

Data Centers & PUE

Today

7% of the world's energy goes to steel production

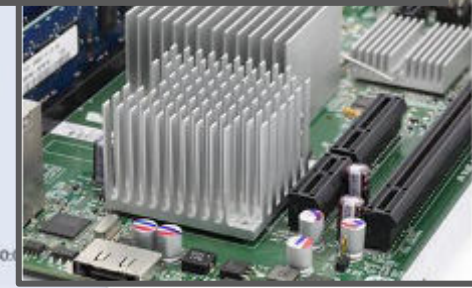
5% goes into data centers

It will surpass steel production this year likely

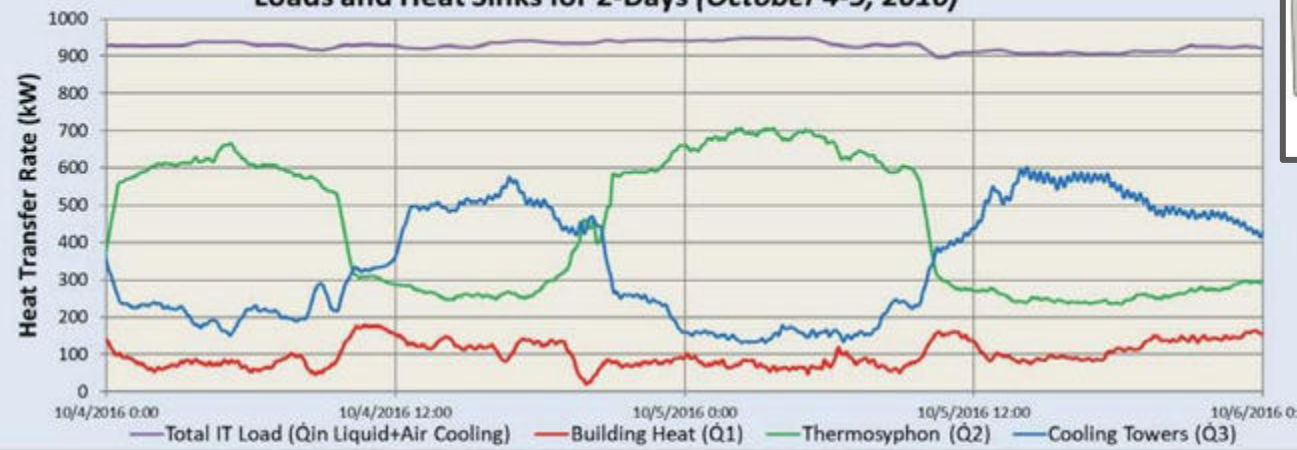
Power Use Effectiveness	PUE	$(\text{Facility Energy} + \text{IT Energy}) / \text{IT Energy}$
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Rack Density	RD	Amount of power per rack of gear delivered - kW
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	PUE	Rack Density
Standard (Pure Storage)	2.0 - 1.8	Up to 10kW per Rack
HyperScaler (Amazon, Google, etc...)	1.3 - 1.5	Up to 20kW per Rack
National Renewable Energy Laboratory	1.06	Greater than 20kW per Rack



Loads and Heat Sinks for 2-Days (October 4-5, 2016)



Outdoor Dry Bulb Temperature (October 4-5, 2016)

