

# ILC Mechanical & Electrical Review

## Conventional **Electrical** System Americas Region Design Summary

March 21, 2012

Randy Wielgos, FNAL

Parsons Electrical Team

Joseph Kim

Keyser Lam

# Electrical Design and Cost Estimating

## Parsons

### Basis of Design

Klystron Cluster & DRFS Schemes

Full Power Beam Operation

Americas Region Standard Voltages

### Conventional Facilities Development of Loads

Mechanical & Electrical Coordination

Determination of Load Characteristics

### Engineering Drawings & Specifications for Estimating

# SCOPE:

- Conventional Electrical scope includes High Voltage and Low Voltage Electrical Transmission and Distribution on the surface and in the tunnel
- Estimating and Costing Follows the RDR WBS system

1.7.2		ELECTRICAL
	1.7.2.1	Engineering, study work and documentation
	1.7.2.1.1	In-house Engineering
	1.7.2.1.2	Outsourced Consultancy Services
	1.7.2.2	High Voltage Equipment, Power Distribution
	1.7.2.2.1	Main Substation
	1.7.2.2.2	Distribution Substations
	1.7.2.2.3	Medium Voltage Distribution & Transforming
	1.7.2.2.4	H.V. cable links from central area
	1.7.2.3	Low Voltage Equipment, Power Distribution
	1.7.2.3.1	Surface buildings (transferred to civil engineer)
	1.7.2.3.2	Shafts and shaft base caverns
	1.7.2.3.3	Tunnel
	1.7.2.4	Emergency Power Sources
	1.7.2.5	Power Network monitoring
	1.7.2.6	Communication equipment
	1.7.2.6.1	Telephone equipment
	1.7.2.6.2	Public address and other communication equipment

Americas Region

Conventional Electrical System Design  
Summary

# **ELECTRICAL LOAD DEVELOPMENT**

# LOAD TABLES - OVERALL

## Electrical (operating) Power in MW

RDR (w adjusted cryo Jan 27 2011)						
Area System	RF Power	Conventional Power (operating power)			Emerg Power	Total
		Conv (incl racks)	NC Magnets	Cryo		
e-sources	1.05	2.46	0.73	0.59	0.06	4.89
e+sources	4.11	8.59	8.9	0.59	0.21	22.4
DR	14	2.38	7.92	2.52	0.23	27.05
RTML	7.14	5.12	4.74	0	0.15	17.15
Main Linac	75.72	23.40	0.78	42.9	0.404	143.20
BDS	0	4.62	2.57	0.41	0.2	7.8
Dumps	0	3.83	0	0	0.12	3.95
IR	0	0	0	0	0	0
Conventional						
TOTALS	102.0	50.4	25.6	47.0	1.4	226.4

DRAFT UPDATED MAR 14 2012

KlyCluster 5Hz Full Power						
RF Power	Conv	Racks	NC Magnets	Cryo	Emerg Power	Total
1.05	2.46		0.73		0.06	4.3
1.48			4.94	1.18		7.6
12.75			4.46	2.52		19.7
5.98		0.32	1.26	0		7.6
93.16		5	0.914	44.2		143.1
0			10.43	0.41		10.8
0	1		0	0		1
0			0.58	1.324		1.9
	16.21				5.822	22
114.4	19.7	5.2	23.3	49.6	5.9	218

New numbers since Granada2011

placeholder from RDR (no info)

a) Refer to CFS criteria tables for details

b) Dumps elect power for assoc components from RDR  
BDS dump parameters dated May 2 200

Developed By Parsons

Area System
e-sources
e+sources
DR
RTML
Main Linac
BDS
Dumps
IR
Conventional
TOTALS

KlyCluster Low Power (baseline)						
RF Power	Conv	Racks	NC Magnets	Cryo	Emerg Power	Total
1.05	2.46		0.73		0.06	4.30
1.48			4.94	1.18		7.6
9.57			2.97	2.52		15.1
4.17		0.32	1.26	0		5.7
66.1		5	0.914	44.2		116
0			10.43	0.41		10.8
0	1		0	0		1
0			0.58	1.324		1.9
	16.21				5.822	22
82.4	19.7	5.2	21.8	49.6	5.9	185

Americas Region

Conventional Electrical System Design  
Summary

# Load Table progress –

## Basis for current Concept design

	Load Tables		
	starting point	use by Parsons	latest
electron source		just a single KW #	Mar 02 2012 (statement only)
positron source	Aug 27 2010	Feb 25 2011	Mar 02 2012
damping ring	Aug 2 2010	Jun 17 2011	Feb 28 2012
rtml	Sep 7 2010	Sep 7 2010	Mar 14 2012
main linac-KCS	Dec 8 2010	Mar 23 2011	Mar 01 2012
main linac-DRFS		Jul/Aug 2011	N/A
<i>ML-rdr style</i>	<i>N/A</i>	<i>N/A</i>	
BDS	Sep 27 2010	Sep 27 2010	Mar 02 2012
IR	Sep 20 2007	Sep 2007 & Jun 30 2010	Mar 09 2012
dumps			Feb 14 2012
Cryo		Feb 8 2011	Mar 07 2012
Laser			Feb 14 2012

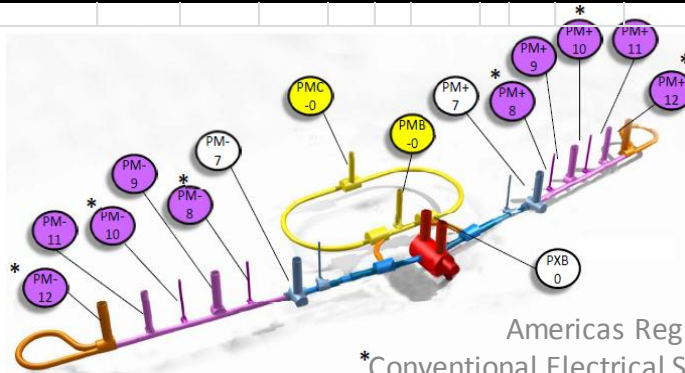
Americas Region

Conventional Electrical System Design  
Summary

# KCS POWER LOAD TABLE (Technical Equipment only)

(sample load distribution) \*EXCLUDING non-technical components \* Conventional Nos by PARSONS

New Shaft Nos	PM-12	PM-11	PM-10	PM-9	PM-8	PM-7	PMB-0	PMC-0	PXA-0	PM+7	PM+8	PM+9	PM+10	PM+11	PM+12	
Old Shaft Nos	Shaft 11	Shaft 7	Shaft 14	Shaft 5	Shaft 15	Shaft 3	Shaft 12	Shaft 13	Shaft 1.0	Shaft 2	Shaft 16	Shaft 4	Shaft 17	Shaft 6	Shaft 10	TOTAL MW *
Total	8.3	18.1	10.1	18.1	10.1	24.8	3.8	14.4	16.7	22.9	10.1	18.1	10.1	18.1	7.8	212
<b>SURFACE</b>																
e - (surface)		0.00				0.00		0		0.30				0.00		0.30
ML RF installed (surface)	29 RF 4.342	66 RF 9.882	66 RF 9.882	66 RF 9.882	66 RF 9.882	66 RF 9.882		0		66 RF 9.882	66 RF 9.882	66 RF 9.882	66 RF 9.882	66 RF 9.882	26 RF 3.893	109.20
ML Racks installed (surface)	29 RF 0.087	66 RF 0.198	66 RF 0.198	66 RF 0.198	66 RF 0.198	66 RF 0.198		0		66 RF 0.198	66 RF 0.198	66 RF 0.198	66 RF 0.198	66 RF 0.198	26 RF 0.078	
CRYO (surface)		7.37		7.37		7.96		2.52	1.73	7.96		7.37		7.37		
<b>TUNNEL</b>																
RTML Total (in tunnels)	45% rtml 3.87					0.00	10% 0.861			0.00					45% rtml 3.87	8.61
ML Racks (tunnel)		105 RF 0.53		108 RF 0.54		81 RF 0.41				81 RF 0.41		108 RF 0.54		101 RF 0.51		3.83
ML conv magnets? (tunnel)		0.15		0.15		0.15				0.15		0.15		0.15		
DR (in tunnel)							20% 2.962	80% 11.8								14.81
e+ TOTAL (in tunnel)						100% 6.25										6.25
e- (in tunnel)										4						4.00
BDS (in tunnel)						0.00			10.578	0.00						10.58
Dumps (in tunnel)									3.95							3.95
IR (tunnel)									0.456							0.456
*doesn't include conventional																212



Americas Region

\*Conventional Electrical System Design  
Summary

# LOAD TABLES - DETAIL

## CONVENTIONAL FACILITIES

PM-9

Surface		Lights		Receptacles		Machines (2.5VA/df)	HVAC (tons x 3.5)	Fans (75VA/df)	Pumps (1VA/df)	Crane (40KVA)	Elevator (60KVA)
		(3VA/df)	(6VA/df)	(5VA/df)	(6VA/df)						
RF Bldg	55051.4		330.34	110.11				110.11	55.06	40.00	
RF Bldg - Fil	1582.29	4.75		3.16							
Surf Proc R	7750.02	23.25		15.50					7.75		
Cryo Bldg	27232.69		163.40	54.47				54.47	27.23		
Shaft Access	7534.74		45.21	15.07				15.07	7.53	40.00	60.00
Fan House	3743.42		22.46	7.49		93.59		7.49	3.74		
Support	2240.51	6.72		11.20				4.48	2.24		
Admin	2240.51	6.72		11.20				4.48	2.24		
Workshop	4036.47		24.22	8.07		100.91		8.07	4.04		
Loading Bay	15317.04		91.90	30.63		382.93		30.63	15.32		
Cool Twr Encl	8362.69	25.09						16.73	8.36		
Other Encl	10821.45	30.96						20.64	10.32		
Sub-total (KVA)		97.49	677.53	244.51	22.41	577.42	0.00	272.17	143.84	80.00	60.00
Total (MVA)			0.775		0.247	0.577	0.000	0.272	0.144	0.080	0.060

