Phase II Final Report for DE-FC02-04CH11234

Cooperative Research and Development
for
Advanced Communication and Control Solutions of Distributed Energy Resources (DER)

This report documents Phase II result for the Detroit Edison (Utility) led team, which also includes: DTE Energy Technologies (Aggregator), Electrical Distribution Design (Virginia Tech company supporting Distribution Engineering Workstation); Systems Integration Specialists Company (economic scheduling and real-time protocol integrator); and OSIsoft (software system for managing real-time information).

Citations

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SUMMARY

Our team completed its Phase II commitments by increasing the number of DERs and selling them into the Midwest Independent System Operator (MISO) Market. It was not easy but we aggregated, communicated controlled, registered various DERs with MISO, and sold them into the market as Demand Response. It seems to be a very cumbersome process in need of standards. We were the first to ever attempt sale into the MISO market and as a result it was perhaps more difficult for that reason, but we all learned along the way.

Among the challenges was getting the attention and convincing others such as MISO, the generation folks and the wires folks that 20 plus DER totaling 16 MW was worth the effort (Detroit Edison is a 12,000 MW utility and MISO much more).

It appeared that those DER which were satisfying distribution constraints were taken more seriously particularly by the wires folks. Sale of the DERs from a utility perspective is seen as primarily a benefit for generation reserve margin, load control and wires benefits. There seems to be less interest in our utility with DER for sale into the market**.** One should understand the generation prices are well below the minimum operational cost of typical standby diesel and natural gas units. In fact, a review of the MISO day-ahead hour by hour pricing revealed that there was only 9 days for a total of 51 hours in the past year (2005) that exceeded the DER day-ahead minimum price and last summer was the hottest summer in recorded history for the Detroit area.

At the end of this project utility recognition was achieved and our 16 MW although no longer sold into the MISO market, will be held back by our Merchant Operations Center (MOC) and used for reserve margin and load control. In this way it will be used to reduce top of stack pricing. The DR SOC monitoring and control via ICCP and PI Process Book work will be left for the Detroit Edison (DECo) SOC's benefit to be used for both monitoring and interoperable control.

The infrastructure developed by DR SOC is still in place to aggregate other such DER in the future. In fact, the Michigan Public Service Commission's Capacity Needs Forum Report has suggested that new generation is needed in the 2009 to 2011 time frame. This project has demonstrated how existing known generation can be aggregated and brought to the market. The mechanism created for this project may be a means of bridging the generation shortfall gap until a new plant or plants can be completed.

The Distribution Engineering Workstation (DEW) our power flow modeling system used in this project is a licensed freeware using open architecture database. All functionally developed in this project will be included and available within the DEW freeware. See EDD's Web site for more information: www.edd-us.com

Phase II Accomplishments

Relocated, installed, upgraded and tested a PI to PI Link between Detroit Edison (DECo) Systems Operation Center (SOC) and Detroit Edison Regional Operations Center (DECo ROC) making SCADA data available for both monitoring and control for use in this DoE project without impacting normal EMS/DMS operations.

Installed and tested an ICCP link with SSL (security) between DECo, the utility, and DTE Energy Technologies (DTECH), the aggregator, making DER data available to the utility for both monitoring and control.

Installed and tested an ICCP link with VPN (security) between DR SOC and Detroit Edison Merchant Operation Center (MOC, bids utility generation into the MISO market).

Installed and tested PI process book with circuit & DER operational models for DECo SOC/ROC operator's use for monitoring of both utility circuit and customer DER parameters. The PI Process Book models also included DER control for the DECo SOC/ROC operators, which was tested and demonstrated control.

The DER Tagging and Operating Procedures were developed, which allowed that control to be done in a safe manner, were modified for required MOC/MISO notification procedures.

During the course of Phase I start and stop control using the ICCP link was demonstrated. During Phase II analog control through the ICCP Link was accomplished.

Electronic Tagging System – Field and server sided procedures are currently used for safety concerns. The integration of an electronic tagging system was demonstrated with the use of procedures and interoperable control through the ICCP Link.

The Distribution Engineering Workstation (DEW) was further modified from its Phase I real-time calculations to include temperature normalized load research statistics, using a 30 hour day-ahead weather feed. This allowed day-ahead forecasting of not only the customer load profile, but also provided for the entire circuit and its overload and low voltage problems. This forecast at the point of common coupling was passed to DTech DR SOC for use in their economic dispatch algorithm.

The DER analysis program developed and tested in Phase I was modified to work with a newly developed contingency analysis program and reconfiguration for restoration programs. This suite of nested analysis programs will make DER operational suggestions both in a planning and real-time modes.

A Point of Common Coupling symbol and methodology was developed to help organize Phase II Demand Resources into their operation categories. This facilitated not only the electrical connectivity of the resource at the PCC, but enabled day-ahead forecasting for available demand response calculations.

Standard Work Instructions were developed for DER notification, sale, and operation into the MISO market.

A software mechanism consisting of a suite of new and revised functionality was developed that integrated with the local ISO such that offers could be made electronically without human intervention.

A suite of software was developed by DR SOC enabling DER usage in real time and day-ahead:

Generation information file exchange with PI and the utility power flow
A utility day-ahead information file
Energy Offer Web Service
Market Result Web Service
Real-Time Meter Data Web Service
Real-Time Notification Web Service

DTech DTA economic scheduling program was modified for utility inputs, point of common coupling estimating, LMP forecasting and MISO market offer.

Registered over 20 DER with the MISO in Demand Response Market.

Electronically completed the sale of DERs into the MISO Demand Response Market.

Progress Demonstrated

This project extended the remote control and monitoring of distributed generation beyond what had been previously seen. Some of the key new items demonstrated with actual systems and field equipment are listed below:

- ICCP Link Reduces Complexity – The ICCP link allowed DECo to integrate distributed generation without having to manage the extreme complexities and diversity of control and monitoring technology. This simplified the integration of distributed generation and allowed many more types of devices to be installed.
- Operating Procedures – The developed procedures were the most extensive procedures for the coordinated operation by a utility and a distributed generation system provider.
- Control Strategy – A new control strategy was developed for this project to meet the unique needs of operating with multiple parties.
- New Equipment Integration – This project allowed several new types of equipment to be integrated with the systems. The solar cell and battery system were the primary examples of this feature.
- The ability to aggregate communicate and control DERs for the benefit of both customer and utility.
- Day-ahead forecasting for circuit conditions, and DER usage, and availability using circuit measurements and temperature load research statistics.

- Sell into the market electronically without human intervention.

Extension

While tremendous progress was made in the control and monitoring of distributed generation, the project schedule and resources limited the work that was planned. The next steps for extending the work are listed below:

- Integrated Utility Interfaces – At the DECo SOC/ROC, there are presently numerous systems with which operators have to interact. Integration could make the system easier to use. Also, control requires user interaction. A more integrated system would allow the system to operate without operator involvement. Currently this is done on DERs installed as Distribution Solutions using DR SOC load flowing. Interoperable control has been tested and demonstrated. The next step, DEW suggestion could be used as the control input and the only operator involvement would be if this did not work correctly or the system were put in an abnormal condition e.g. shutdown or outage. DR SOC crated a mechanism to allow Interoperable control. This control mechanism could have been activated by DEW suggested values.
- Develop standard ICCP naming conventions for utility, DER owners, aggregators, and ISOs.
- Integrate ISO real time notification into dispatch control.
- Automate the must run price point or get ISO to change must run for individual DER within an aggregate zone.
- Seamless switching between modes of operation e.g. standby-voltage control load following and parallel to gird sell back including dynamic generation control.

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TECHNICAL DISCUSSION

The technical discussion will be organized into three major headings **INTRODUCTION**, **PHASE II WORK COMPLETED**, and **OBSERVATIONS & LESSONS LEARNED**.

The first section is **INTRODUCTION**, which will include the sections: **Project Objective and Background and Vision** information.

The next section will be **PHASE II WORK COMPLETED** which will include the following subsections **Detroit Edison Work Completed, DTech DR SOC Work Completed, and DEW Work Completed.**

The final section is **OSERVATIONS & LESSONS LEARNED**, in completing the Phase II work.

INTRODUCTION

Project Objective:

The Phase I proposal created an integrated, but distributed, system and procedures to monitor and control multiple DERs from numerous manufacturers connected to the electric distribution system. Procedures were created which protect the distribution network and personnel that may be working on the network. Using the web as the communication medium for control and monitoring of the DERs, the integration of information and security was accomplished through the use of industry standard protocols such as secure SSL,VPN and ICCP.

The primary objective of Phase II is to develop the procedures for marketing the power of the Phase I aggregated DERs in the energy market, increase the number of DER units, and implement the marketing procedures (interface with ISOs) for the DER generated power. The team is partnering with the Midwest Independent System Operator (MISO), the local ISO, to address the energy market and demonstrate the economic dispatch of DER in response to market signals. Based on phase I demonstrated work, the next step is to demonstrate the prototype link to an ISO control area using standard protocols and to document the working prototype. The selection of standards-based communication technologies offers the ability of the system to be deployed and integrated with other utilities' resources. With the use of a data historian technology to facilitate the aggregation, the developed algorithms and procedures can be verified, audited, and modified.

The team has demonstrated monitoring and control of multiple DERs as outlined in phase I report including procedures to perform these operations in a secure and safe manner. In Phase II, additional DER units were added. We also expanded on our phase I work to enhance communication security and to develop the market model of having DERs, both customer and utility owned, participate in the energy market. We are proposing a two-part DER energy market model--a utility need business model and an independent energy aggregator-business model. The approach of developing two group models of DER energy participation in the market is unique.

The Detroit Edison (DECo, Utility)-led team includes: DTE Energy Technologies (Dtech, DER provider), Electrical Distribution Design (EDD, Virginia Tech company supporting EPRI's Distribution Engineering Workstation, DEW), Systems Integration Specialists Company (SISCO, economic scheduling and real-time protocol integrator), and OSIsoft (PI software system for managing real-time information). This team is focused on developing the application engineering, including software systems necessary for DER's integration, control and sale into the market place.

Background:

Today's electric distribution system is primarily a radial system that was designed to have energy flow from the source to the load (the end-user). The distribution system was not designed to accept multiple DER's feeding energy on to the electric system. A certain amount of electrical energy can normally be accepted by the distribution system with the amount dependant on electric system protection, configuration of the electric circuit and circuit loading. For DERs to be readily acceptable by an electric utility industry, the electric system needs to be modeled to determine how much electrical energy the distribution circuit can accept at any point in time and what type of system protection is needed. The electric system and DER status is also required for DERs to be safely operated on the electric utility system. The aggregation of many DERs can provide a reliable means of managing electric utilities system peaks, meeting our economic challenges for infrastructure, satisfying environmental pressures, and serving our future energy needs. To manage multiple DER units from multiple vendors, the communication and control architectures need to encompass a combination of software and hardware components, including: sensors, data acquisition and communication systems, remote monitoring systems, metering (interval revenue, real-time), local and wide area networks, web-based systems, smart controls, energy management/information systems with control and automation of building energy loads, and demand-response management with integration of real-time market pricing. The most likely operating scenario is for the DERs to be owned, operated, and economically dispatched by different entities. In this deployment, one of the entities has knowledge of the operating conditions of the local electric utility distribution network while the other entity has knowledge about the status of the DER owned by a third entity. This scenario has the most complicated requirements for aggregation and information exchange. Addressing such a scenario will produce technologies, processes, procedures that would be easily applicable to the other deployment scenarios.

If these distributed generation systems were not aggregated and integrated, their individually small power capacities would have limited applications to impact on the overall electricity supply and consumption, resulting in a small market size not viable for mass commercialization. When multiple DER units are aggregated to achieve seamless, integrated operation, the aggregated power will achieve levels that provide support to the grid. This can include a range of markets and applications such as the sale of electricity to wholesale markets, peak shaving, and demand-side management for large customers (including data centers, power parks, manufacturing plants, commercial and institutional buildings, etc.). Additionally, the ability to scale up DER aggregation to respond to changing load demands offers flexibility not readily achievable by central power generation plants. Thus, through aggregation, a viable marketplace will evolve from many DER applications for both off and on grid operations. Growth of the DER marketplace will not only broaden customer choice for electricity services, but will also enable customer participation in energy transactions to meet individual expectations. It should be noted that a listing of known customer generation, above 100kW, was completed as part of DECo's peak load preparedness. The aggregate customer generation totaled 1400MW or 13% of our current annual peak. If harnessed this could be of great value to the utility.

One of the important aspects of the project was to develop a methodology for information integration that was scalable and based upon standards. The project dealt with two sources of information: an internal DECo Energy Management System (EMS) and an external Distributed Energy Resource (DER) operator's control center. It is the combination of this information that was used for the EDD DEW dispatch calculation.

> The Phase I aggregation server, and DEW calculation engine, was located at the DECo's Northern Regional Operation Center (N ROC) which is located at 15600 19 Mile Road, Clinton Township, Michigan.
>
> The EMS information provides the project with the DTE power distribution network Supervisory Control and Data Acquisition (SCADA) information reflecting the current state of the distribution network. The EMS is located at 2000 2nd Avenue, Detroit, Michigan. The EMS is located twenty-six (26) miles from the North ROC. Communication between the North ROC and the EMS location is over a DTE Intranet. The EMS system has an established PI server that houses the SCADA circuit data. It should be noted that the ROCs do not have direct access to PI.
>
> The DER operator information provides the monitoring and control capability of the actual DER. The operator, for the Phase I was DTE Energy Technologies (henceforth referred to as D|Tech DR SOC) and is located at 37849 Interchange Drive, Farmington Hills, Michigan. D|Tech is located thirty-five (35) miles from the N ROC. Communication between the N ROC and D|Tech is via the public Internet. The use of the Internet raised security concerns. These concerns will be addressed in another section of this report.
>
> In Phase II the Phase I aggregation server, and DEW calculation engine, was relocated from DECo's Northern Regional Operation Center (N ROC) to DECo SOC. This was done for two reasons; 1. Control of generation into the market is the responsibility of the SOC 2. Because of the new EMS/DMS system and sale of our Transmission the ROCs and SOC are being merged at the SOC center.

The Universal Protocol Converter and Site Controller (UPC/SC) at DTE Energy Technologies (D|Tech) were developed before the start of this project and is a key element of the project architecture. This device communicates with and controls electrical generation equipment from numerous manufacturers and technologies. This device has been commercially used with fuel cells, solar panels, battery systems, internal combustions engines, external combustion engines, microturbines and other technologies. A similarly large number of manufacturers can be listed. The UPC/SC is installed on-site and provides a common interface for DTE Energy Technologies energy|now System Operations Center™ (D|Tech DR SOC) to interact with field equipment. The data from the field and commands to the equipment are coordinated by server side gateways and stored in databases for use by trained operations personnel and server side applications. All of this traffic is protected by strong encryption and authentication using secured socket layers (SSL). Some of the new DERs added for Phase II required the installation of the UPC/SC as part of the development.

Final Architecture

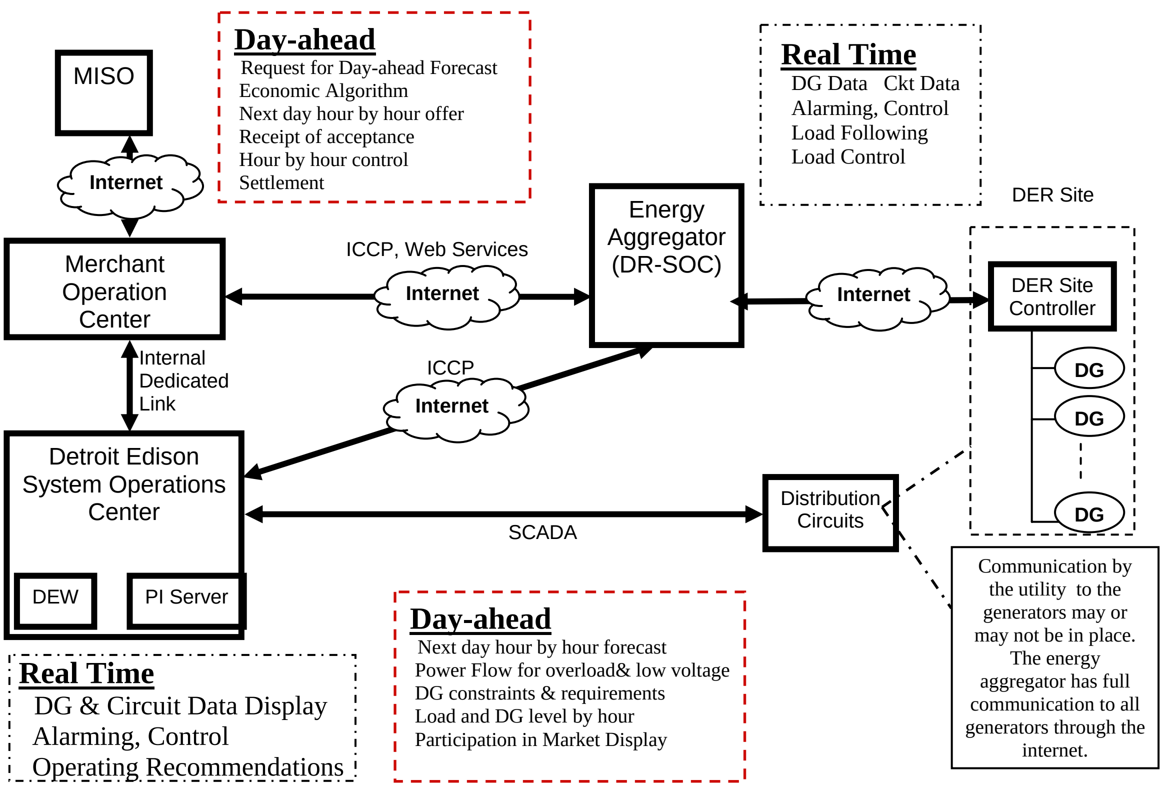


Figure 1 Business Model

WORK COMPLETED

Summary

Our model considers an aggregator providing monitoring, control and aggregation for the utility and the utility as the market representative for the Distributed Energy Resource (DER). The aggregator may bring health and condition monitoring, maintenance, service and control as an agent of the utility. Having the utility involved provides increased value because of his knowledge of wires and its loading. In this way, the utility and customer can use the DER not only for sale into the energy market, but also for the benefit of the wires.

Detroit Edison is using DER as a tool to mitigate overloads and low voltages on its own without regard for market participation. In fact, we are partnering with customers sharing both cost and benefits of distributed generation with our customers. We install a distributed generator at a customer site or bring standby power to the customer in the event of a power outage. At the same time, the distributed generator is a dispatchable asset for the utility to mitigate the effects of an overload or low voltage condition. It also can be used as a generation source or negawatt demand response in the case of a generation shortfall in energy or capacity. This may include providing not only soft transfer to a customer-sited standby unit, but it may also include sellback if the benefits to the system warrant it.

We can do this because we are both a distribution company and a generation company. However, we sold off our transmission.

So becoming the market participant for this generation was a natural transition for both generation and load control. Entering an agreement with customer generation was not something unfamiliar to us either.

Circuit modeling, adding load information, calculating a real time power flow and short term power flow forecasting are all part of this demonstration. One of the primary goals of this DOE project was to develop a template for how others could do this aggregation, communication, control, and sale of DERs. Presented within this volume is not only how we build and forecast our distribution models, but perhaps even more importantly what we did when all the data was not available or perfect. Our simple rule for when the data is either wrong or unknown will be presented. A template that requires perfect data may indeed be no good or at minimum take too long to bring home the benefits of DER aggregation.

August 14 should have taught us that sale and transport of generation should include the effects of the wires. Distribution is no different. Allowing the distribution companies to

be part of the market will insure the wire impacts are taken into account and that, in fact, additional value of the DER can be realized.

Detroit Edison Work Completed

Overview

The Detroit Edison's task is the overall project management, reporting, IT and electrical system security, additional DER installations, integration of DEW, distribution circuit analysis, testing and integration to the MISO.

Work was completed on adding a customer generator to the mix of DER units (see Table 1 below). All 25 electric distribution circuits that contain 31 DER units have been electrically phased in DEW and field verified. All of the 60 distribution circuits adjacent to the 25 are identified and built to pilot using the DEW Contingency Analysis Program and the Reconfiguration for Restoration Program (modified to consider DER as part of the restoration strategy) to quantify contingency system reliability benefits with and without DER. See Appendix E for example reliability calculations.

Phase II DER Units

Table 1 list the DER units available in the Phase II demonstration. The following are the Columns definitions::

1. Item No – consecutive no for the DER
2. Location – DECo reference name
3. Reason for Installation
    a. Distribution Solution – Used to manage load on the distribution circuit
    b. Premium Power – Shared utility / customer DER, owned and operated by the utility as dispatchable asset for circuit loading or generation capacity and provide the customer standby power
    c. Technology Test – New technology demonstration e.g. renewable
    d. Customer Generation – Customer owned DER
    e. Interruptible – Customer interruptible load
4. DER supplier and type of fuel
5. DG Size – Size in kW of the DER
6. Sub station – DECo Substation that the DER is fed from
7. Circuit No – The circuit that the DER is normally connected to
8. Number of Customers – Total number of customer fed by the utility circuit
9. Circuit Miles – The circuit's total number of circuit miles
10. Peak Load – Circuit Peak Load in kW
11. DG % - The DER's percentage as compared to the circuit peak load

Item	Location	Reason for Installation	Supplier & Fuel Type	DG Size (kW)	Substation	Circuit No	Number of Customers	Circuit Miles	Peak Load (kW)	DG as % of Peak Load
1	Milford	Distribution Solution	Deutz Nat. Gas	1,000	Milford	8103	3331	109	15,800	6.3%
2	Redford SC	Premium Power	iPower – GM Nat. Gas	150	Glendale	561	37	3	1,900	7.9%
3	WWSC	Premium Power	iPower – GM Nat. Gas	450	Zachary	9400	152	8	11,200	4.0%
4	Farmington	Customer Owned	iPower – GM Nat. Gas	75	Sunset	9016	215	7	10,000	0.8%
6	Southfield Solar	Technology Test	Siemens – Solar cell	26	Southfield	9010	656	15	4,700	0.6%
7	Union Lake	Distribution Solution	Cummins – Diesel	2,000	Union Lake	1688	1587	21	7,300	27.4%
8	Oakland Water Board	Customer Generation	Diesel	500	Webster	371	1389	9	4,000	12.5%
9	Riverview Biomass	IPO Sellback	Biogas	6,600	Riverview	5145				
10	Adell Communication	Premium Power	Diesel	600	Medina	8533	1009	14	11,200	5.4%
11	Arctic Cold Storage Co.	Premium Power	Diesel	750	Sheldon	9508	228	9	9,600	7.8%
12	Spare @ Cass City	Distribution Solution	Diesel	2,000	Cass City		701	44	3,600	55.6%
13	Southfield Hydrogen Park	Technology Test	Hydrogen	36	Southfield	9010				
14	NextEnergy Microgrid	Technology Test	Hydrogen & Natural Gas	1,000	Amsterdam	New				
15	Beaumont Dialysis	Premium Power	Natural Gas	150	Tienken	8850	1511	21	6,100	2.5%
16	Beaumont Dialysis	Premium Power	Natural Gas	150	Tienken	8850				
17	Botsford Dialysis	Premium Power	Natural Gas	150	Farmington	8892	142	3	1,400	10.7%

18	Grosse Isle Schools	Distribution Solution	Natural Gas	1000	Grosse Ile	2841	883	16	5,200	19.2%
19	Lawrence Technical University	Premium Power	Natural Gas	150	Angola	8862	1328	17	9,100	3.3%
20	Lawrence Technical University	Premium Power	Natural Gas	150	Angola	8862				
21	Macomb Community College	Technology Test	Plug Power – Fuel cell	5	Angola	8877				
22	Henry Ford Community College	Technology Test	Plug Power – Fuel cell	5	Crestwood	8332				
23	Greek Orthodox Church	Distribution Solution	Natural Gas	1,000	Shores	1770	1123	9	5,000	20.0%
24	Wayne State University	Premium Power	Natural Gas	75	Midtown	8317	244	5	6,600	1.1%
25	Wayne State University	Premium Power	Natural Gas	75	Midtown	8317				
26	Wayne State University	Premium Power	Natural Gas	75	Midtown	8317				
27	Interruptible A/C	Customer Solution	Load Reduction	600						
28	Interruptible Load	Customer Solution	Load Reduction	TBD						
29	Meadowbrook Group	Premium Power	Diesel	800	Brooks	8081	2302	3.8	10,800	7.4
30	S.Y.System	Premium Power	Diesel	500	Crestwood	8307	42	6.19	9,100	5.5%
31	Karmann Manufacturing	Premium Power	Diesel	1000	Duvall	9455	254	4.3	10,100	9.9%
32	Washtenaw County Bldg.#4	Premium Power	Natural Gas	255	Emerick	2925	130	2.2	2,500	10%
32	ASC Global	Premium Power	Diesel	2000	Fisher	8188	3168	28.23	13,300	15%
32	Flat Rock Community Ctr.	Premium Power	Diesel	500	Fisher	8188	3168	28.23	13,300	3.7%
33	Metropolitan Baking	Premium Power	DieselLoad Reduction	600	Frisbie	2125	892	3.9	3,200	18.7%
34	Alps Automotive	Premium Power	Diesel	500	Joslyn	9182	23	1.6	10,800	4.6%
35	Trinity Health Care-Warde	Premium Power	Diesel	600	Pioneer	8793	960	41.2	10,400	5.7%

	Lab									
36	Washtenaw County Bldg.#3	Premium Power	Natural Gas	200	Spruce	9874	1220	57.6	8,400	2.3%
37	Golf (NEW)	Distribution Solution	Diesel	2000	Golf	8518	2951	29	14,600	13.7%
38	Ivanhoe (NEW)	Distribution Solution	Bi-Fuel	1500	Ivanhoe	1760	1762	16	6,900	21.7%

Table 1 - Phase II DER Units

Table 1 shows what type of DER units were scheduled for use in Phase II. Several locations needed to be retrofitted with switchgear and communication that include ID number 1, 8, 13, 14, and 28 in Table 1 below. Detroit Edison is managing these installations.

All of the DER units that will be used by the project have been registered in the MISO market. Each site was built in the MISO model as a generation source but entered into the market as Demand Response Resource (DRR). There is one interesting issue that arose when the DER units were registered. Detroit Edison MOC, acting as the agent that registers the DERs in the MISO market, is not allowed to register DERs that are not owned, leased or covered under an existing rate by Detroit Edison. This fact removed units labeled 14, 21 and 22 from the original DER list from being registered. The Oakland Water Board generator (item 8) will be leased by Detroit Edison and will be used as one of the aggregated DERs. The Oakland Water Board 500 kW standby generator work will be to equip the site for parallel operation. Item 9 had to be remove from our list due to Michigan Public Utilities Commission‘s Affiliate Rules Code of Conduct. The Riverview Biomass is own and operated by a non regulated DTE ENERGY affiliate.

The OSISoft PI data historian data points were increased to allow additional data to be stored for the new generators used in the project and their respective circuit heads. Operation and display screen were developed for each of the DERs and will be used by operation including when the units are offered and operating in the MISO market.

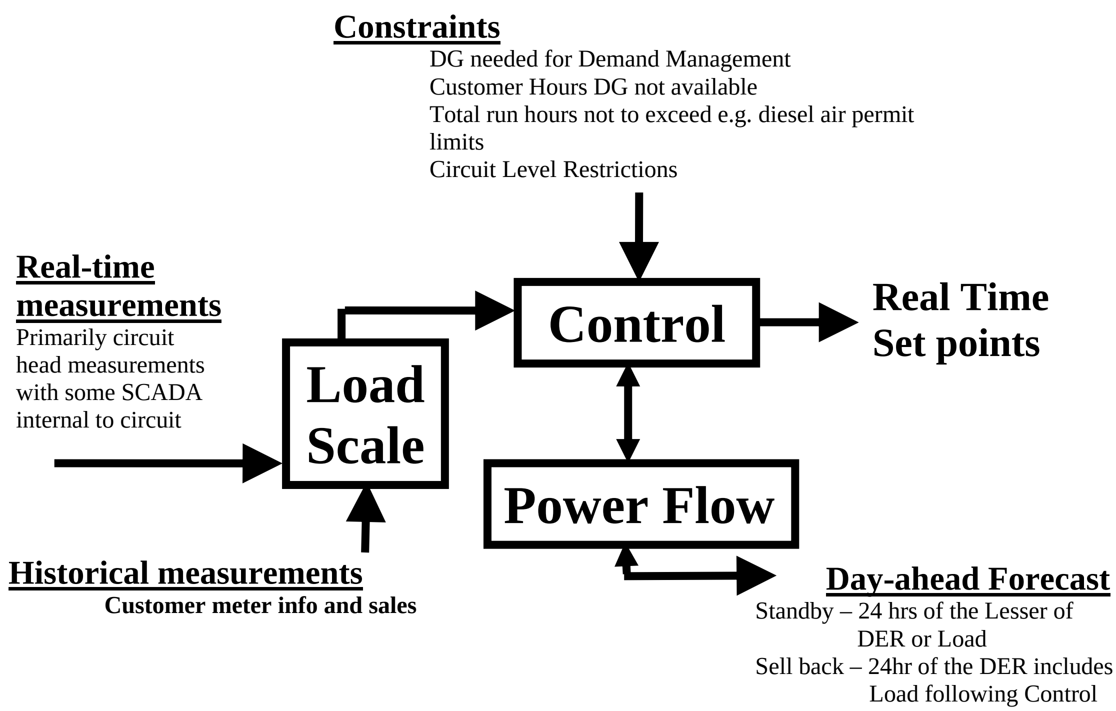
Metering at the start of each circuit was necessary for both real time and day-ahead calculations. Dtech DR SOC was asked to install temporary metering for four of the circuit heads that did not have SCADA because SCADA was not economically viable nor could it be done in time. A temporary meter was jacked into the circuit position at the substation and data brought back to the aggregator then passed back to the utility via the newly established ICCP link to DECo SOC.

Circuit Modeling

Detailed distribution circuit models were created for all circuits having DERs in the project. All circuits were built into a DEW DER system as real three phase circuits, with actual phasing and modeled down to each individual customer meter. Detroit Edison does not have connectivity and phasing available in its current AM/FM system. Detroit Edison is upgrading to an AM/FM model capable of housing and maintaining connectivity and phasing. The circuit models had to be done by hand as is currently the practice with the help of DEW. A connectivity program was added to the DEW suite of applications several years ago to aid Detroit Edison in adding connectivity to its circuit models. The connectivity program takes most of the labor out of connectivity process only requiring human interface when the data is too ambiguous or inconsistent. At the same time, a phase prediction program was developed to at minimum create a balanced power flow or provide a phasing distribution that matched circuit head measurements. With this as our background, all DER circuits were built in DEW with circuit walk down phasing. All circuits adjacent to the DER circuits were built in DEW. Detailed phasing was added when available or guessed at using DEW's phasing prediction program. Maintaining the accuracy of the as-built circuitry was also done with manual updates. Very few circuits required updating during the course of this project. Refer to Appendix A for an overview of each individual circuit and DER.

The load distribution on each individual circuit was initially done by using the ratio of the connected transformer capacity to the known circuit peak which is a typical practice. Larger customer demand loads are substituted for larger customers and the entire load ameliorated again to match the circuit peak load. The customer load for the most recent 12 months was attached including interval metering of the larger primary loads. Where data errors or no load is known the previously calculated transformer loading based on transformer capacity was left as the load. This then became the base case with most loads being time varying loads right down to the individual meters. It is important, at this point, to note that *not all of this detail maybe necessary* for day-ahead forecasting and sale into the market. It can be done less accurately using just transformer capacity and ratios to system load projections. The only time-varying load necessary would be that loading at the Point of Common Coupling.

For circuits that have no problems at peak, the DER would never be required in a system normal configuration, therefore only the PCC would need to be time-varying.



DEW is a Freeware using open architecture database. All functionally developed in this project will be included in DEW.

Figure 2 – DEW Process Diagram

Figure 2 above depicts the DEW functional system its load and measurement inputs and System and Aggregator Outputs.

DEW's Reconfiguration for Restoration Program was modified to also fun the DR Control application enabling our ability to quantify system reliability benefits of DER in restoration efforts. See Appendix F for an example of DER reliability improvements.

Point of Common Coupling Symbols, Definition, and Benefits

A distributed energy resource (DER) point of common coupling (PCC) definition and symbols were developed and implemented with DEW to help define how the DER is connected to the distribution circuit and how it operates. Each one of these DERs behaves differently from a utility perspective and needs to be modeled in DEW.

Interruptible
Standby
Parallel Non-Sellback (or limited sellback)
Parallel Sellback

A Parallel **Sellback** PCC defines the PCC for a generator that can sell back into the electrical grid. Its benefit to the grid is calculated to be the largest value of the generator.

A variation of this would be Parallel **Limited Sellback** defines the point of common coupling for a generator that can only sellback that limited value. It can only sellback into the market the value of the load behind the PCC plus the value of the limited sellback.

A **Standby** PCC type means that the load can only be feed by the electrical grid or by the generator meaning that the benefit to the electrical grid would be the value of the load.

Interruptible is essentially the same as standby without generation.

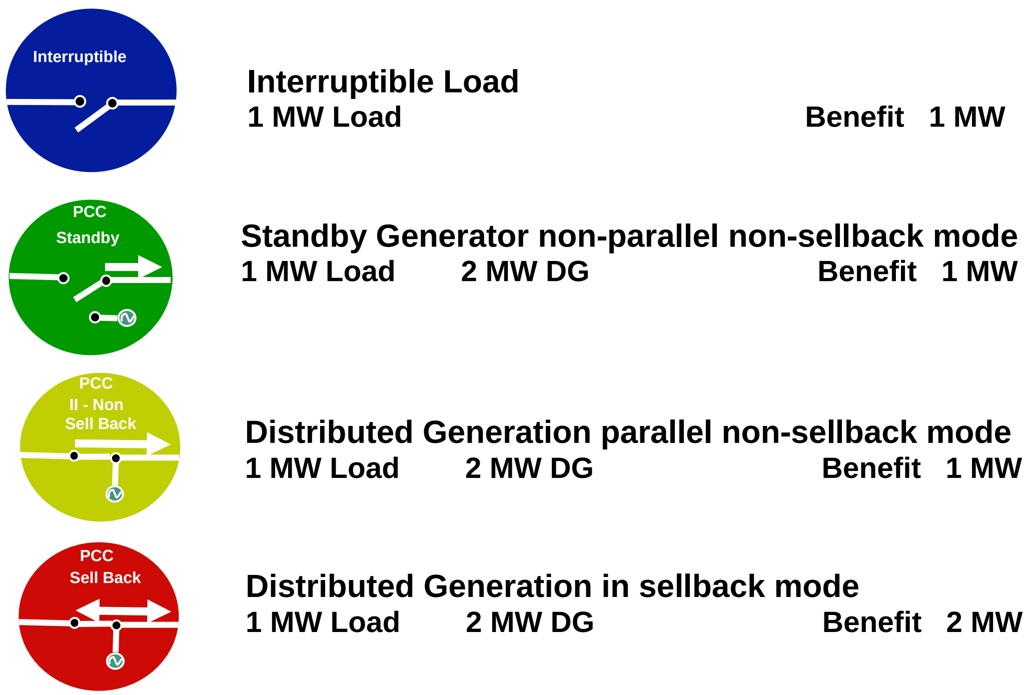
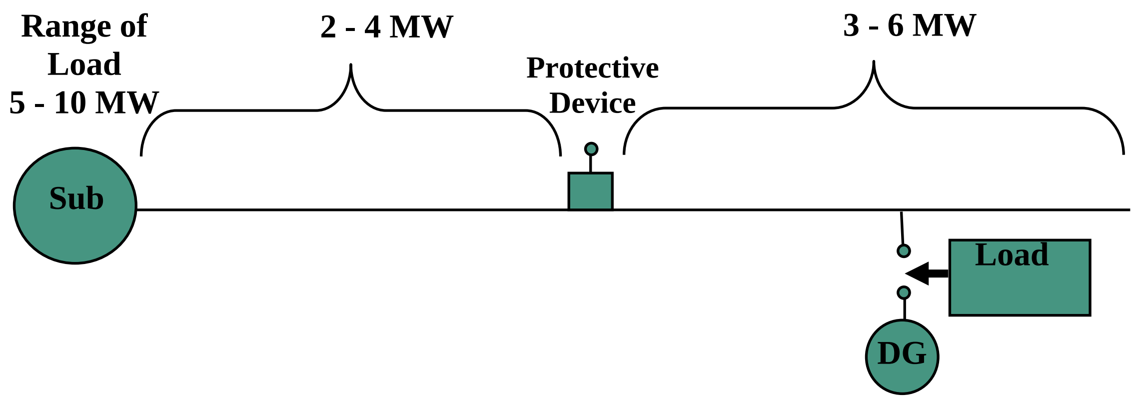


Figure 3 - Point of Common Coupling Symbols Table

Also listed in Figure 3 symbols table above is an example of the amount of load, on site generation and benefit to the grid. One notices that the benefit is maximized by parallel operation which allows sellback.

A more complex example of the difference of each PCC type and the benefits to the utility is listed in the circuit below. Here load following as a means of avoiding transfer trip is also shown.



Day-a-head forecast	Min	Max
• Customer Load	0.5	1
• Customer DG	2	2
• Standby sale	0.5	1
• Sellback sale with Transfer Trip	2	2
• Sellback sale without Transfer Trip (Load Following Maintaining 3 to 1)	1 (3/3)	2 (6/3)

DG – Protective Zone restriction IEEE 1547 (Load to DG = 3 to 1)

Figure 4 - Point of Common Coupling Example Circuit

In Figure 4 a range of circuit loading is shown from 5 MW to 10 MW The circuit loading is shown for each protective line section as 2 to 4 MW on the line section protected by the substation circuit head and 3 to 6 MW on the end of the circuit protected by the mid circuit recloser. A customer load varying from ½ MW to 1 MW with an on site 2 MW DER is shown on the last line section.

The continuing example show interruptible load or standby can only result in a negawatt range much less than the on-site generation. You can only achieve the load offset, not the value of generation, which is usually greater..

By converting the standby non-sellback to sellback with the installation of paralleling switch gear, a *utility/customer/grid* benefit greater than the load can be realized. With the installation of transfer trip, the system and generation can be protected and the maximum benefit can be realized. The installation of transfer trip can sometimes be an expensive proposition. Especially when a simple restriction of the amount of output can maintain a 3 to 1 circuit load to generator load ratio and thus cancel the need for transfer trip all together. In most cases, the need for DER support will correspond to the higher loading time anyway, enabling the *utility/customer/grid* to achieve maximum benefit without the additional cost.

Note it is Detroit Edison's practice to add an additional margin and require 4 to 1 ratio for load flowing without transfer trip 4:1 defined as Total Load (which includes the generator output) to the generator output.

Detroit Edison has begun using load following with the generation it uses to manage peak loading and avoid transfer trip installations. Load following works like this: the output of an ACM meter (a temporary meter jacked in at the substation if SCADA is not available at the circuit position) is used to monitor the effected circuit. This loading value is sent to the DER controller where the turn on and turn off values together with permissive on and permissive offs are set. Note that these values are programmable by Dtech and are feed into Dtech's and can be changed via the communication path. With the introduction of this method of operation, our system operators' attitude of "I must have control" has developed into an appreciation of this no hands approach to managing the loading on a circuit. This frees the operator to focus on trouble and other duties that do require operator intervention. The metaphor used to explain this operating mode to our operators was that it is like fans on a transformer used for cooling during heavy loads or automatic switching of capacitor banks. They go on and off via system needs. The only time an operator is needed is in abnormal times e.g. shutdown or when thing don't work as expected.

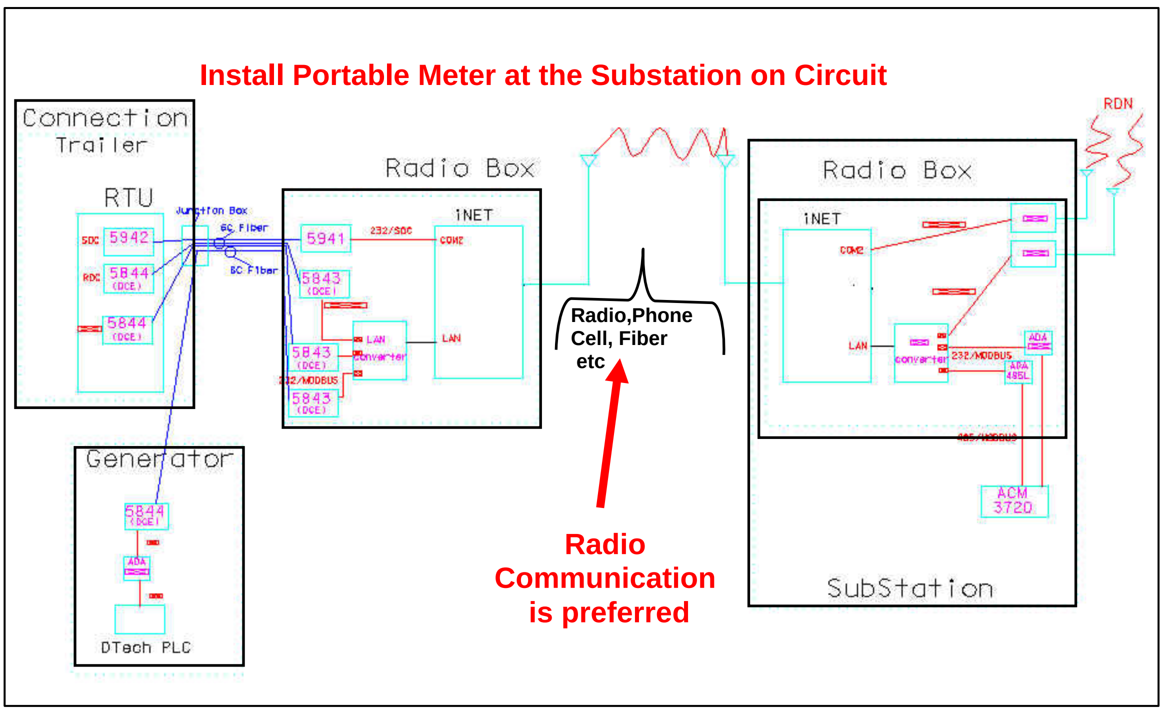


Figure 5 – Depiction of communication methods of circuit head information to DER

Figure 5 above depicts typical communication methodology we use to do load following. That is communicating circuit head information back to the DER site's Dtech UPC/SC and into the generators PLC for control.

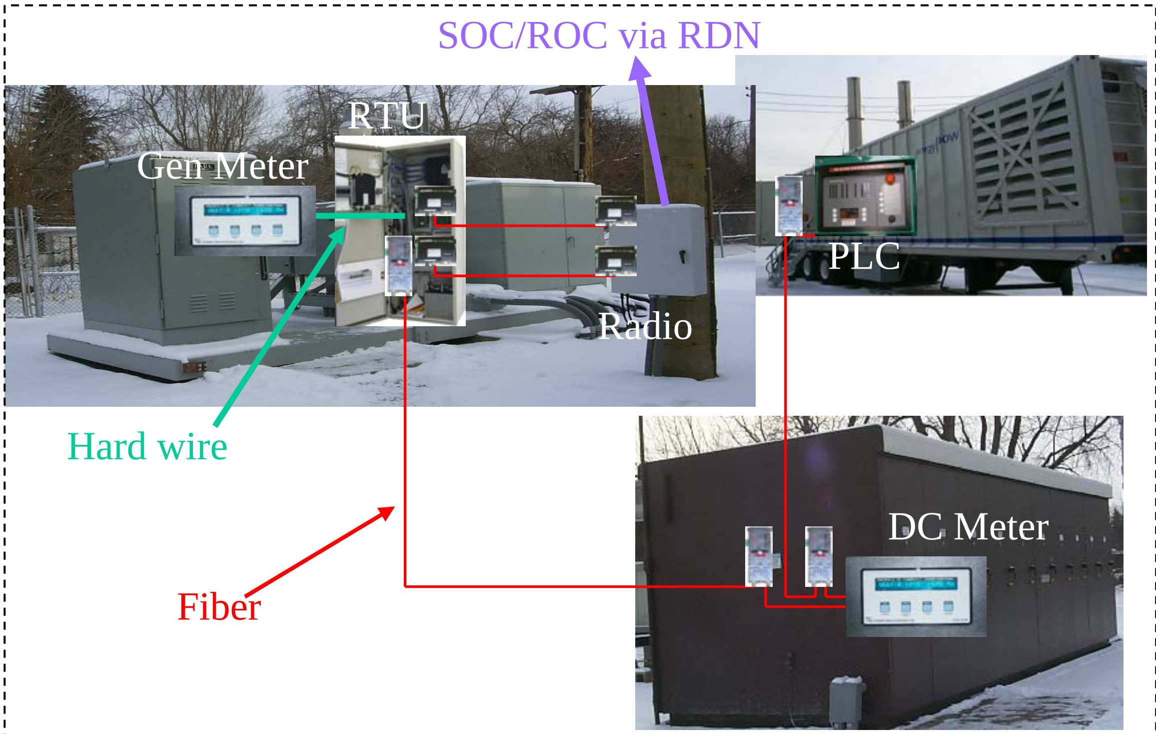


Figure 6 – Union Lake circuit head metering and generator metering & control

Figure 6 above shows an actual site, Union Lake's method of the circuit head monitoring and generator monitoring and control for Union Lake where a generator operating in parallel peak shaving a circuit.

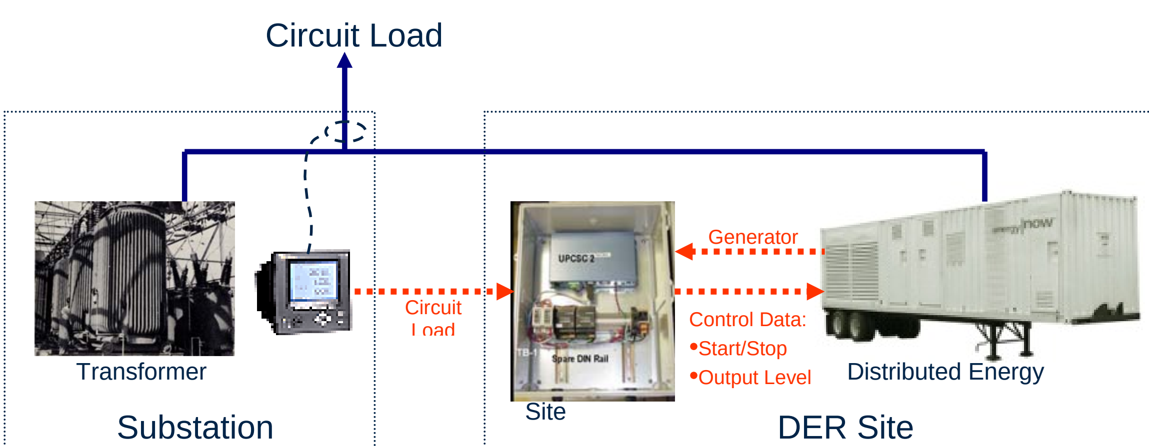


Figure 7 – Typical DR SOC Load Following Installation

Figure 7 – The aggregators method of monitoring and control of the DER using the UPC/SC to take circuit head information and perform control function based upon that information as well as other outside control inputs. The UPCSC box will be discussed later.

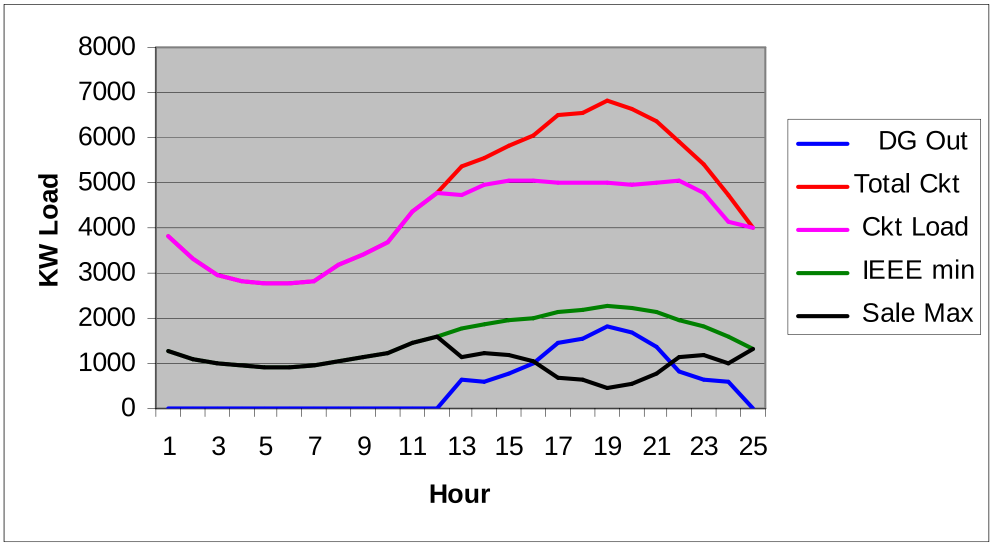


Figure 8 - Union Lake Sellback DER Example

In Figure 8 above the DG Out is the (must run) level of generation required to manage loading on the distribution circuit to prevent overload. This corresponds to a must run condition. The IEEE min is the maximum that the generator can be run at without transfer trip (relies upon under voltage trip within 2 seconds). The sale max is the amount that can be offered into the market in excess of the must run. This is the typical time varying output of DEW and input the DR SOC for planning the day-ahead offer.

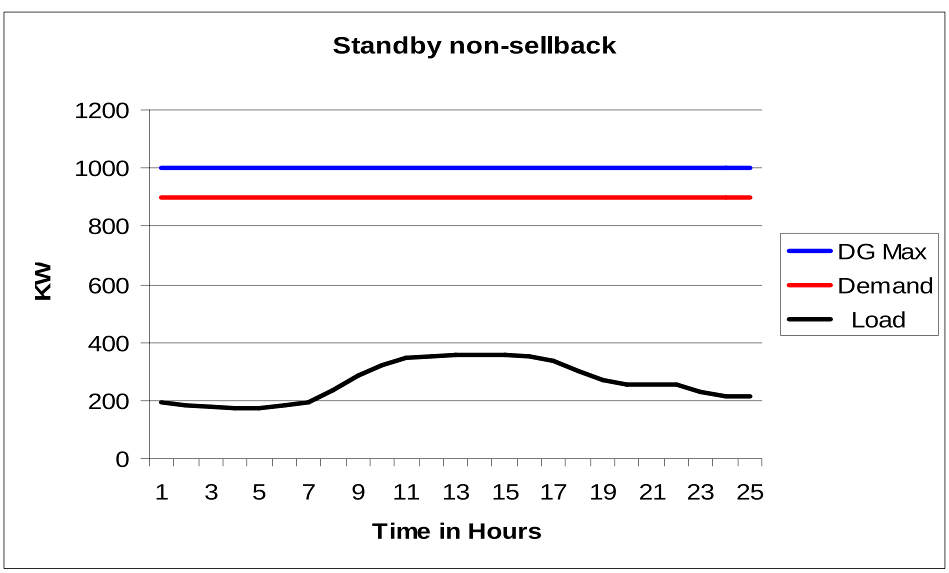


Figure 9 – Lightly Loaded Standby DER Example

In Figure 9 above the diagram represents a lighter load for a standby customer. Even though the customer has a 1000kW generator and a maximum demand of 900 kW the load curve is the only benefit amount that can be offered into the MISO. This is also a typical time varying output of DEW and input the DR SOC for planning the day-ahead offer.

PI Database

Additional work was performed on the project OSI Soft PI data historian to ensure that all the tag data points from DTech, DEW and Detroit Edison SOC have the proper naming convention and are available for analysis, display and operations and will be used when the units are offered into the MISO market. Operations and display screens were developed using PI database as input and PI Process Book to fashion the displays. Detroit Edison is currently in the process of installing a new EMS/DMS system in the next year. It was decided to use PI Process Book for display within the current SOC rather than attempt integrating new DER models within a system that will be retired within a year. PI Process Book Displays are also an excellent way to communicate the models to our Engineer folks.

The following is PI Process Book main display and a circuit model.

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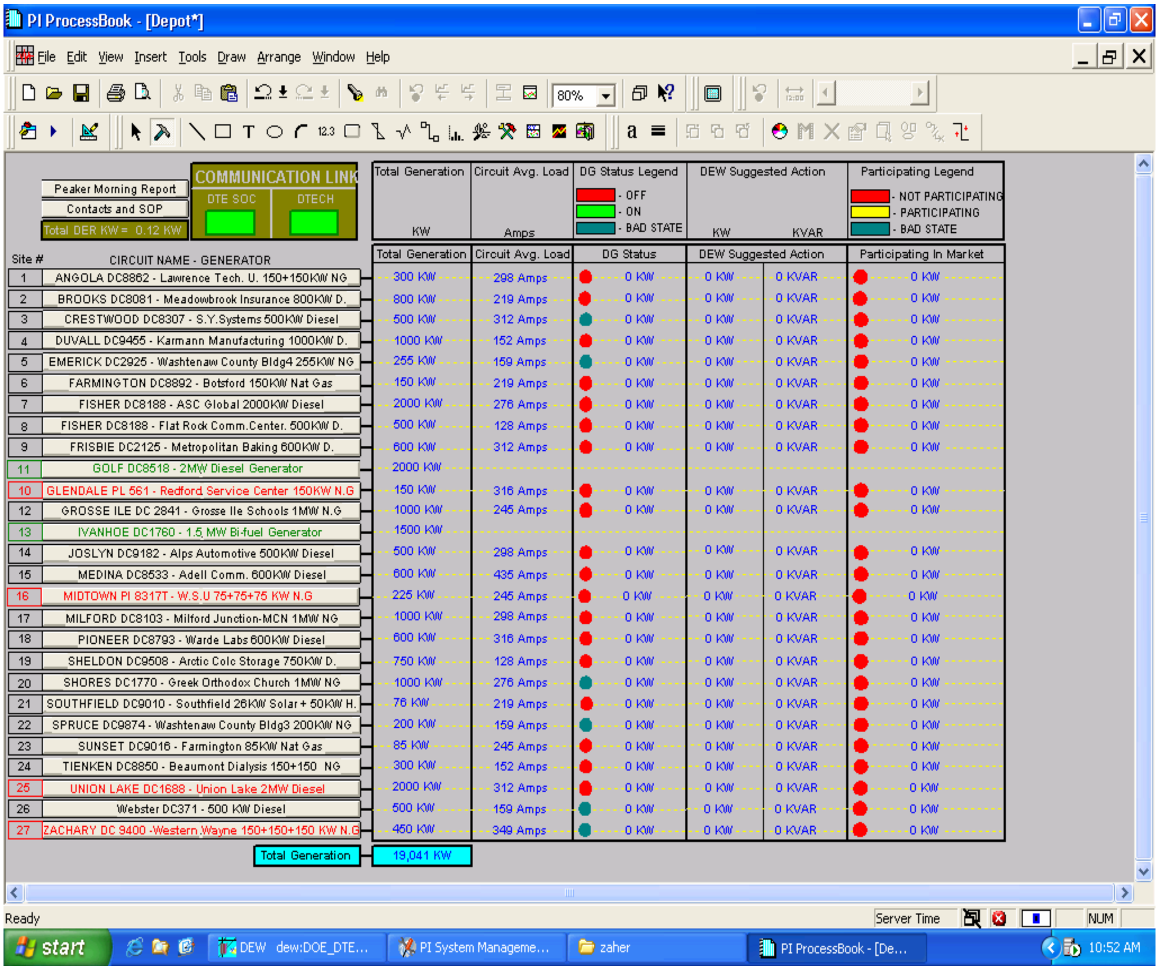


Site #	CIRCUIT NAME - GENERATOR	Total Generation (KW)	Circuit Avg. Load (Amps)	DG Status	DEW Suggested Action (KW)	DEW Suggested Action (KVAR)	Participating In Market
1	ANGOLA DC8862 - Lawrence Tech. U. 150+150KW NG	300 KW	298 Amps	0 KW	0 KW	0 KVAR	0 KW
2	BROOKS DC8081 - Meadowbrook Insurance 800KW D.	800 KW	219 Amps	0 KW	0 KW	0 KVAR	0 KW
3	CRESTWOOD DC8307 - S.Y.Systems 500KW Diesel	500 KW	312 Amps	0 KW	0 KW	0 KVAR	0 KW
4	DUVALL DC9455 - Karmann Manufacturing 1000KW D.	1000 KW	152 Amps	0 KW	0 KW	0 KVAR	0 KW
5	EMERICK DC2925 - Washtenaw County Bldg4 255KW NG	255 KW	159 Amps	0 KW	0 KW	0 KVAR	0 KW
6	FARMINGTON DC8892 - Botsford 150KW Nat Gas	150 KW	219 Amps	0 KW	0 KW	0 KVAR	0 KW
7	FISHER DC8188 - ASC Global 2000KW Diesel	2000 KW	276 Amps	0 KW	0 KW	0 KVAR	0 KW
8	FISHER DC8188 - Flat Rock Comm.Center. 500KW D.	500 KW	128 Amps	0 KW	0 KW	0 KVAR	0 KW
9	FRISBIE DC2125 - Metropolitan Baking 600KW D.	600 KW	312 Amps	0 KW	0 KW	0 KVAR	0 KW
11	GOLF DC8518 - 2MW Diesel Generator	2000 KW					
10	GLENDALE PL 561 - Redford Service Center 150KW N.G	150 KW	316 Amps	0 KW	0 KW	0 KVAR	0 KW
12	GROSSE ILE DC 2841 - Grosse Ile Schools 1MW N.G	1000 KW	245 Amps	0 KW	0 KW	0 KVAR	0 KW
13	IVANHOE DC1760 - 1.5 MW Bi-fuel Generator	1500 KW					
14	JOSLYN DC9182 - Alps Automotive 500KW Diesel	500 KW	298 Amps	0 KW	0 KW	0 KVAR	0 KW
15	MEDINA DC8533 - Adell Comm. 600KW Diesel	600 KW	435 Amps	0 KW	0 KW	0 KVAR	0 KW
16	MIDTOWN PI 8317T - W.S.U 75+75+75 KW N.G	225 KW	245 Amps	0 KW	0 KW	0 KVAR	0 KW
17	MILFORD DC8103 - Milford Junction-MCN 1MW NG	1000 KW	298 Amps	0 KW	0 KW	0 KVAR	0 KW
18	PIONEER DC8793 - Warde Labs 600KW Diesel	600 KW	316 Amps	0 KW	0 KW	0 KVAR	0 KW
19	SHELDON DC9508 - Arctic Colc Storage 750KW D.	750 KW	128 Amps	0 KW	0 KW	0 KVAR	0 KW
20	SHORES DC1770 - Greek Orthodox Church 1MW NG	1000 KW	276 Amps	0 KW	0 KW	0 KVAR	0 KW
21	SOUTHFIELD DC9010 - Southfield 26KW Solar + 50KW H.	76 KW	219 Amps	0 KW	0 KW	0 KVAR	0 KW
22	SPRUCE DC9874 - Washtenaw County Bldg3 200KW NG	200 KW	159 Amps	0 KW	0 KW	0 KVAR	0 KW
23	SUNSET DC9016 - Farmington 85KW Nat Gas	85 KW	245 Amps	0 KW	0 KW	0 KVAR	0 KW
24	TIENKEN DC8850 - Beaumont Dialysis 150+150 NG	300 KW	152 Amps	0 KW	0 KW	0 KVAR	0 KW
25	UNION LAKE DC1688 - Union Lake 2MW Diesel	2000 KW	312 Amps	0 KW	0 KW	0 KVAR	0 KW
26	Webster DC371 - 500 KW Diesel	500 KW	159 Amps	0 KW	0 KW	0 KVAR	0 KW
27	ZACHARY DC 9400 -Western Wayne 150+150+150 KW N.G	450 KW	349 Amps	0 KW	0 KW	0 KVAR	0 KW
	Total Generation	19,041 KW					

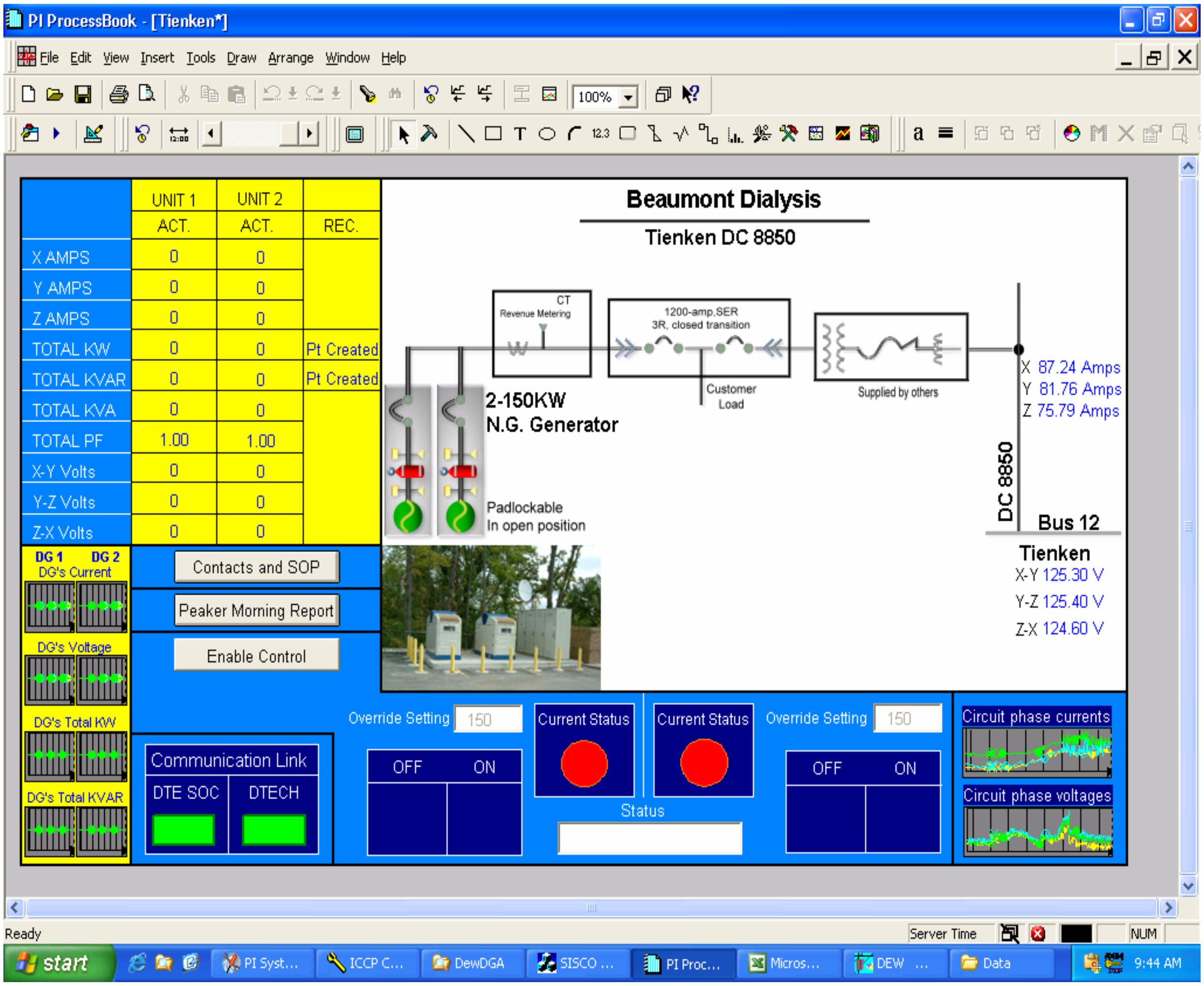
Display 1 – PI Process Book DER Summary Page

Included in Display 1 above are the following:

- Column 1 Site No just a number
- Column 2 Alphabetic listing of each Detroit Edison distribution circuit that has a DER that can be used to manage loading or be offered into the market.
- Column 3 Total available site generation
- Column 4 Real Time average 3 phase current at the circuit head
- Column 5 Generator Status and real time generator output
- Column 6 DEW's Real Time recommended generator output needed (KW and KVAr) to mitigate a circuit overload or short circuit.
- Column 7 Market participation indicator and scheduled hourly expected output required

For more details and examples of all sites refer to Appendix B.

