

The National Institutes of Health – Bethesda

Thermal Energy Storage System Installation & Optimization

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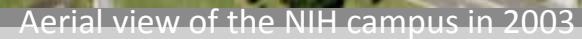
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IDEA Campus Energy Conference | February 2019



- 75 buildings over 300 acres
- Total area~12 million sqft, many state-of-the-art biomedical research facilities
- World-Class Research Hospital
 - 240 Bed Capacity
- \$37 billion annually in medical research
- Leading Biomedical Research Center




NIH Central Utility Plant (CUP) Overview

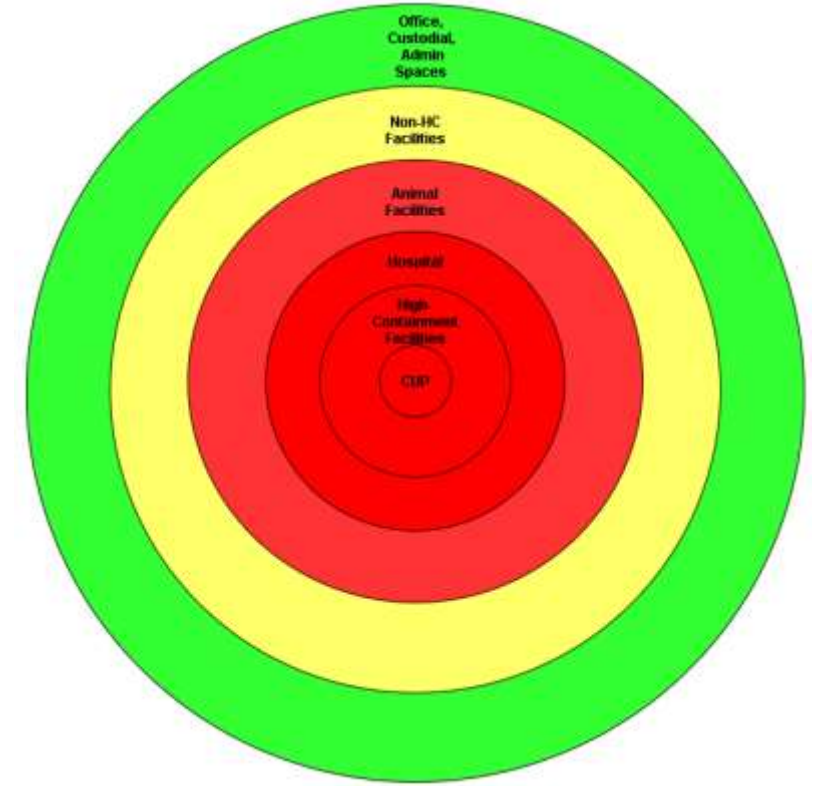
- One of the largest CUPs under one roof
 - Provides campus with chilled water, steam, electricity, and compressed air
- CUP Components
 - Twelve 5,000 Ton capacity chillers
 - 7.75 million gal CHW thermal storage tank
 - 5 million gal Industrial Water System
 - Five gas/ diesel dual fuel fired boilers
 - 800 KPPH, 980 KPPH with Cogen
- Cogeneration Power Plant
 - One of the largest US government Cogen plants
 - 23 MW, 180KPPH steam (40% of campus demand)



