



University of Idaho

College of Engineering

UI CAMPUS MICROGRID EXPANSION SENIOR DESIGN

“THE FACILITATORS”

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VALUE PROPOSITION

Our project reveals the effects associated with the expansion of the microgrid and will expose the pros and cons pertaining to the capacity, connectivity, protection, and overall efficiency of the grid. We will also highlight the best suited technology for these applications.

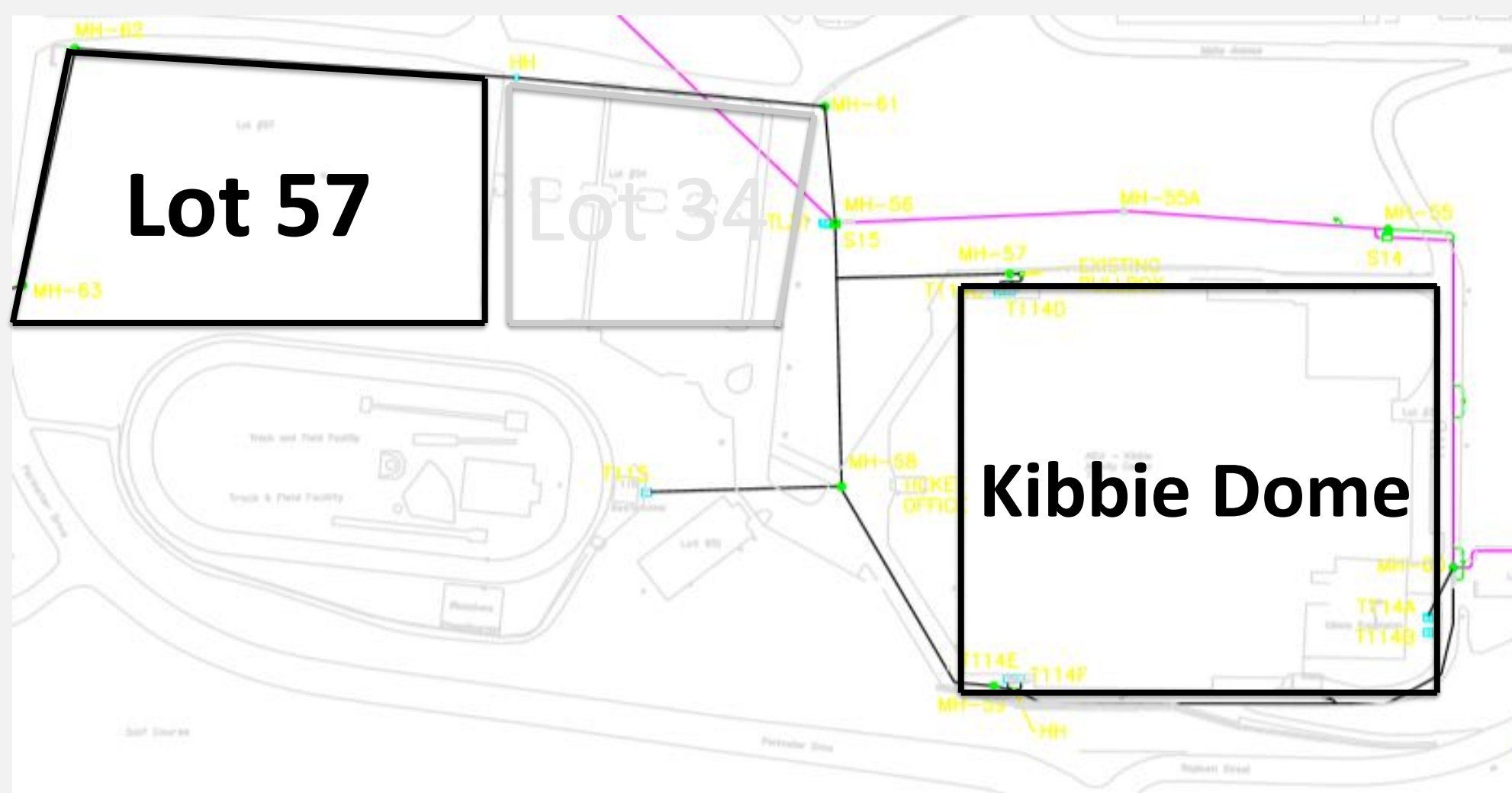
PROJECT GOAL

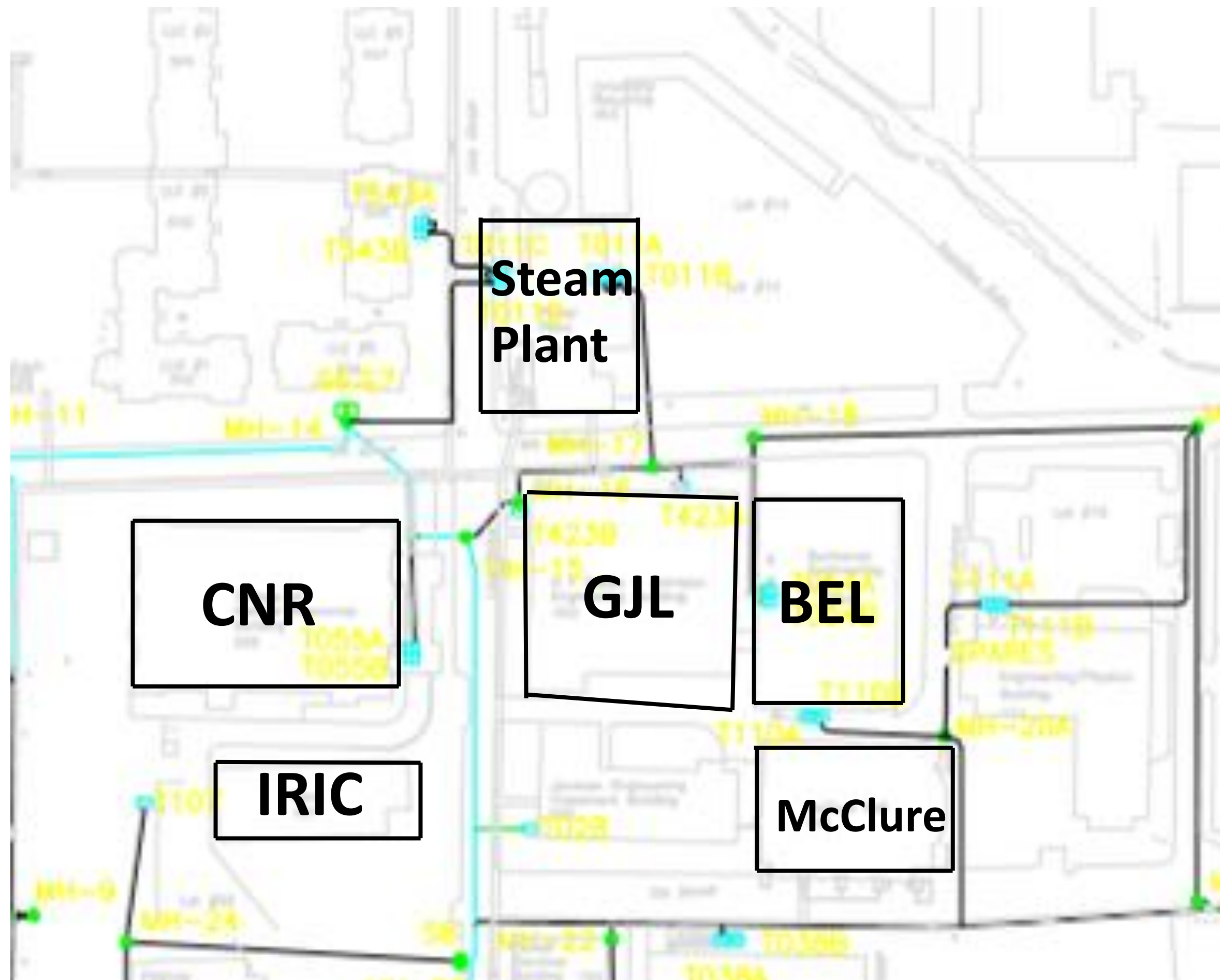
- I Expand the current campus microgrid design to integrate the new solar generation from the 1 MW array, the IRIC array, as well as the critical load of the wells.
- I Relays, switches, and controls will be tactfully integrated to ensure effective grid diagnostics and controllability. (Islanding/Load Shedding)