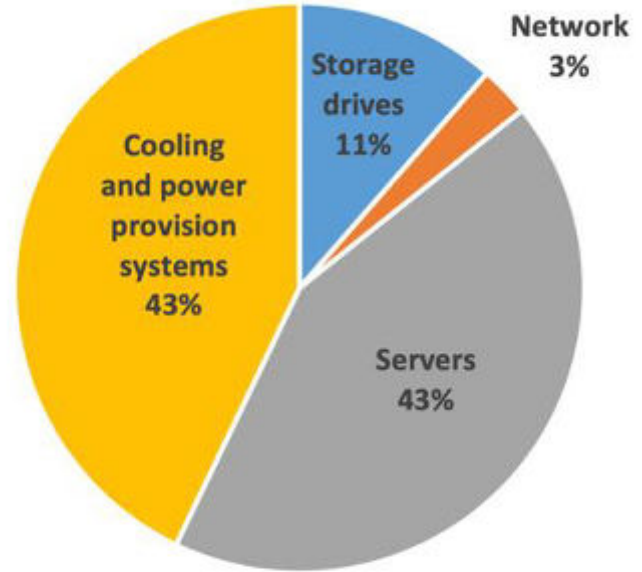


AI Workloads generate most heat
Summer is the hotels months

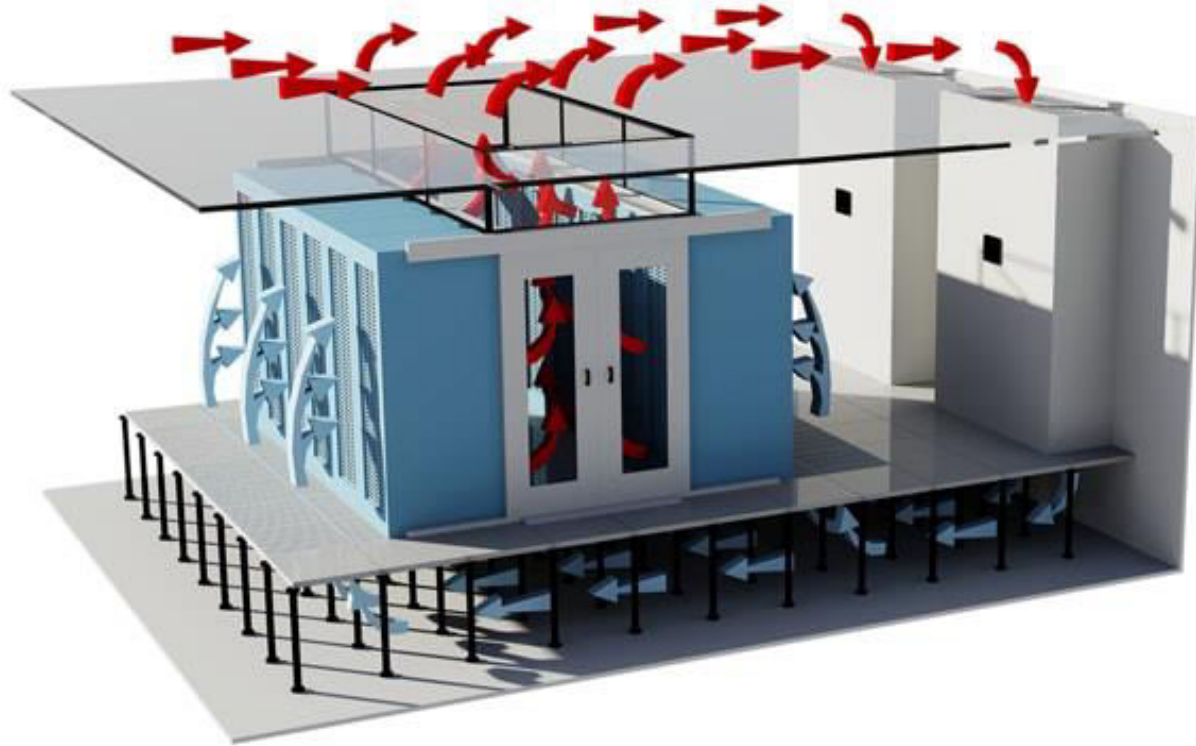
Allocation of costs	
Power	70%
Network	20%
Services	10%
Space	0%

Power is THE business driver

Allocation of Power ~ PUE 2.0



Cooling is THE PUE > 1 driver



The more cooling, the greater rack density \$

Temp in datacenter is governed by humans

Water Cooling:

Water is capable of absorbing more heat at 3,500 times faster than air

Computers and water don't mix

Fresh Water is limited resource as well

But gamers have been doing it, and...