<b>Tunnel</b>	Tunnel Distance	2062
	Spacing between lighting fixture (m)	3
	No. of Lighting Fixture	697
	Wattage per lighting fixture	74
	Total wattage (MW): Lights	0.05

	120V Duplex	120V Twist Lock	208V Simplex	480V Welding
Spacing between receptacle (m)	15	15	60	60
No. of receptacle	139	139	35	35
Wattage per receptacle	180	180	200	40000
Total wattage (MW)	0.03	0.03	0.01	1.39
		0.06		



# LOAD TABLES - DEVELOPMENT

Load Summary - PM-9									
LOAD (Location/Description)	Quantity	MW	MVA	Connected Load (MVA)	Demand Factor	Diversity Factor	Plant Load (MVA)	Voltage (KV)	N (Normal), E (Emergency)
RTM, Total									
DR									
±± Total									
±± Total									
BDS									
CRWD		7.370	8.671	8.671	1.00	1.00	8.671	0.48	N
RF	66	9.882	11.626	11.626	0.97	1.00	11.274	0.48	N
RF Rack	66	0.198	0.233	0.233	0.97	1.00	0.226	0.48	N
Conventional Power									
- Lights			0.775	0.775	0.80	0.90	0.558	0.277	N
- Receptacles			0.267	0.267	0.20	0.90	0.140	0.32	25% - E
- HVAC									
- Fans			0.272	0.272	0.80	0.90	0.19	0.48	N
- Pumps			0.144	0.144	0.80	0.90	0.104	0.48	N
- Machines			0.577	0.577	0.80	0.90	0.416	0.48	N
- Crane			0.080	0.080	1.00	0.90	0.072	0.48	E
- Elevator			0.040	0.040	1.00	0.90	0.054	0.48	E
HVAC/Pump									
- Chillers									
- Cooling Towers		0.134	0.158	0.158	0.80	0.90	0.134	0.48	N
- Chilled Water Pumps									
- Cooling Water Pumps		0.204	0.240	0.240	0.80	0.90	0.173	0.48	N
- Surface LCV Pumps		0.106	0.127	0.127	0.80	0.90	0.091	0.48	N
- CRAC		0.134	0.158	0.158	0.80	0.90	0.134	0.48	N
- Surface Admin HVAC Unit		0.014	0.016	0.016	0.80	0.90	0.012	0.48	N
- Ventilation Units		0.150	0.176	0.176	0.80	0.90	0.127	0.48	E
RTM, Total									
±± Total									
±± Total									
BDS									
DR									
Dumps									
IR									
RF									
RF Rack (SKW)	54	0.270	0.318	0.318	1.00	1.00	0.318	0.48	N
Conventional Power									
- Lights		0.052	0.061	0.061	0.80	0.90	0.000	0.277	N
- Welding Receptacles		1.395	1.641	1.641	0.05	0.00	0.000	0.48	N
- Receptacles		0.057	0.067	0.067	0.05	0.00	0.000	0.48/0.32	N
- Magnets		0.075	0.088	0.088	1.00	1.00	0.068	0.48	N
HVAC/Pump									
- Process Water Pumps									
- Low Conductivity Water Pumps		0.140	0.165	0.165	0.80	0.90	0.119	0.48	N
- Low Conductivity Water Booster Pumps		0.040	0.071	0.071	0.80	0.90	0.051	0.48	N
- Fan Coil Units		0.025	0.029	0.029	0.80	0.90	0.021	0.48	N
- Sump Pumps		0.006	0.007	0.007	0.80	0.90	0.005	0.48	E
- Groundwater Lift Pump		0.025	0.029	0.029	1.00	0.90	0.026	0.48	E

Sub-total: 22.88 Normal  
0.42 Emergency

	Normal (MVA)	Emergency (MVA)
Sub-total	22.88	0.42
*35NS15-10"	13.61	
*35NS15-9" Total	36.48	0.42

## MW

Megawatt, a unit of power equal to one million watts

## MVA

Megavolt-ampere, a unit of power equal to one million VA, applied in AC power, where  $MVA = MW/PF$

## Connected Load

Name plate or maximum load connected to a system.

## Demand Factor

The ratio of actual power an equipment draws to the nameplate connected power.

## Diversity Factor

The percent of time available that a machine, piece of equipment, or facility has its maximum or nominal load or demand and turned on.

## Plant Load

Connected Load x Demand Factor x Diversity Factor

# LOAD TABLES – SUMMARY DETAIL

Location: Switchgear	CENTRAL REGION: 60NS1CR						CENTRAL REGION: 35NS1CR				CENTRAL REGION: 35NS2CR				CENTRAL REGION: 60NS2CR			
	PM-9: 60NS15-9						PM-7: 35NS15-7				PM-6: 35NS15+7				PM-8: 60NS15+9			
	PM-11: 60NS15-11			PM-11: 35NS15-11			PM-10: 35NS15-10			PM-10: 35NS15-10			PM-10: 35NS15+10			PM-11: 60NS15+11		
	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12	PM-12: 35NS15-12
RTML Total																		
DR																		
air Total																		
air Total																		
SDS																		
CRFD																		
CRFD	4.992	11.274	11.274	11.274	11.274	11.274	9.365	2.035	2.965	9.365	11.274	11.274	11.274	11.274	11.274	11.274	4.227	
CRFD	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Conventional Power																		
- Lights	0.374	0.556	0.424	0.556	0.424	0.556	0.344	0.221	0.556	0.424	0.556	0.424	0.556	0.424	0.556	0.374		
- Receptacles	0.033	0.048	0.044	0.048	0.044	0.048	0.068	0.058	0.048	0.042	0.048	0.042	0.048	0.042	0.048	0.033		
- HVAC																		
- Fans	0.131	0.196	0.148	0.196	0.148	0.196	0.134	0.084	0.196	0.148	0.196	0.148	0.196	0.148	0.196	0.131		
- Pumps	0.070	0.104	0.079	0.104	0.079	0.104	0.068	0.042	0.104	0.079	0.104	0.079	0.104	0.079	0.104	0.070		
- Machines	0.401	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.416	0.401		
- Crane	0.072	0.072	0.072	0.072	0.072	0.072	0.108	0.108	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072		
- Elevator	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054		
HVAC/Pump																		
- Chillers							1.447	0.993	0.063	1.330	1.447							
- Cooling Towers	0.056	0.114	0.056	0.114	0.056	0.114	0.176	0.087	0.019	0.063	0.063	0.176	0.056	0.114	0.056	0.114	0.056	
- Chilled Water Pumps							0.078	0.025	0.005	0.069	0.078							
- Cooling Water Pumps	0.015	0.271	0.033	0.173	0.033	0.274	0.020	0.017	0.068	0.069	0.274	0.033	0.173	0.033	0.271	0.015		
- Surface LCV Pumps	0.041	0.114	0.091	0.091	0.091	0.091				0.091	0.091	0.091	0.091	0.091	0.114	0.041		
- CRAC	0.114	0.114	0.114	0.114	0.114	0.114				0.114	0.114	0.114	0.114	0.114	0.114	0.114		
- Surface Admin HVAC Unit	0.012	0.012	0.012	0.012	0.012	0.012				0.012	0.012	0.012	0.012	0.012	0.012	0.012		
- Ventilation Units	0.127	0.127	0.127	0.127	0.127	0.127				0.127	0.127	0.127	0.127	0.127	0.127	0.127		
Sub-total (Surface)	6.53	22.11	13.17	22.25	13.17	24.63	0.51	2.91	0.70	4.51	24.99	13.17	22.25	13.17	22.37	5.81		
RTML Total	4.553																	
air Total							7.353											
air Total																		
SDS																		
DR																		
Dumps																		
DR																		
DR																		
DR																		
Conventional Power																		
- Lights																		
- Welding Receptacles																		
- Receptacles																		
- Magnets	0.088	0.088	0.088	0.088	0.088	0.088				0.088	0.088	0.088	0.088	0.088	0.088	0.088		
HVAC/Pump																		
- Process Water Pumps							0.491			0.491								
- LCV Pumps		0.212		0.119		0.119	0.066			0.091	0.119		0.119		0.212			
- LCV Booster Pumps		0.098		0.091		0.091	0.019			0.219	0.091		0.051		0.098			
- Fan Coil Units		0.068		0.021		0.068	0.044			0.065	0.021		0.021		0.068			
- Sump Pumps	0.005	0.005	0.005	0.005	0.005	0.014	0.003	0.002		0.003	0.014	0.005	0.005	0.005	0.005	0.005		
- Process Admin LCV Pumps	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006		0.006	0.006	0.006	0.006	0.006	0.006	0.006		
Sub-total (Tunnel)	4.81	0.82	0.44	0.63	0.44	8.80	4.67	5.19	12.44	14.08	6.15	0.44	0.63	0.44	0.82	4.79		
Sub-total by shaft (Surface + Tunnel)	11.35	22.93	13.61	22.88	13.61	33.43			13.14	18.58	31.14	13.60	22.88	13.60	23.18	10.60		
Sub-total	34.27		36.48			47.04					76.47	44.74			36.48	70.27	33.79	
Central Region Main Distribution		76.75				60.32					76.47	44.74			70.27			
Total (MVA)																		

**MW**  
Megawatt, a unit of power equal to one million watts

**MVA**  
Megavolt-ampere, a unit of power equal to one million VA, applied in AC power, where MVA = MW/PF

**Connected Load**  
Name plate or maximum load connected to a system.

**Demand Factor**  
The ratio of actual power an equipment draws to the nameplate connected power.

**Diversity Factor**  
The percent of time available that a machine, piece of equipment, or facility has its maximum or nominal load or demand and turned on.

