PJM Generator Interconnection R74 Carlls Corner 4.8 MW Feasibility / Impact Study

September 2007

Docs # 438655

General

Queue R74 is a PPL Shoreham Energy, LLC (PPL Energy) request to interconnect a 4.8 MW Capacity Resource at the Cumberland County Improvement Authority (CCIA) Landfill consisting of three 1.6 MW landfill gas-fueled reciprocating engine-generators. The R74 interconnection facilities are located on CCIA (Cumberland County Improvement Authority) property at 169 Jesse Bridge Road, Deerfield Township, New Jersey. PPL Energy's schedule for commercial operation is 1st or 2rd Quarter 2008.

Direct Connection Requirements

Primary Metering

A new revenue quality meter will be installed at the Point of Interconnection. This will be a new retail billing location for the Cumberland County Improvement Authority (CCIA) and the official measurement of megawatt hours (MWH) and megavar hours (MVARH) received into and delivered by the Atlantic City Electric Company (Atlantic) System by the net generation and load behind this meter. Interconnection Customer will be required to provide a phone line within close proximity (approximately three feet) of the revenue meter to enable Atlantic to remotely interrogate the meter. Metering will conform with the requirements of Atlantic's "Technical Considerations Covering Parallel Operations of Customer Owned Generation of One Megawatt or Greater and Interconnected with the Conectiv Power Delivery System" and in accordance with PJM Manuals M-01 and M-14D. The Atlantic work scope will include providing, installing and owning the meter.

Interconnection Customer has the option to provide, own, install, operate and maintain the Primary Metering, instead of Atlantic. In such case, the Revenue Metering must meet Atlantic and PJM technical standards listed above, provide for dial-up data access by Atlantic and be subject to audit per the PJM Tariff. The values for hourly megawatt hours sent as e-Meter to PJM by the Interconnection Customer must, within accepted tolerance, match the values measured by the Revenue Metering.

Generator Metering

A separate revenue quality meter will be required on the output of each generator to measure the sum of the output of the generators if the Interconnection Customer desires to enter into a Standby Agreement with Atlantic. If the Interconnection Customer will not enter into a Standby agreement with Atlantic, then a generator revenue meter will not be required.

If the Interconnection Customer enters into a Standby Agreement, then the Atlantic work scope would include: procuring Atlantic-owned "Generator Revenue" meter, performing final connections between Atlantic meter at metering enclosure, and metering instrument transformers, as well as programming and testing of Atlantic-owned meter. The Interconnection Customer work scope would include: procuring and installing instrument transformers (per Atlantic specifications), procuring and installing Interconnection Customer meter instruments

and pulling Atlantic supplied control cable between the instrument transformers and the Atlantic-owned "Generator Revenue" meter. Interconnection Customer will be required to provide a phone line within close proximity (approximately three feet) of the revenue meter to enable Atlantic to remotely interrogate the meter. (One line could service both the primary and generator meter if all are in reasonably close proximity, otherwise another phone line will be necessary). Option - If the Interconnection Customer requires the same generator meter data, the metering system could utilize dual winding instrument transformers with one output going to Atlantic and the other output going to the Interconnection Customer. This option would be less costly if elected before construction because it would eliminate one set of metering instrument transformers that would be purchased by the Interconnection Customer.

Telemetry Requirements

Atlantic will require real-time telemetry from the Point of Interconnection and from generator output to be sent to Atlantic's City Electric's Energy Control Center at NCRO in Newark, Delaware. The specific telemetry data points required for Point of Interconnection (site billing/revenue meter) are: MW, MVAR, MWH, MVARH, interconnection bus voltage and amp flow. The required telemetry data points for the generator(s) are: MW, MVAR, MWH, MVARH, generator bus voltage and generator breaker open/closed status (can be for the sum of all 3 generators). The PJM modular RTU is acceptable for sending Atlantic-required telemetry data to Atlantic via the internet. In this case, the telemetry data points described above will need to be sent to PJM via the modular RTU so Atlantic can retrieve them from PJM. If the data is not sent to PJM, then a data line, furnished by the Interconnection Customer, will need to be used to send this data to Atlantic. These telemetry data point requirements are outlined in Atlantic's "Technical Considerations Covering Parallel Operations of Customer Owned Generation of One Megawatt or Greater and Interconnected with the Conectiv Power Delivery System."

The MWH and MVARH values that are telemetered to Atlantic must originate from the Primary Meter and Generator Meter(s) (if applicable) described above.

