University of Illinois Utility Master Plan and Dispatch Model

Presented by:

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ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Affiliated Engineers

International District Energy Association
Campus Energy 2017
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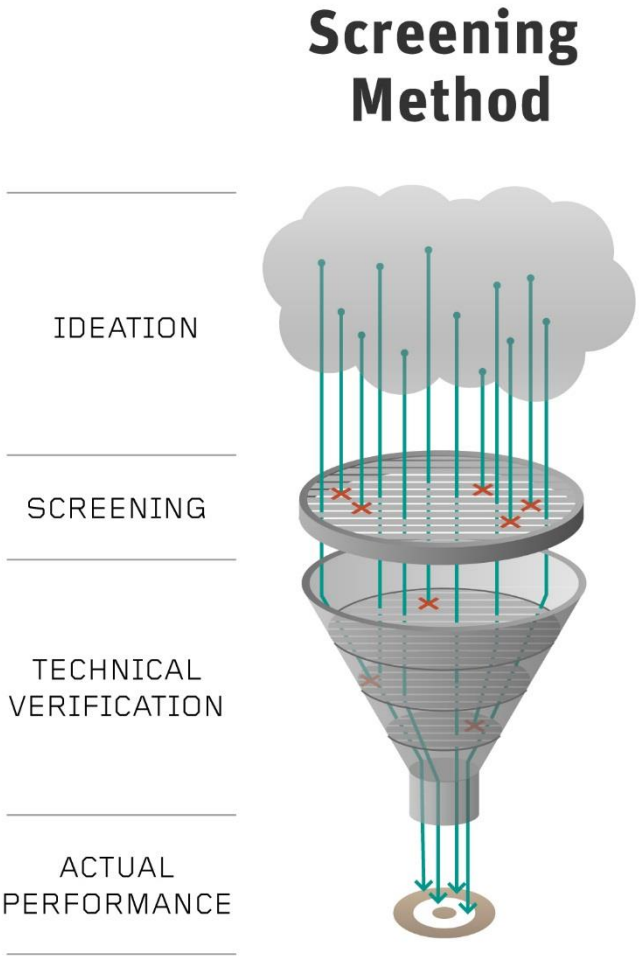
University of Illinois, Urbana - Champaign

- **Abbott Power Plant (APP)**
  - 760,000 pph steam production
  - 89 MW electric production
- **APP generates 275,000 MWH or roughly 50% of campus electricity**
- **APP produces electricity at a carbon dioxide rate of 0.87 lb/kWh**
  - Below EPA standard of 1.0 lb/kWh
  - Under the MACT limits by factor of 15
- **New 5.8 MW photovoltaic facility**
- **DOE Large Scale Testing of Post-Combustion Carbon Capture Technology**
- **Distributed Central Chilled Water System**
  - Six plants producing 58,400 tons chilled water
  - Thermal energy storage
- **Energy consumption dropped more than 24% since 2007**

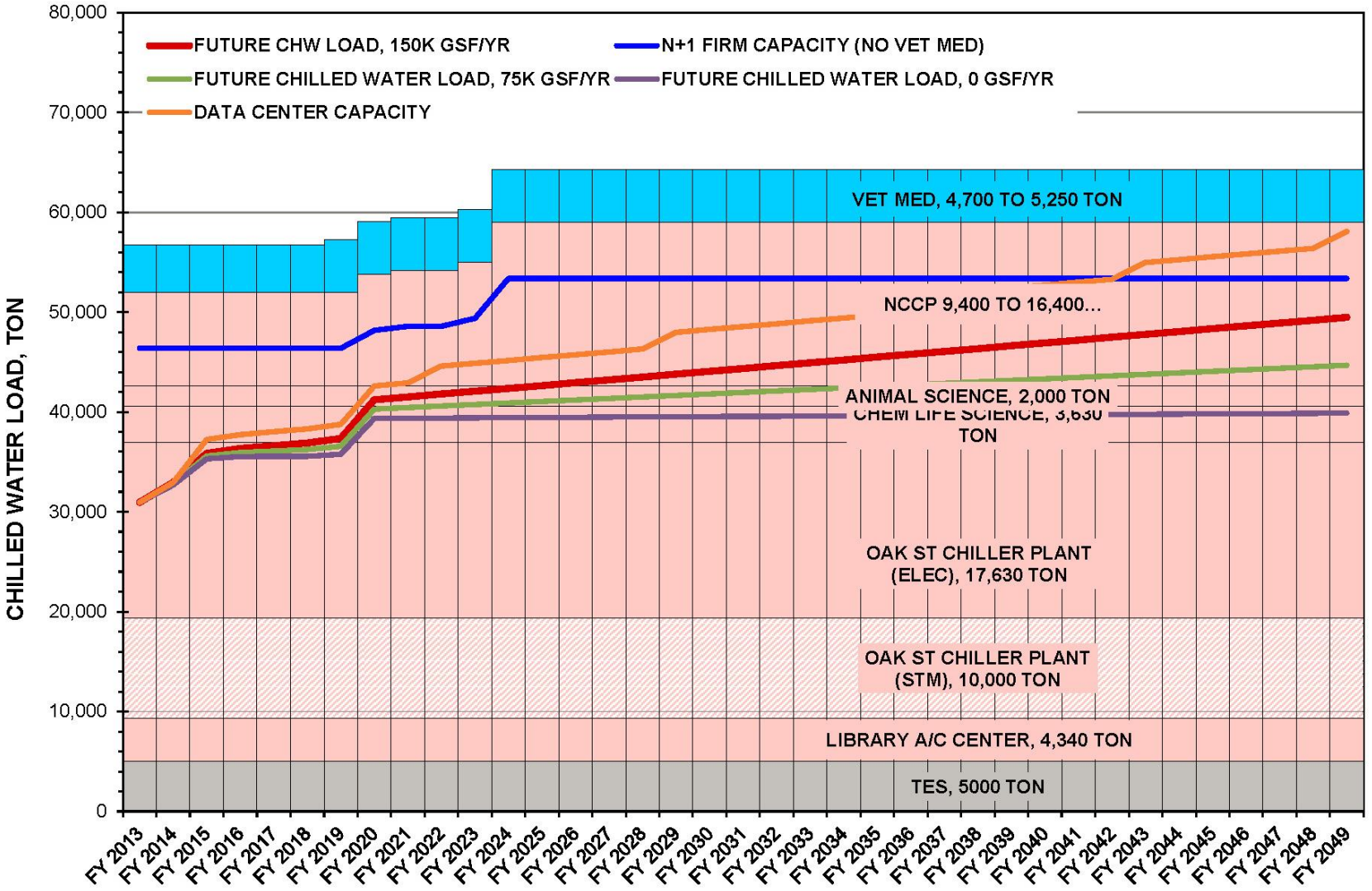
Utilities Production and Distribution Master Plan

Utility Master Plan Approach

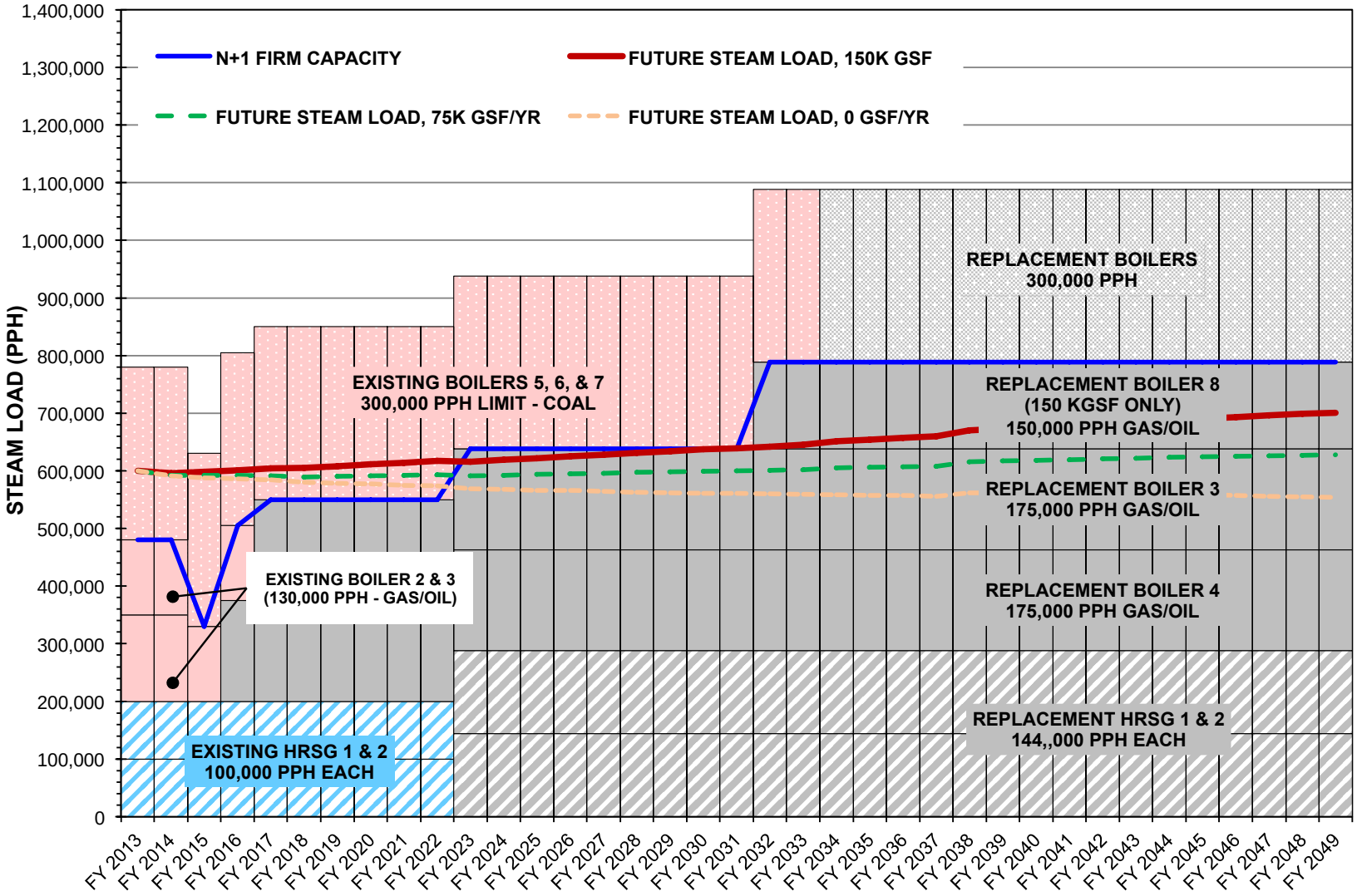
- Detailed Condition Assessment
- Modeling
- Multiple Loading Scenarios
- Initial Screening Analysis
- Stakeholder Involvement
- Detailed Optimization