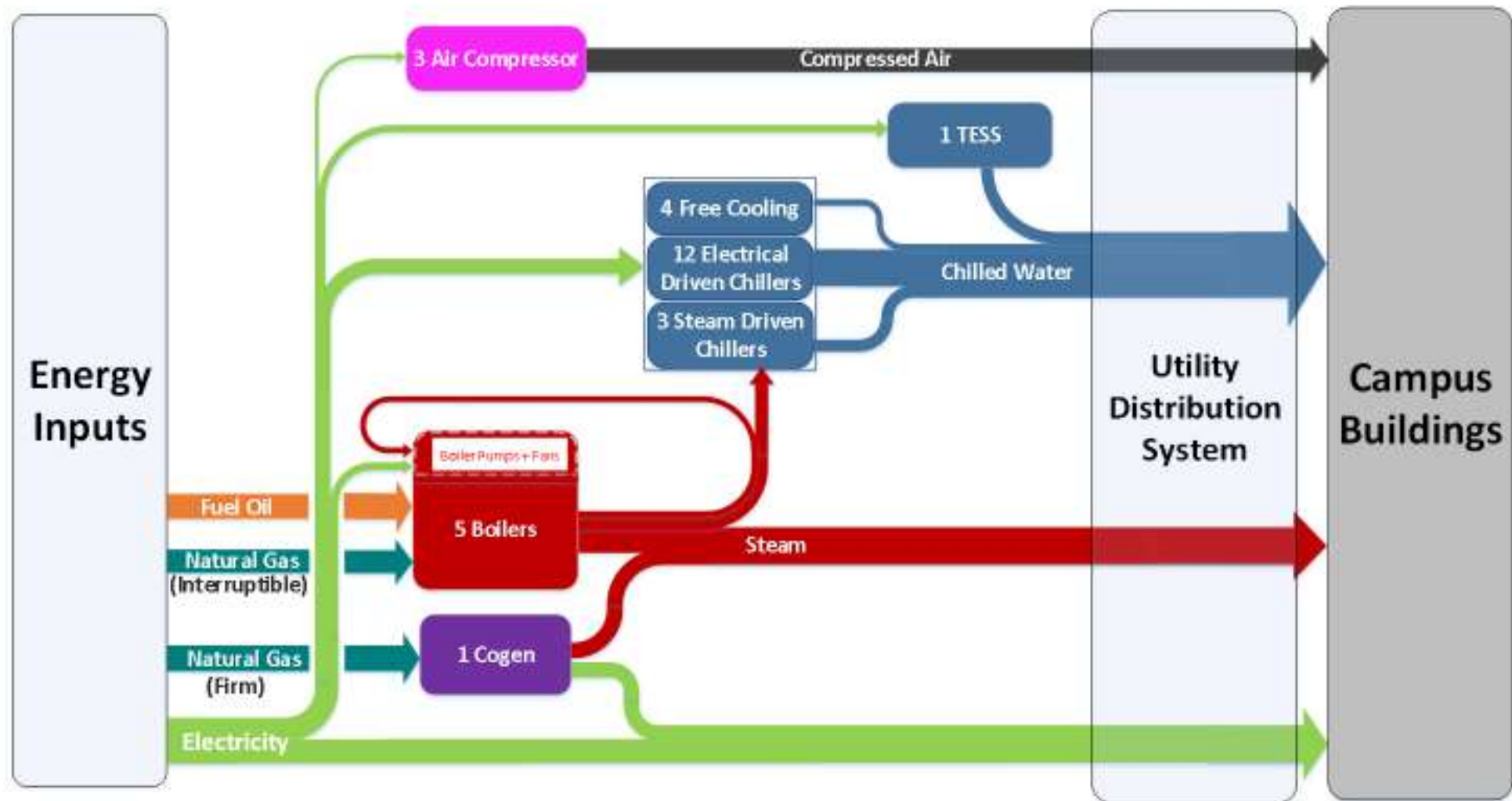
Why is Operation of NIH CUP So Special?

- Reliability is crucial for the mission critical spaces served
 - High Containment Facilities
 - Research Labs
 - Animal facilities
 - World Renowned Research Hospital
- 

NO CUP = NO FUNCTIONING NIH



