AP1000 vs BWRX-300 Powered Datacenter

Parth Patel
ME 4315- Dr. Simmons

Table of Contents

- Problem
- AP1000 vs BWRX-300
- Data Center
- Economic Analysis
- Conclusions

The Problem

Goal: Evaluate the technical performance of two nuclear technologies (AP 1000 vs BWRX-300) coupled to provide power for a liquid-cooled 100MW LLM data center

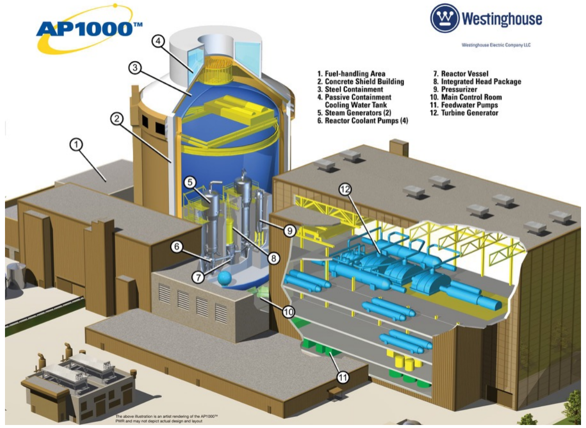
- Rankine-Cycle Models:
  - AP1000 3-loop PWR (indirect cycle)
  - BWRX-300 direct cycle SMR with moisture separator reheater

- Parametric Analysis:
  - Nuclear analysis, environmental effects, and system optimization effects

- Liquid-to-Chip Data Center:
  - 100MW hyperscale data center with complete chiller + primary loop for 42 MW heat rejection system
  - 26 YVAA-500 chillers, N+2 configuration and secondary coolant loop using Liebert XDU-1350 cold plate manifold.

LCOE cost analysis to determine feasibility for full-scale implementation

AP1000 cutaway image (Westinghouse):
NuclearStreet – AP1000 Plant Illustration



BWRX-300 rendering (GE-Hitachi):
GlobalEnergyWorld, "GE Hitachi BWRX-300 Modular SMR."