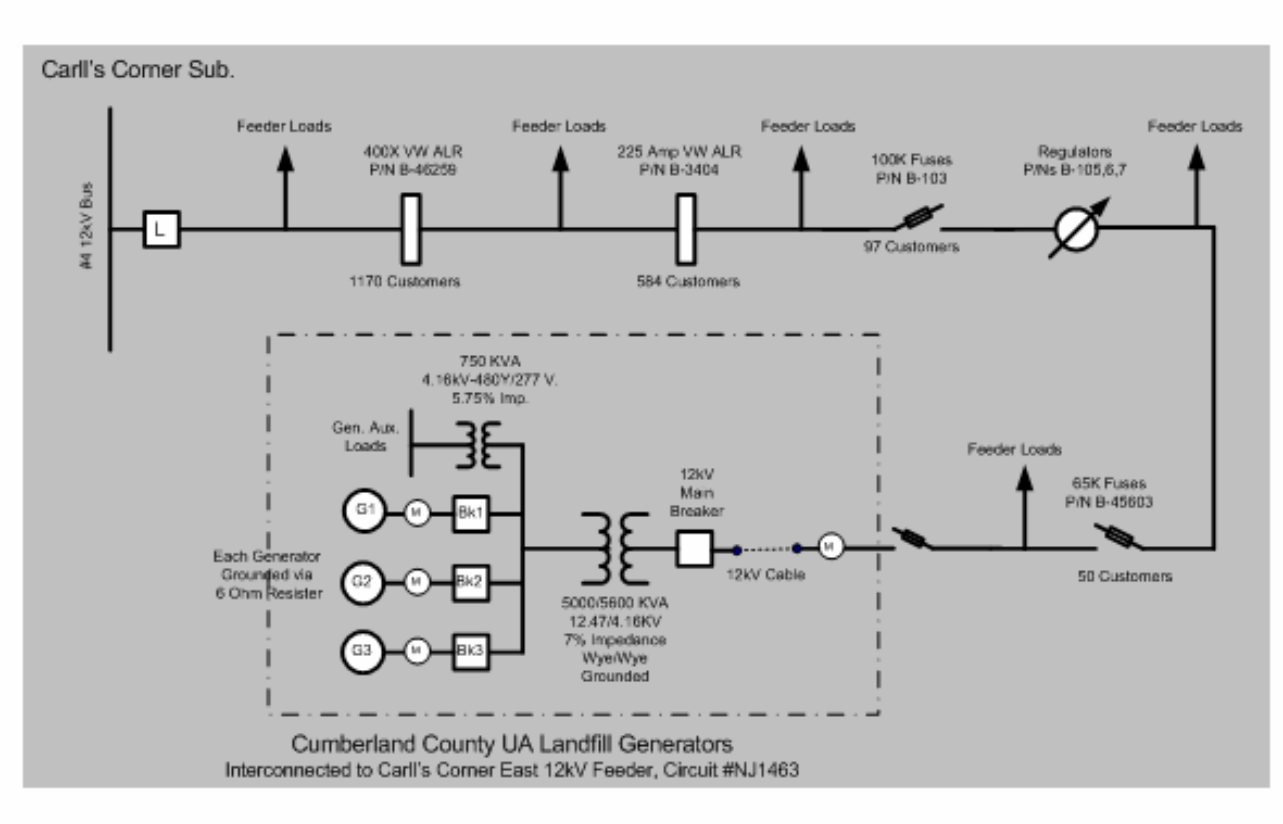
Atlantic has included the cost of providing (2) analog and (2) pulse outputs from the Primary and Generator Revenue Meters for this purpose. The pulse outputs shall be used as the source of the MWH and MVARH telemetry. The analog outputs may be used for the instantaneous MW and MVAR telemetry, at the option of the Interconnection Customer. Atlantic will terminate the telecommunications wiring at the meter end. The telecommunication wiring and the PJM modular RTU device, if utilized, will be provided and installed by the Interconnection Customer.

Reactive Requirements

The Interconnection Customer shall design its Customer Facility with the ability to maintain a power factor of at least 0.95 leading to 0.90 lagging measured at the Point of Interconnection, consistent with the PJM Tariff requirements.

Feeder Circuit Interconnection Configuration

The proposed generators will be connected to the Carll's Corner Substation, East 12kV Feeder, Circuit #NJ1463. There are existing 65K Amp fuses, 100K Amps fuses, a 225 Amp VW Automatic Line Recloser (ALR) and a 400X Amp VW Automatic Line Recloser between Carll's Corner Substation and the proposed generator interconnection site. A sketch showing the main elements of the distribution feeder circuit up to the generator site is provided below.



Short Circuit Review

The Carll's Corner East 12kV Feeder circuit and the proposed interconnected generators were modeled to evaluate the impact on feeder short circuit currents. The System Protection ASPEN Short Circuit Program was used to calculate short circuit values. Feeder data was taken from the East 12kV Feeder CYMEDIST model and assumes that existing conductor types will remain.

A comparison of existing fault values and the resulting short circuit currents with the proposed generators in service is provided in the tables below. The two Carll's Corner Substation Combustion Turbines are on line. All system conditions are "Normal".

3-Phase Faults

Location	No Generation	One Generator	Two Generators	Three Generators	Maximum Increase
Carll's Corner 69kV Bus	11540 Amps	11601 Amps	11623 Amps	11633 Amps	0.806 %
Carll's Corner 12kV Bus	9629 Amps	9964 Amps	10077 Amps	10130 Amps	5.203 %
400 X ALR P/N B-46259	2910 Amps	3281 Amps	3432 Amps	3508 Amps	20.550 %
225 A ALR P/N B-3404	1860 Amps	2261 Amps	2443 Amps	2540 Amps	36.559 %
100 K Fuses P/N B-103	1538 Amps	1957 Amps	2165 Amps	2278 Amps	48.114 %
65 K Fuses P/N B-45603	1268 Amps	1701 Amps	1954 Amps	2109 Amps	66.325 %
CC IA 12kV Bus	816 Amps	1246 Amps	1587 Amps	1852 Amps	126.961 %
CC IA 4.16kV Bus	2095 Amps	3798 Amps	5599 Amps	7425 Amps	254.415 %

1L-G Faults

Location	No Generation	One Generator	Two Generators	Three Generators	Maximum Increase
Carll's Corner 69kV Bus	11709 Amps	11752 Amps	11766 Amps	11774 Amps	0.555 %
Carll's Corner 12kV Bus	10152 Amps	10399 Amps	10486 Amps	10529 Amps	3.714 %
400 X ALR P/N B-46259	1944 Amps	2062 Amps	2120 Amps	2163 Amps	11.265 %
225 A ALR P/N B-3404	1176 Amps	1288 Amps	1349 Amps	1395 Amps	18.622 %
100 K Fuses P/N B-103	959 Amps	1070 Amps	1134 Amps	1183 Amps	23.358 %
65 K Fuses P/N B-45603	804 Amps	920 Amps	994 Amps	1054 Amps	31.095 %
CC IA 12kV Bus	539 Amps	658 Amps	755 Amps	845 Amps	56.772 %
CC IA 4.16kV Bus	1457 Amps	1924 Amps	2306 Amps	2656 Amps	82.292 %

The relatively small size of the generators and their interconnection near the end of the feeder circuit limits the short circuit impact to those locations nearer the generators. There is little impact to faults near Carll's Corner Substation. There is negligible impact on the area 69kV system. The resistance grounding of the generators limits the increase in 1L-G faults. Even the larger fault current increases near the generator site are still well within equipment ratings.

In summary, there is minimal impact on area total short circuit currents and no ACE breakers or other equipment appears to be over stressed as a result of this generator interconnection.

