Resources Planning Group

DTE Energy

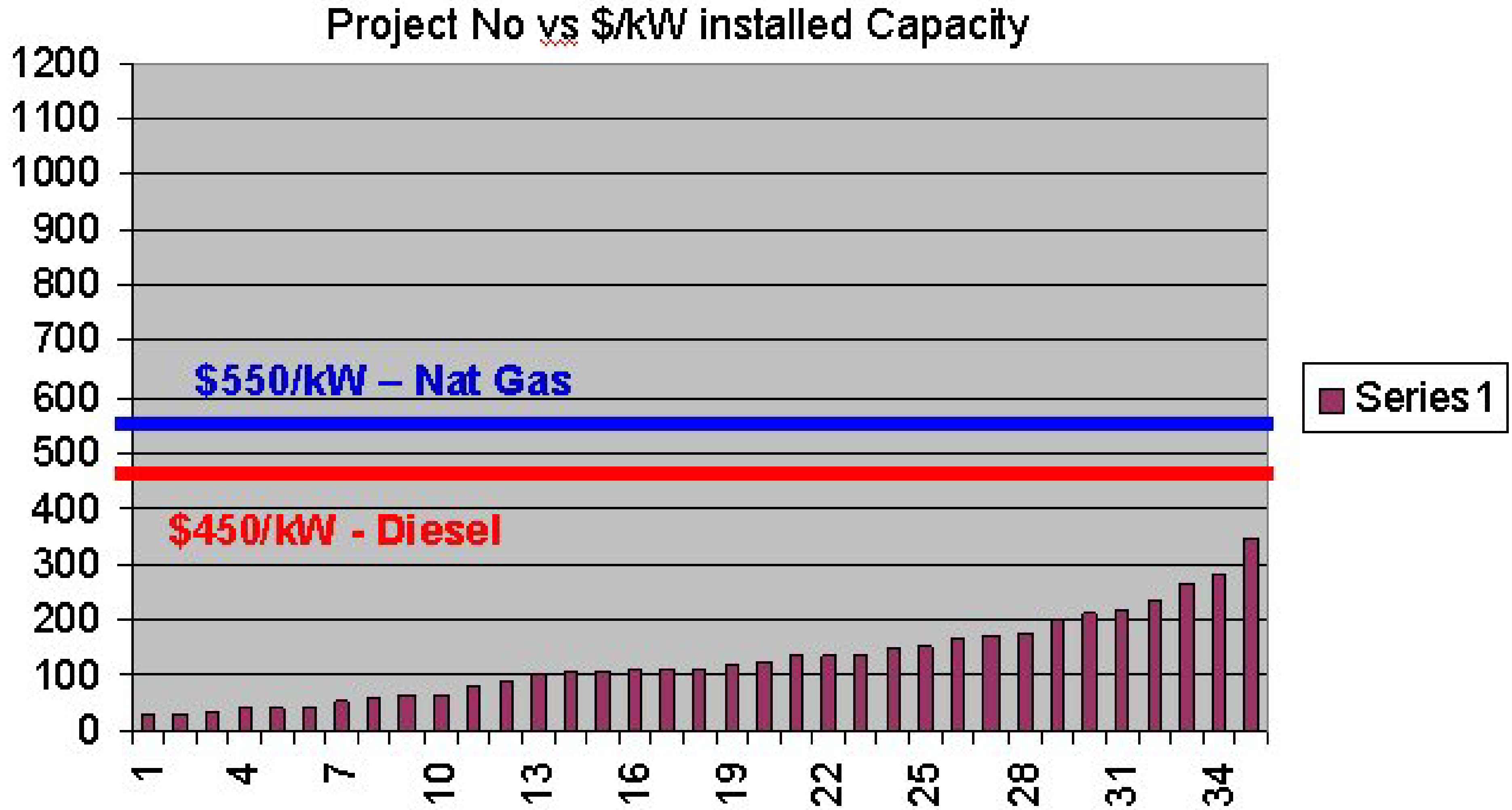
- Integrates distributed generation into the regulated electric utility's planning and operating processes
- Champions distributed generation integration into the utility
  - Distributed generation system design
  - Control and communication
  - Interconnection protection issues
  - Community relations
  - Manage utility distributed generation installations
  - Operations
- Facilitates communication between all groups who have a stake in distributed generation
- Identifies interconnection issues and develops procedures and solutions for interconnection

Bottom Line DG Messages

- DG is just another tool (like a capacitor) helps to solve some distribution problems but not a cure all - should be used if economically viable.
- Distribution DG is not generation for generation sake it is as an economic replacement for sticks, wires, & substation (its really distribution capacity).
- Project economics should consider:
  - The cost per criteria short fall ($/kW short fall).
  - Not just by cost per capacity added ($/kW capacity).
  - DG cost consequences of ‘do-nothing.’
- Distributed generation will never replace distribution in fact DG will only be viable a small percentage of time.

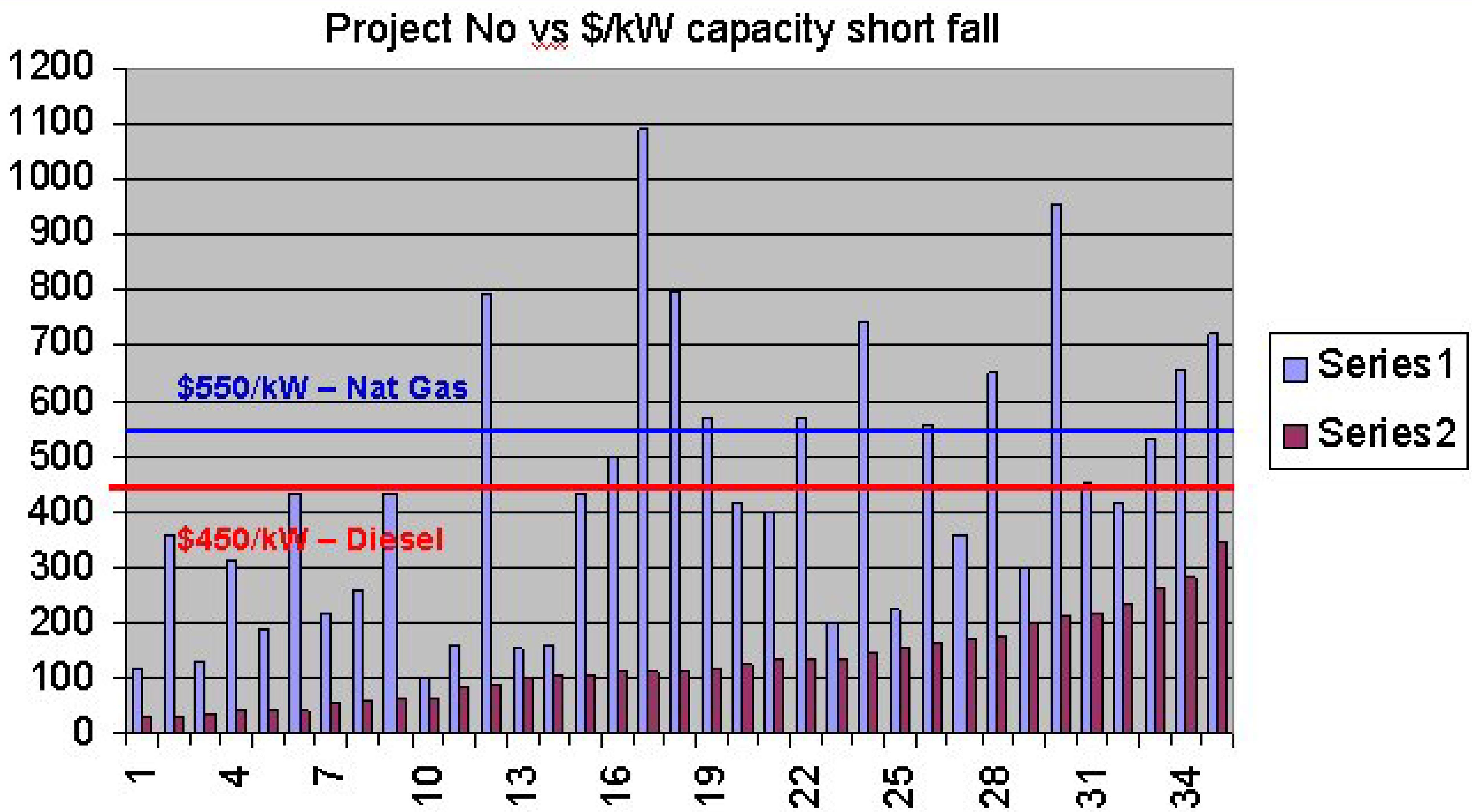
Initial Screening
DG Integration – 2003 Review
Project No vs Project Cost per kW

DTE Energy



Graph represents Overload and New Business Project Not Reliability Projects
The cost per kW for Reliability projects is typically very high.