**Plant Load**  
Connected Load x Demand Factor x Diversity Factor

Developed By Parsons

Location	Load (MVA)
PM-12	0.38
PM-11	0.42
PM-10	0.39
PM-9	0.42
PM-7	0.54
Shaft 12	0.07
Shaft 13	0.06
Cent. Reg.	0.47
PM-7	0.54
PM-9	0.42
PM-10	0.39
PM-11	0.42
PM-12	0.38

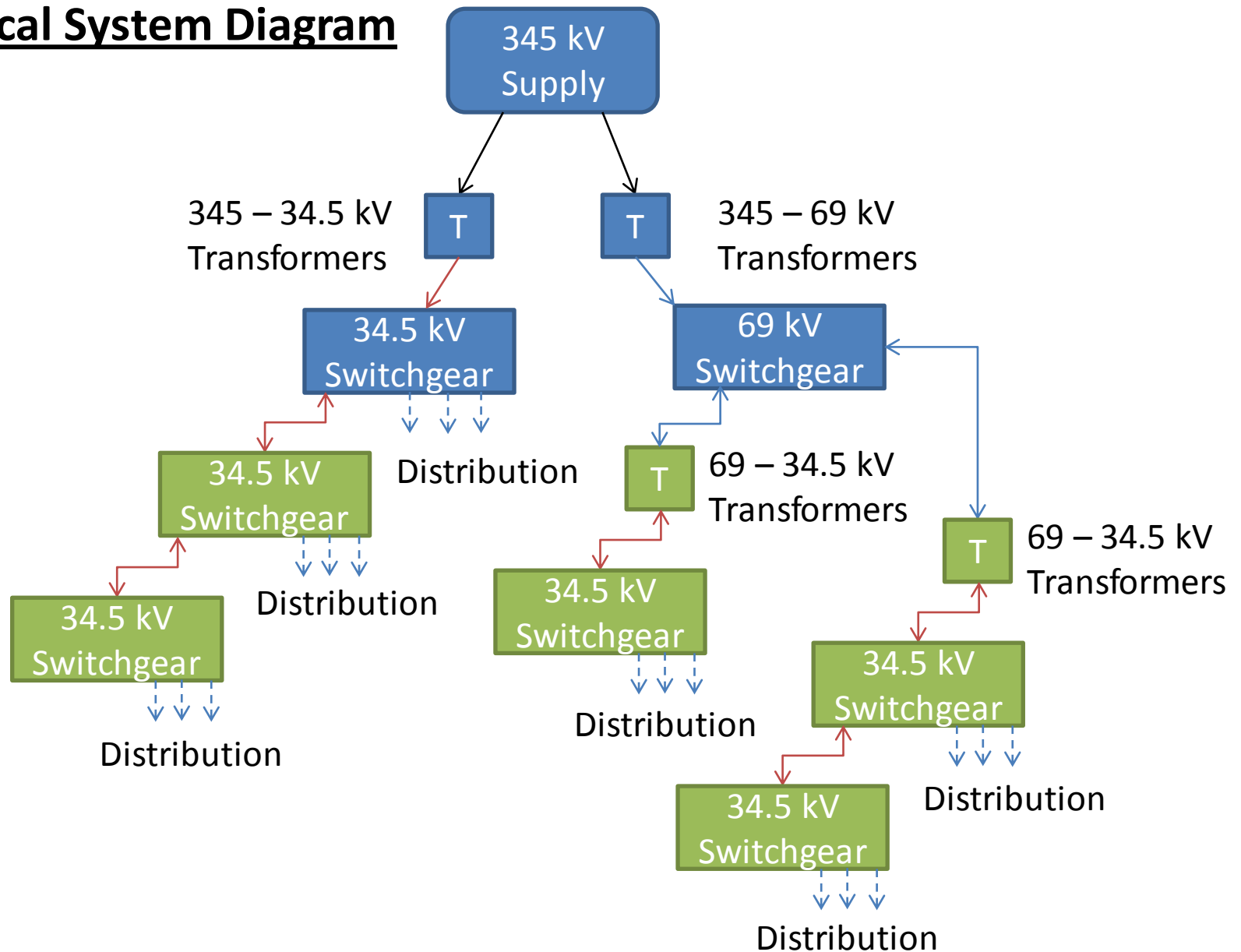
ILC PLANT LOAD SUMMARY - KCS

Americas Region  
Conventional Electrical System Design  
Summary

EMERGENCY POWER LOAD  
SUMMARY

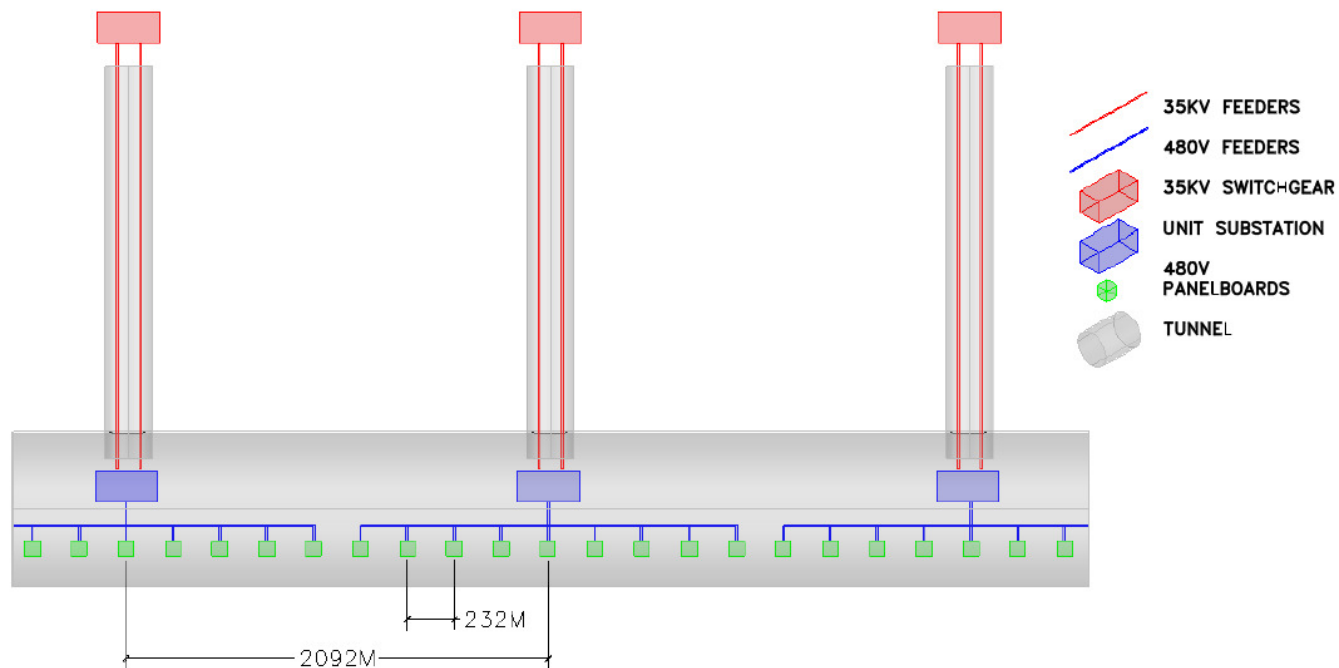
# **ELECTRICAL SYSTEM DESIGN**

# Electrical System Diagram



# Electrical System Tunnel Distribution

- Conventional Power Distribution for KCS
- Each 35kV/480V unit substation feeds nine 480V panel boards
- Distance between shafts is approximately 2.1km, and distance from the unit substation to the furthest panel board is approximately 1km.
- Distance between 480V panel boards is approximately 232m.