ENERGY SOURCES & CUP EQUIPMENT PORTFOLIO



Purpose of Thermal Storage at NIH

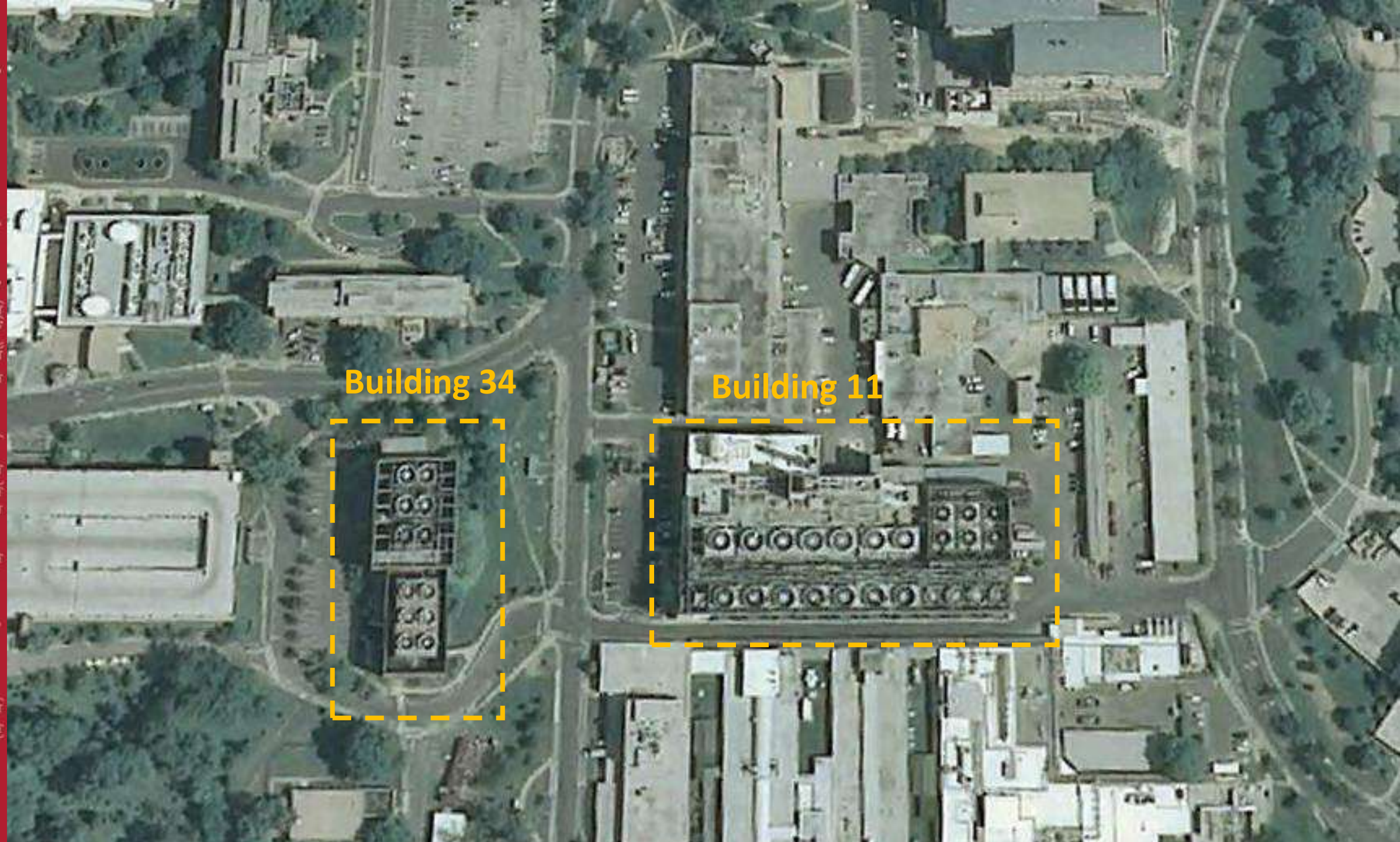
- Energy Savings
 - Load Shift from Day to Night
 - Load Leveling
- Optimization of Chiller Operation
- Source of Emergency Chilled Water
- Allows Bldg. 11 Chiller Replacement
- Increase System Reliability