Feeder Circuit Intermediate Fuse Concerns

Unbalance Conditions

There are existing 65K Amp fuses at P/N B-45603 and 100K Amp fuses at P/N B-103 between Carll's Corner Substation and the proposed generator interconnection site. The protection on the three CC IA generators will have to detect and disconnect the generators for all utility circuit faults that cause one or more of these fuses to open. An open fuse will leave the downstream generators single-phased. Sustained generator operation under this condition would damage the generators. The proposed generator multi-function relay (Basler BE1-GPS100 or GE SR489) includes an unbalance detection negative sequence current (46) element to detect single phasing which should provide some degree of protection for this condition.

Fuse Loading

The three generators are each rated 1600 kW or 1778 KVA @ 0.9 PF. The total output is therefore 4800 kW, 5334 KVA or 237 Amps at 12kV. This value of current exceeds the rating of the 65K Amp fuses and the 100K Amp fuses. There are 50 customers beyond the 65K Amp fuses plus 47 more customers beyond the 100K Amp fuses. These customers will help offset some of the generator output so that the actual load through the fuses would be somewhat less than the above value. However, it appears that the existing fuses cannot support the generator output.

Elimination of circuit protection at these fuse locations is possible only if an upstream Automatic Line Recloser can adequately detect all downstream circuit faults. The existing 225 Amp VW ALR at P/N B-3404 cannot provide reliable protection for all downstream faults, particularly 1L-G faults. There are 584 customers beyond this existing 225 Amp VW ALR. In addition to the fault sensitivity issue, the District Engineer may have concerns with exposing all these customers to an interruption for faults beyond the existing 100K Amp fuse location.

In conclusion, it appears that the existing 65K Amp and 100K Amp circuit fusing must be replaced to accommodate the generation interconnection. The following circuit protection changes are recommended:

1. Replace the existing 100K Amp fuses at P/N B-103 with an electronic Automatic Line Recloser with a SEL-351R controller. The electronic recloser will have separate settings for the phase and ground elements which will allow improved sensitivity for downstream 1L-G faults. The phase units will have to be set high enough to accommodate the net generator output through this point. A recloser at this location will also retain the feeder section isolation presently provided by the 100K Amp fuses.
2. Eliminate the existing 65K Amp fuses at P/N B-45603. The proposed upstream electronic Automatic Line Recloser at P/N B-103 should be able to adequately detect circuit faults beyond the 65K Amp fuse location. There are only 47 customers between the 65K Amp fuse location and the proposed upstream Automatic Line Recloser at P/N B-103. The elimination of the 65K Amp fuses should have minimal impact on the service reliability to these intermediate 47 customers. (The District Engineer may want to comment on this proposal.)

Islanding Detection

Background

In the event of source circuit loss, the generators must not continue to operate in an island condition with other Atlantic City Electric load. In addition, the generators must be disconnected before any auto reclose on the ACE source circuit. Local protection at the generator site must detect islanding and disconnect the generator. Frequency and voltage sensing is generally used to detect islanding in addition to being used for fault detection and to prevent abnormal generator operation outside allowable ranges. Trip values and operating times for voltage and frequency protection are outlined in IEEE Standard 1547, *IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems*. The generator protection must sense these quantities at the Point of Interconnection (POI) and disconnect the generator within the times shown below.

Voltage Setting	Clearing Time	Frequency Setting	Clearing Time
V<50%	0.16 sec.	>60.5 Hz	0.16 sec.
50%<V<88%	2.0 sec.	<57.0 Hz	0.16 sec.
110%<V<120%	1.0 sec.	Adjustable Setting: < 59.8-57 HZ	0.16 – 300 sec.
V>120%	0.16 sec.	(Specific setting to be determined later)	

To utilize frequency and voltage protection to detect islanding, the voltage and/or frequency must decline to the required setting range and within the necessary clearing time. For this to occur, a certain amount of generation to load mismatch is required. The IEEE 1547 Standard (Section 4.4, "Islanding" & "Footnote 12") require that the generator capacity be less than one third of the minimum load in the local electric power system. This criteria was used to evaluate the generator isolation cases detailed below.

Trip of the Proposed New Electronic ALR at P/N B-103 (Existing 100K Amp Fuse Location)

A trip of this proposed ALR will leave the proposed generators islanded with approximately 97 other ACE customers. The Carll's Corner East 12kV Feeder has a total customer count of 1953. Assuming an equal load distribution among all customers, the load beyond the proposed ALR at P/N B-103 should represent 100(97)/1953 = 4.97% of the total feeder load. The East 12kV Feeder load forecast for year 2007 is 11.5 MVA. Therefore, the load beyond the proposed ALR at P/N B-103 should be approximately 0.0497(11500) = 571.55 KVA.

The CC IA generator output will vary from 1778 KVA with one unit in operation up to 5443 KVA with all three units in operation. The generator output capability far exceeds the load that is isolated with the generators when the proposed new ALR at P/N B-103 opens. It will not be possible to detect generator islanding via the local generator frequency and voltage relays. The generators will not trip and the ALR could auto reclose into an out of synch condition. It is therefore required that transfer trip be installed between the proposed ALR location at P/N B-103 and the CC IA generators. The ALR controller will be programmed to send transfer trip to

the generators and permit an auto reclose only after confirmation has been received that the CC IA generators have tripped.

Trip of the Existing 225 Amp VW ALR at P/N B-3404

A trip of this existing ALR will leave the proposed generators islanded with approximately 584 other ACE customers. The Carll's Corner East 12kV Feeder has a total customer count of 1953. Assuming an equal load distribution among all customers, the load beyond the existing ALR at P/N B-3404 should represent 100(584)/1953 = 29.90% of the total feeder load. The East 12kV Feeder load forecast for year 2007 is 11.5 MVA. Therefore, the load beyond the existing ALR at P/N B-3404 should be approximately 0.2990(11500) = 3438.8 KVA.