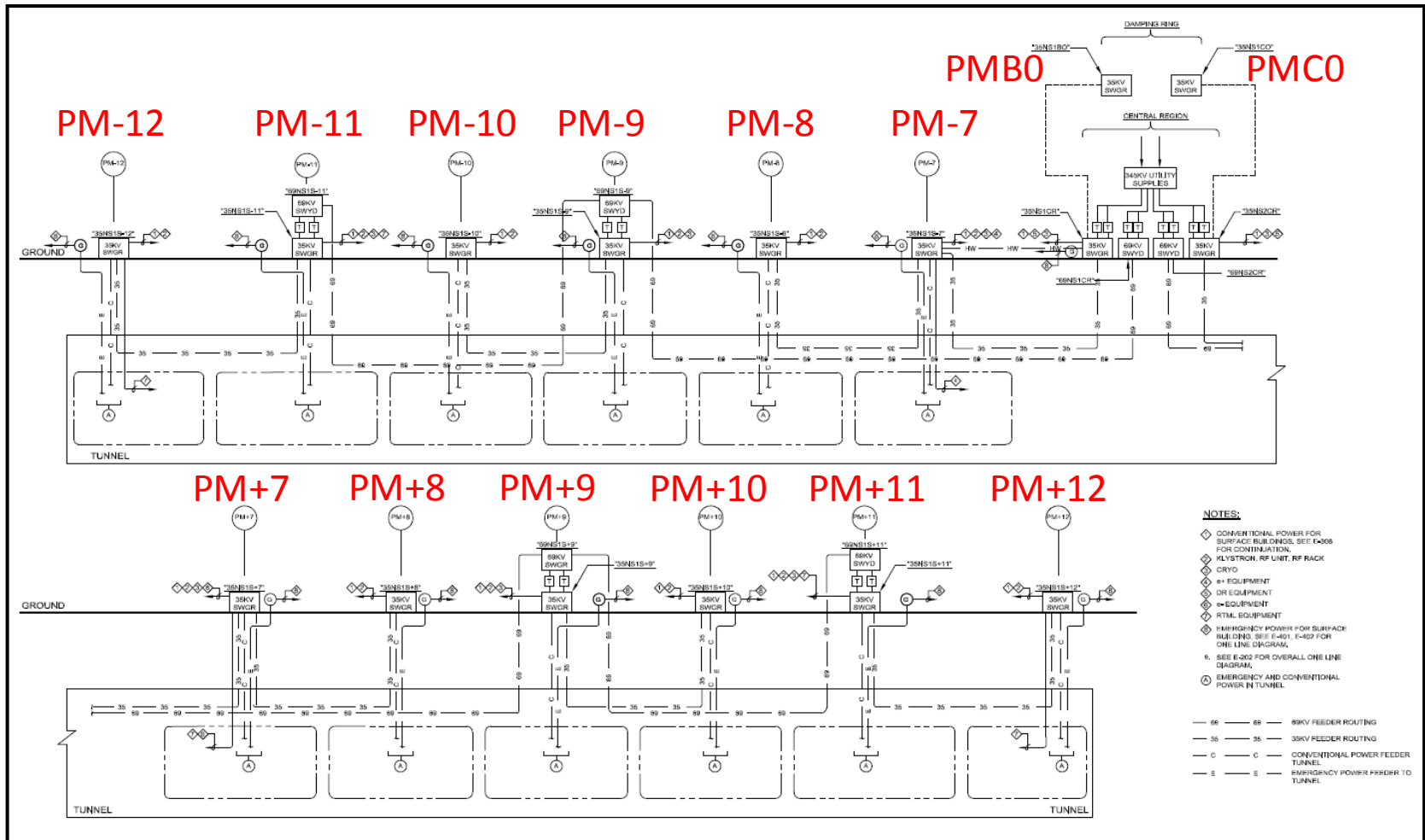


Americas Region

Conventional Electrical System Design  
Summary

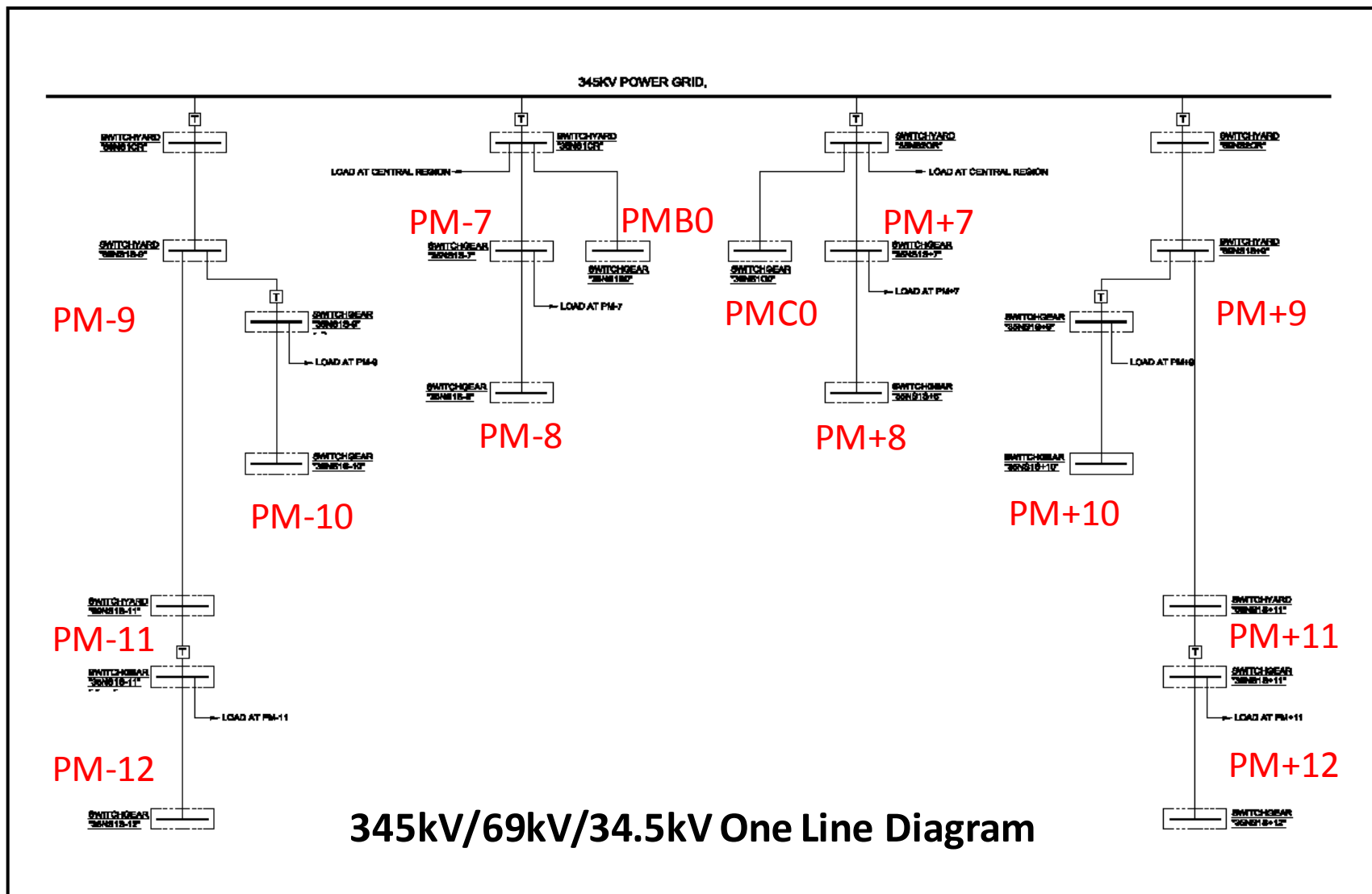
# Emergency/Standby Power Systems

- Fire detection and alarm systems.
- Exit sign illumination.
- Emergency lighting.
- Elevator car lighting.
- Fire Command Station lighting.
- Two-way fire department communication systems.
- Elevators, elevator equipment, and elevator machine room/controller cooling.
- Air handling systems for the tunnels and elevator lobbies.
- Lighting for HVAC mechanical equipment rooms.
- Cranes, Sump/Lift Pumps.
- Ref: Hughes Associates - Life Safety/Fire Protection Code Analysis
- Project Requirement



# Power System Configuration

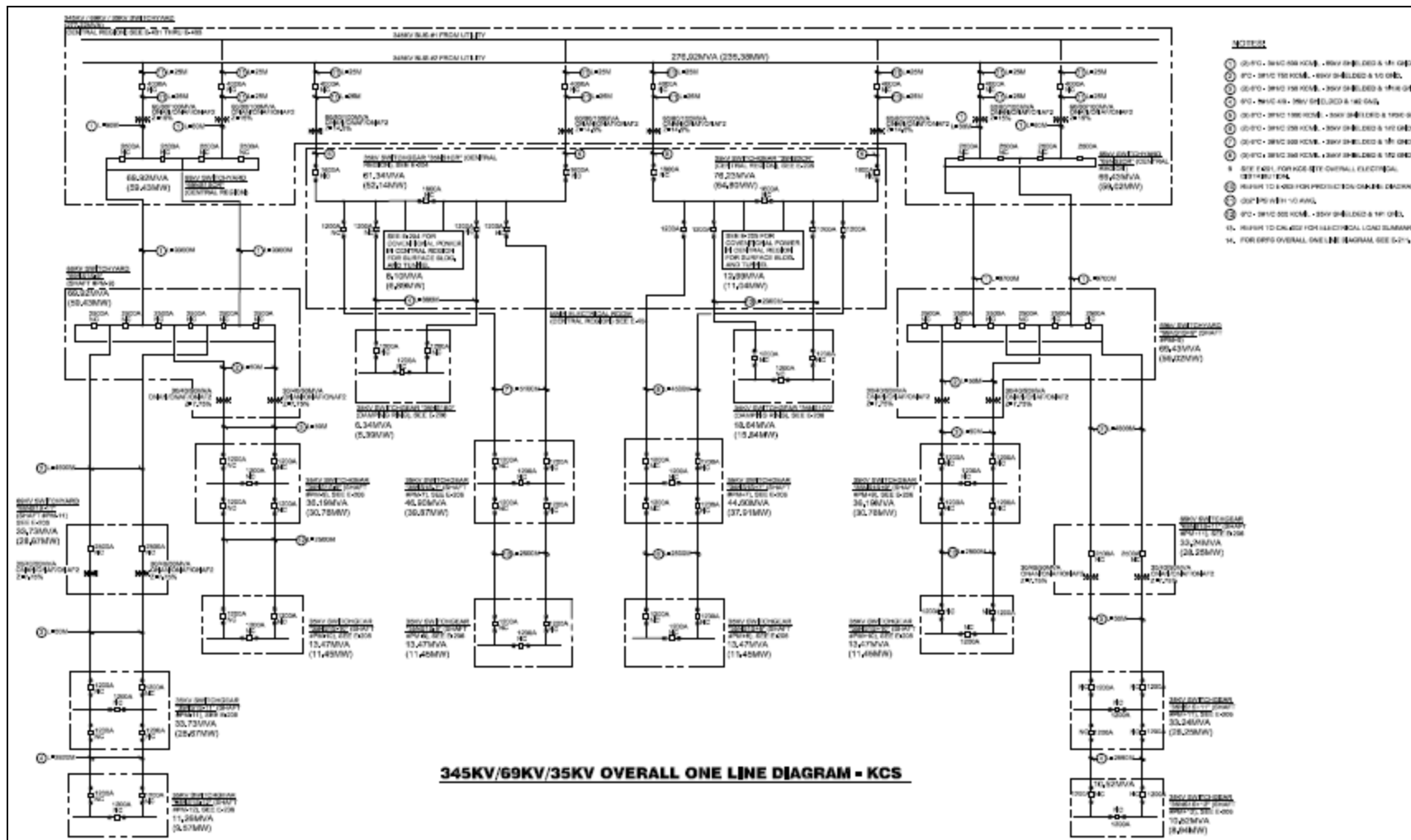
Americas Region  
Conventional Electrical System Design  
Summary