- Volume: 7.75 MG
- Diameter: 120'-0"
- Height: 96'-6"
- Design DT: 10°F
- Capacity: 47,500 Ton-hour
- Max Discharge/Charge: 5 hours
- Flow Rate Range:
 - 3,000 GPM to 24,000 GPM
- Steel - API 650

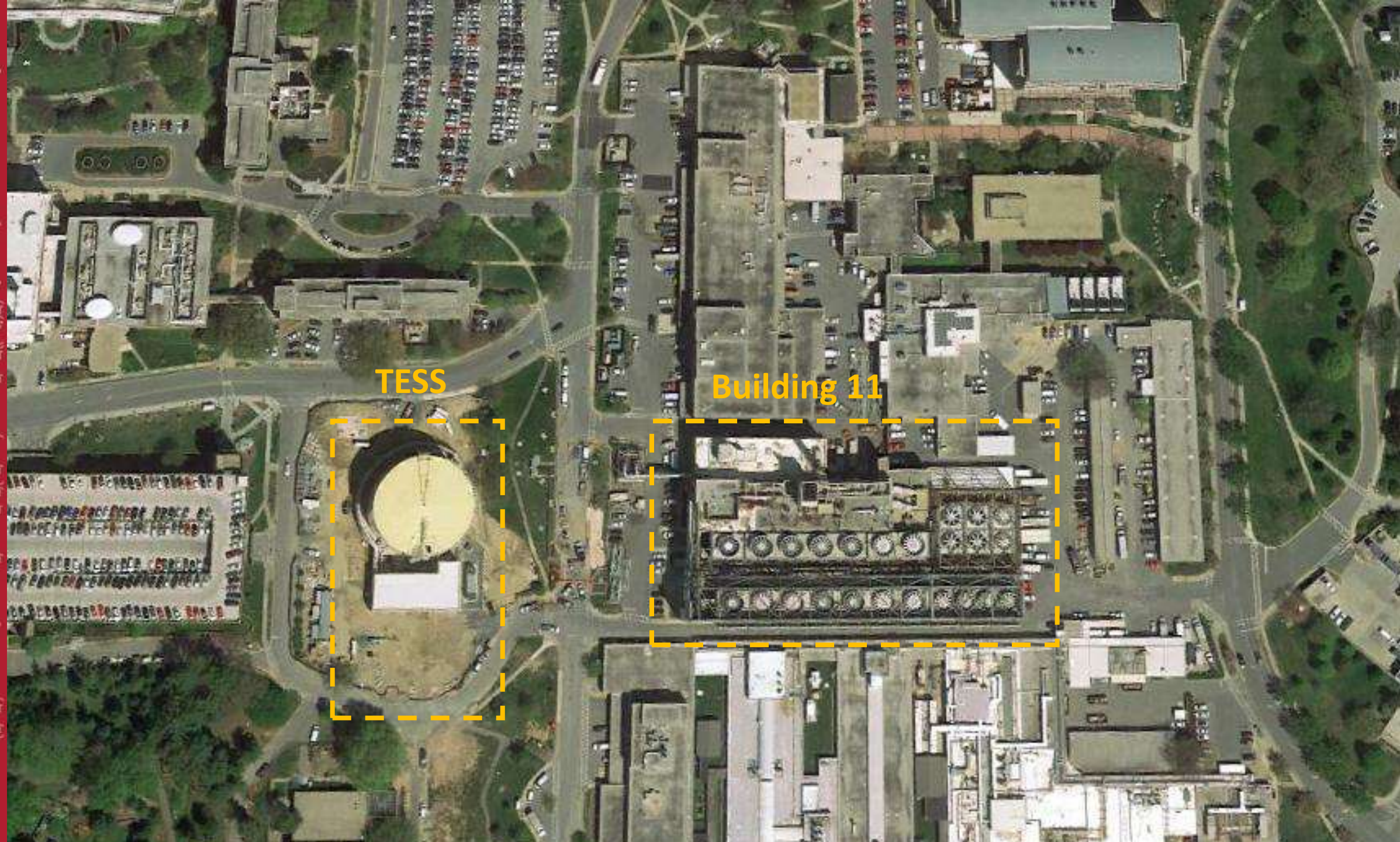


The formulae $\frac{\partial H_1}{\partial t} + \frac{\partial}{\partial y} \left(\rho \frac{\partial H_1}{\partial y} \right) - \frac{\partial}{\partial x} \left(\rho \frac{\partial H_1}{\partial x} \right) + \rho \left(\frac{\partial H_1}{\partial t} + \frac{\partial}{\partial y} \left(\rho \frac{\partial H_1}{\partial y} \right) - \frac{\partial}{\partial x} \left(\rho \frac{\partial H_1}{\partial x} \right) \right) + \rho \left(\frac{\partial H_1}{\partial t} + \frac{\partial}{\partial y} \left(\rho \frac{\partial H_1}{\partial y} \right) - \frac{\partial}{\partial x} \left(\rho \frac{\partial H_1}{\partial x} \right) \right)$ for building state of the art $\frac{\partial H_2}{\partial t} + \frac{\partial}{\partial y} \left(\rho \frac{\partial H_2}{\partial y} \right) - \frac{\partial}{\partial x} \left(\rho \frac{\partial H_2}{\partial x} \right) + \rho \left(\frac{\partial H_2}{\partial t} + \frac{\partial}{\partial y} \left(\rho \frac{\partial H_2}{\partial y} \right) - \frac{\partial}{\partial x} \left(\rho \frac{\partial H_2}{\partial x} \right) \right) + \rho \left(\frac{\partial H_2}{\partial t} + \frac{\partial}{\partial y} \left(\rho \frac{\partial H_2}{\partial y} \right) - \frac{\partial}{\partial x} \left(\rho \frac{\partial H_2}{\partial x} \right) \right)$ for building biomedical research facilities.