By clicking on one of the buttons that make up column 2 you can drill down to the individual circuit views of the real time operating system within PI Process Book.



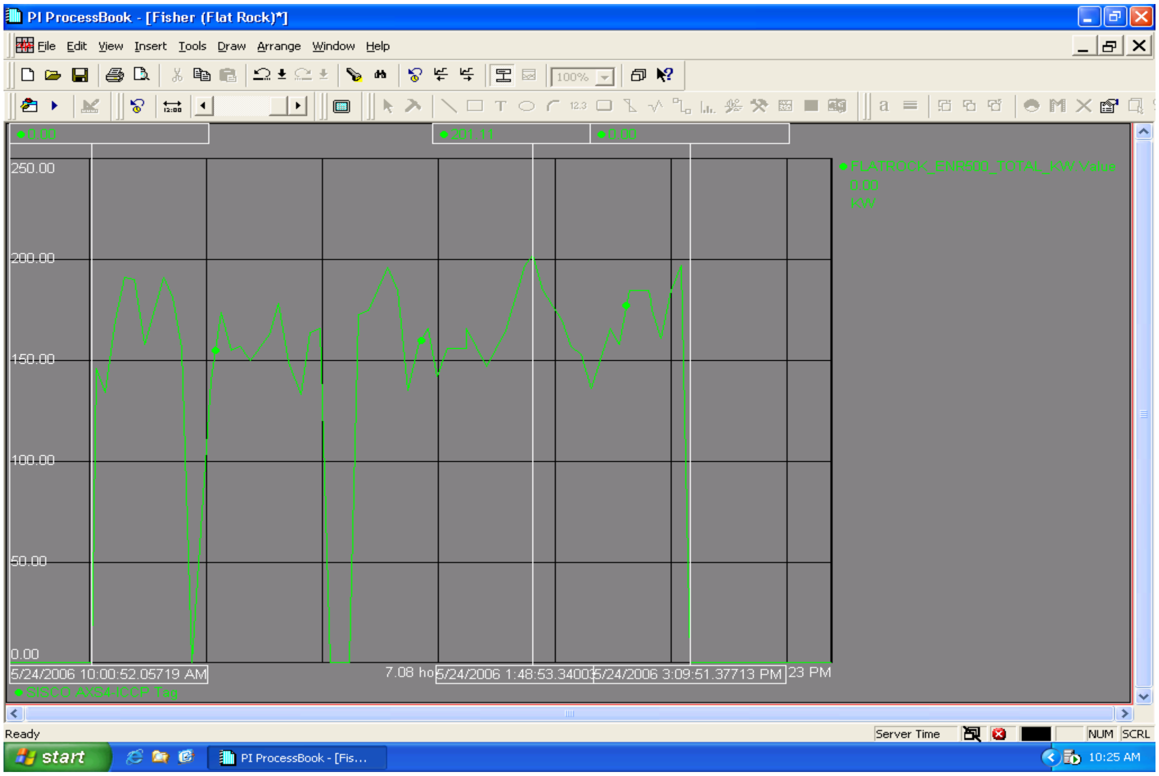
Display 2 –PI Process Book DER Circuit Page

Display 2 above is one of those drilled down views for Beaumont Dialysis on the Tienken distribution circuit. This represent the circuit exit from the substation Real Time values for the head of circuit as well as the DER real time output and DEW recommendations for mitigating a calculated real time overload or low voltage. More detail on the DR algorithm can be found in Appendix D. Monitoring of the individual DER as well as interoperable control can be access from this display. For more details please refer to Appendix B.

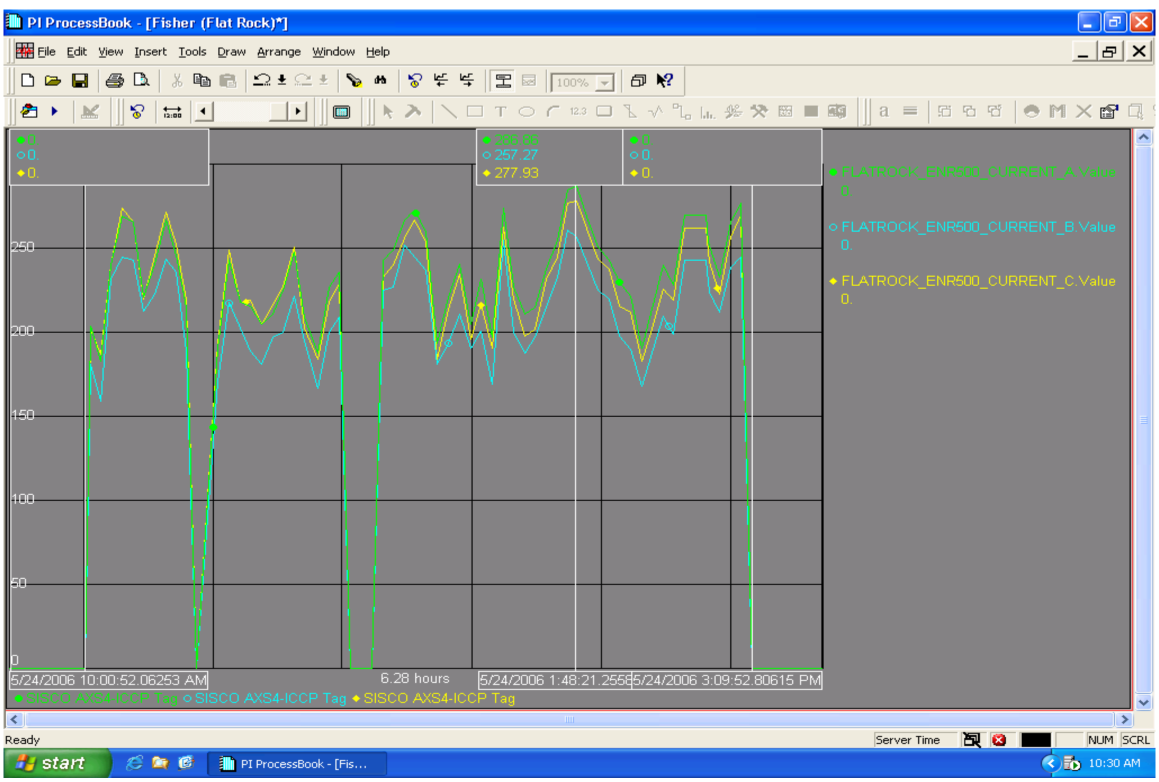
By double Clicking on any of the miniaturized graphs on the PI process book display you can access a graphical tool called (**Trend**) which helps you to create a plot of the values of selected tags (i.e. KW, Volts, KVA, KVAR …etc) over a specified time range.

The following two graphs show the behavior of the KW and phase current curves of Flat rock's DG during the sell process for 5 hours on 5-24-2006.

Similar results are also available for DER owner via the Dtech DR SOC web site.



Display 3 Flat Rock DER Total KW Example



Display 4 Flat Rock DER Phase Current Example

DR-SOC Work Completed

Summary

The goals of the DR-SOC during the *Advanced Communication & Control of Distributed Energy Resources – Phase II* project were two-fold: To increase distribution system reliability and provide economic benefits to the utility, Detroit Edison. The challenge was to accomplish both goals simultaneously. Where the focus in the first phase of the project was solely to utilize DER to add reliability to the utility distribution system, the challenge of the second phase was to improve on that reliability meanwhile adding the ability for the utility to earn a profit at the same time.

Like Phase I of the project, distribution system reliability was increased by offsetting system load through demand reduction. Additionally the DR-SOC utilized DEW (Distributed Energy Workstation) to predict distribution system problems and recommend solutions using aggregated DER. This functionality was enhanced for the second phase of the project through the addition of the must-run concept as well as the DEW's ability to predict the maximum output of a unit such that it does not violate the 4:1 utility-interconnect. Finally, improvements were made to the functionality that allows the Detroit Edison SOC to control the DER directly for emergency response, consisting primarily of improvements in the timing and reliability of control commands.

DR-SOC Overview

The Central Station model for delivering power allows for on-site control rooms and dedicated SCADA systems for monitoring and controlling Power Plants, Transmission and Distribution. These control and monitoring functions are still needed for smaller-scale Distributed Generation systems.

As result the design goals of the DR-SOC were to develop a low cost SCADA alternative to replace private networks with lower cost Internet communications as well as develop low-cost data logger (RTU) and site controller. Additionally, the DER-site must be able to manage potential loss of Internet communication with the DR-SOC. In this situation, the local site controls must continue to operate the DER equipment on their own. The control may not as reliable or economical without the DR-SOC, but still offer safe operation.

The following is a listing of services currently provided by the DR-SOC:
Monitors DER system conditions and health of units
Dispatch maintenance crews
Schedule and dispatch customer equipment
Economic Dispatch
Advanced Aggregation

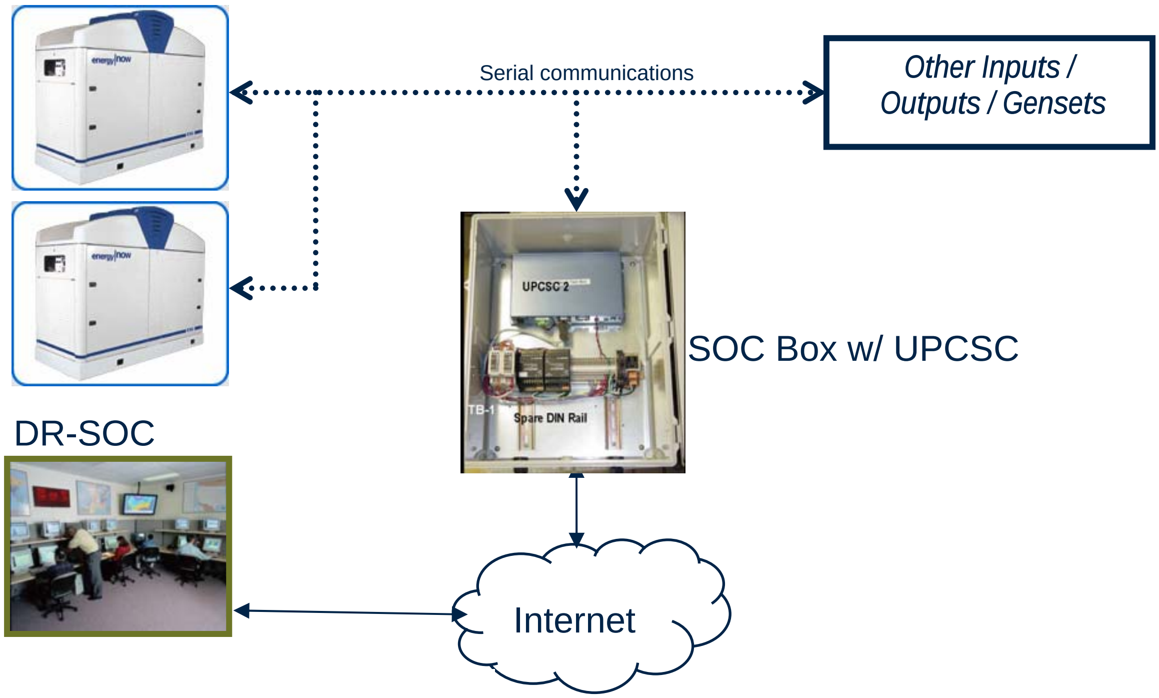


Figure 12: DR-SOC Architecture

Figure 12 displays how the DR-SOC monitors, controls, and communicates with the DER. The SOC Box with a Universal Protocol Converter and Site Controller (UPC/SC) has been developed to work with various types of DER equipment. This box has been used in this project to monitor and control each of the DERs of various types and manufactures for monitoring communication and control. Table 2 illustrates the available Internet communication options:

Connectivity	Reliability	Cost	Limitations
Customer LAN	Most reliable	Least expensive	Firewall issues
Cable	Good reliability	Moderate cost	Not available everywhere
DSL / ISDN	Moderate reliability	Moderate cost	Not available everywhere
Cellular Wireless	High reliability	Moderate cost	High latency
Satellite	High reliability	Most expensive	High latency
Dial-up/Modem (Low-risk Monitoring Sites)	Good reliability	Cheap	Infrequent updates due to limited throughput

Table 2 - Communication Options

DR SOC will use the best available for each individual site, recognizing that all options at a particular site may not be available.

DR-SOC Control Options

The DR-SOC provides a variety of control options that allow Detroit Edison to utilize DER to supplement its distribution system for added reliability. Below are two examples that apply to the *Advanced Communication & Control of Distributed Energy Resources – Phase II* project, Non-Sellback and Sellback.

Non-Sellback:
Detroit Edison has installed DER at a series of customer sites around its distribution system. The DERs are attached to the facility load through a transfer switch. This is the point of common coupling. At any given time, the load through the point of common coupling is served either entirely by Detroit Edison or entirely by the DER, depending on the position of the switch. Detroit Edison provides these customers with discounted rates so that it can remove the customer's load from the distribution system by switching them off of the grid and onto the standby generator to remove load from the grid. Figure13 illustrates the architecture:

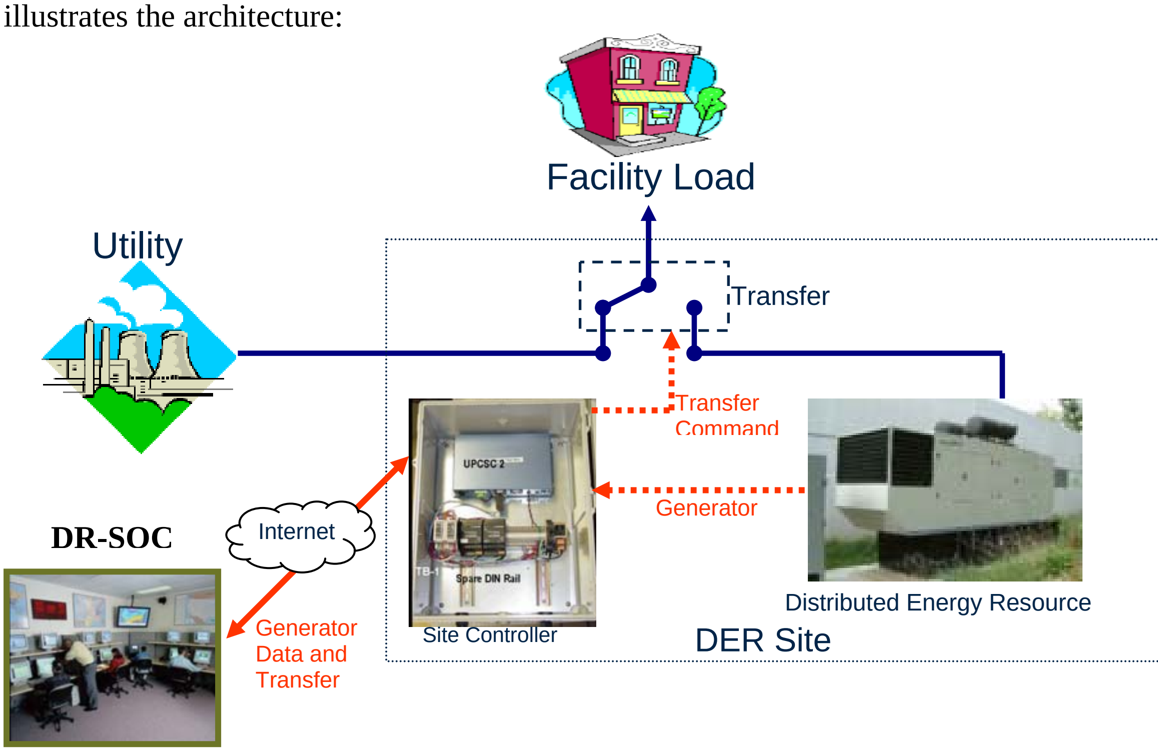


Figure 13: Non-Sellback - Demand Reduction and Back-up Power

Sellback:
Detroit Edison has installed multiple grid-parallel generators at various points along its distributions system to provide support to overloaded circuits and substation transformers. These sites are sellback because the DER can export power to the grid. The DER capacity can be used to manage the loading on the overloaded element. Figure 14 illustrates the architecture for these peak-shaving applications.

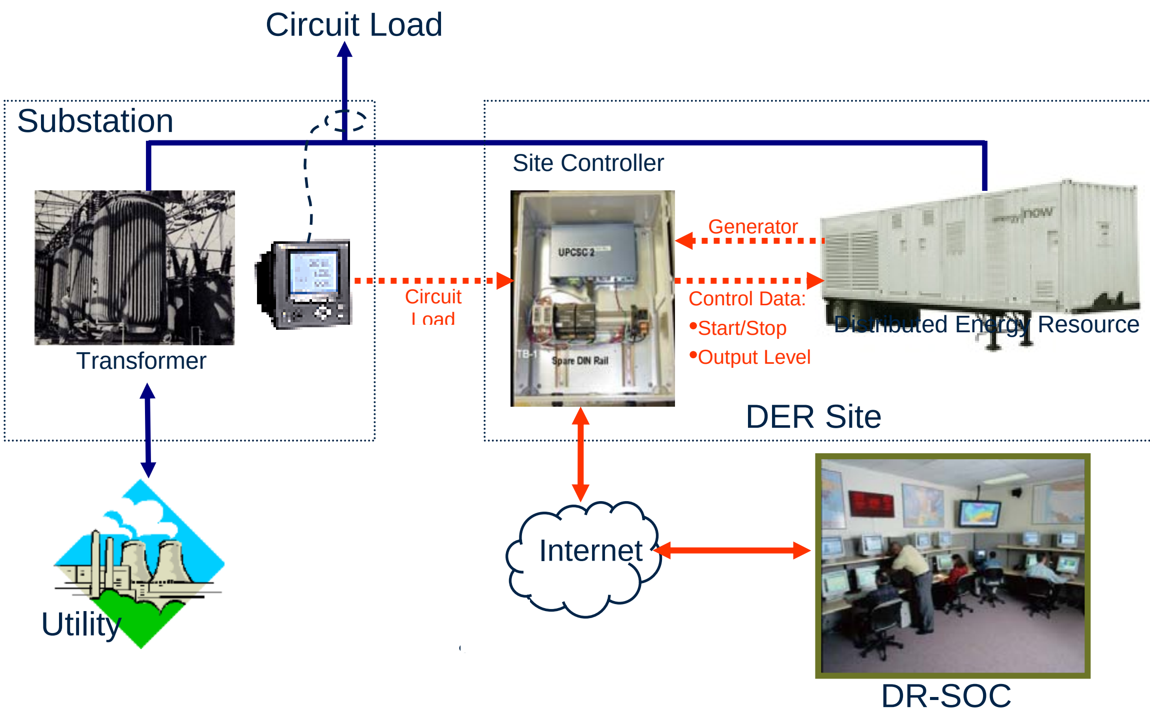


Figure 14: Sellback – Peak-Shaving

Other DER sites exist on the Detroit Edison distribution system that simply provide continuous duty generation that is set up to run parallel to the grid. These sites can be set up at the DR-SOC to run for the economic benefit of the customer. Figure 15 illustrates the architecture of the grid-parallel, continuous duty sites.

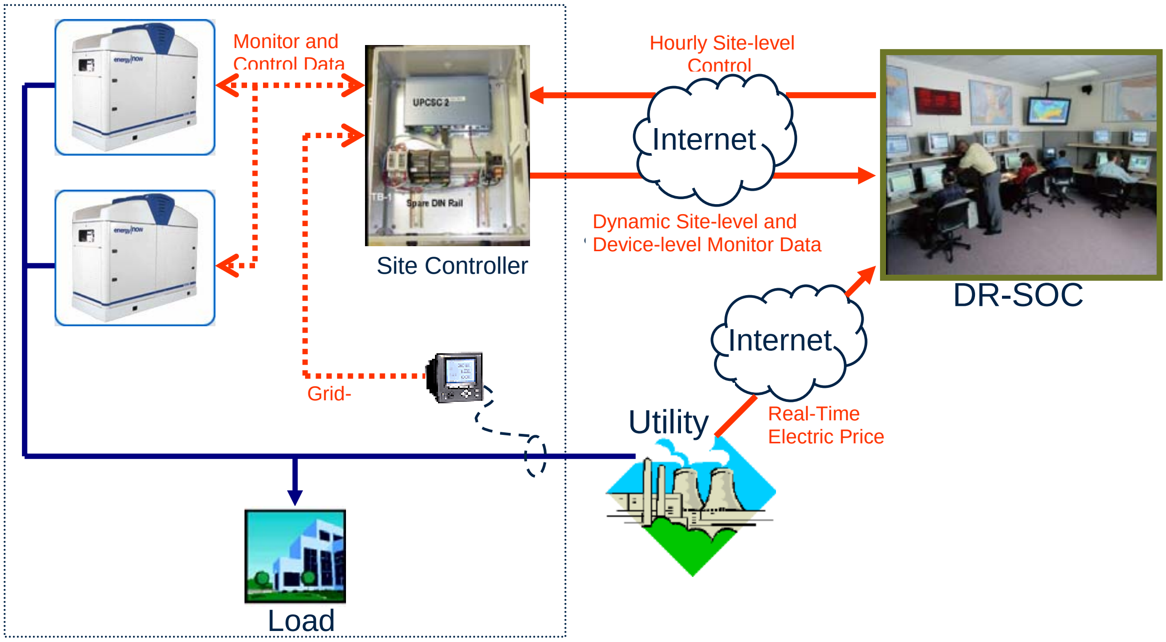


Figure 15: Sellback – Grid Parallel Continuous Duty

Project Overview

From the DR-SOC perspective, the majority of the work involved in Phase II was centered on offering the DER into the energy market so that money could be made on capacity that was already being used for distribution reliability. The key to this was integrating with the local ISO (Independent System Operator), MISO, such that offers could be made electronically without human intervention. From the DR-SOC perspective this involved utilizing the DTA economic dispatch software to generate aggregated energy offers to MISO. Additional work for the DR-SOC involved integrating with the Distributed Energy Workstation at Detroit Edison. Although the DR-SOC integrated with DEW during Phase I, new functionality required the DR-SOC to develop new tools to support it.

MOC Overview

Demand response offers to MISO are posted to the DECo MOC over the Internet using an XML file. This file is posted to a Web Service at the MOC daily and is encrypted using a VPN (Virtual Private Network). DR-SOC began development of the software that is responsible for generating and posting this offer file according to documentation provided by the MOC. MOC intended to use a custom Web Service to handle the transaction on their end and supplied DR-SOC with sample XML files to be used in this development.

DEW Overview

The Distributed Energy Workstation (DEW) algorithm is run daily to provide DR-SOC with recommendations with regard to running the DER sites to provide reliability to the distribution system wherever necessary. The DEW resides in the DECo SOC and its algorithm is triggered daily by DR-SOC using an XML file posted to a Web Service on the DEW machine. The XML file contains up-to-date generator and aggregate zone information that DEW uses as input to its algorithm. DR-SOC developed the software that generates the DEW trigger file using actual generator and aggregate zone information.

When the DEW algorithm has completed its calculations, an XML file is generated containing the reliability parameters for each aggregate zone including N-1, reserve margin, and load-following requirements for each unit in a zone, as well as a list of units that “must-run” in order to provide support to parts of the distribution system that are predicted to have problems. The DEW posts this file back to DR-SOC using a Web Service running at DR-SOC and is encrypted using a VPN tunnel. The data from this file is then stored and used as input to the DTA algorithm and in turn affects the offer that is submitted to MISO. DR-SOC developed the Web Service that accepts the DEW results file and stores the data to its database for use by DTA.

Economic Dispatch

For Phase II, the DR-SOC made modifications to the DTA (Economic Dispatch Algorithm) algorithm that is used as the central aggregating software to generate offers to MISO. One major change was adding an “aggregate DTA” mode, which included upgrading calculations from hourly to day-ahead (24 hours). Additionally, the algorithm was modified to utilize the DEW results rather than user-provided information, as input for reliability purposes. Finally, the distinction between sellback and non-sellback sites was factored into the calculations. Previously, DTA only allowed calculations on sellback sites.

DR-SOC Communications

Overview

As the central entity in the project, most of the development efforts were focused on establishing the data infrastructure and communication between the other involved parties, Merchant Operation Center (MOC) and Detroit Edison.

This communication is the heart of the development of the economic dispatch system. Additional development was required to provide the computing power and network resources needed to support the project on the DR-SOC back end.

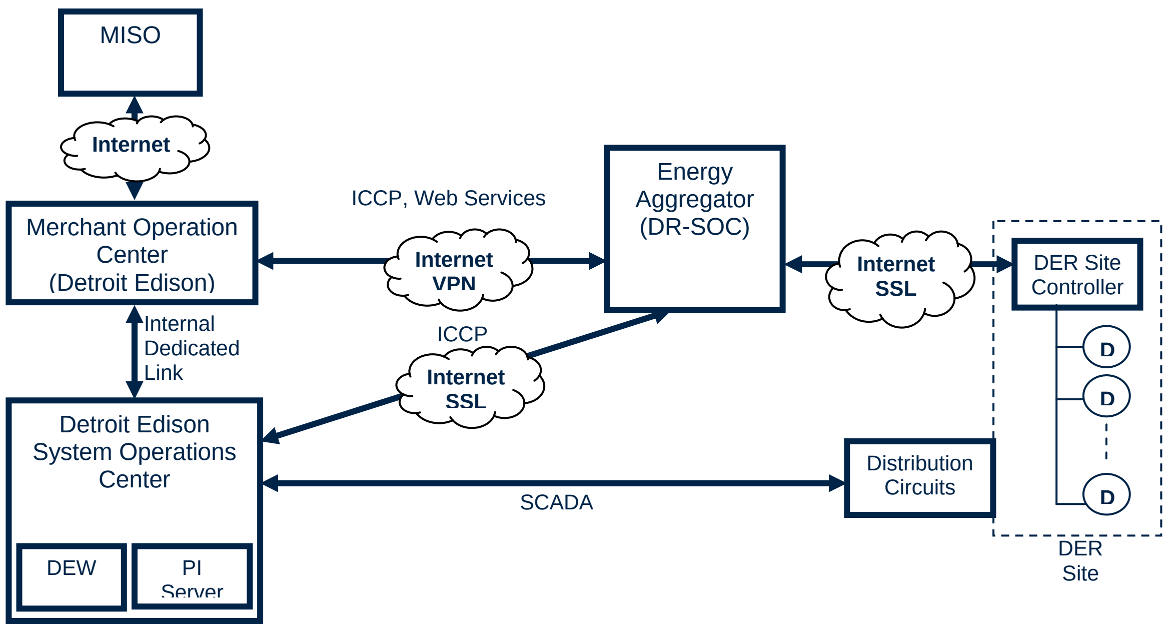


Figure 16: Communications – Overview

Communication Overview

The first step in creating the necessary communication paths was to establish Virtual Private Network (VPN) connectivity between the DR-SOC, MOC, and Detroit Edison.

With the VPN "tunnels" in place, the first piece of data infrastructure that was to be addressed was the ICCP link. This link is responsible for carrying monitor data from DR-SOC to the Detroit Edison SOC as well as control information from Detroit Edison back to DR-SOC. There is also an ICCP connection between the DR-SOC and MOC, which is responsible for sending real-time monitor information to MISO and receiving real-time control information from MISO (via MOC), which had to be established. In order to meet one of the requirements of the project, to utilize ICCP security features, the DR-SOC needed to update the version of SISCO's ICCP software package that it had installed on its ICCP gateway. SISCO aided in the upgrade.

The second phase of this project required the addition of multiple distributed generation sites. Monitor and control points for these sites were added to the system to allow them to be transferred back and forth over the ICCP links. The points for Detroit Edison SOC were manually entered into SISCO's AX-S4 ICCP application which handles the ICCP transactions on the ICCP gateway then stores those values in OSIsoft PI database for access by DEW and PI Process book for Operator Displays.

The ICCP link between the DR-SOC and Detroit Edison was relocated from the Detroit Edison Regional Operation Center (ROC) to Detroit Edison Systems Operation Center DECo SOC because generation is handled by the DECo SOC.

A software package called Kassl XGate was researched and installed on the ICCP gateway that allows the connection to the DR-SOC database using XML files. This addresses an issue that came out of the phase-one observations requiring an improvement in monitor data reliability over ICCP.

The DR-SOC DOE-Server for handling all specialized software for the project was built. This runs FreeBSD UNIX. A custom list of software packages that are needed to support the Phase II functionality was installed. The machine was racked and attached to the ICCP gateway using a Virtual Local Area Network (VLAN) so that the two machines can share the VPN links put in place between the DR-SOC, and the Detroit Edison MOC and SOC. This machine utilizes the VPN to send generation offers to MISO (via MOC) and receive offer acceptance from MISO. Additionally, it utilizes the VPN to trigger daily DEW calculations at Detroit Edison and receive the results of these calculations.

a. ICCP points for the link between the DR-SOC and MOC were manually added to the SISCO AX-S4 ICCP application on the ICCP gateway. The link was established with the help of MOC engineers. Similar to the link with Detroit Edison SOC, test data was used to validate the link.

b. With the DOE server built, DR-SOC began development work necessary to migrate the current DTA (economic dispatch) application from the Windows environment on which it currently runs to the UNIX environment installed on the DOE server. The majority of this work was the replacement of the BEA Weblogic portion of the software that schedules the many tasks the application performs. The appropriate replacements were made and the application was regression tested against existing sites.

c. With both ICCP links active, DR-SOC developed the software to communicate between XGate (the XML interface to the SISCO AX-S4 ICCP software) and the database that stores all data from the distributed energy resources. Monitor data was checked for correctness on both ends of the link. Special points were set up to provide MOC with real-time site-level MW data from the device-level kW data that is stored in the DR-SOC system. These points sum the amount of generation for a particular site (or node) and divide by 1000 to get MW.

d. A prototype DEW-trigger Web Service was tested at DR-SOC. The Web Service that runs on the DOE workstation at Detroit Edison receives XML generator information from DR-SOC on a daily basis. This triggers the DEW calculations for the following day.

e. The DTA application was deployed on the UNIX-based DOE server at DR-SOC. The application is written in Java, a platform-independent language, however a platform-specific version of the JBoss application server was required to run the application on UNIX.

f. The first of which was the Web Service that DR-SOC uses to retrieve the offer-acceptances from MISO (via MOC). A prototype of this Web Service was successfully tested. The second Web Service allows DR-SOC to post the generation offer to MOC's nMarket server.

Security

Security of all data was a critical aspect of the project. Data encryption was accomplished using a variety of tools. These tools included a combination of VPN and SSL, password protection of all control interfaces, limiting user access, and physical security of all servers and interface terminals.

The design phase also uncovered many IT architecture issues that were not foreseen in the initial scope, such as an ICCP secure socket layer (SSL) can not be established between DR-SOC and MOC because the MOC EMS operating system is not able accept the ICCP SSL. This is due to the age of the EMS software at MOC. A work around is to establish a secure VPN using ICCP without SSL. The communication link between DR-SOC and Detroit Edison SOC can accept an ICCP SSL as part of the original scope allowing us to test that functionality.

DR-SOC Integration with DEW

Overview

A key aspect of the Detroit Edison Advanced Communication & Control of Distributed Energy Resources – Phase II project was the integration between the DR-SOC and the Distributed Energy Workstation (DEW). A major goal of the project was to provide added reliability to the Detroit Edison distribution system using DER. With the DR-SOC possessing intimate knowledge of DER operations and the DEW possessing intimate knowledge of the Detroit Edison distribution system, these two entities work well together to achieve this goal. In order to work together effectively the DR-SOC and DEW must share the information they possess with one another. This was achieved electronically by passing XML files between a pair of Web Services:

Generator Info File (sent by DR-SOC to DEW)
DEW Results (sent by DEW to DR-SOC)

The first file is used by the DR-SOC to remotely trigger the DEW application's calculations and the second is used by DEW to return the results of its calculations to the DR-SOC. The DR-SOC then uses the DEW results in composing the energy offer for MISO.

Triggering DEW Remotely

In order for DEW to make the appropriate calculations on the DER and aggregate zones involved in the project, it requires the most up-to-date information about each of them as possible. This information is provided in XML form by the DR-SOC once a day at 1:00AM. The following information is included in this file:

Generator Name:
This is an identifier that DEW uses to identify a particular DER on the distribution system.

Aggregate Zone:
This is the aggregate zone name to which the DER belongs. This is the CP-node identifier that is registered with MISO.

Minimum KW:
This is the minimum kW output that the DER is capable of producing.

Maximum KW:
This is the maximum kW output or capacity that the DER is capable of producing.

Real-Time Flag:
This is a flag indicating that real-time output data is available. In other words the kW and kVAr values provided in this information set are current and valid.

KW:
This is the amount of active power that the DER is currently generating.

kVAr:
This is the amount of reactive power that the DER is currently generating.

Load Following:
This is a flag indicating whether or not the DER is capable of load-following. All non-sellback stand-by DER must be able to load-follow in order to serve customer loads when they are transferred off of the grid. Sellback DER need not be load-following, although many are capable. DER such as Hydrogen fuel cells are not good for load-following and this value would consequently be set to false.

Aggregate Hour:
This is a set of 24 flags corresponding to the 24 hours in a day, indicating whether or not the DER is available for that hour.

Once DEW receives the Generator Info XML, it immediately begins running its calculations based on the data therein and the real-time conditions on the distribution system. It receives its distribution system data from the Detroit Edison SCADA system

Handling DEW Results

It was unknown exactly how long the DEW calculations will take to complete, so the DR-SOC developed a Web Service that allows DEW to post its results back asynchronously. The results arrive in XML format to the DR-SOC, where they are then parsed and stored to a database.

The DEW results are divided into two main sections: Reliability Information and Load Forecasting. These sections combine to provide the DR-SOC with all the information it needs to run its DTA algorithm in Aggregate Dispatch Mode. The following describes each section of the DEW results and the data they provide:

Reliability Information:
This section provides DER-level recommendations based on what DEW has calculated as the most beneficial way to operate the DER for the purpose of adding reliability and support to the Detroit Edison distribution system. The DEW reliability information contains a set of 24 records for each of the DER specified in the Generator Information XML; one record for each hour in the Day-Ahead. Each record contains the following information:

a. Hour Number:
   This is the zero-based number of the hour of the day that this record represents (0-23).

b. Reserve Margin:
   This parameter is an input to the DTA algorithm, but is currently unused.

c. N-1 Requirement:
   This parameter is an input to the DTA algorithm, but is currently unused.

d. Unit List:
   This is a list of the DER and a number of parameters specific to each. Units are only included in this list if information about them has been provided by the DR-SOC in the Generator Information XML, used to trigger DEW. The following parameters are defined for each DER in the Unit List:

   1. Unit Name:
      This is the shared name that DEW and the DR-SOC use to identify a particular DER.

   2. Must-Run kW:
      If this value is greater than 0, the DEW has calculated that this unit must run for this hour due to some issue on the distribution system. The value itself represents the active power this DER must generate for the hour.

   3. Must-Run kVAr:

If this value is greater than 0, the DEW has calculated that this unit must run for this hour due to some issue on the distribution system. The value itself represents the reactive power this DER must generate for the hour. This value is not used by the DR-SOC because VAr control is not implemented on any of the project DER.

4. Maximum kW:
   If this unit is part of a sellback DER site, then DEW will provide a kW value over which the DER may not be dispatched. This value could be less than the capacity of the unit if DEW calculates that the necessary 4:1 utility-interconnect protection ratio (Total Load: Generator Output) may be violated. The maximum kW that is provided represents the maximum active output of the generator for the hour while still maintaining that ratio. This is based on a predicted load at the point of common coupling.

Load Forecasting

This section provides the DR-SOC with load forecasts for each DER site (not aggregate zone) for each hour of the Day-Ahead. Rather than attempt to forecast the load within the DTA algorithm, it was determined that it would be more accurate to use DEW for utility customers whose load is not currently monitored by DR SOC. DEW has more resources from which to draw information as well as a more sophisticated prediction algorithm that even takes into account weather forecasts in its calculations.

The DER-site load forecast that is provided in this section is the load at the point of common coupling associated with a DER-site. Where meters were not available, the DR-SOC installed temporary meters at the circuit head and send data back to Detroit Edison for use in the load forecasting algorithm via ICCP and into PI.

The DR-SOC stores the 24-hour load forecast for each DER-site in a database and retrieves the data when it begins running its DTA algorithm. The load of the DER-site is an important input to the DTA algorithm and by utilizing that which is provided by DEW, DTA has a better chance of calculating accurate results.

DR-SOC Integration with MISO

Overview

The integration of the DR-SOC with the Midwest ISO was an integral part of the Detroit Edison Advanced Communication & Control of Distributed Energy Resources – Phase II project. In order to receive economic benefit for running the DER, the DR-SOC designed infrastructure to bid the DER into the MISO energy market electronically without human intervention. Nearly all communication between Energy-Aggregator (DR-SOC) and MISO occurs through the MOC using nMarket Web Services.

This infrastructure consists of five steps, each required to complete a sale. Table 3 lists each step:

#	Description	Source	Destination	Method	Timing
1	Energy Offer	DR-SOC	MOC	Web Service	Daily
2	Market Result	MOC	DR-SOC	Web Service	Daily
3	Settlement Data	DR-SOC	MOC	Web Service	Daily
4	Real-Time Meter Data	MISO	DR-SOC	Web Service	Real-time
5	Real-Time Notifications	DR-SOC	MOC	ICCP	Real-time

Table 3: MISO Communication Steps

These steps will be detailed individually in the following section. The following timeline displays when the first three, non-real-time steps are executed (the two real-time steps are executed constantly):

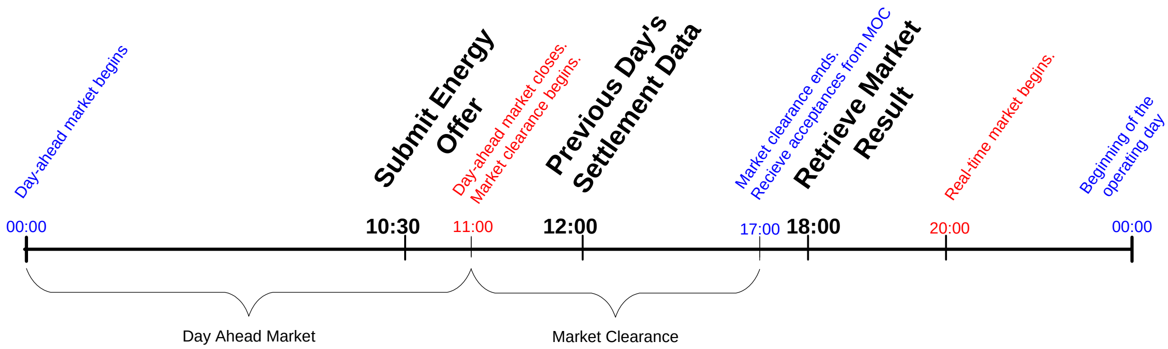


Figure 17: MISO Communication Timeline

A key entity in the DR-SOC's communication with MISO is the Detroit Edison Merchant Operation Center (MOC). The MOC served as the liaison between the two parties because of their existing role as a registered Market Participant in the energy market. All communication included in the aforementioned five steps occurs between the DR-SOC and MOC with MOC in turn communicating the appropriate information to MISO. The Project DER registered with MISO separately from Detroit Edison generation to ease financial settlement process

Aggregate Zone Registration

In order to participate in the MISO energy-market, each aggregate zone had to be registered with MISO as a Commercial Pricing Node (CP-Node). The DER Sites in the Detroit Edison service area are grouped into Aggregate Zones based on the transmission node to which they are assigned. The registration process was handled by the Detroit Edison MOC and included providing MISO with such information as zone ID, minimum MW output, maximum MW capacity, average start-up cost, etc. Many zones contained multiple units, some even spread among multiple customer DER sites. The sum of each unit's maximum output was used as the maximum capacity for the entire zone, and the lowest of the minimum output levels of any unit in the zone was provided as the minimum output for the entire zone. Energy offers for MISO are generated on an aggregate zone level.

In Figure 18 gives examples of various combinations of DER, Sites, and LMP or Aggregate Zones. Western Wayne example is an example of a LMP node with a single DER site on single circuit. The Brownstown 40kV LMP node is an example of two single DER each on different sites each on their own circuit within the aggregated zone. The Southfield LMP node is an example of multiple DERs on multiple sites each on different circuits within the aggregate zone. The DTA architecture between DEW and DR SOC accommodates all of these possibilities.

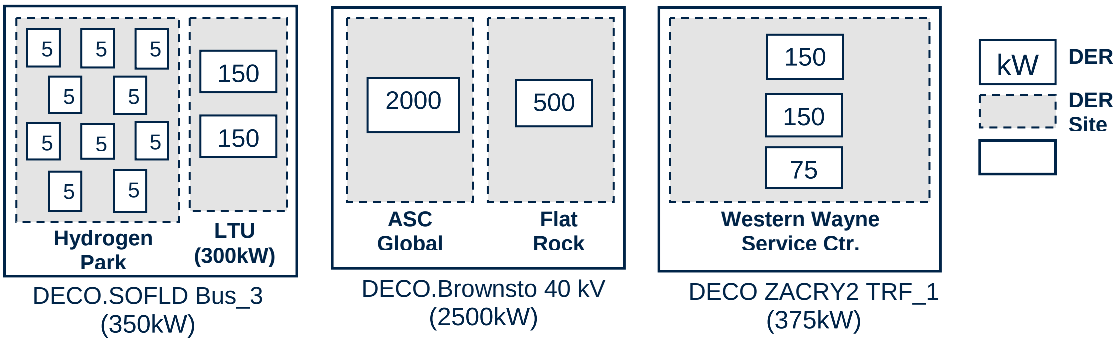


Figure 18: Aggregate Zones Examples

Energy Offer

The energy offer is the most important of all steps involved in selling DER power into the energy market. As the name suggests, the energy offer presents the cost of operating each aggregate zone to MISO. They may then either accept or reject the offer based on their predictions of demand and the cost of energy. This process occurs daily, although once an offer is submitted to MISO it remains in effect every subsequent day unless a change request is made and submitted. The DR-SOC submits an offer daily because of Detroit Edison's consideration of the reliability of the distribution system. The state of the distribution system can vary day to day with the weather and other volatile factors, in turn affecting the contents of the offer.

The DR-SOC makes its offer into the Day-Ahead market so data must be submitted by 11:00AM CST each morning. At 11:00AM CST, MISO begins the Market Clearance period where it matches up offered energy with demand bids.

The offer consists of two separate XML files that are transmitted to the Detroit Edison MOC each day at 10:30AM. The XML files are posted to the Detroit Edison MOC's production nMarket server which is the communication hub between MISO and Detroit Edison. The nMarket server provides a Web Service called the Import Servlet which the DR-SOC uses to post the files. These files both contain data for all registered aggregate zones:

Operational Parameters

The operational parameters file tells MISO how to interpret the price curve for each aggregate zone. This is called the "Commit Status". The values that can be set for this parameter are "ECONOMIC", "MUST RUN", or "UNAVAILABLE". Because MISO does not allow fractions of an aggregate zone's capacity be assigned different Commit Statuses, for any zone that is available for aggregations, the DR-SOC specifies as "ECONOMIC". This directs MISO to examine the price curves for that zone to determine whether to accept the zone's capacity into the market. On the other hand, if an aggregate zone is not available to be offered into the energy market, the DR-SOC will specify its Commit Status as "UNAVAILABLE". This will direct MISO to ignore any price curves for the zone and automatically exclude it from the market. The operational parameters, like any other part of the offer, will remain in effect until updated. For the purposes of this project, the operational parameters for each zone are updated daily even if nothing has changed for any particular zone.

Aggregate Zone-level Price Curves

The price-curve file contains the data that MISO uses to determine if an aggregate zone deemed "ECOMONIC" in the operational parameters file should be accepted into the Day-Ahead energy market. 24 price curves exist in this file for each aggregate zone that is registered with MISO, one curve for each hour of the Day-Ahead. Curves can range from 1 to 16 price points. Each price point consists of a MWh value and a corresponding $/MWh value. MISO requires these price points be listed in descending order by MWh value.

The DR-SOC software generates the price curves for each zone based on the recommendations resulting from its DTA software calculations. A script is run each day at 10:30PM, which aggregates the set of units in each zone such that a curve is formed by creating various combinations of the DTA-dispatched units within the zone. Each combination represents a price point on the curve. The total cost of running each of these combinations is then computed and the points are sorted in descending order by total capacity.

Market Result

The market result is computed by MISO and retrieved daily by the DR-SOC after the Day-Ahead market has cleared. The Day-Ahead market clears based on the energy offer that is submitted to MISO prior to the 11:00AM CST deadline. Market clearance for the Day-Ahead ends at 5:00PM CST, after which the DR-SOC can retrieve the market result. The retrieval of the market result occurs by way of the MOC by accessing another Web Service on their nMarket server called the "Outbound API". The DR-SOC provides a query XML file to the Web Service which specifies which parameters from the market result it requires. These parameters include the desired timeframe, which is the entire 24 hour period of the Day-Ahead. Additionally, it specifies that it requires the MWh and price at which each zone has been accepted for each of the 24 hours. If the MISO has chosen not to accept a zones offer for a particular hour, the MWh value will be 0.

After receiving the query, the MOC returns the appropriate market result data to the DR-SOC in an XML file. This XML file is parsed by the DR-SOC and results stored for use during the operating day (the Day-Ahead itself). If an offer has been accepted for a particular zone for a particular hour, the MWh and price specified in the market result will match a price point on the offer curve for that zone and hour. The DR-SOC tracks which units are included in each price point and will flag the units included in the accepted price-point for operation during the hour in question the next day. When that hour is reached the next day, the DR-SOC dispatches the appropriate commands to each DER in the field to operate according to MISO's acceptance for the entire hour.

Settlement Data

Detroit Edison must send daily metered Settlement Data to MISO in order to receive financial settlement for operating according to what had been accepted into the market. The DR-SOC takes responsibility for providing this data to MISO because of its intimate knowledge of the operation of the units. The DR-SOC aggregates the output of all generators in an aggregate zone each hour of a day and archives the data in its database. The following day, at 12:00 noon CST, the DR-SOC transmits this data in XML form to the MISO via MOC for each aggregate zone. MISO uses this data to verify that the units that were accepted into the market actually ran as expected, and then assesses the appropriate awards and/or penalties accordingly.

Real-Time Meter Data

MISO must consider what happens on the transmission system in real-time as an Independent Service Operator. Consequently what has been arranged to run in the Day-Ahead market might not always serve the ISO's number one priority, system reliability. To address the issue, MISO has developed a system which allows it to modify its operational directives for CP-Nodes in real-time. A key element to this system is that MISO must be aware of the state of each CP-Node in real-time in the form of meter data.

The DR-SOC provides real-time meter data to MISO by way of MOC using ICCP. MISO normally requires billing-grade meter data for these purposes but due to the nature of the project, non-billing grade generator output data is acceptable. The DR-SOC aggregates the generator output of all generators in a particular aggregate zone and passes the data to MOC as a real-time MW value. The value is updated every time any generator in the zone reports data back to the DR-SOC from the DER site.

Real-Time Notifications

MISO can make modifications to what it has accepted into the Day-Ahead market in real-time using Real-Time Notifications. The notifications are dispatch commands sent approximately every five minutes that should match up with what has been accepted into the Day-Ahead market, however MISO can deviate from its original plan if conditions on the transmission system require.

Unlike the other tasks involved in integrating with MISO, the Real-Time Notifications do not go through the MOC. They are posted by MISO directly to a Web Service at the DR-SOC. Due to time constraints, the DR-SOC was unable to act on these notifications, but rather followed what had been accepted into the Day-Ahead market only.

The DTA Economic Dispatch Algorithm

Overview

In 2003, DTE Energy Technologies developed a proprietary economic dispatch algorithm (DTA) that works in conjunction with its existing DER monitoring and control infrastructure. DTA considers electric and thermal costs of DER vs. grid/boiler to determine the best economic operating conditions for the customer.

The Algorithm inputs are as follows:

- Static DER Parameters (Maintenance Costs, Capacity, Efficiency, etc)
- On-site Conditions (Electric Load, Thermal Load, Ambient Temp., etc)
- Real-time Electricity and Fuel Prices

The algorithm output consists of hourly recommendations for economic operation of DER for each site.

DER Site Setup

Prior to major development work on the DTA algorithm, the sites involved in the project had to be prepared for use by DTA. The sites already existed in the DR-SOC monitoring system but were not set up for economic dispatch, which is the basis of aggregated dispatch.

DTA Algorithm Changes

The first step in modifying the DTA economic dispatch algorithm was to create a series of new database tables to support the aggregated dispatch functionality required by the project. Tables were created to store DEW results, store day-ahead DTA results to be offered to MISO, to store site-commands based on MISO acceptance, and to store additional configuration parameters.

The next step in modifying the DTA economic dispatch algorithm was to create a set of scheduled jobs that run within the algorithm during aggregated dispatch. There were three new jobs created

Calculation Job:
This is the primary job that is responsible for taking the DEW reliability recommendations, DER parameters, and site/zone information to calculate the most economic way to operate the DER such that reliability is maintained. This job runs once a day, after DEW results have been posted, and generates results to be used in the day-ahead offer to MISO.

Command Issuer Job:
This job is responsible for issuing commands to the DER sites themselves and runs on an hourly basis. Once MISO has accepted day-ahead offers, this job will consult the database to construct site commands that are in accordance with what has been accepted and issue them to the sites. This job runs hourly.

Database Cleanup Job:
This job is responsible for managing the amount of data that is generated by the aggregated dispatch algorithm. Because multiple tables are required to support this functionality, a plethora of data is generated every day. This job will delete any data in these tables that is older than one week to keep them at a manageable size. This job runs daily.

The DTA aggregated dispatch method had to be modified for the point of common coupling (PCC). The load forecasting at the common point of coupling for each DER site was initially to be calculated by DTA. However it became apparent that necessary metering on the DR-SOC system was not available for all sites so the load forecasting responsibility was moved to DEW. At some sites the aggregator may not have access to the customer load information directly. DEW utilizing utility information has access to metering at the points of common coupling as well as weather data and other information which allow it to make much more accurate load forecasts and thus allow for more accurate economic calculations by DTA. This information will be provided in the same XML file as the DEW results.

It was determined that DEW must provide DR-SOC with information on the maximum kW output that each DER may generate as part of its results package. This information will only apply to sites in which a ratio of DER-output-to-load must be maintained according to DER interconnection standards. DTA is to utilize the DEW-provided maximum kW as the effective capacity of the DER unit in its calculations.

To support the DTA aggregation method changes, a database table was created to store the DEW-generated load forecasts and changes were made to utilize the DEW-specified maximum kW for each unit as the effective capacity of that unit. Support for the DEW-specified must-run units was previously unavailable but was also implemented in this phase of development.

A test site was required to validate the changes that had been made to support the new aggregated dispatch functionality. Rather than using any of the commissioned sites involved in the project, DR-SOC modified an existing de-commissioned site to test each new feature. The testing was ultimately successful.

A meeting between DR-SOC and MOC took place in which details of the energy-offer were discussed. Plans were changed slightly when MOC opted to use their third-party nMarket server to receive the offer rather than a custom Web Service. Changes were made to the DR-SOC software to support this new system.

Problems and Challenges

Temporary Meters

A problem arose when it became clear the Detroit Edison SCADA system did not monitor circuit load data for each circuit equipped with a DER. This data was needed to validate the load reduction when DER’s were dispatched. In addition, this data assists Detroit Edison in evaluating circuit overload conditions. Project deadlines didn’t allow enough time for Detroit Edison to install the necessary meters and communications to provide this data to DEW using its SCADA system.

It was decided that temporary meters had to be installed. The DR-SOC offered a viable solution because of its low-cost and short installation time. Additionally communication lines already existed between the DR-SOC and Detroit Edison that could be utilized to provide the data to the Detroit Edison SCADA system and DEW. PML ION meters were installed at the appropriate sites. These meters have the ability to email their data back to the DR-SOC servers over a wireless service. At the DR-SOC, software was developed to receive these emails, parse them, and then insert their content into the database where it could then be passed over the ICCP link along with all of the other DER site monitor data.

Intra-zone MISO Operational Parameters

The way the DR-SOC integrates with MISO is unique because unlike most market participants, Detroit Edison's CP-Nodes are actually made up of multiple power sources sometimes spread among multiple locations. At the transmission level, MISO treats each aggregate zone (Commercial Pricing Node) as though it were one large generator. Consequently, their offer framework does not allow the market participant to specify a variety of commit statuses within an aggregate zone. MISO will only pay the LMP for must-run generation whereas economic generation is paid depending on what is offered and the demand in the market.

The reason this is a concern is because DEW can specify any subset of a zone's capacity as must-run. However the DR-SOC cannot, within the offer, identify that capacity as must-run while identifying the remainder as economic. If the must-run generation is offered as economic, MISO could choose not to clear it to run, then a penalty could be incurred when the unit does run. On the other hand, if the economic units are offered as must-runs, Detroit Edison would not make money because the LMP could often be less than the cost to run the unit. Furthermore, Detroit Edison would be committed to running each unit it offered even at a loss or risk incurring penalties.

To address this issue it was decided that all aggregate zones would be offered economically. However to ensure that the DEW-specified must-run units would be cleared into the market, it was decided that the price curve for these units would be set low enough to guarantee a sale. The exact level was decided to be $35 at the time of the demonstration based on historical data from the Detroit Edison MOC. However, this value could be changed manually at the DR-SOC if daily LMPs changed. With this scheme, the must-run units are still run at a loss, however rather than a total loss as in the case of non-participation in the market, Detroit Edison is still guaranteed enough payment to offset a fraction of its costs to run.

MISO Price-Curve Format

A problem arose as result of MISO typically dealing with much larger capacities. The XML file format that MISO specifies to provide energy offer price curves only allows for 100kW resolution in the MWh value of each price point. The implications of this are that for sites where units exist with capacities less than 100 kW, combinations of the units are limited. Limiting the number of combinations of units results in less points on the price curve for each site. Unfortunately there is nothing to be done to resolve this other than lobby MISO to change the resolution of their price points to accommodate DER and smaller-capacity units.

ICCP Generator Control State

During testing of the Detroit Edison SOC's control of the DER over ICCP, it was discovered that a restart of the OSIsoft PI connection to the ICCP link, would cause PI to immediately dispatch values to all of the control points according to the last state it had stored for each point. This was a problem on multiple levels.