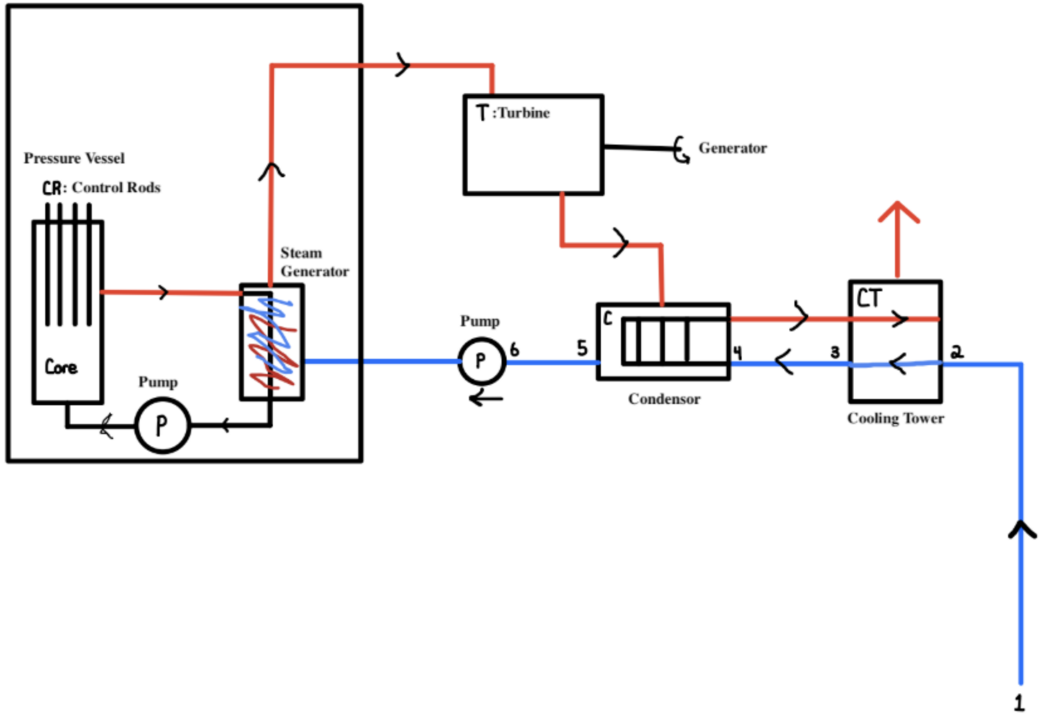
Georgia Tech

AP1000 vs BWRX-300

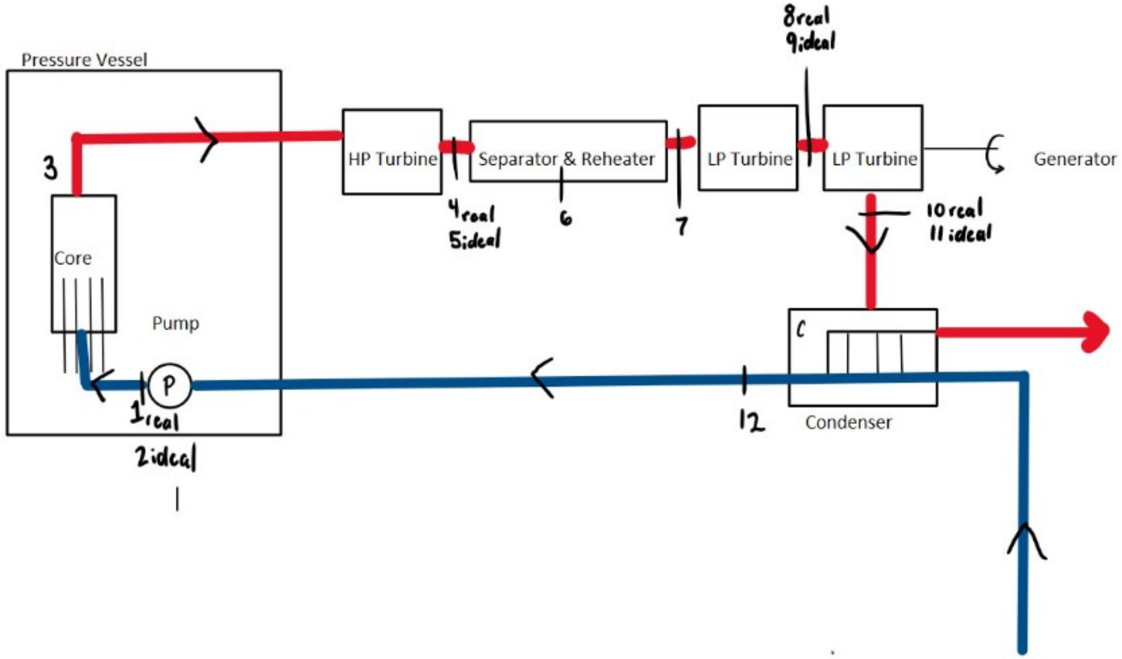
Georgia Tech

Plant Layout Comparison

Westinghouse AP1000



GE-Hitachi BWRX-300



Georgia Tech

Plant Performance

Category	Metric	AP1000	BWRX-300	Engineering Implication
Reactor	Net Electrical Output	1,224 MW	293.9 MW	AP1000 is 12× too large for a single DC; BWRX matches ~300 MW scale
	Thermal Efficiency	**36.24%**	33.49%	>Ap1000 efficiency (superheating)
	Exergy Efficiency	40.24%	**64.69%**	>BWRX 2nd-law performance (direct cycle)
Steam & Cooling	Steam Mass Flow	1,886 kg/s	**334.8 kg/s**	BWRX-300 uses ~6× less steam
	Cooling Water Flow	49,696 kg/s	**15,701 kg/s**	AP1000 requires large river/ocean; BWRX can use standard cooling tower
	Condenser Heat Rejection	~2,490 MW	**656 MW**	AP1000 heat load is 4× larger

Georgia Tech

Category	Metric	AP1000	BWRX-300	Engineering Implication
Overall Feasibility	Fit for 100 MW Data Center	Poor: 12× oversupply	Ideal: 300 MW SMR scale	BWRX-300 matches data center load profiles
	Deployment Infrastructure	High cooling/water requirement	Smaller, modular, deployable	**BWRX-300 is feasible for this application**

Parametric Effects:

- Mass Flow Rate (Nuclear Core Effects)
  ↑ Mass flow → ↓ Void fraction → ↑ Reactivity
  ↓ Mass flow → ↑ Void fraction → ↓ Reactivity

- Environmental / Heat-Sink Effects
  ↑ Cooling-water temperature → ↑ Condenser pressure → ↓ Net electrical output

- System Optimization Effects
  ↑ Reheat temperature + ↑ Turbine efficiency → ↑ Cycle performance / ↑ Net power

Georgia Tech

Energy Consumption Analysis

	BWRX-300	AP-1000
Nameplate Capacity (MW)	300	1115
Gross Capacity (MW)	294	1224
Total Energy Output (MWh)	2628000	9767400