Building 34

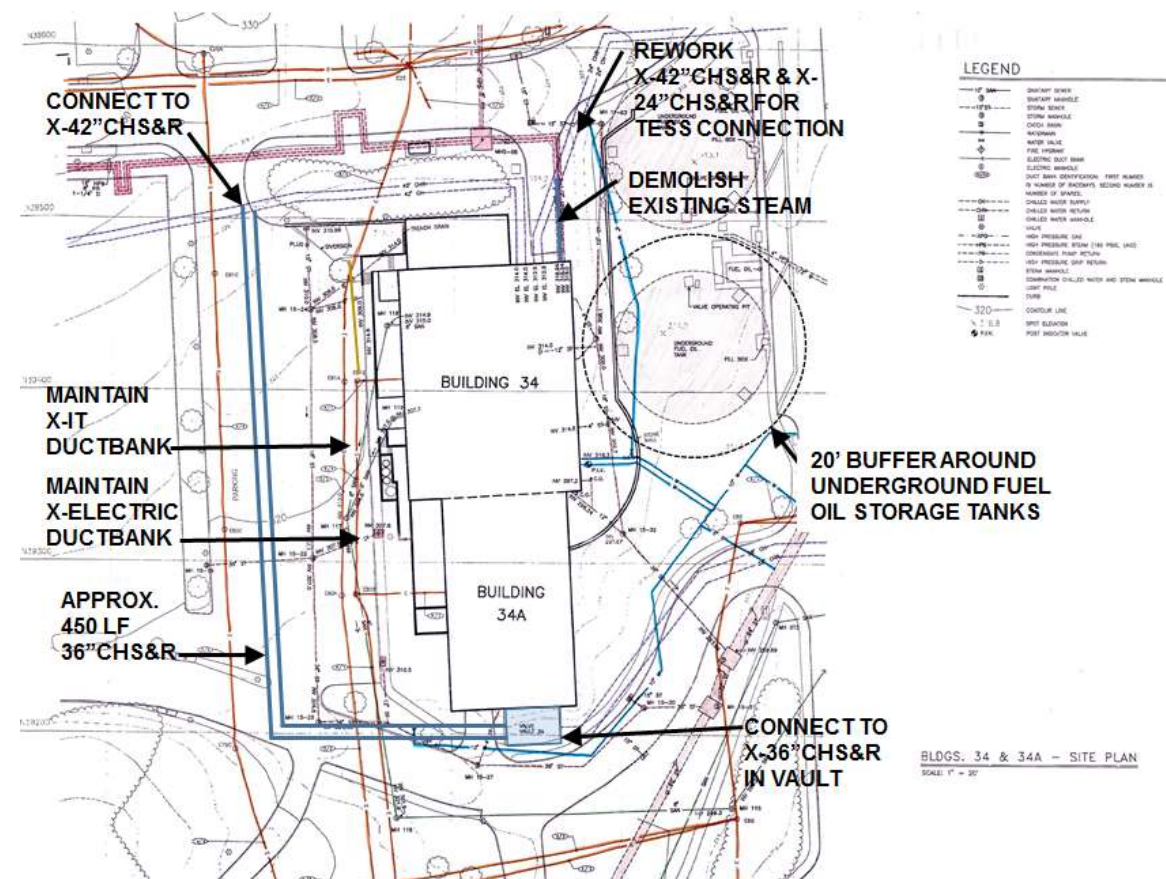
Building 11

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Site

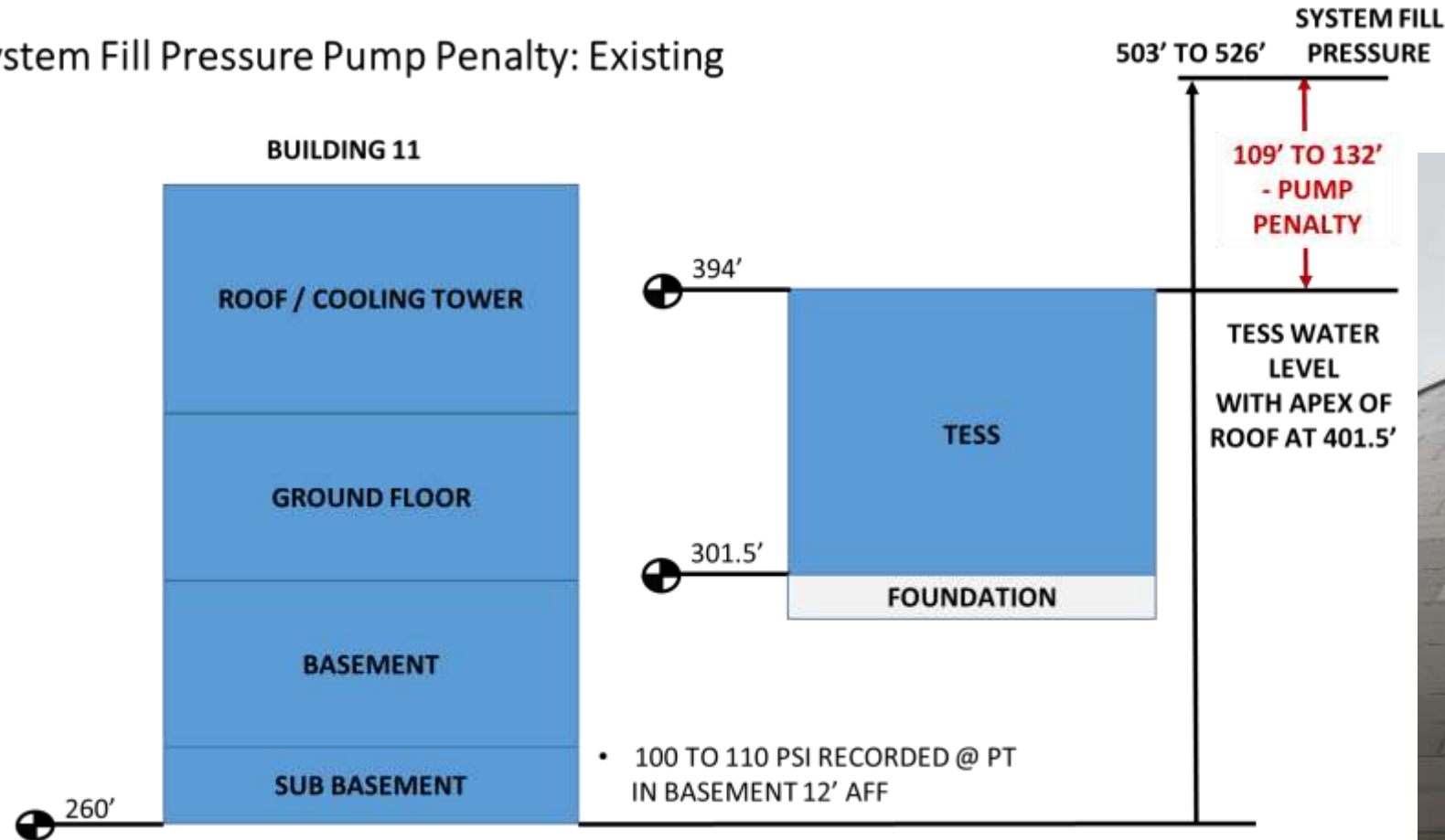
Building 34

- Chilled Water
- Fuel Oil Tanks
- Electrical Ductbanks
- IT Ductbanks
- Fire Alarm