The CC IA generator output will vary from 1778 KVA with one unit in operation, to 3556 KVA with two units in operation and up to 5443 KVA with all three units in operation. The generator output capability will exceed the load that is isolated with the generators when the existing ALR at P/N B-3404 opens and two or more generators are in operation. Again, it will not be possible to detect generator islanding via the local generator frequency and voltage relays. The generators will not trip and the ALR could auto reclose into an out of synch condition. It is therefore required that the existing 225 Amp VW ALR be replaced with an electronic ALR with a SEL-351R controller. In addition, transfer trip will need to be installed between the ALR location at P/N B-3404 and the CC IA generators. The ALR controller will be programmed to send transfer trip to the generators and permit an auto reclose only after confirmation has been received that the CC IA generators have tripped.

Trip of the Existing 400X VW ALR at P/N B-46259

A trip of this existing ALR will leave the proposed generators islanded with approximately 1170 other ACE customers. The Carll's Corner East 12kV Feeder has a total customer count of 1953. Assuming an equal load distribution among all customers, the load beyond the existing ALR at P/N B-46259 should represent 100(1170)/1953 = 59.91% of the total feeder load. The East 12kV Feeder load forecast for year 2007 is 11.5 MVA. Therefore, the load beyond the existing ALR at P/N B-46259 should be approximately 0.5991(11500) = 6889.6 KVA.

The CC IA generator output will vary from 1778 KVA with one unit in operation up to 5443 KVA with all three units in operation. At peak load, the generation capacity is exceeded even with all three generators in operation. However, the 3 to 1 load to generation ratio required in IEEE 1547 is not satisfied. In addition, the load to generation ratio will farther erode under non-peak load conditions. It is not possible to insure that generator islanding will be detected by the local generator frequency and voltage relays. The generators most likely will not trip and the ALR could auto reclose into an out of synch condition. It is therefore required that the existing 400X Amp VW ALR be replaced with an electronic ALR with a SEL-351R controller. In addition, transfer trip will need to be installed between the ALR location at P/N B-46259 and the CC IA generators. The ALR controller will be programmed to send transfer trip to the generators and permit an auto reclose only after confirmation has been received that the CC IA generators have tripped.

Trip of the East 12kV Feeder Breaker " L" at Carll's Corner Substation

A trip of the East 12kV Feeder Breaker "L" will leave the proposed generators islanded with the entire East 12kV Feeder load. The East 12kV Feeder load forecast for year 2007 is 11.5 MVA. At peak load level and assuming all three generators are operating, the load to generation ratio will be 11.5/5.443 = 2.11/1. This ratio is less than the 3 to 1 load to generation ratio required in IEEE 1547. The load to generation ratio will farther erode under non-peak load conditions. It is not possible to insure that generator islanding will be detected by the local generator frequency and voltage relays. The generators may not trip and the East 12kV Feeder breaker could auto reclose into an out of synch condition. The East 12kV Feeder breaker has a high speed reclose. It is therefore required that transfer trip be installed between Carll's Corner Substation and the CC IA generators. A SEL-351 relay will also need to be installed to replace the existing type IAC77 over current relays and the existing type ACR reclosing relay on the East 12kV Feeder terminal. The SEL-351 relay will be programmed to send transfer trip to the generators whenever the East 12kV Feeder breaker opens. The SEL-351 relay will also be programmed to permit an auto reclose only after confirmation has been received that the CC IA generators have tripped.

Trip of the Carll's Corner #4 69/12kV Transformer

A trip of the Carll's Corner #4 69/12kV Transformer will leave the proposed generators islanded with the entire load of the Carll's Corner East and South 12kV Feeders. (The protective relaying associated with the #4 Transformer does not presently trip the two 12kV feeder breakers.) The year 2007 forecast load is 11.5 MVA for the East 12kV Feeder and 13.3 MVA for the South 12kV Feeder or 24.8 MVA total. At peak load level and assuming all three generators are operating, the load to generation ratio will be 24.8/5.443 = 4.56/1. This ratio meets the 3 to 1 load to generation ratio required in IEEE 1547. However, the ratio will decrease under non-peak conditions Non-peak load is typically estimated by System Operations as being 40% of peak. Under non-peak conditions, the load to generation ratio will decrease to 0.40(24.8)/5.443 = 1.82/1. Under non-peak conditions, it is not possible to insure that generator islanding will be detected by the local generator frequency and voltage relays. The generation could remain on line supplying the East and South 12kV Feeder. The generator protection may be able to detect some fault conditions on the Carll's Corner #4 Transformer. However, the generation protection sensitivity is unknown and the generator protection will be unable to detect a ground on the transformer high side delta winding. Therefore, it is recommended that the protective schemes for the Carll's Corner #4 Transformer be modified to include tripping the East 12kV Feeder breaker. The tripping of the East 12kV Feeder breaker will, in turn, send transfer trip to the CC IA generators.

Trip of the Carll's Corner #2 69kV Bus

A trip of the Carll's Corner #2 69kV Bus will leave the proposed generators islanded with the entire load of the Carll's Corner East and South 12kV Feeders plus the load of the Carll's Corner #3 69/12k Transformer. (The protective relaying associated with the #2 69kV Bus does not presently trip the 12kV feeder breakers.) The combined total load is 47.7 MVA at 2007 peak.

The desired 3 to 1 load to generation ratio required in IEEE 1547 would probably be satisfied even under non-peak conditions. However, the CC IA generators could continue to energize a ground fault on the 69kV delta side of the Carll's Corner #4 Transformer. The resulting high over voltages could cause additional equipment damage. Therefore, it is recommended that the protective scheme for the Carll's Corner 69kV #2 Bus be modified to include tripping of the East 12kV Feeder breaker. The tripping of the East 12kV Feeder breaker will, in turn, send transfer trip to the CC IA generators.

Trip of the Carll's Corner-Laurel 69kV Line while the Carll's Corner-Sherman Ave. 69kV Line Is Out
Or
Trip of the Carll's Corner-Sherman Ave. 69kV Line while the Carll's Corner-Laurel 69kV Line Is Out

The preceding are single contingency conditions that could occur. Either of these two events could leave the proposed CC IA generators islanded with the entire Carll's Corner Substation load. The Carll's Corner Substation forecast load for year 2007 is 47.7 MVA. At peak load level and assuming all three generators are operating, the load to generation ratio will be 47.7/5.443 = 8.76/1. This ratio meets the 3 to 1 load to generation ratio required in IEEE 1547. The resulting ratio will decrease under non-peak conditions Non-peak load is typically estimated by System Operations as being 40% of peak. Under non-peak conditions, the load to generation ratio will decrease to 0.40(47.7)/5.443 = 3.51/1. This ratio still meets the IEEE 1547 requirement.