First of all, if a control point had never been sent, PI would maintain a value of zero for that point as its default state. Consequently, if the PI system was rebooted, it would immediately send a zero for these points without knowledge that control had never been initiated using those points. The results could be disastrous. If a unit was under DTA control or serving a customer on standby because of an outage, the zeros coming over the link would cause the unit to be shut down immediately. A similar result arose when control had been sent to a unit over ICCP such as a start command. If the unit had since been shut down by other means for maintenance purposes or because MISO did not want the unit to run and the link was restarted, the start command would immediately be re-issued. This could cause serious problems if the unit was not supposed to be running.

To address this issue, the DR-SOC added a write-back value. This way if the link was restarted and the write-back value was sent, the DR-SOC would ignore the update. This scheme takes the responsibility of tracking state out of the hands of the PI server and leaves it solely with the DR-SOC where it belongs.

Forecasting LMP in DTA

A key input parameter of the DTA algorithm is the price of electricity from the utility. This value is used in a comparison with the cost of running DER to determine which the more economic power source is. With the new Aggregate DTA, this comparison is performed for times in the future, for this reason the price of electricity, specifically the LMP that MISO uses must be forecasted to allow the algorithm to make an accurate decision.

Due to the limited availability of to-the-second real-time forecasting data, the DR-SOC implemented a forecasted LMP algorithm that uses the current LMP data, day-ahead LMP predictions as well as the previous day’s calculated estimations from MISO, adjusting the price curve based on minimum, average and maximum current 5-minute LMP data for the main Detroit Edison Commercial Pricing Nodes and a daily configurable pricing structure. The output of this algorithm has produced results that fall within 15% of the actual market price, baring major disruptions and outages. Considering project deadlines and available resources, this was determined to be acceptable accuracy.

DEW Work Completed

Overview

Detroit Edison’s uses DEW which combines both demand loads and kWHR load data coupled with load research statistics for estimating on the distribution system models.

DEW has analysis programs;
Component Admittance – calculates all real 3-phase admittances as a function of line construction.
Load Estimation – estimates loads from consumption data, kWHR, and load research statistics as a function of time.
Power Flow – Calculates independent circuit flow phase parameters e.g. voltage & current
Network Fault – Calculates fault currents for looped and multisource distribution systems (75% of DECo’s 4.8kV Delta system has 3 and 2 phase closed loop or rings)

Fuse Checker - Specific analyzes DER's fault current impact on the existing distribution protection system over sub transient, transient, and either synchronic or saturated conditions
Reconfiguration for Restoration – Determines how to reconfigure a distribution system of circuits after an outage has occurred or been planned to restore as many customers as possible with causing overload or low voltage.
Loss Minimization - Determines how to reconfigure a distribution system of circuits to minimize cost.
Real Time Power Flow – Power Flow linked to PI providing real time calculations responding to changes in measurement data. This functionality was developed during Phase I of this project
DR Control – This functionality was developed during Phase I of this project to run on top of the real time power flow calculating the amount of DER output necessary to correct an overload or low voltage if present.

These existing applications will be used to handle power quality, reliability, and internal economics involved with the dispatch of DERs.

The primary work within DEW centered on developing hourly load forecasts based upon weather conditions and further development of DR Control algorithm. The forecast work was required to provide accurate day-ahead forecasts using temperature normalized load research statistics.

The further development of the DR Control, developed in Phase I of this project, was to integrate it with the forecast particularly to determine the minimum and maximum DG levels including must runs

A Contingency Analysis application was developed that allowed the automatic outage and assessment of the loss of any single element such as loss of circuit head. This application can be streamed with the Reconfiguration for Restoration Analysis application to assess circuit reliability.

The Reconfiguration for Restoration Analysis was then modified to make use of DGs in power restoration operations. Modification of the existing Reconfiguration for Restoration were made including load shedding which together with DG has been implemented as an option in the program. See Appendix E for example reliability calculations with the use of DG.

Weather-Dependent Load Forecasting

The DG Control process primarily uses estimates of circuit conditions rather than measurements. Estimating the loading of customers throughout the circuit model plays a central role in the success of the control. Because system load is usually monitored at only a few points in the circuit, determining circuit loads accurately is a challenging process. The flows at the majority of points in a circuit are estimated by control software, as opposed to obtaining the flow information through instrumentation and communication hardware that need to be installed throughout the many miles of the distribution circuit. For this estimation, the software uses a model of the circuit along with historical customer load data and load research statistics. The circuit model and load data includes

- Multi-phase circuit topology information
- Type, status, rating, configuration, impedance, and admittance of the components present in the circuit
- Location and classes of customers connected throughout the circuit
- Raw load research data for the various classes of customers
- Load research statistics for the various classes of customers
- Historical kWh and/or kW/kVar measurements for the customers

The circuit model is detailed so as to include the distribution transformers and secondaries, where numbers of customers fed by each transformer and the load research class of each customer are modeled.

In general, load is monitored at substations, major system equipment locations, and major customer (load) sites. Besides such load data, the only load information commonly available is billing-cycle customer kilowatt-hour (kWh) consumptions. The estimation of load is described next.

Start-of-circuit Measurements

Start-of-circuit measurements generally consist of voltage magnitude, current magnitude, and/or power flows. They are used to affect scaling of estimated loads throughout the distribution circuit model such that the power flow solution matches the start-of-circuit measurements.

Historical Load Measurements

Historical load measurements consist of monthly kWh measurements or periodic (such as every 15-minute or hourly) kW/kVar measurements obtained at customer sites. These measurements are used in the estimation of loading at each customer site in the circuit model.

For a few, mostly large customers, kW, and sometimes kVar, measurements are available. The kW/kVar measurements are available at least once an hour. Thus, for a non-leap year, there are 8760 measurements for a given customer.

For the kWh measurements, there are 12 measurements used for each customer. These kWh measurements do not match those in the billing system, but are parsed so that the values for all customers line up on monthly boundaries. This will be discussed further below. The historical customer load measurements are stored in database tables and loaded into computer memory with the circuit.

Load Research Statistics

With the help of electronic recorders, utilities can automatically gather hourly sample load data from diverse classes of customers. This raw data (load research data) is then analyzed to obtain load research statistics. For a given month, day, hour of day, and weather condition, the kWh measurements are combined with load research statistics to predict kW/kVar loading levels.

The fact that kW/kVar loads are monitored at a very limited number of customer locations leaves us with billing-cycle kWh consumptions being the most commonly available load information. Load research statistics are used to estimate power consumptions from the kWh-metering readings. The load research statistics are a function of customer class, numbers of customers, type-of-day, type-of-month, hour-of-day, and weather condition.

Examples of customer classes modeled by load research statistics include such classes as “residential with electric heat”, “residential without air condition” and “small commercial.” Depending upon the amount of raw load-research data available, day types may be modeled as weekdays, weekends, and holidays, or as Monday, Tuesday, Wednesday, and so forth. Similarly, month types may be modeled as winter, summer, spring and fall, or as January, February, and so forth. Examples of weather conditions include "hot, humid, no wind July day" or "normal day in July." Weather conditions are defined by temperature, humidity, and wind speed ranges. Once hourly load estimates are available throughout the circuit, the power flow can use the load estimates to predict circuit flows.

There are four types of load research statistics used in the calculation, which are parsing factors, C-factors, diversity factors, and diversified load curves. With sufficient raw load-research data, these statistics may be calculated as a function of weather conditions. These elements of load-research statistics are explained below.

Kilowatt-hour Parsing Factors

For the most part customer kWh usage is not recorded at the end of the last day of each month. Hence, billing meter data does not directly reflect energy usage within individual months. In the application of load research statistics, the first step is to obtain estimates of monthly kWh usage. Parsing factors are used for this purpose. For a given customer class, the parsing factors represent the annual, fractional energy usage as a function of the day of year.

Figure 19 depicts a parsing factor curve for a residential class of customer. The parsing factor varies between 0 and 1.0 and is plotted on the y-axis. The day-of-year is plotted on the x-axis. Consider the month of February, where it is assumed that a kWh measurement is taken on February 5. This measurement reflects kWh usage from January 15 to February 5.

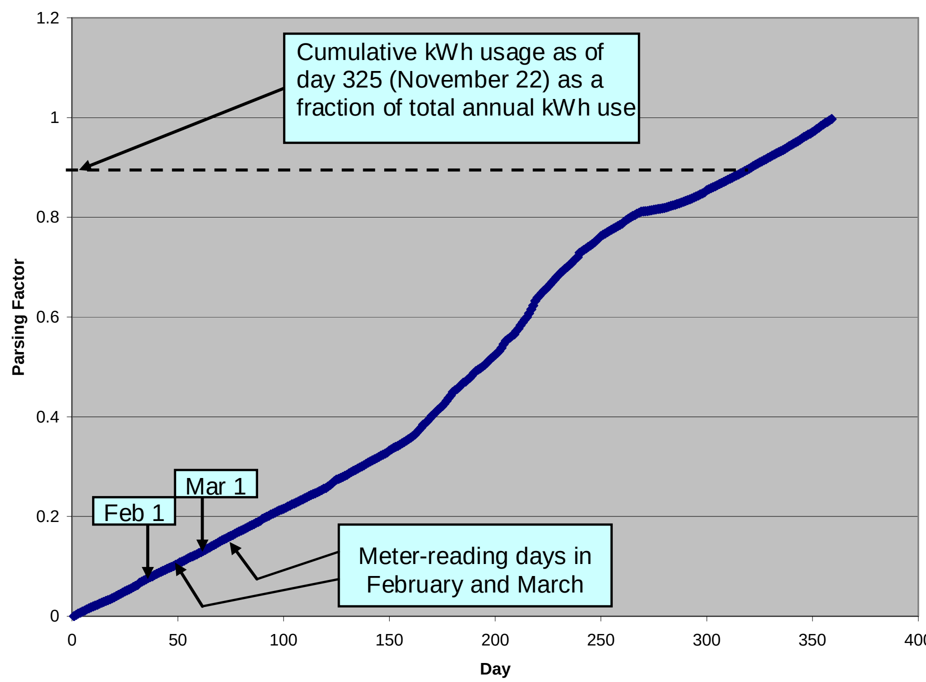


FIGURE 19 Parsing factor curve for residential customer

In Figure 19 it is assumed that another kWh measurement is taken on March 10, reflecting the kWh consumption between February 5 and March 10. Using ratios of parsing factor differences, the parsing factor values for January 15, February 1, February 5, February 28 and March 10 can be used to estimate the kWh usage during February. That is, parsing factor values corresponding to the meter-read dates and the monthly boundaries are used to estimate energy usage during a month, where billing meter reads are not performed on monthly boundaries.

kWh-to-peak-kW Conversion Coefficients (also referred to as C-factors)

C-factors are used to convert kWh measurements for a customer to peak-kW estimates. The C-factor is calculated as a function of class of customer, type of month, type of day, and weather condition. C-factor curves are typically parameterized by the customer class, type of day, and weather condition; and plotted against the month of year.

Figure 20 illustrates a C-factor curve for weekend during March at normal temperatures (that is, normal temperatures for March at that location) as a function of month. Values read from this curve may be used to convert kWh measurements into kW-peak estimates for weekend days.

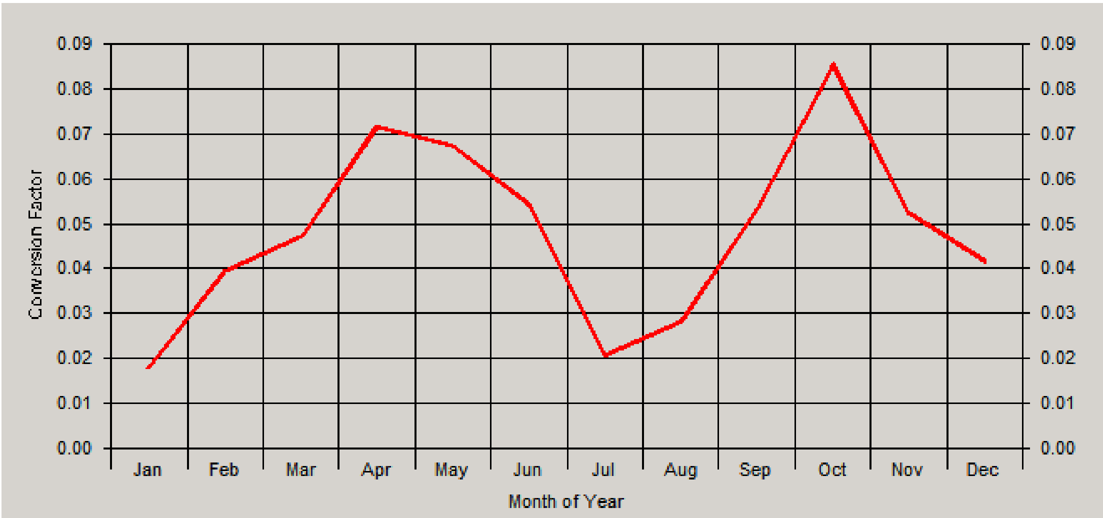


FIGURE 20 kWh-to-Peak-kW conversion coefficients for residential class for weekend days at normal weather conditions.

Diversity Factors

Diversity factors are used to find the aggregated demand of a group of customers. It is defined as the ratio of the sum of individual non-coincident customer peaks in the group to the coincident peak demand of the group itself. The diversity factors are greater than unity. They are defined as function of class of customer, type of month, type of day, weather conditions and number of customers. Diversity factor curves are typically parameterized by the customer class, type of day, type of month, and weather condition; and plotted against number of customers. Figure 21 represents a diversity-factor curve for residential customers for a weekday in March for normal weather conditions.

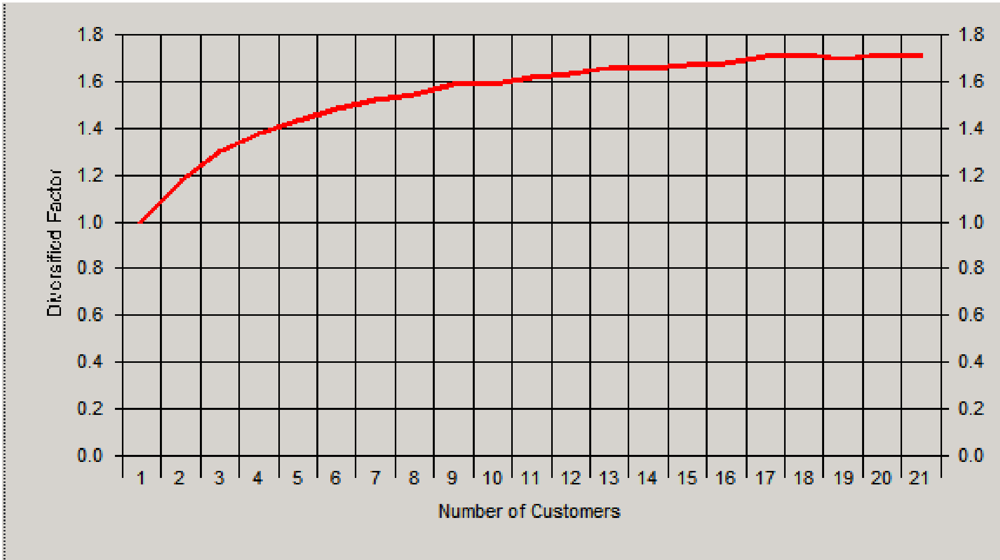


FIGURE 21 Diversity factor curve for residential class for weekdays during March at normal weather conditions

Diversified Load Curves

Diversified load curves are parameterized by class of customer, type of month, type of day, and weather conditions. They show the expected energy use for each hour of the day. Diversified load curves may be used to estimate loading as a function of the hour of day. Diversified load curves may be normalized by dividing each point on the diversified load curve by the peak of the diversified curve itself.

A diversified load curve is shown in Figure 22 for residential customers and normal weather conditions.

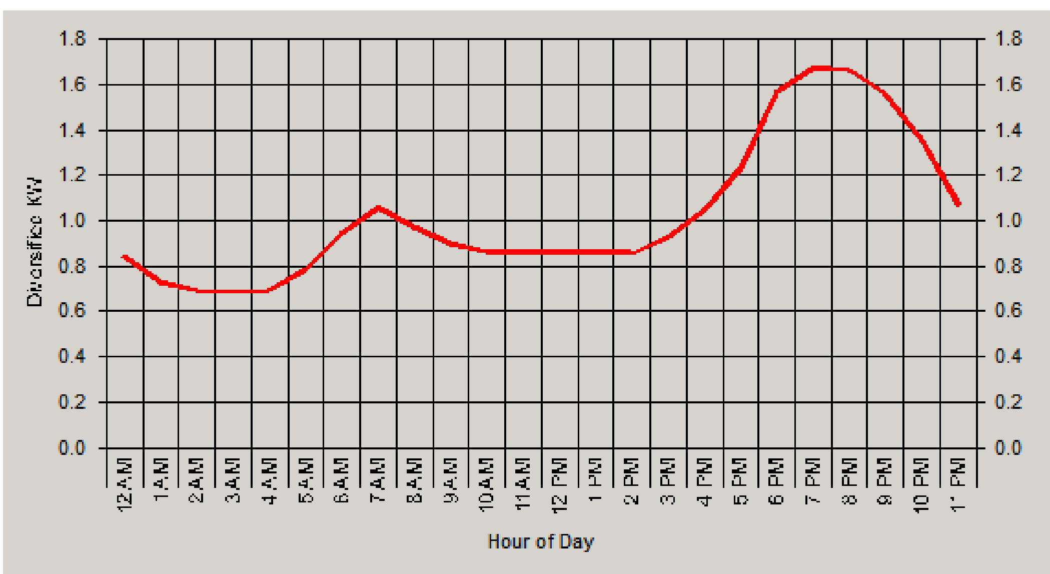


FIGURE 22 Example of diversified load curve for customers of residential class for weekdays in March at normal weather conditions

Temperature/Humidity Load Sensitivity Coefficients

Temperature/humidity load sensitivity coefficients are defined as a function of class of customer. They are used to scale loads to take into account temperature/humidity load sensitivities. They are calculated by correlating load research data with the weather conditions that existed at the time the load research measurements were made.

Weather data was obtained from Detroit Edison. This weather data was used with the load research statistics to calculate weather dependent load scaling factors.

The scaling factors are a function of temperature, where during hot weather the "heat index temperature" may be used and during cold weather the "chill index temperature" may be used. The scaling factors are being calculated as a function of customer class. In performing this customer class based calculation, weather data is correlated with raw load research data based on date/time stamps. A set of curves was developed which model temperature scaling factors as a function of customer class, type of day, and type of month.

This task was reopened when it was discovered that hourly forecasts were needed for the loading at DG sites. In order to identify the points in the circuit model where the hourly load forecasts were needed, two new symbols were added to the model. The new symbols represent sale-back and non-sale-back DG units. The points in the circuit model where the new symbols are placed represent **points of common coupling**, and are thus referred to as PCC points. The hourly forecast software was extended to develop hourly load forecasts not only at the start of each circuit but also for each PCC found within each circuit.

Example: Estimation of Load at a Circuit Point

An example load-estimation calculation is presented in this section. For simplicity, weather considerations have been neglected: Consider a point in a circuit, at which two customers of the same load-research class, say Class R, get power from the circuit. It is assumed that below this selected point the circuit is radial. The objective is to estimate the peak-kW of the group of these two customers for a weekday in March. Also, it is desired to calculate the combined kW load of the two customers at 2pm on a weekday in March.

Assume that the following monthly kWh measurements are obtained at the customer meters:

$KWH_{m1}(Feb18, Mar16)$ = Measured kWh usage of first customer between the dates February 18 and March 16.

$KWH_{m1}(Mar17, Apr17)$ = Measured kWh usage of first customer between the dates March 17 and April 17.

$KWH_{m2}(Feb20, Mar17)$ = Measured kWh usage of second customer between the dates February 20 and March 17.

$KWH_{m2}(Mar18, Apr19)$ = Measured kWh usage of second customer between the dates March 18 and April 19.

First, it is needed to estimate the energy usages of each customer during the month of March since the recorded measurements do not directly reflect the March usages. Parsing factors are used to estimate the March energy usage from the two measurements available.

Let $p(R, MonX)$ denote the parsing-factor value for customers of Class R for day X in month *Mon*. Using the kWh measurements given above, the estimated kWh-energy-use of Customer 1 during March is then calculated as follows:

$$KWH_{e1}(Mar1, Mar16) = KWH_{m1}(Feb18, Mar16)\,x\,\frac{p(R, Mar16) - p(R, Mar1)}{p(R, Mar16) - p(R, Feb18)}$$

$$KWH_{e1}(Mar17, Mar31) = KWH_{m1}(Mar17, Apr17)\,x\,\frac{p(R, Mar31) - p(R, Mar17)}{p(R, Apr17) - p(R, Mar17)}$$

$$KWH_{e1}(Mar) = KWH_{e1}(Mar1, Mar16) + KWH_{e1}(Mar17, Mar31)$$

where

$KWH_{e1}(Mar)$	= Estimated kWh usage of Customer 1 during March
$KWH_{e1}(Mar1, Mar16)$	= Estimated kWh usage of Customer 1 between March 1 and March 16
$KWH_{e1}(Mar17, Mar31)$	= Estimated kWh usage of Customer 1 between March 17 and March 31.

Similarly, the March-kWh-usage of Customer 2 can be estimated using the following calculations:

$$KWH_{e2}(Mar1, Mar17) = KWH_{m2}(Feb20, Mar17)\,x\,\frac{p(R, Mar17) - p(R, Mar1)}{p(Mar17) - p(Feb20)}$$

$$KWH_{e2}(Mar18, Mar31) = KWH_{m2}(Mar18, Apr19)\,x\,\frac{p(R, Mar31) - p(R, Mar18)}{p(R, Apr19) - p(R, Mar18)}$$

$$KWH_{e2}(Mar) = KWH_{e2}(Mar1, Mar17) + KWH_{e2}(Mar18, Mar31)$$

Next, the peak kW demand by the two customers together is to be estimated. For this we use the C-factors and diversity factors (d) from the load-research statistics. Consider the following:

$C(weekday, Mar, R)$	= The kWh-to-peak-kW factor value for customers of Class R for weekdays during March.
$d(weekday, Mar, R, 2)$	= The diversity-factor value for two customers of Class R for weekdays during March.
$KW_{peak}(Sum)$	= Sum of the individual kW peaks (non-coincident peaks) for the two customers.
$KW_{peak}(Group)$	= The group peak (coincident peak) for the two customers.

Then, the non-coincident and coincident peaks are calculated by

$$KW_{peak}(Sum) = C(weekday, Mar, R)\ x\ (\ KWH_{e1}(Mar) + KWH_{e2}(Mar)\ )$$

$$KW_{peak}(Group) = KW_{peak}(Sum)\ /\ d(weekday, Mar, R, 2)$$

Once the estimated peak of the group of customers on a weekday in March is estimated, the diversified load curve associated with Class R on a weekday in March can be used to see the daily load pattern. Then, the diversified load curve can be referred to for finding the time point (hour) of day at which the peak would occur. The kW demands at other time points can be examined as well. The normalized diversified load curve is used for this purpose. The normalized curve has the maximum value of unity at its peak-kW time point. Suppose *k(2pm, weekday, Mar)* is the normalized diversified load curve value for customers of Class R at 2pm on weekdays in March. Then, the estimated load at 2pm, $KW_e(Group, 2pm, weekday, Mar)$ is given by

$$KW_e(Group, 2pm, weekday, Mar) = k(2pm, weekday, Mar) \times KW_{peak}(Group)$$

Real-time Control of DG for Eliminating Circuit Problems

Distributed generation (DG) may be used to delay or even avoid large capital investments. Often a DG is used to solve problems that exist for only short periods of time. For instance, an overload or low voltage problem may exist on a circuit for perhaps 100 hours per year or less. In such cases the cost of the DG solution may be much less than any other alternative solution. Furthermore, the DG solution can often be implemented quicker than the alternatives.

Figure 23 illustrates the system architecture for DG control that is used to eliminate overload and/or under-voltage problems in a distribution circuit. The DG control may involve multiple DGs.

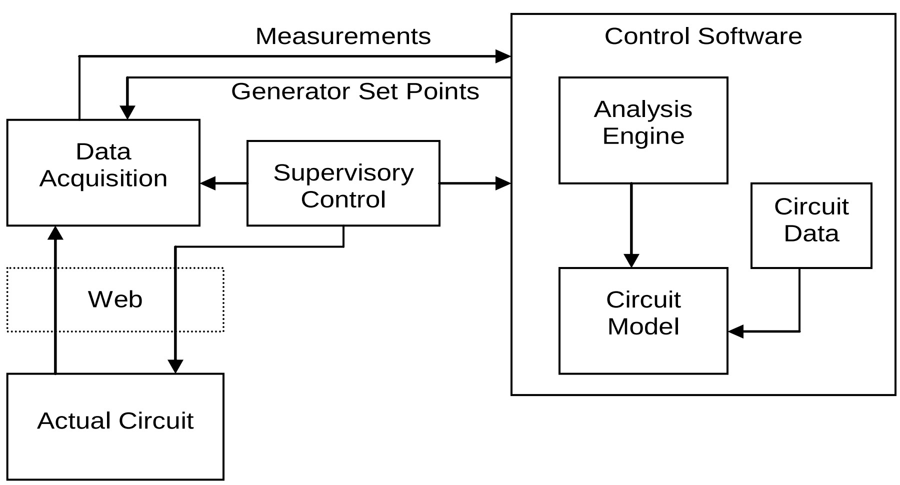


FIGURE 23 Block diagram of overall control system for circuit-problem elimination by DG

As illustrated in Figure 23, a real-time data acquisition system collects start-of-circuit and DG measurements, and perhaps internal circuit measurements, and provides these measurements as inputs to the control software. The control software houses an accurate model of the circuit along with historical load measurements. An analysis engine uses the circuit model, historical load measurements, load research statistics data and real-time measurements to estimate voltages and flows in the circuit. As part of the analysis, a check is made to see if any overload and/or under-voltage problems are estimated to exist. If problems are detected, the analysis engine simulates circuit flows that would occur as the DG generation is varied. This simulation is used to calculate DG generation levels that would correct the problems.

A simulated generation level that would eliminate the circuit problems is provided back to a time-series data storage of the data acquisition as recommended DG generation. The DG generation runs under supervisory control, and a system operator collects the recommendations made by the control software and makes a final decision as to the control actions that are actually taken.

Data Acquisition

Data gathered from instrumentation hardware on the circuit consists of measurements that are generally taken at the start-of-circuit and at the DG. OSIsoft PI, a time-series database is the major element in the data acquisition system. The time-series database performs the important function of time synchronization of the DG and circuit measurements.

The start-of-circuit measurements typically consist of voltage and current measurements, where currents are provided for all three phases. The DG measurements include the minimum and maximum allowable DG power generation and the actual kW and kVar generation levels at which the DG is running. The minimum and maximum power generation constraints represent generation levels at which operation is not practical. These levels may change as a function of the status of equipment at the DG location.

The real-time measurements are provided to the control software via the data acquisition system. The measurements incorporate measurement time as well as geographical location tags. The control software uses the geographical location tags to locate the components in the circuit model to which the measurements apply.

Supervisory Control

Supervisory control is performed by a system operator at a regional control center. The operator needs information concerning when the DG should be turned on and at what generation level the DG needs to be run in order to eliminate circuit problems. The control software continually evaluates circuit conditions and sends generation recommendations. The system operator reviews the recommendations and makes supervisory control decisions about whether or not generation actions should be taken.

As part of the system operator's decision process, the operator tries to ensure that the recommended generation actions will not cause any problems that may have been overlooked by the simulation. For this, the operator or his analyst may use the simulation software to perform further evaluations. This time the software runs in an interactive mode whereby the operator or analyst can review circuit conditions in greater detail.

After significant field experience, the system operators have gained confidence in the control system and software, and have requested the ability to go fully automated with the DG control.

Control Software

A functional view of the DG control algorithm inside the control software is shown in Figure 24. All the functions of Figure 24 share the same circuit model and data. As a matter of fact, the exchange of results among these functions occurs through the circuit model. As stated before, the circuit model can be detailed to the level of the distribution transformers and secondaries.

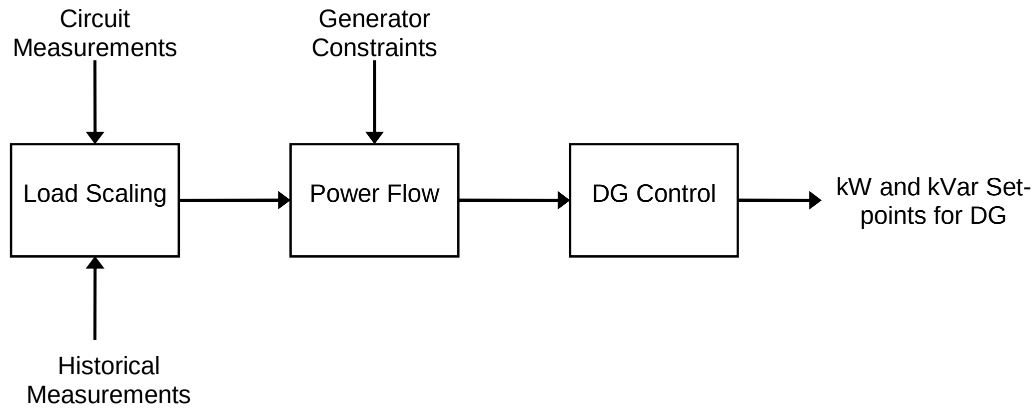


FIGURE 24 Functional view of control software

Figure 24 illustrates that the DG Control responsible for calculating the generation set-points makes use of a power flow engine. The power flow engine estimates loads throughout the circuit. As discussed in the previous sections, load research statistics are applied to historical kWh measurements to estimate loading throughout the circuit model for a specified hour, type-of-day, type-of-month, and weather condition. For customers that have hourly kW/kVar measurements, these measurements are used to estimate loading. Load estimates are then scaled so that power flow calculations match closely with real-time circuit measurements, where the real-time measurements have been time synchronized. Also, the power flow engine evaluates out-of-limit voltages and overloads throughout the circuit.

The circuit model with the scaled loads is used by the control algorithm to determine generation levels that are needed to eliminate circuit problems. The first action of the DG Control algorithm is to search the circuit model to detect problems such as low voltage or equipment overloads. If problems are found, DG Control makes use of the power flow engine to calculate generation levels that will eliminate the problems. In setting generation levels, the control algorithm takes into account minimum-power, maximum-power and power-factor generation constraints.

Since DG power is often more expensive than the power available at the start-of-circuit, the control algorithm calculates just the generation needed and no more from each DG to eliminate the circuit problems. In some cases, however, increasing DG generation even to its maximum level does not help remove the circuit problems. In such cases, the control algorithm recommends the maximum generation, also informing the operator that the problem cannot be entirely solved with DG generation

See Appendix D for example output of the DR Control Algorithm.

Control of DG Aggregates

The DG control algorithm described in the preceding sections runs 24-7, taking in real-time circuit and generation measurements and providing recommended DG generation levels. This circuit control evaluates DG generation for controlling individual circuit problems. At this level of control it is also verified that turning on a DG will not create local circuit problems. That is, the generation available from a DG can be limited by the circuit loading. Thus, the circuit-level DG control sets limits on DG generation based upon circuit loading conditions.

If a DG is not needed for circuit-level control, and it will not cause circuit problems if turned on, then it is released for use by an upper-level control. That upper-level control can be used to aggregate DGs into a block of generation. DG aggregates may be created from a single circuit that has many DGs or from DGs located in many circuits within a distribution service area. Thus, DGs across many circuits in distribution areas can be controlled from a single control point. Then, the aggregated DGs can be made available for transmission system use.

A three-level DG control hierarchy is illustrated in Figure 25. At the lowest level (Level 1) are the local controllers at DG sites. These controllers are responsible for handling import/export of DG power into or from the DG sites. A circuit can have a number of DG sites from which DG power can be imported into the circuit. The controllers at the circuit level (Level 2) manage to command Level-1 controllers on how much power DG sites are needed to produce. The aggregate control in Level 3 is associated with many distribution circuits within a distribution service area(s), and handles the circuits controllers involved. It is also interfaced with a transmission system entity – let it be the Independent System Operator, ISO.

All the DGs that are aggregated by the control at Level 3 look like a single generator to the ISO. After evaluating the DG power present at its lower levels, the aggregate control informs the ISO of the DG power that can be made available for transmission system use. After some negotiations, the ISO tells the aggregate control how much power will be needed. The aggregate control then talks to the circuit controls in order to provide the requested power in the best way possible. Data flow among the controls at different levels can be seen in Figure 26. For simplicity, only a partial view of the data flow is presented. The view shown involves one circuit and one DG site in that circuit. The complete view would involve the data flow with multiple circuits and multiple DGs under circuits. The nomenclature used in Figure 26 is presented.

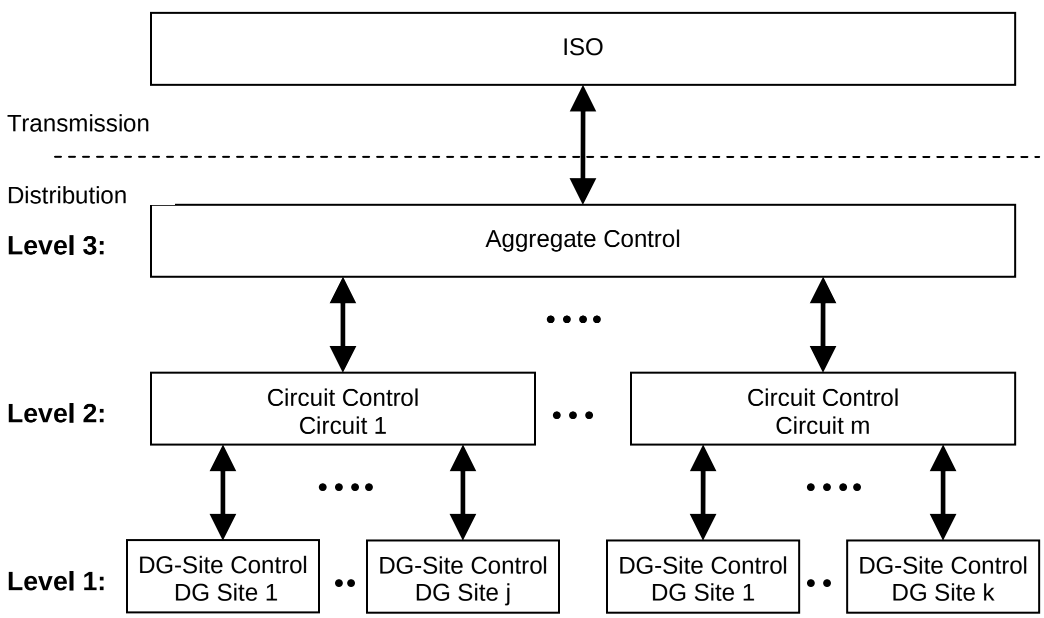


FIGURE 25 Control hierarchy for DG aggregation.

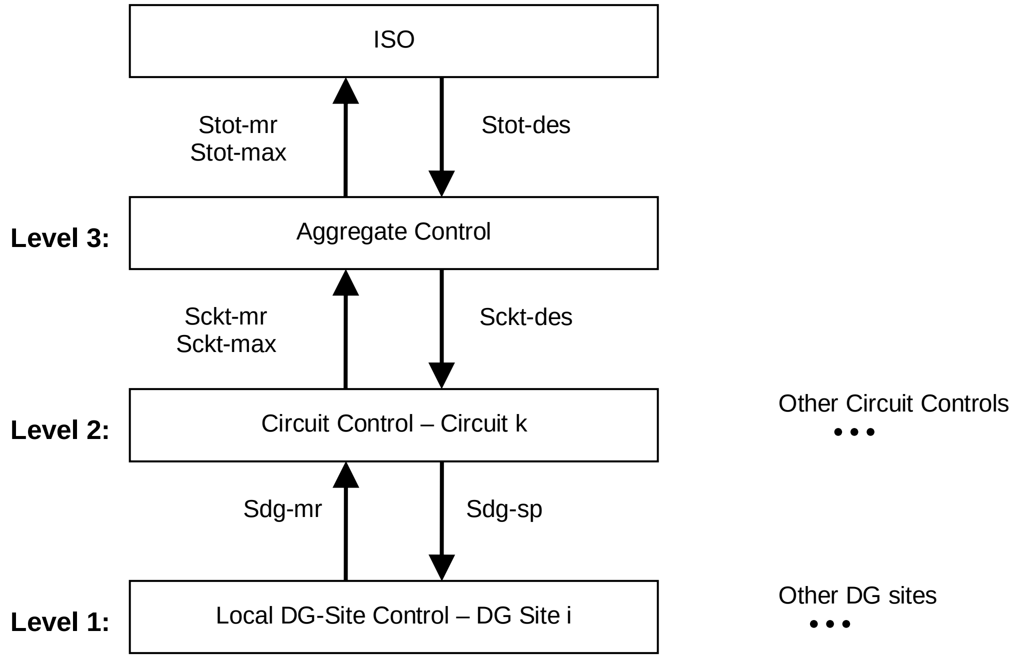


FIGURE 26 Data flow among ISO, aggregate controller, a circuit controller (Circuit k), and a DG-site controller (DG Site i in Circuit k).

Sdg-mr : must-run power generation (kW, kVar) from DG site
Sdg-sp : desired power generation (kW, kVar) from DG site
Sckt-mr : must-run power generation (kW, kVar) needed by circuit
Sckt-max : maximum power generation (kW, kVar) available from circuit
Sckt-des : desired power generation (kW, kVar) from circuit
Stot-mr : total must-run power generation (kW, kVar) needed by all circuits
Stot-max : total power generation (kW, kVar) available from all circuits
Stot-des : total desired power generation (kW, kVar) needed by ISO from aggregate DG control

Data Flow

Given weather data and circuit conditions such as voltage and current measurements taken at the start of circuit, the circuit controllers at Level 2 calculate flows and voltages for the circuits. Consider for example *Circuit k* shown in Level 2 in Figure 26. The circuit controller of *Circuit k* checks voltages and loadings in the circuit. If any circuit problem such as under-voltage or overloaded locations in the circuit is found, then the controllable DGs in the circuit are considered by the circuit controller to see if they can be used to eliminate the problems. If the use of DGs helps solve the circuit problems, then the DG kW and kVar generation levels at which the problems are eliminated are recorded. Such generation quantities are labeled as “must run”, which means that the circuit itself needs that DG generation for fixing its own problems.

Consider *DG Site i* in Figure 26. *Sdg-mr* represent the power (kW and kVar) that is needed from *DG Site i* in order to remove the problems that will occur in *Circuit k* according to the given weather data and circuit conditions. *Sdg-mr* will be zero if no circuit problem is estimated to occur with *DG Site i* producing no power.

The “must run” generations of the DG sites within a circuit are summed and the total is identified as the “must-run” generation needed by the circuit. This evaluation is done by the circuit controller. The total generation available from all the DG sites within the circuit is also calculated by the circuit controller. This total is referred to as total or maximum generation available from the circuit. In Figure 26, *Sckt-mr* and *Sckt-max* indicate must-run and maximum generations from *Circuit k*, respectively. The circuit controller may also know the type and operating characteristics of the DGs. Therefore, “must-run” and maximum generations may actually be further decomposed into available base-load generation and available load-following generation.

Must-run and maximum generations are passed to the aggregate control at Level 3. The aggregate control then sums the “must run” generations needed by the circuits at Level 2, and the total is identified as “must-run” generation needed by the DG aggregator (*Stot-mr* in Figure 26*)*. Similarly, the maximum available generation (*Stot-max*) is calculated by summing the available generations collected from the circuit controllers. These two quantities are communicated to the ISO. Generation costs may also be communicated to the ISO, which is not considered here.

The aggregate control negotiates with the ISO. The power (*Stot-des* in Figure 26) that will be needed from the aggregate control is determined through the negotiations. The aggregate control takes this requested power and divides it among the DGs in the circuits under its control. *Sckt-des*, for instance, represents the power generation that the aggregate control allocates for *Circuit m* to provide. The circuit controllers at Level 2 manage the DG-site controls within the circuits associated. A circuit controller determines how to use the DGs in the circuit so that the power requested by the aggregate control can be supplied in the optimum manner. The economic and reliability considerations are taken into account in this process. At the end, each DG site is assigned a power amount to generate. The power values are then communicated to the corresponding local controllers at DG sites. These values become the set-points for the generator controllers. For instance, *Sdg-sp* in Figure 26 are used as the kW and kVar set-points for the DG at *DG Site i* in *Circuit k*.

Circuit-Level Control

The circuit-level control consists of the basic functions shown in Figure 27. Typically, only few locations, such as the start of the circuit and DG sites, have measurements taken. In the absence of a complete data acquisition system –with the help of these limited measurements– it is not possible to determine the flows throughout the rest of the circuit. Therefore, the circuit model along with the available measurements is used to estimate the flows in the circuit.

In the most common scenario, real-time current and voltage measurements taken at the start of the circuit are input into the circuit model. Real-time kW and kVar measurements taken at the DGs are fed into the model as well. *Power Flow* then calculates voltages and currents throughout the circuit. Since the load data (location, class, historical measurements, and load research data such as load curves, coincidence and diversity factors) is already available, *Power Flow* can calculate the flows and uses *Load Scaling* so that the calculated flows can match the measurements. In this matching process, *Load Scaling* adjusts the circuit loads until the calculated flows come reasonably close to the measured flows.

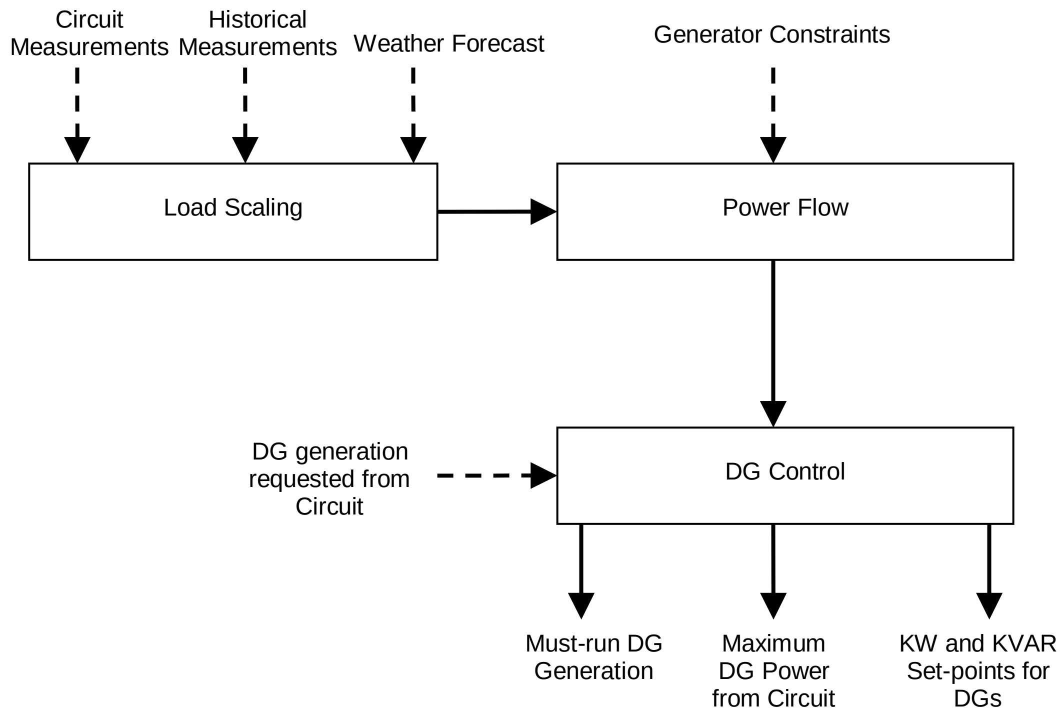


FIGURE 27 Circuit-Level DG-Control functions

In the absence of real-time circuit measurements, circuit flows (i.e., flows at circuit starts) are estimated by using historical measurements and weather data. Then the estimated flows are used as if they were measurements at the start of the circuit, and *Load Scaling* again adjusts load sizes so that the estimated and measured flows match.

In another scenario, suppose that the circuit has no overload or under-voltage problem while some DGs in the circuit are still generating power. In such case, *DG Control* attempts to reduce the generation to check if the no-problem condition can be obtained with less DG generation or no generation at all. If so, the reduced generation levels will be reported as "must run."

As a result, given real-time or historical measurements, weather-forecast data and generator constraints the circuit-level DG control calculates "must-run" and maximum generation of the circuit. This information is reported to the aggregation control at the higher level, as explained before. In response to a DG-power request (or generation request in general) from the aggregate control, the circuit-level control takes the requested power as an input parameter to *DG Control* as shown in Figure 27. *DG Control* then evaluates how the requested power can be realized from the participating DGs in the circuit. At the end of calculations generations that need to be supplied from the DG sites are determined. Generator constraints, fuel costs, generator operating characteristics, circuit-loss effects, reliability effects and other parameters can be considered in this determination process. Hence, the generations resulting from the calculations become kW and kVar settings for the DG sites. Subsequently, they are sent to the local controllers at the DG sites.

Reconfiguration with DGs on Circuit Reliability and Efficiency

Along with voltage and power-flow control, DGs can be placed within the distribution system for simultaneously improving efficiency and reliability. That is, there are many locations within a circuit from which a DG can implement some desired voltage or flow control, and of these many locations, the location that results in the optimum improvement in efficiency and/or reliability can be selected.

Within a system of circuits, the circuits can be reconfigured via switching operations, and DG generation can be shifted from one circuit to another in order to implement some desired control. With such switching operations, the DG does not necessarily need to be operated as an island. That is, a DG that is connected to an un-energized circuit may be switched to an energized circuit, and then brought on line. Thus, a DG can be placed to serve a number of circuits, and can be looked at as increasing both efficiency and reliability for the system of circuits.

For a single circuit or a system of circuits, the DG site placement for best reliability is generally not the same as the placement for best efficiency. Percent changes in system reliability and percent changes in efficiency can be used to determine desirable locations from a limited set of geographical locations where the DG may be placed.

To obtain good locations for efficiency and/or reliability improvements, exhaustive searches and/or optimization methods may be applied. The exhaustive search approach often works well because there are generally only a very limited number of physical sites for placing DGs. This is due to constraints placed on the siting from community impact and available land considerations.

The method that is used to site the DG should take into account the time-varying loading of the circuits involved. Placing a DG based upon just peak loading conditions will generally not result in the best reliability or efficiency when the entire time-varying load pattern is considered. The procedure to determine the optimum location to place a DG can be composed of the following steps:

1. Perform load research statistics on the system, and plot the load curve.
2. Divide the load curve into different load windows, so that the loading condition in each window is relatively constant.
3. Adjust the DG output for different load windows to prevent back feed to the substation.
4. Perform exhaustive search for the load condition of each window with the corresponding DG output, and obtain the optimal locations based on the two criteria for comparison.

Based on the simulations we performed using the procedure above, our findings are summarized below.

Reliability and efficiency in a single circuit: It is not uncommon that DGs are placed near to substations for convenience. We note that placing DGs further out on a circuit, instead of locating them close to the substation, can help enhance a system's reliability. Also, it is a common practice in industry that decisions are based on power flow analysis run for the peak load. However, we noticed that placing a DG where only the peak load condition is evaluated may not provide the best location for minimum losses or reliability improvement. The reliability of a system may vary as a function of the time-varying load. In general, the system reliability may decrease as the loading increases.

Reliability in a system of circuits: If DGs are to be shut down when circuits experience outages, for the best improvement in system reliability it is better to place DGs in circuits that have the lowest failure rates. Also, in case DGs can be quickly restarted following switching operations with alternate feeds, circuit component failure rate is not a determining factor in considering optimal DG placement for reliability improvement.

System reliability is influenced by loading patterns: If all the circuits in a system exhibit the same loading pattern, then applying a DG may help to enhance system reliability more during light load periods than during heavy load periods. On the other hand, when the circuits in a system exhibit different loading patterns, adding a DG may yield the largest improvement in system reliability during periods of high load.

Comparing minimum loss with maximum reliability: The optimal DG placements for minimum loss and maximum reliability are different during light load conditions and close to one another during heavy load periods. The cost of improvements in reliability can in part be evaluated by the trade off with the cost of the losses in efficiency.

See Appendix E for an example reliability calculation.

OSERVATIONS & LESSONS LEARNED

As simple as it may seem to be naming conventions are very important, developing standard would be of great benefit to all.

Offering into the market every day is laborious particularly because of must runs.

There is one interesting issue that arose when the DER units were registered. Detroit Edison MOC, acting as the agent that registers the DERs in the MISO market, is not allowed to register DERs that are not owned, leased or covered under an existing rate by Detroit Edison. Also, one has to be careful not to double count for instance if a customer is already on an interruptible rate and include in the ISO as interruptible load, The DER can not be sold into the market without being taken out of the interruptible. Furthermore, The Riverview Biomass is own and operated by a non regulated DTE ENERGY affiliate and had to be removed from our list of DER due to Michigan Public Utilities Commission‘s Affiliate Rules Code of Conduct for utilities and their affiliates.

A problem arose as result of MISO typically dealing with much larger capacities. The XML file format that MISO specifies to provide energy offer price curves only allows for 100kW resolution in the MWh value of each price point. The implications of this are that for sites where units exist with capacities less than 100 kW, combinations of the units are limited. Limiting the number of combinations of units results in less points on the price curve for each site. Unfortunately there is nothing to be done to resolve this other than lobby MISO to change the resolution of their price points to accommodate DER and smaller-capacity units.

During testing of the Detroit Edison SOC’s control of the DER over ICCP, it was discovered that a restart of the OSIsoft PI connection to the ICCP link, would cause PI to immediately dispatch values to all of the control points according to the last state it had stored for each point. This was a problem on multiple levels.

To address this issue, the DR-SOC added a write-back value. This way if the link was restarted and the write-back value was sent, the DR-SOC would ignore the update. This scheme takes the responsibility of tracking state out of the hands of the PI server and leaves it solely with the DR-SOC where it belongs.

A problem was encountered when the DEW Web service was not able to open the database to start a calculation. The problem seems to have been the result of an automatic Microsoft update of the XP operating system, which changed the security level of the DEW Web service program. The problem is now fixed, but uncovering it and fixing it was difficult. Why the security level of the web service was changed, so that it could not open the database, is still not understood.

The aggregator maybe also able to provide circuit monitoring bask to the utility faster and cheaper then the utility.

MISO Modeling only considers a sign generator connected at the CP Node and it can only be must run or economic. We were able to put in multiple price curves to represent must run and economic.

Our standby DERs generation totaling 8 MW but could only result in a non coincident negawatt peak of approximately a of 6 MW or could be as low of 1.2 MW or 20% of that peak. This demonstrated the need for accurate time varying modeling at the point of common coupling particularly if penalties can be assessed for non delivery. MISO does not access penalties for Demand Response Resources but other ISOs do

In Michigan the standby generation general permitting does not preclude using the generation in the market only limited the number of hours to 500. In other states such as those in the PJM foot print environmental permitting does not allow sale into the market. The standby generation can only be operated during loss of power or emergencies.