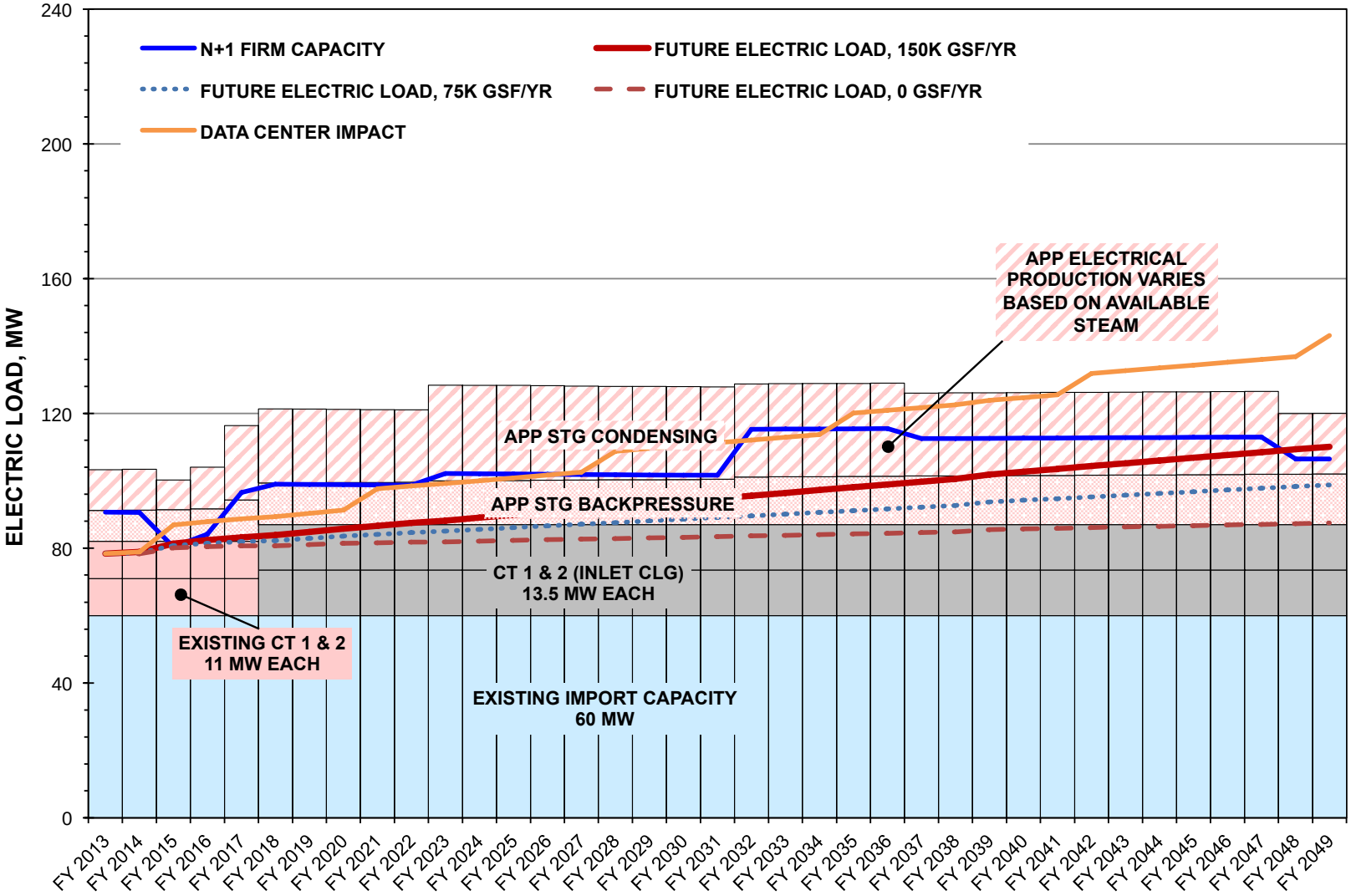
Chilled Water Capacity Vs Future Load



Steam Capacity Vs Future Load



Electrical Capacity Vs Future Load



Future System Global Approaches

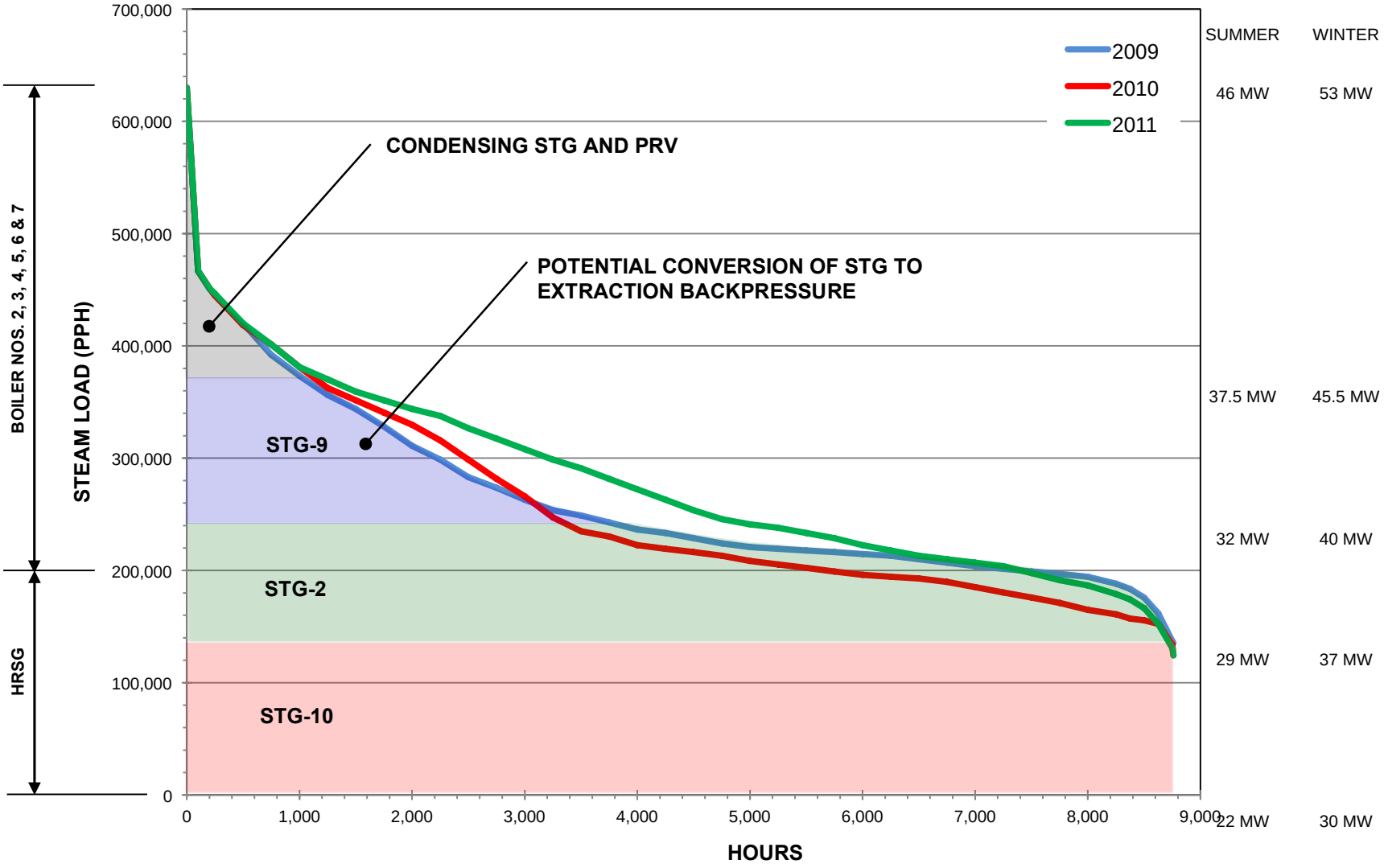
- **Theme 1 Options – NG (with oil backup) and continued power production**
- **Theme 2 Options – NG as primary fuel and no power production**
- **Theme 3 Options – NG as primary fuel with partial renewables**
- **Theme 4 Options – Full renewables and alternative fuels**

LIFE CYCLE COST SUMMARY ($ MILLIONS)