Initial Screening
DG Integration – 2003 Review
Project No vs Project Cost per kW



Distributed Generation at DTE Energy

Technology Testing

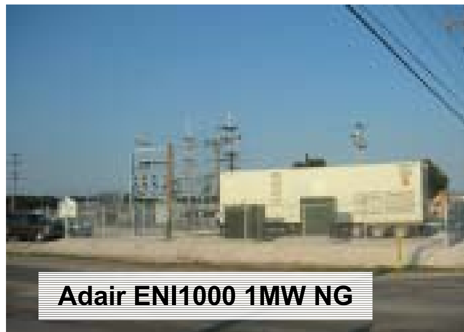

Southfield Solar & Future H Power Park

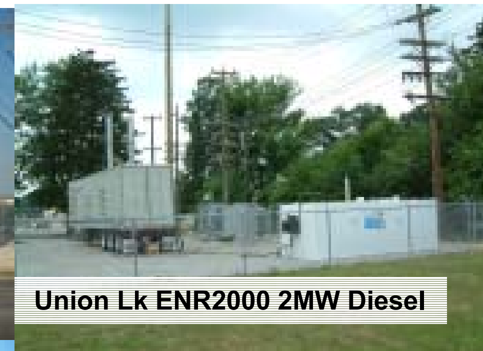

ZBB Flow Battery

Substation Battery Replacement Project

Substation Applications

Temporary & Maintenance


Adair ENI1000 1MW NG

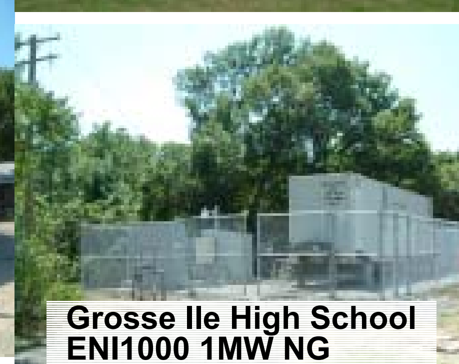

Union Lk ENR2000 2MW Diesel

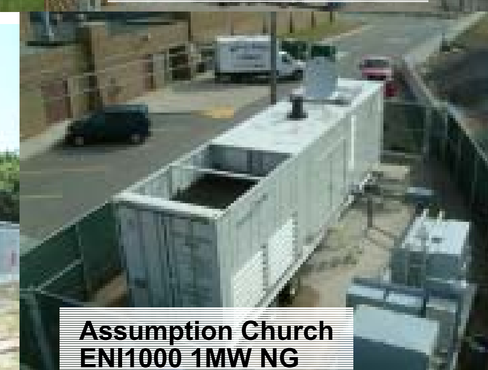

Substation Islanding ENR2000 2MW Diesel

Circuit Applications

Emergency & Temporary

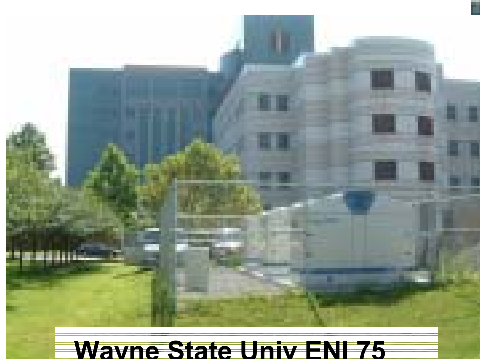

Emergency ENR2000 2MW Diesel

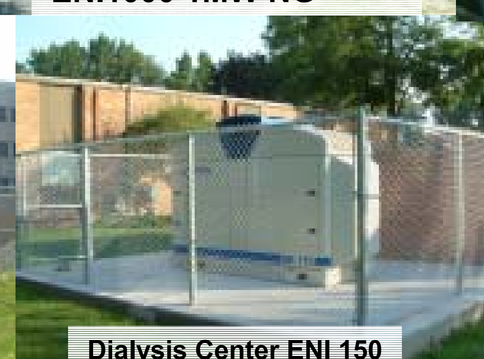

Grosse Ile High School ENI1000 1MW NG


Assumption Church ENI1000 1MW NG

Customer Partnership Applications

Premium Power


Wayne State Univ ENI 75


Dialysis Center ENI 150


Service Center ENI 150 & 75

Technology Demonstrations

Grid Connected Photo Voltaic Systems

SolarCurrents 1 in Ann Arbor 28.4 kW (1996)

SolarCurrents 2 in Southfield 26.0 kW (1997)

2004 Hydrogen Power Park site

Zinc Bromine Battery System

Advanced Battery Energy Storage System (ABESS) for grid supported application. 400 kWh (200 kVA) Zinc/Bromine flow battery - SANDIA National Lab

Project objective is to test battery system at two utility sites

Site 1 (Fall 2000) - Power quality & peak shaving at Akron

Site 2 (Summer-Fall 2001 & 2002) - Peak shaving at Lum

Fuel Cell for Battery Replacement in Substations

Demonstrate the application of Plug Power PEM fuel cell as a replacement for batteries. Next generation substation battery replacement fuel cell design.

Internal to Distribution Circuit

Collins – Previous Emergency Installation

An emergency installation of a 2MW DG ending daily circuit outages forced by overload. The $500K spent on an emergency generator and circuit work were roughly equivalent to annual charges for a one year delay of the $6.4M substation project.

Grosse Ile - Current Temporary Installation

A five year project offsetting eventual T&D expansion on the island. A $3.8M Grosse Ile Substation expansion project has be offered as part of the 2004 PVA. The DG installation cost is $800K.

St. Clair Shores – Current Temporary Installation

Land locked circuit in need of relief before the new Erin Substation is built. No other cost effective solution existed.

Wayne Circuit – In-Progress Temporary/Emergency Installation

To provide circuit relief due to delay in Zebra Project construction. No other cost effective solution to prevent rotating blackouts.

Substation Applications

Adair – Temporary Installation (No in time project solution available)

A traditional substation solution could not be completed in time. Costs were approximately breakeven. The substation budget cost was $800k, and DG project was $870k. The DGs installation allowed for the deferral of the substation project an additional year. Project completed.

Union Lake – Current Temporary Installation

Traditional Union Lake conversion project to relieve an emergency overload could not be completed before summer overload. The equivalent annual cost of the Union Lake conversion project as proposed was $137k ($1.7M over 60 years @ 8%). The equivalent annual cost of the interim DG solution was $61k ($600K over 20 years @ 8%). The DG will allow further deferral of the T&D project.

Quail – Previous Maintenance Installation

Saved 800 customers from having 2-10 hour outages in order to repair a 40kV feed damaged by a tornado.

Richville – Future Maintenance Installation

Same situation as Quail above damaged by a tornado

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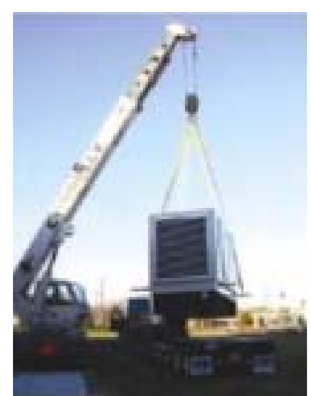
Premium Power – Utility Owns the Generation

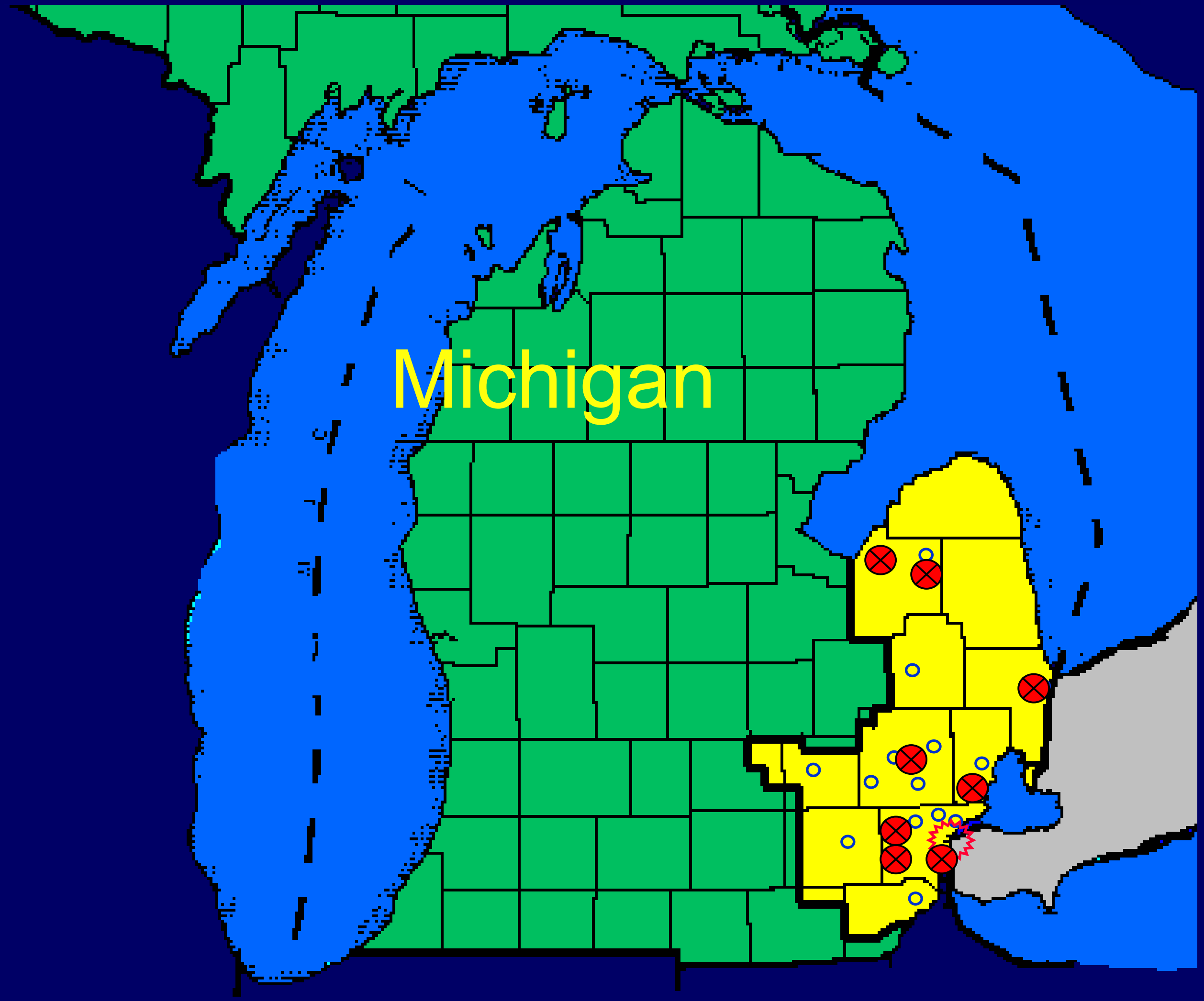
Glendale DC 561	150 kW Redford SC
Zachary DC 9400	375 kW WWSC
Tiknken DC 8850	300 kW Botsford Dialysis
Indian DC 1423	150 kW Beaumont Dialysis
Midtown DC 8317	225 kW Wayne State
Angola DC 8877	300 kW Lawrence Tech
Medina DC 8533	600 kW Adell Communication*
Sheldon DC 9508	750 kW Artic Cold Storage *

4,150 kW and more coming



ASC®
American Specialty Cars

Detroit Edison Service Territory Location of Distribution DG Solutions



Getting it done

- Site considerations
- Design
- Approval and Permitting
- Options and methods of Control
- Cost
- After Action Review

Siting

- At the Substation (We own the land)
- Remote from substation is the best
- Look for Larger Customers
- Have Access to 3-phase power
- Aesthetic Consideration (Obscure for both sight and sound)
- Available 55’ x 32’ footprint
- Churches, Schools, Airports, Water treatment, Governmental and Community properties, Municipal yards, larger industrial and commercial
- Have Access to Nat. Gas