- I Determine which loads can be supported given available generation and under specific use case scenarios.
- I Account for seasonal changes and their effects on energy efficiency.



AVAILABLE GENERATION

- I UI Steam Plant Turbines
- I IRIC Solar Array
- I Solar Backup Power Array
- I Backup Generators





LOADS

- I Buchanan Engineering Lab
- I Gauss-Johnson Engineering Lab
- I College of Natural Resources
- I McClure
- I Steam Plant
- I Wells
- I IRIC

USE CASES

Worst case scenario

- I All necessary generation must be diverted to supplying the load of the wells to provide water to campus and aide in fire suppression.

Best Case scenario

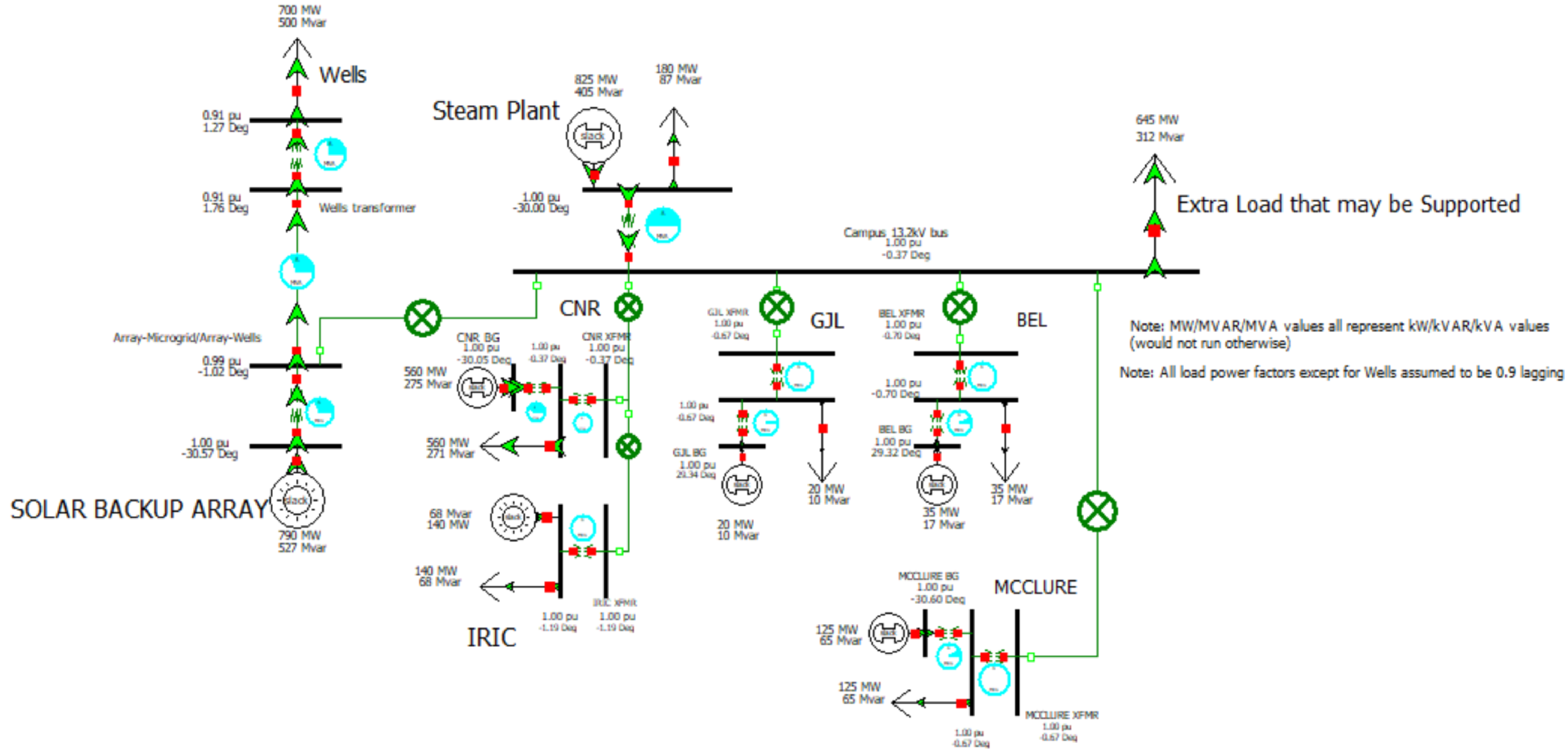
- I Available generation from not running well pumps may be used to support additional load on campus.