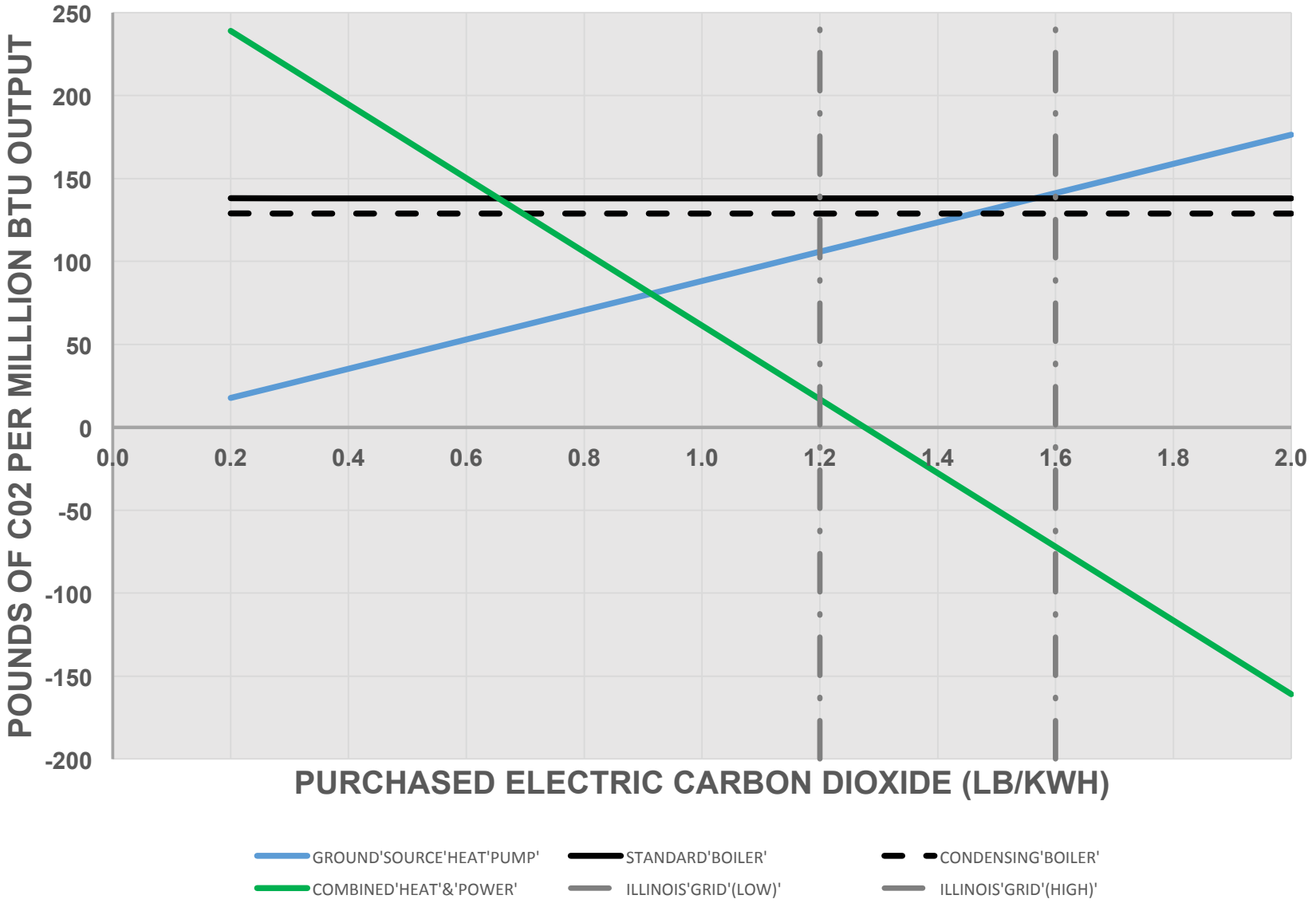
OPT. NO.	DESCRIPTION				NO CAMPUS GROWTH					150,000 GSF/YEAR GROWTH				
	ABBOTT PP					$0 PER TON GHG		$10 PER TON GHG			$0 PER TON GHG		$10 PER TON GHG	
	COAL	GAS	BIO	NEW PLANT	PV CAPEX	TOTAL PRESENT VALUE	TPV BAU DIFF.	TOTAL PRESENT VALUE	TPV BAU DIFF.	PV CAPEX	TOTAL PRESENT VALUE	TPV BAU DIFF.	TOTAL PRESENT VALUE	TPV BAU DIFF.
BAU	●	●			269	1,704	---	1,769	---	288	1,842	---	1,919	---
1.1		●			221	1,638	(66)	1,694	(75)	236	1,767	(75)	1,835	(84)
1.2		●		CHP	250	1,720	16	1,768	(1)	255	1,825	(17)	1,884	(36)
1.3		●		BLR	226	1,663	(41)	1,719	(50)	230	1,780	(62)	1,849	(70)
2.1		●			212	1,820	116	1,902	133	223	1,951	109	2,047	127
2.2		●		BLR	216	1,826	123	1,908	140	216	1,946	104	2,041	122
2.3				CBLR	454	2,124	421	2,203	435	454	2,277	435	2,368	449
3.1			●		294	1,726	22	1,779	10	305	1,846	4	1,909	(10)
3.2		●		HRC	266	1,673	(30)	1,729	(39)	281	1,817	(25)	1,884	(35)
3.3		●		WIND	299	1,725	22	1,777	8	314	1,853	11	1,916	(3)
3.4		●		PHV	413	1,851	147	1,906	137	428	1,976	134	2,043	124
3.5		●	●		274	1,793	89	1,842	74	285	1,924	82	1,984	65
4.1			●		265	2,004	300	2,047	278	273	2,137	295	2,189	270
4.2				GHRC	468	1,912	208	1,993	224	476	2,058	215	2,149	230

NOTES: 1. CHP - COMBINED HEAT AND POWER
BLR - BOILERS
CBLR - BUILDING CONDENSING BOILERS
HRC - HEAT RECOVERY CHILLERS
GHRC - GEOTHERMAL HEAT RECOVERY CHILLERS
PHV - PHOTOVOLTAIC SOLAR
PV - PRESENT VALUE
TPV - TOTAL PRESENT VALUE
GHG - GREEN HOUSE GAS

APP Steam Production Curve



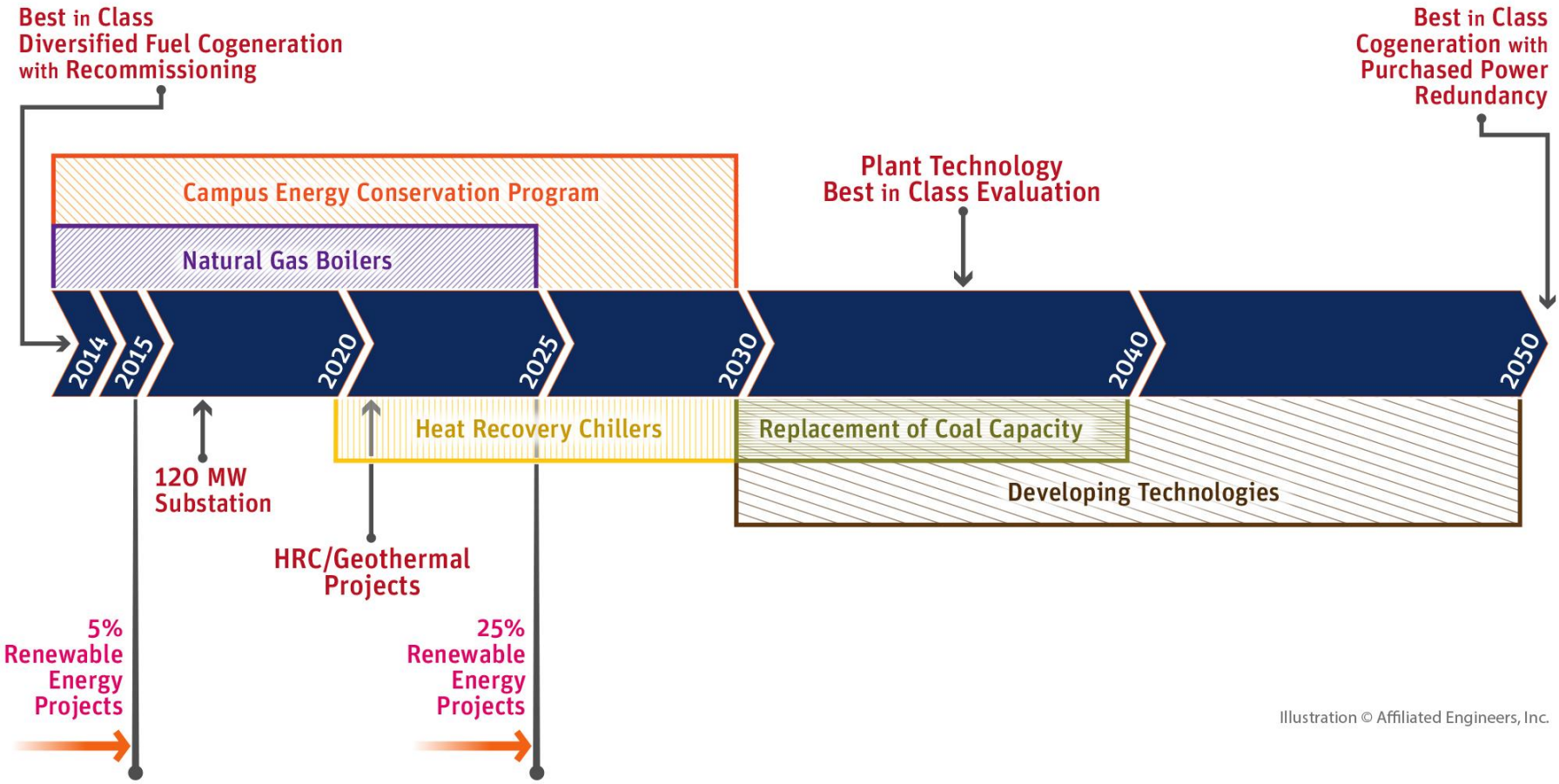
Carbon Footprint for Various Heating Technologies



Utility Master Plan Recommendations

- Increase campus electrical import to 120 MW
- Install three new gas/oil superheated steam boilers
- Install additional backpressure steam turbine generator capacity
- Commit to net zero GSF growth
- Continue with best-in-class diversified fuel cogeneration
- Apply heat-recovery-chiller technologies
- Develop renewable energy projects
- Re-evaluate APP technologies before 2030