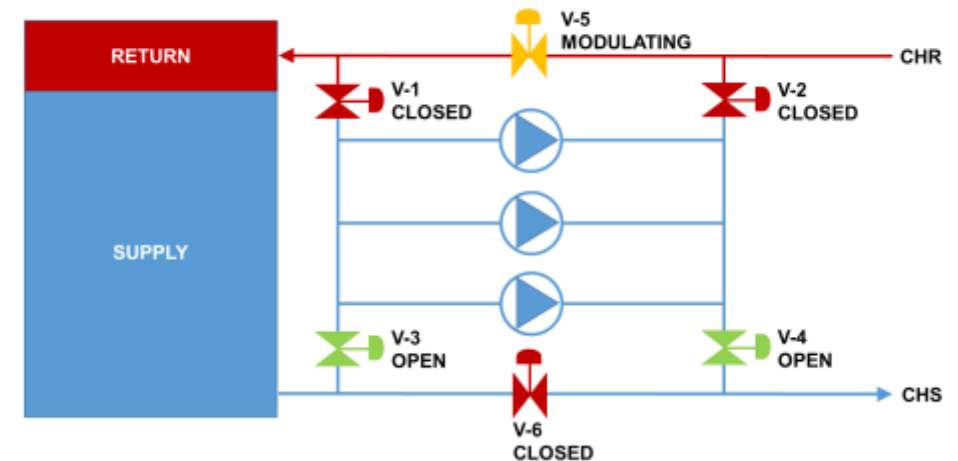
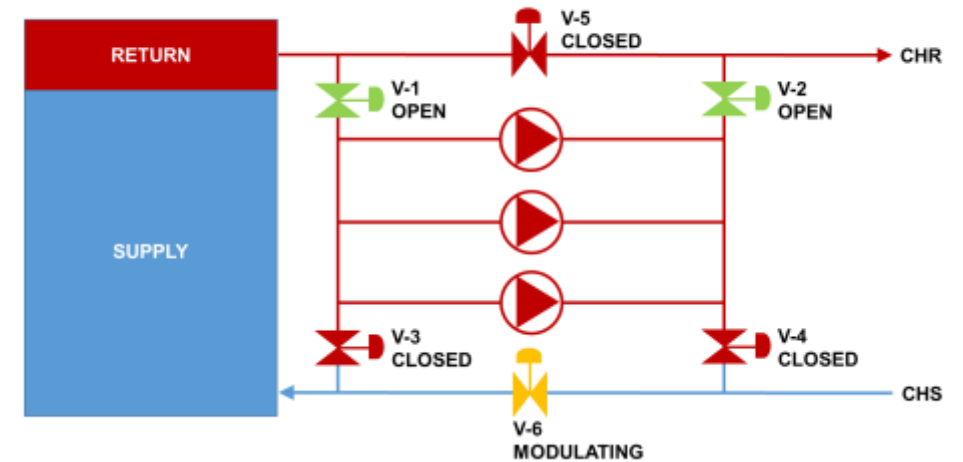
System Arrangement & Basic Operation

System Fill Pressure Pump Penalty: Existing



System Arrangement & Basic Operation

- Operating Modes
 - Manual
 - Time of Day
 - Load Leveling
- System Pressure Control Modes
 - Fixed Return Pressure (Building 11)
 - Differential Pressure
 - Remote Return Pressure



- Testing Operation Prior to Open to System

- Charge
- Discharge
- Alarm Testing
- Automatic Shutdown
- Makeup level control
- Power Failure