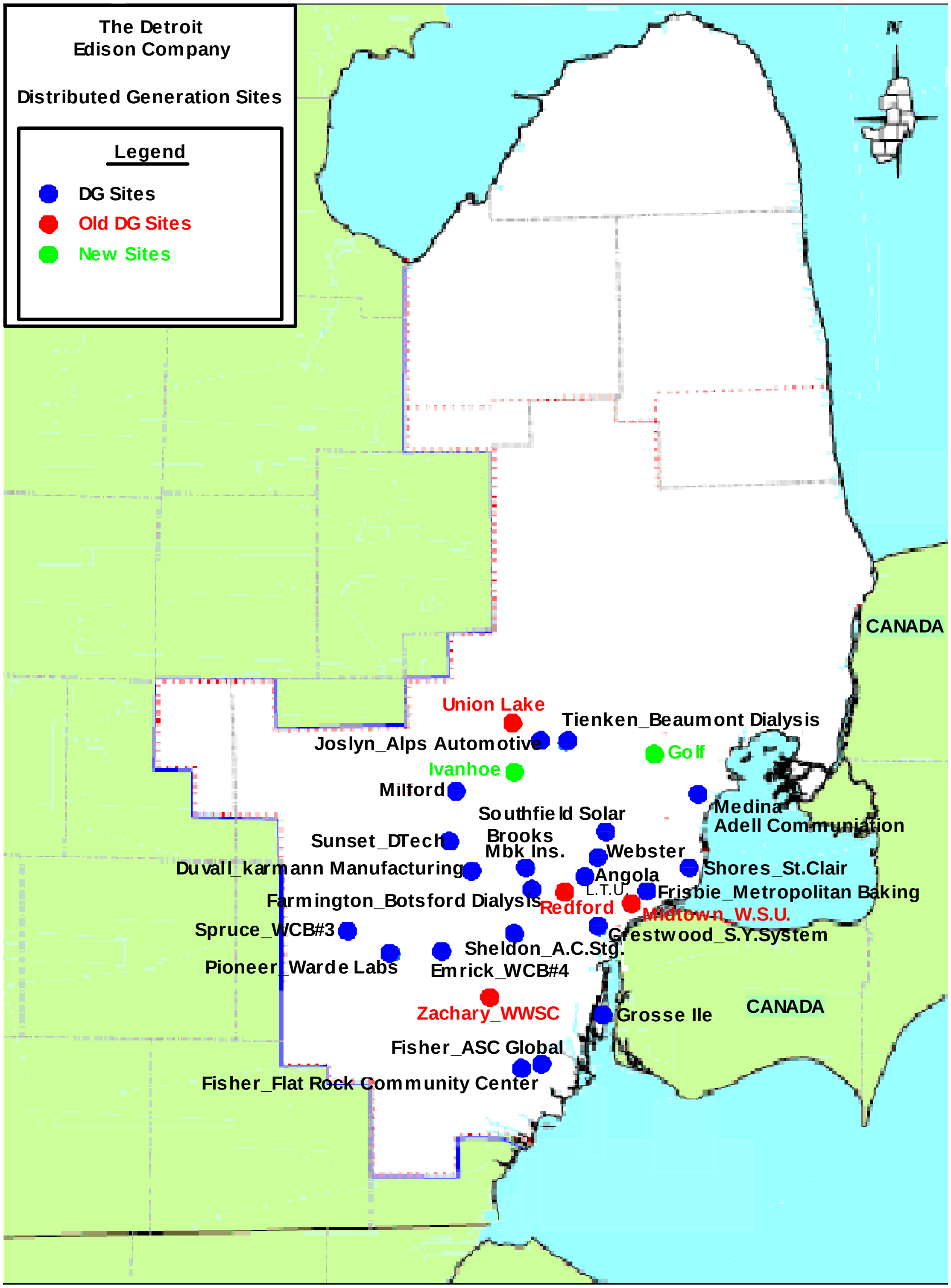
Appendix A

Circuit Information + D.G. Sites

Contents

Sell Back units:
(NEW)Golf DC 8518 ------------- Golf – 2000KW Diesel
Grosse Ile DC 2841 ------ Grosse Ile School – 1000KW N.G
(NEW) Ivanhoe DC 1760 --------- Ivanhoe – 1500KW Bi-Fuel
Milford DC 8103 --------- Milford Junction – 1000 KW N.G
Shores DC 1770 --------- Assumption Greek Orthodox Church – 1000 KW N.G
Southfield DC 9010 ------ Hydrogen Technology Park – 26 KW Solar + 50 KW H
Sunset DC 9016 ---------- Farmington – 75 KW N.G
Union Lake DC 1688 ---- Union Lake – 2000KW Diesel
Webster DC 371----------- Oakland Water – 500KW Diesel
Zachary DC 9400 -------- WWSC – 375KW N.G

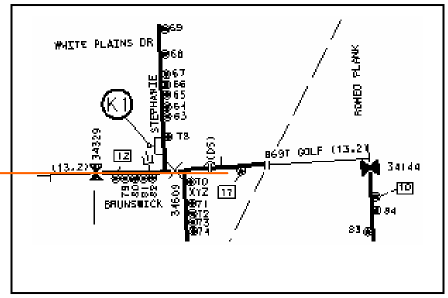
None sell back units:
Angola DC 8862 ---------- Lawrence Technological University – 150+150KW NG
Brooks DC 8081 ---------- Meadowbrook Group – 800KW Diesel
Crestwood DC 8307 ------ S.Y System – 500KW Diesel
Duvall DC 9455 ----------- Karmann Manufacturing – 1000KW Diesel
Emerick DC 2925 --------- Washtenaw County Bldg. # 4 – 255KW N.G
Farmington DC 8892 ----- Botsford Dialysis – 150KW N.G
Fisher DC 8188 ------------ ASC Global – 2000KW Diesel
Fisher DC 8188 ------------ Flat Rock Com. Center – 500KW Diesel
Frisbie DC 2125 ----------- Metropolitan Baking – 600KW Diesel
Glendale PL 561 ----------- Redford Service Center – 150 KW N.G
Joslyn DC 9182 ------------ Alps Automotive – 500 KW Diesel
Medina DC 8533 ---------- Adell Communication – 600 KW Diesel
Midtown PL 8317 ----------Wayne State University – 75+75+75 KW
Pioneer DC 9793 ----------- Trinity Health Care – 600 KW Diesel
Sheldon DC 9508 ---------- Arctic Cold Storage – 750 KW Diesel
Spruce DC 9874 ----------- Washtenaw County Bldg. # 3 – 200 KW N.G
Tienken DC 8850 --------- Beaumont Dialysis – 150 + 150 KW N.G


The Detroit
Edison Company
Distributed Generation Sites
Legend
DG Sites
Old DG Sites
New Sites
N
CANADA
Union Lake
Tienken_Beaumont Dialysis
Joslyn_Alps Automotive
Golf
Ivanhoe
Milford
Medina
Adell Communication
Southfield Solar
Sunset_DTech
Brooks
Mbk Ins.
Webster
Duvall_karmann Manufacturing
Angola
Shores_St.Clair
L.T.U.
Frisbie_Metropolitan Baking
Farmington_Botsford Dialysis
Redford
Midtown_W.S.U.
Spruce_WCB#3
Crestwood_S.Y.System
Sheldon_A.C.Stg.
Pioneer_Warde Labs
Emrick_WCB#4
Zachary_WWSC
Grosse Ile
CANADA
Fisher_ASC Global
Fisher_Flat Rock Community Center

Sell back units

Golf DC 8518 13.2KV
&
Golf DG – 2000KW Diesel

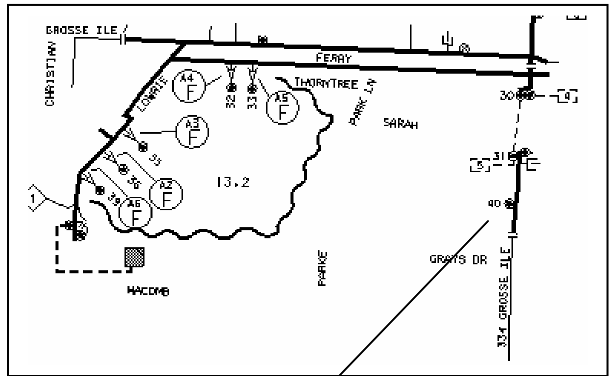
Address: 17800 21 mile
Macomb Township, MI, 48042



No. of Customers: 2951
No. Circuit Miles: 29
DG Distance from Sub: 3400 ft
Circuit Peak Load: 14.6 MW
DG % of Ckt. Peak Load: 13.7%

Grosse Ile DC 2841 4.8KV
&
Grosse Ile School – 1000 KW Nat. Gas

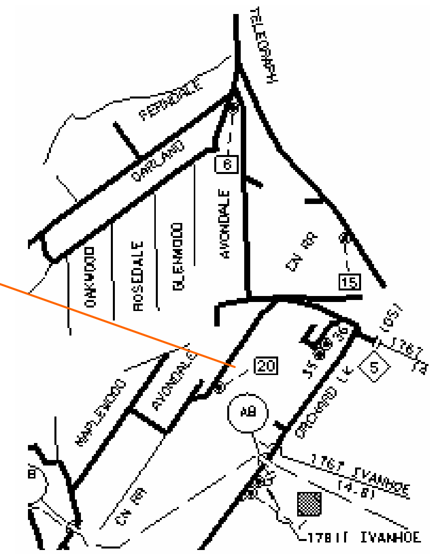
Address: 23276 East River Rd
Grosse Ile, MI, 48138



No. of Customers: 883
No. Circuit Miles: 16
DG Distance from Sub: 8600ft
Circuit Peak Load: 5.2MW
DG % of Ckt. Peak Load: 19%

Ivanhoe DC 1760 4.8KV
&
Ivanhoe DG – 1500KW Bi-Fuel

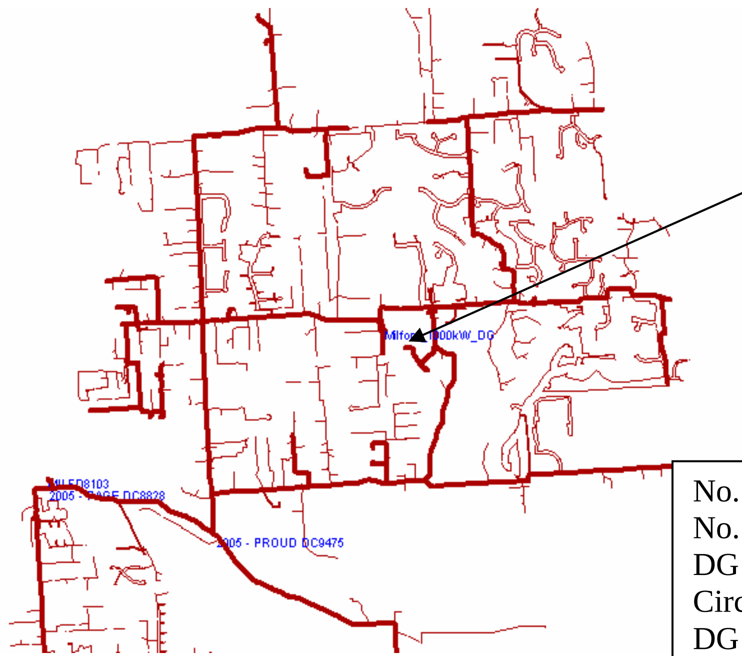
Address:1970 Orchard Lake Rd
Sylvan Lake, MI, 48320

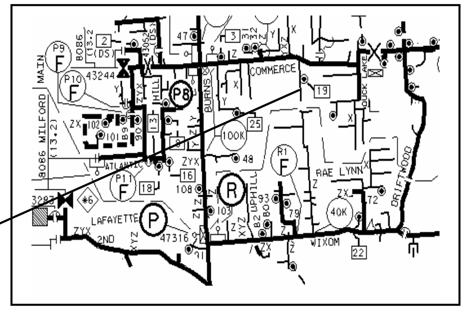


No. of Customers: 1762
No. Circuit Miles: 16
DG Distance from Sub: 3200 ft
Circuit Peak Load: 6.9 MW
DG % of Ckt. Peak Load: 21.7%

Milford DC 8103 13.2KV
&
Milford Junction-MCN – 1000 KW Nat. Gas

Address: 5070 Duck Lake Rd
Commerce, MI, 48382

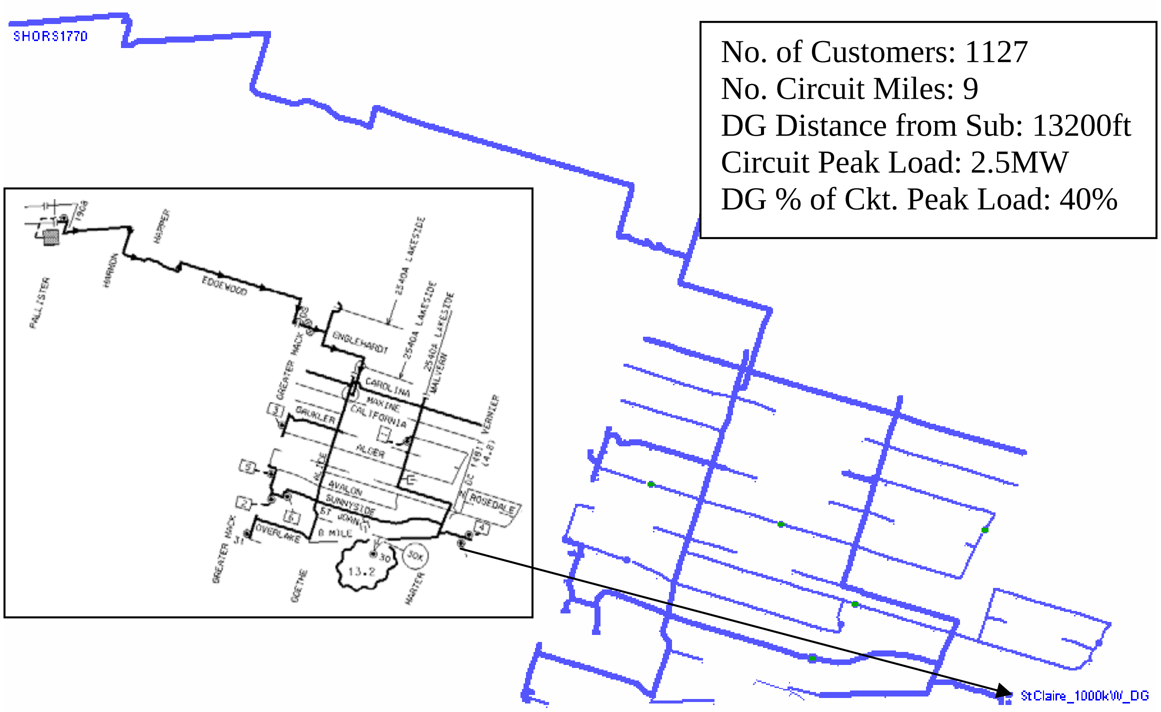




No. of Customers: 3209
No. Circuit Miles: 88
DG Distance from Sub: 17600ft
Circuit Peak Load: 12.7MW
DG % of Ckt. Peak Load: 7.87%

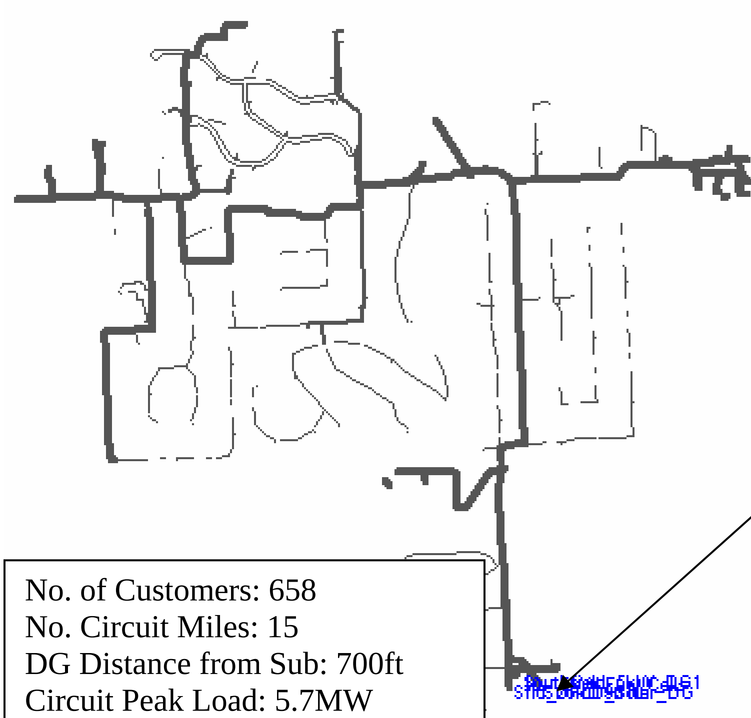
Shores DC 1770 4.8KV **Address: 21800 Mater**
& **St. Clair Shores, MI, 48080**
Assumption Greek Orthodox Church – 1000 KW Nat. Gas

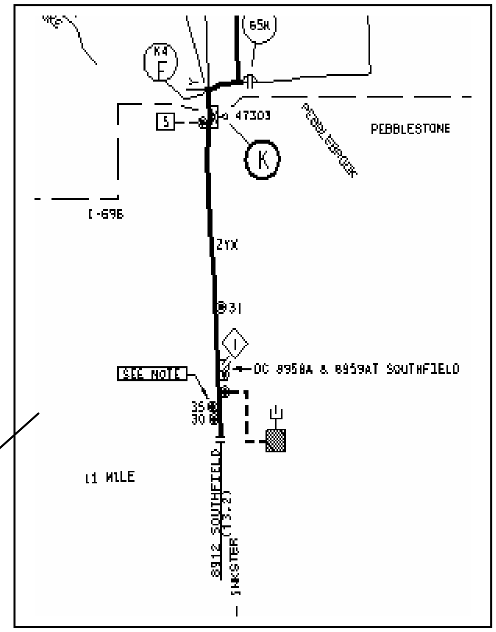
No. of Customers: 1127
No. Circuit Miles: 9
DG Distance from Sub: 13200ft
Circuit Peak Load: 2.5MW
DG % of Ckt. Peak Load: 40%



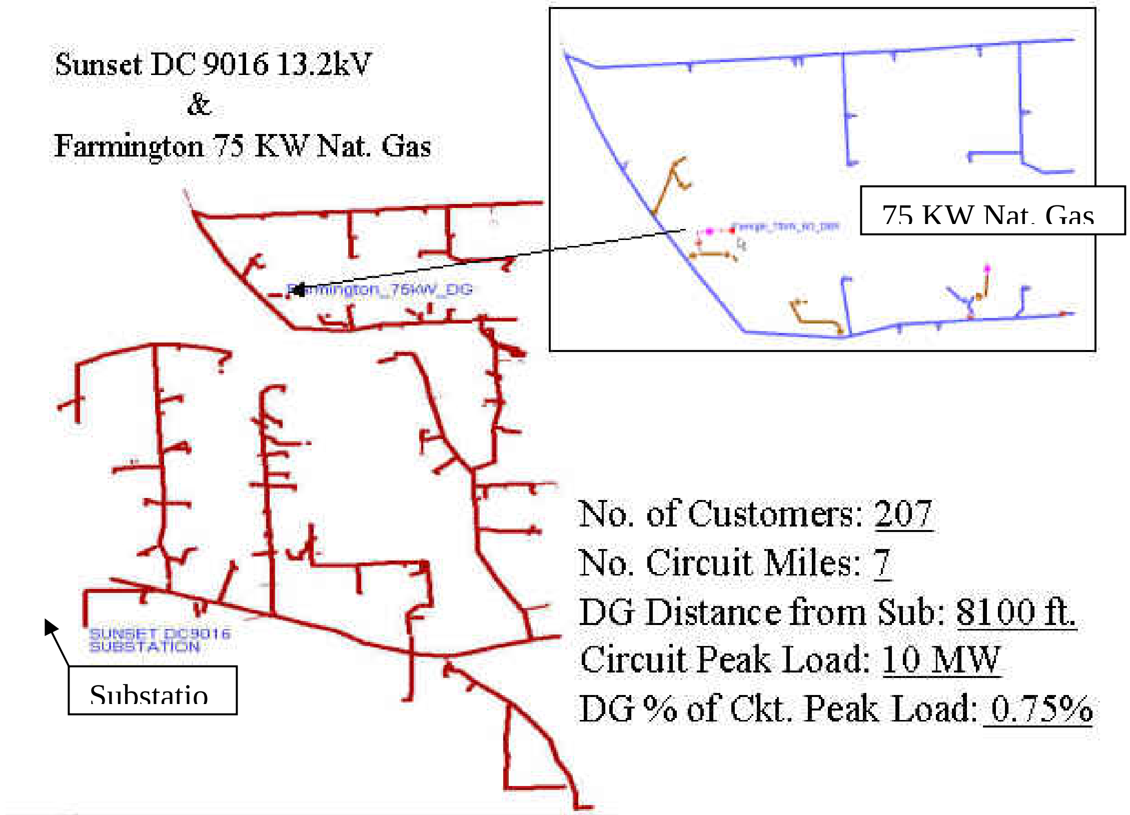
Southfield DC 9010 13.2KV
&
Hydrogen Technology Park
26 KW Solar Cells + 50 KW Hydrogen

Address: 27400 Eleven mile Rd.
Southfield, MI, 48034

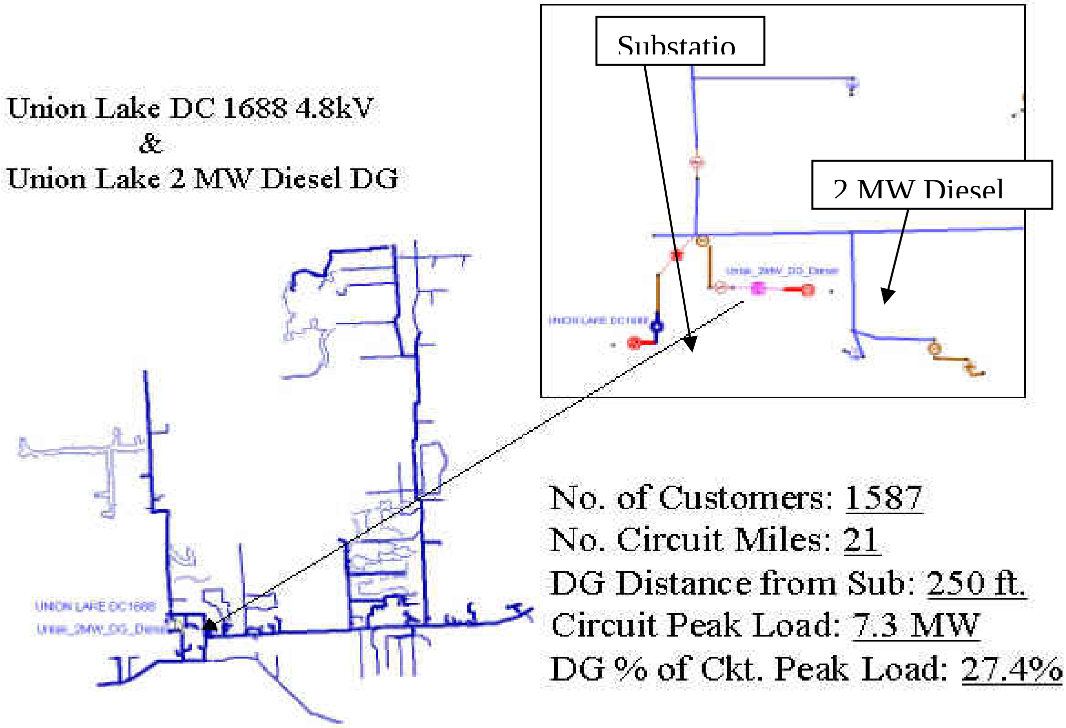




No. of Customers: 658
No. Circuit Miles: 15
DG Distance from Sub: 700ft
Circuit Peak Load: 5.7MW
DG % of Ckt. Peak Load: 1.33%

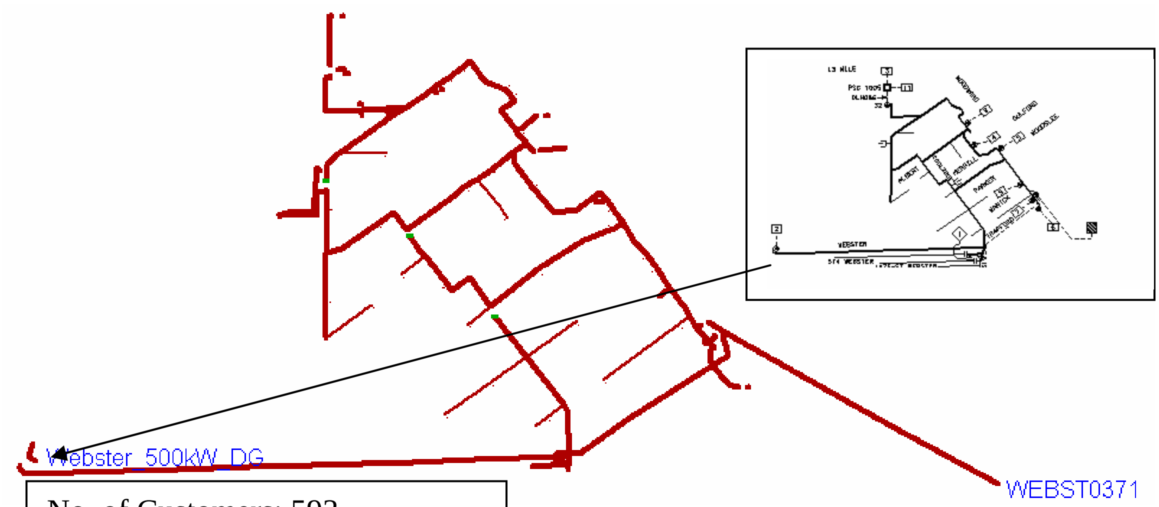

Sunset DC 9016 13.2kV
&
Farmington 75 KW Nat. Gas
Farmington_75KW_DG
75 KW Nat. Gas
SUNSET DC9016
SUBSTATION
Substatio
No. of Customers: 207
No. Circuit Miles: 7
DG Distance from Sub: 8100 ft.
Circuit Peak Load: 10 MW
DG % of Ckt. Peak Load: 0.75%


energy|now


Union Lake DC 1688 4.8kV
&
Union Lake 2 MW Diesel DG
Substatio
2 MW Diesel
UNION LAKE DC1688
No. of Customers: 1587
No. Circuit Miles: 21
DG Distance from Sub: 250 ft.
Circuit Peak Load: 7.3 MW
DG % of Ckt. Peak Load: 27.4%

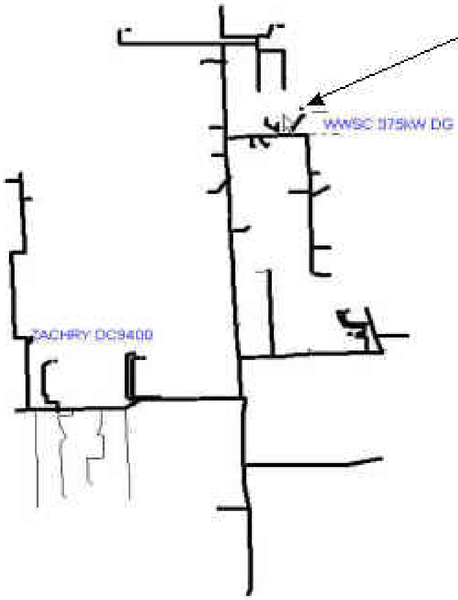
Webster DC 371 4.8KV
&
Oakland Water – 500KW Diesel

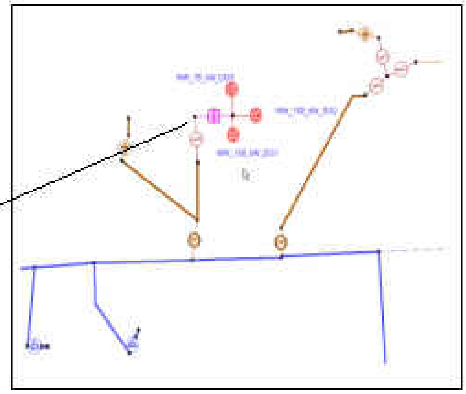
Address: 3910 W.Webster Rd
Royal Oak, MI, 48073



No. of Customers: 593
No. Circuit Miles: 4
DG Distance from Sub: 6200 ft
Circuit Peak Load: 3.7 MW
DG % of Ckt. Peak Load: 13.5%

Zachary DC 9400 13.2kV
&
WWSC 375 KW Nat. Gas



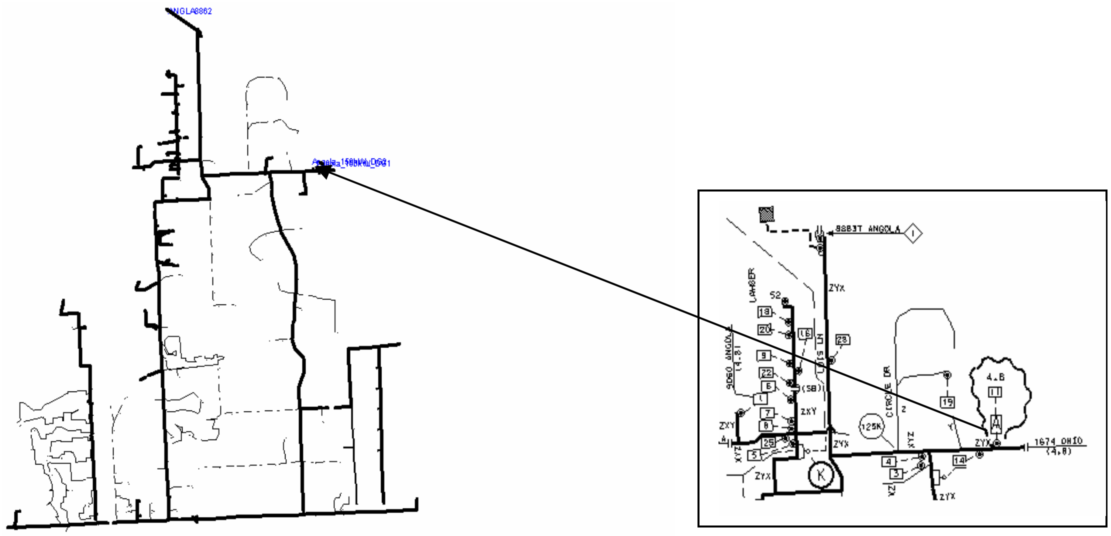


No. of Customers: 152
No. Circuit Miles: 8
DG Distance from Sub: 7400 ft.
Circuit Peak Load: 11.2 MW
DG % of Ckt. Peak Load: 3.35%

None sell back units

Angola DC 8862
&
Lawrence Tech. University 150+150 KW Nat. Gas

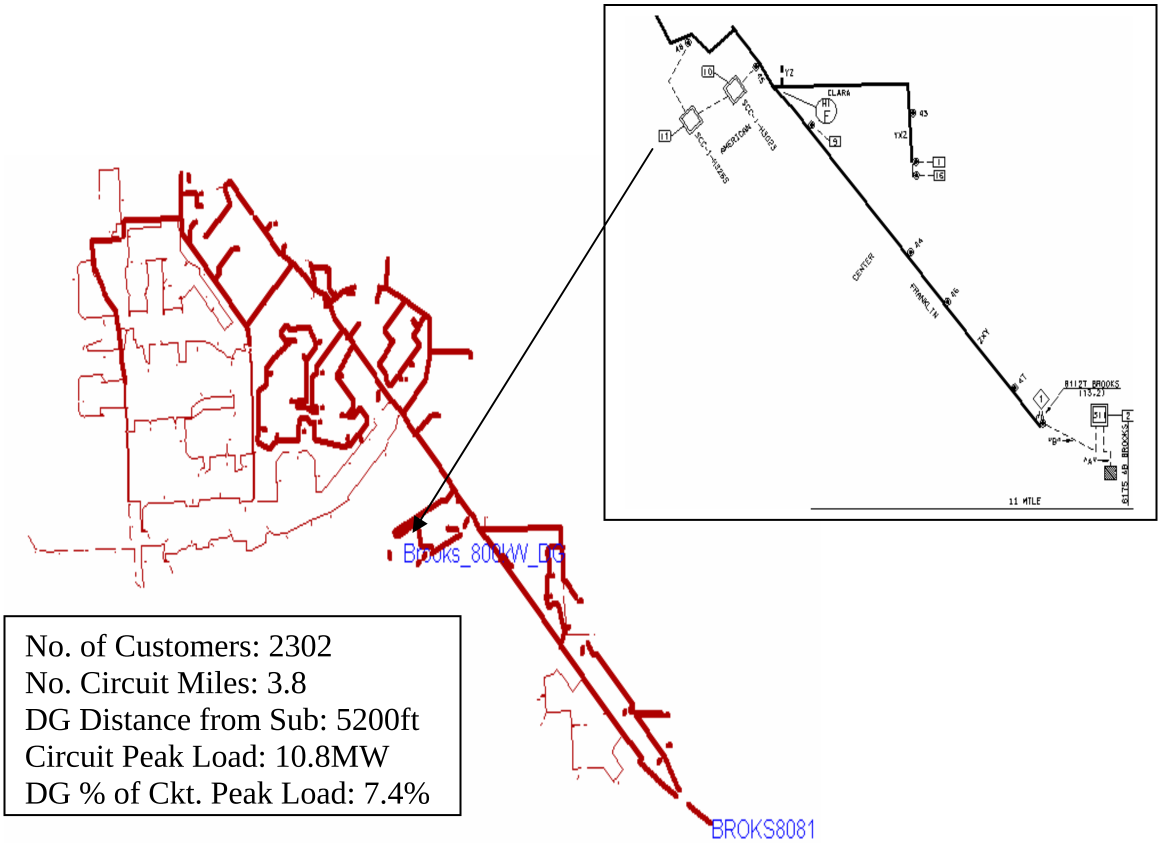
Address: 21000 W 10 Mile Rd
Southfield, MI, 48075



No. of Customers: 1328
No. Circuit Miles: 17
DG Distance from Sub: 2100 ft
Circuit Peak Load: 9.1 MW
DG % of Ckt. Peak Load: 3.3%

Brooks DC 8081
&
Meadowbrook Group 800 KW Diesel

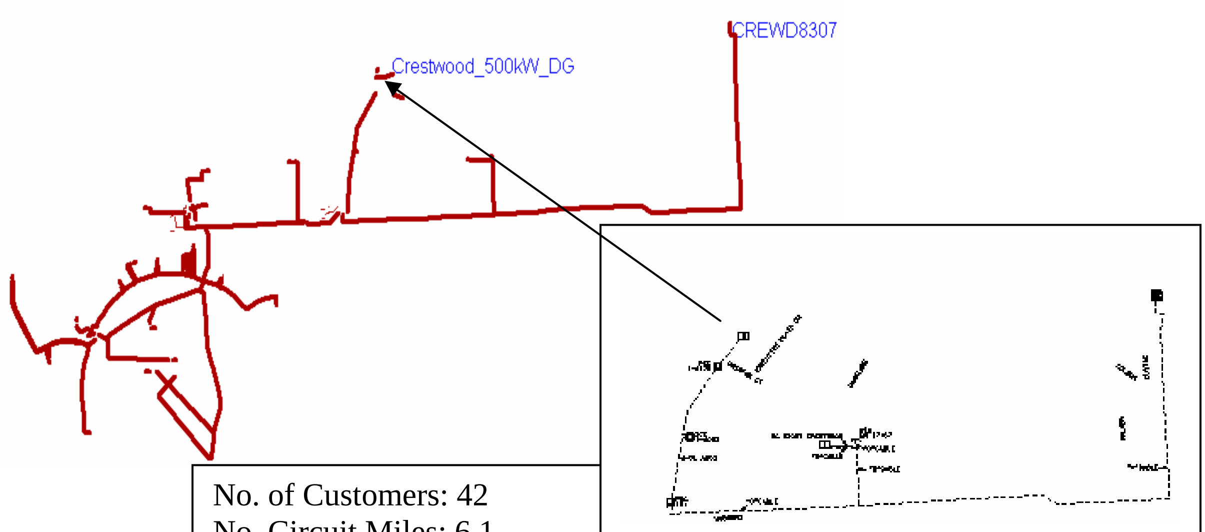
Address: 26255 American Dr.
Southfield, MI, 48034



No. of Customers: 2302
No. Circuit Miles: 3.8
DG Distance from Sub: 5200ft
Circuit Peak Load: 10.8MW
DG % of Ckt. Peak Load: 7.4%

Crestwood DC 8307
&
SY System 500 KW Diesel

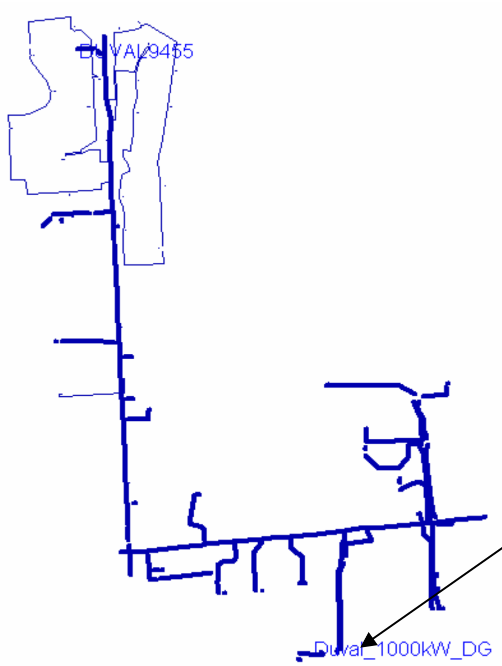
Address: 17000 Executive Plaza Dr
Dearborn, MI, 48126

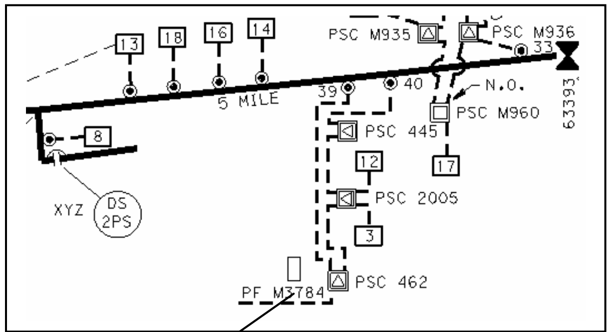


No. of Customers: 42
No. Circuit Miles: 6.1
DG Distance from Sub: 10000ft
Circuit Peak Load: 9.1MW
DG % of Ckt. Peak Load: 5.5%

Duvall DC 9455
&
Karmann Manufacturing 1 MW Diesel

Address: 14988 Pilot Dr.
Plymouth, MI, 48170

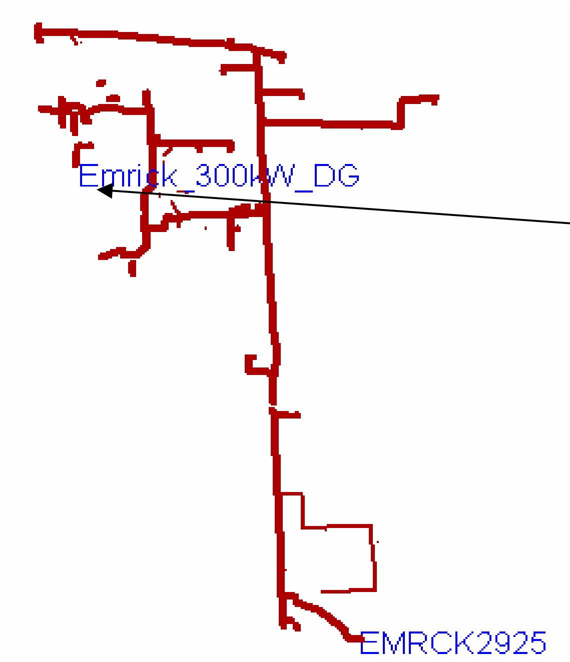


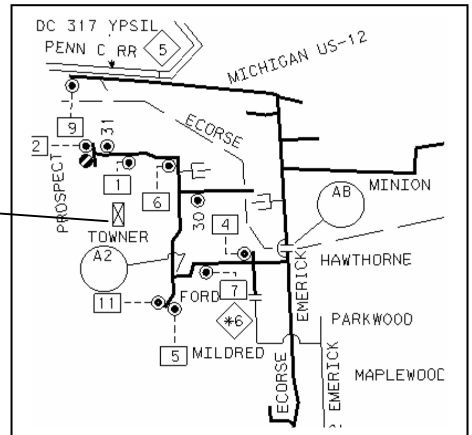


No. of Customers: 254
No. Circuit Miles: 4.3
DG Distance from Sub: 9600ft
Circuit Peak Load: 10.1MW
DG % of Ckt. Peak Load: 9.9%

Emerick DC 2925
&
Washtenaw County Bldg. 4 - 255 KW Nat. Gas

Address: 555 Towner St.
Ypsilanti, MI, 48198

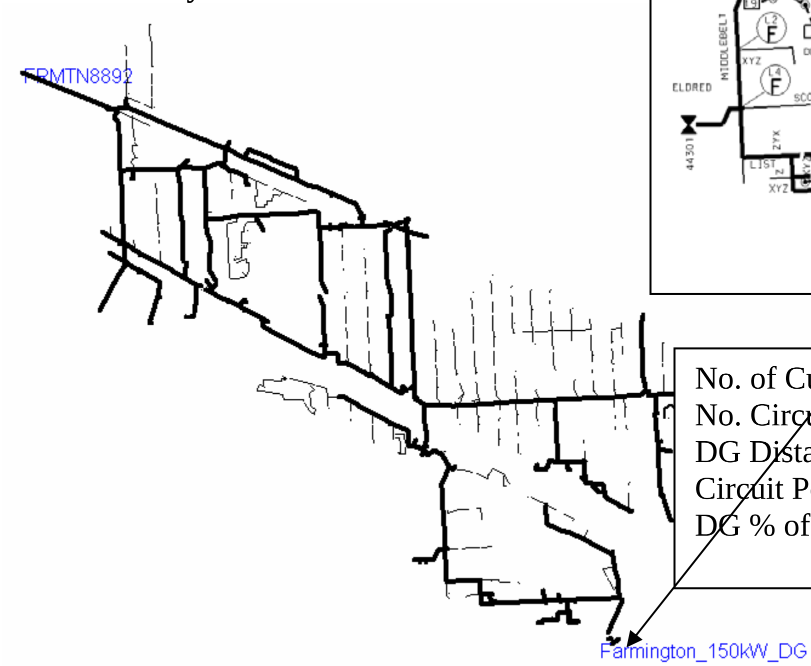


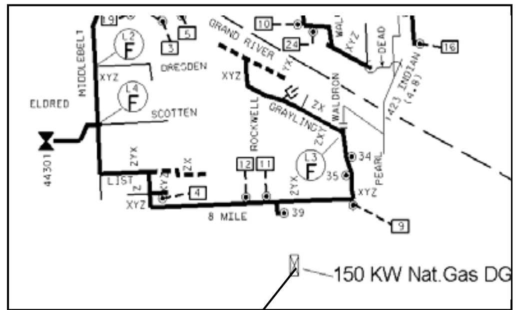


No. of Customers: 130
No. Circuit Miles: 2.2
DG Distance from Sub: 5100ft
Circuit Peak Load: 2.5MW
DG % of Ckt. Peak Load: 10%

Farmington 8852 4.8 KW
&
Botsford Dialysis 150 KW Nat. Gas

Address: 28425 8 Mile
Wayne

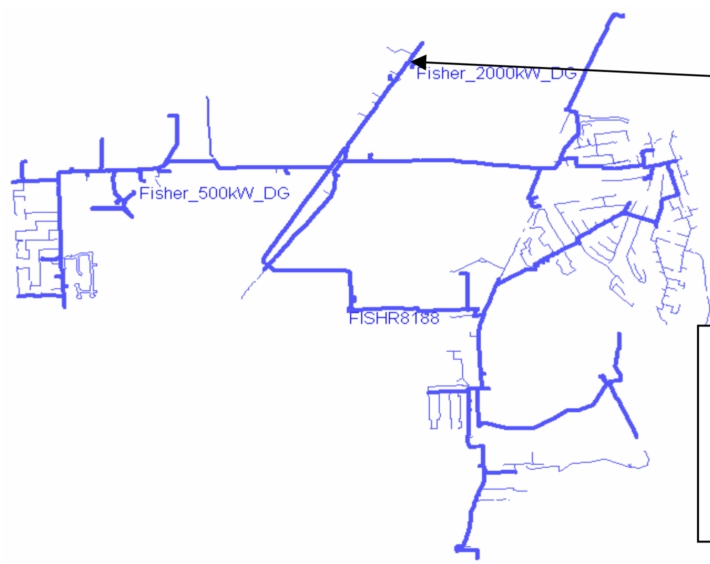


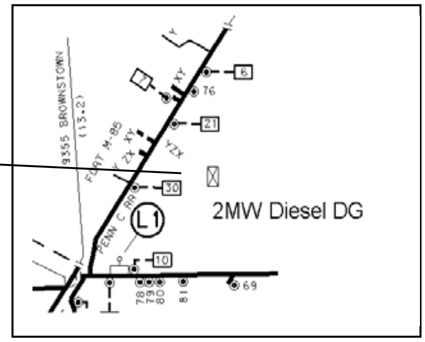


No. of Customers: 142
No. Circuit Miles: 3
DG Distance from Sub: 15200 ft
Circuit Peak Load: 1.4 MW
DG % of Ckt. Peak Load: 10.7%

Fisher DC 8188
&
ASC Incorporated 2MW Diesel

Address: 28005 Fort St.
Brownstown Twp, MI, 48183

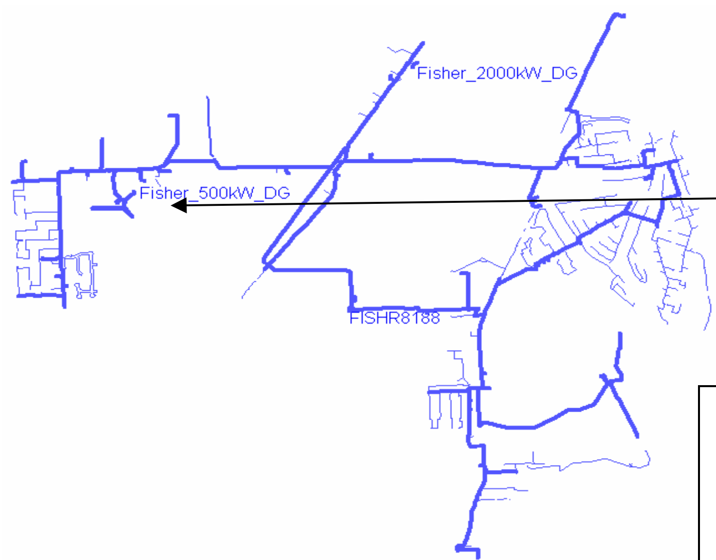


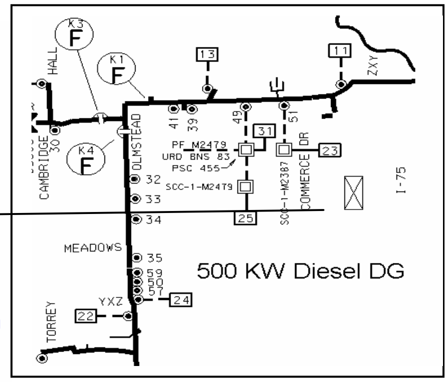


No. of Customers: 3168
No. Circuit Miles: 28.23
DG Distance from Sub: 12200ft
Circuit Peak Load: 13.3 MW
DG % of Ckt. Peak Load: 15%

Fisher DC 8188
&
Flat Rock Community Center 500 KW Diesel

Address: 1 Maguire St.
Flat Rock, MI, 48134

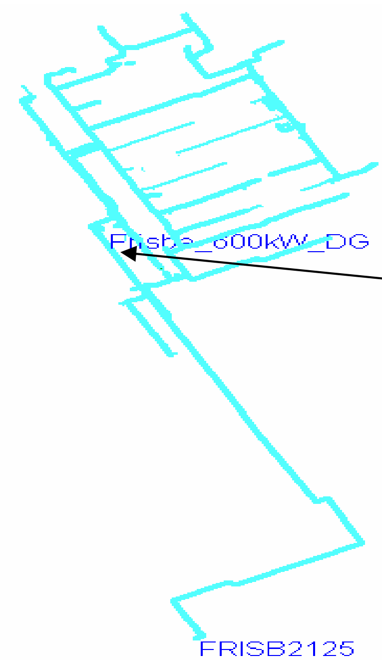


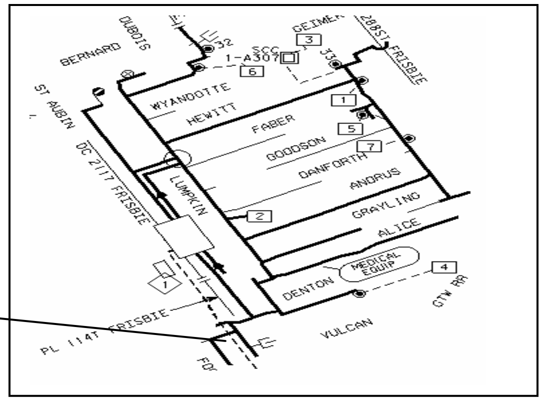


No. of Customers: 3168
No. Circuit Miles: 28.23
DG Distance from Sub: 13900ft
Circuit Peak Load: 13.3MW
DG % of Ckt. Peak Load: 3.7%

Frisbie DC 2125
&
Metropolitan Baking 600 KW Diesel

Address: 8579 Lumpkin
Hamtramck, MI, 48212

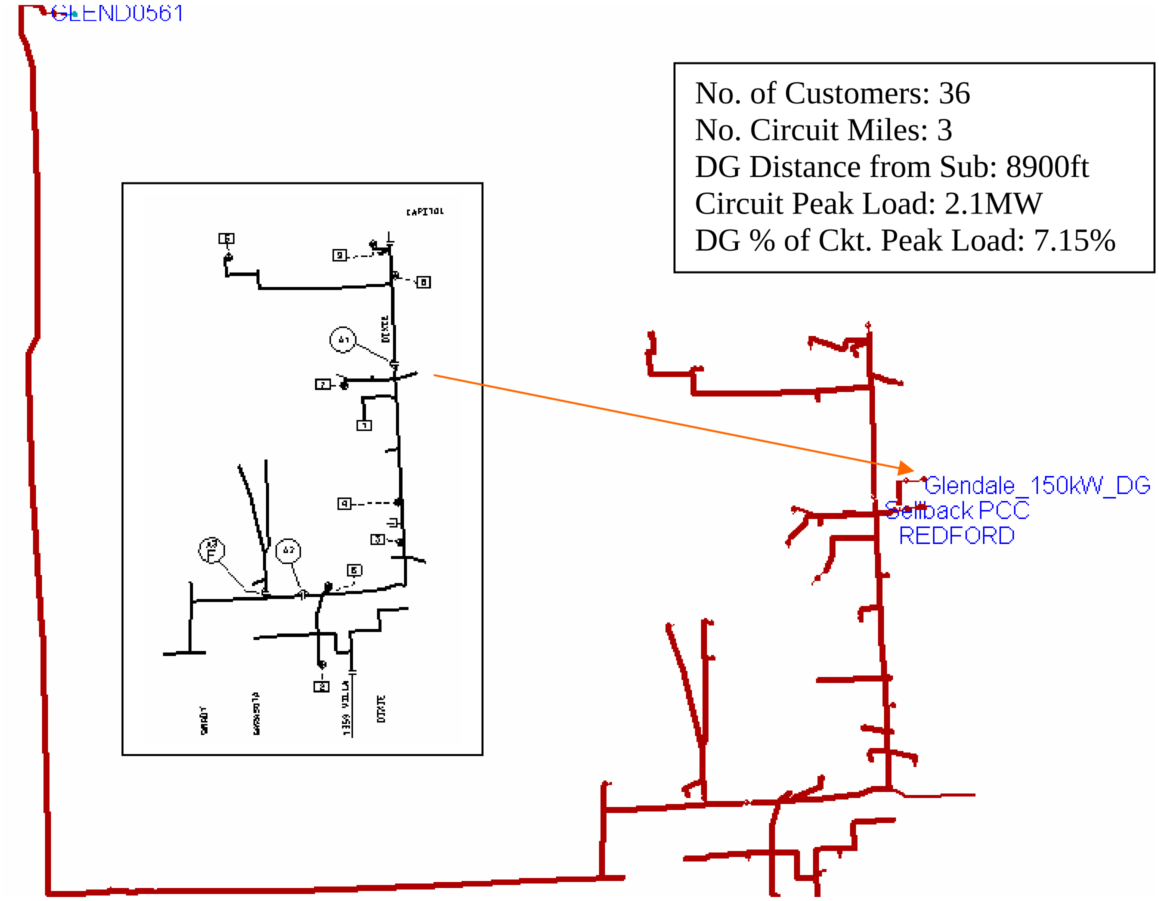




No. of Customers: 892
No. Circuit Miles: 3.9
DG Distance from Sub: 8700ft
Circuit Peak Load: 3.2MW
DG % of Ckt. Peak Load: 18.7%

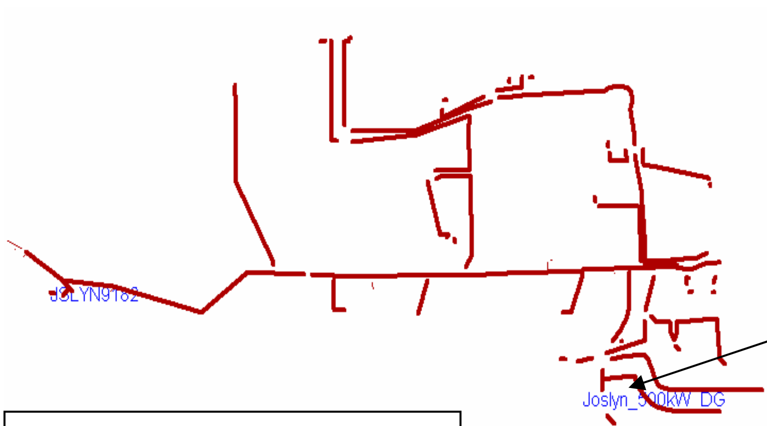
Glendale PL561
&
Redford Service Centre 150 KW N.G

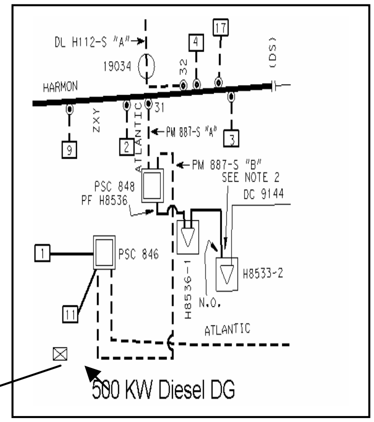
Address: 12000 Dixie
Redford, MI, 48198



Joslyn DC 9182
&
Alps Automotive 500 KW Diesel

Address: 1500 Atlantic Blvd
Auburn Hills, Mi, 48326

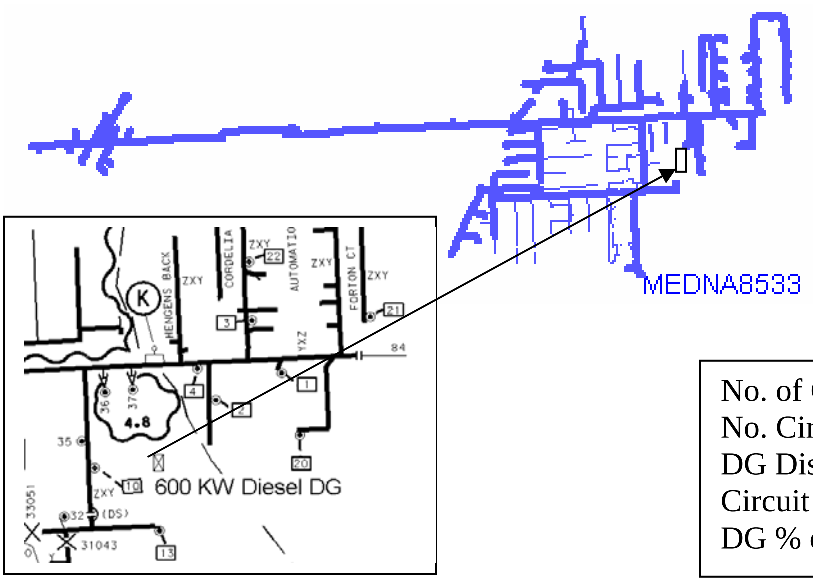




No. of Customers: 23
No. Circuit Miles: 1.6
DG Distance from Sub: 5000ft
Circuit Peak Load: 10.8 MW
DG % of Ckt. Peak Load: 4.6%

Medina DC 8533
&
Adell Communication 600 KW Diesel

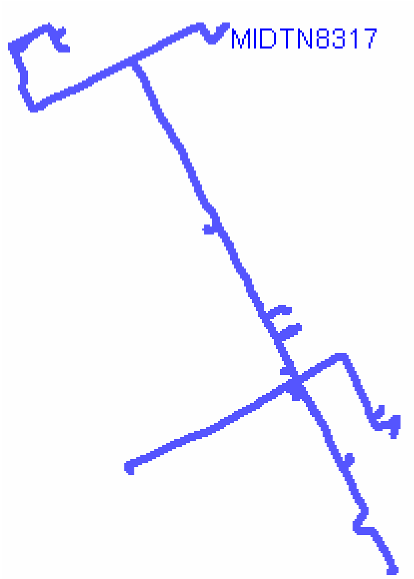
Address: 22590 15 Mile Rd
Clinton Twp, MI, 48035



No. of Customers: 1009
No. Circuit Miles: 14
DG Distance from Sub:4700 ft
Circuit Peak Load: 11.2MW
DG % of Ckt. Peak Load: 5.4%

Midtown DC 8317
&
Wayne State University 75+75+75 KW Nat. Gas

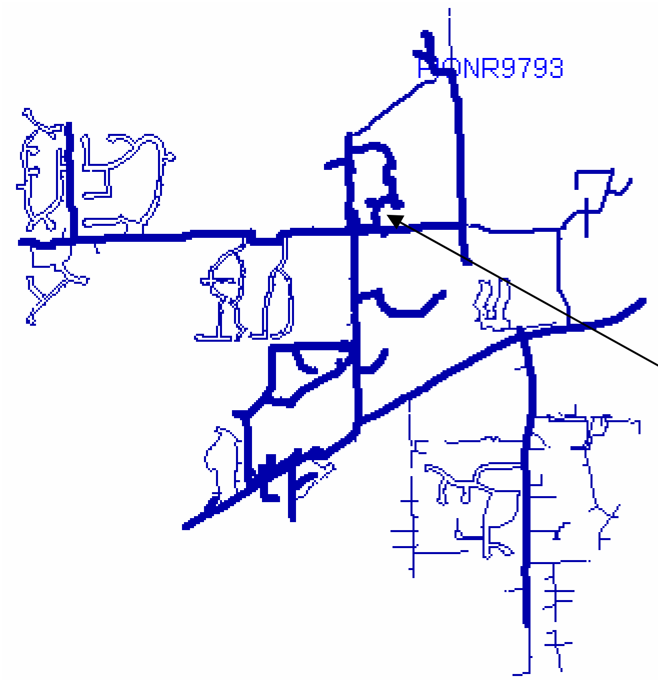
Address: 421 E. Canfield
Detroit, MI

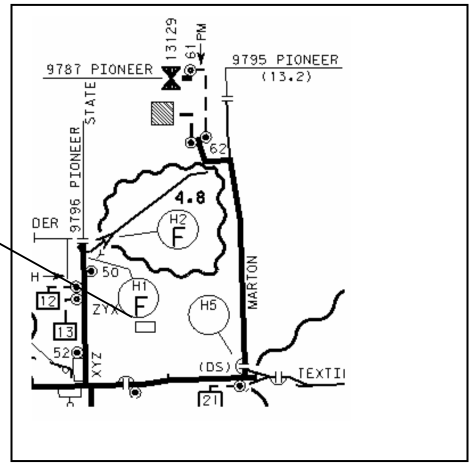


No. of Customers: 244
No. Circuit Miles: 5
DG Distance from Sub:
Circuit Peak Load: 6.6 MW
DG % of Ckt. Peak Load: 1.1%

Pioneer DC 9793 & Trinity Health Care - 600 KW Diesel

Address: 300 Textile Rd. Ann Arbor, MI, 48108

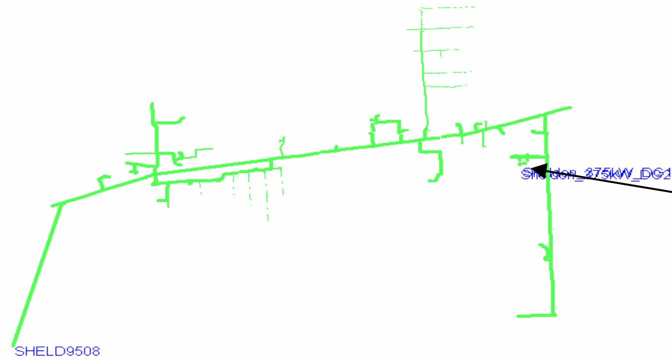


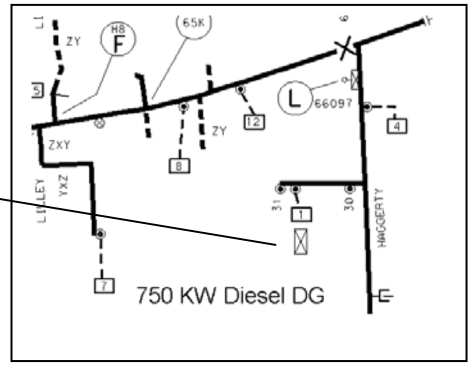


No. of Customers: 960
No. Circuit Miles: 41.2
DG Distance from Sub: 9100ft
Circuit Peak Load: 10.4MW
DG % of Ckt. Peak Load: 5.7%

Sheldon DC 9508
&
Arctic Cold Storage 750 KW Diesel

Address: 4360 S Haggerty Rd
Canton, MI, 48188

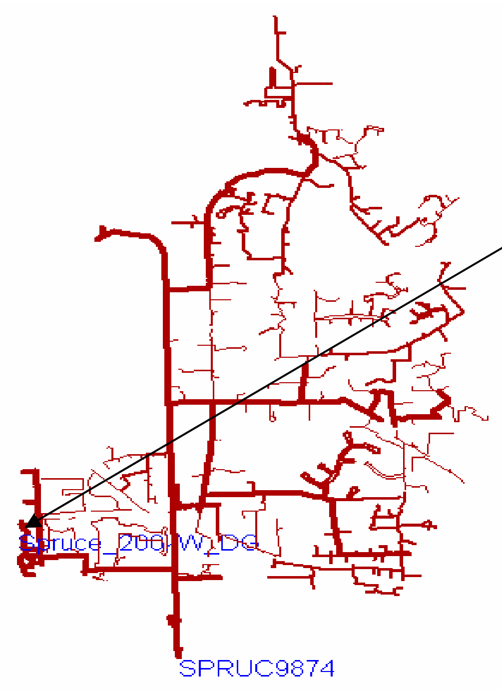


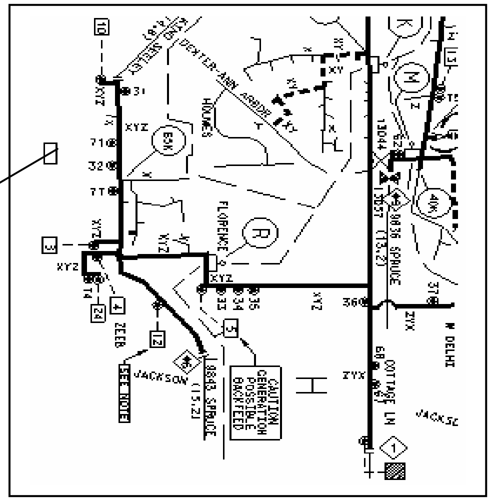


No. of Customers: 228
No. Circuit Miles: 9
DG Distance from Sub:11800 ft
Circuit Peak Load: 9.6MW
DG % of Ckt. Peak Load: 7.8%

Spruce DC 9874
&
Washtenaw County Bldg. 3 - 200 KW Nat. Gas

Address: 705 N Zeeb Rd.
Ann Arbor, MI, 48103

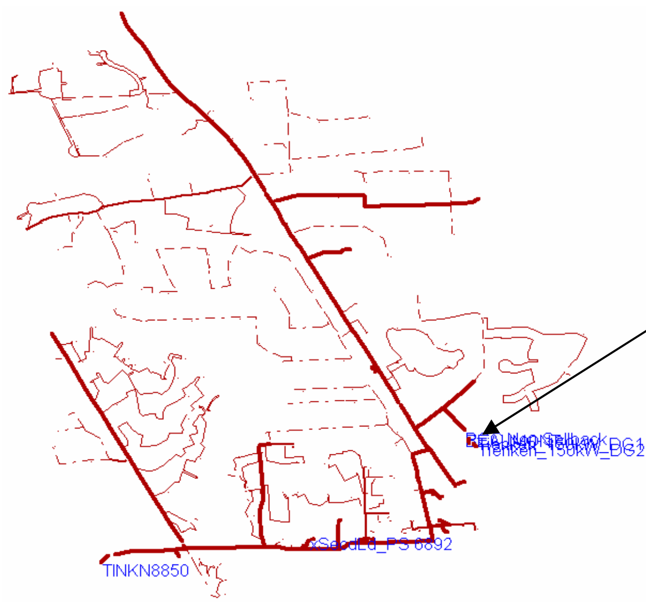


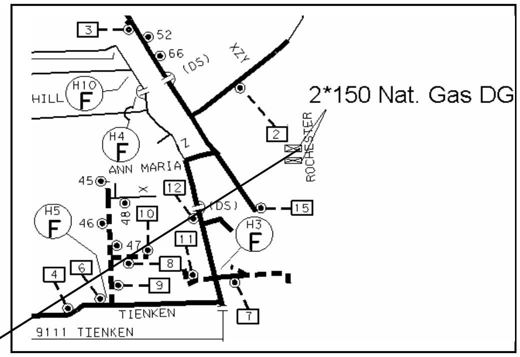


No. of Customers: 1220
No. Circuit Miles: 57.6
DG Distance from Sub: 9800ft
Circuit Peak Load: 8.4MW
DG % of Ckt. Peak Load: 2.38%

Tienken DC 8850 13.2KV
&
Beaumont Dialysis 150+150 KW Nat. Gas

Address: 6900 Rochester Rd.
Rochester Hills, MI, 48306





No. of Customers: 1511
No. Circuit Miles: 21
DG Distance from Sub: 6800 ft
Circuit Peak Load: 6.1 MW
DG % of Ckt. Peak Load: 2.5%

Appendix B

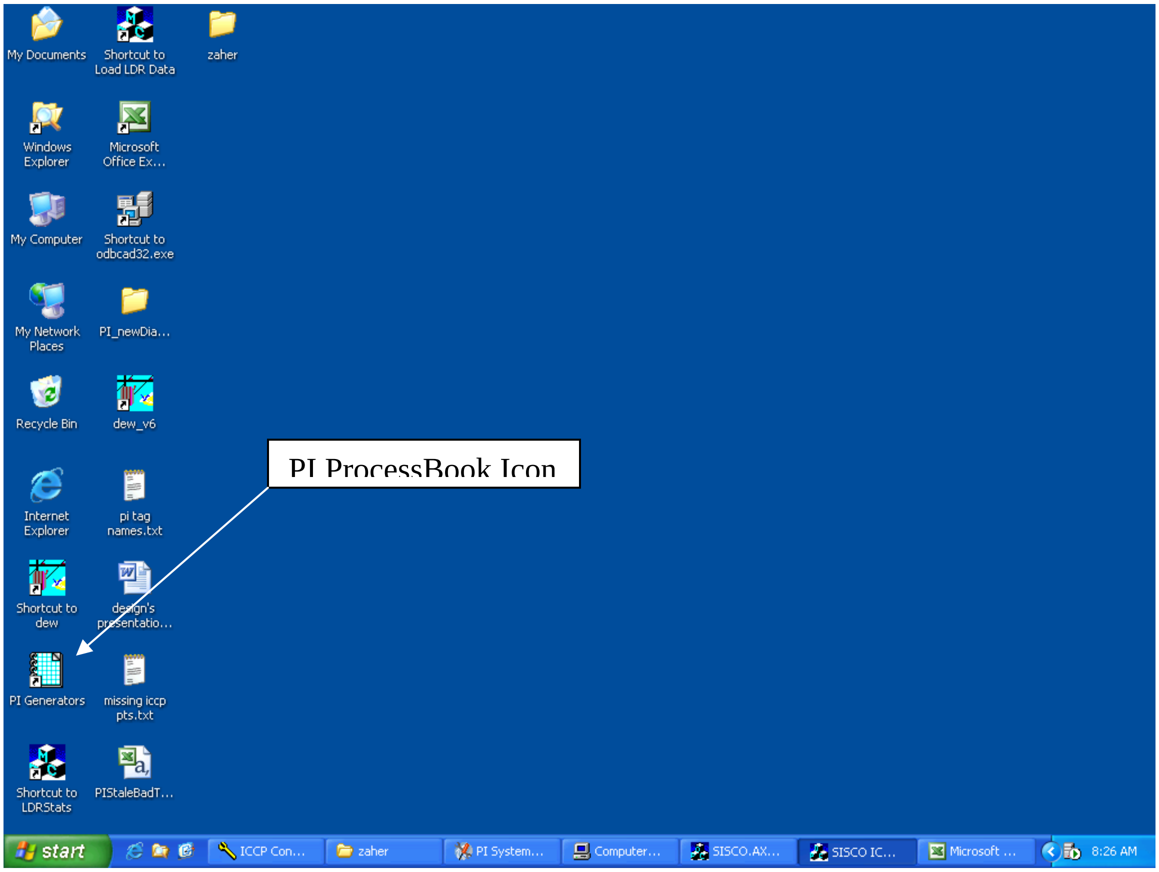
PI Process Book

Table of Contents

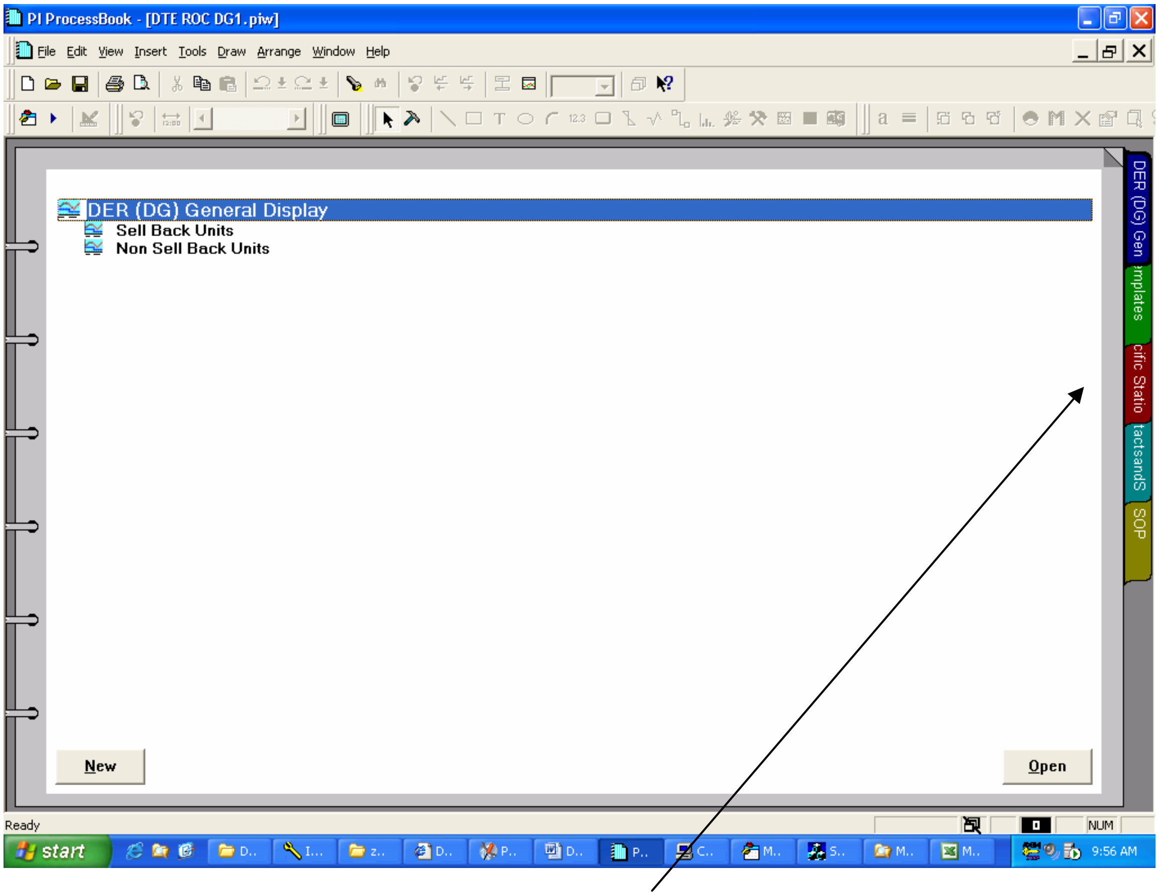
Overview:

PI-Process Book is a real time graphical user interface for the PI (Plant Information) System. It has the characteristics of real time process monitoring display system. It provides real time and historical plant information needed to monitor and improve the critical processes in the plants.