Design - DG Connection Skid

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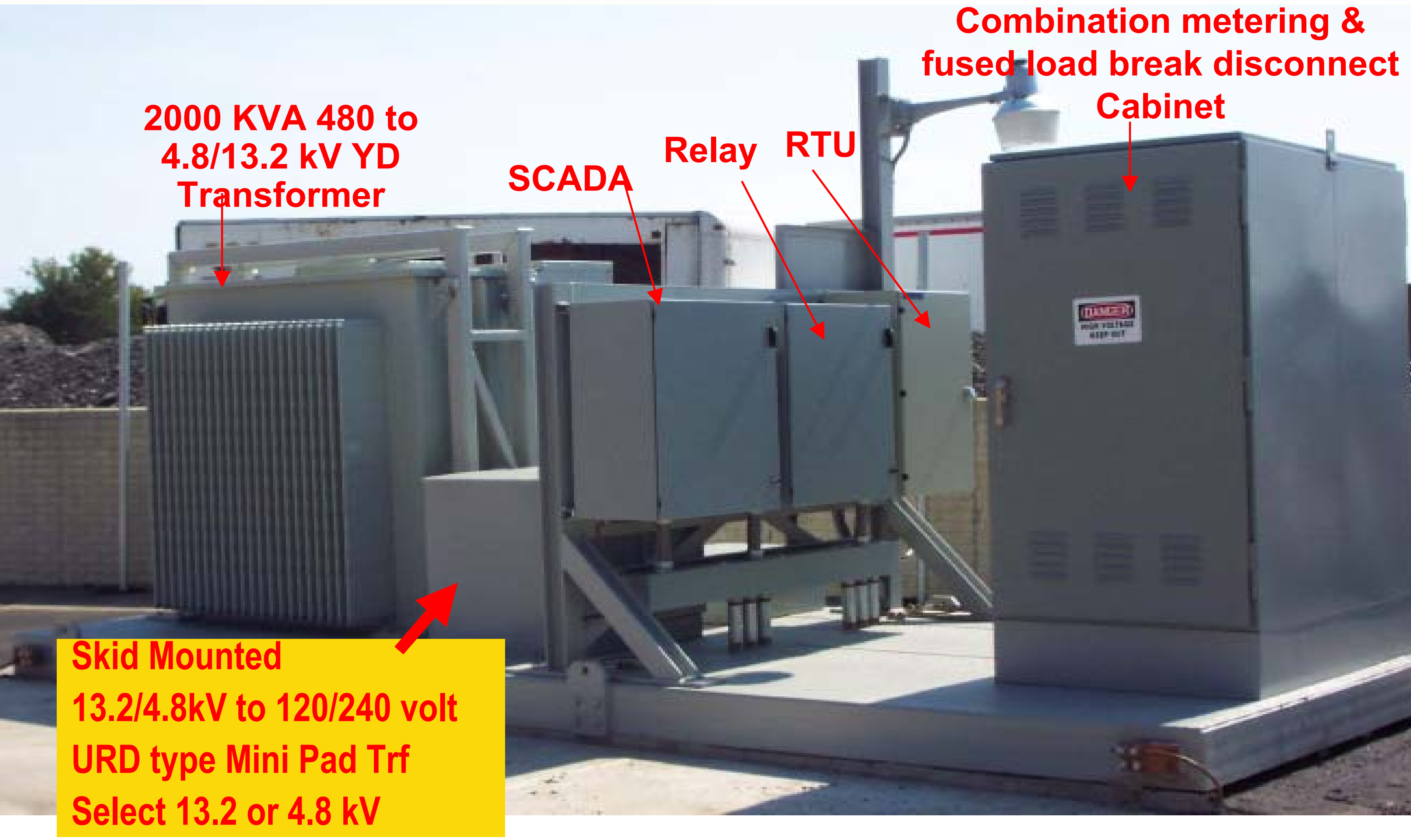

DG Connection Trailer - Dual Voltage, OH/UG Connection, Protection & Communication

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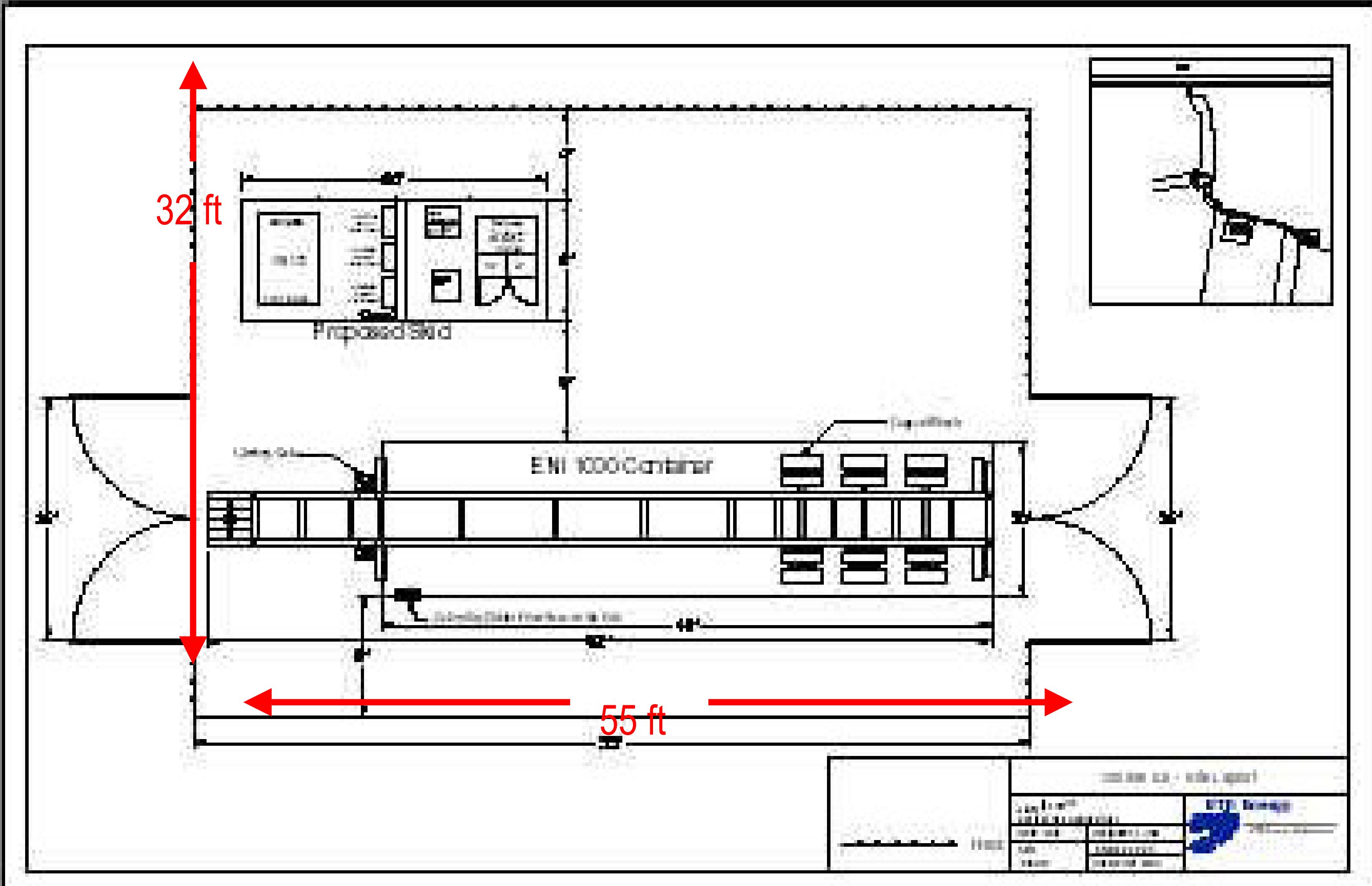
Typical DG Site Layout



Siting
&
Approval Process

"the sales presentation"

Grosse Ile School and Area

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Load Analysis for 2002 Summer

Date	Time	Hours	Day	High Temp (ºF)
7/1/2002	3pm - 9pm	6	Monday	95
7/2/2002	1pm - 10pm	9	Tuesday	96
7/3/2002	1pm - 9pm	8	Wednesday	97
7/4/2002	1pm - 7pm	6	Thursday	95
7/29/2002	3pm - 4pm	1	Monday	91
7/31/2002	3pm - 9pm	6	Wednesday	93
8/1/2002	1pm - 10pm	9	Thursday	92
	Total Hours	**45**	**Avg Temp**	**94.1**

The Lease

“The great enemy of clear language is insincerity. When there is a gap between one’s real and one’s declared aim, one turns, as it were instinctively, to long words and exhausted idioms, like a cuttlefish (octopus) squirting out ink”
George Orwell, “Politics and the English Language”