An unknown factor is the status of the local Carll's Corner combustion turbines. Simultaneous operation of the Carll's Corner combustion turbines would impact the preceding load to generation ratios. However, a scheme presently exists at Carll's Corner Substation which will trip the combustion turbines if both the Laurel and Sherman Ave. 69kV breakers are open. The tripping of the combustion turbines will restore the load to generation ratios that were calculated above. As long as the Carll's Corner combustion turbine GSU transformers are connected to the Carll's Corner 69kV Bus and provide a ground reference, no hazardous over voltages will occur. Therefore, it appears that no design modifications are needed for these two single contingency outages.

Since the preceding required transfer tripping schemes are critical for anti-islanding protection, the interconnection scheme at the CC IA generation site must be designed so that the generation is tripped if any transfer trip channel fails or if any transfer trip equipment fails.

Feeder Circuit Fault Detection

The generator must automatically and immediately disconnect in the event of fault conditions on the ACE source circuit. The IEEE 1547 document (Section 4.1.2, "Integration with Area EPS Grounding" and Section 4.2.1 "Area EPS Faults") requires that interconnected generators disconnect for utility source circuit faults and not cause over voltages.

Generator Impact on Upstream Fault Detection of East 12kV Feeder Faults

Faults at each upstream protective device were reviewed to determine the impact on existing and proposed circuit protection. For these cases, all three CC IA generators are on line and the Carll's Corner combustion turbines are not running. These fault cases are summarized in the following table.

East 12kV Feeder Circuit Faults

Fault Location	3-Phase Fault	1L-G Fault
Near CC IA 12kV Bus	1894 Amps Total	844 Amps Total
	811 Amps Via Carlls Corner	680 Amps Via Carlls Corner
	1149 Amps Via Generators	277 Amps Via Generators
Near Existing 65k Amp Fuses P/N B-45603	2098 Amps Total	1052 Amps Total
	1257 Amps Via Carlls Corner	926 Amps Via Carlls Corner
	841 Amps Via Generators	236 Amps Via Generators
Near Proposed New ALR (Existing 100k Amp Fuse Location At P/N B-103)	2063 Amps Total	1181 Amps Total
	1522 Amps Via Carlls Corner	1072 Amps Via Carlls Corner
	750 Amps Via Generators	224 Amps Via Generators
Near Proposed Electronic ALR (Existing 225 Amp VW ALR Location At P/N B-3404	2517 Amps Total	1391 Amps Total
	1837 Amps Via Carlls Corner	1286 Amps Via Carlls Corner
	631 Amps Via Generators	213 Amps Via Generators
Near Proposed Electronic ALR (Existing 400X Amp VW ALR Location At P/N B-46259	3453 Amps Total	2149 Amps Total
	2857 Amps Via Carlls Corner	2052 Amps Via Carlls Corner
	610 Amps Via Generators	191 Amps Via Generators
Faults Near Carll's Corner 12kV Bus	9572 Amps Total	11124 Amps Total
	9067 Amps Via Carlls Corner	10090 Amps Via Carlls Corner
	532 Amps Via Generators	92 Amps Via Generators

Based on the preceding fault study, the following conclusions can be reached.

1. The East 12kV Feeder relays can be set with adequate sensitivity to detect all feeder faults up to the downstream ALR location at P/N B-46259. The East 12kV Feeder relays should also be able to be set to backup this downstream ALR. The contribution via the generators for Carll's Corner 12kV Bus faults will be less than the feeder relay pickup. Therefore, the East 12kV Feeder relays need not be made directional. (Directional control on the proposed SEL-351 relay is available if ever needed.)
2. The proposed electronic ALR at P/N B-46259 (existing 400X VW ALR location) would need a phase sensitivity setting no greater than 800 Amps to insure detection of all phase faults up to the next downstream ALR at P/N B-3404. The ground sensitivity settings must

be no greater 650 Amps to detect downstream ground faults. The actual ALR settings will probably be less than the estimated maximum values. The ALR settings can be made high enough so that directional control is not needed.

3. The proposed electronic ALR at P/N B-3404 (existing 225 Amp VW ALR location) would need a phase sensitivity setting no greater than about 650 Amps to cover phase faults up to the next downstream protective device. The ground sensitivity setting must be no greater than about 500 Amps to cover downstream ground faults. Again, the actual ALR settings will probably be less than the estimated values. It appears that the ALR settings can be made high enough so that directional control is not needed.
4. The proposed electronic ALR at P/N B-103 (existing 100K Amp fuse location) would require a phase sensitivity setting no greater than about 350 Amps to cover phase faults all the way to the CC IA 12kV interconnection point. The ground sensitivity setting must be no greater than about 300 Amps to cover downstream ground faults. With these ALR settings, the possibility still exists that the ALR could trip for feeder phase faults upstream of this ALR location. However, the likelihood of an ALR trip for an upstream phase fault is low. The ALR will have relatively low multiples of pickup. The upstream ALR will most likely operate first and send transfer trip to the CC IA generators. The consequence of possible trip of this ALR trip should not be significant. The ALR will auto reclose once the feeder circuit is restored.
5. The feeder ALRs do not have to detect upstream faults. The upstream protective device will operate for these circuit faults and send transfer trip to the CC IA generators.

In summary, feeder fault detection will not be seriously compromised with the addition of the CCIA generation provided that the proposed system enhancements are implemented. Glassboro District Engineering will have to provide input on the specific ALR trip settings and possible concerns with coordination.