DESIGN APPROACH

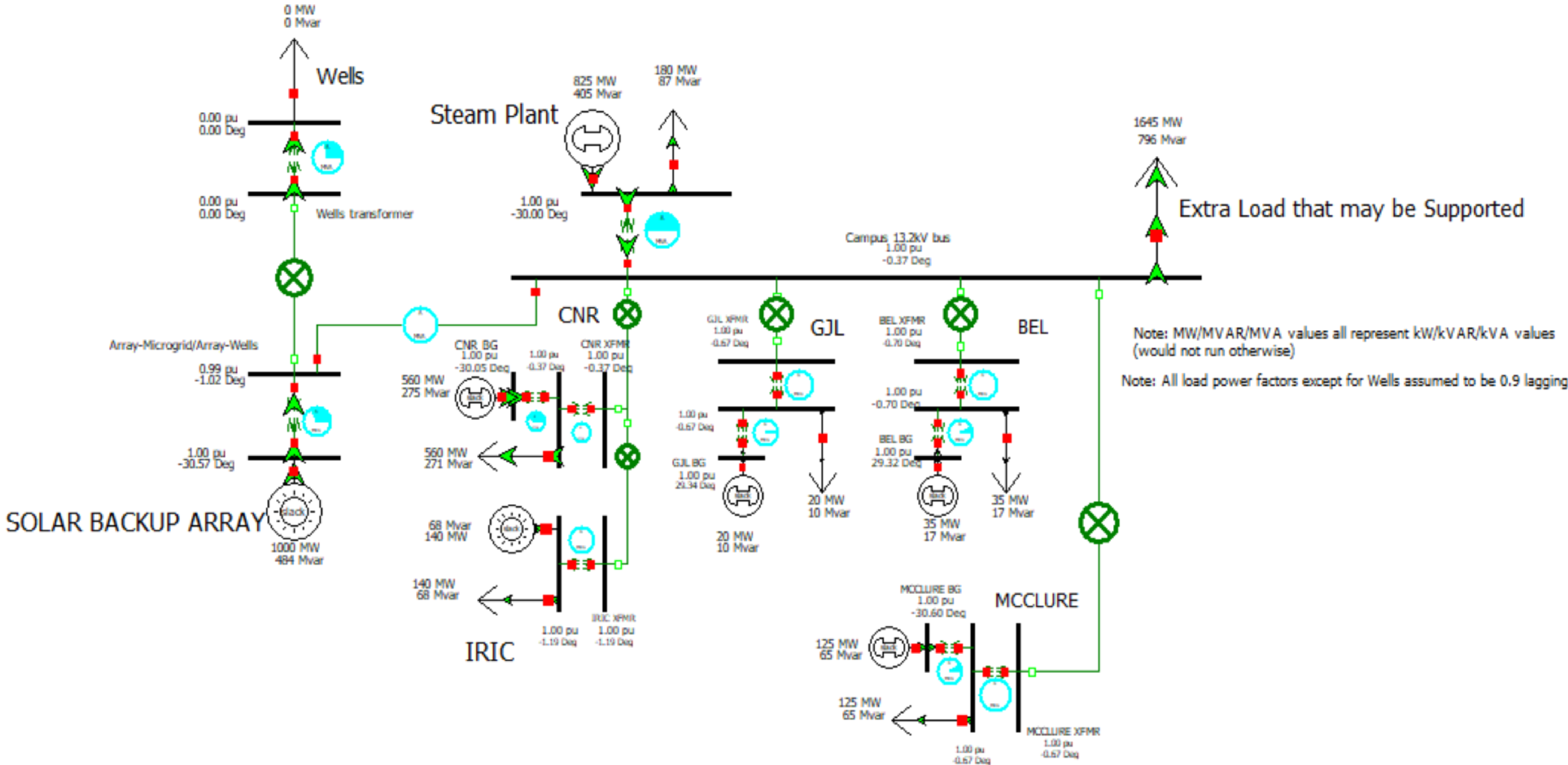
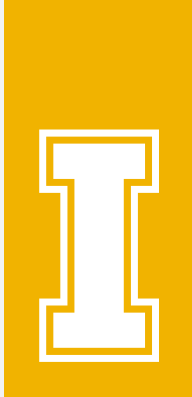
Simulate the expanded microgrid using PowerWorld:

- I Power flow analysis
- I Seasonal Analysis
- I Fault Analysis
- I Load shedding Analysis
- I N-1 Contingency analysis (What if scenarios)
- I Determine necessary equipment and allocation

POWER FLOW ANALYSIS (WORST CASE SCENARIO)