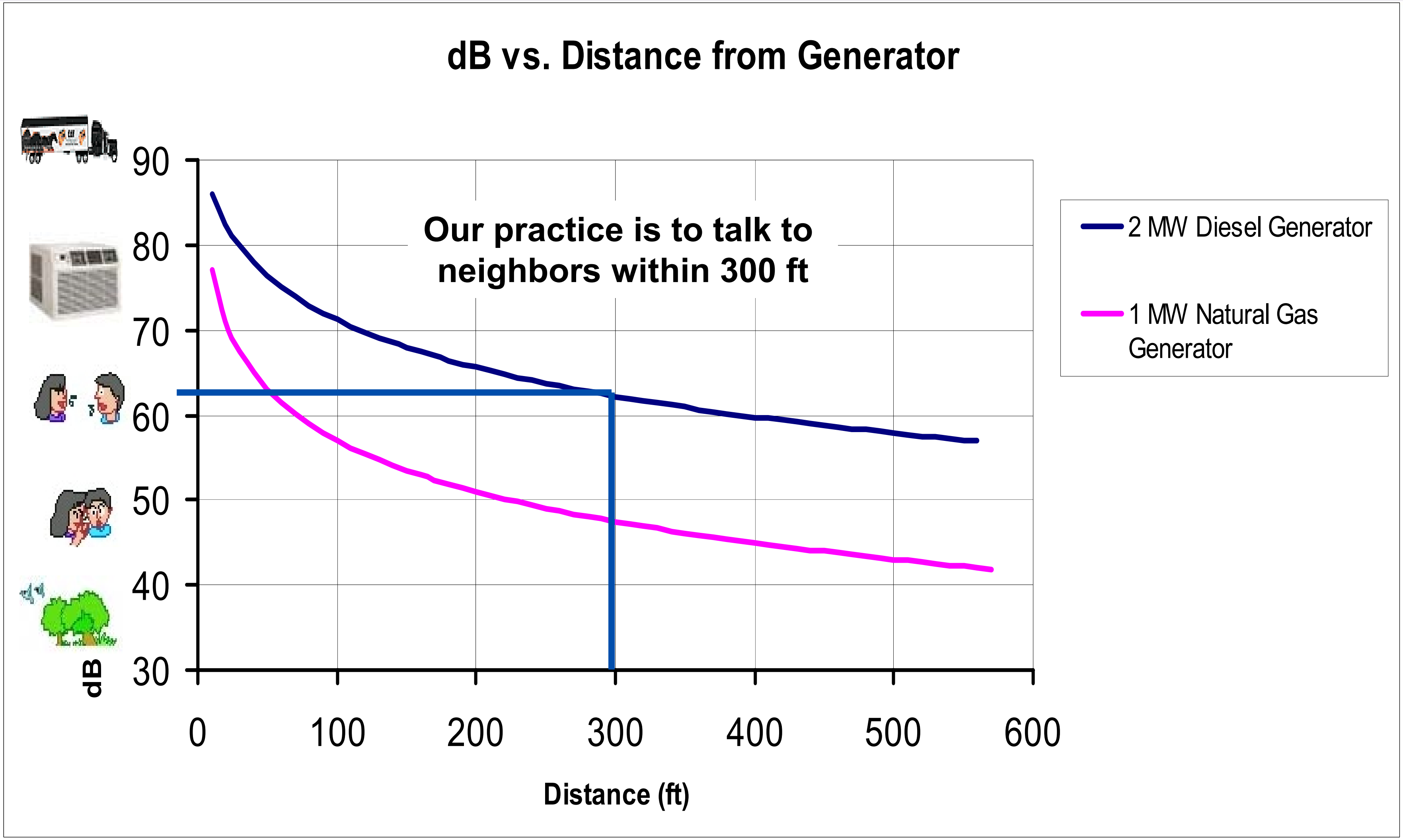
Keep it Simple

We have a 3 page lease

Permitting –Stress Emergency & Temporary

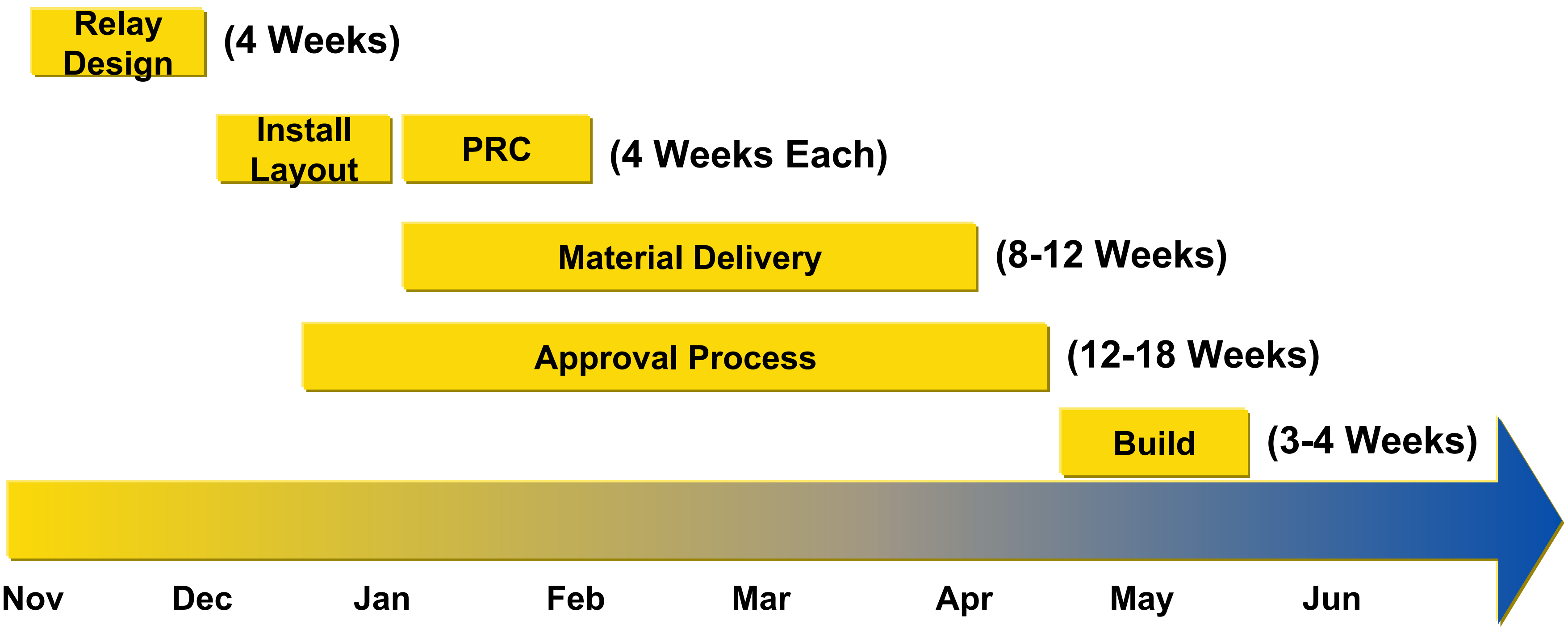
- Community Approval (Request administrative reviews on the basis that electricity is an essential service and the utility has a mandate to serve. Offer names of other community leaders were you have sited using this approach)
  - DECo Property inside existing fence
  - DECo Property not inside existing fence
  - Customer Property (Ask the customer to speak to the community)
- Noise
  - Local concern or responsible community
  - Industrial, commercial, residential
  - Nuisances clause
  - They don't know how or can't measure level
  - 55db night day 45 night time.
  - Noise decreases 6 db as you double the distance
  - ENI 1000 74 @ 7Meters - 55db @ 56 meters
- EMF Effects
  - Public perception and their inherent opposition
  - Same techniques as a substation lines etc.
- Environmental (Seeking special utility Status "Permit by rule")
  - Air Permit
  - Spill Prevention
  - Fire Prevention
  - Wet land evaluation

Noise – db vs. distance



Schedule

- **DG Project Timeline**



DG Checklist

- DG in commissioning sequence
- DG Pre-Start Checklist
- Distributed Generation Operational Running Log
- Department of Environmental Quality fuel delivery log (diesel)
- Generator & Skid Transportation Procedure
- Generator & Skid Winter Storage Procedure
- Distributed Generation Preventive Maintenance Matrix

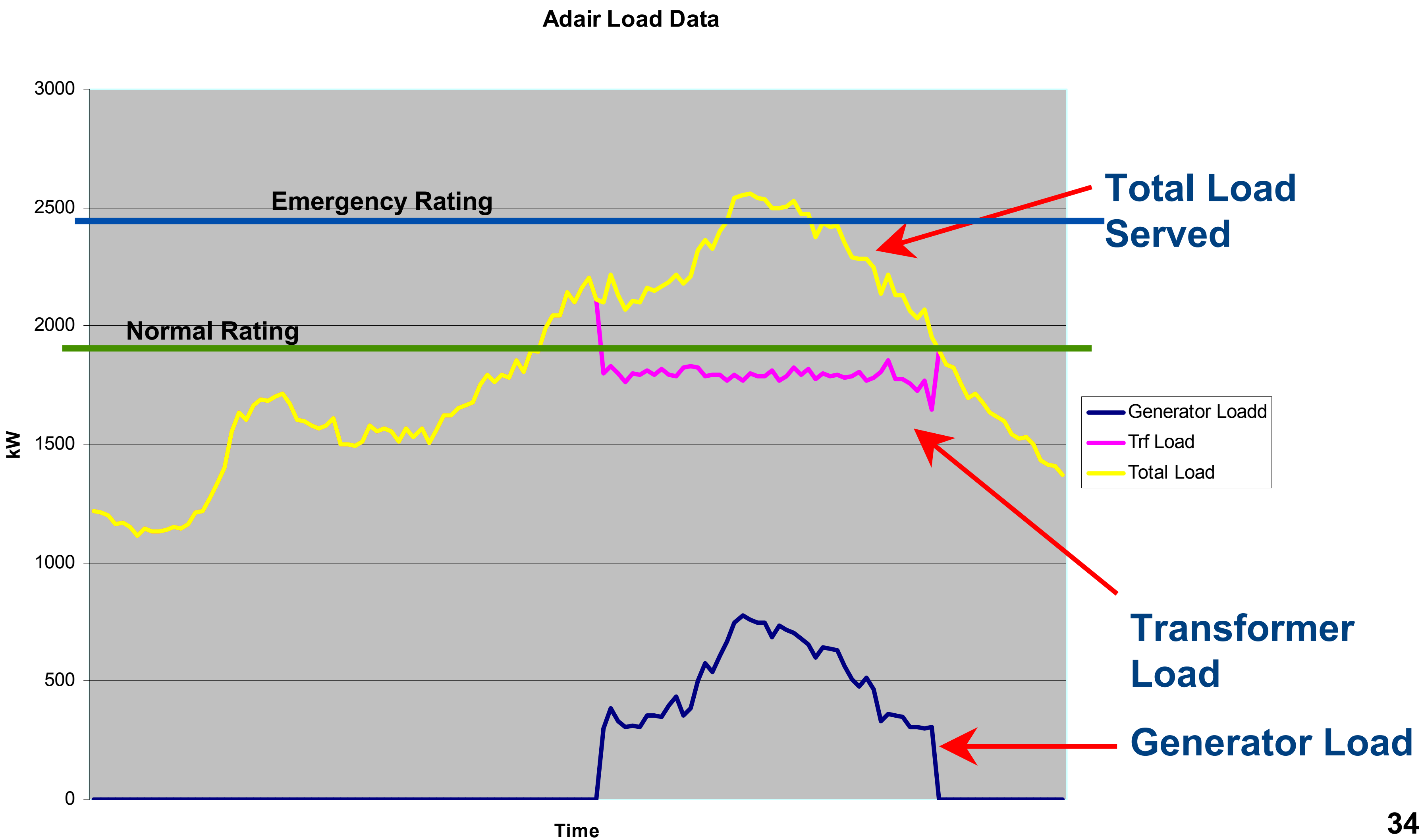
Operations – System Monitoring

- Communication Paths
  - Radio
  - Phone
  - Cell
  - Satellite
- We communicate with the Generator
  - Portable Meter (all Circuits via substation phone)
  - Hard Wire (Union Lake Substation – same ground mat)
  - Fiber (Adair Substation – different ground mat)
  - Radio (All SCADA to SOC&ROC)
  - Cell Phone (Generator parameters via d|tech)
  - Satellite (Generator parameters via d|tech)
  - Satellite of emergency generator (All SCADA to SOC&ROC)

Operations - Generator

- Control - On/Off
  - Manual Operating agent pushes button and sets output
  - Automated - ROC Operator request On & Off
    - On/Off fixed output
    - On/Off can order output to change in fixed increments
  - Automatic - No operator required
    - On/Off fixed output
    - On/Off load following
    - Temperature control
- Portable Meter installed for monitor & control input
- Monitor
  - Primary Alarms (shuts Generator down)
  - Minor Alarms (No shutdown but should check out)
  - Health Monitoring
  - Status and Data

Adair– Automatic Load Following



2003 DG Installations
Load Analysis –Managing the Load

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Location	Days Over Day-to-Day	Hours Above Emerg	Hours Above Day-to-Day	2003 % Summer Day-to-Day Without Generator	2003 % Summer Emergency Without Generator	2003 % Summer Day-to-Day With Generator	2003 % Summer Emergency With Generator
Adair Transformer 1	27	7	182	128%	98%	100%	77%
Grosse Ile DC 2841	7	0	45	111%	96%	89%	77%
Shores DC 1770	7	0	21.5	122%	109%	97%	87%
Union Lake DC 1688	26	7	265	143%	114%	104%	83%

What is an After Action Review?