Ability of the Local Generator Protection to Detect 12kV Circuit Faults

In this particular application, transfer trip will be installed from each upstream ALR and from the East 12kV Feeder Terminal at Carll's Corner Substation to satisfy the requirements for anti-islanding detection. Each upstream protective device will be capable of detecting downstream faults within its protection zone. In addition, the CC IA generators will be permitted to operate only if the transfer trip channels are in operation. However, the interconnected generator owner is still responsible to install and maintain local interconnection protection that will detect fault conditions on the East 12kV Feeder circuit and disconnect the generators. Specific set points will be reviewed later.

Generator Transformer Connection

The proposed generator step up transformer will be wye-wye grounded. The generators themselves are each ground through a 6 ohm resister. Consequently, over voltages on the un-faulted phases will occur for a 12kV 1L-G fault once the upstream protective device has operated and the fault is supplied only via the generators. It is critical that these over voltages be detected and the generation tripped as quickly as possible to prevent equipment damage. Phase-neutral voltage monitoring must be applied on each 12kV phase. The proposed One Line Diagram

shows three 12kV phase-ground connected PTs supplying the Main 12kV Breaker SEL-351S relay. Over voltage elements within the SEL-351S relay can be used to provide the necessary protection. The voltage element settings must follow the requirement of IEEE 1547. Specific voltage settings can be reviewed later.

Abnormal ACE System Conditions

Under certain maintenance or emergency conditions, the portion of the Carll's Corner East 12kV Feeder that interconnects with the Cumberland County IA generators could be transferred to another ACE feeder circuit. Since it is not possible to cover every possible contingency, the required load to generation capacity mismatch cannot be guaranteed. In addition, no protection enhancements such as transfer trip will be installed on these other circuits. Therefore during these abnormal or emergency conditions, the generators must be taken off line. Again, this is to insure that the generator is not islanded with ACE customer load and that the generator is not subjected to possible damage caused by out of synch auto circuit reclose.

Proposed Customer's Protective Relays

Documentation from the customer indicates that each generator will have either a Basler BE1-GPS100 or GE SR489 generator multi-function microprocessor relay. Either relay should be satisfactory. The main 12kV Interconnection Breaker will have a SEL-351S relay. The proposed One-Line shows phase and ground over current elements, over/under voltage elements, over/under frequency elements, a power element and the reclosing function being utilized in this relay. The voltage and frequency elements in the preceding relays must be set to meet the requirements of IEEE 1547. The proposed One-Line shows that the relay failure contact of the interconnection SEL-351S relay will be used to trip the three generators.

The planned used of the SEL-351S relay on the 12kV Interconnection Breaker will facilitate the installation of the required transfer tripping schemes. If desired, the transfer trip signal could be received by the SEL-351S relay and mapped to an output contact to trip the three generators. Input contacts to the SEL-351S relay can be used to monitor the open/close status of the generator breakers. The open status of the generator breakers will by sent via the transfer trip channels to each upstream protective device to control auto reclosing. Alternatively, other means could be used to interface with transfer trip.

Generator Site Main Primary Fuse

The preliminary Cumberland County IA generator One-Line Diagram shows a main incoming 12kV fuse ahead of the primary metering. The type and size of this fuse is not specified. Based on the size of the 5600 KVA step up transformer, the primary current would be approximately 250 Amps. A fuse size of approximately 300 Amps would be needed. However, it will not be possible to set and coordinate upstream circuit protection with a fuse size of this magnitude. A fuse of this size will not provide sufficient sensitivity to insure detection of downstream faults.

In addition, this fuse poses the same single phasing concerns that were discussed earlier. One or more open fuses will leave the generator single phased. Consequently, it is recommended that this main incoming 12kV fuse be eliminated and replaced with an electronic Automatic Line Recloser with a SEL-351R controller. It is also required that three phase voltage sensing be stalled so that at least the phase over current elements in this ALR can be made directional. This will allow optimizing sensitivity for faults downstream of the ALR and still retain adequate load carrying capability for handling generation output.

Voltage Regulation

The set of regulators found on P/N B105, B106 and B107 are reversible and have adequate capacities even when the generators are installed.

Summary of System Enhancements/Changes Needed

At ACE

1. Eliminate the East 12kV Feeder 65K Amp fuses at P/N B-45603.

2. Replace the existing East 12kV Feeder 100K Amp fuses at P/N B-103 with an electronic Automatic Line Recloser (ALR) with a SEL-351R controller.

3. Replace the existing East 12kV Feeder 225 Amp VW ALR at P/N B-3404 with an electronic Automatic Line Recloser (ALR) with a SEL-351R controller.

4. Replace the existing East 12kV Feeder 400X VW ALR at P/N B-46259 with an electronic Automatic Line Recloser (ALR) with a SEL-351R controller.

5. Add a SEL-351 relay to the East 12kV Feeder Terminal at Carll's Corner Substation. Also remove the existing ACR reclosing relay and utilized the reclosing function within the SEL-351 relay.

6. Modify the Carll's Corner #4 69/12kV Transformer protection to include tripping the East 12kV Feeder Breaker "L".

7. Modify the #2 69kV Bus protection to include tripping the East 12kV Feeder Breaker "L".

8. Install a fiber optic bi-directional transfer trip communication channels between:

    a. Carll's Corner Substation and the Cumberland County IA generation site.
    b. The East 12kV Feeder electronic ALR location at P/N B-46259 and the Cumberland County IA generation site.
    c. The East 12kV Feeder electronic ALR location at P/N B-3404 and the Cumberland County IA generation site.

d. The East 12kV Feeder proposed new electronic ALR location at P/N B-103 and the Cumberland County IA generation site.

The transfer trip channels will interface with the East Feeder proposed SEL-351 relay at Carll's Corner Substation and with the SEL-351R controller at the ALR locations. The transfer trip channel will use SEL Mirrored Bits® protocol. Transfer trip will be sent from the East 12kV Feeder Terminal and from each ALR to the Cumberland County IA site. The open/close status of the generator breakers will be sent from the Cumberland County IA generator site to the East 12kV Feeder Terminal and to each ALR controller.