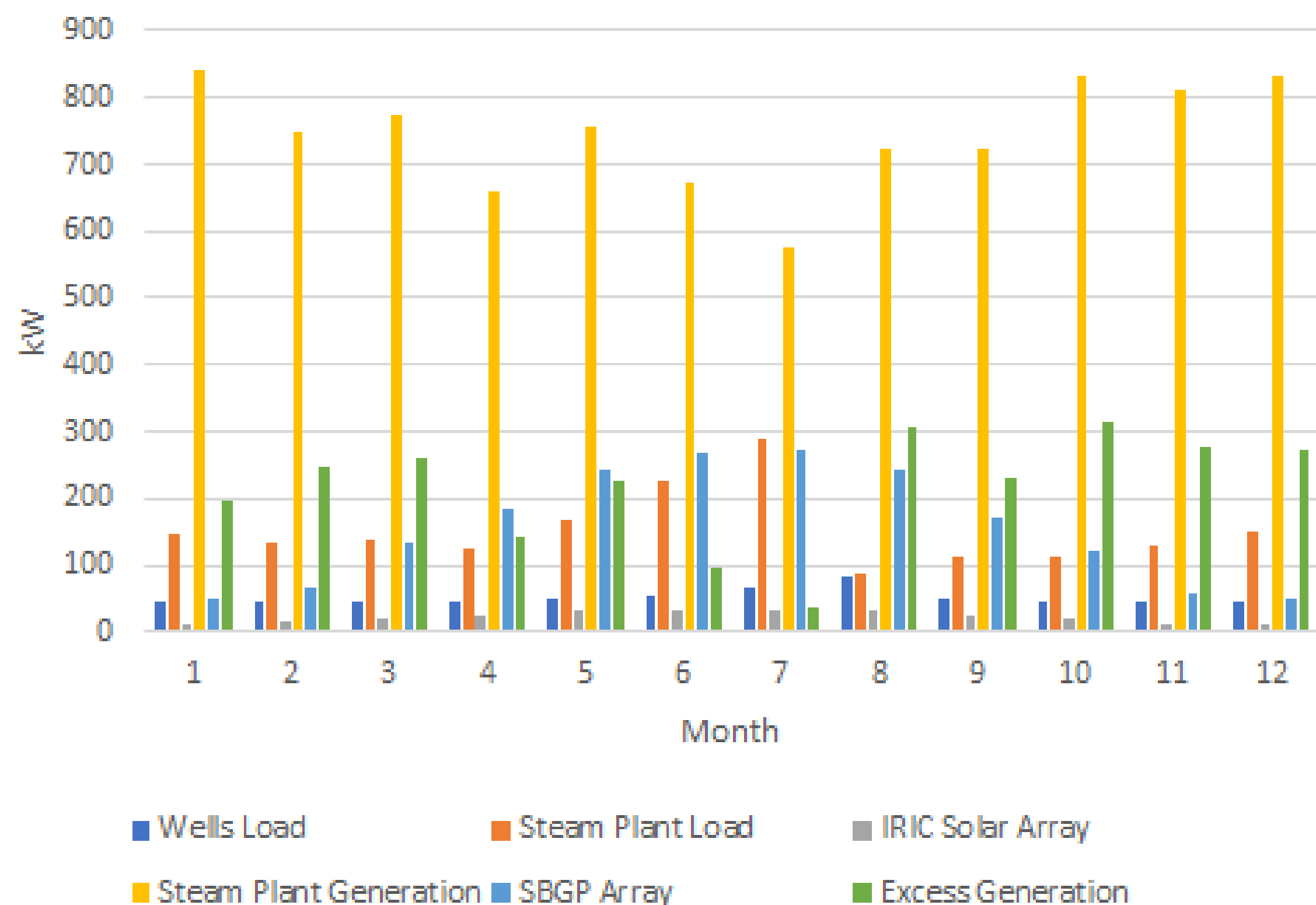
POWER FLOW ANALYSIS (BEST CASE SCENARIO)