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An AAR is a “real time” vehicle for organized reflection and action.

- Think of it as a “learning practice” rather than just a tool.

The Four Questions

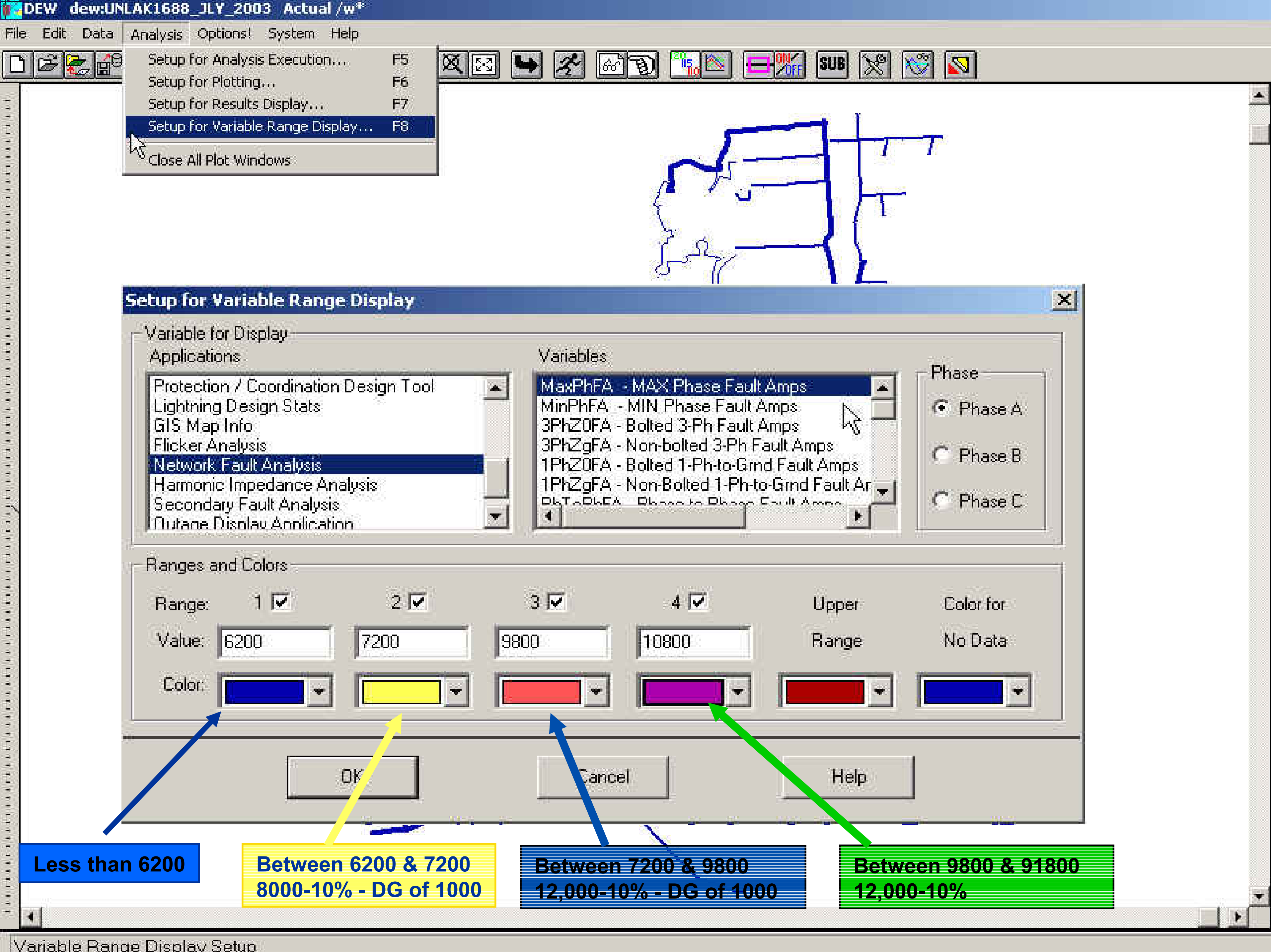
1. What was intended to happen?
2. What actually happened and why?
3. What can we learn?
4. What can we do to make it better?

Planning - Studies

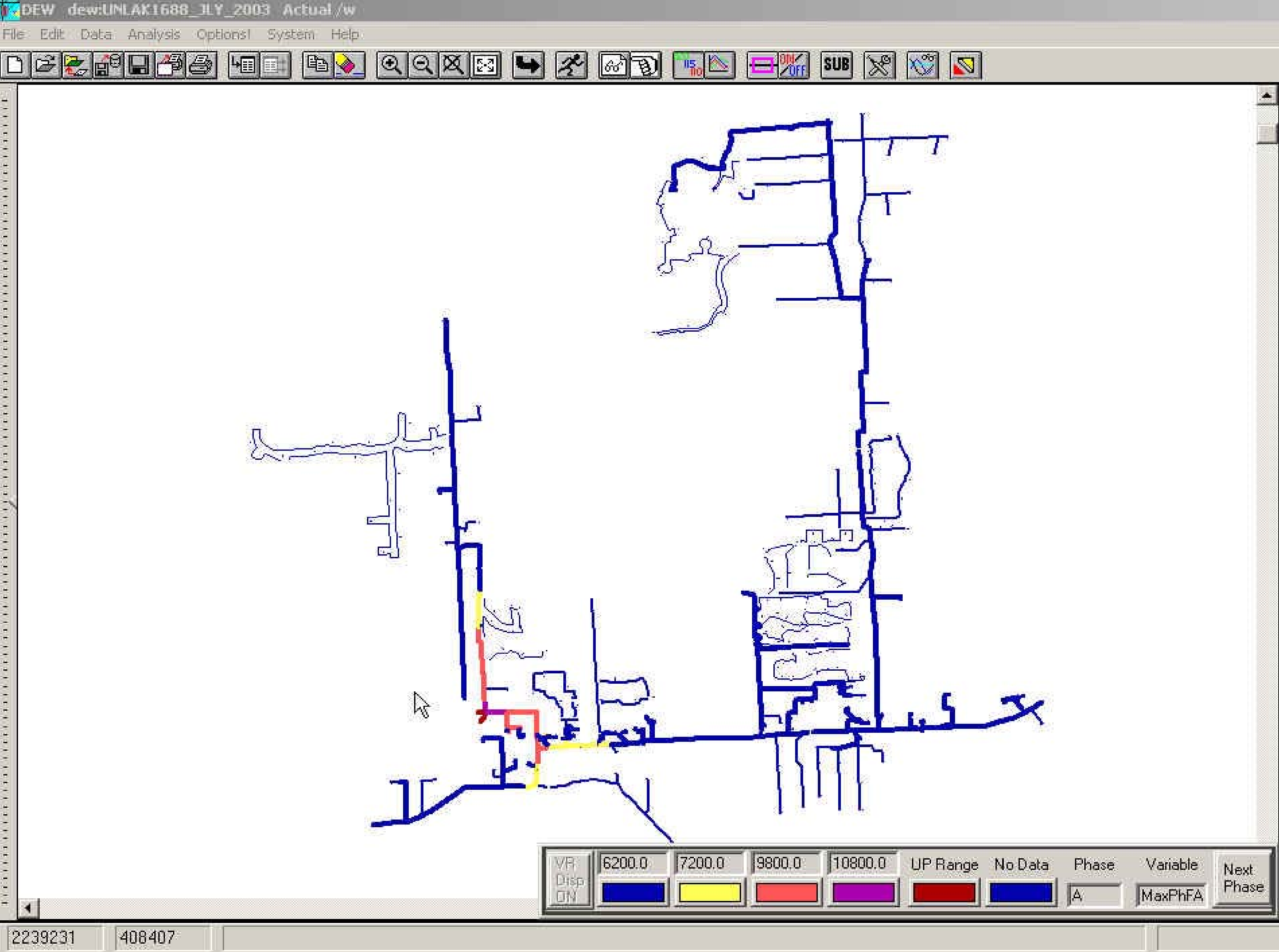
- Distribution Planning Studies
  - Power Flow Studies quantifying overload and voltage effects before and after DR
  - Determine the impacts of DG on the distribution system
    - High voltage
    - Capacitors
    - Light load
    - Unidirectional regulators
- Protection
  - Islanding – If potential island load is 3 or 4 times DR capacity this will allow margin for o/u voltage and freq to operate without transfer trip
  - Sensitivity
    - Determine min fault levels for trip setting
    - Determine max fault levels for equipment interrupting ratings
  - Selectivity - Determine coordination problems