Start PI Process Book by double clicking on PI icon from the user desktop.



The main PI Process Book window will appear.



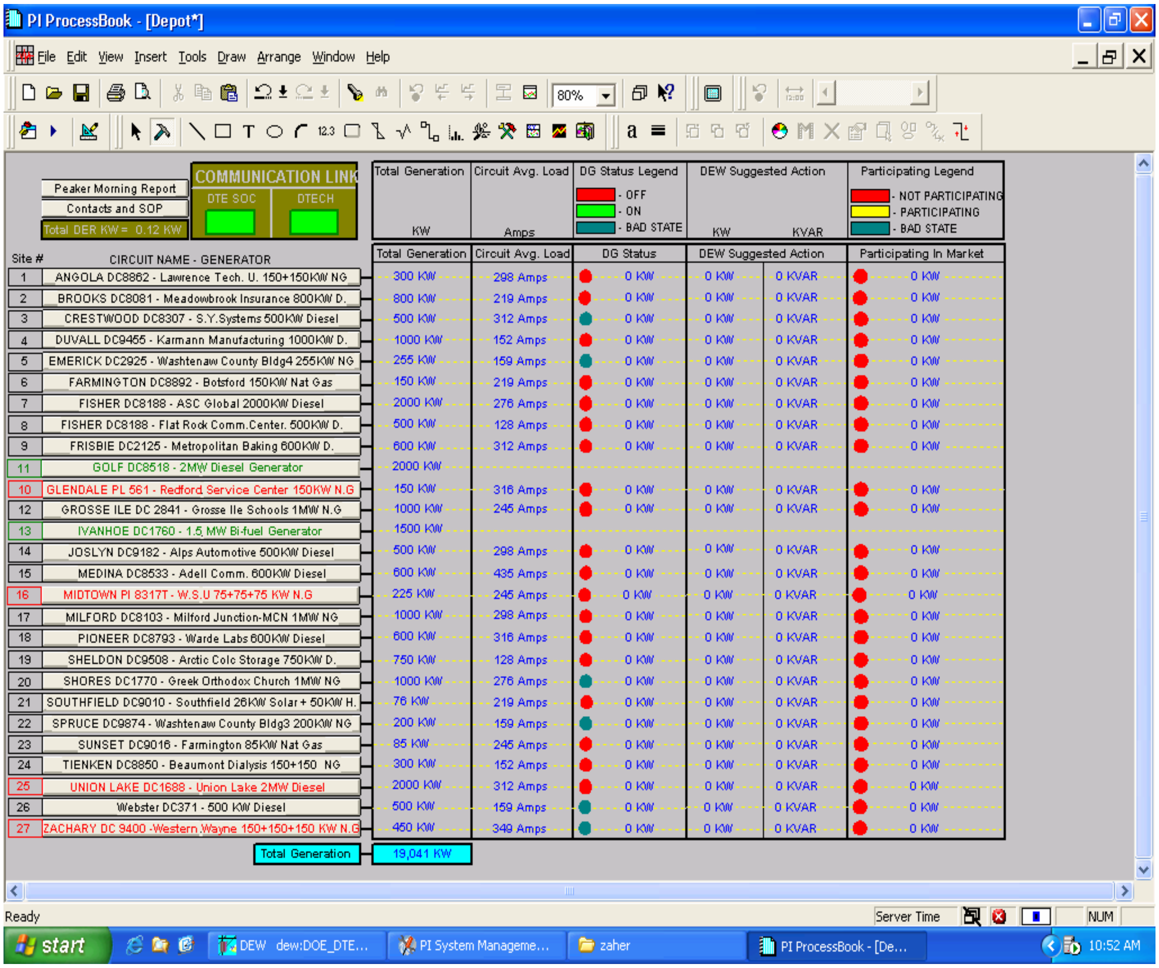
The **DTE ROC DG1** file contains five (5) Process Book entries which they are located on the right side of the main window. They are:

1) DER (DG) General Display.
   - Sellback Units.
   - Non Sellback Units.
2) Templates.
3) Specific station displays.
4) Contact and SOP.
5) SOP.

To open an entry or a sub-entry:

Select the entry you want to open from the right menu. Select the desired entry name from the screen, and then click the open button on the lower-right corner, or double click the entry name when the **Run** mode is on.

By opening DER (DG) General Display entry the DG's general display appears.



Site #	CIRCUIT NAME - GENERATOR	Total Generation	Circuit Avg. Load	DG Status	DEW Suggested Action (KW)	DEW Suggested Action (KVAR)	Participating In Market
1	ANGOLA DC8862 - Lawrence Tech. U. 150+150KW NG	300 KW	298 Amps	0 KW	0 KW	0 KVAR	0 KW
2	BROOKS DC8081 - Meadowbrook Insurance 800KW D.	800 KW	219 Amps	0 KW	0 KW	0 KVAR	0 KW
3	CRESTWOOD DC8307 - S.Y.Systems 500KW Diesel	500 KW	312 Amps	0 KW	0 KW	0 KVAR	0 KW
4	DUVALL DC9455 - Karmann Manufacturing 1000KW D.	1000 KW	152 Amps	0 KW	0 KW	0 KVAR	0 KW
5	EMERICK DC2925 - Washtenaw County Bldg4 255KW NG	255 KW	159 Amps	0 KW	0 KW	0 KVAR	0 KW
6	FARMINGTON DC8892 - Botsford 150KW Nat Gas	150 KW	219 Amps	0 KW	0 KW	0 KVAR	0 KW
7	FISHER DC8188 - ASC Global 2000KW Diesel	2000 KW	276 Amps	0 KW	0 KW	0 KVAR	0 KW
8	FISHER DC8188 - Flat Rock Comm.Center. 500KW D.	500 KW	128 Amps	0 KW	0 KW	0 KVAR	0 KW
9	FRISBIE DC2125 - Metropolitan Baking 600KW D.	600 KW	312 Amps	0 KW	0 KW	0 KVAR	0 KW
11	GOLF DC8518 - 2MW Diesel Generator	2000 KW					
10	GLENDALE PL 561 - Redford Service Center 150KW N.G	150 KW	316 Amps	0 KW	0 KW	0 KVAR	0 KW
12	GROSSE ILE DC 2841 - Grosse Ile Schools 1MW N.G	1000 KW	245 Amps	0 KW	0 KW	0 KVAR	0 KW
13	IVANHOE DC1760 - 1.5 MW Bi-fuel Generator	1500 KW					
14	JOSLYN DC9182 - Alps Automotive 500KW Diesel	500 KW	298 Amps	0 KW	0 KW	0 KVAR	0 KW
15	MEDINA DC8533 - Adell Comm. 600KW Diesel	600 KW	435 Amps	0 KW	0 KW	0 KVAR	0 KW
16	MIDTOWN PI 8317T - W.S.U 75+75+75 KW N.G	225 KW	245 Amps	0 KW	0 KW	0 KVAR	0 KW
17	MILFORD DC8103 - Milford Junction-MCN 1MW NG	1000 KW	298 Amps	0 KW	0 KW	0 KVAR	0 KW
18	PIONEER DC8793 - Warde Labs 600KW Diesel	600 KW	316 Amps	0 KW	0 KW	0 KVAR	0 KW
19	SHELDON DC9508 - Arctic Colc Storage 750KW D.	750 KW	128 Amps	0 KW	0 KW	0 KVAR	0 KW
20	SHORES DC1770 - Greek Orthodox Church 1MW NG	1000 KW	276 Amps	0 KW	0 KW	0 KVAR	0 KW
21	SOUTHFIELD DC9010 - Southfield 26KW Solar + 50KW H.	76 KW	219 Amps	0 KW	0 KW	0 KVAR	0 KW
22	SPRUCE DC9874 - Washtenaw County Bldg3 200KW NG	200 KW	159 Amps	0 KW	0 KW	0 KVAR	0 KW
23	SUNSET DC9016 - Farmington 85KW Nat Gas	85 KW	245 Amps	0 KW	0 KW	0 KVAR	0 KW
24	TIENKEN DC8850 - Beaumont Dialysis 150+150 NG	300 KW	152 Amps	0 KW	0 KW	0 KVAR	0 KW
25	UNION LAKE DC1688 - Union Lake 2MW Diesel	2000 KW	312 Amps	0 KW	0 KW	0 KVAR	0 KW
26	Webster DC371 - 500 KW Diesel	500 KW	159 Amps	0 KW	0 KW	0 KVAR	0 KW
27	ZACHARY DC 9400 -Western Wayne 150+150+150 KW N.G	450 KW	349 Amps	0 KW	0 KW	0 KVAR	0 KW
	Total Generation	19,041 KW					

Contents:
Date and time.

Peaker Morning report: is a link to an excel spreadsheet which shows the today's total capability, availability, and MW loss summary for the DGs.

Contacts and SOP: button provides a quick reference link for the Detroit Edison ROC operators to the DER contact information, as well as the tagging and operating procedures developed as part of this project as well as our internal System Operating Procedures (SOP) developed for those DERs over 1MW or larger.

COMMUNICATION LINK: reflects the status of the ICCP links for both Detroit Edison's (DTE) System Operating Center and DTECH SOC.

Total DER KW: provides the total KW load for all DGs.

Total generation: displays the capability of each unit in KW.

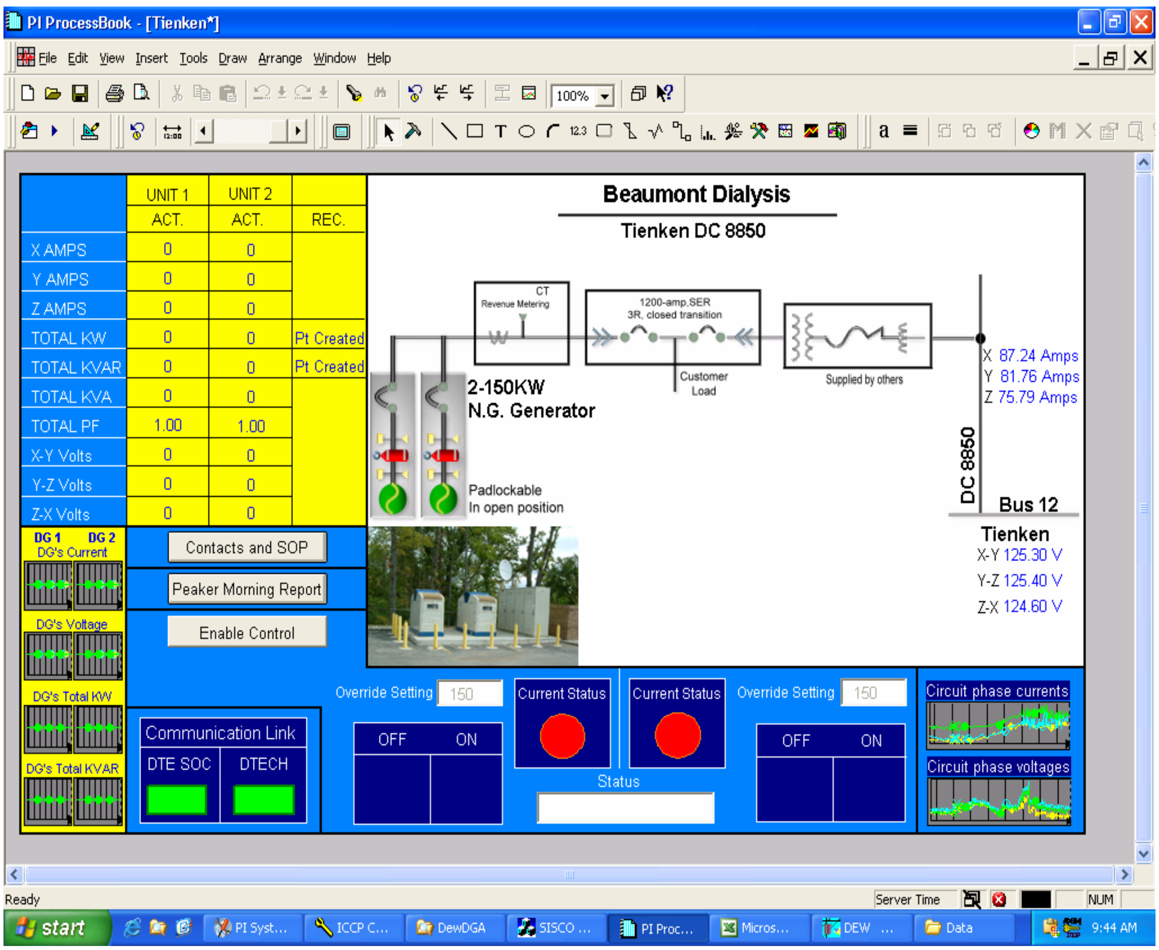
Circuit Ave. Load: shows the average load of each circuit in Amps.
DG Status: shows both the status of the generator (on/off) as well as the KW output for that DER.

DEW Suggested Action: is given for KW, KVAR, and action needed by the Detroit Edison's SOC operators.

Participating in market.

Circuit Name: these buttons are the Phase II Detroit Edison circuits that the DERs for Phase II and Premium Power DGs are located on.

By clicking on any of the circuit name button a new display screen appears. It includes the following depictions of the Detroit Edison distribution circuit (DC) configurations and start of circuit phase voltages, on a 120-volt base, the phase currents in amps, and the actual current, voltage, KW, KVAR, and KVA values for each generator. It also shows a one-line diagram of the Detroit Edison SCADA data and of the DER, for the aggregator DER SOC data. In addition, there are two on/off buttons which enable user to control over the desired generator.

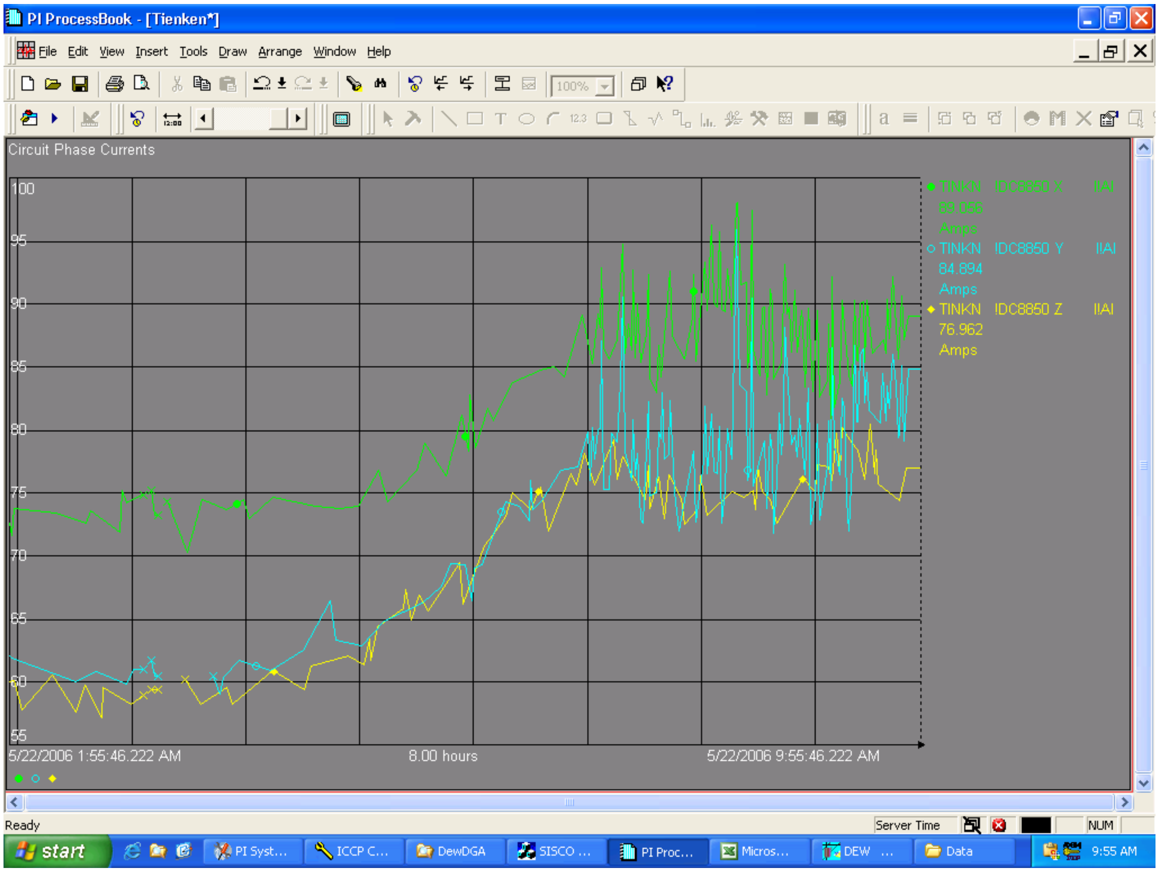


Contents:

Communication Link, Contacts and SOP, Peaker Morning Report, Current Status: buttons are the same links that appear on the previous page.

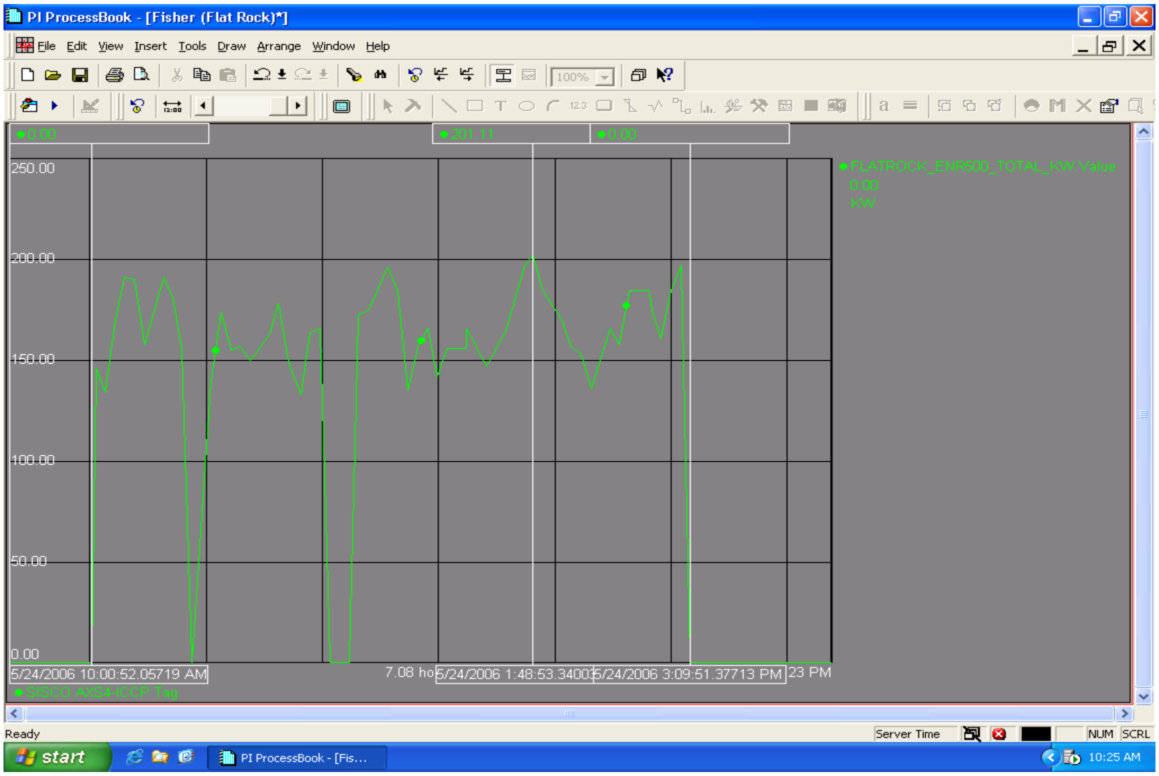
Enable/Disable Control button: **by clicking the enable control button a new message will appear asking to check if the procedure has been followed. If yes (the customer, via the aggregator, has turned over control to the utility), then check out the message and then the** on **and** off **buttons are now visible after the operating procedures are followed.**

PI process book has a graph feature enabling the operator to review operation of the DER. By double clicking on either the DG or circuit's trend, a graph similar to the following will appear.

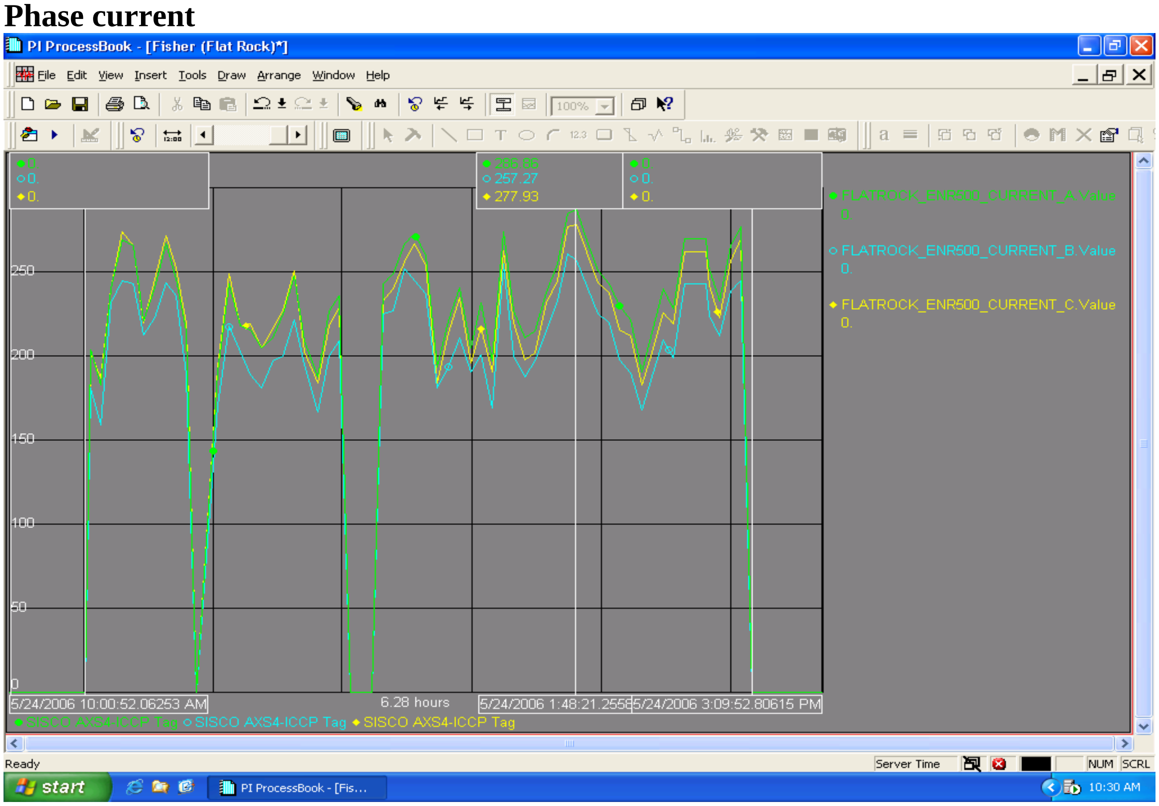


The following two graphs show the behavior of the KW and phase current curves of Flat rock's DG during the sell process for 5 hours on 5-24-2006.

KW

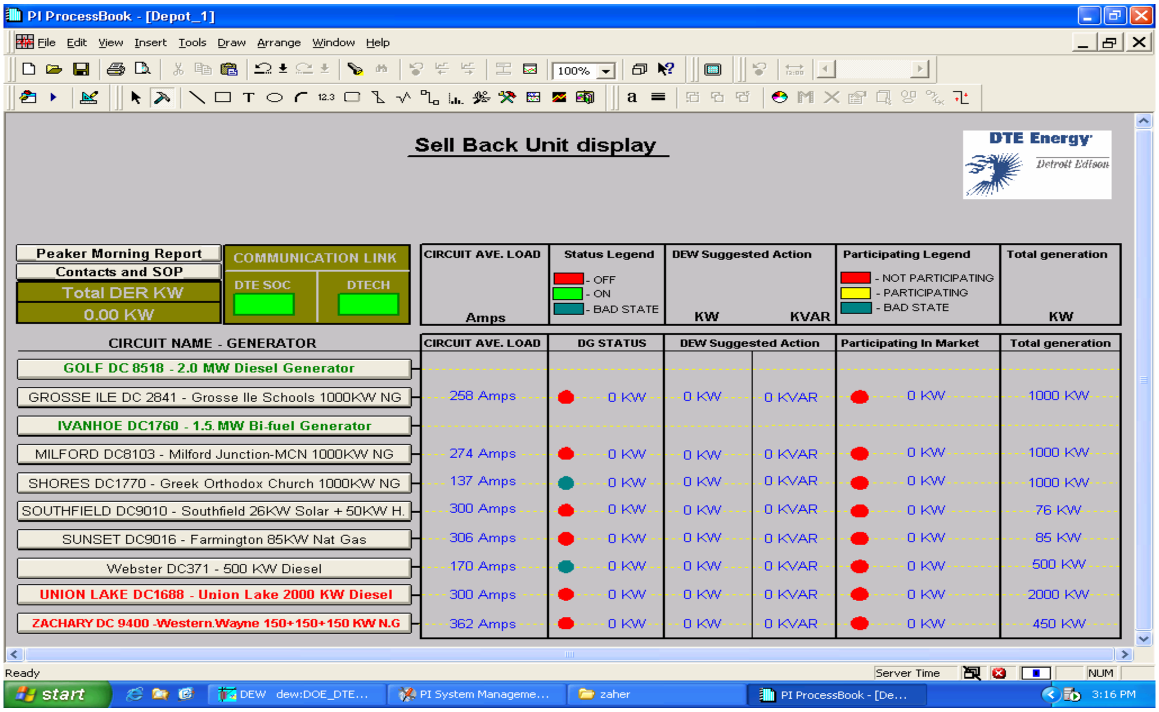


Phase current

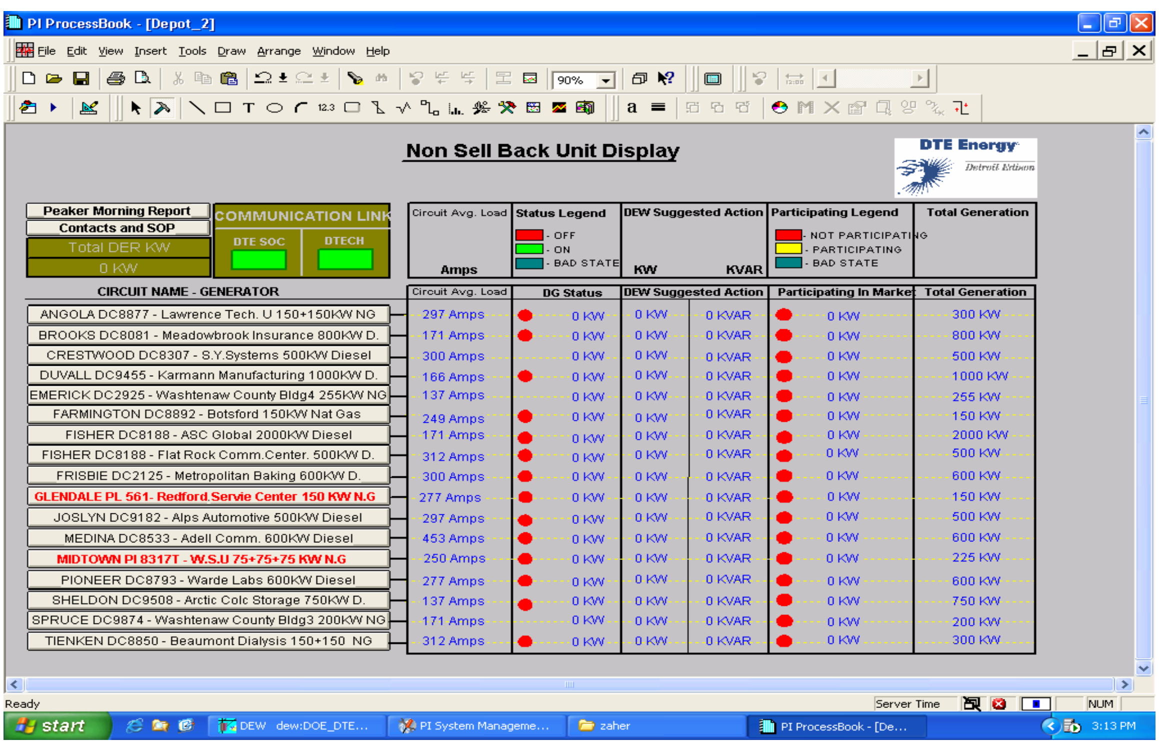


The following are the sell back and non sell back displays, and the remaining displays of the Detroit Edison distribution circuits that are used for the Phase II project.

Sell Back Unit Display

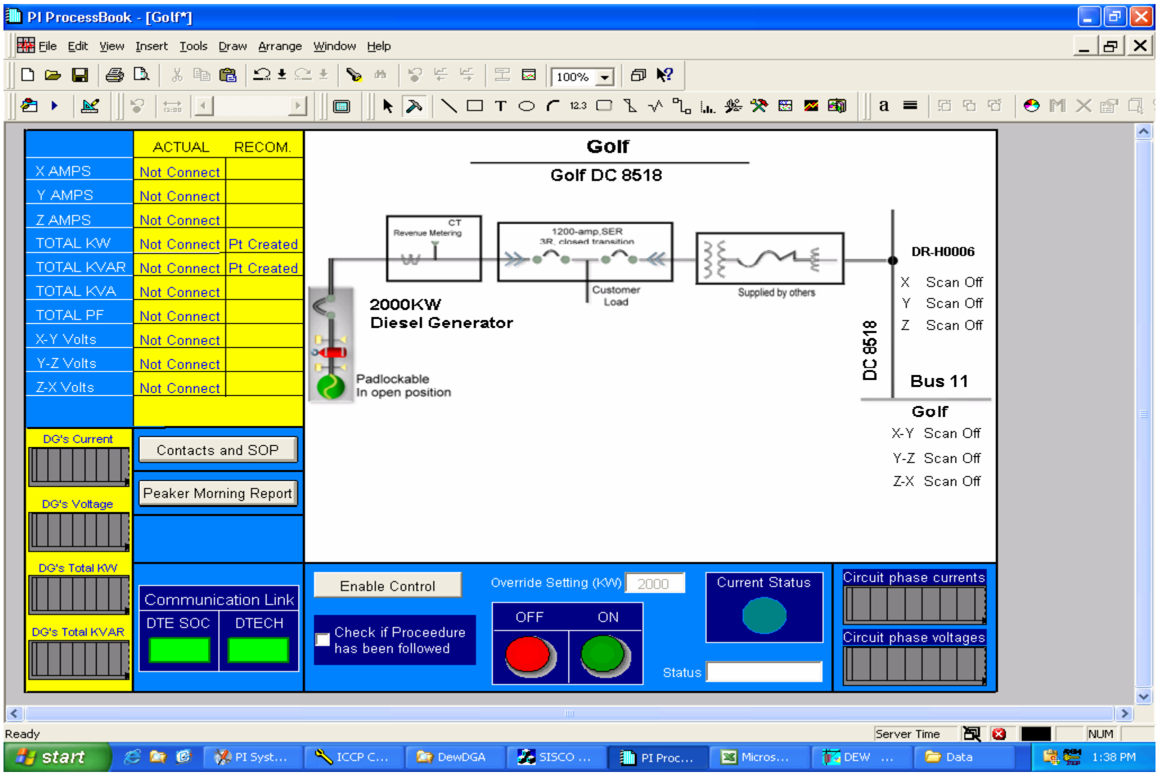


Non Sell Back Unit Display

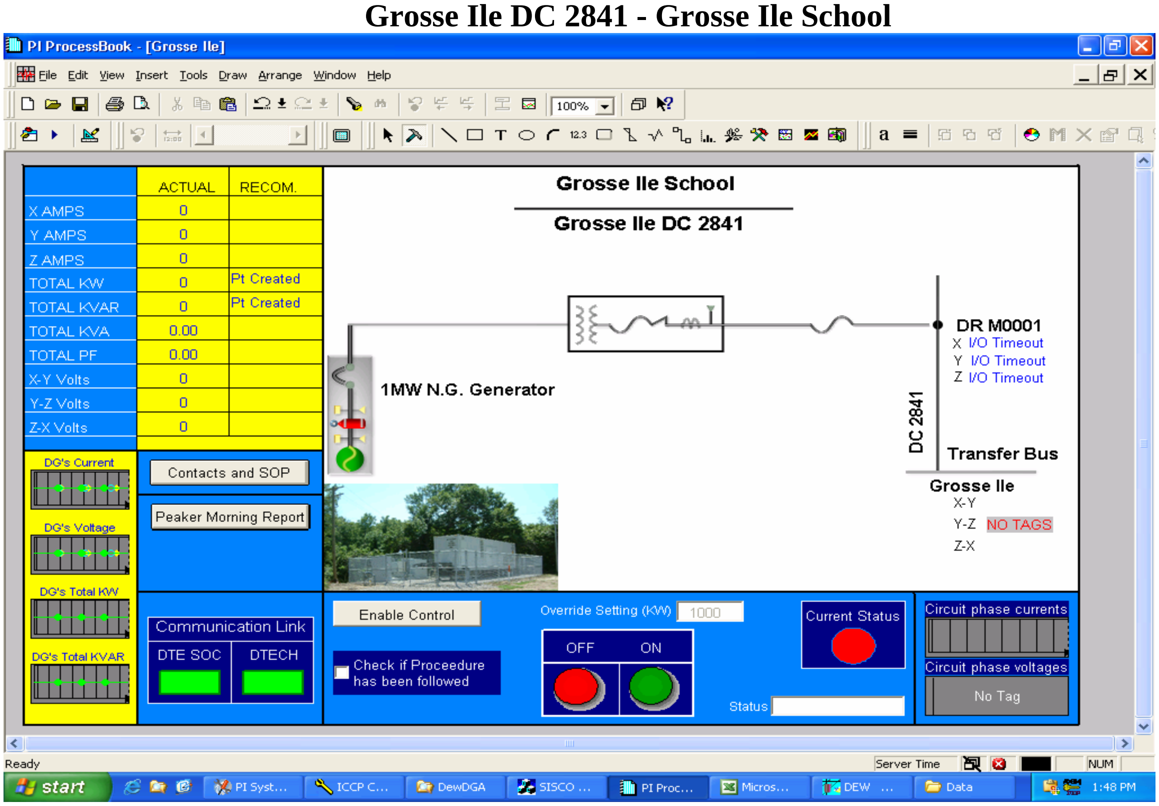


Sell back units

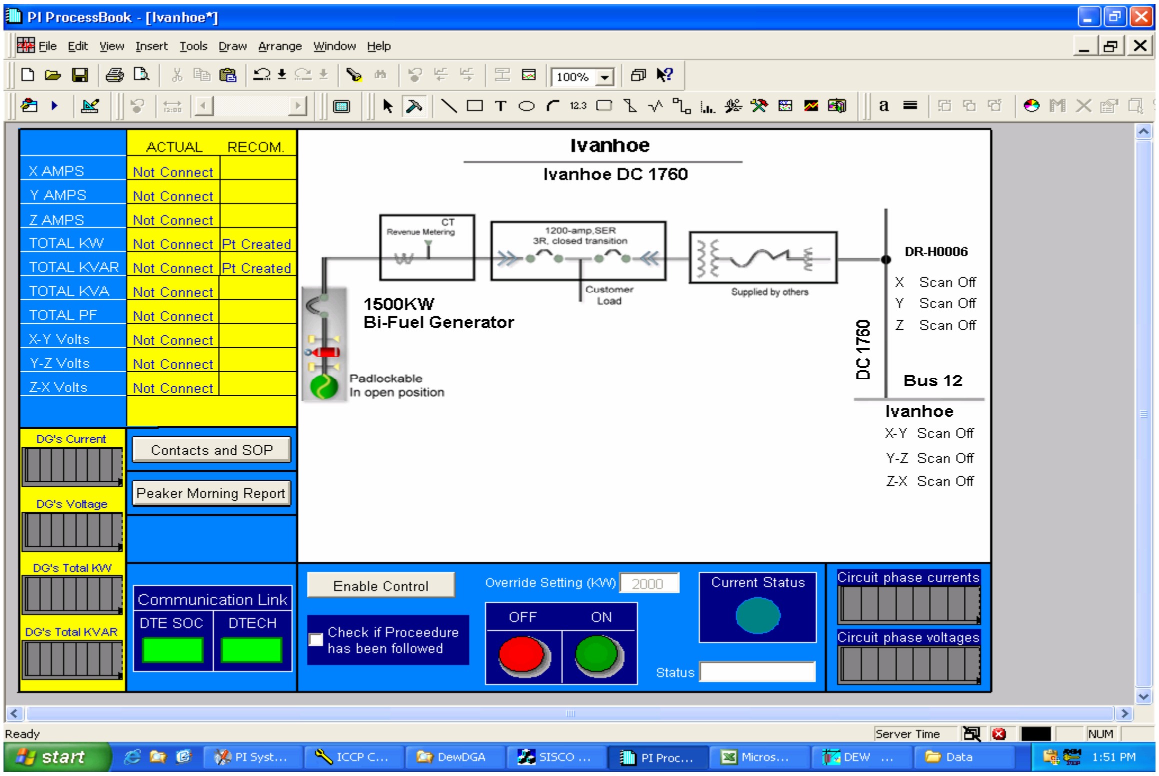
Golf DC8518 - Golf



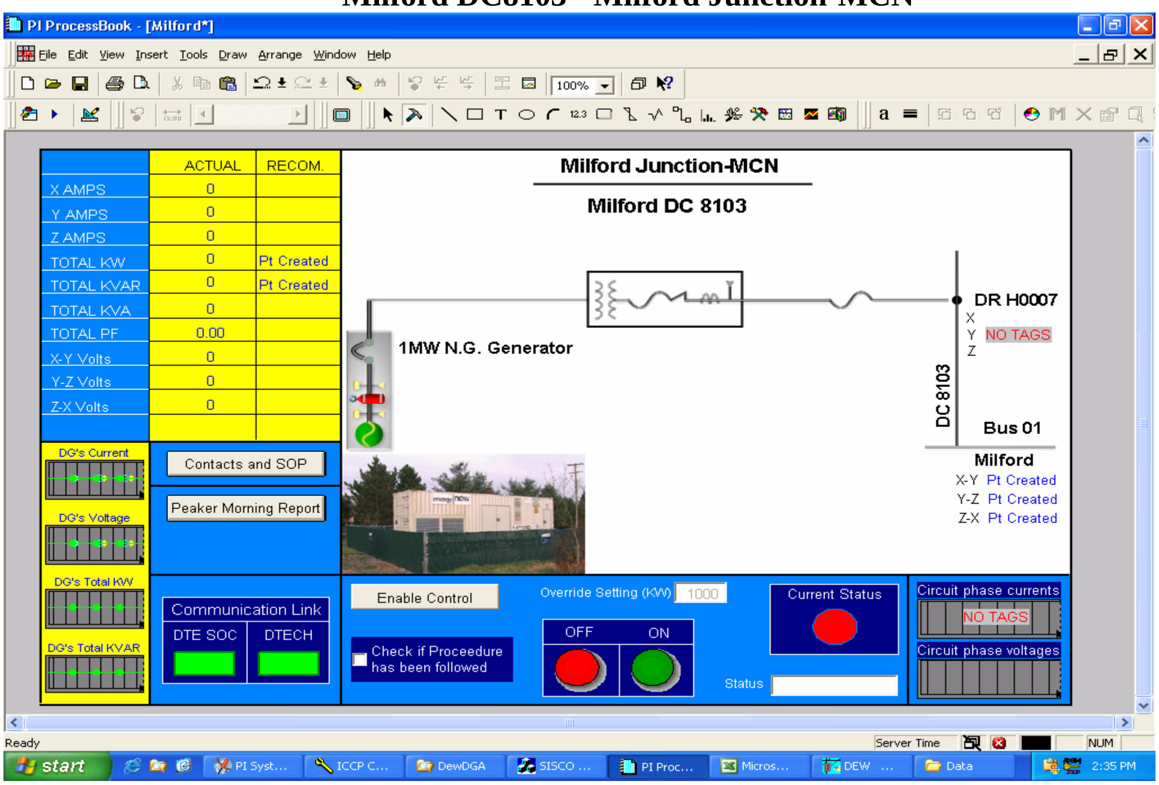
Grosse Ile DC 2841 - Grosse Ile School



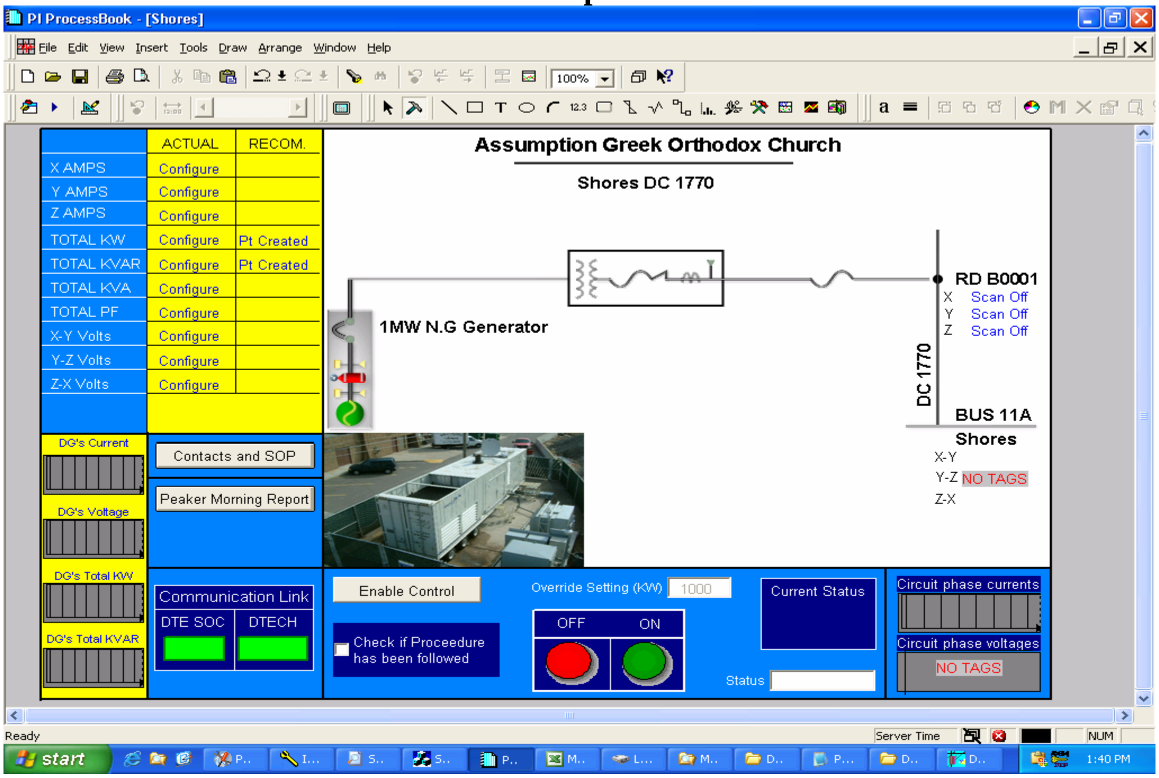
Ivanhoe DC1760 - Ivanhoe



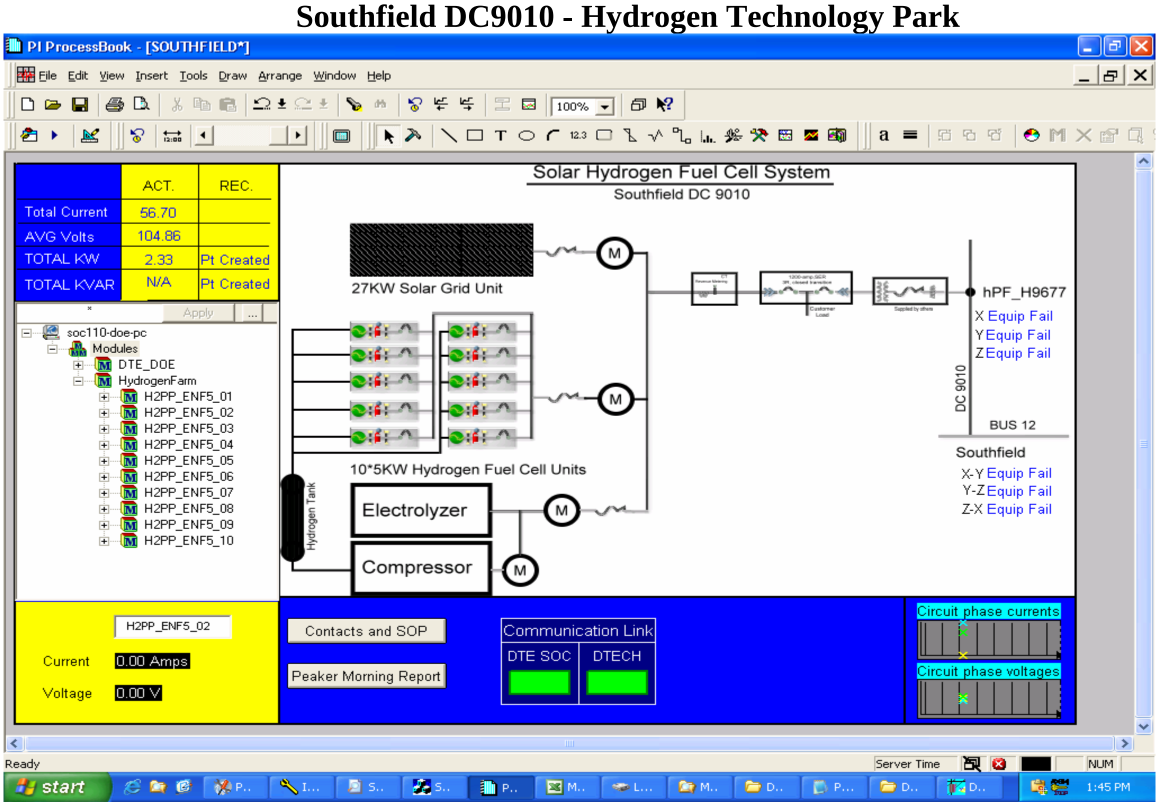
Milford DC8103 - Milford Junction-MCN



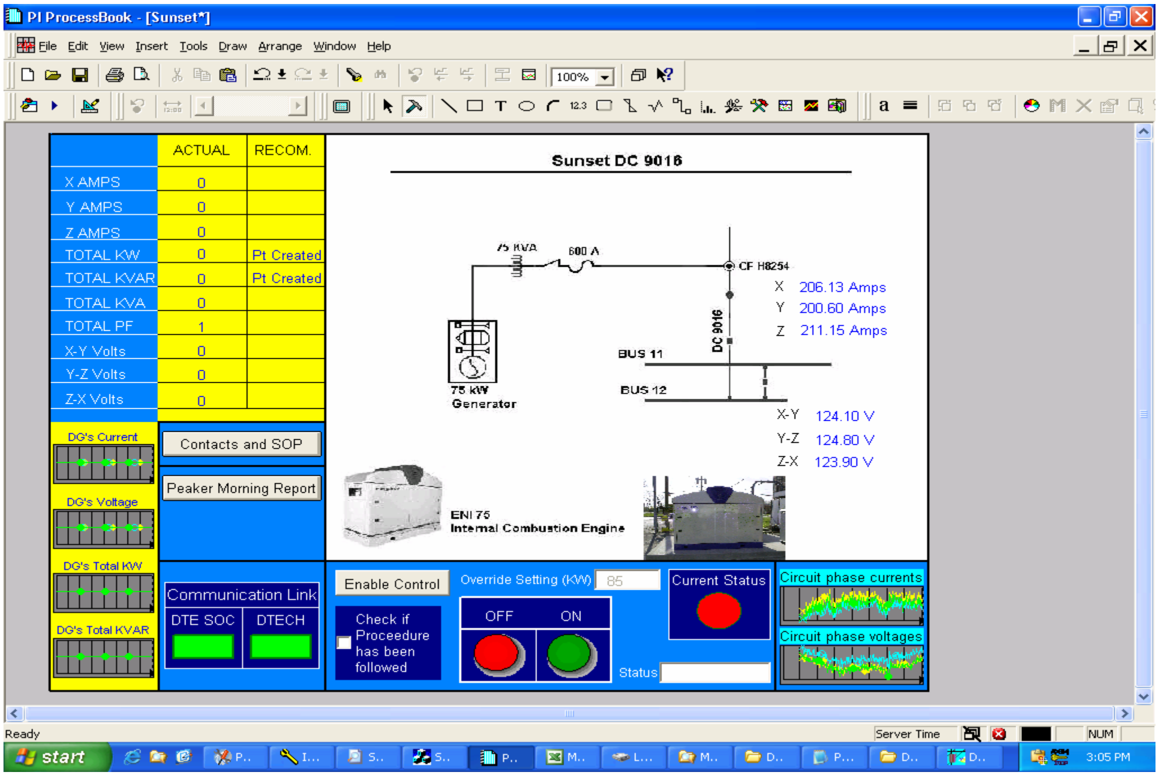
Shores DC1770 - Assumption Greek Orthodox Church



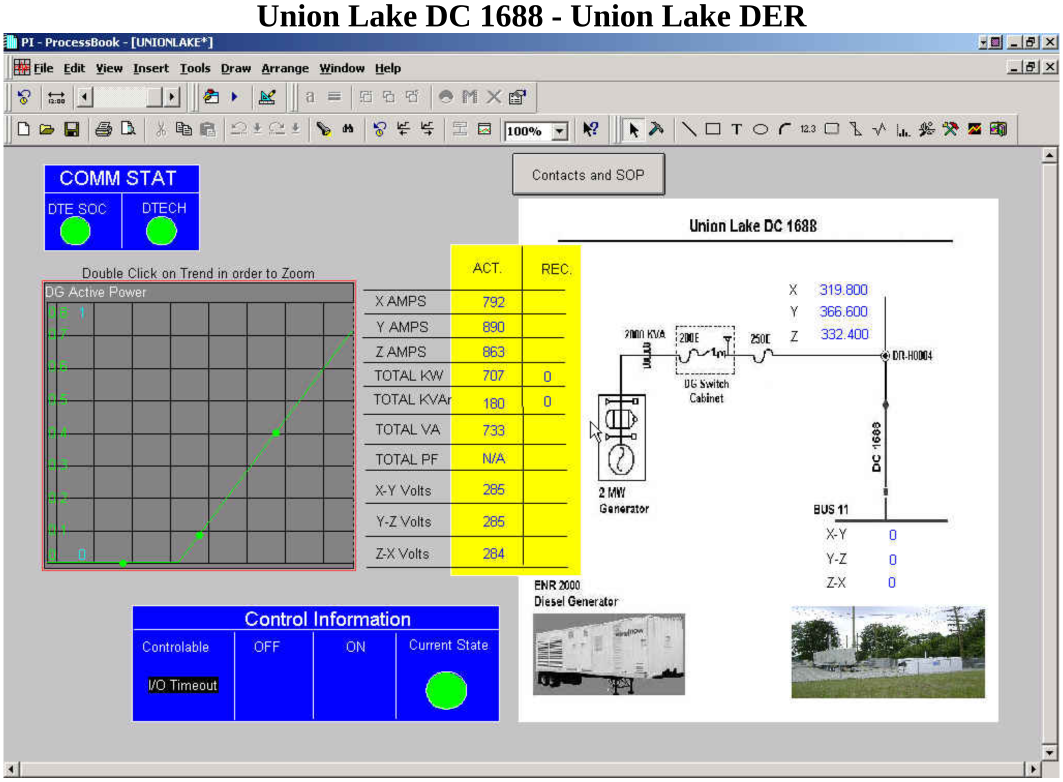
Southfield DC9010 - Hydrogen Technology Park