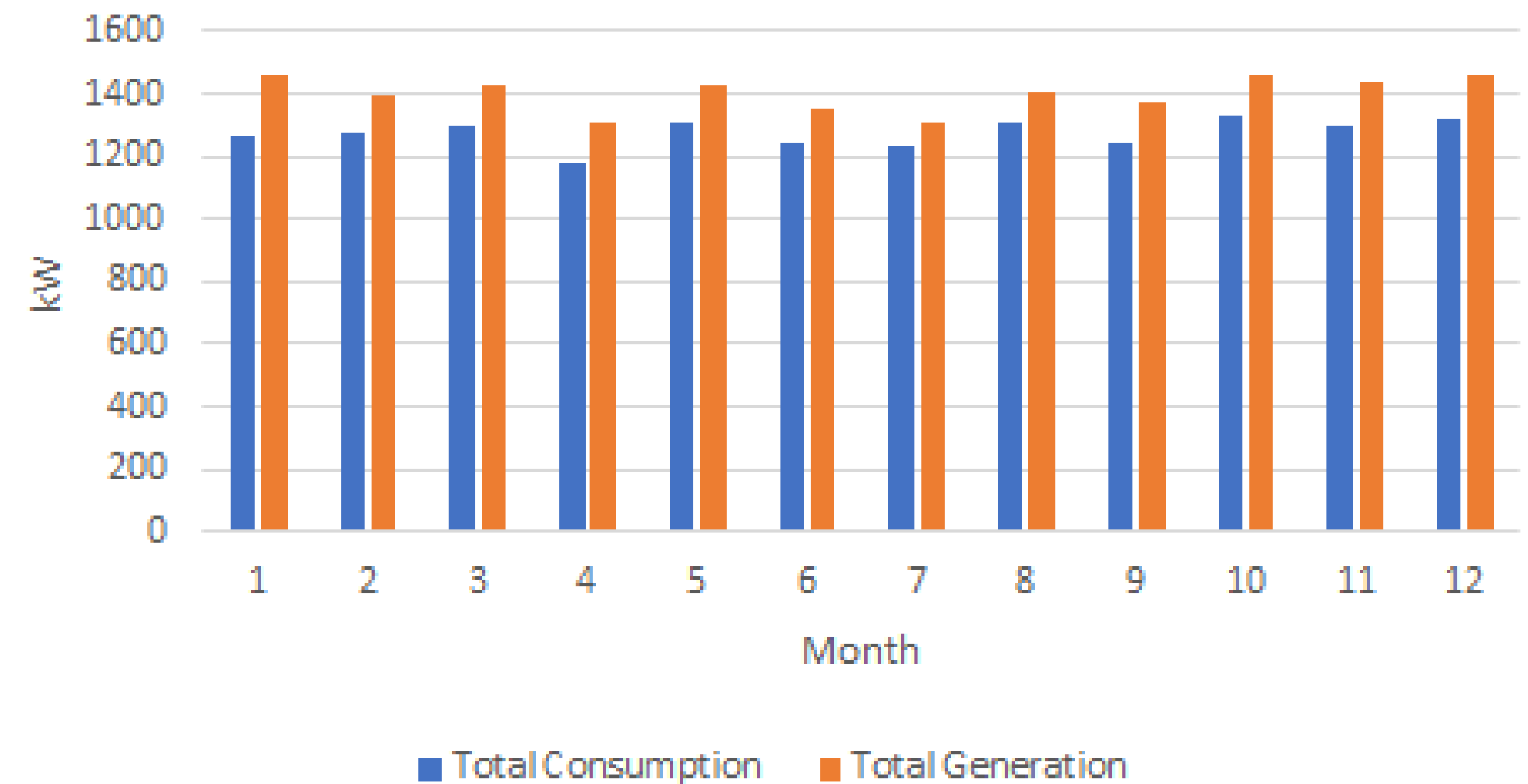


SEASONAL ANALYSIS

Monthly Values for Loads and Generation

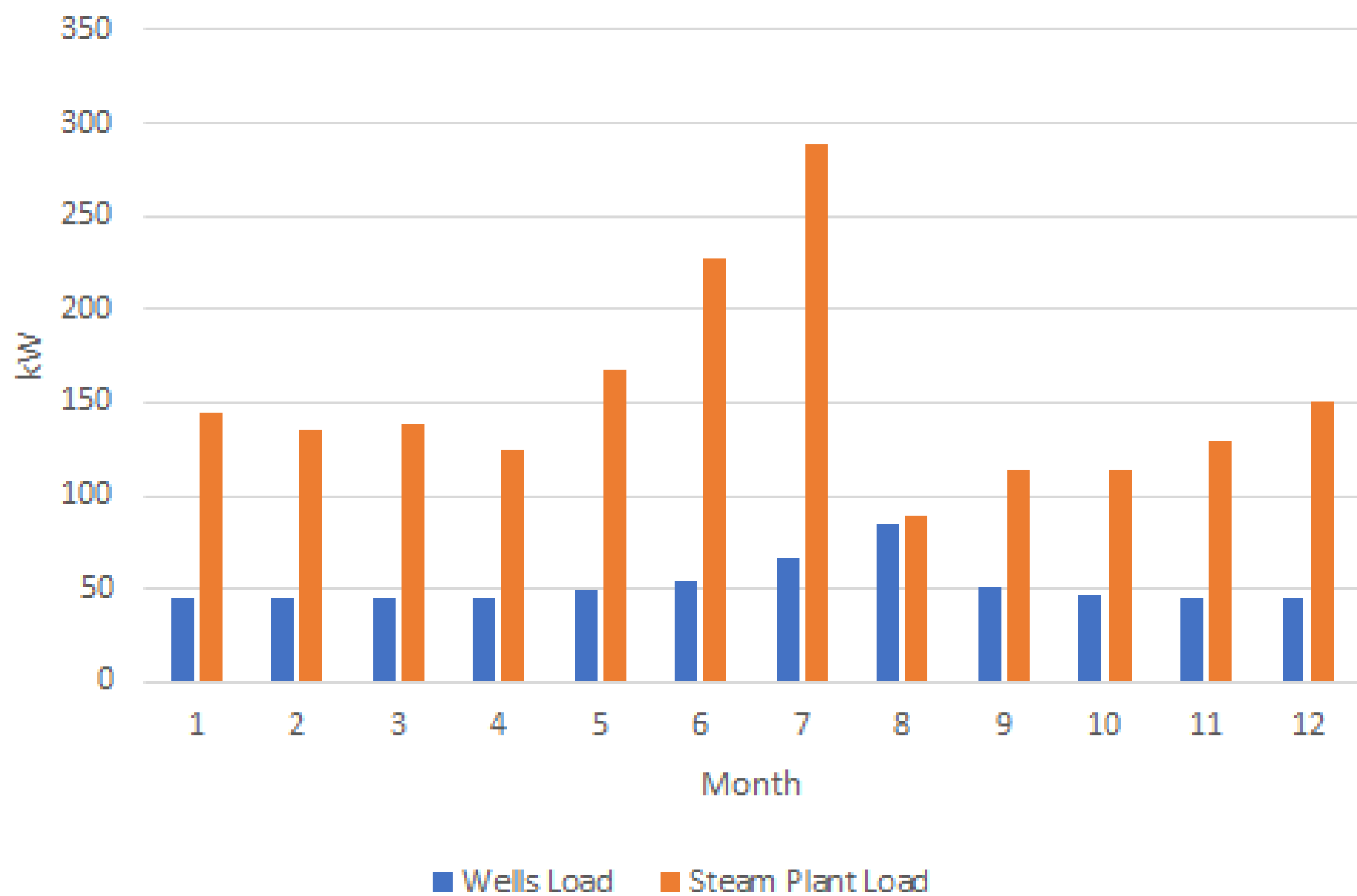


Monthly Total Consumption and Generation

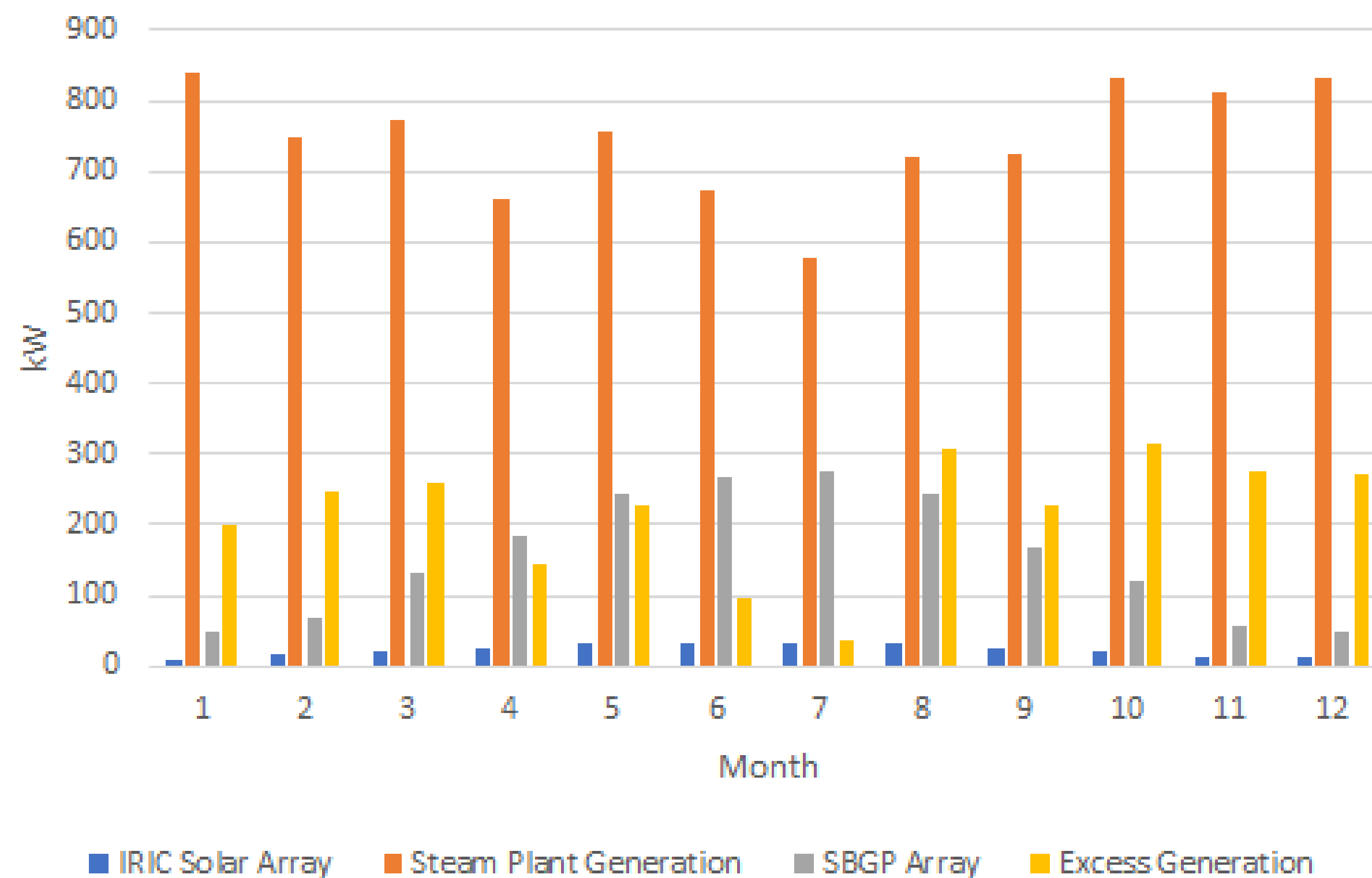


SEASONAL ANALYSIS CONT.

Monthly Values for Loads



Monthly Values for Generation





FAULT ANALYSIS

BUS RECORDS:

	Number	Name	Phase Volt A	Phase Volt B	Phase Volt C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	SOLAR BACKUP	0.22180	0.79696	0.94349	-76.98	-126.69	64.61
2	2	Array-Microgrid	0.38773	0.99476	0.64654	38.34	-121.02	71.19
3	3	Wells transform	0.35515	0.91118	0.59222	41.11	-118.24	73.96
4	4	Wells	0.35299	0.90563	0.58861	40.63	-118.73	73.48
5	5	Campus 13.2kV	0.99684	0.99684	0.99684	-0.37	-120.37	119.63
6	6	Steam Plant	1.00000	1.00000	1.00000	-30.00	-150.00	90.00
7	7	CNR XFMR	0.99727	0.99727	0.99727	-0.37	-120.37	119.63
8	8	CNR	0.99727	0.99727	0.99727	-0.37	-120.37	119.63
9	9	CNR BG	1.00000	1.00000	1.00000	-30.05	-150.05	89.95
10	10	IRIC XFMR	1.00000	1.00000	1.00000	-1.19	-121.19	118.81
11	11	IRIC	1.00000	1.00000	1.00000	-1.19	-121.19	118.81
12	12	GJL XFMR	0.99990	0.99990	0.99990	-0.67	-120.67	119.33
13	13	GJL	0.99990	0.99990	0.99990	-0.67	-120.67	119.33
14	14	GJL BG	1.00000	1.00000	1.00000	29.34	-90.66	149.34
15	15	BEL XFMR	0.99983	0.99983	0.99983	-0.70	-120.70	119.30
16	16	BEL	0.99983	0.99983	0.99983	-0.70	-120.70	119.30
17	17	BEL BG	1.00000	1.00000	1.00000	29.32	-90.68	149.32
18	18	MCCLURE XFMR	0.99935	0.99935	0.99935	-0.67	-120.67	119.33
19	19	MCCLURE	0.99935	0.99935	0.99935	-0.67	-120.67	119.33