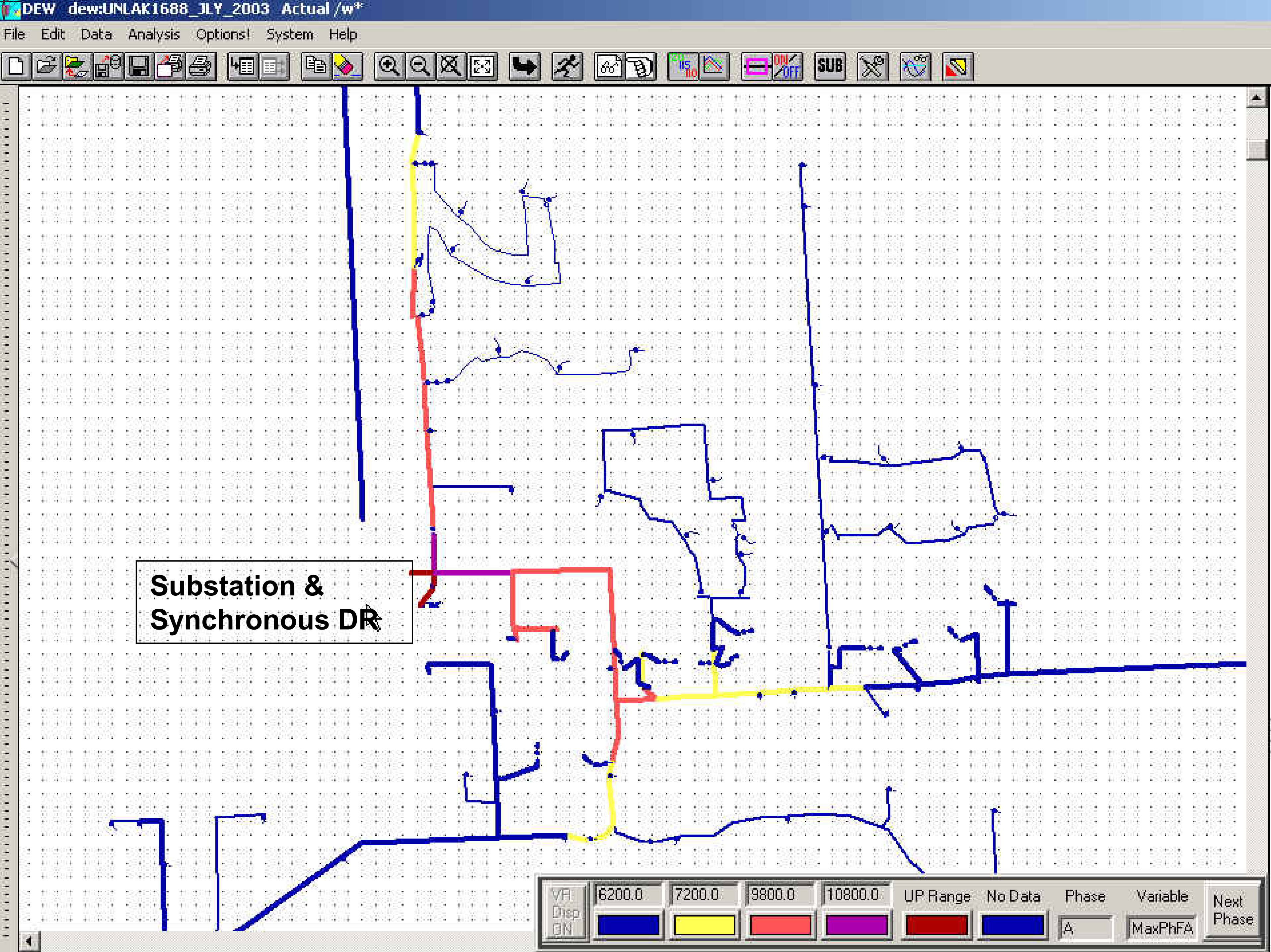
DEW Modeling and Analysis

- DEW is a graphical analysis tool used to model distribution electrical systems
- DEW is used to
  - Identifying locations for DR
  - Quantify impact of DR's on the distribution system
  - Model cogen, induction, inverter and synchronous generators
  - Perform planning engineering analysis
    - Load analysis
    - Voltage studies
    - Harmonic Analysis
  - Perform multiple source fault analysis
    - Fault studies
    - Protection coordination
    - Time varying analysis



DEW dew:UNLAK1688_JLY_2003 Actual /w*
File Edit Data Analysis Options! System Help
Setup for Analysis Execution... F5
Setup for Plotting... F6
Setup for Results Display... F7
Setup for Variable Range Display... F8
Close All Plot Windows
Setup for Variable Range Display
Variable for Display
Applications
Protection / Coordination Design Tool
Lightning Design Stats
GIS Map Info
Flicker Analysis
Network Fault Analysis
Harmonic Impedance Analysis
Secondary Fault Analysis
Variables
MaxPhFA - MAX Phase Fault Amps
MinPhFA - MIN Phase Fault Amps
3PhZ0FA - Bolted 3-Ph Fault Amps
3PhZgFA - Non-bolted 3-Ph Fault Amps
1PhZ0FA - Bolted 1-Ph-to-Grnd Fault Amps
Phase
Phase A
Phase B
Phase C
Ranges and Colors
Range: 1 2 3 4
Upper Range
Color for No Data
Value: 6200 7200 9800 10800
Color:
OK
Cancel
Help
Less than 6200
Between 6200 & 7200
8000-10% - DG of 1000
Between 7200 & 9800
12,000-10% - DG of 1000
Between 9800 & 91800
12,000-10%
Variable Range Display Setup


DEW dew:UNLAK1688_JLY_2003 Actual /w
File Edit Data Analysis Options! System Help
SUB
VR Disp ON
6200.0
7200.0
9800.0
10800.0
UP Range
No Data
Phase
A
Variable
MaxPhFA
Next Phase
2239231
408407


DEW dew:UNLAK1688_JLY_2003 Actual /w*
File Edit Data Analysis Options! System Help
SUB
Substation &
Synchronous DR
VR Disp ON
6200.0
7200.0
9800.0
10800.0
UP Range
No Data
Phase
A
Variable
MaxPhFA
Next Phase

Protection Issue: Nuisance Fuse Blowing

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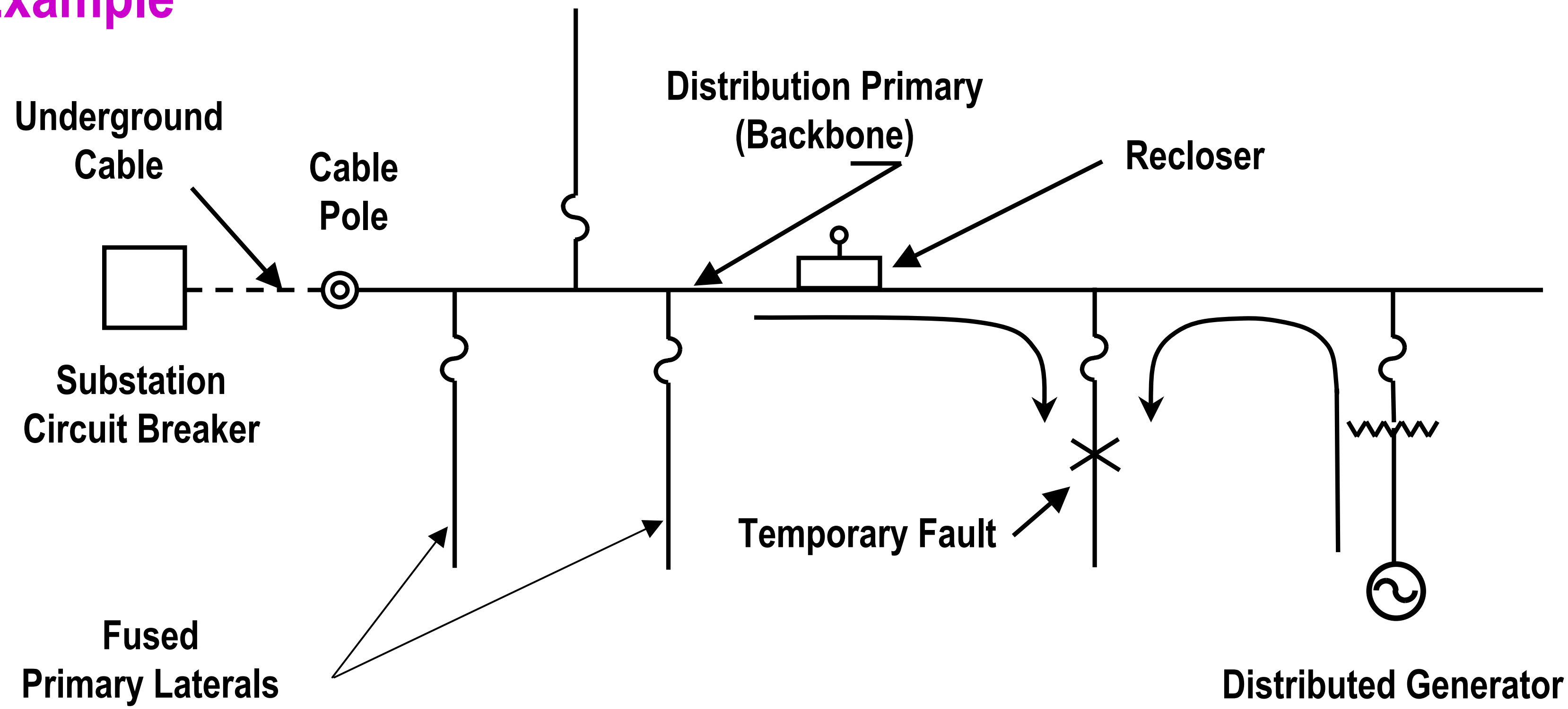
Example



For various fault current levels, fuse sizes, recloser sizes and breaker trip currents determine limits of DR penetration to cause inselectivity

Synchronous Generator Fault Characteristics

- Subtransient reactance X” T”
- Transient reactance X’ T’
- Synchronous reactance

- Fault Current is typically 5 times load current

- Synchronous generators are usually the biggest concern of protection studies

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DEW Modeling and Analysis
Synchronous Generator Faults

Generator Short Circuit Current

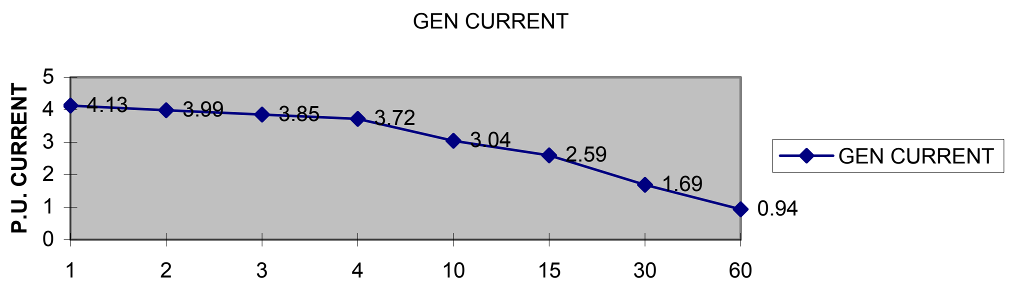
$$I_t=(I''-I')*e^{-t/T''}+(I'-I)*e^{-t/T'}+I$$

select object then use format/object/superscript to edit

Colorado Cicuit Study for IOG

Enter Subtransient, transient and synchronous reactance and time constants in box