## Power System Configuration - KCS

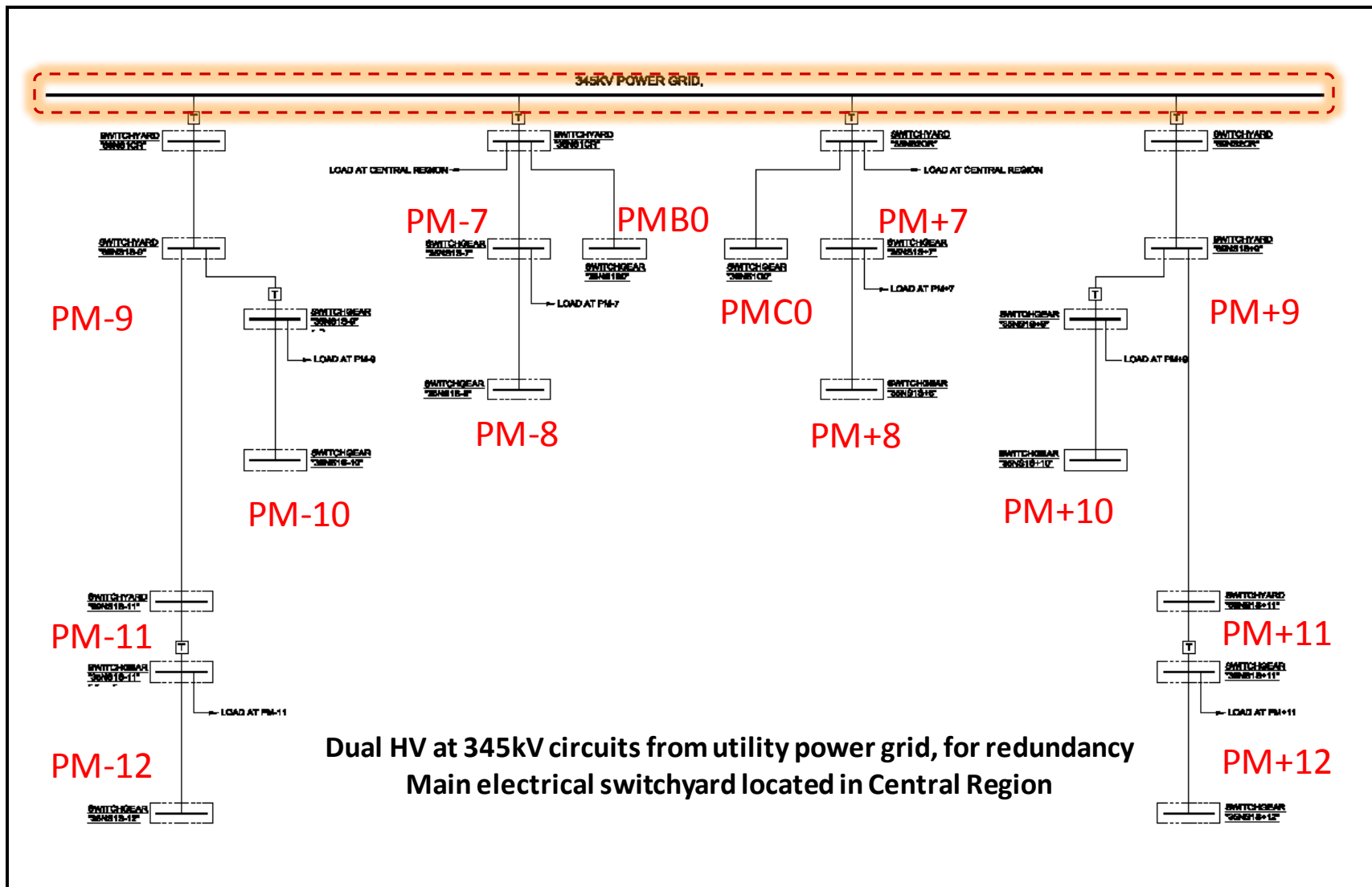
Americas Region  
Conventional Electrical System Design  
Summary