The fiber optic transfer trip path can follow the circuit path of the East 12kV Feeder to minimize the construction length needed to connect with each device. A fail safe communication channel (i.e. trip on loss is signal) is needed in this application since a grounded 12kV phase conductor will result in over voltages on the two un-faulted phases when the upstream protective device opens and the generation has not yet tripped. This over voltage can damage equipment and subject other ACE customers to hazardous voltages. As such, the use of spread spectrum radio links are not recommended since a momentary loss of the radio channel could result in nuisance tripping of the CC IA generators.

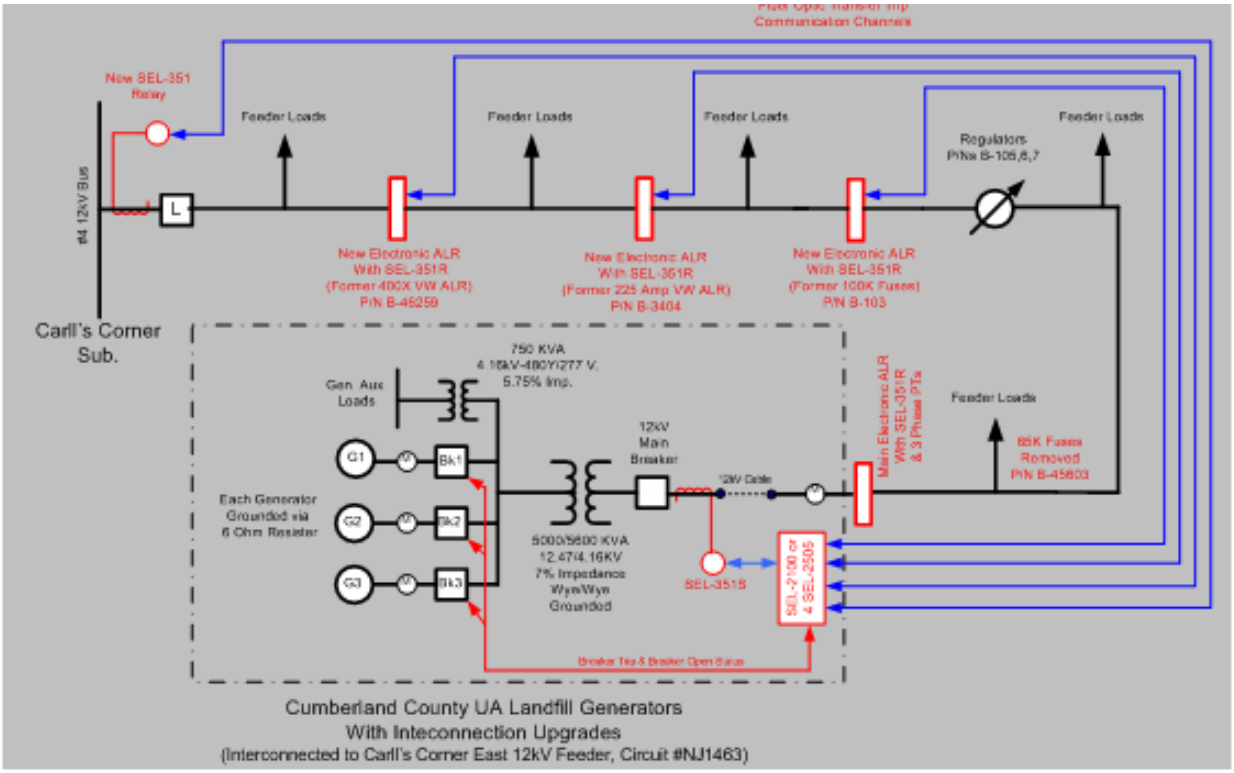
<u>At Cumberland County UA Generator Site</u>

1. Install a SEL-2100 Logic Processor to interface with the four incoming transfer trip channels. The SEL-2100 Logic Processor will be programmed to provide a trip signal to the CC IA generators either directly or through the SEL-351S relay on the 12kV Main Interconnection Breaker when transfer trip is received on any transfer trip channel. Alternatively, the customer could elect to install four SEL-2505 Remote I/O Modules, one for each communication channel. The trip output contacts from the SEL-2505 Remote I/O Modules would be hard wired to trip the three generator breakers upon receipt of a trip signal on any channel.

   The generators must also be tripped if any communication channel is lost. The open status of all three generator breakers will be supplied to a contact input on the SEL-2100 Logic Processor or to each of the SEL-2505 units and transmitted to the remote locations to supervise auto reclose. All transfer trip communications will be via SEL Mirrored Bits® protocol.

2. In lieu of the main incoming 12kV fuse, install an electronic Automatic Line Recloser with a SEL-351R controller to protect for downstream faults in the CC IA owned equipment and to prevent downstream faults from impacting service reliability to other ACE customers. Three phase potential sensing must also be installed so that directional over current elements can be utilized in this ALR. This required Automatic Line Recloser can be either customer owned or ACE owned. Glassboro District Engineering should be consulted regarding ownership preference for this main 12kV ALR.

The diagram below illustrates the proposed system enhancements needed to support the interconnection of the proposed Cumberland County IA generation.



Network Impacts

The Queue R74 project was studied as a 4.8 MW injection into the Carlls Corner 12 kV bus. The project was evaluated for compliance with transmission system reliability criteria for summer peak conditions in 2012. Potential network impacts were as follows:

Local Transmission System Impacts (Normal system conditions with all facilities in service)

No Problems were identified

Generator Deliverability
(Single or N-1 contingencies for the Capacity portion only of the interconnection)

No Problems were identified

Multiple Facility Contingency
(Double Circuit Tower Line contingencies only for the full energy output. Stuck breaker and bus fault contingencies will be performed for the Impact Study)

No Problems were identified

Contribution to Previously Identified Overloads
(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

No problems were identified

Stability Analysis
Not required for generating stations less than 30 MW.

New System Reinforcements
(Upgrades required to mitigate reliability criteria violations, i.e. "Network Impacts", initially caused by the addition of this project generation)

None.