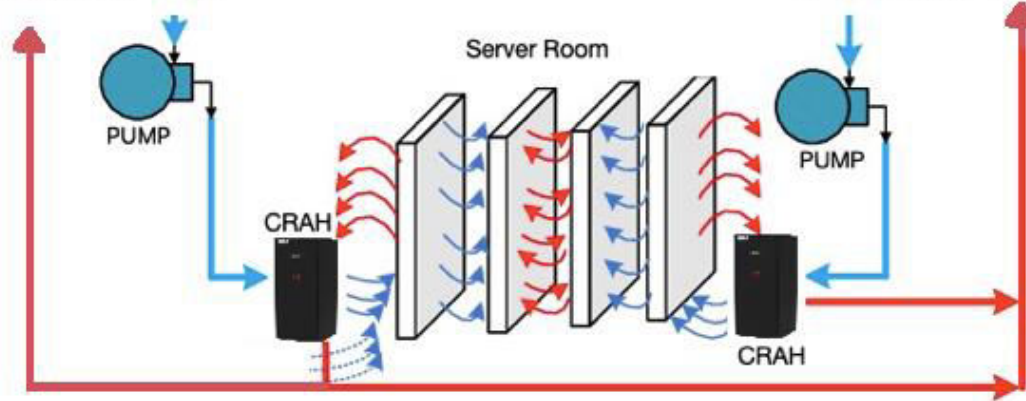
Cost Savings - High Rack Density
Efficiency - Low PUE