## 345kV/69kV/34.5kV One Line Diagram Power System Configuration - KCS

Americas Region  
Conventional Electrical System Design  
Summary

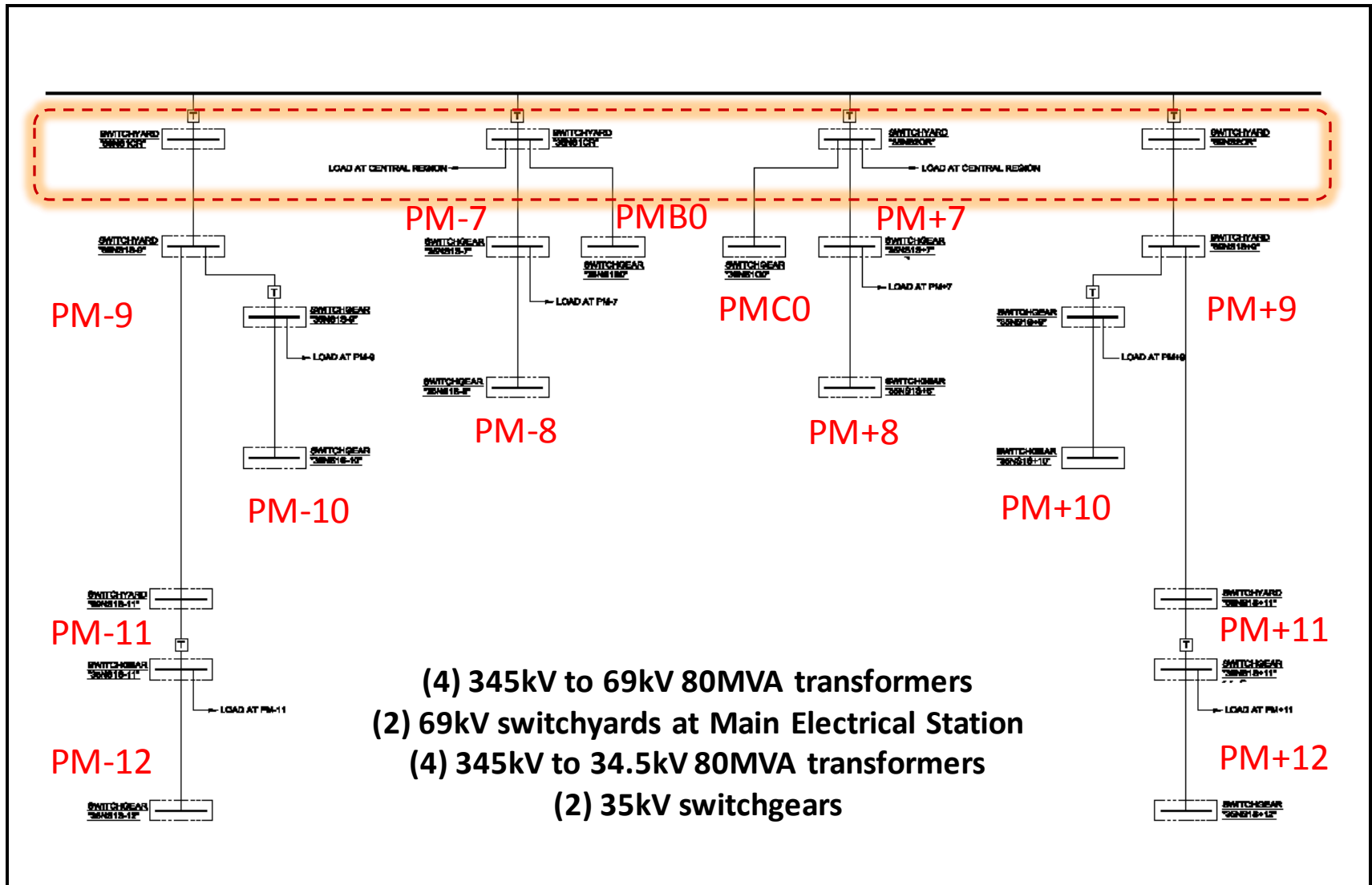


## High Voltage Power Distribution

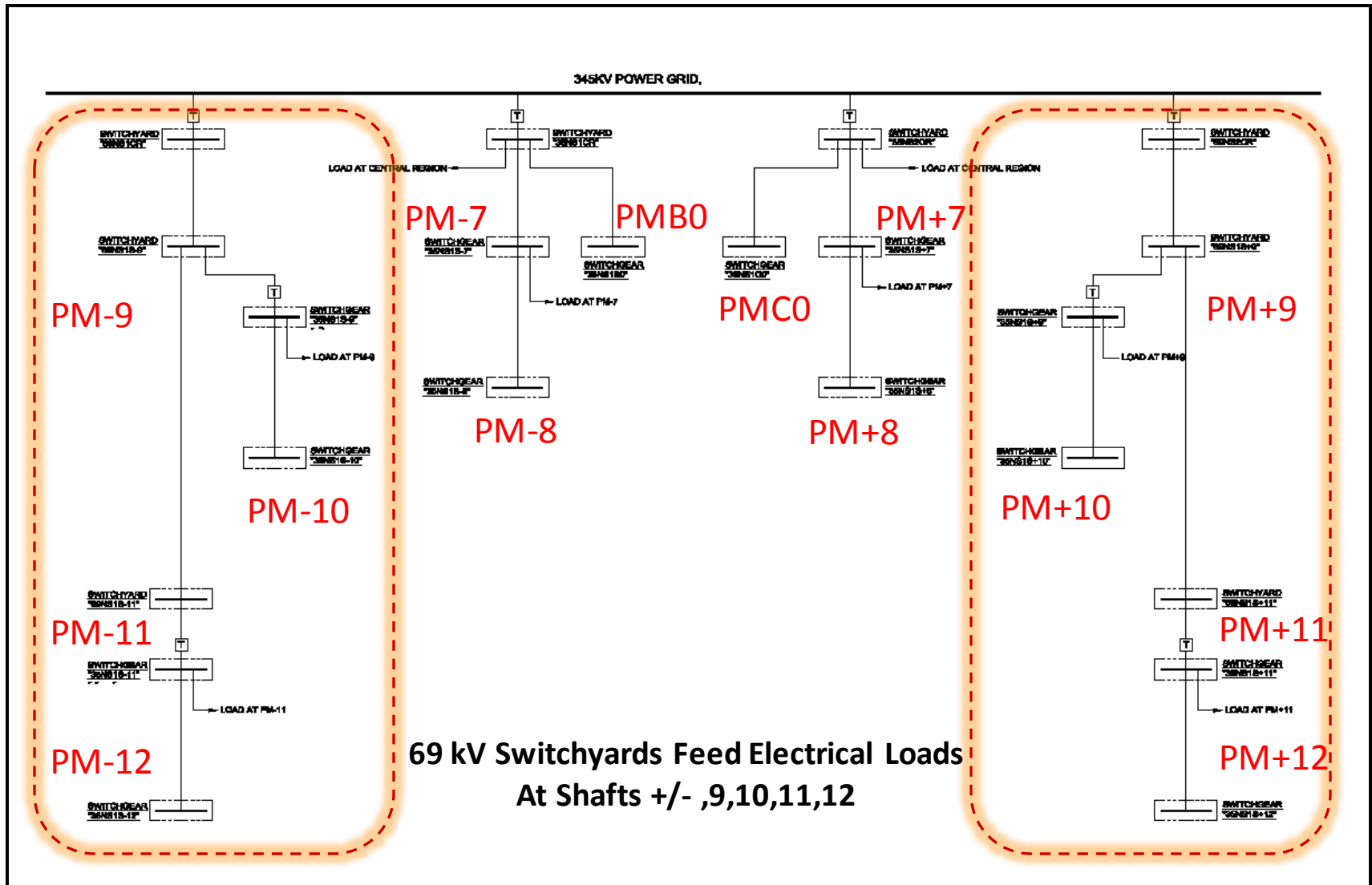
Americas Region

Conventional Electrical System Design

Summary



## High Voltage Power Distribution

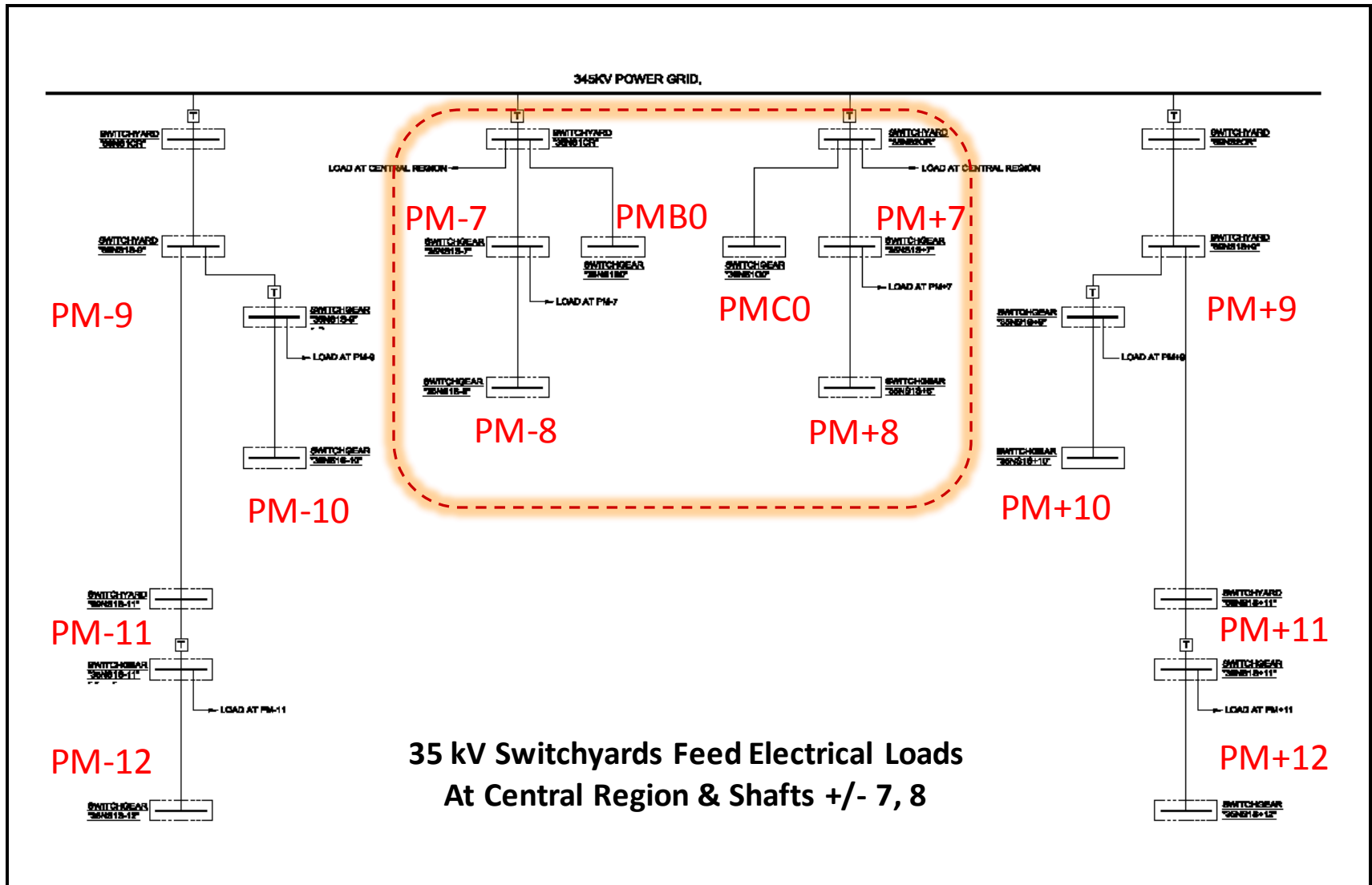


## Medium Voltage Power Distribution

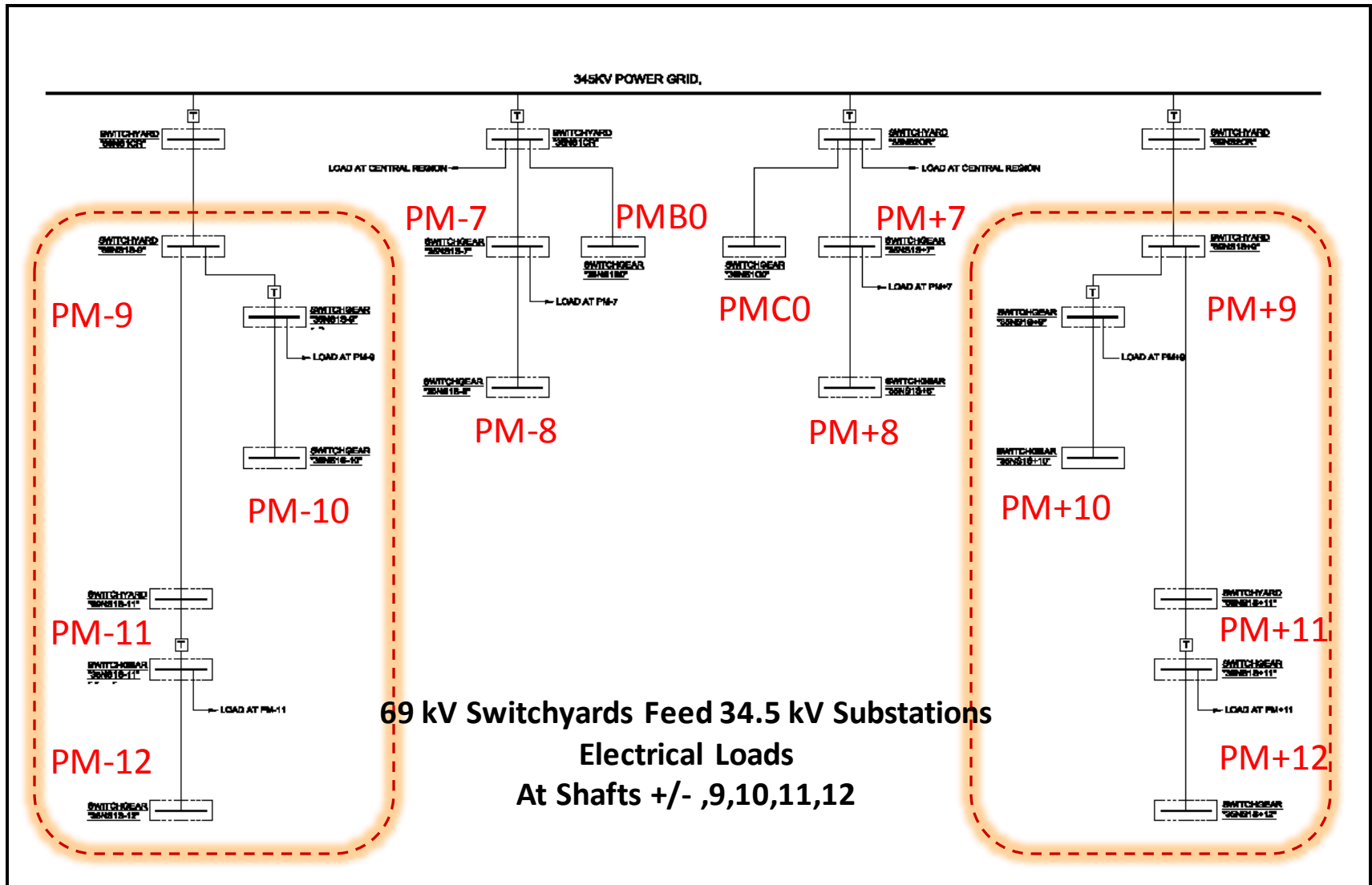