Implemented Projects



OPTION 1.1 INFRASTRUCTURE IMPROVEMENT SCHEDULE (TOTAL PROJECT COSTS in 2014

UNIVERSITY OF ILLINOIS - URBANA CHAMPAIGN

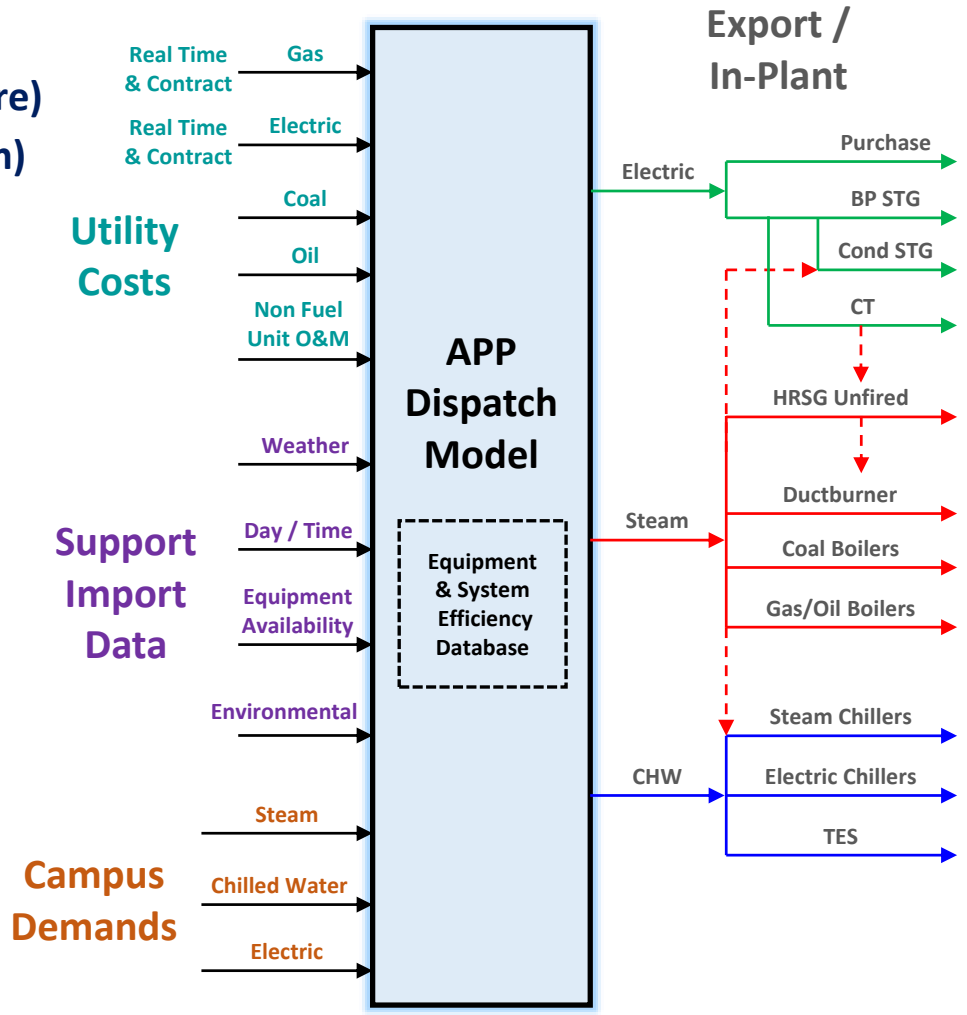
SYSTEM	NO.	DESCRIPTION	TOTAL COST ($)	YEAR 2014 ($)	2015 ($)	2016 ($)	2017 ($)	2018 ($)	2019 ($)
STEAM	H-1	ANCILLARY EQUIPMENT REPAIRS	3,375,000	750,000	750,000	650,000	125,000	600,000	500,000
	H-2	ADDITIONAL BP STG	4,660,000	---	4,660,000	---	---	---	---
	H-3	REPLACEMENT OF HRSG 1 AND 2	27,228,000	---	---	---	---	---	---
	H-4	THIRD GAS BOILER	9,500,000	---	---	9,500,000	---	---	---
	H-5	COMBUSTION TURBINE INLET COOLING	1,250,000	---	---	---	---	1,250,000	---
	H-6	STEAM TUNNEL AND VAULT REPAIR	8,652,000	1,125,000	---	105,800	2,695,800	105,800	2,430,800
	C-7	ASCP REPLACEMENT CHILLERS/TOWERS	5,090,000	---	---	2,088,000	---	---	---
	C-8	ASCP CODE AND LIFE SAFETY	32,000	---	---	18,000	7,000	---	---
	C-9	CLSCP REPLACEMENT CHILLERS/TOWERS	8,506,000	1,742,000	1,742,000	5,022,000	---	---	---
	C-11	CLSCP CODE AND LIFE SAFETY	22,000	---	---	11,000	---	---	---
	C-12	VMCP REPLACEMENT CHILLERS/TOWERS	4,459,000	---	---	576,000	---	---	1,159,000
	C-14	VMCP PIPING/PUMP UPGRADES	65,000	---	---	---	65,000	---	---
	C-15	VMCP CODE AND LIFE SAFETY	6,000	---	---	6,000	---	---	---
	C-16	TES PRESSURE SUSTAINING VALVE MODIFICATIONS	50,000	25,000	25,000	---	---	---	---
	C-17	UPGRADE PORTIONS OF DISTRIBUTION PIPING	850,000	---	400,000	150,000	150,000	150,000	---
	---	SUBTOTAL	39,972,000	3,495,000	4,170,000	12,727,000	222,000	150,000	1,159,000
ELECT.	E-1	MV DISTRIBUTION EQUIPMENT	9,509,000	---	1,694,000	391,000	496,000	761,000	391,000
	E-2	MV DISTRIBUTION CABLING	5,533,000	---	695,000	695,000	695,000	695,000	695,000
	E-3	HV TRANSFORMERS, CIRCUIT BREAKERS, RELAYS	927,000	---	---	---	---	---	927,000
	E-4	INCREASE IMPORT CAPACITY TO 120 MW	16,287,000	---	---	---	8,287,000	8,000,000	---
	---	SUBTOTAL	32,256,000	---	2,389,000	1,086,000	9,478,000	9,456,000	2,013,000
OTHER	O-1	ENERGY EFFICIENCY PROGRAM	22,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
	O-2	RENEWABLE ENERGY PROJECT/PURCHASE	5,500,000	500,000	500,000	500,000	500,000	500,000	500,000
	---	SUBTOTAL	27,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000
TOTAL			178,040,000	8,427,250	17,273,850	32,857,850	15,129,850	16,203,600	10,744,600

	C-8	ASCP CODE AND LIFE SAFETY	32,000	---	---	18,000	7,000	---	---	---	---	---	7,000
	C-9	CLSCP REPLACEMENT CHILLERS/TOWERS	8,506,000	1,742,000	1,742,000	5,022,000	---	---	---	---	---	---	---
	C-11	CLSCP CODE AND LIFE SAFETY	22,000	---	---	11,000	---	---	---	---	---	---	11,000
	C-12	VMCP REPLACEMENT CHILLERS/TOWERS	4,459,000	---	---	576,000	---	---	1,159,000	---	---	2,724,000	---
	C-14	VMCP PIPING/PUMP UPGRADES	65,000	---	---	---	65,000	---	---	---	---	---	---
	C-15	VMCP CODE AND LIFE SAFETY	6,000	---	---	6,000	---	---	---	---	---	---	---
	C-16	TES PRESSURE SUSTAINING VALVE MODIFICATIONS	50,000	25,000	25,000	---	---	---	---	---	---	---	---
	C-17	UPGRADE PORTIONS OF DISTRIBUTION PIPING	850,000	---	400,000	150,000	150,000	150,000	---	---	---	---	---
	---	SUBTOTAL	39,972,000	3,495,000	4,170,000	12,727,000	222,000	150,000	1,159,000	3,002,000	1,589,000	4,271,000	9,020,000	167,000
ELECT.	E-1	MV DISTRIBUTION EQUIPMENT	9,509,000	---	1,694,000	391,000	496,000	761,000	391,000	939,000	783,000	1,172,000	2,190,000	692,000
	E-2	MV DISTRIBUTION CABLING	5,533,000	---	695,000	695,000	695,000	695,000	695,000	411,600	411,600	411,600	411,600	411,600
	E-3	HV TRANSFORMERS, CIRCUIT BREAKERS, RELAYS	927,000	---	---	---	---	---	927,000	---	---	---	---	---
	E-4	INCREASE IMPORT CAPACITY TO 120 MW	16,287,000	---	---	---	8,287,000	8,000,000	---	---	---	---	---	---
	---	SUBTOTAL	32,256,000	---	2,389,000	1,086,000	9,478,000	9,456,000	2,013,000	1,350,600	1,194,600	1,583,600	2,601,600	1,103,600
OTHER	O-1	ENERGY EFFICIENCY PROGRAM	22,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000
	O-2	RENEWABLE ENERGY PROJECT/PURCHASE	5,500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
	---	SUBTOTAL	27,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000
TOTAL			178,040,000	8,427,250	17,273,850	32,857,850	15,129,850	16,203,600	10,744,600	10,077,400	7,425,400	10,496,400	43,491,400	5,912,400