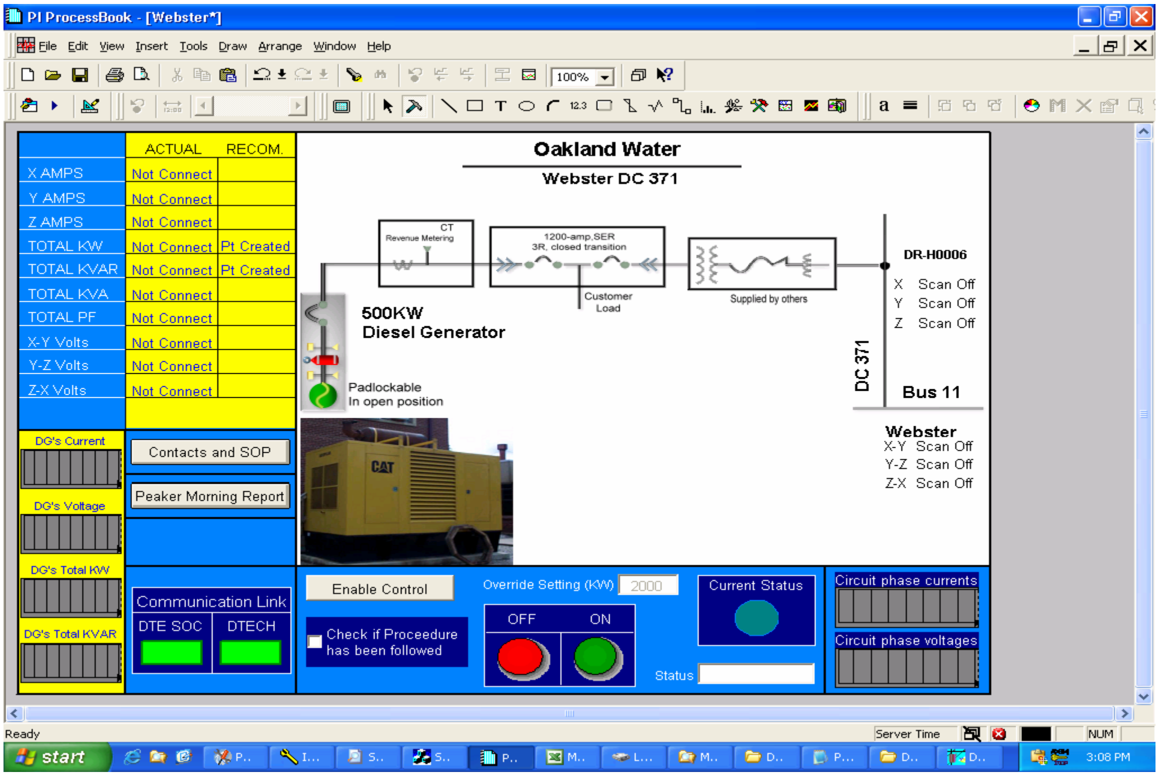
Sunset DC9016



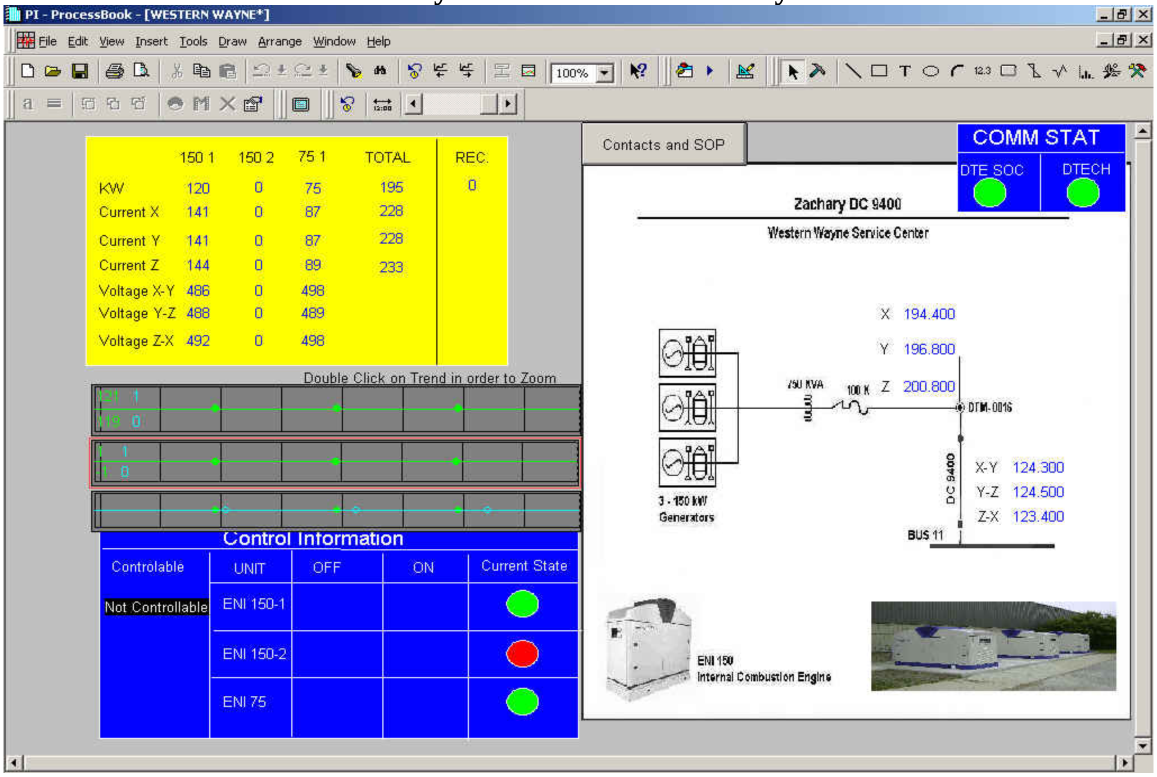
Union Lake DC 1688 - Union Lake DER



Webster DC371 - Oakland Water

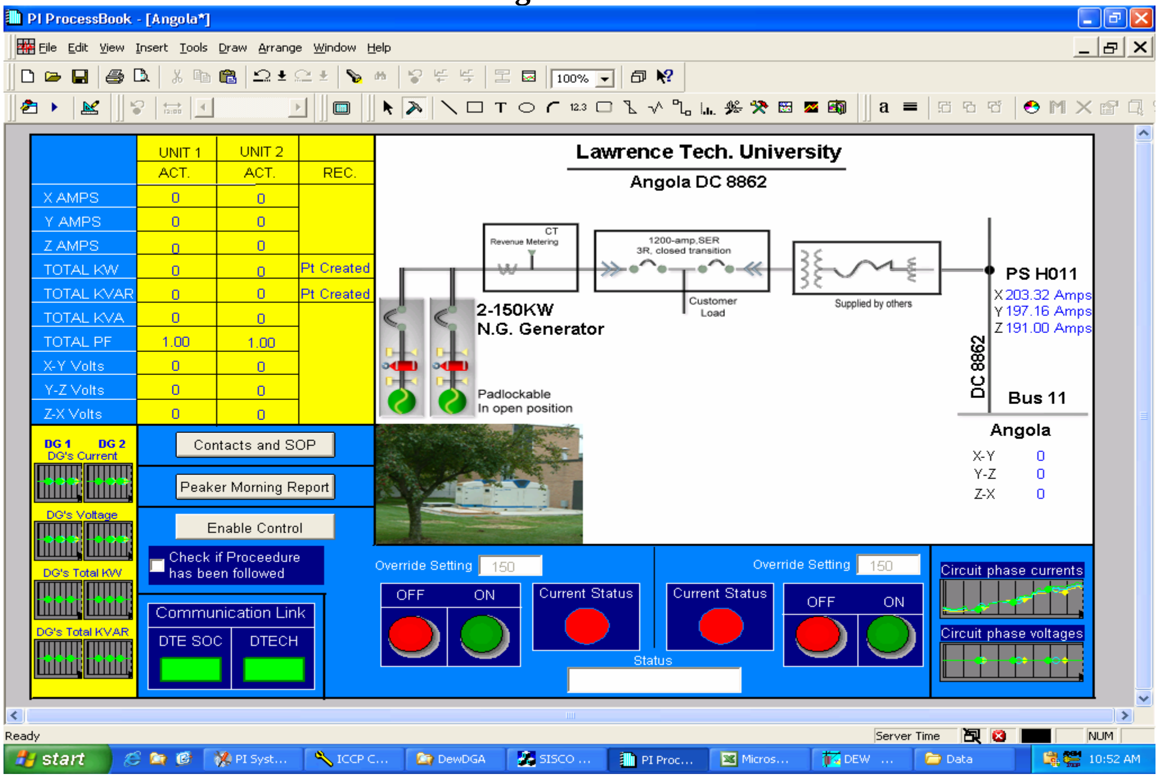


Zachary DC 9400 - Western Wayne

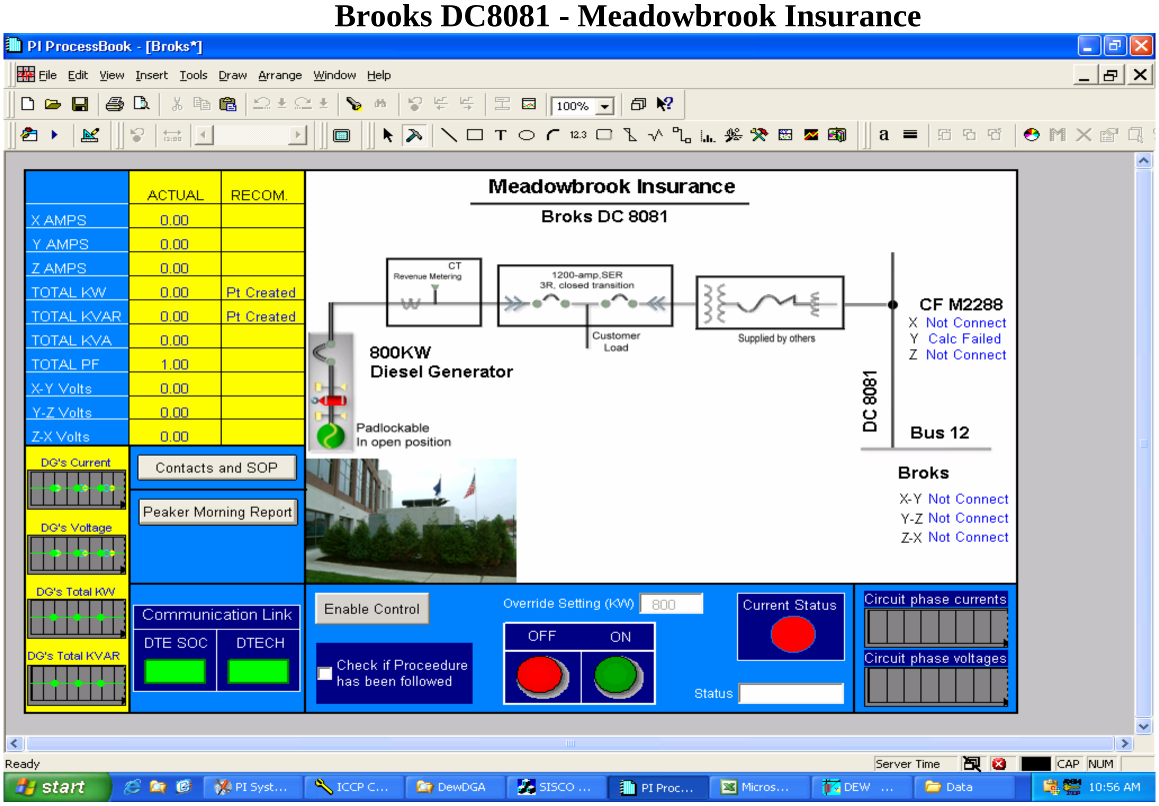


None sell back units

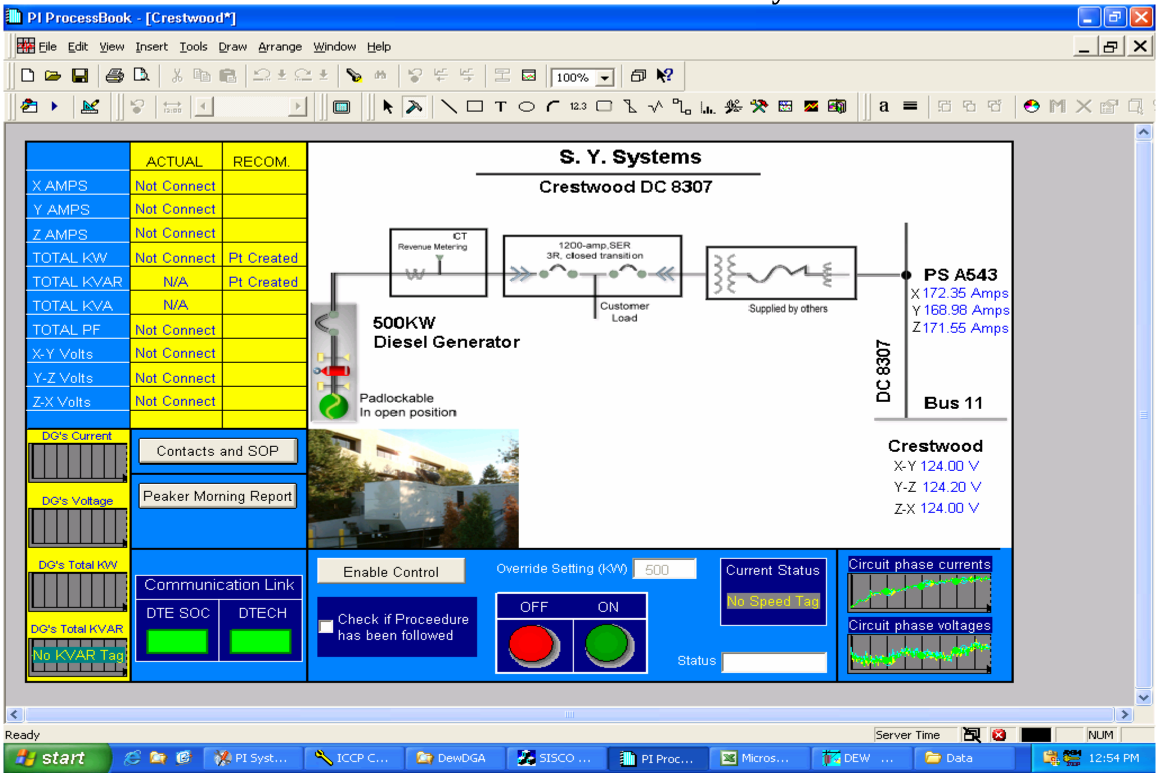
Angola DC8862 - LTU



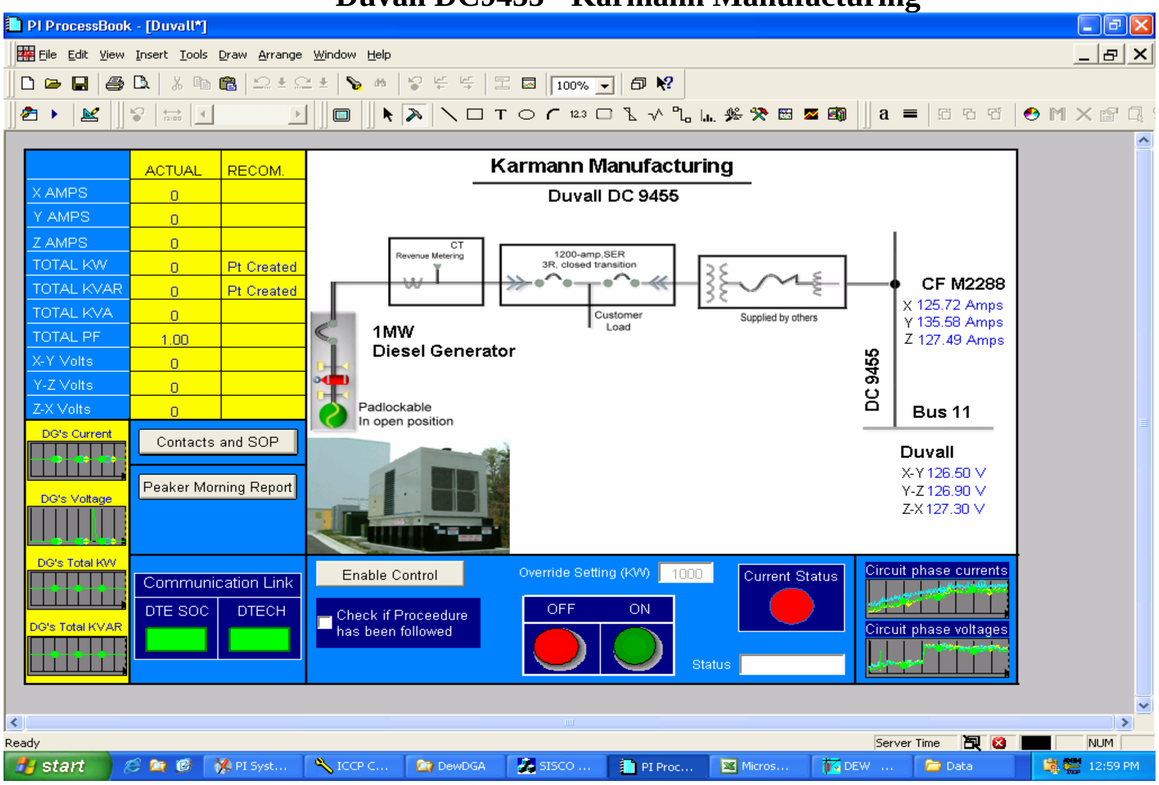
Brooks DC8081 - Meadowbrook Insurance



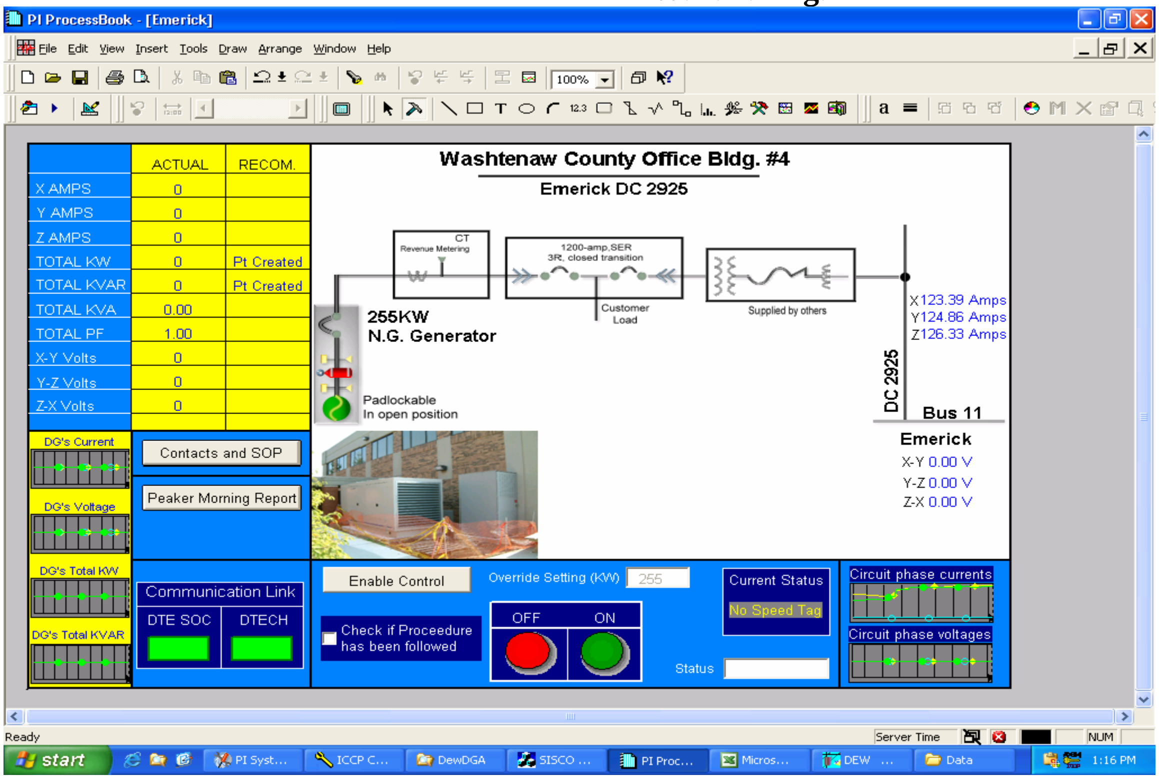
Crestwood DC8307 - S.Y.System



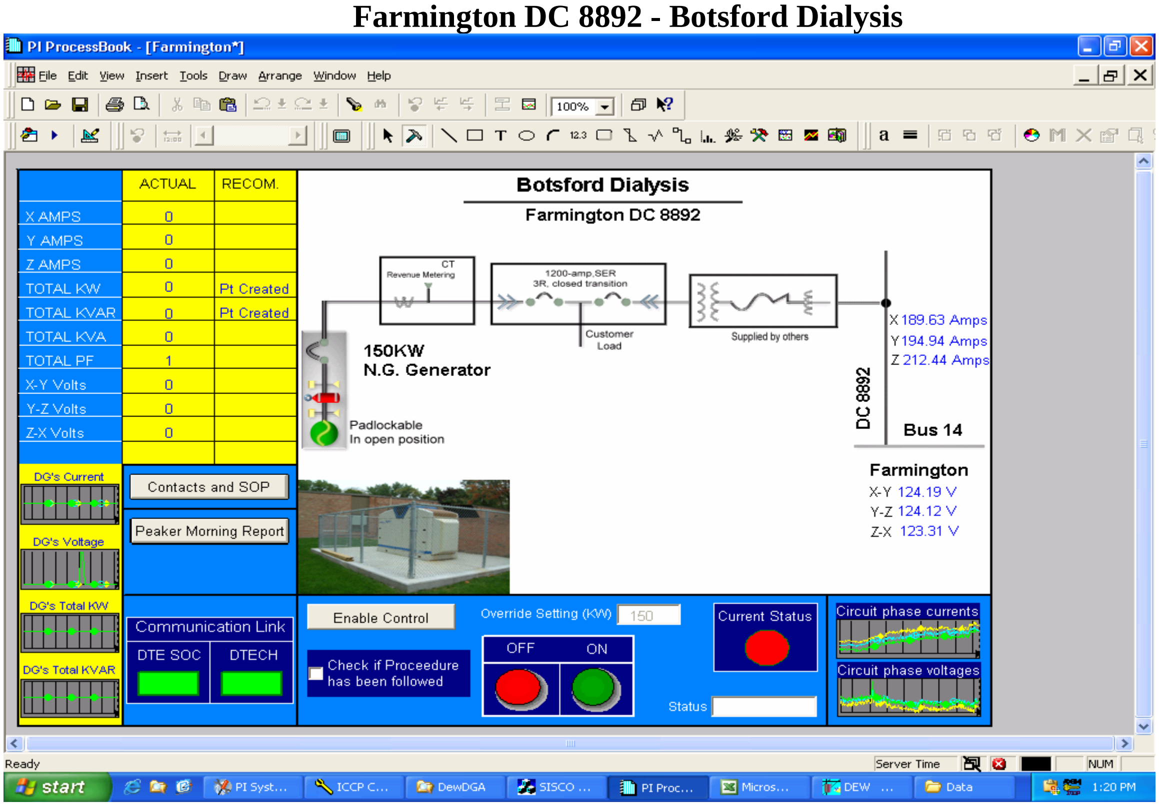
Duvall DC9455 - Karmann Manufacturing



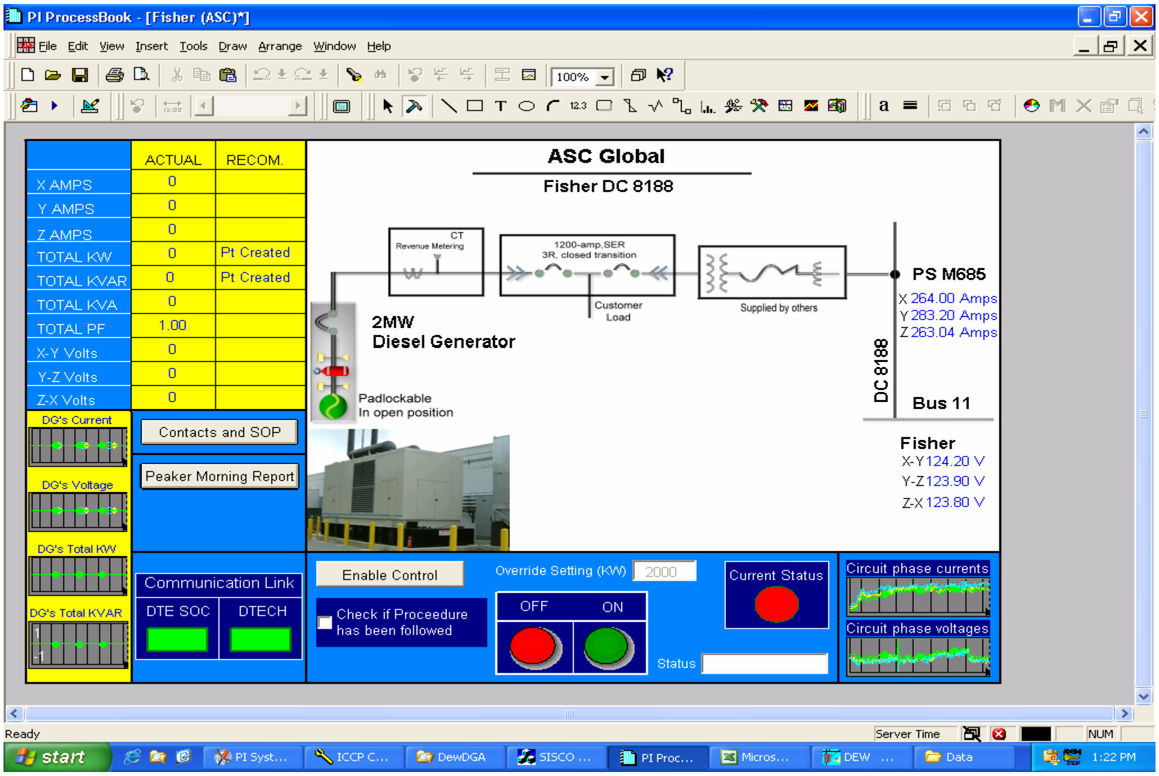
Emerick DC2925 - W.C.O.Bldg. #4



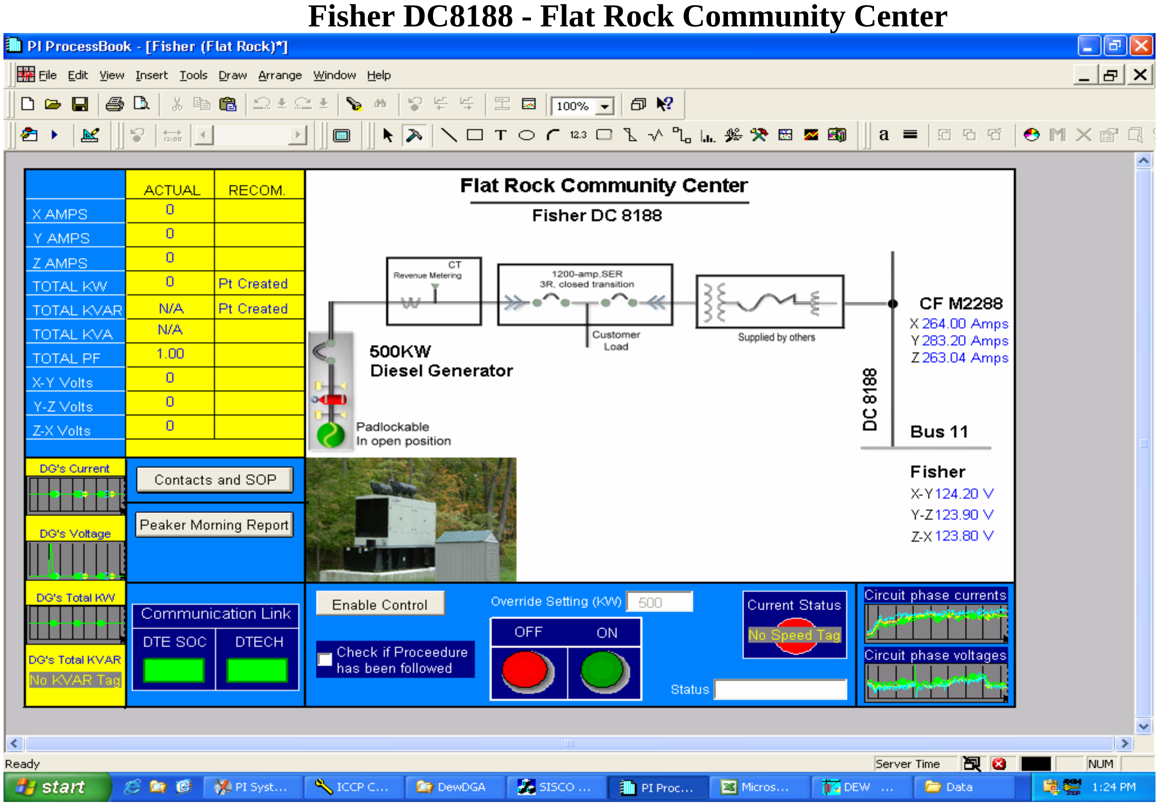
Farmington DC 8892 - Botsford Dialysis



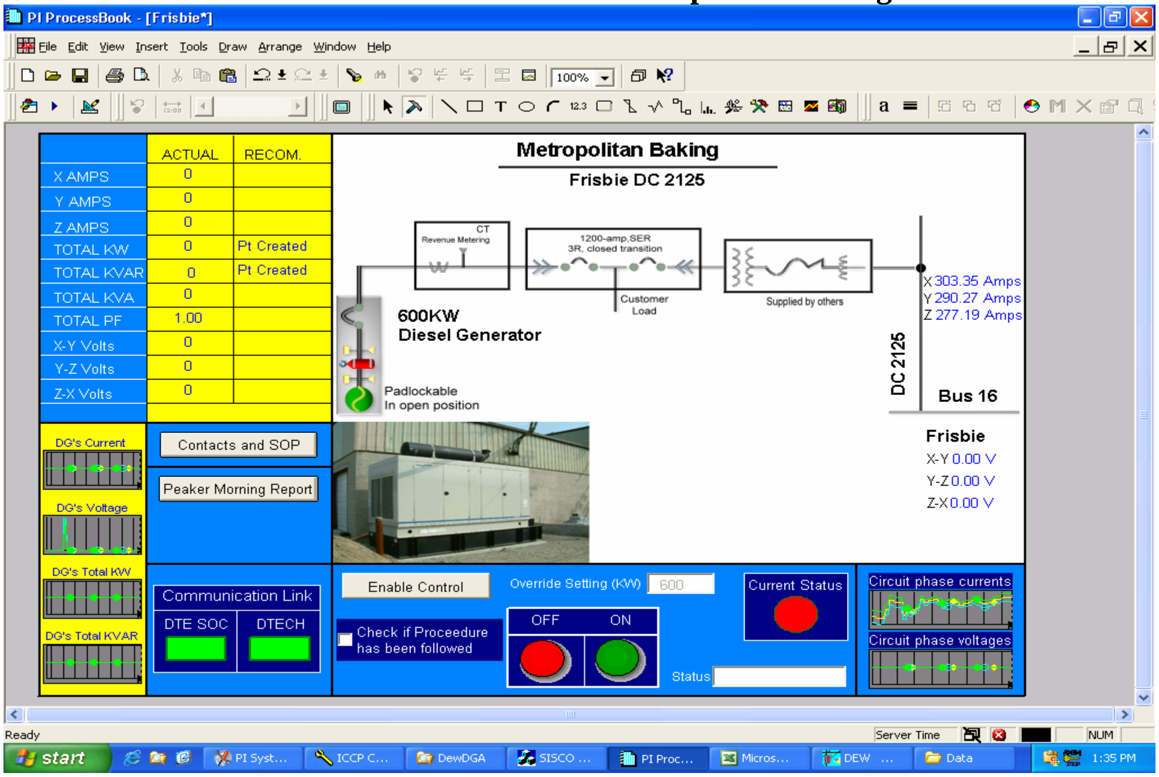
Fisher DC8188 - ASC Global



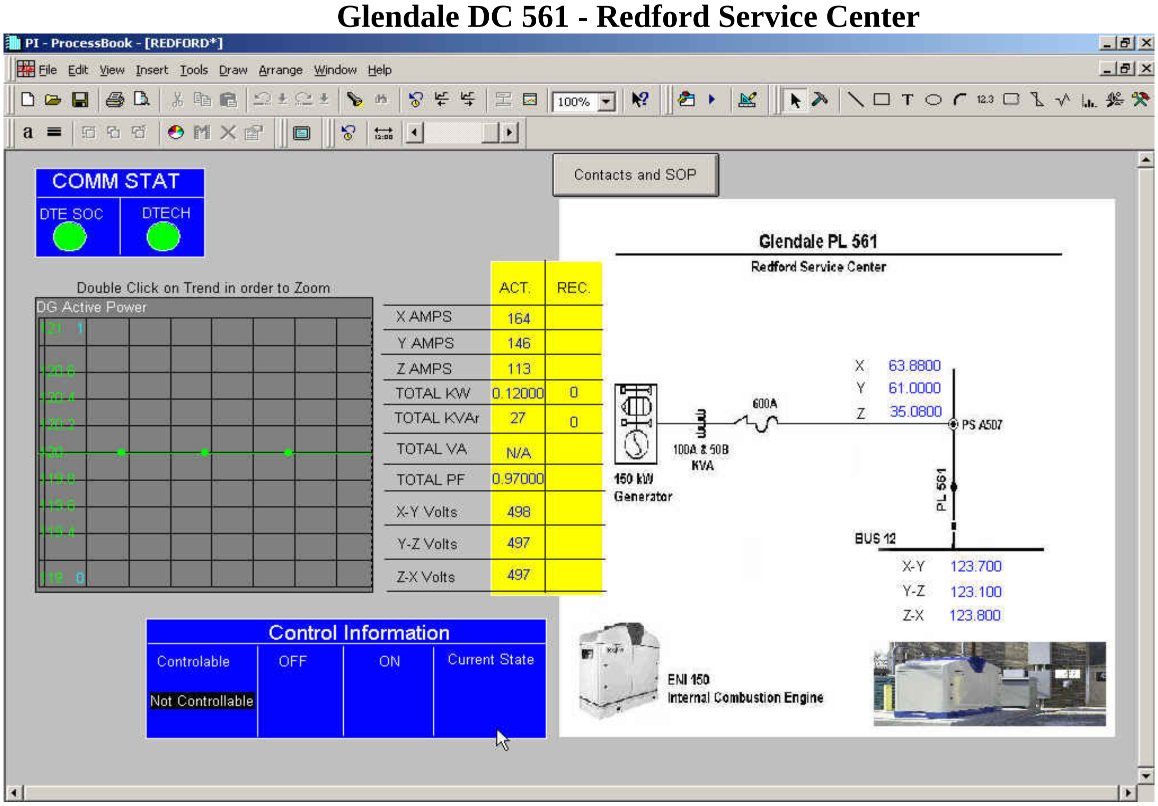
Fisher DC8188 - Flat Rock Community Center



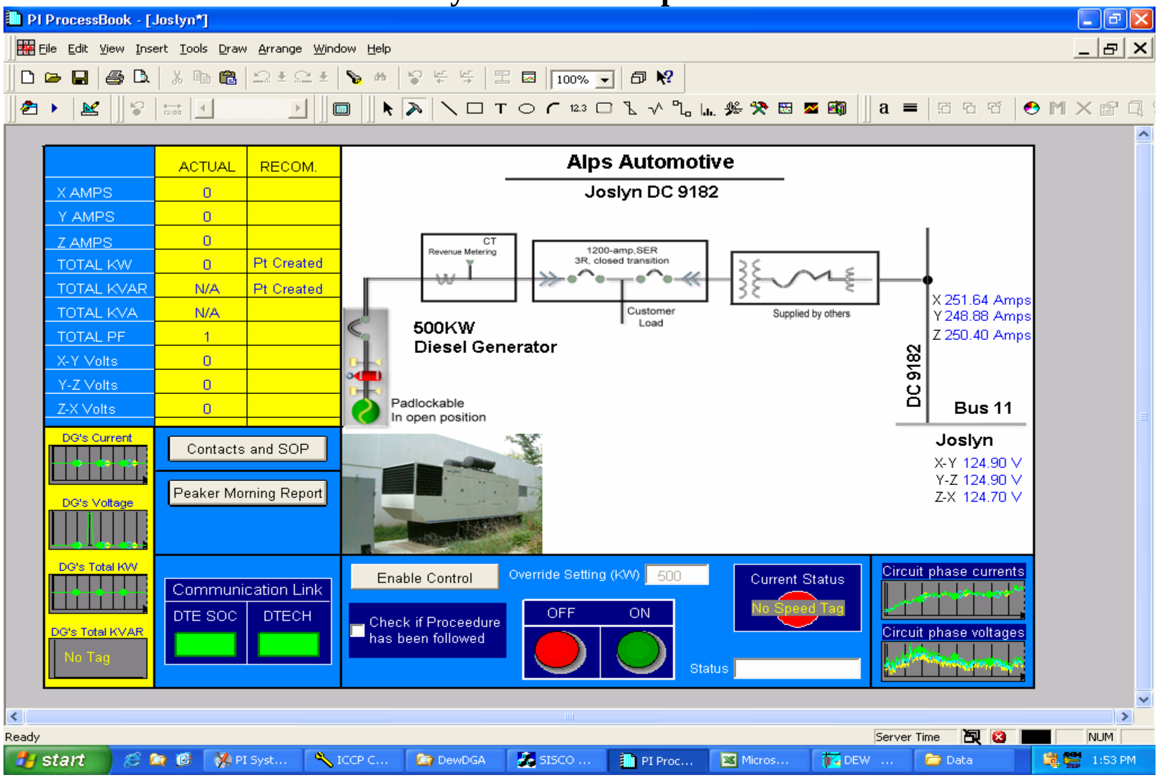
Frisbie DC2125 - Metropolitan Baking



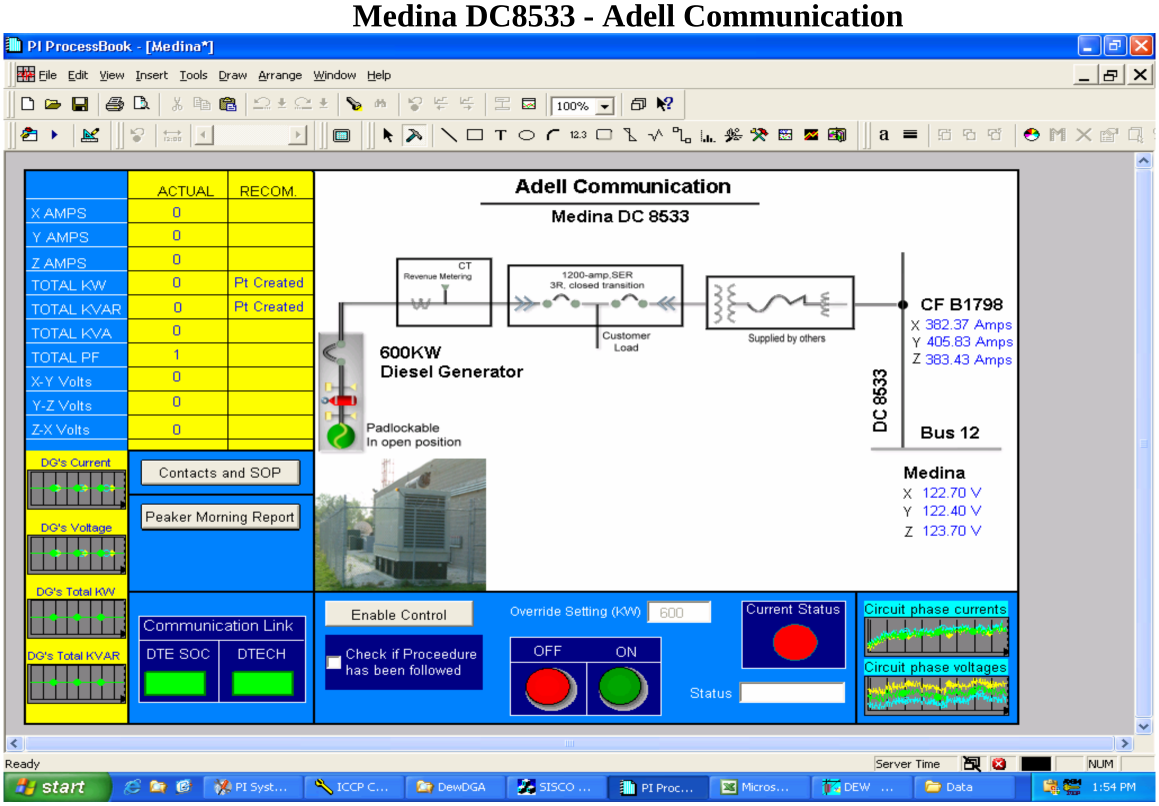
Glendale DC 561 - Redford Service Center



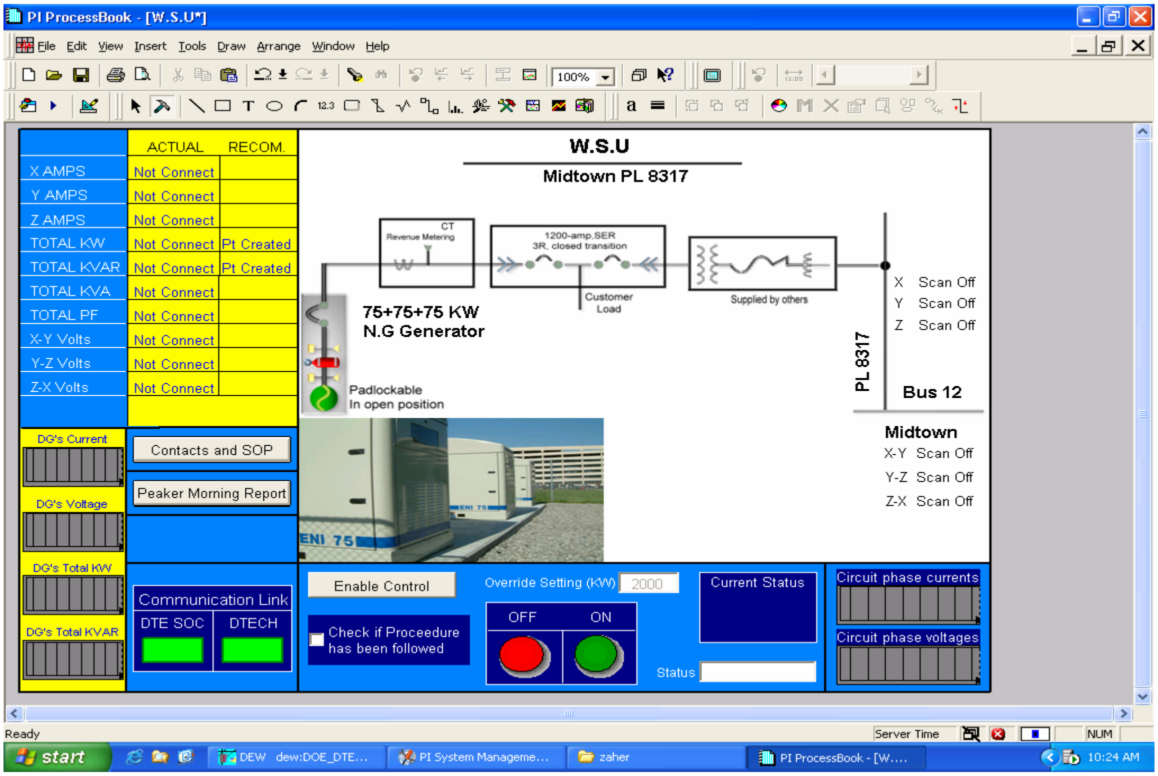
Joslyn DC9182 - Alps Automotive



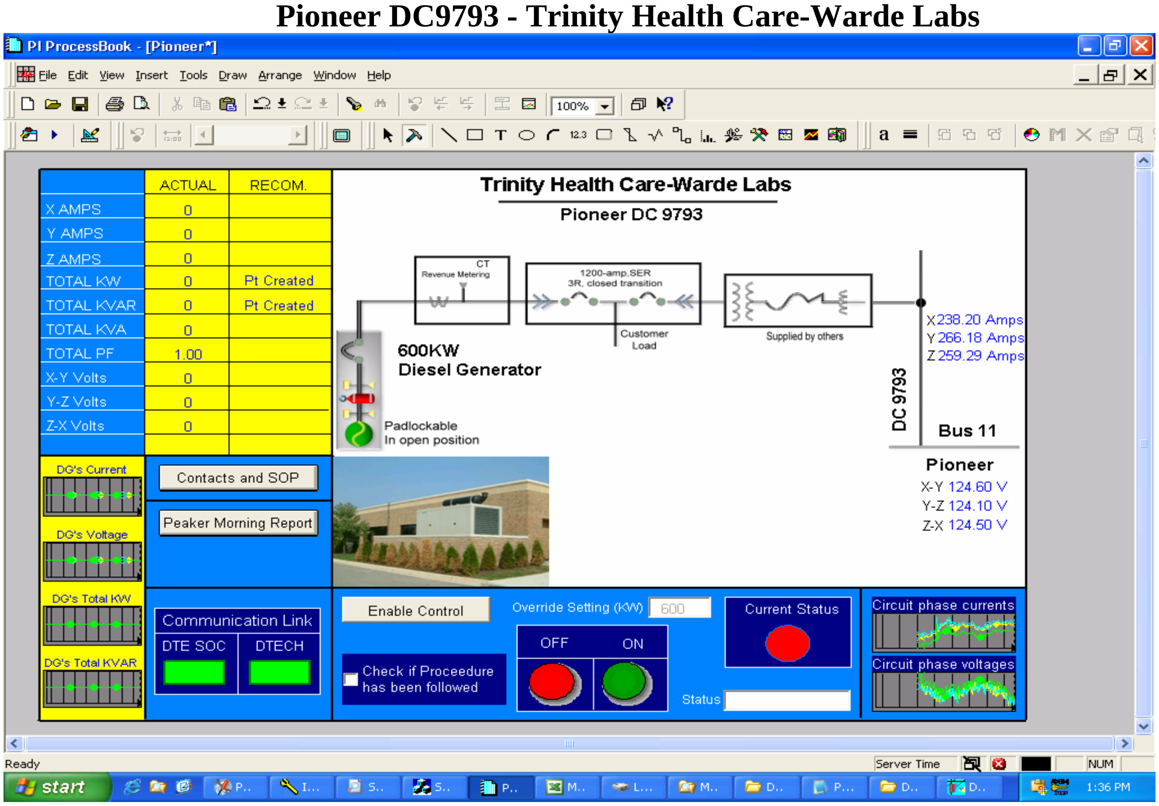
Medina DC8533 - Adell Communication



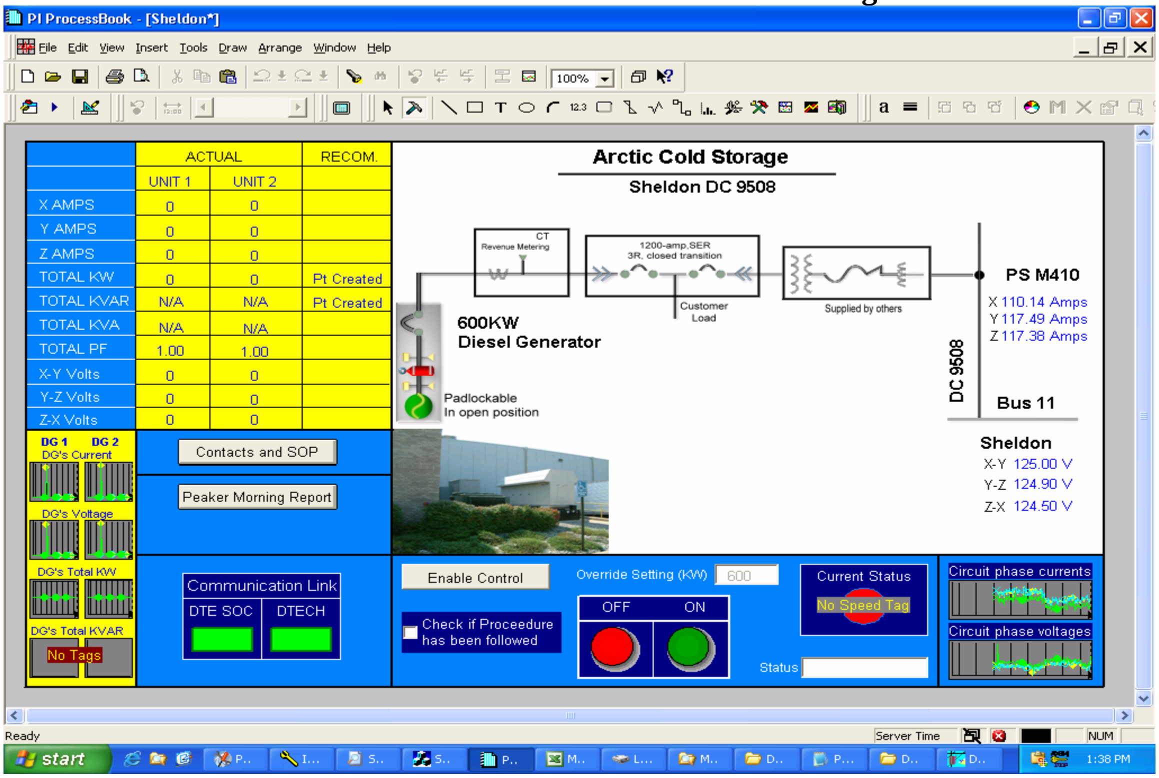
Midtown PL 8317 - W.S.U



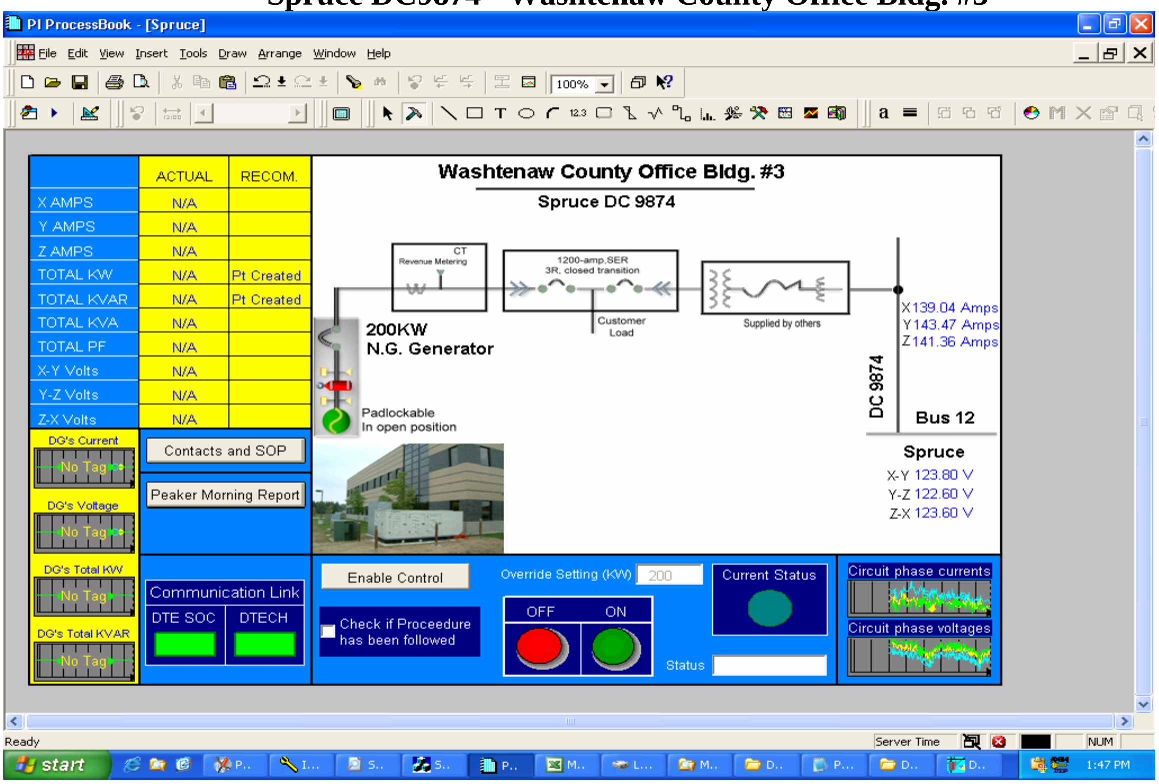
Pioneer DC9793 - Trinity Health Care-Warde Labs



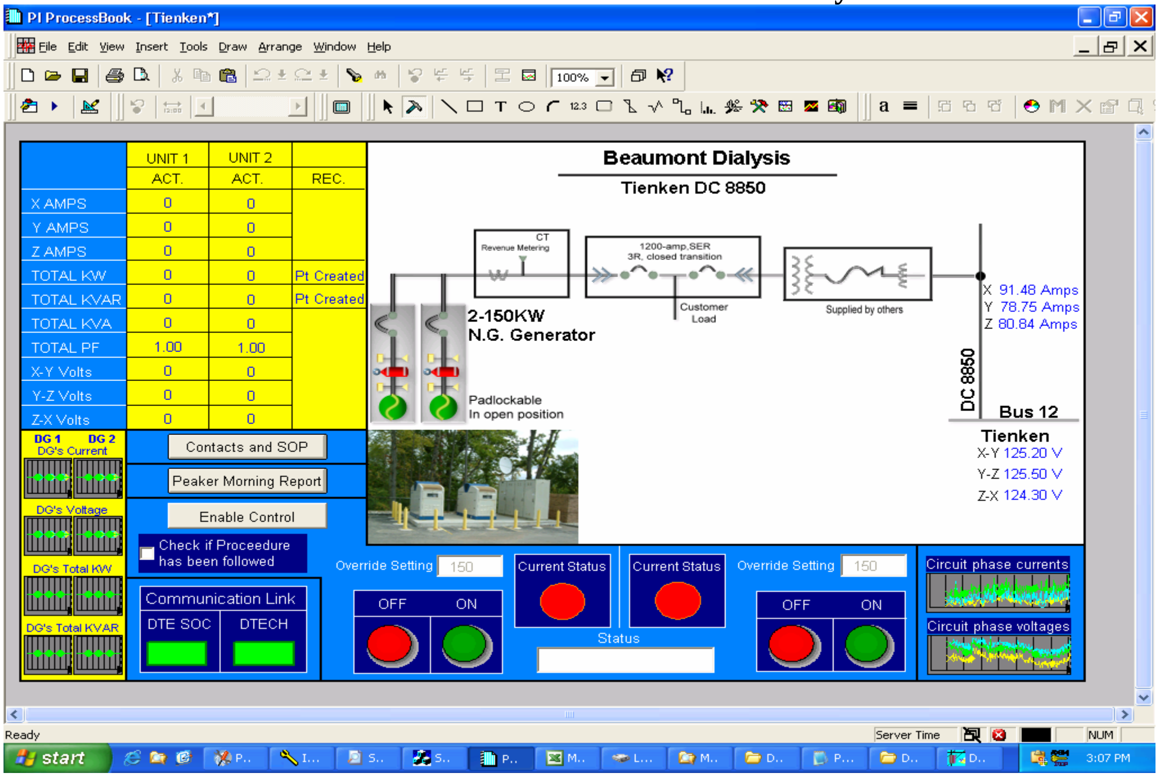
Sheldon DC9508 - Arctic Cold Storage



Spruce DC9874 - Washtenaw County Office Bldg. #3



Tienken DC8850 - Beaumont Dialysis



Appendix C
Tagging and Operating Procedures

Procedure for Distributed Resources Control by Detroit Edison

The Regional System Supervisor (RSS) will call DTE Energy Technologies SOC and request permission to operate distributed resources at a specific site. The RSS will also give the approximate time duration of the request. DTE Energy Technologies personnel will set a digital point (ICCP Remote Control Cut-Off) to a value of “1” to allow remote control. DTE Energy Technologies then informs the RSS that this has been completed and he/she can now operate the generators at the site.

After the stated duration, the RSS will inform DTE Energy Technologies SOC that they no longer require control capability at the site. DTECH SOC personnel will set the “ICCP Remote Control Cut-Off” point to a value of “0” which disables remote control capabilities at the site.

<u>Department of Energy Distributed Generation Project</u>

Drafted By: **Kevin Wisniewski, DTE Energy Technologies**
Heather Storey, The Detroit Edison Company

Comment Signatures:

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Mike Sheufelt, NROC Senior System Supervisor

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    F. Loss of Normal Communication

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    B. Miscellaneous
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SECTION 1

SCOPE

A general/generic operational procedure for control and dispatch of distributed generation and alternative energy resources for DTE Energy. Site specific operating procedures and information can be found in the Section 7 appendices.

This procedure is not a substitute for common sense and sound judgement. Common sense and sound judgement are expected to be utilized at all times since no document can cover all possible contingencies.

SECTION 2

COMMUNICATION PROCEDURE

a) SCHEDULED OPERATION

1. Planned starting of the DR unit based on criteria for that site or a request from N-ROC & S-ROC a week or more in advance. The D|Tech SOC will confirm and begin monitoring those sites more closely. D|Tech SOC will also notify the N-ROC/S-ROC of any data communication problems and make arrangements to resolve these issues.

b) UNSCHEDULED OPERATION

1. Immediate unplanned starting of the DR unit that is not a scheduled event. N-ROC & S-ROC will call D|Tech SOC when the unscheduled start is expected. D|Tech will provide on-demand startups and shutdowns as requested. D|Tech SOC will actively monitor the site/units starting when the request is made and until the sites/units are shut down.

c) D|Tech SOC

1. D|Tech SOC will confirm start, run times, loading (schedules), and any other pertinent information with the RSS. This information shall be logged by both parties.

d) ABNORMAL EVENT/ALARM NOTIFICATIONS

1. ROCs and D|Tech SOC agree to inform each other whenever there is an alarm or other abnormal condition.

e) IT DATA/COMMUNICATION

1. Any IT/Data errors or problems should be reported to the D|Tech SOC operator as soon as possible. The D|Tech SOC Operator will be responsible for starting the trouble report and forwarding it through the appropriate channels.

f) LOSS OF NORMAL COMMUNICATION

1. For a loss of telephone and cell-phone service, a radio communication system needs to be established between D|Tech SOC and the ROCs. It is also necessary to establish conventional analog phone links between D|Tech SOC and the ROCs.
2. D|Tech SOC will provide 24/7 coverage contact for both D|Tech IT technicians and DR/DR Service technicians. These individuals will be dispatched directly to the site from D|Tech.
3. ICCP failure needs further analysis as to the effect on monitoring and control.
4. For loss of SCADA or D|Tech Enterprise Navigator at any of these sites, verbal communication will need to be established between D|Tech SOC and the ROCs for monitoring.

SECTION 3

Distributed Resource Operation Modes

There are various modes of operation of the distributed resources.

a. Local
   For these installations, the distributed resource will start by a local operator. These locations could include the following sites: Adair, Glendale-Redford, Zachary-Western Wayne, Southfield, and Lum. For site specific information, see attached appendices.

b. Remote
   For these installations, the distributed resource will be started by the ROC or by contacting the D|Tech SOC to send a remote start where available or send a D|Tech technician if necessary to assist manual start-up. Loading will vary according to site requirements and controls programming. Remote load control may be available in the future. These locations include the following: Union Lake and Sunset- DTECH Farmington Hills Office. For site specific information, see attached appendices.

c. Automatic
   For these installations, the distributed resource will start and load automatically based on various parameters. These locations include the following sites: Adair, Glendale-Redford, Zachary-Western Wayne, Southfield, and Lum. For site specific information, see attached appendices.

d. Normal Operation Failure
   For site specific information, see site specific appendices and section 2.

SECTION 4

Trips, Alarms, and Faults

Since monitoring and control differs at each site, refer to attached site specific appendices for site-specific information.

SECTION 5

PROTECTION, TAGGING, and SAFETY

The purpose of this section is to ensure adequate safety and tagging procedures are created and followed to provide the maximum level of personnel safety and equipment protection.

At locations with potential sources of backfeed, the Distributed Resource (generators or alternative energy source) must be taken off-line or out of service when in abnormal configuration. The distributed resource must have a visible break when taken off-line or out of service. When these distributed resources are connected to the system via distribution circuit, the distribution circuit operating map must identify the potential source of backfeed.