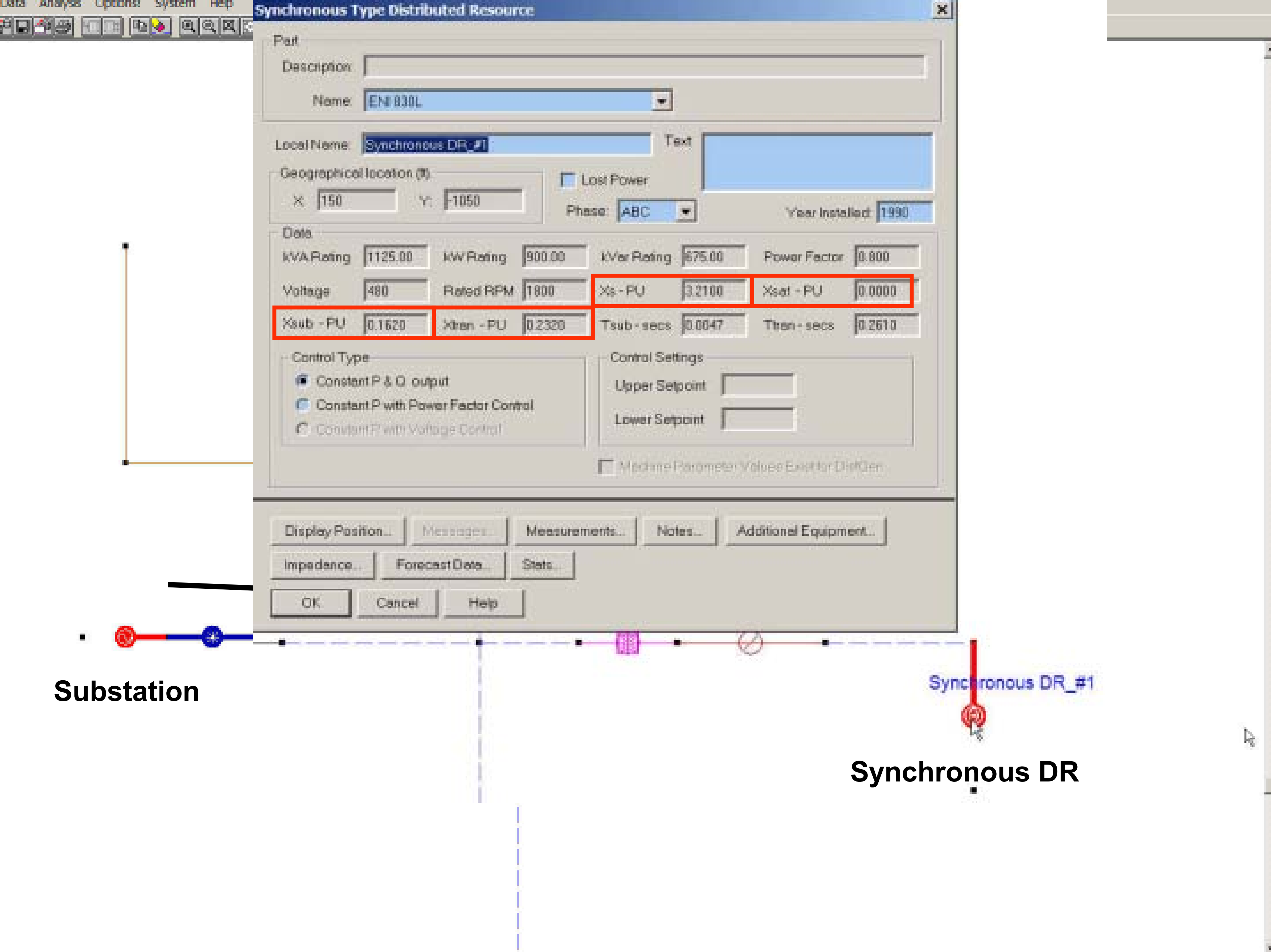
T"	0.00239
T'	0.405
X"	0.158
X'	0.234
X	1.59
E	1
I"=E/X"	6.32911392
I'=E/X'	4.27350427
I=E/X	0.62893082



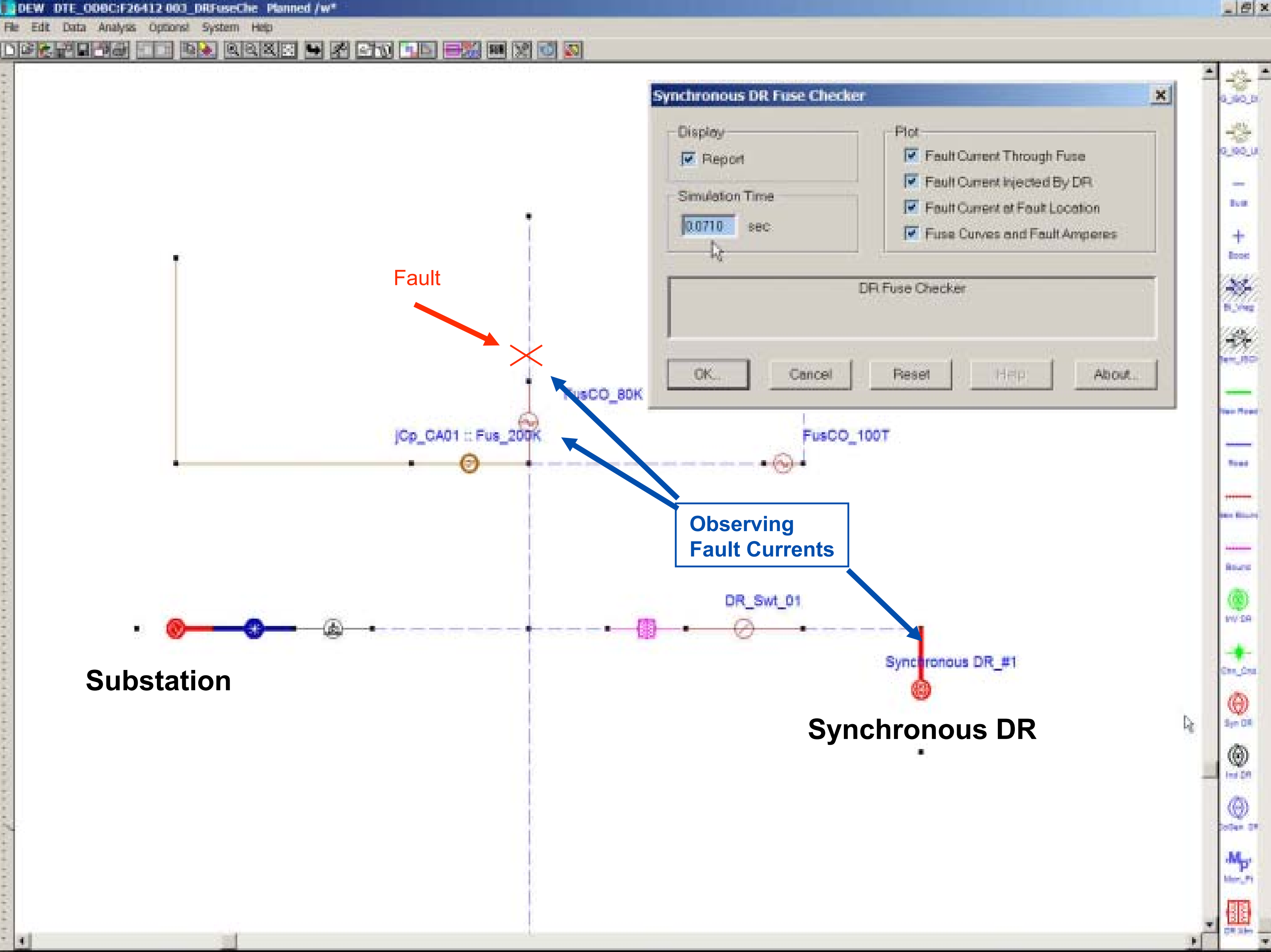
Enter the time in cycles you want the current plotted at

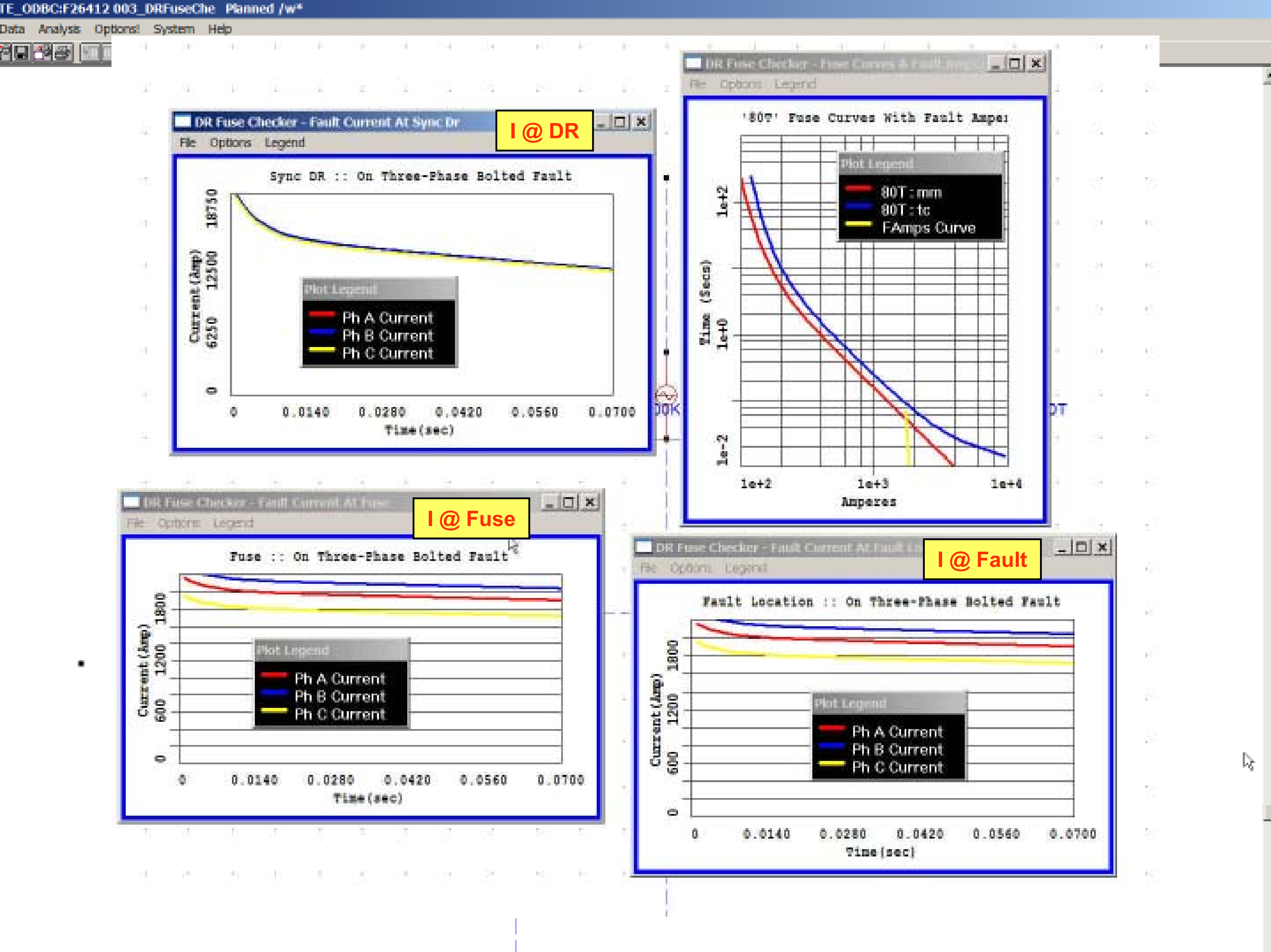
cycles		1	2	3	4	10	15	30	60
I(t)		4.128507	3.985582	3.850264	3.720403	3.044076	2.594967	1.689493	0.937552
EQUIVALENT X (1/I(t)		0.242218	0.250904	0.259722	0.268788	0.328507	0.385361	0.591893	1.066607
time/cycl	1/60	0.016667	0.033333	0.05	0.066667	0.166667	0.25	0.5	1