PUE ~ 2.0
Rack Density ~ 5 -10 kW

Fresh Air

Fresh Air



— Cold

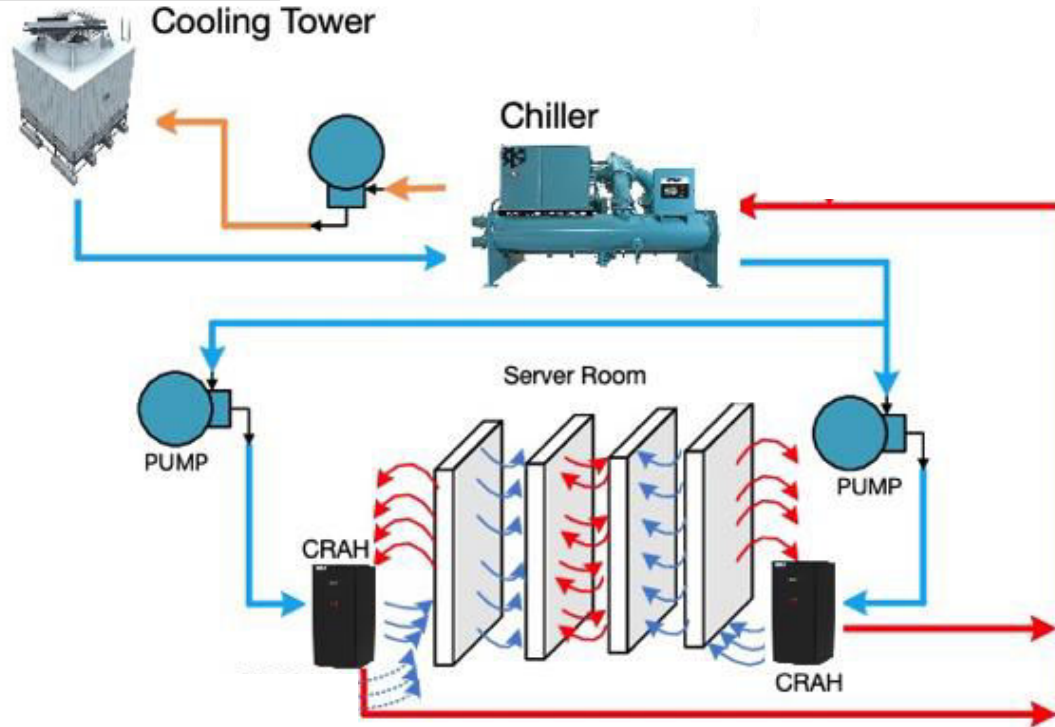
— Hot

↪ Fresh cold air

↪ Exhausted hot air



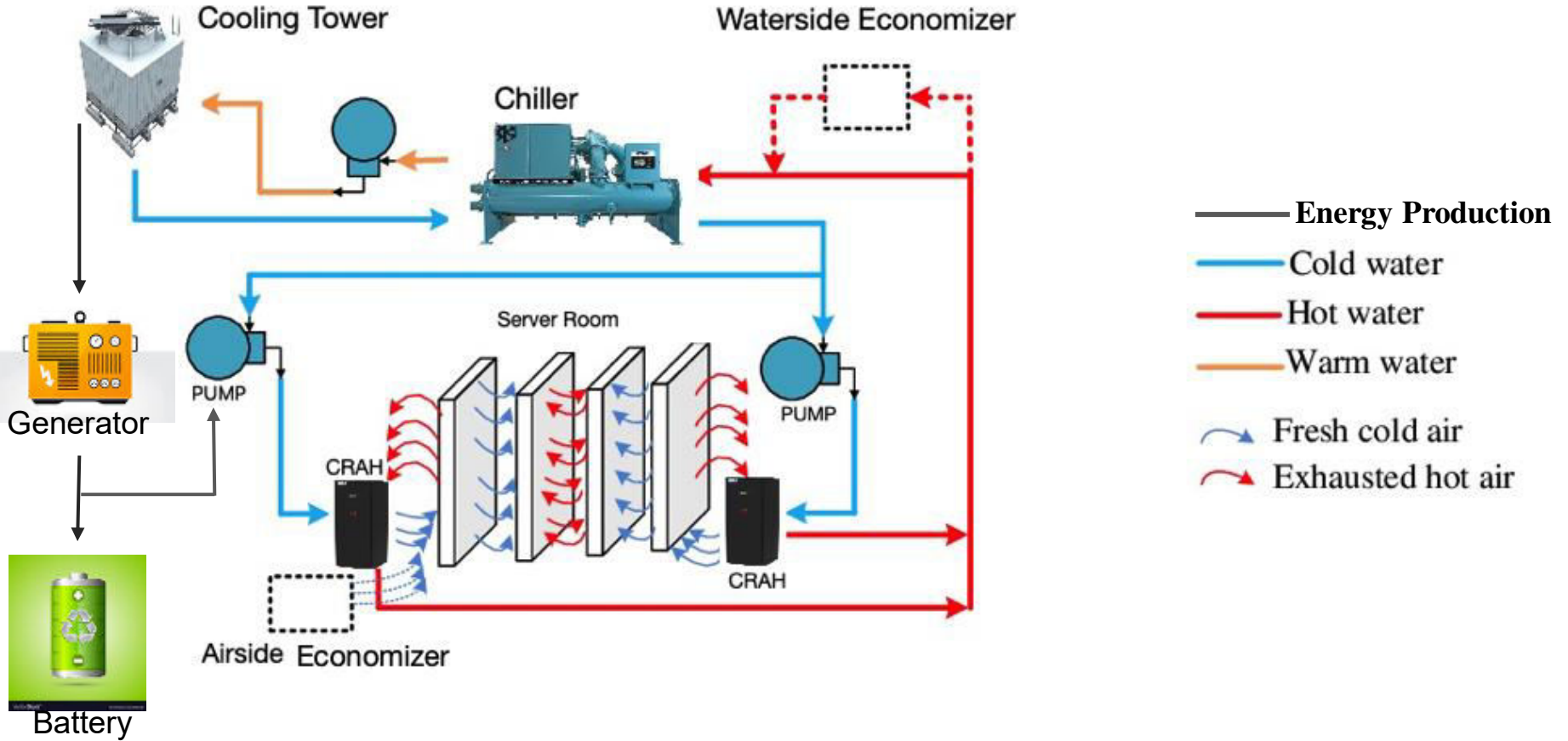
PUE ~ 1.7
Rack Density ~ 10kW



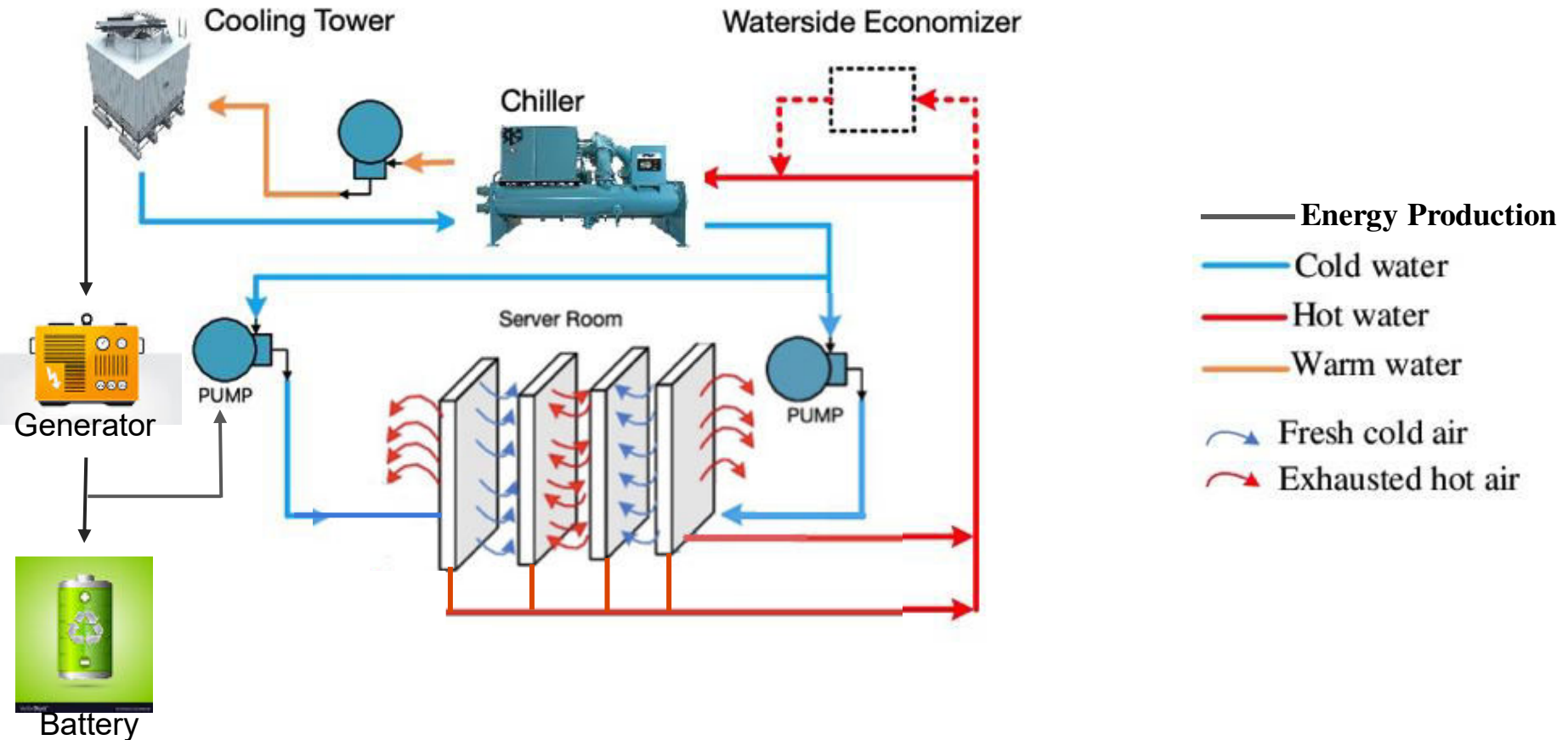
- Cold water
- Hot water
- Warm water
- Fresh cold air
- Exhausted hot air

PUE ~ 1.5

Rack Density ~ 15kW