Circuit Operating Map

Name	Acronym	Circuit Number	Region	Service Center
Adair	ADAIR	322	NE	MAR
Redford	GLEND	561	SE	RFD
Western Wayne	ZACRY	9400	SW	WWS
Farmington	SNSET	9016	SW	NHS
Lum Battery	STDF	2628	NE	
Solar Cells	SOLFD	9010	NW	RYO
Union Lake	UNLAK	1688	NW	PON

Anyone working on DR equipment may request protection and tagging. All requests **SHALL** be made through the operating agent. **ALL** DTE tagging and safety procedures and practices **SHALL** be followed. Final acceptance of the protection provided shall be to the satisfaction of the requesting party, however, merit should be accorded the opinions and judgment of the personnel performing the switching and tagging. All personnel provided with protection **MUST** inform the operating agent who in turn MUST inform the operating authority when work is complete and they are clear of the potential hazard. These individuals may be required to sign applicable documents, forms, or tags accepting the provided protection and relinquishing the need and control for protection before the equipment can be returned to normal service.

ALL switching, tagging, jumpering, etc, At the point of common coupling will be accomplished by Detroit Edison personnel. Package provided equipment protection may be accomplished by the service technicians (non-DTE personnel).

SECTION 6

LOGGING and RECORD KEEPING

ALL events related to Distributed Generation/Alternative Resources operations and services shall be logged including the context of verbal communications. These entries will include (but not limited to) normal operational dispatches and service requests (see attachment B.1: D|Tech SOC Operator Log Entries).

SECTION 7

GLOSSARY, TERMS, and ABBREVIATIONS

A. General

Automatic	Operation of a DR unit based on Algorithms or other site specific criteria that is requested by an operating authority and incorporated by D|Tech (Peak shaving, kW demand, load level, economic dispatch, etc...)
AR	Alternate Resource. Solar Cell, Fuel Cell, Windmill, etc.
CSS	Central System Supervisor
DEM	Distributed Energy Manager
DMS	Distribution Management System
DR	Distributed Resource. A conventional generator or alternator driven by a combustion turbine, water turbine, internal combustion engine, or external combustion engine (Sterling Engine).
EEM Suite	The Silicon Energy software package used by D|Tech.
EMS	Energy Management System
Enterprise Navigator	A module in the EEM Suite for viewing energy and process data.
ETR	Estimated Time of Return (to/for service).
FLT (Flt)	Fault
CCP	Inter Center Control Protocol. A standardized method of sending and retrieving data points/values between data centers (computers).
Local	Local operation of a DR unit requested by an operating agent thru the operating authority to D|Tech which will result in a change from an automatic mode to local. (Emergency request for voltage support or load relief)
NSS	North Regional System Supervisor
NROC	North Region Operations Center
Operating Agent	Primary, Sub-station operators and D|Tech.
Operating Authority	NROC and SROC
Remote	Remote operation of a DR unit that is requested by an operating authority sent to D|Tech which will result in a change from an automatic mode to remote. (Emergency request for voltage support or load relief)
ROC	Regional Operations Center
RSS	Regional System Supervisor
SCADA	Supervisory Control and Data Acquisition
Scheduled	Planned starting of the DR unit based on criteria for that site or a request for a start of a unit a week or more in advance.
SOC	System Operations Center
SROC	South Region Operations Center
SSS	South Regional System Supervisor
Unscheduled	Immediate unplanned starting of the DR unit that is not a scheduled event.

B. ISO Standard

A & amp	Ampere	Kilo (prefix) [times 1000]	k
AC	Alternating Current	Kilopascal	kPa
Alternating Current	AC	Kilovolt Ampere	kVA
Ampere	A & amp	Kilovolt Ampere Reactive	kvar
Atm	Atmospheres	Kilowatt	kW
Atmospheres	atm	kPa	Kilopascal
British Thermal Unit	Btu	kVA	Kilovolt Ampere
Btu	British Thermal Unit	kvar	Kilovolt Ampere Reactive
C	Celsius	kW	Kilowatt
Ccft	Hundred Cubic Feet	M [times 1,000,000]	Mega (prefix)
Celsius	C	Mega (prefix) [times 1,000,000]	M
cft	Cubic Feet	Megavolt Ampere	MVA
Cubic Feet	cft	Megavolt Ampere Reactive	Mvar
DC	Direct Current	Megawatt	MW
Deg	Degree (temperature)	MVA	Megavolt Ampere
deg C	Degree Celsius	Mvar	Megavolt Ampere Reactive
deg F	Degree Fahrenheit	MW	Megawatt
Degree (temperature)	Deg	Pa	Pascal
Degree Celsius	deg C	Pascal	Pa
Degree Fahrenheit	deg F	Pf	Power Factor
Direct Current	DC	Pounds per Square Inch (normally gauge pressure above atmospheric pressure)	psi
F	Fahrenheit	Pounds per Square Inch Absolute	psia
Fahrenheit	F	Pounds Per Square Inch-Gauge	psig
Feet	ft	Power Factor	Pf
Frequency (Hertz)	Hz	psi	Pounds per Square Inch
ft	Feet	psia	Pounds per Square Inch Absolute
gal	Gallon	psig	Pounds Per Square Inch-Gauge
Gallon	gal	Revolutions per Minute	rpm
Hour & Hours	hr & hrs	rpm	Revolutions per Minute
hr & hrs	Hour & Hours	Therm	Therm
Hundred Cubic Feet	Ccft	V	Volt
Hz	Frequency (Hertz)	Var	Volt Ampere Reactive
Inches of Water	inH2O	Volt	V
inH2O	Inches of Water	Volt Ampere Reactive	Var
k [times 1000]	Kilo (prefix)	W	Watt
		Watt	W

SECTION 8

Appendices

A. Sites:
   1. Adair Appendix A.1
   2. Union Lake Appendix A.2

B. Miscellaneous
   1. D|TECH SOC OPERATOR LOG ENTRIES Appendix B.1

Date: October 7, 2003

Station: ADAIR (DC 322 Adair)

A one-MW natural Gas Distributed Generator has been installed at Adair Substation to prevent overloading Adair Transformer 1 during heavy loading periods. The generator and its associated equipment are connected to the system via cable pole DR-C0001 on DC 322 Adair (See Appendix F). The Operating Authority for the generator is the North Regional System Supervisor (NSS). Since the generator is located on substation property, the Operating Agent is the substation operator.

Normal Generator Operation

The distributed generator will be brought on-line when the load on Adair Transformer 1 is approaching its 444 Amperes (3.7 MVA). With the portable oil cooler operating, the emergency rating of Transformer is 577 Amps.

The generator will start automatically at an output of 36 amps (300 kW) when the load on Adair Transformer 1 exceeds 444 amps (3.7 MVA). The generator controller will sample the load every 30 seconds and will automatically increase or decrease its output to maintain 228 amps (1.9 MVA) on Adair Transformer 1 until either of the following occurs:

- The generator maximum output of 120 Amps (1 MVA) is reached. At this point, the load on Adair Transformer 1 will begin to exceed 228 Amps (1.9 MVA). If the emergency rating of the transformer is exceeded, the North Regional Operating Center will need to take all necessary actions to protect substation equipment.

- The generator minimum output of 36 Amps (300 kW) is reached and the load on Adair Transformer 1 is less than 396 Amps (3.3 MVA). At this point, the generator will automatically shut down and be taken off line.

**** Note: The generator requires a fifteen-minute cool-off period after shutdown before it can be restarted.***

The generator breaker has Emergency Trip and status in the Distribution Management System.

The generator at Adair ***must remain off-line*** whenever DC 322 Adair is in an abnormal configuration.

Alarming at Adair

The ***Generator Control Permissive On*** **(GEN CTL PERM ON)** alarm in the Distribution Management System (DMS) will alert the System Supervisor when any phase on Transformer 1 exceeds 444 amps (3.7 MVA). This is a notification that the generator is about to start. The generator will automatically start following this notification. If the generator does not start, the NSS should contact D|TECH for assistance (See Appendix A for telephone numbers).

The ***Generator Control Permissive Off*** **(GEN CTL PERM OFF)** alarm in the Distribution Management System (DMS) will alert the System Supervisor to take the generator off-line. This alarm occurs when the generator breaker is closed and the load of Transformer 1 is below 396 Amps (3.3 MVA) on all three phases. If this alarm is received, the NSS should direct D|TECH to shut down the generator. As long as the automatic generator controls are working properly, the ***Generator Control Permissive Off*** (**GEN CTL PERM OFF)** alarm should not be received.

The ***Generator Major Alarm*** **(G1 MAJOR ALARM)** in DMS will alert the System Supervisor that the **generator will shut down and the unit will be prohibited from restarting**. This alarm is a collective output taken from the generator and can be triggered by any of the alarms listed in Appendix B.

The ***Generator Minor Alarm*** **(G1 MINOR ALARM)** in DMS will alert the System Supervisor that the **generator will NOT be shut down, but the unit will be prohibited from restarting**. This alarm is a collective output taken from the generator and can be triggered by any of the alarms listed in Appendix C.

Appendix E lists all DMS alarms available at Adair.

Periodic Testing of the Distributed Generator

The Adair generator will be run periodically to perform operational tests. These periodic tests will have to be arranged by the North Regional System Supervisor.

To ensure a high level of performance throughout the year, the generator will be run twice a month. On these days, the generator should be started at 11:00 A.M. and run for at least two hours at a level of 36 Amps (300 kW).

SCADA Monitoring and Control

The Amp, MW, MVAR, and Voltage values will be available in the Energy Management System (EMS) and the DMS for the following equipment: Adair Transformer 1, the generator, DC 322, and DC 321. Breaker status and control on DC 322 and the generator is also available for use by the System Supervisors at Adair.

A list of all DMS monitoring points available at Adair is shown in Appendix D. Appendix G shows the DMS display for Adair substation.

Relaying

Reverse power relays are installed on the secondary of Transformer 1. These relays will trip the generator if there is insufficient power flow from Transformer 1 to Adair Bus 11 (4.8-kV). The generator will also trip if the power flow is reversed (flowing from the 4.8-kV into the 40-kV). This relaying is intended to insure that the generator will be automatically shutdown for loss of the 40-kV source.

Any opening of the three-phase substation recloser on DC 322 Adair will cause the generator to trip. This trip circuit is “hardwired” to the generator through a local fiber optic system. The scheme is intended to prevent the generator from feeding an islanded load that is isolated from its normal source. If the fiber optic communication is lost, the generator will be tripped after a 15-second time delay.

If the generator’s 480-volt breaker is closed, reclosing is blocked on the substation recloser of DC 322. This is intended to prevent an out of synchronism closing of the recloser should the tripping of the generator fail to occur.

The generator can be tripped remotely through the SCADA “Remote Trip” command.

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Appendix A

Additional Information for Adair Substation

	Name	**Number**
Substation Operator:	Marysville AFC	810.783.2046
Substation Operator (Off Hours):		SEAS
Relay/Pert:		313.235.3846
Relay/Pert (Off Hours):		Refer to On Call Sheet
D|TECH: SOC	Operational 07:00 to 23:00)	248.427.2352
D|TECH (Off Hours):	On Call Pager	1.877.406.9612
Adair Substation		810.329.4298
Service	PMT	248-684-0440

Note: This information was supplied on September 8, 2003 and should be verified periodically.

Appendix B

Generator Major Alarm

Any of the following faults will initiate the Generator Major Alarm. A Generator Major Alarm ***will shut down*** the unit while it is running and inhibit it from restarting.

1. P196 Lube Oil Pressure Too Low
2. Interval Pre-/Post-Lube Pressure Too Low
3. P196 Pre-Lube Pressure At Start
4. T208 Lube Oil Over Temperature
5. L234 Lube Oil Level Too Low
6. L234 Lube Oil Level Too High
7. Lube Oil Filter Dirty
8. T201 Over Temperature Receiver
9. S200 Over Speed
10. S200 Low Speed
11. P145 Over Pressure Crank Case
12. Engine Does Not Start
13. T461 Over Temp. Comb. Chamber A1
14. T462 Over Temp. Comb. Chamber A2
15. T463 Over Temp. Comb. Chamber A3
16. T464 Over Temp. Comb. Chamber A4
17. T465 Over Temp. Comb. Chamber A5
18. T466 Over Temp. Comb. Chamber A6
19. T471 Over Temp. Comb. Chamber B1
20. T472 Over Temp. Comb. Chamber B2
21. T473 Over Temp. Comb. Chamber B3
22. T474 Over Temp. Comb. Chamber B4
23. T475 Over Temp. Comb. Chamber B5
24. T476 Over Temp. Comb. Chamber B6
25. T461 Low Temp. Comb. Chamber A1
26. T462 Low Temp. Comb. Chamber A2
27. T463 Low Temp. Comb. Chamber A3
28. T464 Low Temp. Comb. Chamber A4
29. T465 Low Temp. Comb. Chamber A5
30. T466 Low Temp. Comb. Chamber A6
31. T471 Low Temp. Comb. Chamber B1
32. T472 Low Temp. Comb. Chamber B2
33. T473 Low Temp. Comb. Chamber B3
34. T474 Low Temp. Comb. Chamber B4
35. T475 Low Temp. Comb. Chamber B5

Generator Major Alarm (Continued)

36. T476 Low Temp. Comb. Chamber B6
37. Comb. Chamber Monitoring A (mean v.)
38. Comb. Chamber Monitoring B (mean v.)
39. Over Temp. Comb. Chamber Mean Value A
40. Over Temp. Comb. Chamber Mean Value B
41. T207 Over Temp. Jacket Water Engine Inlet
42. T206 Over Temp. Jacket Water Engine Outlet
43. DP Flow Monitoring Engine Cooling Circuit
44. DP Flow Monitoring Intercooler Circuit
45. Low Water Engine Cooling Circuit
46. Low Water Intercooler Circuit
47. T160 Over Temperature Cabinet Air
48. Cabinet Ventilation
49. T203 Over Temperature Air Inlet
50. Mixture Controller
51. Engine Overload
52. Power Control
53. Power Reduction Below 80% Necessary
54. Power Too Long Below 30%
55. P124 Gas Pressure
56. T209 Over Temp. Generator Winding U1
57. T210 Over Temp. Generator Winding V1
58. T211 Over Temp. Generator Winding W1
59. Synchronization Failure
60. Reverse Power
61. Collective Fault Generator Protection
62. Mains Failure
63. Mains Failure Sequence Fault
64. Circuit Breaker TEM
65. Reset While Engine Was Running
66. Internal Quick Stop
67. External Quick Stop Without Heat Removal
68. External Quick Stop With Heat Removal
69. Security Chain Open
70. Ignition System Collective Fault
71. Speed Governor Collective Fault
72. Stepper Motor Board Collective Fault
73. CAN-Bus Collective Fault
74. Control Parameters
75. P196 Lube Oil Pressure Before Filter Sensor
76. T208 Lube Oil Sensor

Generator Major Alarm (Continued)

77. L234 Lube Oil Level Sensor
78. T201 Receiver Sensor
79. P145 Crank Case Pressure Sensor
80. S200 Speed Governor Actual Speed Sensor
81. T203 Air Inlet Sensor
82. T461 Comb. Chamber A1 Sensor
83. T462 Comb. Chamber A2 Sensor
84. T463 Comb. Chamber A3 Sensor
85. T464 Comb. Chamber A4 Sensor
86. T465 Comb. Chamber A5 Sensor
87. T466 Comb. Chamber A6 Sensor
88. T471 Comb. Chamber B1 Sensor
89. T472 Comb. Chamber B2 Sensor
90. T473 Comb. Chamber B3 Sensor
91. T474 Comb. Chamber B4 Sensor
92. T475 Comb. Chamber B5 Sensor
93. T476 Comb. Chamber B6 Sensor
94. T Cold Junction A Sensor
95. T Cold Junction B Sensor
96. T206 Jacket Water Engine Outlet Sensor
97. T207 Jacket Water Engine Inlet Sensor
98. T202 Jacket Water GK Inlet Sensor
99. E199 Demand Analog Sensor
100. E198 Actual Power Generator Sensor
101. T209 Generator Winding U Sensor
102. T210 Generator Winding V Sensor
103. T211 Generator Winding W Sensor
104. CAN-Bus Digital Inputs
105. CAN-Bus Digital Outputs
106. Local Digital Inputs
107. Local Digital Outputs
108. E149 Supply Voltage TEM

Appendix C

Generator Minor Alarm

Any of the following alarms will initiate the Generator Minor Alarm. A Generator Minor Alarm ***will not shut down*** the unit while it is running, but the generator will be inhibited from restarting.

1. P196 Lube Oil Pressure Too Low
2. Interval Pre-/Re-lube Pressure Too Low
3. T208 Lube Oil Over Temperature
4. L234 Lube Oil Level Too Low
5. L234 Lube Oil Level Too High
6. Lube Oil Filter Dirty
7. P157 Exhaust Back Pressure Too High
8. S200 Speed Before Start Too High
9. P145 Low Pressure Crank Case
10. T461 Low Temperature Comb. Chamber A1
11. T462 Low Temperature Comb. Chamber A2
12. T463 Low Temperature Comb. Chamber A3
13. T464 Low Temperature Comb. Chamber A4
14. T465 Low Temperature Comb. Chamber A5
15. T466 Low Temperature Comb. Chamber A6
16. T471 Low Temperature Comb. Chamber B1
17. T472 Low Temperature Comb. Chamber B2
18. T473 Low Temperature Comb. Chamber B3
19. T474 Low Temperature Comb. Chamber B4
20. T475 Low Temperature Comb. Chamber B5
21. T476 Low Temperature Comb. Chamber B6
22. T206 Over Temp. Jacket Water Engine Outlet
23. T160 Over Temperature Cabinet Air
24. T203 Over Temperature Air Inlet
25. Power Too Long Under 30%
26. Mains Failure
27. T209 Over Temperature Generator Winding U1
28. T210 Over Temperature Generator Winding V1
29. T211 Over Temperature Generator Winding W1
30. Ignition System Collective Alarm
31. Anti-Knock Governor Collective Alarm
32. Stepper Motor Board Collective Alarm
33. CAN-Bus Collective Alarm
34. Earth Fault Analog Inputs
35. Speed Governor Collective Alarm

Generator Minor Alarm (Continued)

36. Supply Voltage Below 18 V
37. Supply Voltage Above 30 V
38. T203 Air Inlet Sensor
39. T405 GK Dry Cooler Outlet Sensor
40. T419 NK Dry Cooler Outlet Sensor
41. T160 Cabinet Air Sensor
42. Collective Alarm Digital Inputs Bus
43. Collective Alarm Digital Outputs Bus
44. Collective Alarm Digital Outputs TEM
45. Parametrizable Measurement 01
46. Parametrizable Measurement 02

Appendix D

Monitoring Points in DAS

Point Name
DC321 X-Y 4.8KV
DC321 Y-Z 4.8KV
DC321 Z-X 4.8KV
DC322 X-Y 4.8KV
DC322 Y-Z 4.8KV
DC322 Z-X 4.8KV
GEN 1 X-Y 4.8KV
GEN 1 Y-Z 4.8KV
GEN 1 Z-X 4.8KV
TRF 1 X-Y 4.8KV
TRF 1 Y-Z 4.8KV
TRF 1 Z-X 4.8KV
DC321 MW
DC321 MV
DC321 I
DC321 VA
DC321 X I
DC321 Y I
DC321 Z I
DC322 MW
DC322 MV
DC322 I

Point Name
DC322 VA
DC322 X I
DC322 Y I
DC322 Z I
DC322 COMM FAIL
DC322 CTRL BAT
DC322 TEST VOLTS
RTU BAT
GEN 1 MW
GEN 1 MV
GEN 1 I
GEN 1 VA
GEN 1 X I
GEN 1 Y I
GEN 1 Z I
TRF 1 MW
TRF 1 MV
TRF 1 I
TRF 1 VA
TRF 1 X I
TRF 1 Y I
TRF 1 Z I

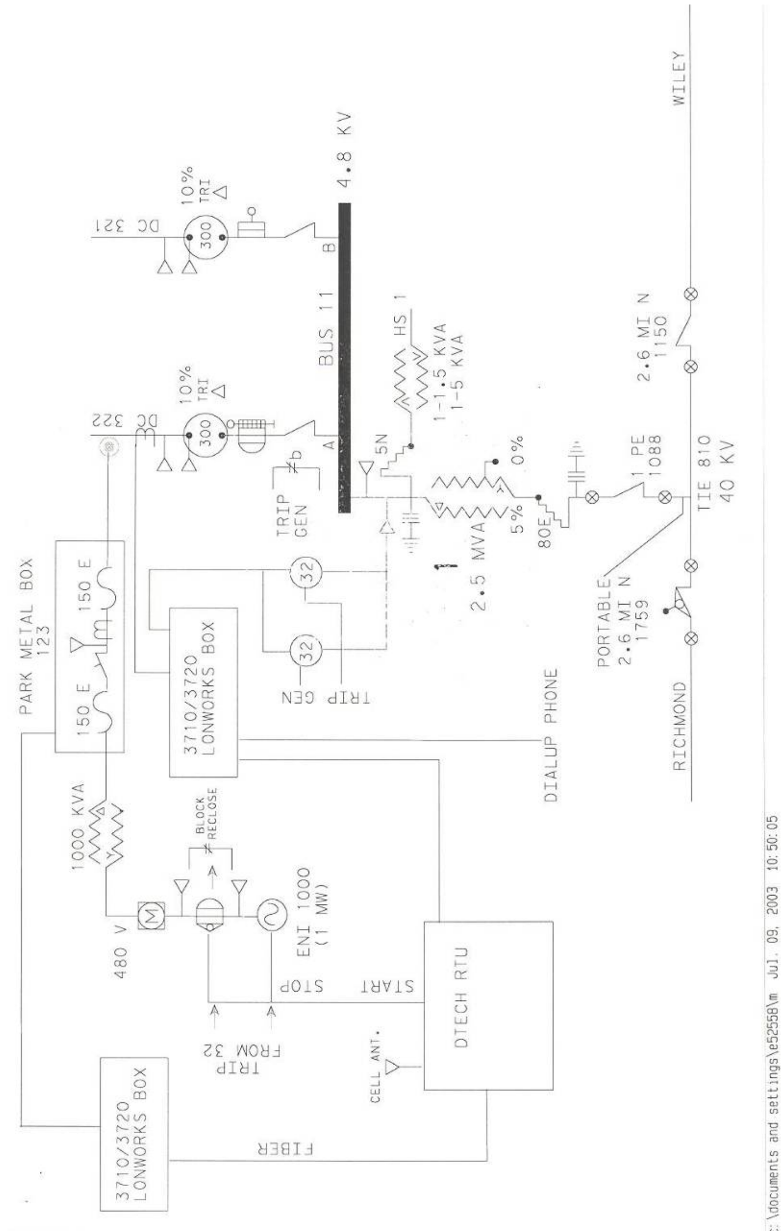
Appendix E

Alarm Points in DAS

Point Name
END ELEMENT
DC322 BKR
DC322 CHECK BAT
DC322 CTRL OK
DC322 END ELE
DC322 GND FLT
DC322 HOT LINE
DC322 NORM PROF
DC322 REC LO
DC322 REC MALFN
DC322 RECLOSE
DC322 RTU FAIL
DC322 RTU PWR
DC322 SPV CTRL
DC322 SW MODE
DC322 X FLT
DC322 Y FLT
DC322 OPEN
DC322 CLOSE
DC322 REC DIS
DC322 REC ENAB
DC322 SW MODE

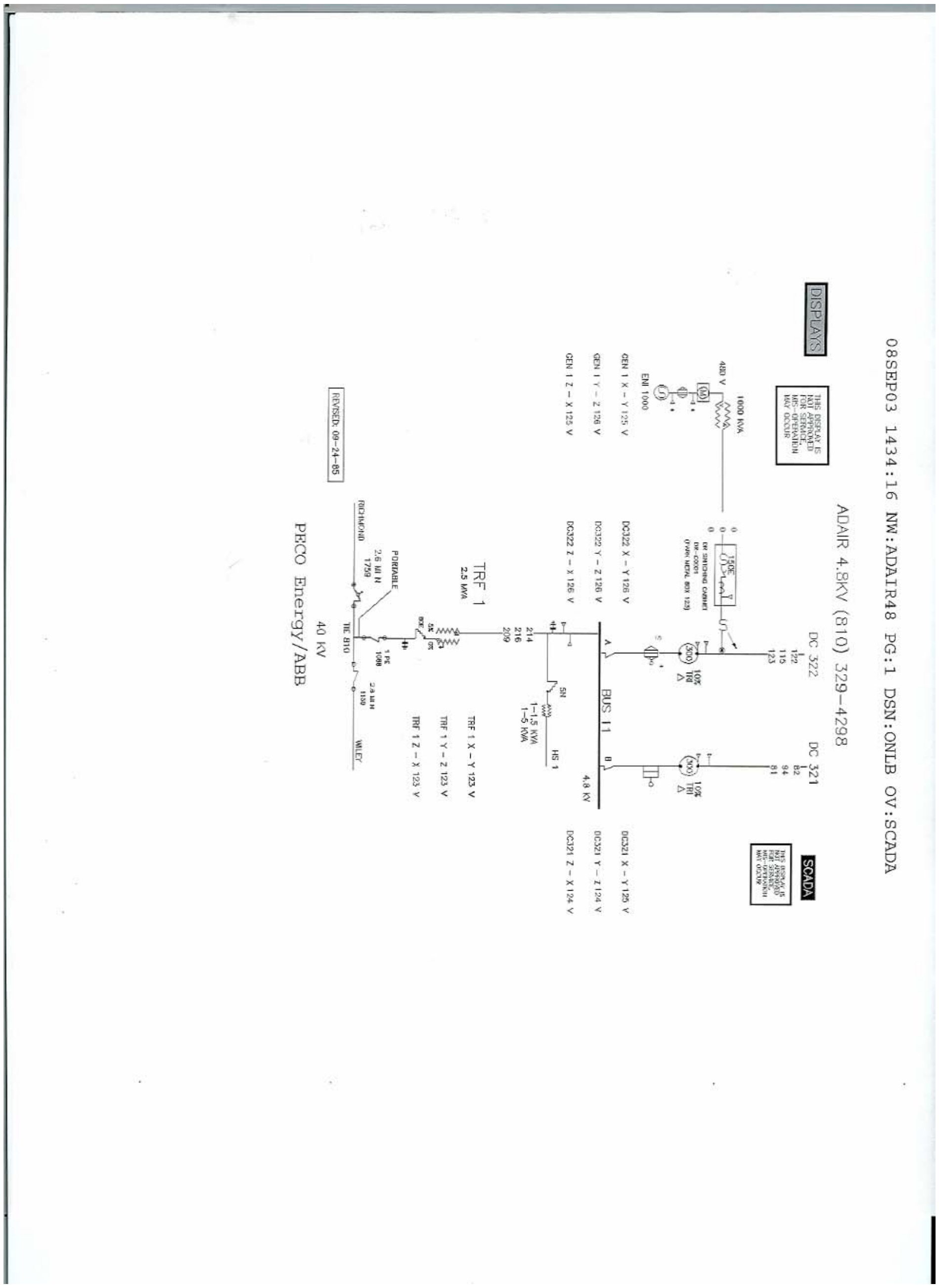
Point Name
DC322 Z FLT
G1 MAJOR ALARM
G1 MINOR ALARM
G1 RLY LOSS AC
GEN 1 BREAKER
GEN1 METER
TRF1 METER
DC322 METER
DC321 METER
BE1-32R RELAY
GND DETECTOR
LOSS OF AC
LOW 4.8KV VOLTS
STA AL PWR
STA AL SW L/R
TRF-REG TMP
G1 CTL PERM OFF
G1 CTL PERM ON
GEN1 TRIP
POS. A METER
POS. B METER
POS. A BKR

Appendix F
Connection Diagram for Adair Generator



Appendix G

DMS Display



Date: September 11, 2003

Station: **Union Lake (DC 1688 Union Lake**)

A 2-MW diesel Distributed Generator has been installed at Union Lake Substation to prevent overloading DC 1688 Union Lake during heavy loading periods. The generator and its associated equipment are connected to the system via cable pole DR H0004 on DC 1688 Union Lake (See Appendix F for connection diagram). The Operating Authority for the generator is the North Regional System Supervisor (NRSS). Since the generator is located on substation property, the Operating Agent is the substation operator.

Normal Generator Operation

The summer emergency rating of DC 1688 Union Lake is 770 Amps (6.4 MVA). The summer day-to-day rating of DC 1688 Union Lake is 612 Amps (5.1 MVA). The distributed generator should be brought on-line when the load exceeds it summer day-to-day rating.

Whenever the load exceeds 625 Amps (5.2 MVA) on any phase of DC 1688 Union Lake, the generator should be placed online. The NSS will receive the PERMISSIVE ON alarm when this load level is reached. The NRSS should contact D|TECH to start the generator. (See Appendix A for telephone numbers)

Since the transfer trip scheme is not functional, the generator must be limited to an output of 84 amps (0.7 MVA). The generator should only be run when the under/over frequency relays and under/over voltage relays are operational and the load of DC 1688 Union Lake exceeds 480 amps (4 MVA). The generator can be run at a higher output if necessary as long as the generator output does not exceed 25% of the total circuit load. *

Note: Once the generator is running, the circuit load does not include the generator output. For this reason, the total circuit load is calculated by adding the load on the circuit to the generator output.

The NSS will receive the BE1-81 alarm when there is no DC power for the under/over frequency relays. If this alarm is received, the generator should be taken off-line and kept off-line until the power to the relays is restored.

When the load on DC 1688 Union Lake falls below 505 Amps (4.2 MVA) and the generator is running, the PERMISSIVE OFF alarm will be received by the NSS. The NSS should contact D|TECH to turn off the generator if the generator is being used to relieve DC 1688 Union Lake. (See Appendix A for telephone numbers)**

***** Note: The generator requires a fifteen-minute cool-off period after shutdown before it can be restarted.***

Emergency Trip of the generator breaker is available in the Data Management System (DMS).

The generator at Union Lake ***must remain off-line*** whenever DC 1688 Union Lake is in an abnormal configuration.

Alarming at Union Lake Substation

The ***Generator Permissive On*** **(PERMISSIVE ON)** alarm in the Distribution Management System (DMS) will alert the System Supervisor when any phase on DC 1688 Union Lake exceeds 625 amps (5.2 MVA). This is a notification that the generator should be started. The NSS should contact D|TECH to start the generator. (See Appendix A for telephone numbers). ***

The ***Generator Permissive Off*** **(PERMISSIVE OFF)** alarm in the Distribution Management System (DMS) will alert the System Supervisor to take the generator off-line. This alarm occurs when the generator breaker is closed and the load of DC 1688 Union Lake is below 505 Amps (4.2 MVA) on all three phases. If this alarm is received, the NSS should direct D|TECH to shut down the generator. (See Appendix A for telephone numbers)***

******* *Note: Since the transfer trip scheme is not functional, the generator must be limited to an output of 84 amps (0.7 MVA). The generator should only be run when the under/over frequency relays and under/over voltage relays are operational and the load of DC 1688 Union Lake exceeds 480 amps (4 MVA). The generator can be run at a higher or lower output if necessary as long as the generator output does not exceed 25% of the total circuit load.*

The ***Generator Major Alarm*** **(MAJOR GEN ALARM)** in DMS will alert the System Supervisor that the **generator will shut down** and the unit will be prohibited from restarting. This alarm is a collective output taken from the generator and can be triggered by any of the faults listed in Appendix B. A list of troubleshooting procedures from the generator manual is listed in Appendix G.

The ***Generator Minor Alarm*** **(MINOR GEN ALARM)** in DMS will alert the System Supervisor that the **generator will NOT be shut down**, but the unit will be prohibited from restarting. This alarm is a collective output taken from the generator and can be triggered by any of the alarms listed in Appendix C. A list of troubleshooting procedures from the generator manual is listed in Appendix G.

The ***BE1-32R Alarm (*****BE1-32R*****)*** in DMS will alert the System Supervisor that there is no DC power to the reverse power relays. The generator can still run without the reverse power relays, but the ratio of the load to generator output must be 4:1.

The ***BE1-81 Alarm (*****BE1-81*****)*** in DMS will alert the System Supervisor that there is no DC power to the under/over frequency relays. If this alarm is received and the Transfer trip scheme is not operational, the NSS should direct D|TECH to shut down the generator. The generator should not be started unless there is DC power to the under/over frequency relays.

Appendix E lists all DMS alarms available at Union Lake. Appendix H shows the DMS displays.

Periodic Testing of the Distributed Generator

The Union Lake generator will be run periodically to perform operational tests. These periodic tests will have to be arranged through the North Regional System Supervisor.

Monitoring and Control

The Amp, MW, MVAR, and Voltage values on the generator are available in the Energy Management System (EMS) and the DMS. The D|TECH web site can be used for an alternate way to view these values for the generator. The web sit can be access by going to the following web page:

http://www.energy-now.com/

***Note this web site requires Internet access. The web site also requires a username and password.**

Portable metering equipment has been installed on DC 1688 Union Lake. The current circuit readings can be obtained by going to the following web page:

http://162.9.240.166/pqweb/webreports/PDC-Northwest.html

This web page can also be reached from the Regional Operating Center web site by clicking on resources and then clicking Northwest under the Portable Monitor-Circuit Load Reports.

A list of all DMS monitoring points available at Union Lake is shown in Appendix D.

Relaying

Since the transfer trip scheme is currently not functional, the generator must be limited to an output of 84 amps (0.7 MVA) and the load on DC 1688 Union Lake must be greater than 480 amps (4 MVA) to provide adequate protection.

Reverse power relaying to protect against back feeding the 40 kV for faults on the 40 kV is not installed at Union Lake Substation, but it will be installed at a later date. For this reason, the generator must only be run during peak loading periods to ensure that the undervoltage relaying will provide protection for 40 kV faults.

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Appendix A

Additional Information for Union Lake Substation

	Name	**Number**
Substation Operator:	Pontiac AFC	586.745.5082
Substation Operator (Off Hours):		SEAS
Relay/Pert:		313.235.3846
Relay/Pert (Off Hours):		Refer to On Call Sheet
D|TECH:	D|TECH System Operations Center (Operational 07:00 to 23:00)	248.427.2352
D|TECH (Off Hours):	D|TECH Toll Free Number	1.877.406.9612
Union Lake Substation		313.235.2794

Note: This information was supplied on July 23, 2003 and should be verified periodically.

Appendix B

Generator Major Alarm[1]

Any of the following faults will initiate the Generator Major Alarm. Any of these faults ***will shut down*** the unit while it is running and will inhibit it from restarting.

*CAT	CODE	LAMP	DISPLAYED MESSAGE
A	556	Shtdn	Blowby pressure
A	586	Shtdn	Run/Stop Switch
A	587	Shtdn	Run/Stop Switch
D	688	Shtdn	High oil level alarm
A	1322	Shtdn	Load gov kW setpoint oor hi
A	1323	Shtdn	Load gov kW setpoint oor lo
A	1331	Shtdn	AVR driver shorted
A	1332	Shtdn	Manual switch oor lo
A	1333	Shtdn	Manual switch oor hi
A	1327	Shtdn	Load gov kW analog oor
A	1334	Shtdn	Critical scaler oor
NA	1336	Shtdn	Cooldown Complete
NA	1341	Shtdn	Load demand stop
A	1342	Shtdn	Slot 0 card
A	1343	Shtdn	Slot 1 card
A	1344	Shtdn	Slot 2 card
A	1345	Shtdn	Slot 3 card
A	1346	Shtdn	Slot 4 incorrect
A	1347	Shtdn	Slot 5 card
A	1348	Shtdn	Slot 6 card
A	1349	Shtdn	Slot 7 card
D	1433	Shtdn	Emergency stop - local
D	1434	Shtdn	Emergency stop - remote
A	1437	Shtdn	E-stop path fuse blown
A	111	Shtdn	Internal ECM error
A	112	Shtdn	Actuator not responding
A	115	Shtdn	No speed signal
A	116	Shtdn	Time press sensor high
A	117	Shtdn	Time press sensor low
C	151	Shtdn	High coolant temp alarm
A	155	Shtdn	Manifold air temp alarm
A	214	Shtdn	High oil temperature

[1] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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Generator Major Alarm (Continued)[2]:

*CAT	CODE	LAMP	DISPLAYED MESSAGE
A	228	Shtdn	Low coolant pressure
A	234	Shtdn	Overspeed
D	235	Shtdn	Coolant level alarm
A	236	Shtdn	Position sensor
D	253	Shtdn	Oil level alarm
A	254	Shtdn	Fuel shutoff valve
A	266	Shtdn	Fuel temperature
B	415	Shtdn	Low oil pressure alarm
A	455	Shtdn	Fuel control valve sensor
A	514	Shtdn	Fuel control valve
A	1445	Shtdn	Alternator short circuit
A	1446	Shtdn	AC output voltage is high
A	1447	Shtdn	AC output voltage is low
A	1448	Shtdn	AC output frequency low
A	1452	Shtdn	Gen CB failed to close
A	1453	Shtdn	Gen CB failed to open
A	1455	Shtdn	Util CB contact
A	1459	Shtdn	Reverse kW
A	1461	Shtdn	Loss of field
A	1472	Shtdn	Overcurrent
A	1473	Shtdn	Watchdog failure
A	1474	Shtdn	Software version mismatch
A	1481	Shtdn	AVR driver open
A	1485	Shtdn	EFC driver shorted
A	1486	Shtdn	EFC driver open
A	2114	Shtdn	High aftercooler temp

***Category Fault Code Definitions:**

- **Category A Fault Codes:** These codes pertain to engine or alternator shutdown faults that require immediate repair by qualified service personnel (generator set non-operational). Control prevents the generator set from being restarted.

[2] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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- **<u>Category B Fault Codes:</u>** These codes consist of faults that can affect genset performance or cause engine, alternator, or connected equipment damage. Operate only when generator set is powering critical loads and cannot be shutdown. Requires repair by qualified service personnel.

- **<u>Category C Fault Codes:</u>** These codes consist of faults that do not affect the generator set performance but require qualified service personnel to repair. These codes indicate a defective sensor or harness, leaving no engine protection. (Engine damage can occur without detection.) **Continued operation may void generator set warranty if damage occurs that relates to fault condition.**

- **<u>Category D Fault Codes:</u>** These codes consist of faults that are repairable by site personnel. Qualified service personnel will repair Service if site personnel cannot resolve the problem after taking the corrective actions suggested in Appendix G.

- **<u>Category NA Fault Codes:</u>** These codes consist of faults that are non-critical operational status of generator set, external faults, or customer fault inputs. May require repair by qualified service personnel.

Appendix C

Generator Minor Alarm[3]

Any of the following alarms will initiate the Generator Minor Alarm. These alarms ***will not shut down*** the unit while it is running, but the unit should be brought down for service

*CAT	CODE	LAMP	DISPLAYED MESSAGE
B	546	Wrng	Fuel pressure sensor
B	547	Wrng	Fuel pressure sensor
B	554	Wrng	Fuel rail pressure sensor
B	555	Wrng	Blowby pressure
D	611	Wrng	Engine hot
B	689	Wrng	Crank shaft sensor
B	719	Wrng	Blowby pressure sensor
B	729	Wrng	Blowby pressure sensor
B	778	Wrng	Camshaft sensor
B	1319	Wrng	High alternator temp
C	1321	Wrng	Common warning driver
B	1324	Wrng	Load gov kVAR oor hi
B	1325	Wrng	Load gov kVAR oor lo
B	1326	Wrng	Backup starter disconnect
D	1328	Wrng	Genset CB tripped
B	1329	Wrng	AVR DC power failure
B	1335	Wrng	Non critical scaler oor
C	1351	Wrng	Slot 4/network enabled
C	1414	Wrng	Run relay contact
C	1415	Wrng	Run relay driver
D	1416	Wrng	Fail to shutdown
D	1417	Wrng	Power down error
B	1419	Wrng	Fuel rail driver
B	1421	Wrng	Timing rail driver #1
B	1422	Wrng	Timing rail driver #2
C	1424	Wrng	High side driver
C	1427	Wrng	Overspeed relay driver
C	1428	Wrng	LOP shutdown relay driver
D	1435	Wrng	Engine cold
B	1436	Wrng	PT fuel system drivers
D	1438	Wrng	Fail to crank

[3] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

Cummings Power Generation, 9-2001

Generator Minor Alarm[4] (Continued)

*CAT	CODE	LAMP	DISPLAYED MESSAGE
D	1439	Wrng	Fuel level low in day
D	1441	Wrng	Fuel level low in main
D	1442	Wrng	Battery is weak
B	113	Wrng	Actuator sensor fault
B	118	Wrng	Pump press sensor high
B	119	Wrng	Pump press sensor low
C	121	Wrng	No engine speed signal
B	122	Wrng	Manifold air press sensor
B	123	Wrng	Manifold air press sensor
C	135	Wrng	Oil pressure sensor
C	141	Wrng	Oil pressure sensor
B	143	Wrng	Low oil pressure
C	144	Wrng	Coolant temperature sensor
C	145	Wrng	Coolant temperature sensor
D	146	Wrng	High coolant temp warning
D	152	Wrng	Low coolant temp
C	153	Wrng	Manifold air temp sensor
C	154	Wrng	Manifold air temp sensor
D	197	Wrng	Coolant level warning
C	212	Wrng	Oil temperature sensor
C	213	Wrng	Oil temperature sensor
C	221	Wrng	Air pressure sensor
C	222	Wrng	Air pressure sensor
C	231	Wrng	Coolant pressure sensor
C	232	Wrng	Coolant pressure sensor
A	233	Wrng	Coolant pressure warning
C	259	Wrng	Fuel shutoff valve
C	261	Wrng	Fuel temperature sensor
C	263	Wrng	Fuel temperature sensor
C	265	Wrng	Fuel temperature sensor
B	316	Wrng	Fuel supply pump
B	318	Wrng	Fuel supply pump
D	326	Wrng	Oil level warning
B	343	Wrng	Internal ECM error
C	359	Wrng	Engine failed to start

[4] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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Generator Minor Alarm[5] (Continued)

*CAT	CODE	LAMP	DISPLAYED MESSAGE
A	378	Wrng	Fueling actuator #1
A	379	Wrng	Fueling actuator #1
A	394	Wrng	Fueling actuator #1
A	395	Wrng	Fueling actuator #1
A	396	Wrng	Fueling actuator #2
A	397	Wrng	Fueling actuator #2
A	398	Wrng	Fueling actuator #2
A	399	Wrng	Fueling actuator #2
B	421	Wrng	High oil temperature
B	423	Wrng	Fuel timing
D	441	Wrng	Low battery voltage
D	442	Wrng	High battery voltage
B	449	Wrng	High fuel supply pressure
B	451	Wrng	Fuel rail pressure sensor
B	452	Wrng	Fuel rail pressure sensor
B	467	Wrng	Timing rail act sensor
B	468	Wrng	Fuel rail actuator sensor
D	471	Wrng	Low oil level
B	482	Wrng	High fuel supply pressure
B	488	Wrng	High intake manifold temp
C	498	Wrng	Oil level sensor
C	499	Wrng	Oil level sensor
D	1443	Wrng	Battery is dead
B	1444	Wrng	kW overload
A	1449	Wrng	AC output frequency high
B	1451	Wrng	Gen/Bus voltage differ
C	1454	Wrng	Gen CB position contact
NA	1456	Wrng	Bus out of range
NA	1457	Wrng	Fail to synchronize
NA	1458	Wrng	Phase rotation
B	1462	Wrng	High ground current
C	1466	Wrng	Modem failure
C	1467	Wrng	Unable to connect modem
C	1468	Wrng	Network error
B	1471	Wrng	High current

[5] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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Generator Minor Alarm[6] (Continued)

*CAT	CODE	LAMP	DISPLAYED MESSAGE
C	1475	Wrng	First start backup
C	1476	Wrng	LonWorks card
C	1477	Wrng	Crank relay contact
C	1478	Wrng	Crank relay driver
C	1487	Wrng	Auto acknowledge driver
C	1488	Wrng	Warning LED driver
C	1489	Wrng	Shutdown LED driver
C	1491	Wrng	Ready to load relay driver
C	1492	Wrng	Load dump relay driver
C	1493	Wrng	Display control driver
C	1494	Wrng	Modem power relay driver
C	1495	Wrng	Common shutdown2 driver
C	1496	Wrng	Auto mode relay driver
C	1497	Wrng	Manual run LED driver
C	1498	Wrng	Exercise run LED driver
C	1499	Wrng	Remote start LED driver
C	2111	Wrng	Aftercooler temp sensor
C	2112	Wrng	Aftercooler temp sensor
B	2113	Wrng	High aftercooler temp sensor

***Category Fault Code Definitions:**

- **Category A Fault Codes:** These codes pertain to engine or alternator shutdown faults that require immediate repair by qualified service personnel (generator set non-operational). Control prevents the generator set from being restarted.

- **Category B Fault Codes:** These codes consist of faults that can affect genset performance or cause engine, alternator, or connected equipment damage. Operate only when generator set is powering critical loads and cannot be shutdown. Requires repair by qualified service personnel.

[6] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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Generator Minor Alarm[7] (Continued)

- **Category C Fault Codes:** These codes consist of faults that do not affect the generator set performance but require qualified service personnel to repair. These codes indicate a defective sensor or harness, leaving no engine protection. (Engine damage can occur without detection.) Continued operation may void generator set warranty if damage occurs that relates to fault condition.

- **Category D Fault Codes:** These codes consist of faults that are repairable by site personnel. Qualified service personnel will repair Service if site personnel cannot resolve the problem after taking the corrective actions suggested in Appendix G.

- **Category NA Fault Codes:** These codes consist of faults that are non-critical operational status of generator set, external faults, or customer fault inputs. May require repair by qualified service personnel.

[7] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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Appendix D

Monitoring Points in DAS

Point Name
GEN 1 X 13.2 KV
GEN 1 X AMPS (13.2 KV)
GEN1 TOTAL MW
GEN 1 TOTAL MVAR
GEN 1 Y 13.2 KV
GEN 1 Y AMPS (13.2 KV)
GEN 1 Z 13.2 KV
GEN 1 Z AMPS (13.2 KV)
GEN 1 XY 4.8 KV
GEN 1 X AMPS (4.8 KV)
GEN 1 TOTAL MW
GEN 1 TOTAL MVAR
GEN1 YZ 4.8 KV
GEN1 Y AMPS (4.8 KV)
GEN 1 ZX 4.8 KV
GEN 1 Z AMPS (4.8 KV)
DC 1688 XY 4.8 KV
DC 1688 X AMPS
DC 1688 TOTAL MW
DC 1688 TOTAL MVAR
DC 1688 YZ 4.8 KV
DC 1688 Y AMPS
DC 1688 ZX 4.8 KV
DC 1688 Z AMPS

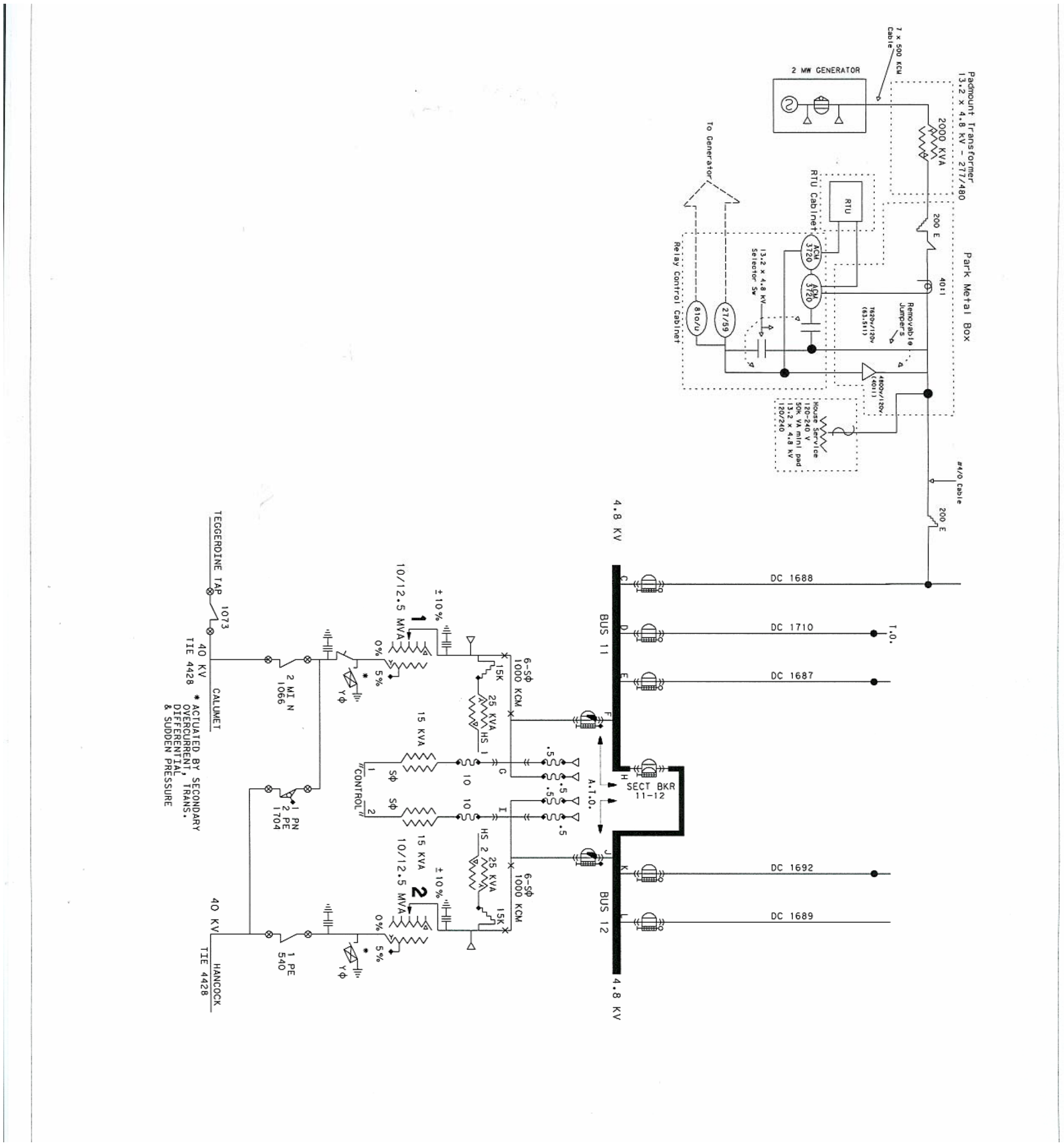
Appendix E

Alarm Points in DAS

Point Name
END ELEMENT
LOSS OF AC
GEN 1 BKR
GEN 1 13.2 KV METER
GEN 1 4.8 KV METER
GEN 1 MAJOR ALARM
GEN 1 MINOR ALARM
STATION METER
PERMISSIVE ON
PERMISSIVE OFF
BE1-32R
BE1-81
GEN 1 TRIP
UNUSABLE CLOSE

Appendix F

Connection Diagram for Union Lake Generator



Appendix G
Warning and Shutdown Codes for Union Lake Generator[8]

WARNING: Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and Mechanical hazards should perform service procedures. Review safety precautions.	
CODE:**146** LAMP: **Warning** Message: **HIGH COOLANT TEMP WARNING**	Indicates engine has begun to overheat and jacket water coolant temperature has risen to an unacceptable level. If generator is powering non-critical and critical loads and cannot be shut down, use the following. a. Reduce load if possible by turning off non-critical loads. b. Check air inlets and outlets and remove any obstructions to airflow. If engine can be stopped, follow 151 High Coolant Temp Alarm procedure.
CODE:**151** LAMP: **Shutdown** Message: **HIGH COOLANT TEMP ALARM**	Indicates engine has overheated (jacket water coolant temperature has risen above the shutdown trip point or the coolant level is low. Allow engine to cool down completely before proceeding with the following checks: a. Check jacket water coolant level and replenish if low. Look for coolant leakage and repair if necessary. b. Check for obstructions to cooling airflow and correct as necessary. c. Check fan belt and repair if necessary. d. Reset control and restart after locating and correcting problem.

[8] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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Warning and Shutdown Codes for Union Lake Generator[9] (Continued)

WARNING: Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and Mechanical hazards should perform service procedures. Review safety precautions.	
CODE:**152** LAMP: **Warning** Message: **LOW COOLANT TEMP**	Indicates engine coolant heater is not operating or is not circulating coolant. Set is in standby mode but is not operating. Warning occurs when engine jacket water coolant temperature is 70 degrees F (21 degrees C) or lower. **NOTE: In applications where the ambient temperature falls below 40 degrees F (4 degrees C), Low Coolant Temp may be indicated even though the coolant heaters are operating.** Check for the following conditions: a. Coolant heater not connected to power supply. Check for blown fuse or disconnected heater cord and correct as required. b. Check for low jacket water coolant level and replenish if required. Look for possible coolant leakage points and repair as required.
CODE:**197** LAMP: **Warning** Message: **COOLANT LEVEL WARNING**	Indicates engine jacket water coolant level has fallen to an unacceptable level. If generator is powering critical loads and cannot be shut down, wait until next shutdown period, then follow **235 Coolant Level Alarm** procedure. If engine can be stopped, follow **235** procedure.

[9] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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Warning and Shutdown Codes for Union Lake Generator[10] (Continued)

WARNING: Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and Mechanical hazards should perform service procedures. Review safety precautions.	
CODE:**359** LAMP: **Warning** Message: **ENGINE FAILED TO START**	Indicates possible fault with control or starting system. Check for the following conditions: a. Poor battery cable connections. Clean the battery cable terminals and tighten all connections. b. Discharged or defective battery. Recharge or replace the battery.
CODE:**441** LAMP: **Warning** Message: **LOW BATTERY VOLTAGE**	Indicates battery voltage is below 24 VDC. a. Discharged or defective battery. Check the battery charge fuse. Recharge or replace the battery. b. Poor battery cable connections. Clean the battery cable terminals and tighten all connections. c. Check engine DC alternator. Replace engine DC alternator if normal battery charging voltage (24 to 26 VDC) is not obtained. d. Check float level if applicable (raise float level)
CODE:**471** LAMP: **Warning** Message: **LOW OIL LEVEL**	Indicates engine oil has dropped to an unacceptable level. If generator is powering critical loads and cannot be shut down, wait until next shutdown period, then follow **253 Oil Level Alarm** procedure. If engine can be stopped follow **253** procedure.
CODE:**611** LAMP: **Warning** Message: **ENGINE HOT**	a. Indicates that engine hot shut down has occurred (cool-down timers were bypassed). This condition will occur when the engine coolant temperature is above the normal operating level and the operator presses the Emergency Switch or moves the 0/Manual/Auto switch to 0 (Off) position. This type of shutdown should be avoided. Can cause possible loss of

[10] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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	performance and engine damage.

Warning and Shutdown Codes for Union Lake Generator[11] (Continued)

WARNING: Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and Mechanical hazards should perform service procedures. Review safety precautions.	
CODE:**253** LAMP: **Shutdown** Message: **OIL LEVEL ALARM**	Indicates engine oil level has dropped below the shutdown trip point. Check oil level, lines and filters. If oil system OK but oil level is low, replenish. Reset control and restart
CODE:**326** LAMP: **Warning** Message: **OIL LEVEL WARNING**	Indicates that the engine oil level has exceeded the warning trip point for high oil level. If generator is powering critical loads and cannot be shut down, wait until next shutdown period, then follow **688 High Oil Level Alarm** procedure. If engine can be stopped follow **688** procedure.
CODE:**688** LAMP: **Warning** Message: **HIGH OIL LEVEL ALARM**	Indicates that the engine oil level has exceeded the alarm trip point for high oil level. Check oil level. Drain oil to operating level.
CODE:**235** LAMP: **Shutdown** Message: **COOLANT LEVEL ALARM**	Indicates engine jacket water coolant level has fallen below the alarm trip point. Allow engine to cool down completely before proceeding. a. Check jacket water coolant level and replenish if low. Look for possible coolant leakage points and repair if necessary. b. Reset control and restart after locating and correcting problem.
CODE:**1311 through 1318** LAMP: **Shutdown/Warning** Message: **Customer Defined Fault**	When any one of these customer-defined inputs is detected by the control, the corresponding fault message is displayed. The nature of the fault is an optional customer selection. These fault functions can be programmed to

[11] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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	initiate a shutdown or warning as indicated by the Warning or Shutdown lamp. **Note:** Customer fault messages are editable. The message displayed for the code shown (1311 through 1318) is determined by the customer.

Warning and Shutdown Codes for Union Lake Generator[12] (Continued)

WARNING: Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and Mechanical hazards should perform service procedures. Review safety precautions.	
CODE:**1416** LAMP: **Warning** Message: **FAIL TO SHUTDOWN**	Status- indicates that the "Fault Bypass" mode is enabled. Service personnel for troubleshooting purposes primarily use this mode. In this mode the generator set ignores the majority of system shutdown faults.
CODE:**1417** LAMP: **Warning** Message: **POWER DOWN ERROR**	Indicates that the control can not power down due to some unknown condition. Possible drain on battery. Contact an authorized service center for service.
CODE:**1433/1434** LAMP: **Shutdown** Message: **EMERGENCY STOP – LOCAL/ EMERGENCY STOP - REMOTE**	Indicates local or remote Emergency Stop. Emergency Stop shutdown status can be reset only at the local control panel. To reset the local/remote Emergency Stop button: • Pull the button out. • Move the O/Manual/Auto switch to O (off). • Press the front panel Fault Acknowledge button. • Select Manual or Auto, as required.
CODE:**1438** LAMP: **Warning** Message: **FAIL TO CRANK**	Indicates possible fault with control or starting system. Check for the following conditions. a. Poor battery cable connections. Clean the battery cable terminals and tighten all connections. b. Discharged or defective battery. Recharge or replace the battery.
CODE:**1439** LAMP: **Warning** Message: **FUEL LEVEL LOW IN DAY**	Indicates fuel supply is running low. Check fuel supply and replenish as required.