Key points:
- **Transient reactance is used for most relay studies**
- **The transient time constant falls in the range of most protective equipment**
- **However for extended fault periods, the study is complicated by the changing value of current - - relay and fuse characteristics assume a steady value of current**

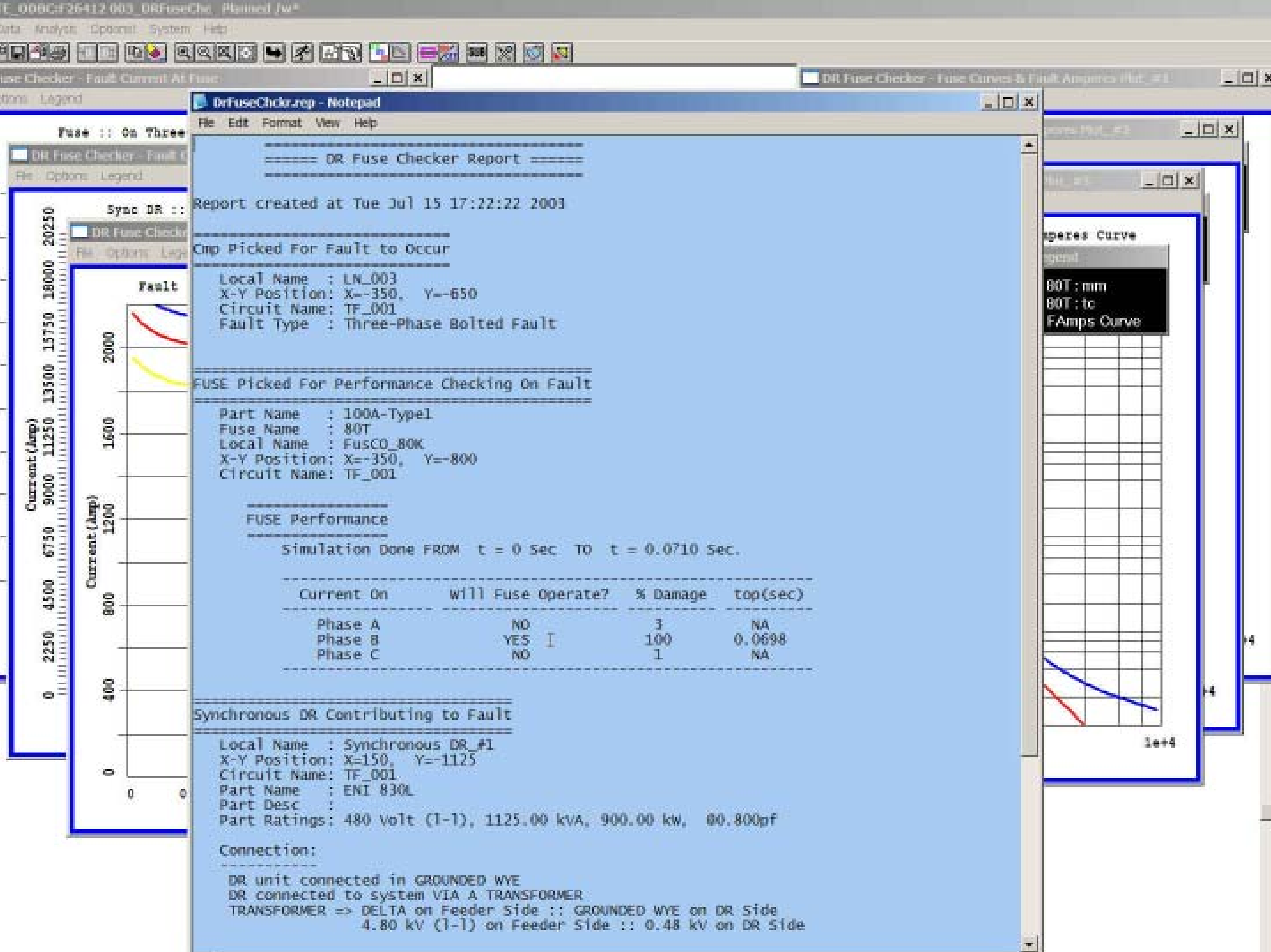


Synchronous Type Distributed Resource
Part
Description:
Name: ENI 830L
Local Name: Synchronous DR_#1
Text
Geographical location (ft)
X: 150
Y: -1050
Lost Power
Phase: ABC
Year Installed: 1990
Data
kVA Rating 1125.00
kW Rating 900.00
kVar Rating 675.00
Power Factor 0.800
Voltage 480
Rated RPM 1800
Xs - PU 3.2100
Xsat - PU 0.0000
Xsub - PU 0.1620
Xtran - PU 0.2320
Tsub - secs 0.0047
Ttran - secs 0.2610
Control Type
Constant P & Q output
Constant P with Power Factor Control
Constant P with Voltage Control
Control Settings
Upper Setpoint
Lower Setpoint
Display Position...
Messages...
Measurements...
Notes...
Additional Equipment...
Impedance...
Forecast Data...
Stats...
OK
Cancel
Help
Synchronous DR_#1
Substation
Synchronous DR


DEW DTE_ODBC:F26412 003_DRFuseChe Planned /w*
File Edit Data Analysis Options System Help
Synchronous DR Fuse Checker
Display
Report
Simulation Time
0.0710
sec
Plot
Fault Current Through Fuse
Fault Current Injected By DR
Fault Current at Fault Location
Fuse Curves and Fault Amperes
DR Fuse Checker
OK
Cancel
Reset
Help
About...
Fault
FusCO_80K
jCp_CA01 :: Fus_200K
FusCO_100T
Observing
Fault Currents
DR_Swt_01
Synchronous DR_#1
Substation
Synchronous DR



Data Analysis Options! System Help
DR Fuse Checker - Fault Current At Sync Dr
I @ DR
File Options Legend
Sync DR :: On Three-Phase Bolted Fault
Current (Amp)
0
6250
12500
18750
0 0.0140 0.0280 0.0420 0.0560 0.0700
Time(sec)
Plot Legend
Ph A Current
Ph B Current
Ph C Current
File Options Legend
'80T' Fuse Curves With Fault Ampe
Plot Legend
80T : mm
80T : tc
FAmps Curve
Time (Secs)
1e-2
1e+0
1e+2
1e+2 1e+3 1e+4
Amperes
I @ Fuse
File Options Legend
Fuse :: On Three-Phase Bolted Fault
Current (Amp)
0
600
1200
1800
0 0.0140 0.0280 0.0420 0.0560 0.0700
Time(sec)
Plot Legend
Ph A Current
Ph B Current
Ph C Current
I @ Fault
File Options Legend
Fault Location :: On Three-Phase Bolted Fault
Current (Amp)
0
600
1200
1800
0 0.0140 0.0280 0.0420 0.0560 0.0700
Time(sec)
Plot Legend
Ph A Current
Ph B Current
Ph C Current



```
             ====================================
             ====== DR Fuse Checker Report ======
             ====================================

Report created at Tue Jul 15 17:22:22 2003

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Cmp Picked For Fault to Occur
-----------------------------
   Local Name  : LN_003
   X-Y Position: X=-350,  Y=-650
   Circuit Name: TF_001
   Fault Type  : Three-Phase Bolted Fault


============================================
FUSE Picked For Performance Checking On Fault
============================================
   Part Name    : 100A-Type1
   Fuse Name    : 80T
   Local Name   : FusCO_80K
   X-Y Position: X=-350,  Y=-800
   Circuit Name: TF_001

      ================
      FUSE Performance
      ================
          Simulation Done FROM  t = 0 Sec  TO  t = 0.0710 Sec.

          ------------------------------------------------------------
            Current On       Will Fuse Operate?   % Damage   top(sec)
          ----------------  -------------------  ---------  ----------
              Phase A               NO              3          NA
              Phase B               YES             100        0.0698
              Phase C               NO              1          NA
          ------------------------------------------------------------

====================================
Synchronous DR Contributing to Fault
====================================
   Local Name  : Synchronous DR_#1
   X-Y Position: X=150,  Y=-1125
   Circuit Name: TF_001
   Part Name   : ENI 830L
   Part Desc   :
   Part Ratings: 480 Volt (l-l), 1125.00 kVA, 900.00 kW,  80.800pf

   Connection:
   -----------
    DR unit connected in GROUNDED WYE
    DR connected to system VIA A TRANSFORMER
    TRANSFORMER => DELTA on Feeder Side :: GROUNDED WYE on DR Side
                  4.80 kV (l-l) on Feeder Side :: 0.48 kV on DR Side
```

DTE Energy

Detroit Edison
Advanced Communication & Control of Distributed Energy Resources

Integrating into DEW Real-time

Circuit measurements
DER status
DER control

energy.gov
U.S. DEPARTMENT OF ENERGY

DTE Energy
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DTE Energy
DTE Technology

SISCO

OSIsoft

EDD

Future

- DTE's DOE Aggregation Communication and Control
- Designing/Testing method of transfer trip using radio
- Testing of Island detection at Maintenance installations
- Generator installation for Reliability
- Integrate closed transitioning into our current design
- DG and Connection on 1 trailer pre-wired (1.5 MW blended fuel Nat gas & Diesel)
- Design and build a no fence generator connection system (portable)
- EPRI DG Best Practices for Integration of DER into Utility System planning and Operation

Summary

- DG is being installed
  - To support the distribution system
  - To partner with customers
- DG is one way of delivering just-in-time and “right-sized” capacity to resolve capacity short fall while minimizing the initial capital outlay
- DG is just another tool in the distribution engineers tool kit to resolve distribution and customer problems
- DEW is our interconnection tool of choice