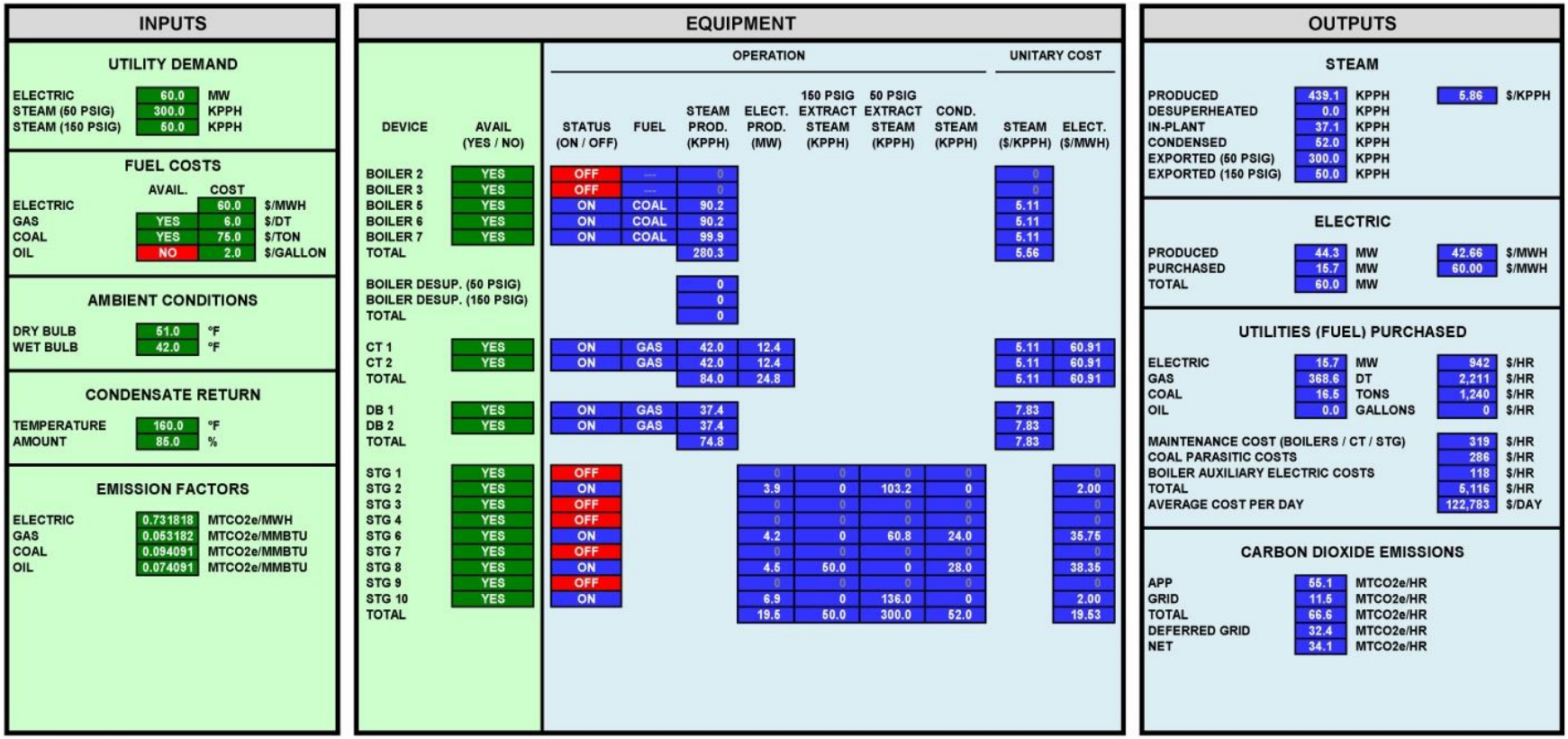
Dispatch Model

UIUC Dispatch Model

- **Two models were developed:**
  - TOPS (Thermal Optimization Plant Software)
  - CHAMP (Chiller Activity Modeling Program)
- **Mission:**
  - Assist in Operational Decisions
  - Reduce Annual Operating Costs
- **Phase 1:**
  - Model Point in Time Operation
- **Phase 2:**
  - Incorporate Real Time Utility Pricing
  - Real Time Utility Demands



TOPS User Screen



INPUTS

UTILITY DEMAND

ELECTRIC	60.0	MW
STEAM (50 PSIG)	300.0	KPPH
STEAM (150 PSIG)	50.0	KPPH

FUEL COSTS

	AVAIL.	COST	
ELECTRIC		60.0	$/MWH
GAS	YES	6.0	$/DT
COAL	YES	75.0	$/TON
OIL	NO	2.0	$/GALLON

AMBIENT CONDITIONS

DRY BULB	51.0	°F
WET BULB	42.0	°F

CONDENSATE RETURN

TEMPERATURE	160.0	°F
AMOUNT	85.0	%

EMISSION FACTORS

ELECTRIC	0.731818	MTCO2e/MWH
GAS	0.053182	MTCO2e/MMBTU
COAL	0.094091	MTCO2e/MMBTU
OIL	0.074091	MTCO2e/MMBTU

EQUIPMENT

DEVICE	AVAIL (YES / NO)	OPERATION: STATUS (ON / OFF)	FUEL	STEAM PROD. (KPPH)	ELECT. PROD. (MW)	150 PSIG EXTRACT STEAM (KPPH)	50 PSIG EXTRACT STEAM (KPPH)	COND. STEAM (KPPH)	UNITARY COST: STEAM ($/KPPH)	ELECT. ($/MWH)
BOILER 2	YES	OFF	---	0					0	
BOILER 3	YES	OFF	---	0					0	
BOILER 5	YES	ON	COAL	90.2					5.11	
BOILER 6	YES	ON	COAL	90.2					5.11	
BOILER 7	YES	ON	COAL	99.9					5.11	
TOTAL				280.3					5.56	
BOILER DESUP. (50 PSIG)				0						
BOILER DESUP. (150 PSIG)				0						
TOTAL				0						
CT 1	YES	ON	GAS	42.0	12.4				5.11	60.91
CT 2	YES	ON	GAS	42.0	12.4				5.11	60.91
TOTAL				84.0	24.8				5.11	60.91
DB 1	YES	ON	GAS	37.4					7.83	
DB 2	YES	ON	GAS	37.4					7.83	
TOTAL				74.8					7.83	
STG 1	YES	OFF			0	0	0	0		0
STG 2	YES	ON			3.9	0	103.2	0		2.00
STG 3	YES	OFF			0	0	0	0		0
STG 4	YES	OFF			0	0	0	0		0
STG 6	YES	ON			4.2	0	60.8	24.0		35.75
STG 7	YES	OFF			0	0	0	0		0
STG 8	YES	ON			4.5	50.0	0	28.0		38.35
STG 9	YES	OFF			0	0	0	0		0
STG 10	YES	ON			6.9	0	136.0	0		2.00
TOTAL					19.5	50.0	300.0	52.0		19.53

OUTPUTS

STEAM

PRODUCED	439.1	KPPH	5.86	$/KPPH
DESUPERHEATED	0.0	KPPH		
IN-PLANT	37.1	KPPH		
CONDENSED	52.0	KPPH		
EXPORTED (50 PSIG)	300.0	KPPH		
EXPORTED (150 PSIG)	50.0	KPPH		

ELECTRIC

PRODUCED	44.3	MW	42.66	$/MWH
PURCHASED	15.7	MW	60.00	$/MWH
TOTAL	60.0	MW		

UTILITIES (FUEL) PURCHASED

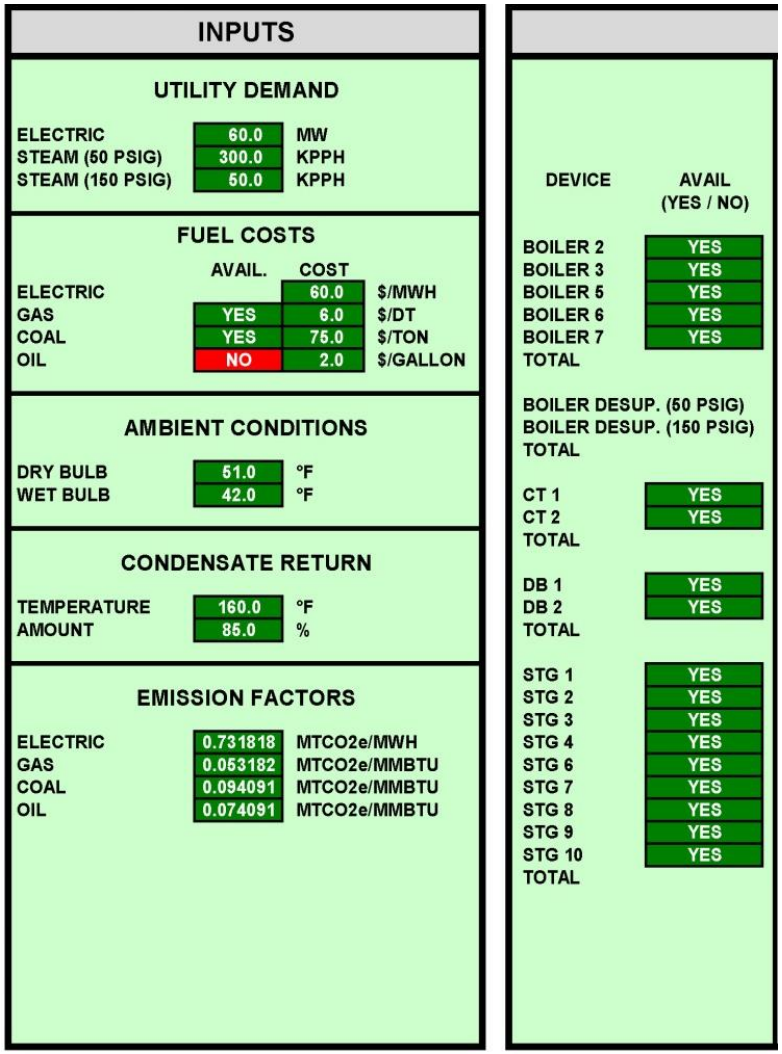
ELECTRIC	15.7	MW	942	$/HR
GAS	368.6	DT	2,211	$/HR
COAL	16.5	TONS	1,240	$/HR
OIL	0.0	GALLONS	0	$/HR
MAINTENANCE COST (BOILERS / CT / STG)			319	$/HR
COAL PARASITIC COSTS			286	$/HR
BOILER AUXILIARY ELECTRIC COSTS			118	$/HR
TOTAL			5,116	$/HR
AVERAGE COST PER DAY			122,783	$/DAY