[12] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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Warning and Shutdown Codes for Union Lake Generator[13] (Continued)

WARNING: Many troubleshooting procedures present hazards that can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and Mechanical hazards should perform service procedures. Review safety precautions.	
CODE:**1441** LAMP: **Warning** Message: **FUEL LEVEL LOW IN MAIN**	Indicates fuel supply is running low. Check fuel supply and replenish as required.
CODE:**1442** LAMP: **Warning** Message: **BATTERY IS WEAK**	Indicates battery voltage drops below 14.4 volts for two seconds, during starting. Discharged or defective battery. See Warning message **441 Low Battery Voltage.**
CODE:**1443** LAMP: **Warning** Message: **BATTERY IS DEAD**	Indicates battery has dropped below genset operating range (3.5 volts when cranking) to power the starter and the control circuitry. See Warning message **441 Low Battery Voltage.**

[13] Operator's Manual-PowerCommand Control 3200 Series Generator Sets

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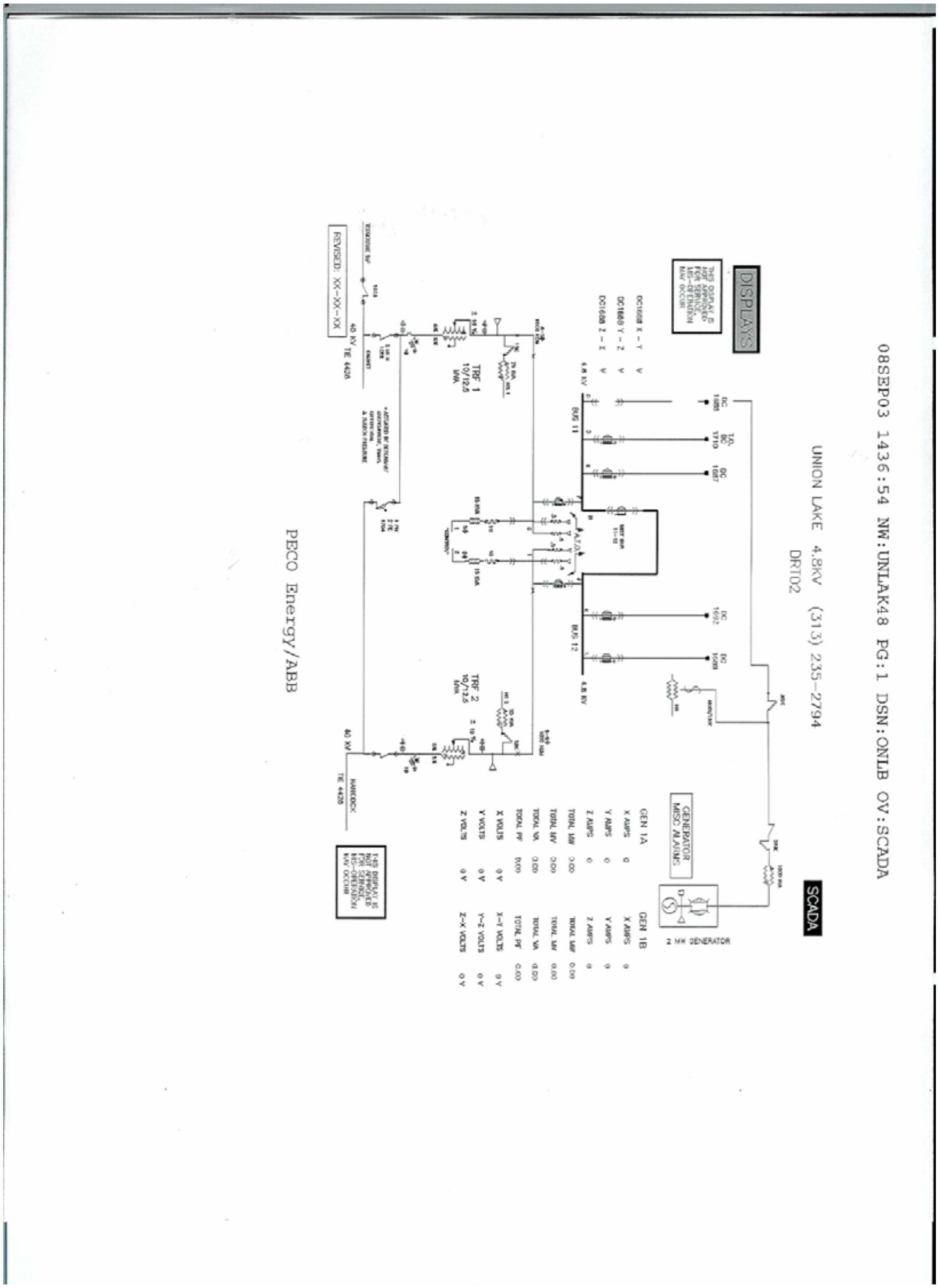
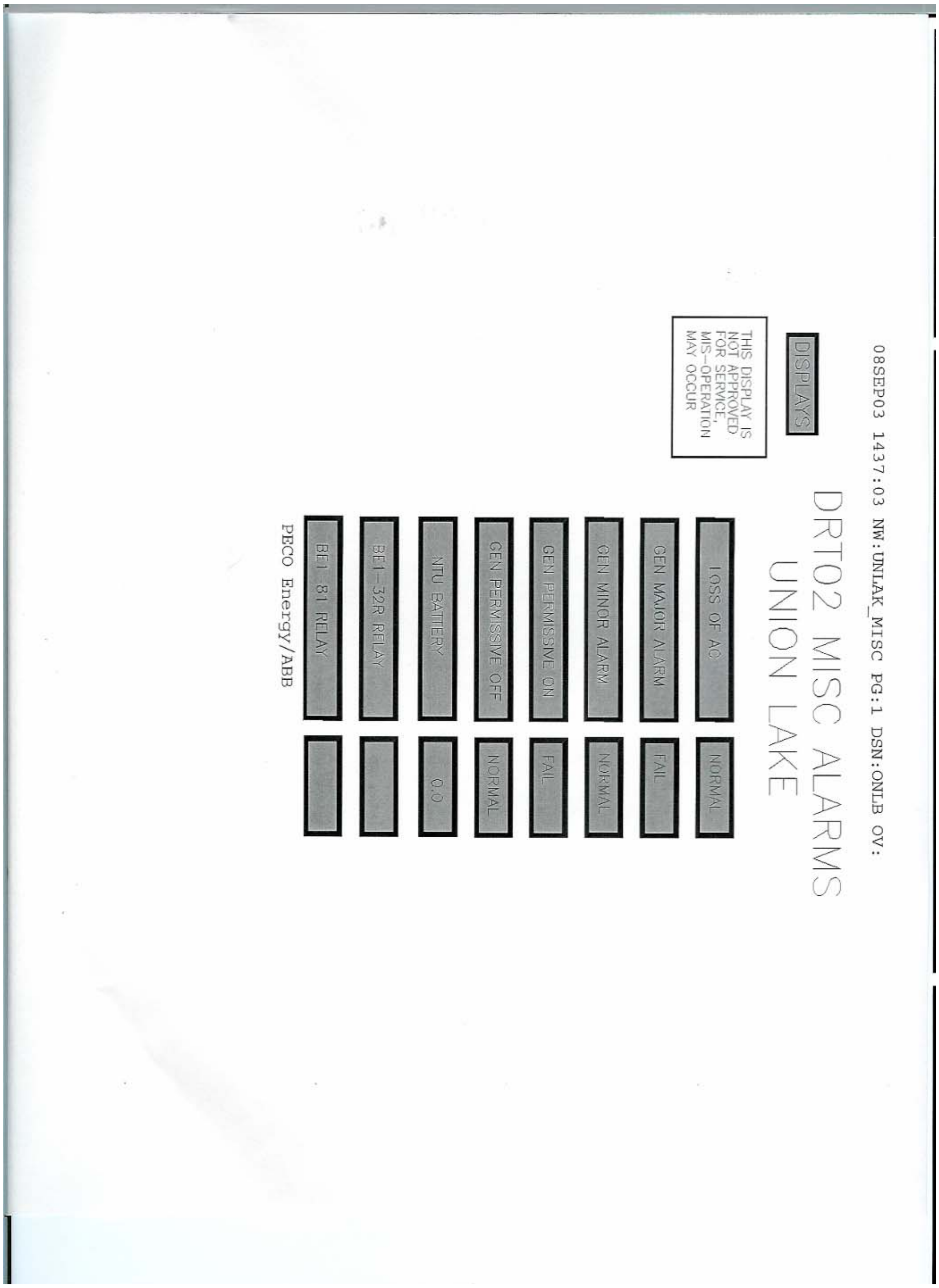
Appendix H

DMS Displays



Appendix H

DMS Displays (Continued)



D|TECH SOC OPERATOR LOG ENTRIES

This is a list of the types of entries an operator should consider for entry in the daily log. It is not all inclusive and certainly any significant event or information would be helpful. Logging can be a significant source of data to aid in the reconstruction or analysis of a given situation, it is better to include too much information than not enough.

1. Unit trips: include approximate time (exact if known), cause if known, any other data relative to the incident such as ETR (Estimated Time of Repair/Return to Service) severe weather conditions, etc.

2. Operating notes peculiar to a specific unit's or site's idiosyncrasies.

3. DEM (Distributed Energy Manager) dispatch requests such as start/stop and unit load changes. When practical, confirm the name and callback phone number of the person initiating the request.

4. Special instructions for the Dispatchers such as priorities, potential hazards, site entrance requirements, severe weather, etc.

5. Communications disruptions, problems, errors, failures, etc.

6. SOC Customer trouble and incident calls and time Dispatch is notified, log the time the dispatch was made by the Dispatcher. Log the time the technician arrives at the site and the time the technician leaves the site.

7. Follow up information.

8. Manual Unit shutdowns (Normal or Emergency) and related information.

9. Any other comments or information the Operator thinks will be useful or of interest for future reference.

Abbreviations if used should be expanded at least once in parenthesis.Similarly, the Operator making the entry should enter at least the first name initial and last name. rather than using initials because the potential for confusion does exist.

Log entry times should be the actual time (SOC using the 24 hour clock) you made the entry and the time (the local time at the site) of the event is then included in the events/data portion of the log. These logs are on the server and may be read by many different levels of the Company so a narrative style similar to normal speech is a good approach. Accuracy is MOST important.

We will have 1 log created per day and each entry is to have at least the 1st initial and last name of the operator making that entry. At the end of the day the log will be saved to the hard drive and at least 1 hard copy printed and placed in the appropriate log binder.

Appendix D

Example DG Control Calculations

Consider the circuit depicted in Figure 2. The circuit is a 13.2 kV grounded circuit and includes a 495 kW synchronous DG placed at the location indicated in the figure. Initially the circuit has no operational problems. Therefore, initially no power is generated by the DG. It is assumed that the minimum generation level for the DG is 30% and a circuit voltage is considered as an under voltage if it falls below 95% of its nominal value.

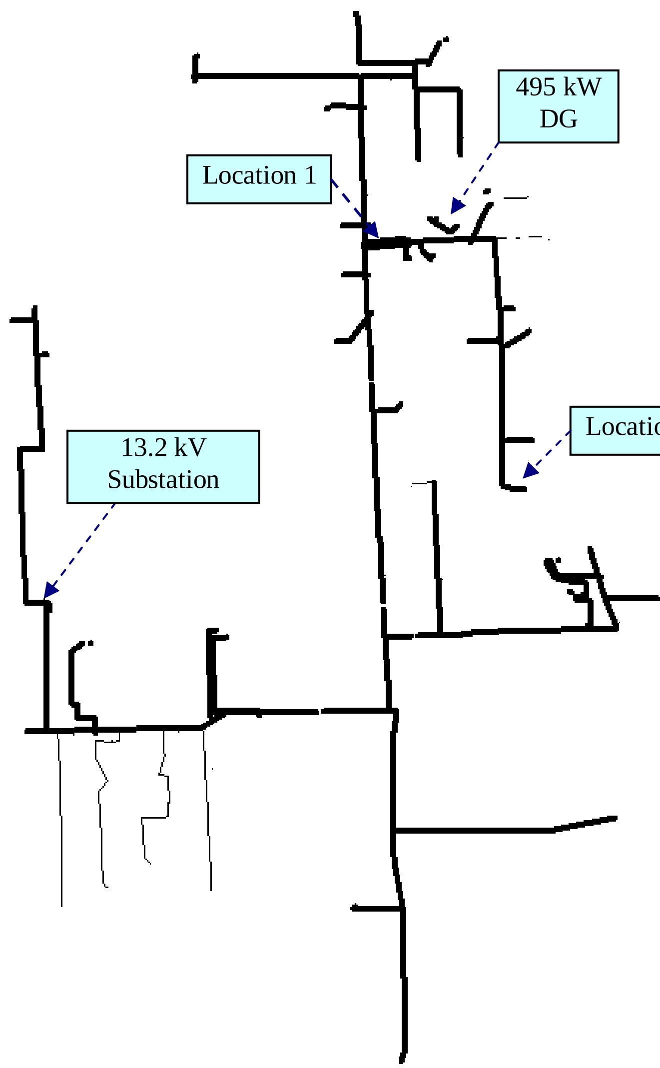


Figure 2. Circuit for Example Control Calculations

Table 1 shows power flow results for the circuit of Figure 2. Note from the report that there are currently no under voltaged or overloaded components in the circuit.

Table 1 Power Flow Analysis Results for Circuit Shown in Figure 2 with No Operational Problems and with DG Turned Off

```
=============================
 R e s u l t s   S u m m a r y
=============================
       Description
   ===========================    ======
    AMP Flow At Start of Ckt   A: 304.1
                               B: 308.0
                               C: 314.1

    Substation TR % Loading        90.7
    # of Undervoltaged Cmps           0
    # of Overloaded Cmps              0
    Worst % Voltage in Ckt       101.97
    Worst % Loading in Ckt         96.8
    KW   Gen  at DG Site            0.0
    KVAR Gen  at DG Site            0.0

====================================================================
 L o c a t i o n    W i t h   W o r s t  % V o l t a g e   L e v e l
====================================================================
                                                  Nominal   |-Pflow Cust Volt -|
         Local Name            Loc X    Loc Y   Cust Volt     A      B      C    %Volt
         ====================  ======== ======== =========  ====== ====== ======  ======
               2-PECX3         2241391   270977   120.00    123.02 123.90 122.36  101.97

=====================================================================
 L o c a t i o n    W i t h   W o r s t   % L o a d i n g   L e v e l
=====================================================================
                                          Nom.     Rated  |---- Pflow AMP ---|
 Local Name            Loc X    Loc Y   Volt(kV)    AMP     A      B      C    %Loading
===================  ======== ======== ========= ======= ====== ====== ======  ======
      iPS_M188        2241287   270976   7.96 Ln    80.0   77.1   76.9   77.5   96.82
```

Next three scenarios will considered. In each scenario a condition will be introduced into the circuit of Figure 2 that will cause operational problems. The DG Control application will then be employed to determine the generation levels at which the DG is to be operated for solving the problem created. Output report results from the DG Control application are presented.

Scenario 1: Overload Problem At Location 1

In this scenario a conductor that is too small is inserted at Location 1 shown in Figure 2. The conductor selected creates an overload condition. The DG Control application is then run to determine the minimum DG set point (i.e., kW and kVAR generation) to eliminate the overload problem. A portion of the output report from the DG Control application is shown in Table 2. The report shows that by selecting a generation level of 307 kW, 63 kVar, the overload is eliminated.

Table 2 Output Report Results from DG Control Application for Overload at Location 1 of Circuit Shown in Figure 2

```
=============================
 R e s u l t s  S u m m a r y
=============================
       Description              BEFORE   AFTER
   ===========================  ======   ======
    AMP Flow At Start of Ckt   A: 304.1    290.8
                               B: 308.0    294.8
                               C: 314.1    300.8

    Substation TR % Loading       90.7     86.8
    # of Undervoltaged Cmps          0        0
    # of Overloaded Cmps             1        0 <-- OVERLOAD problem REMOVED...
    Worst % Voltage in Ckt      101.78   101.91
    Worst % Loading in Ckt       122.4     99.8
    KW   Gen  at DG Site           0.0    307.0 <-- Min KW = 148.5, Max KW = 495.1
    KVAR Gen  at DG Site           0.0     63.0

=======================================================================
 L o c a t i o n s   W i t h   W o r s t  % V o l t a g e   L e v e l s
=======================================================================
                                               Nominal   |-Pflow Cust Volt -|
         Local Name          Loc X    Loc Y   Cust Volt     A      B      C     %Volt
         =================  ======== ======== =========  ====== ====== ======  ======
 BEFORE:    2-PECX3          2241391   270977   120.00   122.81 123.68 122.14  101.78
  AFTER:    2-PECX3          2241391   270977   120.00   123.01 123.82 122.29  101.91

========================================================================
 L o c a t i o n s   W i t h   W o r s t   % L o a d i n g   L e v e l s
========================================================================
                                         Nom.     Rated  |---- Pflow AMP ---|
         Local Name   Loc X    Loc Y   Volt(kV)    AMP     A      B      C    %Loading
         ==========  ======== ======== ========= ======= ====== ====== ======  ======
 BEFORE:  Loc1        2240440   272379   7.96 Ln    57.5   67.3   68.7   70.4  122.43
  AFTER:  Loc1        2240440   272379   7.96 Ln    57.5   54.3   55.7   57.4   99.78

  KW and KVAR Generation at DG Site:
  ==================================
                               |----- P (KW) -----|  |---- Q (KVAR -----|   KVA
                                 A      B      C      A      B      C      Gen
                               ====== ====== ======  ====== ====== ======  =====
   Measured    P-Q Gen BEFORE:    0.0    0.0    0.0     0.0    0.0    0.0     0%
   Recommended P-Q Gen AFTER :  102.3  102.3  102.3    21.0   21.0   21.0    62%
```

Scenario 2: Undervoltage Problem at Location 2

In this scenario the sizes and lengths of the conductors between location 1 and 2 shown in Figure 2 are changed so that larger voltage drops occur due to smaller and longer conductors, resulting in under voltages on the components around Location 2. The DG Control application is run to solve the problem. The output report from the DG Control application is shown in Table 3. The report shows that by selecting a generation level of 148.5 kW, 36 kVar, the undervoltages are eliminated.

Table 3 Output Report Results from DG Control Application for Undervoltages at Location 2 of Circuit Shown in Figure 2

```
=============================
 R e s u l t s  S u m m a r y
=============================
       Desc                      BEFORE   AFTER
   ==========================    ======   ======
    AMP Flow At Start of Ckt   A: 304.1    297.5
                               B: 308.1    301.5
                               C: 314.1    307.5

    Substation TR % Loading        90.7     88.7
    # of Undervoltaged Cmps           4        0 <-- UNDERVOLTAGE problem REMOVED...
    # of Overloaded Cmps              0        0
    Worst % Voltage in Ckt        94.91    95.14
    Worst % Loading in Ckt         96.8     96.8
    KW   Gen  at DG Site            0.0    148.5 <-- Min KW = 148.5, Max KW = 495.1
    KVAR Gen  at DG Site            0.0     36.0

=======================================================================
 L o c a t i o n s   W i t h   W o r s t  % V o l t a g e   L e v e l s
=======================================================================
                                        Nominal   |-Pflow Cust Volt -|
         Local Name   Loc X    Loc Y   Cust Volt     A      B      C     %Volt
         ==========  ======== ======== =========  ====== ====== ======  ======
 BEFORE:  2-PECX3     2241391   270977   120.00   114.63 115.67 113.89   94.91
  AFTER:  2-PECX3     2241391   270977   120.00   114.93 115.93 114.17   95.14

========================================================================
 L o c a t i o n s   W i t h   W o r s t   % L o a d i n g   L e v e l s
========================================================================
                                         Nom.     Rated  |---- Pflow AMP ---|
         Local Name   Loc X    Loc Y   Volt(kV)    AMP     A      B      C     %Lding
         ==========  ======== ======== ========= ======= ====== ====== ======  ======
 BEFORE:  iPS_M188    2241287   270976   7.96 Ln    80.0   77.1   76.9   77.4   96.80
  AFTER:  iPS_M188    2241287   270976   7.96 Ln    80.0   77.1   76.9   77.4   96.80

  KW and KVAR Generation at DG Site:
  ==================================
                               |----- P (KW) -----|  |---- Q (KVAR -----|   KVA
                                 A      B      C       A      B      C      Gen
                               ====== ====== ======  ====== ====== ======  =====
   Measured    P-Q Gen BEFORE:    0.0    0.0    0.0     0.0    0.0    0.0     0%
   Recommended P-Q Gen AFTER :   49.5   49.5   49.5    12.0   12.0   12.0    30%
```

Scenario 3: Overload at Location 1 and Undervoltage at Location 2

In this scenario the conductors between locations 1 and 2 are made smaller such that both overload and a low voltage problems are created. The DG Control application is run to solve the problem. The output report from the DG Control application is shown in Table 4. The report shows that by selecting a generation level of 307 kW, 63 kVar, both the overload and undervoltage problems are eliminated.

Table 4 Output Report Results from DG Control Application for Overload at Location 1 and Undervoltage at Location 2 of Circuit Shown in Figure 2

```
=============================
 R e s u l t s  S u m m a r y
=============================
      Desc                        BEFORE   AFTER
   ==========================    ======   ======
    AMP Flow At Start of Ckt   A: 304.1    290.6
                               B: 308.1    294.7
                               C: 314.1    300.6

    Substation TR % Loading        90.7     86.7
    # of Undervoltaged Cmps           1        0 <-- UNDERVOLTAGE problem REMOVED...
    # of Overloaded Cmps              1        0 <-- OVERLOAD problem REMOVED...
    Worst % Voltage in Ckt        94.97    95.43
    Worst % Loading in Ckt        122.8     99.8
    KW   Gen  at DG Site            0.0    307.0 <-- Min KW = 148.5, Max KW = 495.1
    KVAR Gen  at DG Site            0.0     63.0

=======================================================================
 L o c a t i o n s   W i t h   W o r s t  % V o l t a g e   L e v e l s
=======================================================================
                                          Nominal   |-Pflow Cust Volt -|
         Local Name   Loc X    Loc Y   Cust Volt    A      B      C     %Volt
         ==========  ======== ======== =========  ====== ====== ======  ======
 BEFORE:  2-PECX3     2241391   270977   120.00    114.72 115.72 113.97   94.97
  AFTER:  2-PECX3     2241391   270977   120.00    115.32 116.25 114.51   95.43

========================================================================
 L o c a t i o n s   W i t h   W o r s t   % L o a d i n g   L e v e l s
========================================================================
                                           Nom.     Rated  |---- Pflow AMP ---|
         Local Name   Loc X    Loc Y   Volt(kV)    AMP     A      B      C     %Lding
         ==========  ======== ======== =========  ======= ====== ====== ======  ======
 BEFORE:   Loc1       2240440   272379   7.96 Ln     57.5   67.6   69.0   70.6  122.84
  AFTER:   Loc1       2240440   272379   7.96 Ln     57.5   54.3   55.7   57.4   99.82

  KW and KVAR Generation at DG Site:
  ==================================
                               |----- P (KW) -----|  |---- Q (KVAR -----|   KVA
                                 A      B      C       A      B      C      Gen
                               ====== ====== ======  ====== ====== ======  =====
   Measured    P-Q Gen BEFORE:    0.0    0.0    0.0     0.0    0.0    0.0    0%
   Recommended P-Q Gen AFTER :  102.3  102.3  102.3    21.0   21.0   21.0   62%
```

Appendix E

DEW Examples of DER Reliability Calculations

Case Study: Reliability Improvement with Distributed Generation and Reconfiguration

Test System and Method

The system used for the study consists of two distribution circuits as shown in Figure 10. One of the circuits, circuit SHORS1770, is supplied from a 10 MVA, 4.8-kV substation. Located within SHORS1770 is a distributed generator with a capacity of 1039.8 kVA. The location of the DG is shown by the circle in Figure 10. The other circuit shown in Figure 10 is referred to as LAKSD2540A. LAKSD2540A is also supplied from a 10 MVA, 4.8-kV substation. The two circuits can be connected together by three different tie switches. Normally the tie switches are open.

FIGURE 10 Two-circuit system

In the study performed here, it is assumed that the substation supplying the LAKSD2540A circuit is failed. After the contingency occurs and the failed substation is isolated for repair, power can be restored to loads in the failed circuit from its adjacent circuit, SHORS1770, by closing the tie switches. To help with the power restoration, the DG located in the SHORS1770 circuit is also used. However, depending upon the circuit loading conditions and due to overload and/or low voltage limits, some load points which belong to the failed circuit may not be restored to service.

Following network reconfigurations and DG operations, power flow is used to insure that the operations do not violate any system constraints. As a result, the amount of load that may be picked up without violating system constraints is calculated. The mathematic equations are expressed as follows:

Amount to new load picked up:

$$KVA_D \cong \left(KVA_{F\_SHORS} + KVA_{F\_DG}\right) - \left(KVA_{B\_SHORS} + KVA_{B\_DG}\right) \quad (1)$$

Percentage of load picked up $\cong \dfrac{KVA_D}{KVA_{B\_LAKSD}}$ (2)

Here, we define the original circuit status as the base case, expressed with the subscript $_B$. KVA_{B_LAKSD} is the total three-phase feeder flow for the circuit LAKSD2540A under the base case. KVA_{B_SHORS} is the total three-phase feeder flow for the circuit SHORS1770. KVA_{B_DG} is the power injection of installed generator.

Following the failure of the LAKSD2540A substation and the subsequent operation of the tie switches, the reconfigured network results are indicated with the subscript $_F$. KVA_{F_SHORS} is the total three-phase feeder flow for the SHORS1770 circuit corresponding to the failure case. KVA_{F_DG} is the power injection of the generator following the reconfiguration.

Test Results

In order to simply the analysis process, we are only interested in minimum and maximum load time points, which are October Tuesday 3 AM and August Tuesday 9 PM, respectively. At each time point, we test the system without adding DG and with DG. The analysis results are listed in the following tables. The locations of switches opened are also shown in the figures below. On the figures, the purple rectangle across on one component denotes that there is no power supply on this component.

TABLE 1.Results with DG at minimum load time point (October Tuesday 3 AM)

	Base Case		Failure Case	
LAKSD2540A	KVAB_LAKSD	4565.79	KVAF_LAKSD	0
SHORS1770	KVAB_SHORS	912.21	KVAF_SHORS	4014.44
DG	KVAB_DG	1036.62	KVAF_DG	1039.8
Amount to new load picked up	3105.41			
Percentage of load picked up	68 %			

FIGURE 11 Location of opened switches of reconfiguration with DG at minimum load time point

TABLE 2 Results without DG at minimum load time point

	Base Case		Fail Case	
LAKSD2540A:	KVAB_LAKSD	4565.79	KVAF_LAKSD	0
SHORS1770:	KVAB_SHORS	1951.72	KVAF_SHORS	3809.91
DG:	KVAB_DG	0	KVAF_DG	0
Amount to new load picked up	1858.19			
Percentage of load picked up	40.7 %			

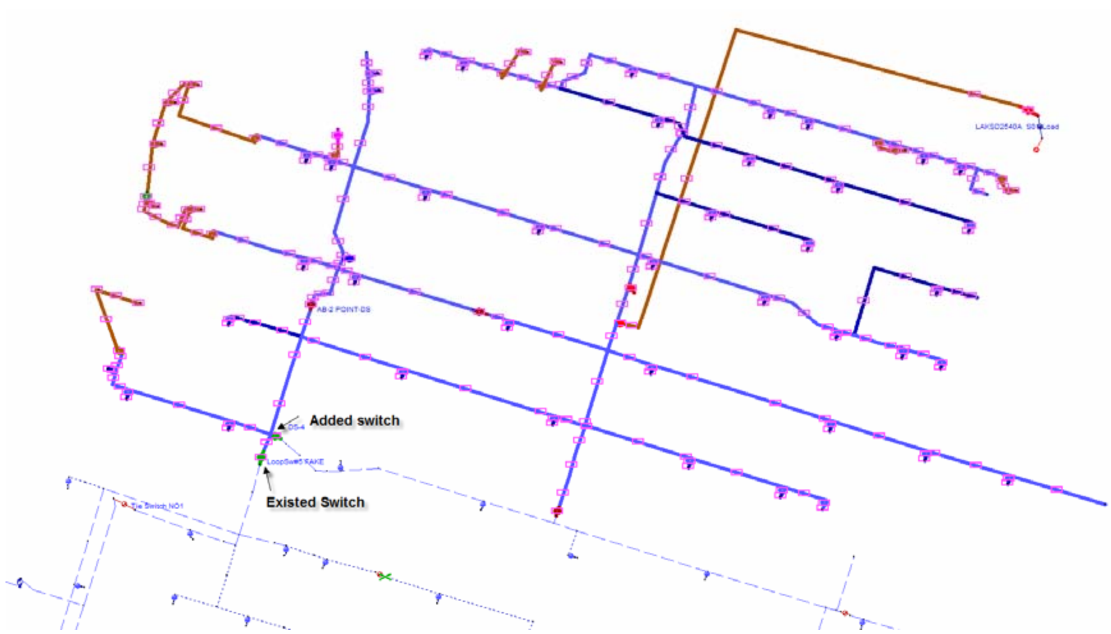


FIGURE 12 Location of opened switches of reconfiguration without DG at minimum load time point

When testing at the maximum load time point, we find that the original circuit SHORS1770 can not be fully supplied by its substation without adding DG. Further, according to current magnitude curves during the 24-hour period from August Tuesday 12 AM to 11 PM, we pick up two more time points to test. The minimum load occurs at 3 AM, and the average medium load point is 1 PM.

TABLE 3 Current magnitudes of the circuit SHORS1770 at August Tuesday

Time Point	IMagA	IMagB	IMagC	IMagAve
12 AM	272.61	271.76	223.87	256.08
1 AM	247.12	246.51	202.82	232.15
2 AM	232.46	232.06	190.73	218.42
3 AM	222.24	222.50	182.71	209.15
4 AM	225.48	225.73	185.43	212.21
5 AM	231.78	231.82	190.80	218.13
6 AM	257.55	257.37	212.61	242.51
7 AM	270.29	269.64	223.43	254.45
8 AM	283.26	281.13	233.59	265.99
9 AM	298.12	293.88	244.75	278.92
10 AM	284.19	256.23	219.54	253.32
11 AM	292.57	264.31	225.96	260.95
12 PM	307.90	279.50	238.04	275.15
1 PM	316.48	287.97	245.06	283.17
2 PM	324.19	295.59	251.18	290.32
3 PM	335.79	306.36	259.97	300.71
4 PM	355.02	323.74	274.26	317.67
5 PM	377.13	346.14	291.85	338.37
6 PM	375.86	345.40	290.65	337.30
7 PM	375.30	345.08	290.15	336.84
8 PM	384.77	354.26	297.67	345.57
9 PM	402.16	373.46	312.86	362.83
10 PM	371.88	343.46	288.03	334.46
11 PM	347.81	347.31	286.60	327.24
Minimum	222.24	222.50	182.71	209.15
Average	308.00	291.72	244.27	281.33
Maximum	402.16	373.46	312.86	362.83

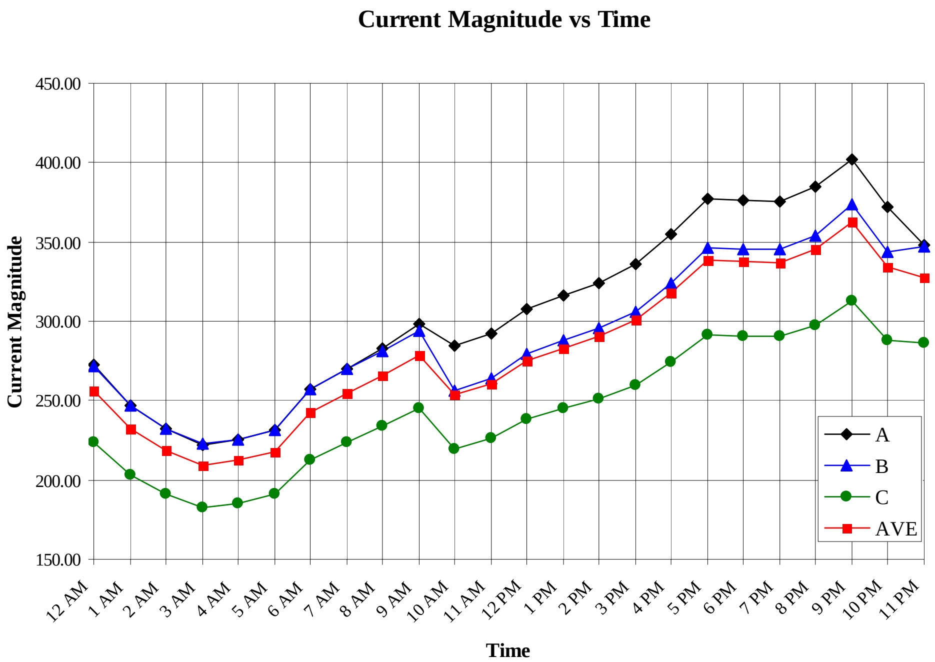


FIGURE 13 Current magnitudes curves of the circuit SHORS1770 at August Tuesday

TABLE 4 Results with DG at August, Tuesday 3 AM

	Base Case		Fail Case	
LAKSD2540A:	KVAB_LAKSD	4565.79	KVAF_LAKSD	Failed
SHORS1770:	KVAB_SHORS	2046.53	KVAF_SHORS	3986.14
DG:	KVAB_DG	1033.99	KVAF_DG	1039.79
Amount to new load picked up	1945.41			
Percentage of load picked up	42.6 %			

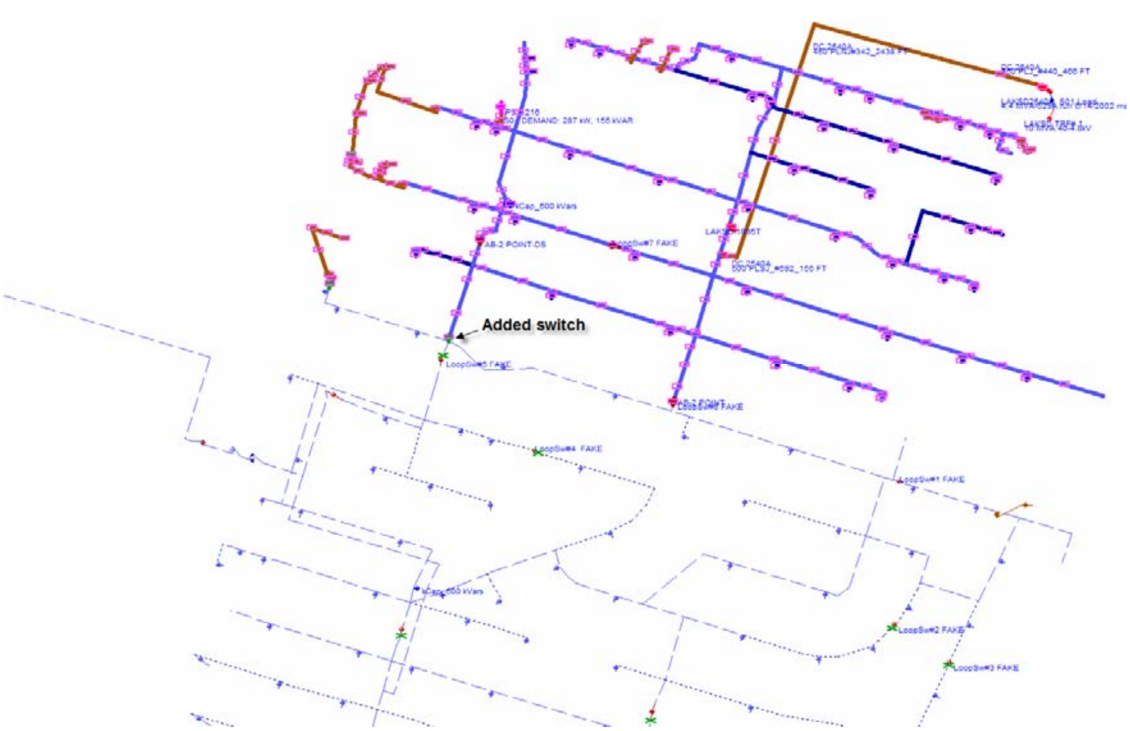


FIGURE 14 Location of opened switches of reconfiguration with DG at August, Tuesday 3AM

TABLE 5 Results with DG at August, Tuesday 1 PM

	Base Case		Fail Case	
LAKSD2540A:	KVAB_LAKSD	4565.79	KVAF_LAKSD	Failed
SHORS1770:	KVAB_SHORS	2716.77	KVAF_SHORS	3911.89
DG:	KVAB_DG	1030.83	KVAF_DG	1037.16
Amount to new load picked up	1201.45			
Percentage of load picked up	26.3 %			

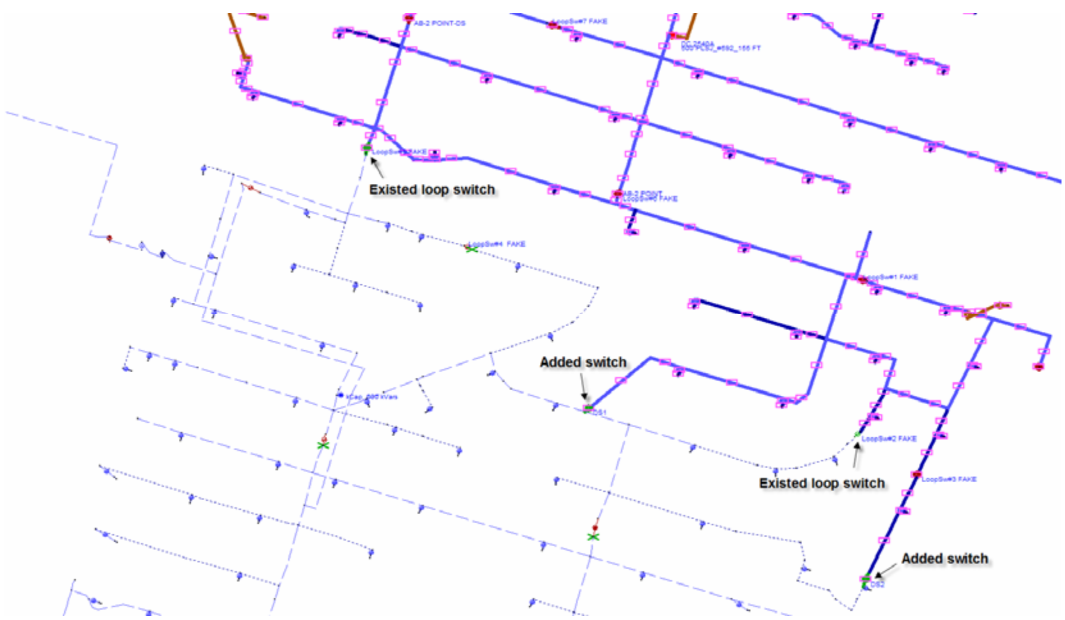


FIGURE 15 Location of opened switches of reconfiguration with DG at August, Tuesday 1 PM

TABLE 6 Results with DG at August, Tuesday 9 PM

	Base Case		Fail Case	
LAKSD2540A:	KVAB_LAKSD	4565.79	KVAF_LAKSD	Failed
SHORS1770:	KVAB_SHORS	3410.07	KVAF_SHORS	3993.26
DG:	KVAB_DG	1032.86	KVAF_DG	1036.67
Amount to new load picked up	587			
Percentage of load picked up	12.9 %			

FIGURE 16 Location of opened switches of reconfiguration with DG at August, Tuesday 9 PM

TABLE 7 Results without DG at August, Tuesday 3 AM

	Base Case		Fail Case	
LAKSD2540A:	KVAB_LAKSD	4565.79	KVAF_LAKSD	Failed
SHORS1770:	KVAB_SHORS	3178.18	KVAF_SHORS	4139.34
DG:	KVAB_DG	0	KVAF_DG	0
Amount to new load picked up	961.16			
Percentage of load picked up	21.1 %			

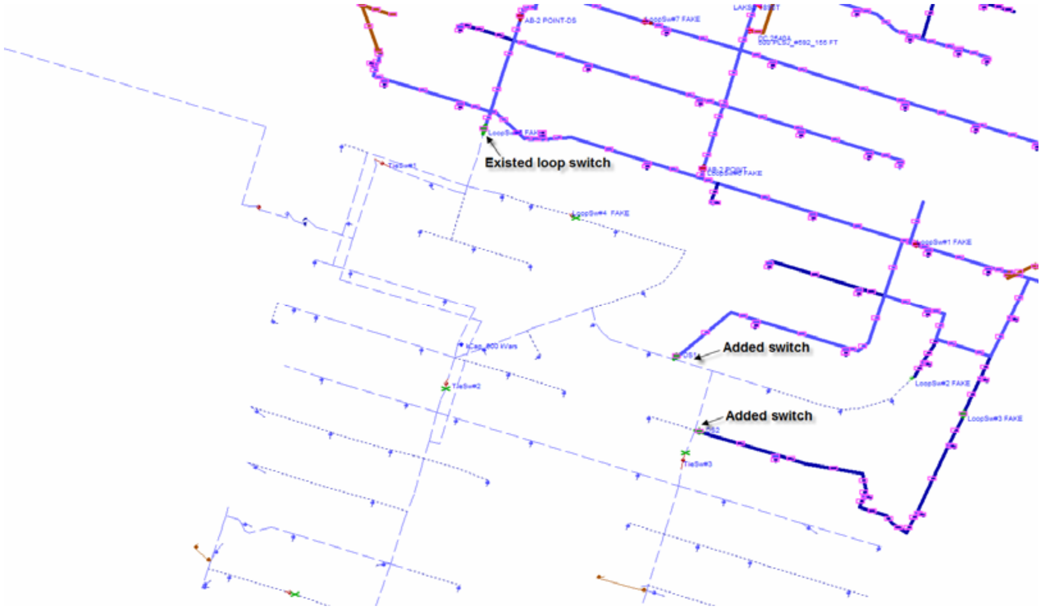


FIGURE 17 Location of opened switches of reconfiguration without DG at August, Tuesday 3 AM

TABLE 8 Results without DG at August, Tuesday 1 PM

	Base Case		Fail Case	
LAKSD2540A:	KVAB_LAKSD	4565.79	KVAF_LAKSD	Failed
SHORS1770:	KVAB_SHORS	3927.79	KVAF_SHORS	3927.79
DG:	KVAB_DG	0	KVAF_DG	0
Amount to new load picked up	0			
Percentage of load picked up	0 %			

TABLE 9 Results without DG at August, Tuesday 9 PM

	Base Case	
LAKSD2540A:	KVAB_LAKSD	4565.79
SHORS1770:	KVAB_SHORS	*3737.07*
DG:	KVAB_DG	0
Amount to new load picked up	0	
Percentage of load picked up	0 %	

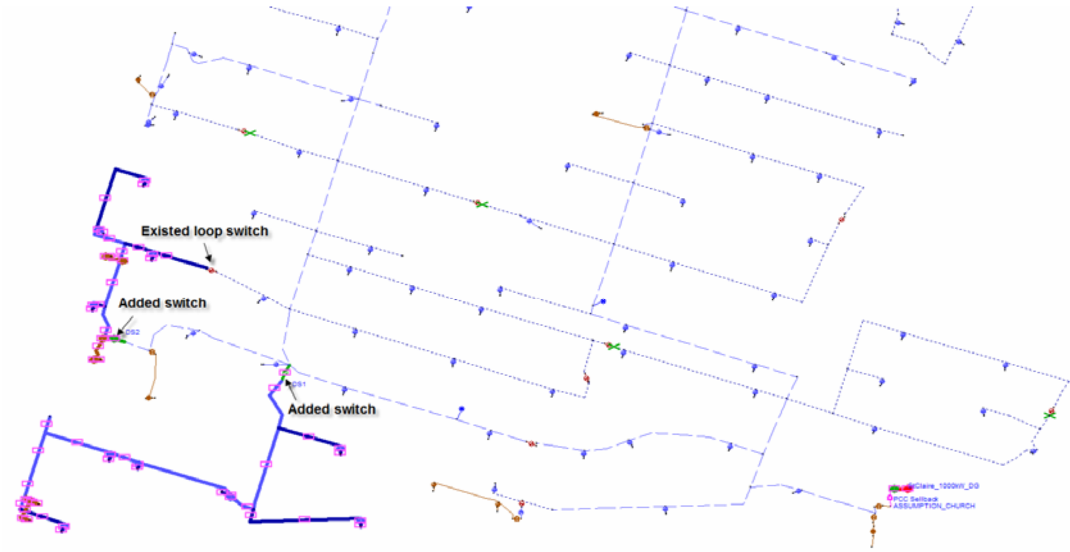


FIGURE 18 Location of opened switches of reconfiguration without DG at August, Tuesday 9 PM

As a result, eight cases have been considered, that is, the network reconfigurations without DG/with DG at four different time points. From the results listed in Table 10, it can be seen that DG can enable load transfers to the adjacent circuit in case that outages occur.

TABLE 10 Comparisons of percentages of load pickup at different load time points

Time Point	Percentage of load pickup with DG (%)	Percentage of load pickup without DG (%)	Difference
Oct. Tues. 3 AM	68.0	40.7	27.3
Aug. Tues. 3 AM	42.6	21.1	21.5
Aug. Tues. 1 PM	26.3	0.0	26.3
Aug. Tues. 9 PM	12.9	0.0	12.9

Appendix F

Standard Work Instruction
Detroit Edison DR as Demand Response in the MISO Energy Market

1.0 PRELIMINARY INFORMATION

1.1 Description: The purpose of this Standard Work Instruction is to provide guidance on how Detroit Edison's distributed resources are offered as Demand Response into the MISO energy market. This will include who is responsible for each step of the process and details of each step as they apply to those responsible.

1.2 Personal Protection Equipment: None

1.3 Special Tools Required: nMarket, Itron EEM-Suite, PI-ProcessBook

1.4 Special Parts Required: None

1.5 Prerequisites: Distributed generation is owned by Detroit Edison and registered with MISO for inclusion in the Day-Ahead and Real-Time energy markets.

1.6 Job Aids:

1.7 Cross References: None

1.8 Attachments: None

1.9 Definitions:

CP-Node: A Commercial Pricing Node (CP-Node) is an entity defined by MISO through which most market activities are tracked. Generation is associated with a CP-Node, loads are associated with a CP-Node, settlement metering takes place at the CP-Node level, and locational pricing is determined at the CP-Node level.
DEM: The Distributed Energy Manager (DEM) is a module within the DR-SOC's EEM-Suite that allows an operator to control remote distributed energy resources electronically over the Internet.

DR-SOC: Distributed Resources- System Operations Center, formerly the DTECH SOC, is the central location from which Detroit Edison DR are monitored and controlled. Communications exist between the DR-SOC, the MOC, and the Detroit Edison SOC systems by way of ICCP and XML Web Services, which allow the DR to be aggregated and sold into the MISO energy markets.

EEM-Suite: The Itron EEM-Suite is the energy management system that runs at the DR-SOC. EEM-Suite provides operator and customer web-interfaces, data gateways, and databases to provide an overall solution for monitoring and controlling DR and other energy-related equipment over the Internet.

ICCP: The Inter-Control Center Communication Protocol (ICCP) provides a robust method of transmitting data points in real-time between data centers over computer networks, such as the Internet.

nMarket: nMarket is a software package at the Detroit Edison Merchant Operation Center (MOC) which provides an electronic interface to MISO.
PI-ProcessBook: The PI-ProcessBook software package allows creation of visual interfaces to any PI database. Detroit Edison utilizes PI-ProcessBook to provide an operator interface to distributed resources for monitoring and control.
VPN: A Virtual Private Network (VPN) is a private data network that makes use of the public Internet, maintaining privacy through the use of a tunneling protocol and security procedures.

2.0 WORK INSTRUCTION

Major Tasks

- **2.1 Generate Day-Ahead and Real-Time Energy Offers**

Duration: N/A (Computer Automated Task)

Responsible Parties: DR-SOC

Description:

DR-SOC: The DR-SOC generates an energy offer for each Commercial-Pricing Node that is registered with MISO for the Day-Ahead and Real-Time markets. This occurs daily at 10:00 AM and is automated by software at the DR-SOC. Each CP Node’s offer is generated as a pair of XML files. One file contains the Day-Ahead offer, the other the Real-Time offer. The offers for each market are identical. Additionally, Day-Ahead and Real-Time operational-parameters XML files are generated that set the “commit status” for each node as “Economic”. The CP-Node offers are also stored to the DTechApps.dbo.DoEEnergyOffer table in the DR-SOC database.

- **2.2 Submitting Energy Offer to MISO**

Duration: N/A (Computer Automated Task)

Responsible Parties: DR-SOC, MOC

Description:

DR-SOC: The DR-SOC submits the Day-Ahead and Real-Time operational-parameters and offers to MISO by way of MOC each day at 10:30 AM. Communication with MOC occurs over a secure Virtual Private Network (VPN) that was set up by Detroit Edison’s Information Protection Group. To submit the offer, the DR-SOC posts the four XML files (two operational-parameters and two energy offers) to the production nMarket server at MOC using the “Import” servlet (*http://<server>:<port>/servlet/Import*). No human intervention is required under normal conditions.

MOC: The MOC receives the daily operational parameters and energy offers daily from the DR-SOC through nMarket. MOC then automatically passes the offers on to MISO electronically for consideration in the Day-Ahead and Real-Time markets before the 11:00 AM deadline. No human intervention is required under normal conditions.

- **2.3 Receiving Acceptance/Awards from MISO**

Duration: N/A (Computer Automated Task)

Responsible Parties: DR-SOC, MOC

Description:

DR-SOC: The DR-SOC receives the Day-Ahead awards from MISO by way of MOC each day at 6:00 PM, after MISO has cleared the Day-Ahead market at 5:00 PM. As with the energy offer submission (section 2.2) Communication with MOC occurs over a secure Virtual Private Network (VPN) that was set up by Detroit Edison’s Information Protection Group. To receive the Day-Ahead awards information, the DR-SOC posts an XML request to the production nMarket server at MOC using the “OutboundAPI” servlet (*http://<server>:<port>/servlet/OutboundAPI*). The nMarket server then responds with an XML file containing the awards for the time period specified in the request. The time period consists of the 24 hours starting at midnight. Once the DR-SOC receives the awards XML, it parses the results and stores the information to its database (DR-SOC DTechApps.dbo.DoEUnitRun table). No human intervention is required under normal conditions.

MOC: The MOC receives the daily request for Day-Ahead awards from the DR-SOC through nMarket. MOC then automatically responds with the requested awards information electronically. This information is stored in its databases. No human intervention is required under normal conditions.

- **2.4 Providing Settlement Data to MISO**

Duration: N/A (Computer Automated Task)

Responsible Parties: DR-SOC, MOC

Description:

DR-SOC: Day-Ahead settlement meter data is provided to MOC by the DR-SOC, to inform MISO as to the actual operation of the DR according to what has been accepted into the Day-Ahead market during the previous day. The DR-SOC generates an XML file containing the meter data for each CP-Node for the entire previous day and sends it to MISO by way of MOC at 12:00 PM each day. As with the energy offer submission (section 2.2), Communication with MOC occurs over a secure Virtual Private Network (VPN) that was set up by Detroit Edison's Information Protection Group. To submit the settlement meter data, the DR-SOC posts a single XML file containing the data for all CP-Nodes to the production nMarket server at MOC using the "Import" servlet (*http://<server>:<port>/servlet/Import*). No human intervention is required under normal conditions. Real-time meter data is sent in real-time over the ICCP link that exists between the DR-SOC and MOC.

MOC: The MOC receives the daily Day-Ahead settlement meter data daily from the DR-SOC through nMarket. MOC then automatically passes the settlement data on to MISO electronically for use in its financial settlements. No human intervention is required under normal conditions.

- **2.5 Notifying MISO of DR Outages**

Duration: 25 Minutes

Responsible Parties: DR-SOC, DECo SOC, MOC

Description:

DR-SOC: MISO must be notified if a committed DR has become unavailable for some reason and therefore unable to meet its Demand Response obligations. The DR-SOC monitors each distributed resource and is responsible for notifying MISO of an outage by way of MOC. The DR-SOC notifies MOC immediately when they become aware of an outage.

MOC: MOC is responsible, as the Market Participant, for notifying the MISO outage scheduler, by telephone, of any issue that will prevent the committed unit(s) from running. MOC is notified by the DR-SOC of any such outages.

DECo-SOC: In the case that the Detroit Edison SOC is shutting down a circuit or doing any other work that prevents a committed DR from running, they must notify the DR-SOC who then notifies MISO by way of MOC.

2.6 Handling Real-Time Dispatch Notifications from MISO

Duration: N/A (Computer Automated Task)

Responsible Parties: DR-SOC, MOC

Description:

DR-SOC: MISO sends the DR-SOC real-time dispatch notifications directly by posting them to a server at the DR-SOC. This server has a public URL (*http://smtpgw.energy-now.com/misoxml/*) that MISO uses to post the dispatch notifications in XML format. The DR-SOC parses the XML file and dispatches the DR according to MISO's direction. No human intervention is required under normal conditions.

- **2.7 Emergency Control from Detroit Edison SOC**

Duration: 15 minutes

Responsible Parties: DR-SOC, DECo SOC

Description:

DR-SOC: The DR-SOC responds to control messages from the Detroit Edison SOC that are passed by ICCP from one operations center to the other. The Detroit Edison SOC will notify the DR-SOC by phone that a DR site is to be controlled. The DR-SOC operator will then take the DR site in question out of "aggregated control mode", the mode used to offer DR into the energy market. When control messages are received over ICCP, the DR-SOC automatically generates a control command, which is issued to the affected DR.

Detroit Edison SOC: The Detroit Edison SOC has the capability to control the DR through the DR-SOC. The SOC operator first notifies the DR-SOC then uses a PI-ProcessBook interface to initiate control of the DR. The PI system is connected to an ICCP link between the DeCo SOC and the DR-SOC, over which the control messages are passed.

- **2.8 Notifying Customers of MISO Scheduled DR Operation**

Duration: N/A

Responsible Parties: DR-SOC

Description:

DR-SOC: The DR-SOC automatically generates a daily email report at 7:00 PM that specifies which DR are scheduled to run each hour of the following day starting at midnight. This email is sent to Thac Nguyen for all Premium Power sites, Rod Knudsen for the Hydrogen Power Park, and the DR-SOC operator for all remaining Detroit Edison sites. If any of the customers does not want their DR to run as scheduled, they must notify the DR-SOC immediately. The DR-SOC will then treat the DR as if it has experienced an outage during the period of time that the customer does not want it to run, and follow the steps under the *2.5 Notify MISO of DR Outages* major task.

- **2.9 Notifying DR-SOC of MISO Dispatch Instructions**

Duration: N/A

Responsible Parties: MOC, DR-SOC

Description:

MOC: The MOC will receive dispatch instructions from MISO according to what the DR-SOC has offered and what has cleared in the Day-Ahead market. MOC will contact the DR-SOC operator to relay these dispatch instructions.

DR-SOC: The SOC operator must log the dispatch instructions in the SOC Operator Log for each DR-Site that has been cleared into the Day-Ahead market. These instructions will be compared to the Market Results that have been received automatically from nMarket. If they do not match, the operator will notify DR-SOC engineering.

2.1 Generate Day-Ahead and Real-Time Energy Offers

2.1.1 No human intervention required; computer automated. Contact the DR-SOC in case of failure: (248) 427-2352

2.2 Submitting Energy Offer to MISO

2.2.1 No human intervention required; computer automated. Contact the DR-SOC in case of failure: (248) 427-2352

2.3 Receiving Acceptance/Awards from MISO

2.3.1 No human intervention required; computer automated. Contact the DR-SOC in case of failure: (248) 427-2352

2.4 Providing Settlement Data to MISO

2.4.1 No human intervention required; computer automated. Contact the DR-SOC in case of failure: (248) 427-2352

2.5 Notifying MISO of DR Outages

2.5.1 DECo SOC: If a circuit shutdown or other incident is planned that will prevent any of the Detroit Edison DR from operating normally, the SOC operator will notify the DR-SOC by phone at (248) 427-2352.

2.5.2 DR-SOC: Mark outage in the DR-SOC operator site log.

2.5.3 DR-SOC: Look up the aggregate zone (CP-node) to which the DR belongs (ex. DECO.SOFLD3)

2.5.4 DR-SOC: Call the MOC Senior Controller desk at 723-887-4156 to indicate that the capacity of the DR in question will be unavailable in the aggregate zone (CP-Node) to which it belongs.

2.5.5 MOC: Make the appropriate entry in the MISO Outage Scheduler according to the information provided by the DR-SOC.

2.6 Handling Real-Time Dispatch Notifications from MISO

2.6.1 No human intervention required; computer automated. Contact the DR-SOC in case of failure: (248) 427-2352

2.7 Emergency Control from Detroit Edison SOC

2.7.1 DECo SOC: For ***Distribution Solutions Sell back units*** DECo SOC/ROC will contact DR SOC of their need to control if time permits. If time does not permit DECo SOC/ROC will use their EMS Emergency Control to stop the generator then contact DR SOC. For ***Premium Power Installations*** DECo SOC/ROC will first contact Marketing (Thac Nguyen, 313-235-7847) then contact DR SOC to outage the unit or grant DECo control.

2.7.2 DR-SOC: Receive call from DECo SOC

2.7.3 DR-SOC: Update the DR-SOC operator site log, with an entry describing which DR is going to be controlled.

2.7.4 DR-SOC: Log into the EEM-Suite. Use the DEM Configuration module to change the Optimal Control Mode from “Aggregate DTA Enabled” to “Disabled”.

2.7.5 DR-SOC: Use the DEM Control module to issue a Flush command to the site.

2.7.6 DR-SOC: Verify control from DECo SOC using Enterprise Navigator display.

2.8 Notifying Customers of MISO Scheduled DR Operation

2.8.1 DR-SOC: Receive daily DR Operation Schedule email at approximately 7:00 PM and review it for any Detroit Edison sites that may have been scheduled that should not run.

2.8.2 DR-SOC: If there is a problem in the email report or another customer calls with a problem with the email report such that some DR is scheduled to be dispatched or shutdown at an inopportune time, make note of the problem in the SOC operator log.

2.8.3 DR-SOC: After marking the email report problem in the log, follow the steps in section *2.5 Notifying MISO of DR Outages* to inform the MOC and MISO that the scheduled operation of the unit will not occur.

2.8.4 DR-SOC: When the time-period during which scheduled operation is to be cancelled arrives, use the EEM-Suite Dem Configuration module to change the Optimal Control Mode of the DR-site in question from “Aggregate DTA Enabled” to “Disabled”, use the DEM Control module to issue a Flush command to the site, and mark this change in the SOC operator log.

2.9 Notifying DR-SOC of MISO Dispatch Instructions

2.9.1 MOC: When new dispatch instructions are received, notify the DR-SOC operator by phone at (248) 427-2352. If the notification is after hours, leave a message and the DR-SOC operator will be paged.

2.9.2 DR-SOC: Note the dispatch instructions in the appropriate SOC Operator Log. Compare the dispatch instructions with the market result information that is sent in the daily email notification. If there is any discrepancy, immediately notify one of the DR-SOC engineers (Jerry Vermeulen or Andy Guibert de Bruet) of the problem so that they can investigate.

END OF WORK INSTRUCTION

3.0 ADMINISTRATIVE INFORMATION

3.1 Procedure Number: 10 – 000 – 000 – 0010

3.2 Title: Detroit Edison DR as Demand Response in the MISO Energy Market

3.3 Revision Number: 1.0

3.4 Responsible Section Head: Haukur Asgeirsson, Supervisor DR Planning

3.5 DTE Energy Author: Cameron Sherding, Rich Seguin

3.6 Creator Name: Cameron Sherding

3.7 Effective Date: 5/18/06

3.8 Revision History (brief description of changes since last version):

Date	Revision	Description of Changes/Pages affected	Author
5/3/06	0.01	All pages affected. Original draft containing DR-SOC tasks and information.	Cameron Sherding
5/4/06	0.02	All pages affected. Updated draft with comments from Andre Guibert de Bruet.	Cameron Sherding
5/5/06	0.03	Pages 1, 4, 6 affected. Updated draft with comments from Jerry Vermeulen	Cameron Sherding
5/10/06	0.04	Pages 5, 6, 7 affected. Made changes to major task 2.5 (Notifying MISO of DR Outages). Added new major task 2.8 (Notifying	Cameron Sherding
5/15/06	0.05	Pages 7, 8 affected. Made changes to 2.5.1 by removing note and 2.7.1 by adding emergency contact procedures	Richard Seguin
5/16/06	0.06	Pages 5, 7 affected. Added MOC information to task 2.5 steps per Greg Ostrowski.	Cameron Sherding
5/18/06	1.0	Pages 6, 9, 10 affected. Added task 2.9, per meeting with Jeff DePriest, Greg Ostrowski, and Anand Jayanthi which specifies procedure for MOC to notify DR-SOC operators of MISO dispatch instructions.	Cameron Sherding

3.9 Periodic Review Due: Once a year (1^{st} Review 3/31/07)

3.10 Impacted Business Units: DR-SOC, Detroit Edison MOC, and SOC

3.11 Retain Document Until: To be determined.