Americas Region

Conventional Electrical System Design

Summary



## Medium Voltage Power Distribution

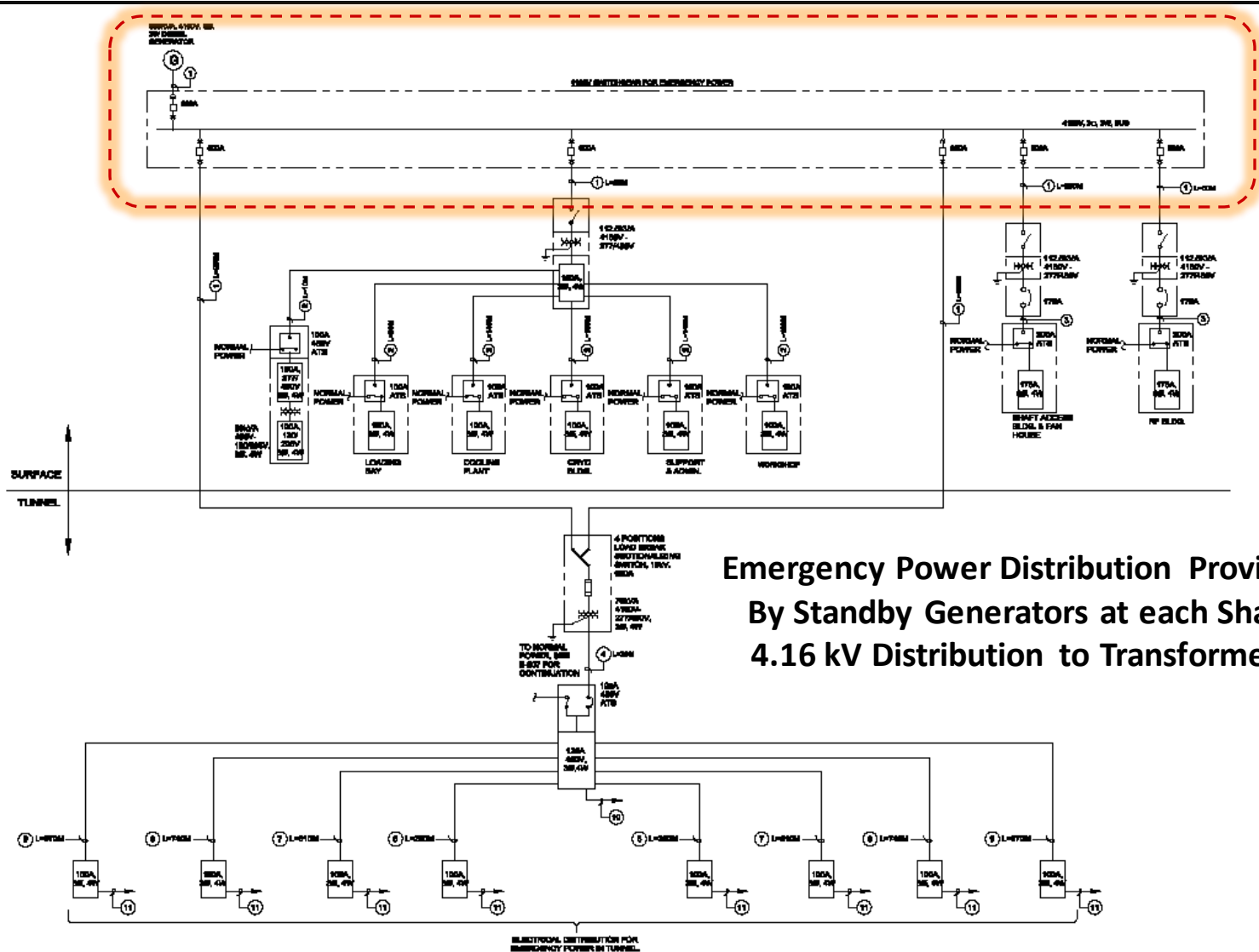


## Medium Voltage Power Distribution

Americas Region

Conventional Electrical System Design

Summary



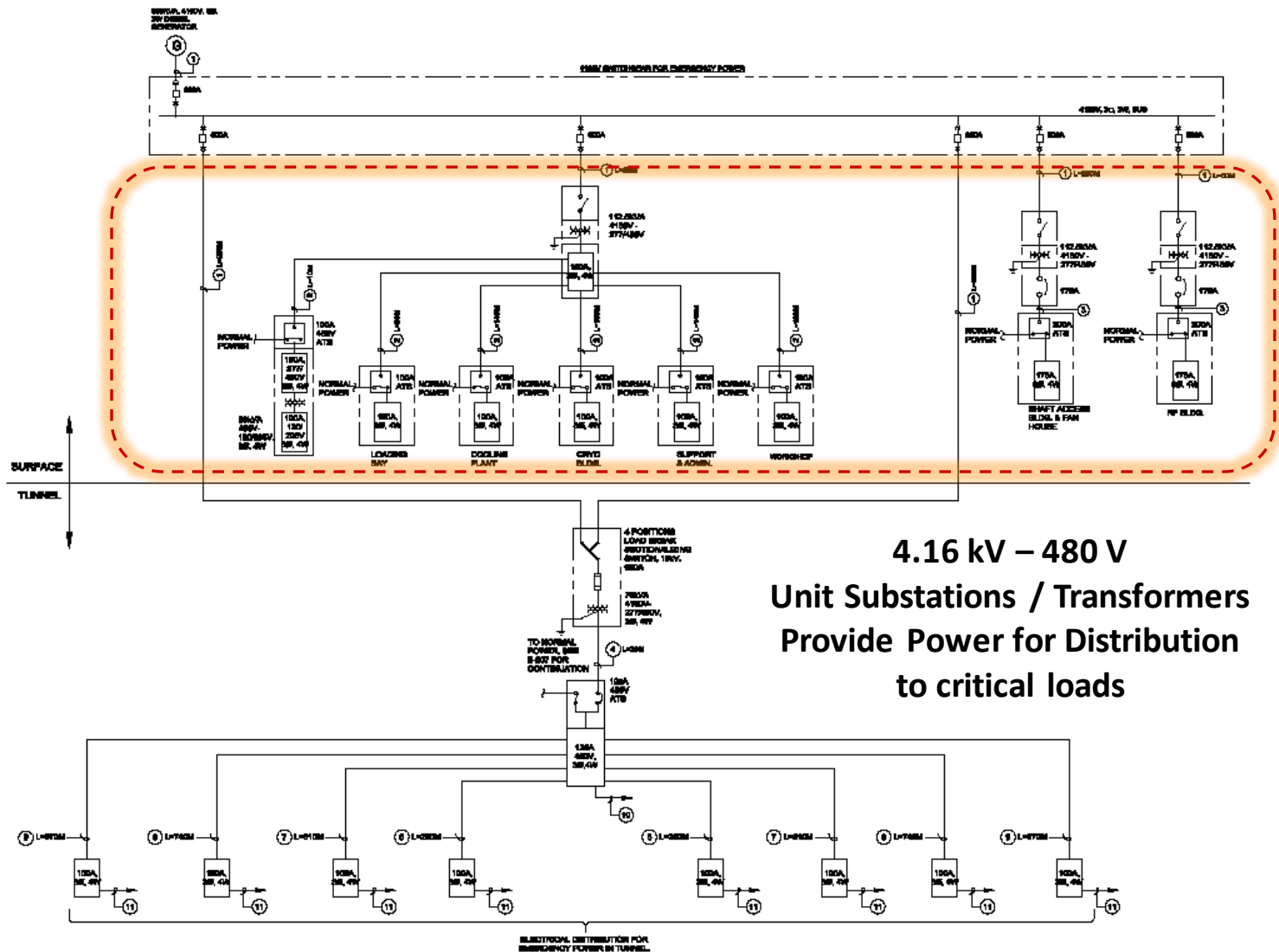
**Emergency Power Distribution Provided  
By Standby Generators at each Shaft  
4.16 kV Distribution to Transformers**