CARBON DIOXIDE EMISSIONS

APP	55.1	MTCO2e/HR
GRID	11.5	MTCO2e/HR
TOTAL	66.6	MTCO2e/HR
DEFERRED GRID	32.4	MTCO2e/HR
NET	34.1	MTCO2e/HR

- User Friendly
- Real Time Calculations
- Input and Output on Same Screen

TOPS Input Screen



INPUTS

UTILITY DEMAND

ELECTRIC	60.0	MW
STEAM (50 PSIG)	300.0	KPPH
STEAM (150 PSIG)	50.0	KPPH

FUEL COSTS

	AVAIL.	COST	
ELECTRIC		60.0	$/MWH
GAS	YES	6.0	$/DT
COAL	YES	75.0	$/TON
OIL	NO	2.0	$/GALLON

AMBIENT CONDITIONS

DRY BULB	51.0	°F
WET BULB	42.0	°F

CONDENSATE RETURN

TEMPERATURE	160.0	°F
AMOUNT	85.0	%

EMISSION FACTORS

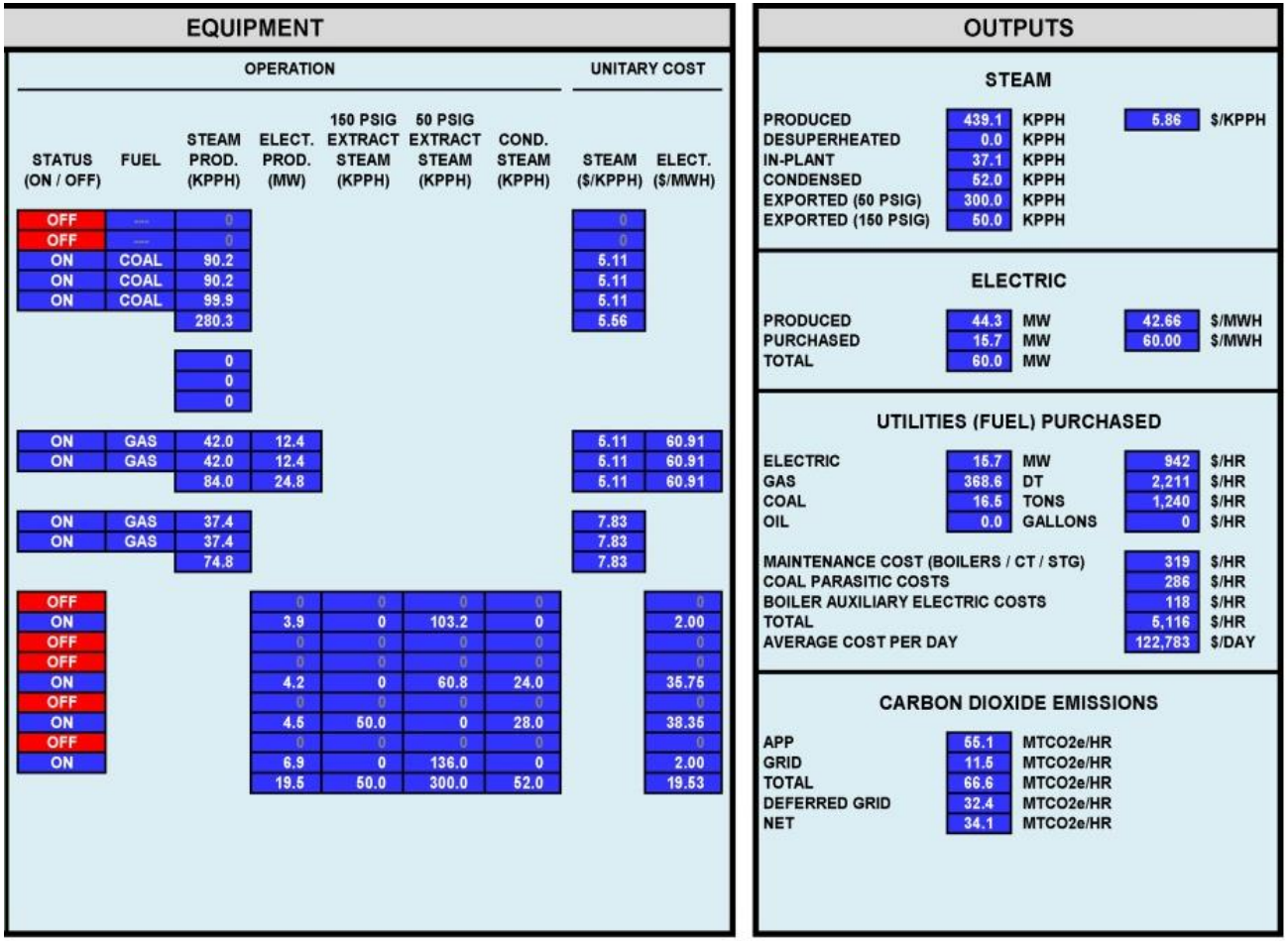
ELECTRIC	0.731818	MTCO2e/MWH
GAS	0.053182	MTCO2e/MMBTU
COAL	0.094091	MTCO2e/MMBTU
OIL	0.074091	MTCO2e/MMBTU

DEVICE	AVAIL (YES / NO)
BOILER 2	YES
BOILER 3	YES
BOILER 5	YES
BOILER 6	YES
BOILER 7	YES
TOTAL	
BOILER DESUP. (50 PSIG)	
BOILER DESUP. (150 PSIG)	
TOTAL	
CT 1	YES
CT 2	YES
TOTAL	
DB 1	YES
DB 2	YES
TOTAL	
STG 1	YES
STG 2	YES
STG 3	YES
STG 4	YES
STG 6	YES
STG 7	YES
STG 8	YES
STG 9	YES
STG 10	YES
TOTAL	

Input Data:

- Utility Loads
- Fuels Costs and Availability
- Ambient Conditions (Combustion Turbine)
- Condensate Return (In-Plant Steam Usage)
- Emission Factors (EPA Based Data)
- Equipment Availability

TOPS Output Screen



EQUIPMENT

OPERATION							UNITARY COST	
STATUS (ON / OFF)	FUEL	STEAM PROD. (KPPH)	ELECT. PROD. (MW)	150 PSIG EXTRACT STEAM (KPPH)	50 PSIG EXTRACT STEAM (KPPH)	COND. STEAM (KPPH)	STEAM ($/KPPH)	ELECT. ($/MWH)
OFF	---	0					0	
OFF	---	0					0	
ON	COAL	90.2					5.11	
ON	COAL	90.2					5.11	
ON	COAL	99.9					5.11	
		280.3					5.56	
		0						
		0						
		0						
ON	GAS	42.0	12.4				5.11	60.91
ON	GAS	42.0	12.4				5.11	60.91
		84.0	24.8				5.11	60.91
ON	GAS	37.4					7.83	
ON	GAS	37.4					7.83	
		74.8					7.83	
OFF		0	0	0	0		0	
ON		3.9	0	103.2	0		2.00	
OFF		0	0	0	0		0	
OFF		0	0	0	0		0	
ON		4.2	0	60.8	24.0		35.75	
OFF		0	0	0	0		0	
ON		4.5	50.0	0	28.0		38.35	
OFF		0	0	0	0		0	
ON		6.9	0	136.0	0		2.00	
		19.5	50.0	300.0	52.0		19.53	

OUTPUTS

STEAM

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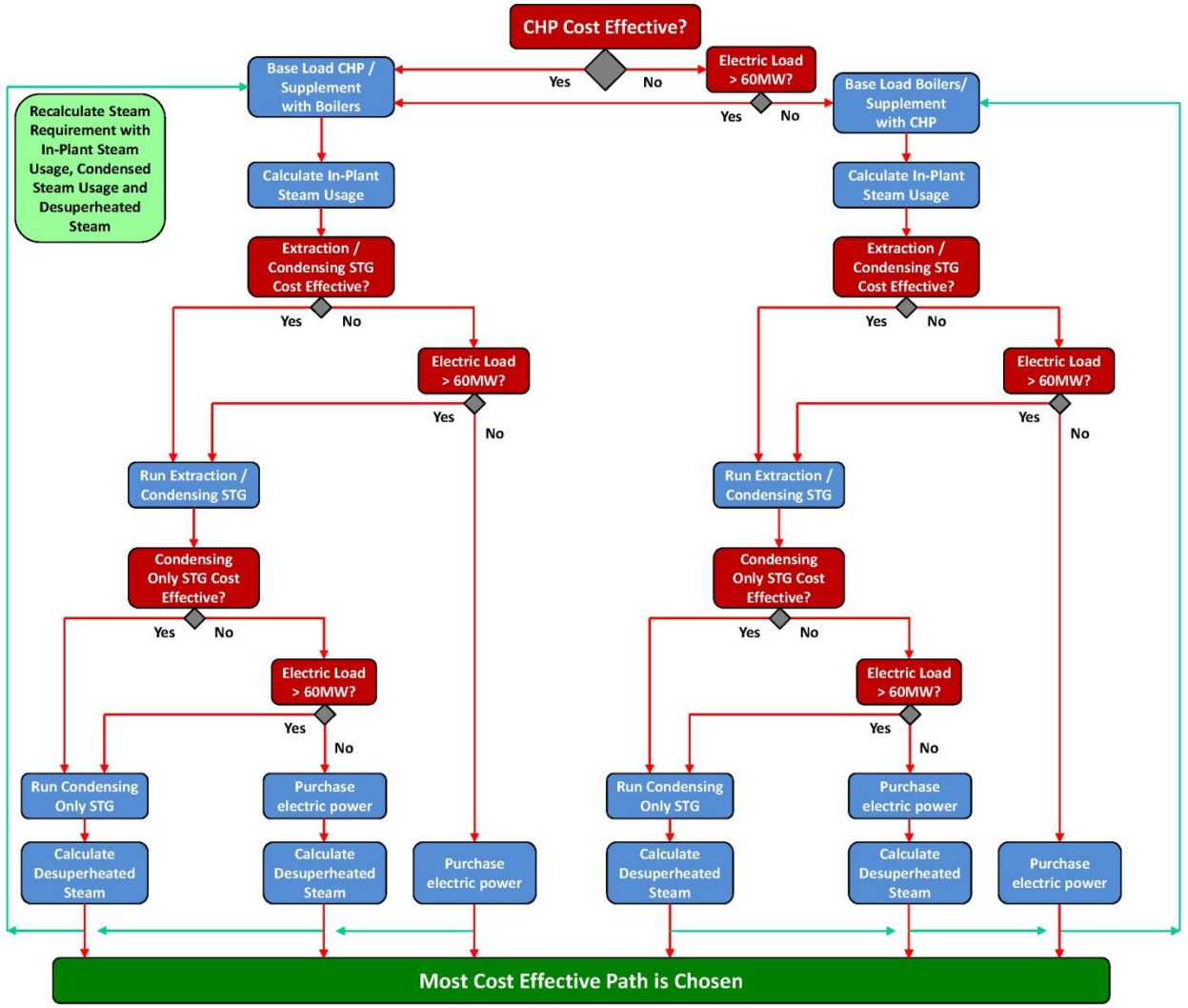
DEFERRED GRID	32.4	MTCO2e/HR
NET	34.1	MTCO2e/HR