ACCOM (South Coast) NRI – Assesed Expanded Chilled Water Capacity				ACCOM (South Coast) NRI – Assesed Expanded Chilled Water Capacity				ACCOM (South Coast) NRI – Assesed Expanded Chilled Water Capacity			
TSSS				TSSS				TSSS			
through alarm manager. Each alarm shall require individual acknowledgement. All operational alarms shall be printed on the alarm printer. Informational messages generated by the alarm printer need not be printed.											
Alarm Description	Control Points	Alarm Trip Point	System Automatic Reaction	Alarm Description	Control Points	Alarm Trip Point	System Automatic Reaction	Alarm Description	Control Points	Alarm Trip Point	System Automatic Reaction
CHRW VSD/Throttle Isolation Valves	TSSS-ZT-1, 2, 3, 4 Position Feedback -0.10mA – <0.00% OPEN	Feedback < -0.05mA (0.5% of Commanded) OPEN	Relays to System Off Mode	Pump Pressure Signal	TSSS-PT-1, 2, 3	Signal Failure Pressure < 1.75 bar (50)	Lock Pump Out of Service Preceded to Next Pump in Rotation	High Pump Bearing Temperature	TSSS-TB-B-1, 1D, 3C, 2B, 3C, 3D	Software Comparison to Alarm Set Point	Preceded to Next Pump in Rotation, Once Next Pump Manufacturer's Specifications
CHRW VSD/Throttle Isolation Valves	TSSS-ZT-7, 8 Position Feedback 4.20mA – >0.100% OPEN	Feedback < 0.1% (0.5% of Commanded) CLOSE	Relays to System Off Mode	Automatic Discharge Pressure Control, Check Valve Failure	TSSS-ZT-9, 10, 11 Pressure Feedback 4.20mA – >0.100% OPEN	Feedback < 0.05% (0.5% of Commanded) OPEN	Lock Pump Out of Service Preceded to Next Pump in Rotation	High Motor Winding Temperature	TSSS-TM-B-1, 1E, 1G, 1H, 1I, 2A, 2B, 2C, 2D, 2E, 2F, 3E, 3F, 3G, 3H, 3I, 3J	Software Comparison to Alarm Set Point	Preceded to Next Pump in Rotation, Once Next Pump Manufacturer's Specifications
CHRW VSD/Throttle Isolation Valves	TSSS-ZT-7, 8 Position Feedback 4.20mA – >0.100% OPEN	Feedback < 0.1% (0.5% of Commanded) CLOSE	Relays to System Off Mode	Pump VFD Fault	TSSS-SA-P-1, 2, 3	Digital Input Open/Isolation Fault VFD is Commanded VFD is Disabled	Preceded to Next Pump in Rotation, Once Next Pump Manufacturer's Specifications	Flow Stability	Building 11, Process 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584,		

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Startup Process -2 Live Testing

- Live Testing w/ Contingency Planning
 - Building 11 Secondary Pumps
 - Primary / Secondary Decoupler Flow
 - Chilled Water Supply Temp
 - Reserve Chiller Capacity
 - Recording / Monitoring Plan (data)
 - Failure Testing (wait...)



Training

- Introduction (Why a tank?)
- Principles of Operation
- System Operating Modes
- System Pressure Control Modes
- Tank Level Control and Alarms
- System Initiation and Start-up
- System Planning Prior to Initiation of Charge/Discharge Cycle
- Key Items to Watch

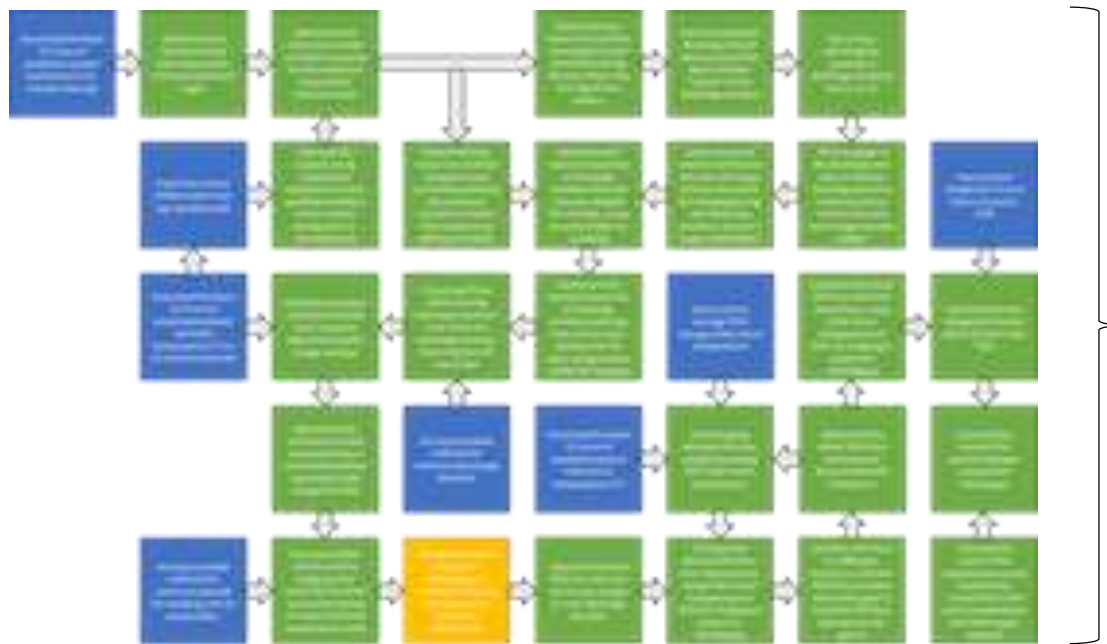


Optimization

- Excel Based Dispatch Model
 - Inputs
 - 72 hours of future load prediction based on weather forecast
 - 72 hours of future forecasted wet bulb temperature
 - Current TESS capacity (ton-hours)
 - Current chiller lead/lag order
 - Criteria
 - Load-level (limit cycles)
 - Wet bulb temperature (efficiency)
 - Real-time LMP for electricity (cost)
 - Result
 - 48 hour future TESS charging/discharging setpoints