PUE > 1.2 Rack Density > 20kW



Driving PUE Lower
Google Containers

Reduce Building Cost?
No need for humans?



Why did it sink?

Land building codes



Google Barges

Reduce overhead, permits, bureaucracy - sea vs land laws

Reduce location risks - can move easily

Cheap water - the San Francisco bay

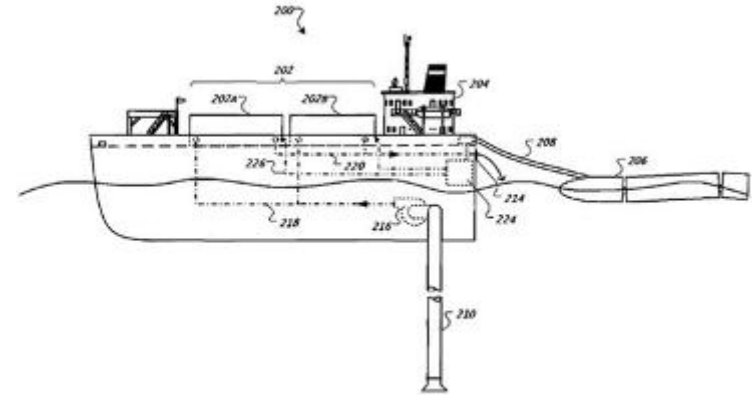


FIG. 2

Why did it sink?