Output Data:

- Most Cost Effective Plant Operation
- Individual Equipment:
  - Steam and Electric Production
  - Unitary Costs
- Total Plant:
  - Utility Generation
  - Utility / Fuel Purchase
  - Hourly and Daily Costs
- CO_2 Emissions
  - Plant Output
  - Purchased / Deferred Utility Electric
  - Net Emissions

TOPS Logic Diagram

- Compares Several Operational Scenarios
- Detailed Part Load Modeling of Components
- Multiple Iterations of Calculations
- Overrides:
  - Maximum Import of 60MW
  - Fuel Availability



TOPS Carbon Emission Sensitivity

- **Most Cost Effective Operation May Not Result in Least Amount of Carbon Emissions**
- **Alternate Approach is Provided with Reduction in Carbon Emissions**
- **Particularly Useful if Carbon Tax is Implemented**

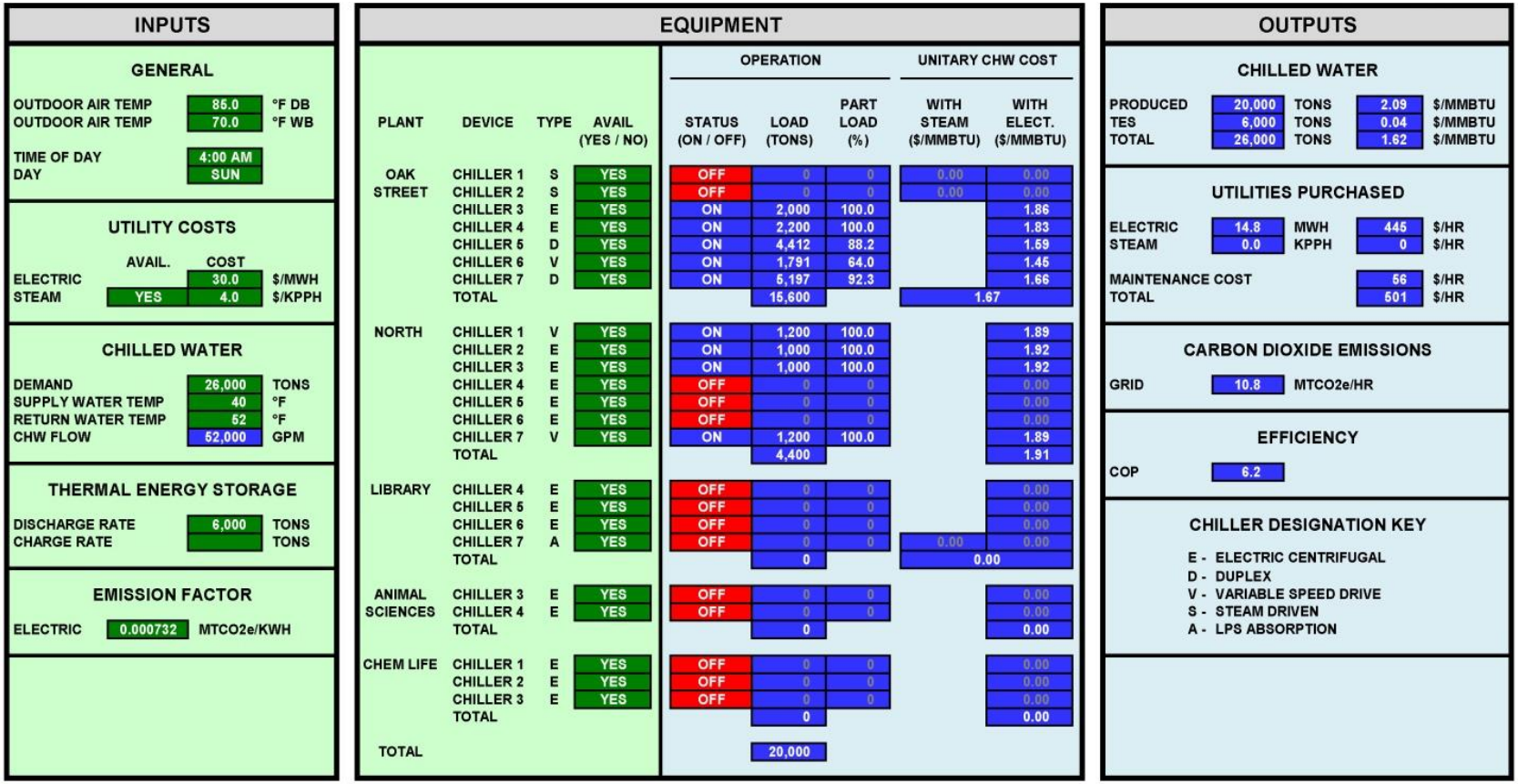
CARBON DIOXIDE EMISSIONS

APP	40.8	MTCO2e/HR
GRID	36.0	MTCO2e/HR
TOTAL	76.8	MTCO2e/HR
DEFERRED GRID	7.9	MTCO2e/HR
NET	68.8	MTCO2e/HR

POTENTIAL W/ ON-SITE POWER GENERATION

NET	39.8	MTCO2e/HR
DIFFERENTIAL	29.0	MTCO2e/HR

CHAMP User Screen



INPUTS

GENERAL

OUTDOOR AIR TEMP	85.0	°F DB
OUTDOOR AIR TEMP	70.0	°F WB
TIME OF DAY	4:00 AM	
DAY	SUN	

UTILITY COSTS

	AVAIL.	COST	
ELECTRIC		30.0	$/MWH
STEAM	YES	4.0	$/KPPH

CHILLED WATER

DEMAND	26,000	TONS
SUPPLY WATER TEMP	40	°F
RETURN WATER TEMP	52	°F
CHW FLOW	52,000	GPM

THERMAL ENERGY STORAGE

DISCHARGE RATE	6,000	TONS
CHARGE RATE		TONS

EMISSION FACTOR

ELECTRIC	0.000732	MTCO2e/KWH

EQUIPMENT

PLANT	DEVICE	TYPE	AVAIL (YES / NO)	OPERATION STATUS (ON / OFF)	OPERATION LOAD (TONS)	OPERATION PART LOAD (%)	UNITARY CHW COST WITH STEAM ($/MMBTU)	UNITARY CHW COST WITH ELECT. ($/MMBTU)
OAK STREET	CHILLER 1	S	YES	OFF	0	0	0.00	0.00
	CHILLER 2	S	YES	OFF	0	0	0.00	0.00
	CHILLER 3	E	YES	ON	2,000	100.0		1.86
	CHILLER 4	E	YES	ON	2,200	100.0		1.83
	CHILLER 5	D	YES	ON	4,412	88.2		1.59
	CHILLER 6	V	YES	ON	1,791	64.0		1.45
	CHILLER 7	D	YES	ON	5,197	92.3		1.66
	TOTAL				15,600		1.67	
NORTH	CHILLER 1	V	YES	ON	1,200	100.0		1.89
	CHILLER 2	E	YES	ON	1,000	100.0		1.92
	CHILLER 3	E	YES	ON	1,000	100.0		1.92
	CHILLER 4	E	YES	OFF	0	0		0.00
	CHILLER 5	E	YES	OFF	0	0		0.00
	CHILLER 6	E	YES	OFF	0	0		0.00
	CHILLER 7	V	YES	ON	1,200	100.0		1.89
	TOTAL				4,400			1.91
LIBRARY	CHILLER 4	E	YES	OFF	0	0		0.00
	CHILLER 5	E	YES	OFF	0	0		0.00
	CHILLER 6	E	YES	OFF	0	0		0.00
	CHILLER 7	A	YES	OFF	0	0	0.00	0.00
	TOTAL				0		0.00	
ANIMAL SCIENCES	CHILLER 3	E	YES	OFF	0	0		0.00
	CHILLER 4	E	YES	OFF	0	0		0.00
	TOTAL				0			0.00
CHEM LIFE	CHILLER 1	E	YES	OFF	0	0		0.00
	CHILLER 2	E	YES	OFF	0	0		0.00
	CHILLER 3	E	YES	OFF	0	0		0.00
	TOTAL				0			0.00
TOTAL					20,000			