Data Center	
Gross Capacity (MW)	100
PUE	1.2
Total Energy Output (MWh)	1051200

HyperScale Amount	
BWRX-300 HyperScale #	2.5
AP-1000 HyperScale #	9.291667

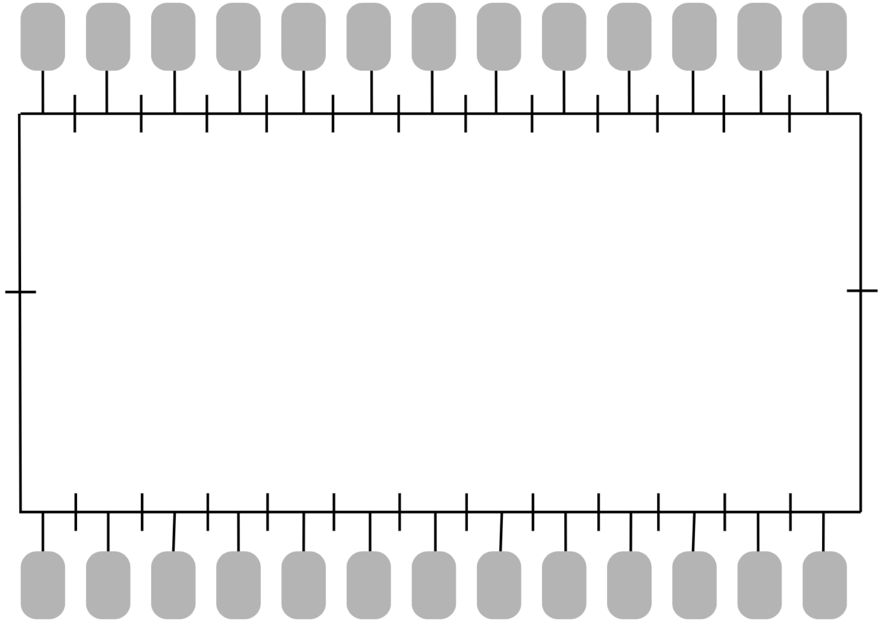
Georgia Tech

Data Center

Data Center Chillers

Primary Loop Data	York YVAA 500
Chiller Count (N+2)	26
Chiller Design Flow Rate (GPM)	1149
Pipe Size (in)	24
Pipe Length (ft)	560
Pump Efficiency	.75

Findings	
Pump Horsepower (HP)	486.4



Georgia Tech

Data Center Cooling Distribution Unit

Liebert XDU-1350	
Model Rating (kW)	1350
Primary Loop Inlet Temp (F)	54
Primary Loop Outlet Temperature (F)	44
Secondary Loop Inlet Temperature (F)	70
Secondary Loop Outlet Temperature (F)	52

Findings	
Overall Heat Transfer Coefficient (Btu/(ft^2*h*F))	464
Length of Heat Exchanger	46.16 in
Number of Plates	140

Georgia Tech

Economics

Georgia Tech

Economics

AP1000 Nuclear Reactor Unit (based of Vogtle Unit 3 or 4)	Basis	Units	Value
Fixed Capital Investment (CAPEX)	Total	$	$15,000,000,000

Nameplate Capacity of the Plant (electrical output)	Initial	MW	1100
Estimated Annual Generation (Gen_t)	Yearly	kWh/yr	9,057,840,000
Levelized Cost of Electricity (LCOE)	Project Life	$/kWh	$0.196

General Electric's BWRX-300 (One Unit)	Basis	Units	Value
Fixed Capital Investment (CAPEX)	Total	$	$5,800,000,000.00

Nameplate Capacity of the Plant	Initial	MW	300
Estimated Annual Generation (Gen_t)	Yearly	kWh/yr	2,365,200,000
Levelized Cost of Electricity (LCOE)	Project Life	$/kWh	$0.268

- 1,051,200,000kWh x $0.196/kWh x 9 (number of data centers) = **$1,854,316,800 energy annually**
- 1,051,200,000kWh x $0.268/kWh x 2 (number of data centers) = **$563,443,200 energy annually**
- $15,000,000,000 (AP1000) + ($2,413,859,194.15 (Ashburn plant total construction cost 2019 adjusted for inflation) x 9) = **$36,724,732,747 total project cost (not including land)**
- $5,800,000,000 (BWRX-300) + ($2,413,859,194.15 (Ashburn plant total construction cost 2019 adjusted for inflation) x 2) = **$10,627,718,7388 total project cost (not including land)**

Concluding Discussion

Concluding Statements

Area

Cost

Enviroment

Safety

Sustainability

Georgia Tech

Questions or Comments?