Hydrophobia - Water Risk to IT Load

Damage to mechanical disk drives

Water waste and too much pumping

Fire Danger & Compliance problems



Microsoft Underwater Data Center



Not practical

But proved ambient temperature without human



Today - PUE 1.1 Rack Density > 100kW



Cooling from ambient temperature at bottom of barge
Vacuum vs Push Water
Flash removes “disk problem”
Solved regulatory problems by much less water use
Rack density of 105kW



Greece

- Ancient history and mythology
- Magnificent mix of weather
- Unique sea and islands
- Beautiful people and hospitality
- Slow life in it's best
- Part of NATO and EU member state
- Euro currency
- Greek alphabet, The roots Orthodox culture
- Home of the Democracy
- Enormous omogenia/diaspora - >6M

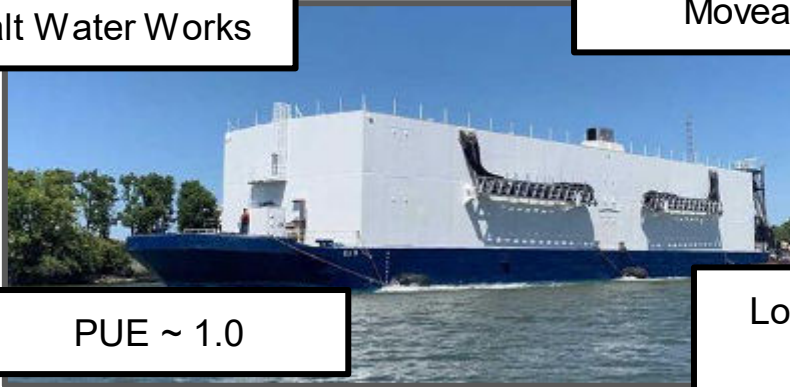


Greece

Power	Energy & Pricing	One of the most expensive in EU
	Energy Mix & Market	Still more monopoly than liberalization
	Cooling	Hot period is extended and high
Network	Market	OTE, the incumbent is still ruling the market. Not so liberal
	Interconnect	Limited in region by land
Space		Earthquakes, Regulation, National Strikes, Some Regional Instability

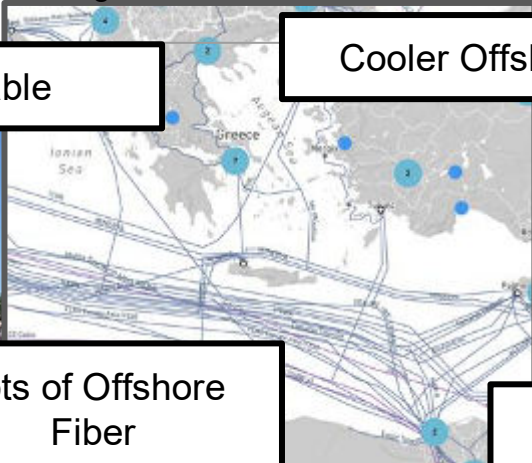
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Salt Water Works



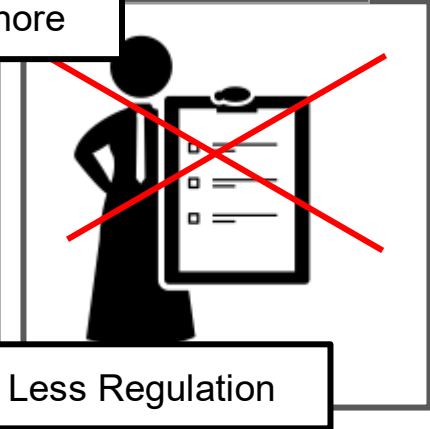
PUE ~ 1.0

Moveable



Lots of Offshore Fiber

Cooler Offshore



Less Regulation

Next How to Get Below 1.0?



+



+



< 1.0