20	20	MCCLURE BG	1.00000	1.00000	1.00000	-30.60	-150.60	89.40



FAULT ANALYSIS CONT.

LINES:

	From Number	From Name	To Number	To Name	Circuit	Xfrmr	Phase Cur A From	Phase Cur B From	Phase Cur C From	Phase Cur A To	Phase Cur B To	Phase Cur C To
1	1	SOLAR BAC	2	Array-Micro	1	YES	23902.85	40467.34	59609.71	445315.84	1142519.25	742582.06
2	2	Array-Micro	3	Wells trans	1	NO	445319.53	1142520.38	742579.25	16193.44	41546.20	27002.88
3	2	Array-Micro	5	Campus 13	1	NO	0.00	0.00	0.00	0.00	0.00	0.00
4	3	Wells trans	4	Wells	1	YES	16193.47	41546.27	27002.98	89064.05	228504.44	148516.38
5	6	Steam Plant	5	Campus 13	1	YES	864741.56	864741.50	864741.50	31445.10	31445.10	31445.10
6	5	Campus 13	7	CNR XFMR	1	NO	0.00	0.00	0.00	0.00	0.00	0.00
7	5	Campus 13	12	GJL XFMR	1	NO	0.00	0.00	0.00	0.00	0.00	0.00
8	5	Campus 13	15	BEL XFMR	1	NO	0.00	0.00	0.00	0.00	0.00	0.00
9	5	Campus 13	18	MCCLURE XFMR	1	NO	0.00	0.00	0.00	0.00	0.00	0.00
10	8	CNR	7	CNR XFMR	1	YES	0.00	0.00	0.00	0.00	0.00	0.00
11	7	CNR XFMR	10	IRIC XFMR	1	NO	0.00	0.00	0.00	0.00	0.00	0.00
12	9	CNR BG	8	CNR	1	YES	1300255.50	1300255.50	1300255.50	750354.44	750354.44	750354.44
13	11	IRIC	10	IRIC XFMR	1	YES	0.02	0.02	0.02	0.00	0.00	0.00
14	12	GJL XFMR	13	GJL	1	YES	0.00	0.00	0.00	0.00	0.00	0.00
15	13	GJL	14	GJL BG	1	YES	26896.67	26896.67	26896.67	46610.46	46610.46	46610.46
16	15	BEL XFMR	16	BEL	1	YES	0.00	0.00	0.00	0.00	0.00	0.00
17	16	BEL	17	BEL BG	1	YES	46809.79	46809.79	46809.78	81116.88	81116.88	81116.88
18	19	MCCLURE XFMR	18	MCCLURE XFMR	1	YES	0.00	0.00	0.00	0.00	0.00	0.00
19	20	MCCLURE XFMR	19	MCCLURE XFMR	1	YES	293855.16	293855.16	293855.16	169577.42	169577.42	169577.41