Contribution to Previously Identified System Reinforcements
(Overloads initially caused by prior Queue positions with additional contribution to overloading by this project. This project may have a % allocation cost responsibility which will be calculated and reported for the Impact Study)

None

Attachment 1

ACE Scope of Work and Cost Estimates

I. Metering

Scope:
ACE's meter technicians will build a new three phase 12kV primary metering cluster mount and assist ACE's overhead crews in the installation of that equipment at Cumberland Landfill's new POI. ACE's metering technicians will also wire the secondary conductors at the each set of new customer owned and installed instrument transformers for each generator metering position, and install three new ACE owned metering devices, and test switches.

ACE will supply the metering enclosures, metering secondary control cables, test switches, meters, and ACP call diverter. Cumberland County Landfill's contractors will install the conduits, metering cabinets, and the needed communication cable to link each generator metering position so that a single phone line can be utilized. The communication cable will allow ACE to interrogate each generator metering position remotely via a single phone line.

Provisions for a voice quality phone line will be required at the POI, and at one of the three generator metering positions. Provisions will also be made by ACE to provide Cumberland County Landfill with analog (MW and MVAR) and pulse (MWh and MVarh) signals at each metering position.

Costs:
Direct (Internal or ACE)
- Labor - $ 12,150
- Material - $ 29,800

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

Metering Total Cost: $ 41,950

II. Substation Engineering

Scope:
At Carlls Corner Substation replace IAC and ACR relays on the East 12kV feeder terminal with SEL 351 type relaying. Revise the #2 Transformer primary and backup differential relay schemes and the #2-69kV bus differential relay scheme to trip the East 12kV feeder.

Costs:
At this time it is not possible to determine which costs will be intermnal labor and which will be external contractors. This will be determined based on workload at the time the work is authorized. All costs are based on 2007 costs and are subject to escalation.
Direct (Internal or ACE)

- Labor - $ 60,000
- Material - $ 4,500

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

Note: Depending on the time of year in which construction takes place to meet the customer's schedule the use of a mobile unit substation to maintain the continuity of service to other customers normally fed via the #2 transformer at Carlls Corner may be required. If needed, these additional costs will be incurred and passed on to the customer. Avoidance of these costs through schedule selection cannot be guaranteed.

Direct
- Labor - $ 61,000
- Material – N/A

Indirect
- Labor – N/A
- Material – N/A

Metering Total Cost: N/A

Substation Engineering Total Cost: $ 125,500

III. Outside Plant Communications

Scope
Install approximately 9 miles of fiber optic cable beginning at the Cumberland IA site on Jesse Bridge Rd and terminating in the ACE Substation Control House at Carll's Corner. Along the route, 3 pole mounted fiber optic terminals will be installed at 3 ALR locations on ACE poles B-46259, B-3404 and B-103.

Costs:
Direct (Internal or ACE)
- Labor - $ 61,093
- Material - $ 80,145

Indirect (External or Contractor)
- Labor - $ 231,033
- Material – N/A

Outside Plant Communications Total Cost: $372,271

IV. Relaying, ALR and Communications

Scope:

Automatic Line personnel will be required to bypass the reclosers to allow functional testing and verify trip signals received at the ALR devices and perform any setting changes to ensure transfer trip schemes initiate and operate as designed.

Costs:

Direct (Internal or ACE)
- Labor - $ 6,000
- Material – N/A

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

Relaying, ALR, and Communications Total Cost: $ 6,000

V. Project Management and Special Billing

Scope:

Coordinate all internal groups working on this project as well as with the customer to insure project completion by the agreed upon in-service date and within budget.

Costs:

Direct (Internal or ACE)
- Labor - $ 11,500 (100 hrs)
- Material – N/A

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

Project Management and Special Billing Total Cost: $ 11,500

VI. System Protection

Scope:

Perform Protection study, Issue internal relay settings and review and approve customer relay settings.

Direct (Internal or ACE)
- Labor - $ 1,840 (16 hrs)
- Material – N/A

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

System Protection Total Cost: $ 1,840

VII. System Operations

Scope:
This would include EMS display work, database work to accommodate additional monitored points for the new generator, verification of accuracy and scaling constants, meeting participation, inclusion of any new data into our PI system.

Direct (Internal or ACE)
Labor - $ 1,610 (14 hrs)
Material – N/A

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

System Operations Total Cost: $ 1,610

VIII. Interconnection Arrangements

Scope:

Perform interconnection technical issue review and resolution. Review installation approach and initial output to insure compliance with agreement.

Direct (Internal or ACE)
- Labor - $ 4,600 (40 hrs)
- Material – N/A

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

Interconnection Arrangements Total Cost: $ 4,600

IX. System Planning

Scope:

Review initial plans and coordinate the Feasibility/impact study. Incorporate the capacity resource into overall system plans.

Direct (Internal or ACE)
- Labor - $ 3,450 (30 hrs)
- Material – N/A

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

System Planning Total Cost: $ 3,450

X. Distribution Engineering

Scope:

Eliminate the East 12kV Feeder 65K Amp fuses at P/N B-45603.

Replace the existing East 12kV Feeder 100K Amp fuses at P/N B-103 with an electronic Automatic Line Recloser (ALR) with a SEL-351R controller.

Replace the existing East 12kV Feeder 225 Amp VW ALR at P/N B-3404 with an electronic Automatic Line Recloser (ALR) with a SEL-351R controller.

Replace the existing East 12kV Feeder 400X VW ALR at P/N B-46259 with an electronic Automatic Line Recloser (ALR) with a SEL-351R controller.

Reconductor approximately 12,400 feet of 3- 4 CU overhead wire to 3- 1/0 AAC overhead wire on Carlls Corner Sub. East 12 kV Feeder from Pole B47595 to G41418.
(Notes: Labor - $ 420,000, and Material – $ 280,000)

Costs:

Direct (Internal or ACE)
- Labor - $ 445,000
- Material - $ 395,000

Indirect (External or Contractor)
- Labor – N/A
- Material – N/A

Distribution Engineering Total Cost: $ 840,000

Total With 18% Overheads (ESAG) and 15% Contingency

Direct (Internal or ACE)
-Labor - $ 906,806
-Material - $ 691,317

Indirect (External or Contractor)
-Labor - $ 313,512
-Material - N/A

PROJECT TOTAL: $ 1,911,634 (Without CIAC 33.5%)