OUTPUTS

CHILLED WATER

PRODUCED	20,000	TONS	2.09	$/MMBTU
TES	6,000	TONS	0.04	$/MMBTU
TOTAL	26,000	TONS	1.62	$/MMBTU

UTILITIES PURCHASED

ELECTRIC	14.8	MWH	445	$/HR
STEAM	0.0	KPPH	0	$/HR
MAINTENANCE COST			56	$/HR
TOTAL			501	$/HR

CARBON DIOXIDE EMISSIONS

GRID	10.8	MTCO2e/HR

EFFICIENCY

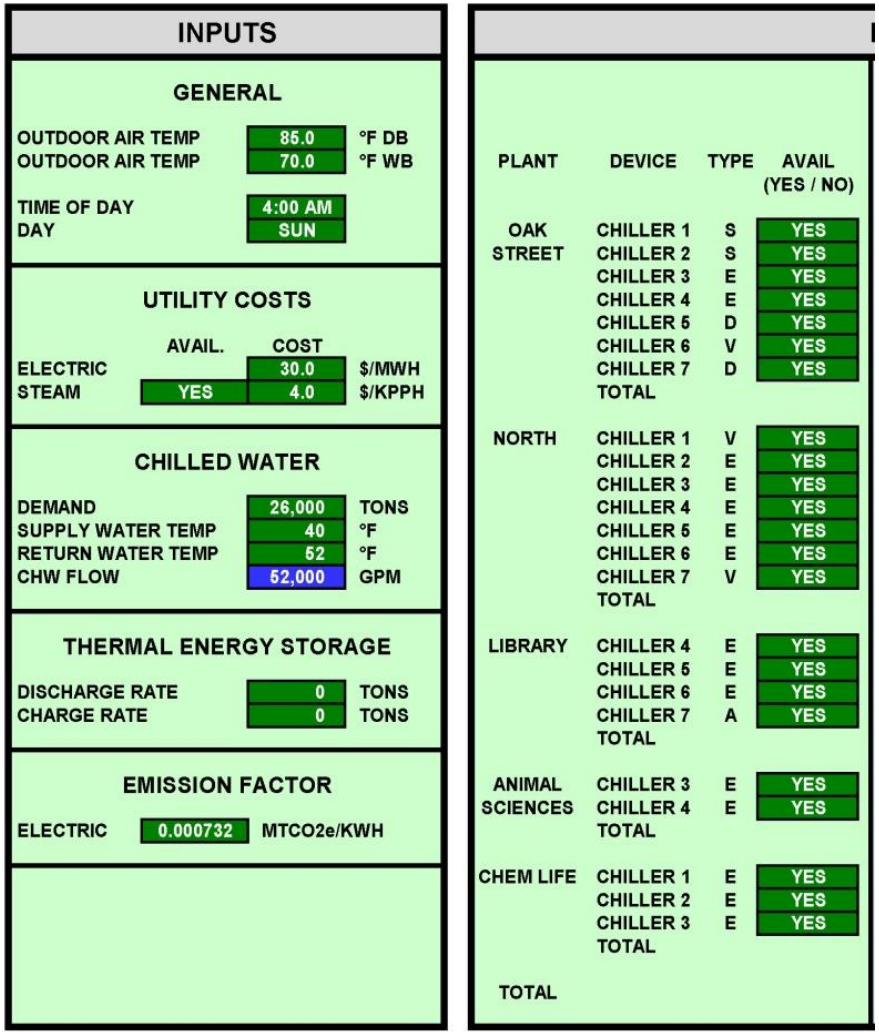
COP	6.2

CHILLER DESIGNATION KEY

E - ELECTRIC CENTRIFUGAL
D - DUPLEX
V - VARIABLE SPEED DRIVE
S - STEAM DRIVEN
A - LPS ABSORPTION

- Similar Design
- Real Time Calculations
- Input and Output on Same Screen

CHAMP Input Screen



INPUTS

GENERAL

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OUTDOOR AIR TEMP	70.0	°F WB
TIME OF DAY	4:00 AM	
DAY	SUN	

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ELECTRIC		30.0	$/MWH
STEAM	YES	4.0	$/KPPH

CHILLED WATER

DEMAND	26,000	TONS
SUPPLY WATER TEMP	40	°F
RETURN WATER TEMP	52	°F
CHW FLOW	52,000	GPM

THERMAL ENERGY STORAGE

DISCHARGE RATE	0	TONS
CHARGE RATE	0	TONS

EMISSION FACTOR

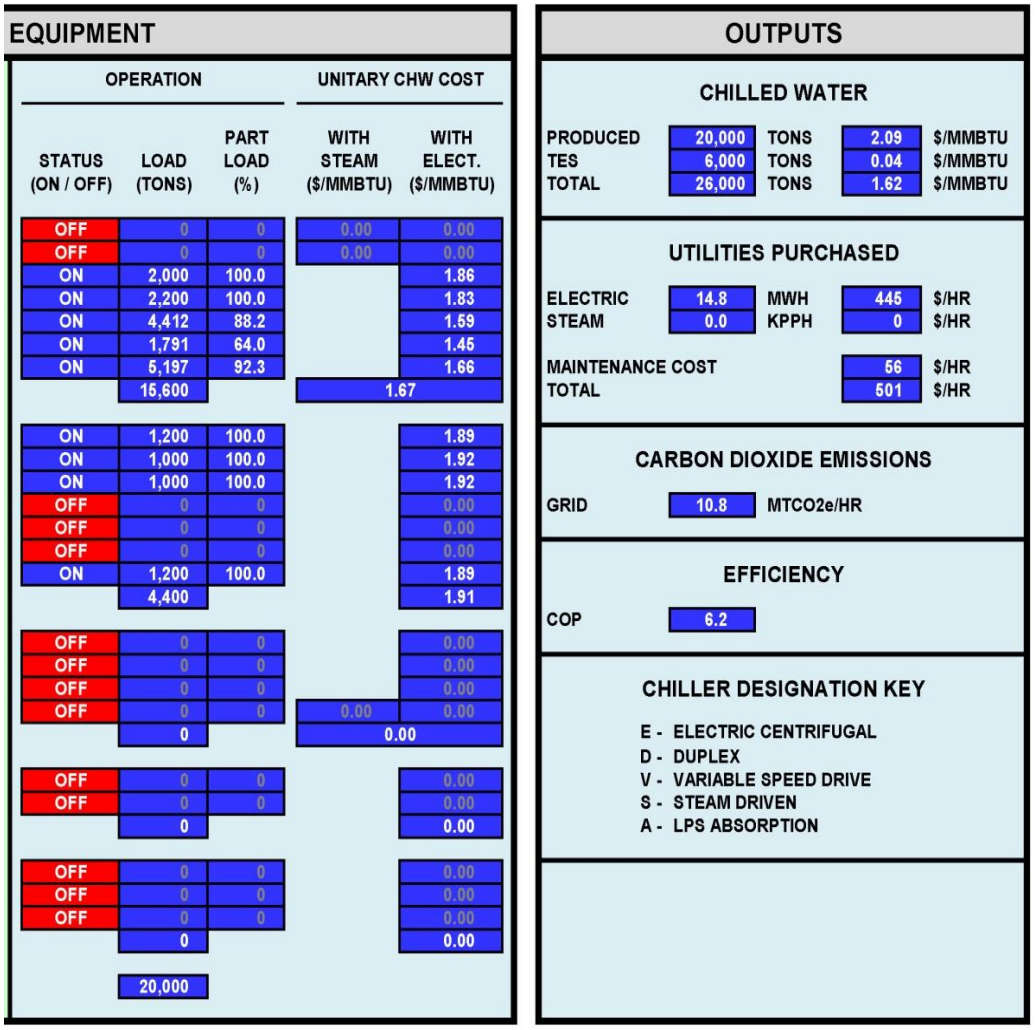
ELECTRIC	0.000732	MTCO2e/KWH

PLANT	DEVICE	TYPE	AVAIL (YES / NO)
OAK STREET	CHILLER 1	S	YES
	CHILLER 2	S	YES
	CHILLER 3	E	YES
	CHILLER 4	E	YES
	CHILLER 5	D	YES
	CHILLER 6	V	YES
	CHILLER 7	D	YES
	TOTAL		
NORTH	CHILLER 1	V	YES
	CHILLER 2	E	YES
	CHILLER 3	E	YES
	CHILLER 4	E	YES
	CHILLER 5	E	YES
	CHILLER 6	E	YES
	CHILLER 7	V	YES
	TOTAL		
LIBRARY	CHILLER 4	E	YES
	CHILLER 5	E	YES
	CHILLER 6	E	YES
	CHILLER 7	A	YES
	TOTAL		
ANIMAL SCIENCES	CHILLER 3	E	YES
	CHILLER 4	E	YES
	TOTAL		
CHEM LIFE	CHILLER 1	E	YES
	CHILLER 2	E	YES
	CHILLER 3	E	YES
	TOTAL		
TOTAL			

Input Data:

- Ambient Conditions (Cooling Tower Performance)
- Fuels Costs and Availability
  - Steam Cost Developed from TOPS
- Chilled Water Load and Temperatures
- Thermal Energy Storage
  - Independent Program was Previously Developed
  - Can be Integrated in CHAMP in Phase 2
- Emission Factors (EPA Based Data)
- Equipment Availability

CHAMP Output Screen



EQUIPMENT

OPERATION			UNITARY CHW COST	
STATUS (ON / OFF)	LOAD (TONS)	PART LOAD (%)	WITH STEAM ($/MMBTU)	WITH ELECT. ($/MMBTU)
OFF	0	0	0.00	0.00
OFF	0	0	0.00	0.00
ON	2,000	100.0		1.86
ON	2,200	100.0		1.83
ON	4,412	88.2		1.59
ON	1,791	64.0		1.45
ON	5,197	92.3		1.66
	15,600		1.67	
ON	1,200	100.0		1.89
ON	1,000	100.0		1.92
ON	1,000	100.0		1.92
OFF	0	0		0.00
OFF	0	0		0.00
OFF	0	0		0.00
ON	1,200	100.0		1.89
	4,400			1.91
OFF	0	0		0.00
OFF	0	0		0.00
OFF	0	0		0.00
OFF	0	0	0.00	0.00
	0		0.00	
OFF	0	0		0.00
OFF	0	0		0.00
	0			0.00
OFF	0	0		0.00
OFF	0	0		0.00
OFF	0	0		0.00
	0			0.00
	20,000			

OUTPUTS

CHILLED WATER

PRODUCED	20,000	TONS	2.09	$/MMBTU
TES	6,000	TONS	0.04	$/MMBTU
TOTAL	26,000	TONS	1.62	$/MMBTU

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ELECTRIC	14.8	MWH	445	$/HR
STEAM	0.0	KPPH	0	$/HR
MAINTENANCE COST			56	$/HR
TOTAL			501	$/HR

CARBON DIOXIDE EMISSIONS

GRID	10.8	MTCO2e/HR

EFFICIENCY

COP	6.2

CHILLER DESIGNATION KEY

E - ELECTRIC CENTRIFUGAL
D - DUPLEX
V - VARIABLE SPEED DRIVE
S - STEAM DRIVEN
A - LPS ABSORPTION

Output Data:

- Most Cost Effective Plant Operation
- Model Includes Chiller, Cooling Tower and Pump Performance
- Hydraulic Modeling was Utilized to Determine Plant Staging
- Individual Equipment:
  - Chilled Water Production
  - Unitary Costs
- Total System:
  - Chilled Water Generation
  - Utility Purchase
  - Hourly Costs
- CO_2 Emissions

Questions?