## Emergency Power Distribution

Americas Region

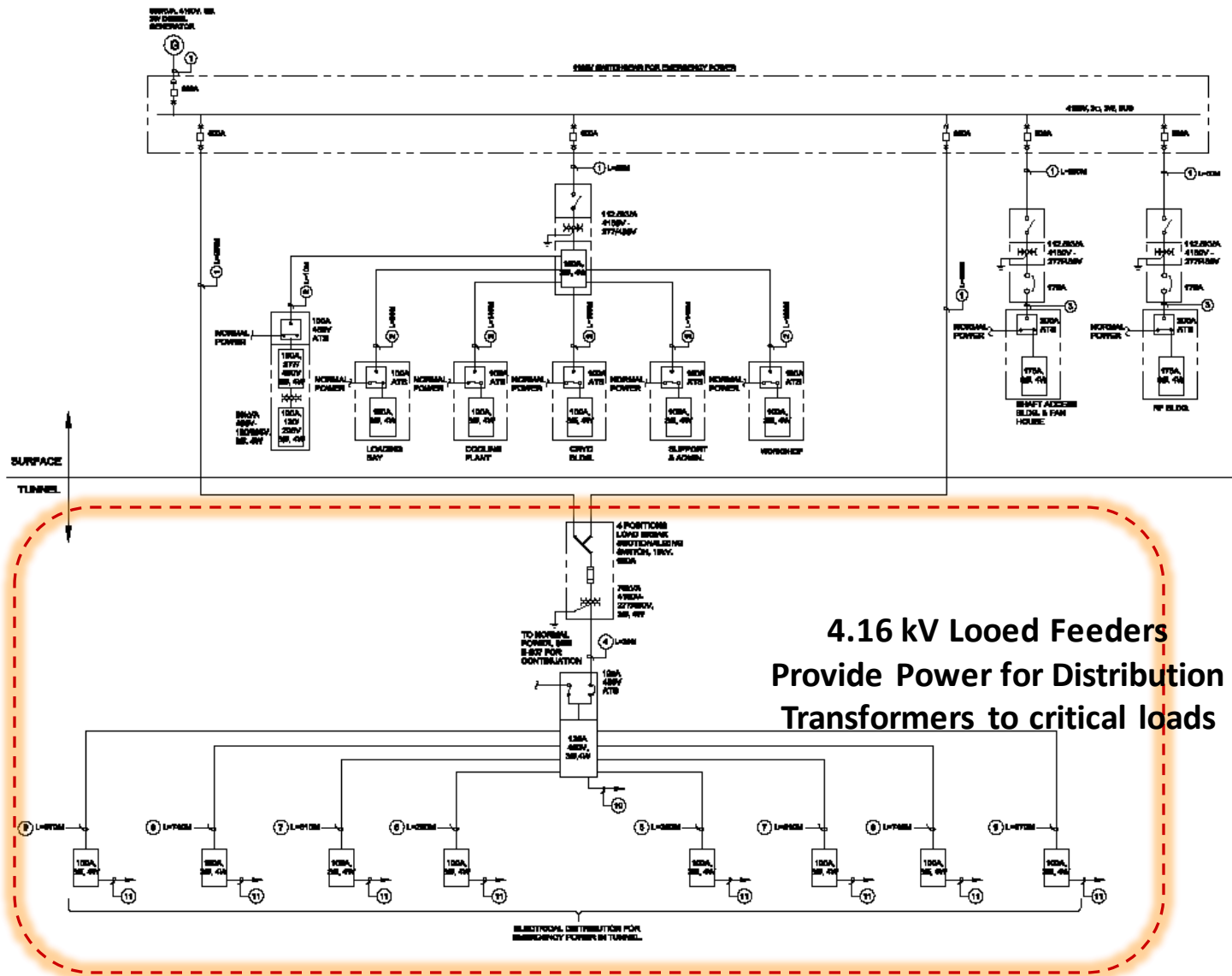
Conventional Electrical System Design

Summary



## Emergency Power Distribution



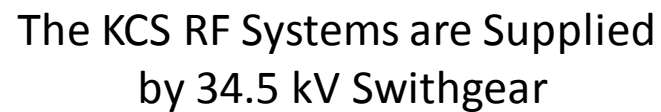


# Emergency Power Distribution

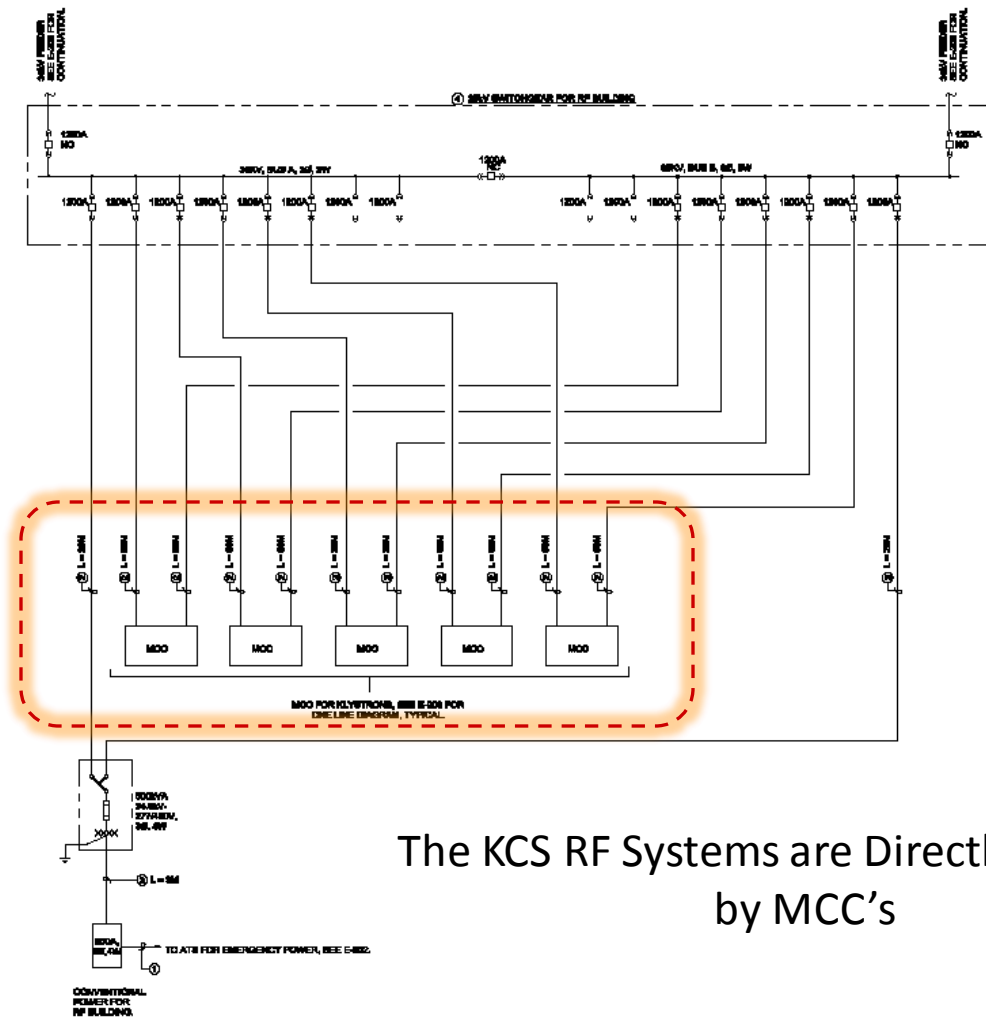
Americas Region

Conventional Electrical System Design

Summary



## Conventional Electrical System Design Summary



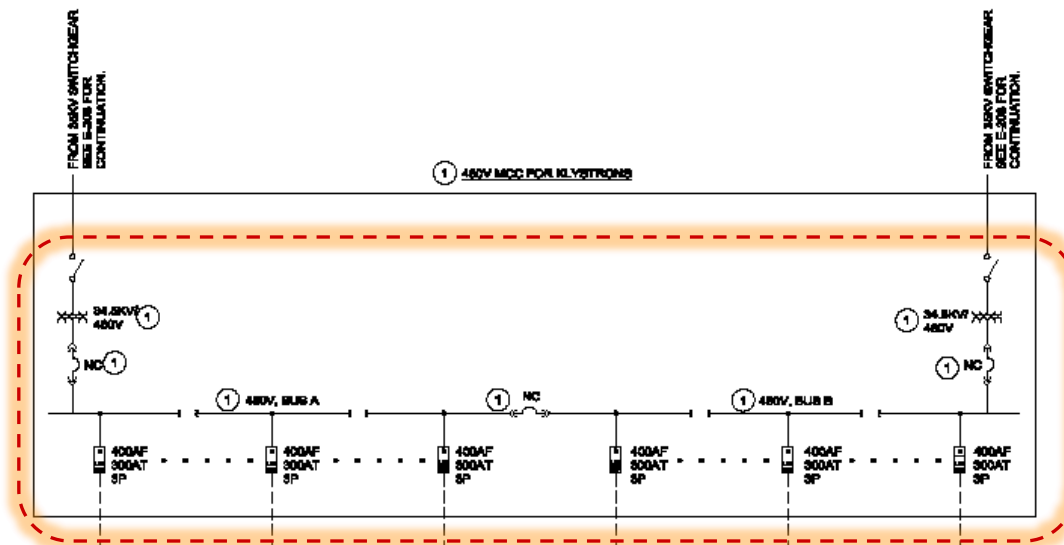
The KCS RF Systems are Directly Supplied  
by MCC's

## Power Distribution for RF

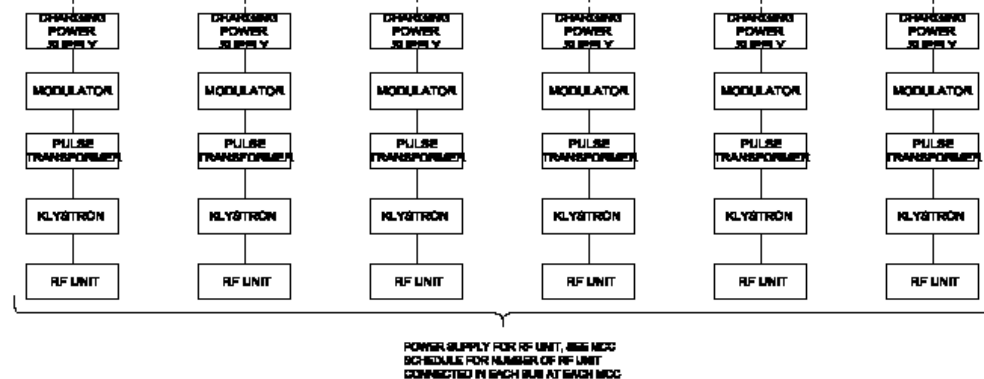
Americas Region

Conventional Electrical System Design

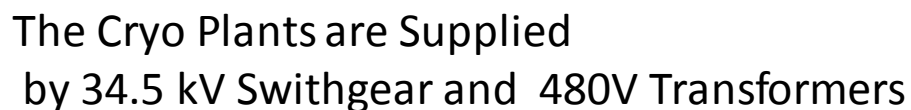
Summary



The KCS RF Systems are Supplied  
by 480V Transformers & MCC's



## Power Distribution for RF



## 29

# Parsons Electrical Cost Estimate

- Bottoms Up Estimate
- Mid 2011 Base Year
- RAW Numbers – “Brick & Mortar”
- KCS - Full Power Criteria

# Questions?