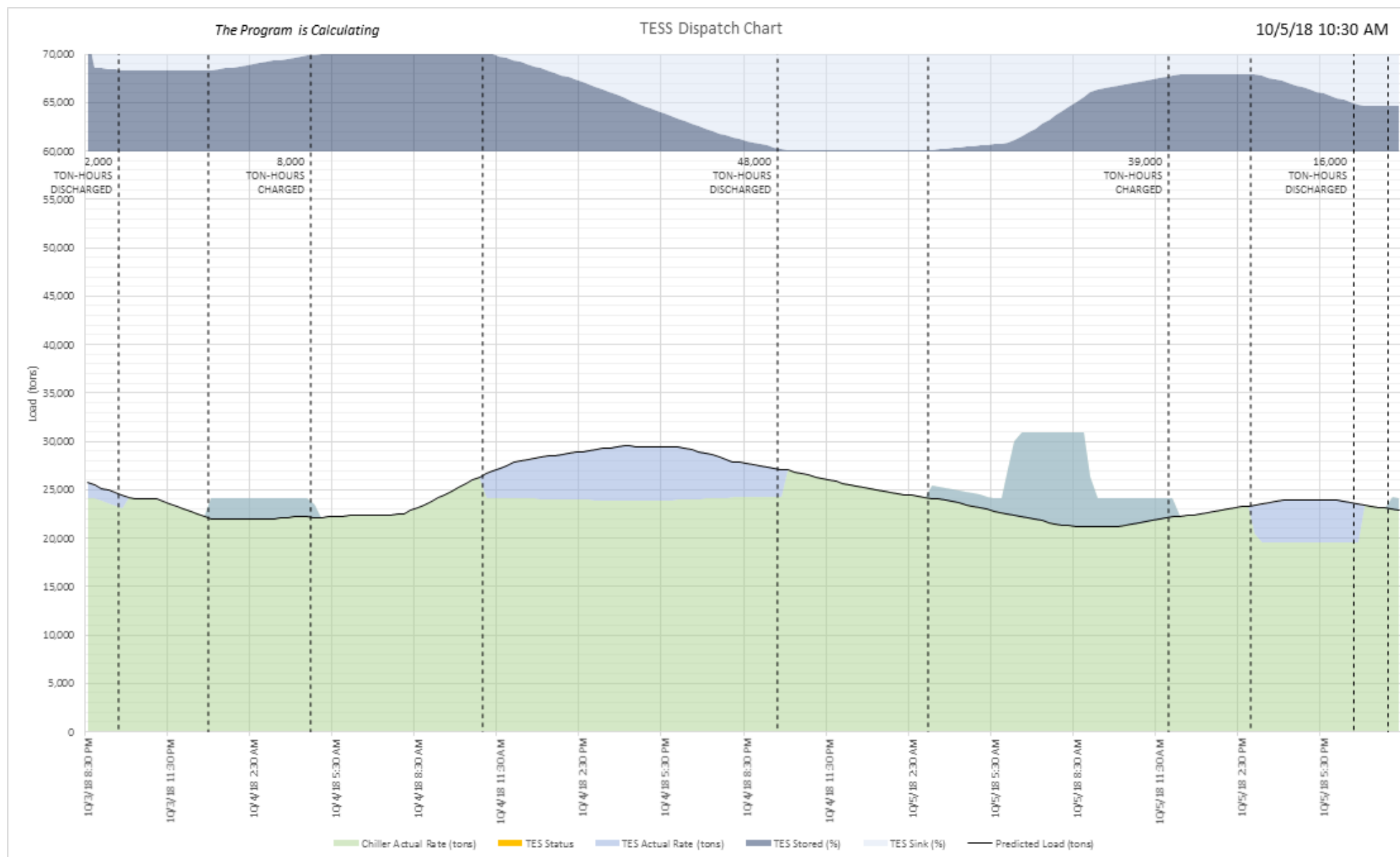
Optimization

- Up to 3,600 TESS dispatch strategies are calculated
- The results are weighted based on input criteria
- The best result is plotted to the screen
- The model repeats the calculation on set interval (5-15 minutes)



Model logic flowchart

Optimization



- Volume: 7.75 MG
- Diameter: 120'-0"
- Height: 96'-6"
- Design DT: 10°F
- Capacity: 47,500 Ton-hour
- Max Discharge/Charge: 5 hours
- Flow Rate Range:
 - 3,000 GPM to 24,000 GPM
- Steel - API 650



- Volume: 7.75 MG
- Diameter: 120'-0"
- Height: 96'-6"
- Design DT: **14°F**
- Capacity: **66,500+ Ton-hour**
- Max Discharge/Charge: 5 hours
- Flow Rate Range:
 - 3,000 GPM to 24,000 GPM
- Steel - API 650



Contact Information

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