FAULT ANALYSIS CONT.

GENERATORS:

	Number of Bus	Name of Bus	Phase Cur A	Phase Cur B	Phase Cur C	Phase Ang A	Phase Ang B	Phase Ang C
1	1	SOLAR BACKUP	73090.05	40467.26	59609.73	-85.88	149.80	59.95
2	6	Steam Plant	1105204.85	1105204.97	1105204.85	-56.12	-176.12	63.88
3	9	CNR BG	1300250.20	1300250.30	1300250.20	-56.20	-176.20	63.80
4	11	IRIC	187206.57	187206.57	187206.58	-27.09	-147.09	92.91
5	14	GJL BG	46610.98	46610.99	46610.98	2.77	-117.23	122.77
6	17	BEL BG	81114.11	81114.11	81114.11	3.39	-116.61	123.39
7	20	MCCLURE BG	293848.04	293848.07	293848.04	-58.14	-178.14	61.86

LOADS:

	Number of Bus	Name of Bus	ID	Phase Cur A	Phase Cur B	Phase Cur C
1	4	Wells	1	89063.91851	228504.14336	148515.93549
2	5	Campus 13.2kV	1	31445.10622	31445.10622	31445.10622
3	6	Steam Plant	1	240469.37330	240469.37330	240469.37330
4	8	CNR	1	750352.76275	750352.76275	750352.76275
5	11	IRIC	1	187206.55320	187206.55320	187206.55320
6	13	GJL	1	26898.40825	26898.40825	26898.40825
7	16	BEL	1	46809.60342	46809.60342	46809.60342
8	19	MCCLURE	1	169574.81793	169574.81793	169574.81793

LOAD SHEDDING ANALYSIS

AFTER CHANGING THE POWER OF THE STEAM TURBINE GENERATOR FROM 1000 MVA TO 900MVA TO SIMULATE THE LOAD IN THE UNDERVOLTAGE STATE.

Name	Area Name	Nom kV	PU Volt	Volt (kV)	Angle (Deg)	Load MW	Load Mvar	Gen MW	Gen Mvar
CNR←									
Campus 13.2k 1		13.20	0.99826	13.177	-1.31	645.00	312.38		
GJL←									
Campus 13.2k 1		13.20	0.99810	13.175	-1.34	645.00	312.38		
BEL←									
Campus 13.2k 1		13.20	0.99811	13.175	-1.46	645.00	312.38		
MCCLURE←									
Campus 13.2k 1		13.20	0.99818	13.176	-1.47	645.00	312.38		

The voltage of campus is closest to 13.2 kV when we choose to shed the CNR.

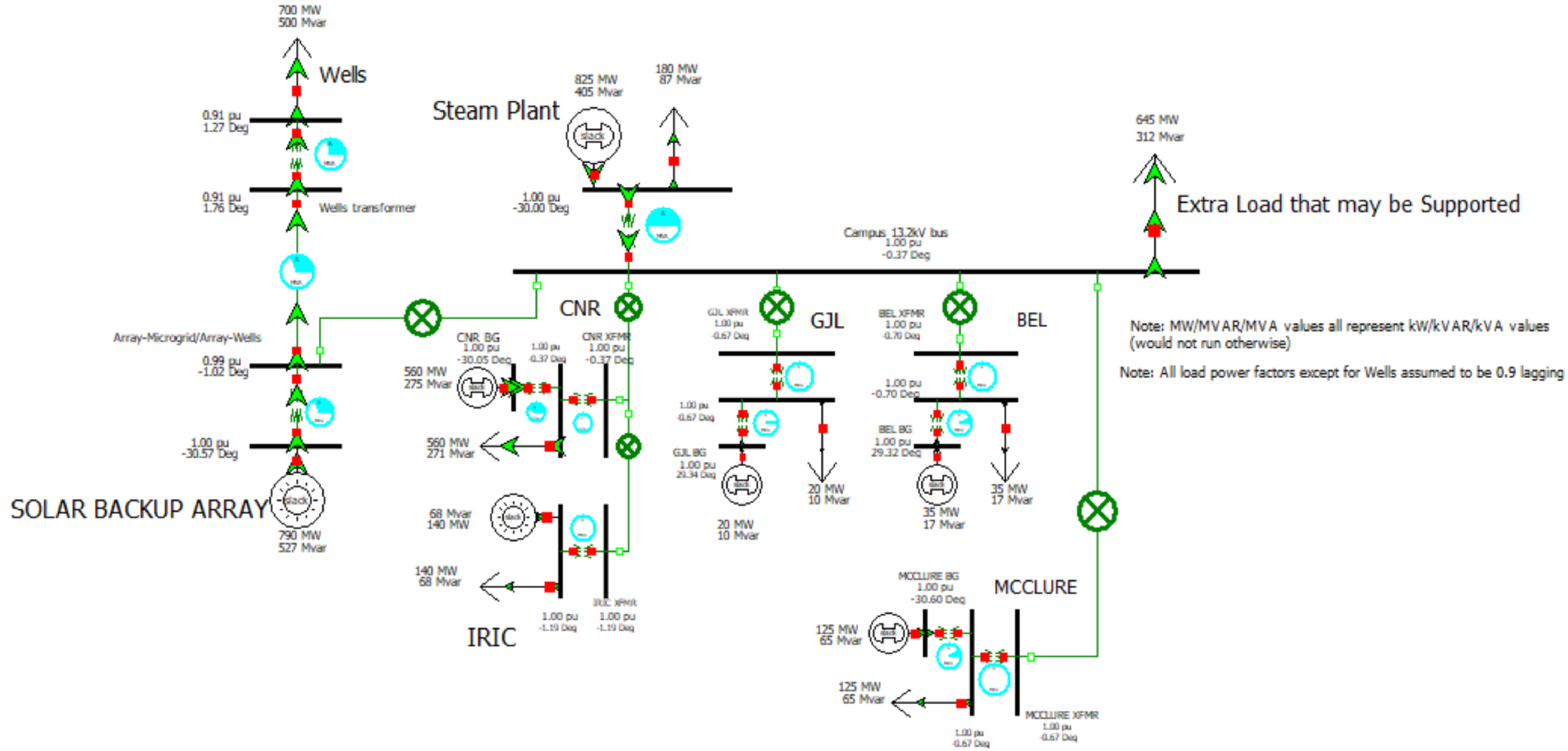
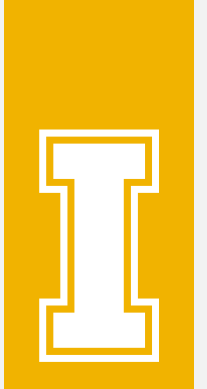


N-1 CONTINGENCY ANALYSIS

CONTINGENCIES :

	Label	Skip	Category	Processed	Solved	Include Remedial Actions	Screen Allow	Post-CTG AUX	Islanded Load	Islanded Gen	Global Actions	Transient Actions	Remedial Actions	Custom Monitor Violations	Violations	Max Branch %	Min Volt	Max Volt
1	T_000001SOLARBACKUPARRAY-000002Array-Microgrid/Array-WellsC1	NO		YES	YES	YES	NO	none	700.00		0	0	0	0	0			
2	T_000002Array-Microgrid/Array-Wells-000003WellstransformerC1	NO		YES	YES	YES	NO	none	700.00		0	0	0	0	0			
3	T_000002Array-Microgrid/Array-Wells-000005Campus13.2kVbusC1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
4	T_000003Wellstransformer-000004WellsC1	NO		YES	YES	YES	NO	none	700.00		0	0	0	0	0			
5	T_000006SteamPlant-000005Campus13.2kVbusC1	NO		YES	YES	YES	NO	none	645.00		0	0	0	0	0			
6	L_000005Campus13.2kVbus-000007CNRXFMRC1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
7	L_000005Campus13.2kVbus-000012GJLXFMR1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
8	L_000005Campus13.2kVbus-000015BELXFMR1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
9	L_000005Campus13.2kVbus-000018MCCLUREXFMRC1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
10	T_000008CNR-000007CNRXFMRC1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
11	L_000007CNRXFMRC-000010IRICXFMR1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
12	T_000009CNRBG-000008CNR1	NO		YES	YES	YES	NO	none	560.00		0	0	0	0	0			
13	T_000011IRIC-000010IRICXFMR1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
14	T_000012GJLXFMR-000013GJLC1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
15	T_000013GJL-000014GJLBGC1	NO		YES	YES	YES	NO	none	20.00		0	0	0	0	0			
16	T_000015BELXFMR-000016BELC1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
17	T_000016BEL-000017BELBGC1	NO		YES	YES	YES	NO	none	35.00		0	0	0	0	0			
18	T_000019MCCLURE-000018MCCLUREXFMRC1	NO		YES	YES	YES	NO	none			0	0	0	0	0			
19	T_000020MCCLUREBG-000019MCCLUREC1	NO		YES	YES	YES	NO	none	125.00		0	0	0	0	0			
20	G_000001SOLARBACKUPARRAYU1	NO		YES	YES	YES	NO	none	700.00		0	0	0	0	0			
21	G_000006SteamPlantU1	NO		YES	YES	YES	NO	none	825.00		0	0	0	0	0			
22	G_000009CNRBGU1	NO		YES	YES	YES	NO	none	560.00		0	0	0	0	0			
23	G_000011IRICU1	NO		YES	YES	YES	NO	none	140.00		0	0	0	0	0			
24	G_000014GJLBGU1	NO		YES	YES	YES	NO	none	20.00		0	0	0	0	0			
25	G_000017BELBGU1	NO		YES	YES	YES	NO	none	35.00		0	0	0	0	0			
26	G_000020MCCLUREBGU1	NO		YES	YES	YES	NO	none	125.00		0	0	0	0	0			

N-1 CONTINGENCY ANALYSIS CONT.



EQUIPMENT

- I SEL-3555 Real Time Automation Controller (RTAC) will provide complete and flexible system control.
- I SEL-751 Relays will allow for data transmission between sources, loads, and RTAC.
- I SEL-451-5 will synchronize backup generators to the micro grid.





BUDGET

Micro-Grid Expansion Budget Fall 2019-Spring 2020							
Items	Cost P.U.	Qty.	Total				
SEL-451-5 (Generator Synchronizer)	\$ 5,615.00	1	\$ 5,615.00			Total Cost:	\$ 37,344.24
SEL-3555 (RTAC)	\$ 7,195.00	1	\$ 7,195.00				
SEL-751 (Relay)	\$ 990.00	8	\$ 7,920.00			Cost of Risk Insurance	\$ 373.44
2 AWG Cable	\$ 1.21	10200	\$ 12,342.00				
1 in 40 conduit	\$ 4.15	1020	\$ 4,233.00			Total Cost w/ Tax:	\$ 39,958.34
1 in 80 conduit	\$ 6.54	6	\$ 39.24				
2 in 40 conduit	\$ 8.31	0	\$ -			Total Cost w/ Tax and w/ 15%	\$ 45,952.09
2 in 80 conduit	\$ 15.70	0	\$ -				
						Total Cost during project:	\$ 100.00
EXPO Poster	\$ 100.00	1	\$ 100.00				



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QUESTIONS?