

“Green” Cloud Computing

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Agenda

- **Evolution of VLSD**
- **Why Container Computer?**
- **Ideas for “green” cooling VLSD**
- **Ideas for “green” power**
- **Summary**



Evolution of VLSD (Very Large Scale Datacenter)

1990

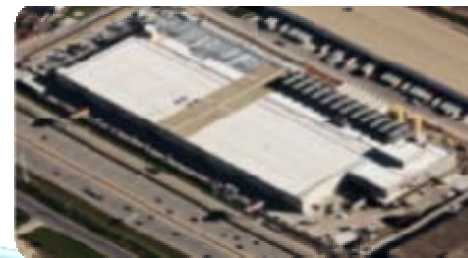
1998

2008

Generation 1
10K Servers

Generation 2
100K Servers

Generation 3
300K Servers



~ 500
KWatts

~ 10
MegaWatts

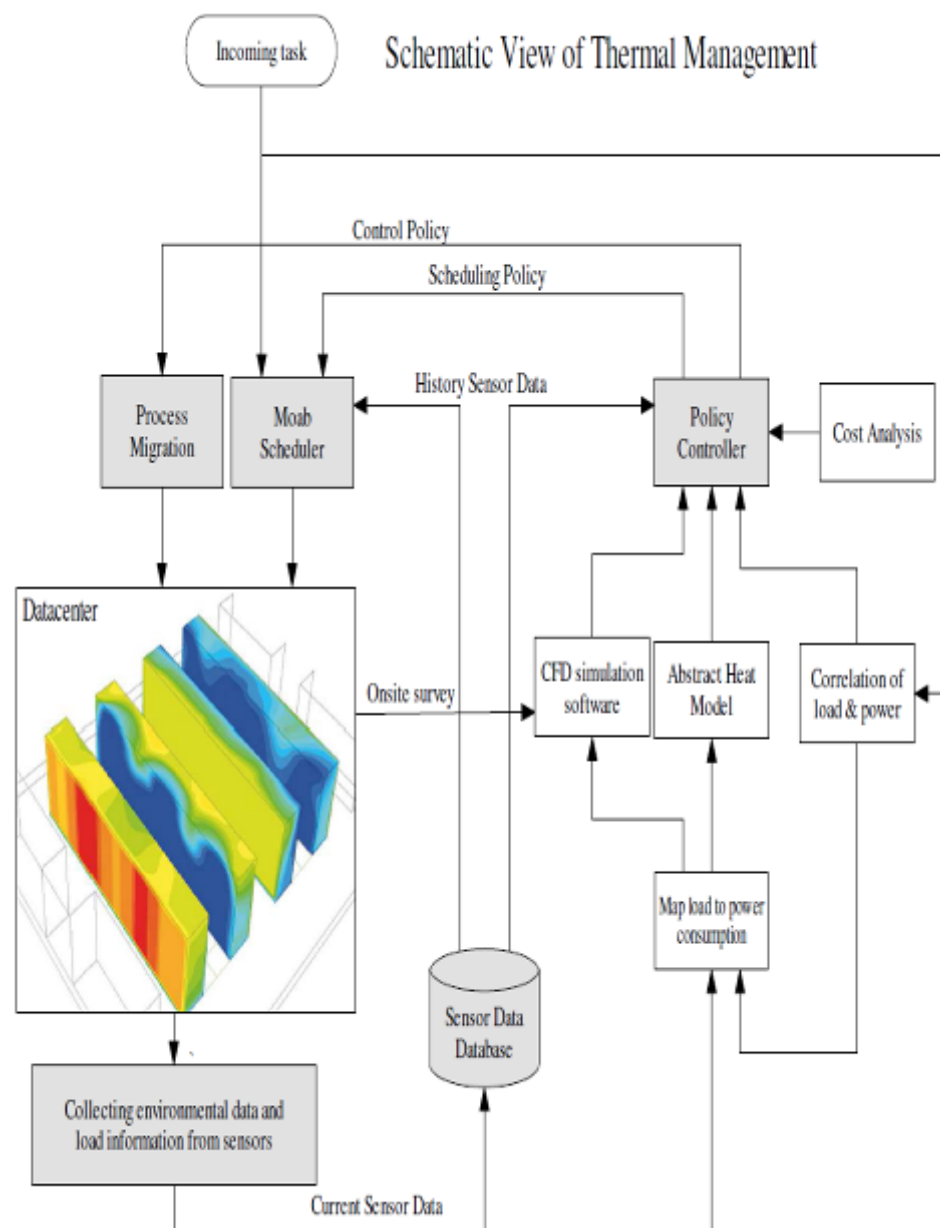
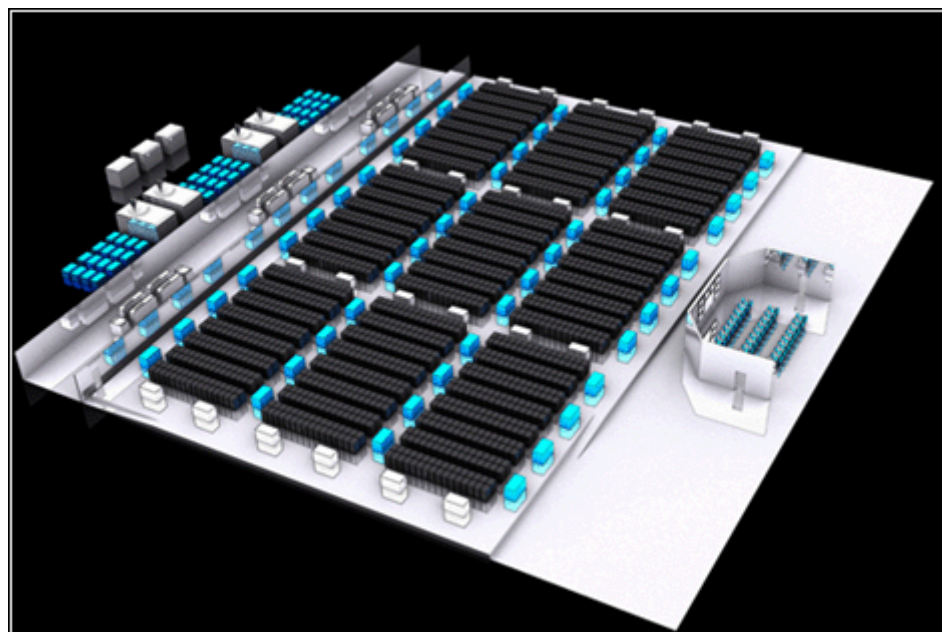
~ 60 MegaWatts → ??



Server Capacity

Server Density and
Manageability

Container Scalability
Power Usage Efficiency
(PUE)



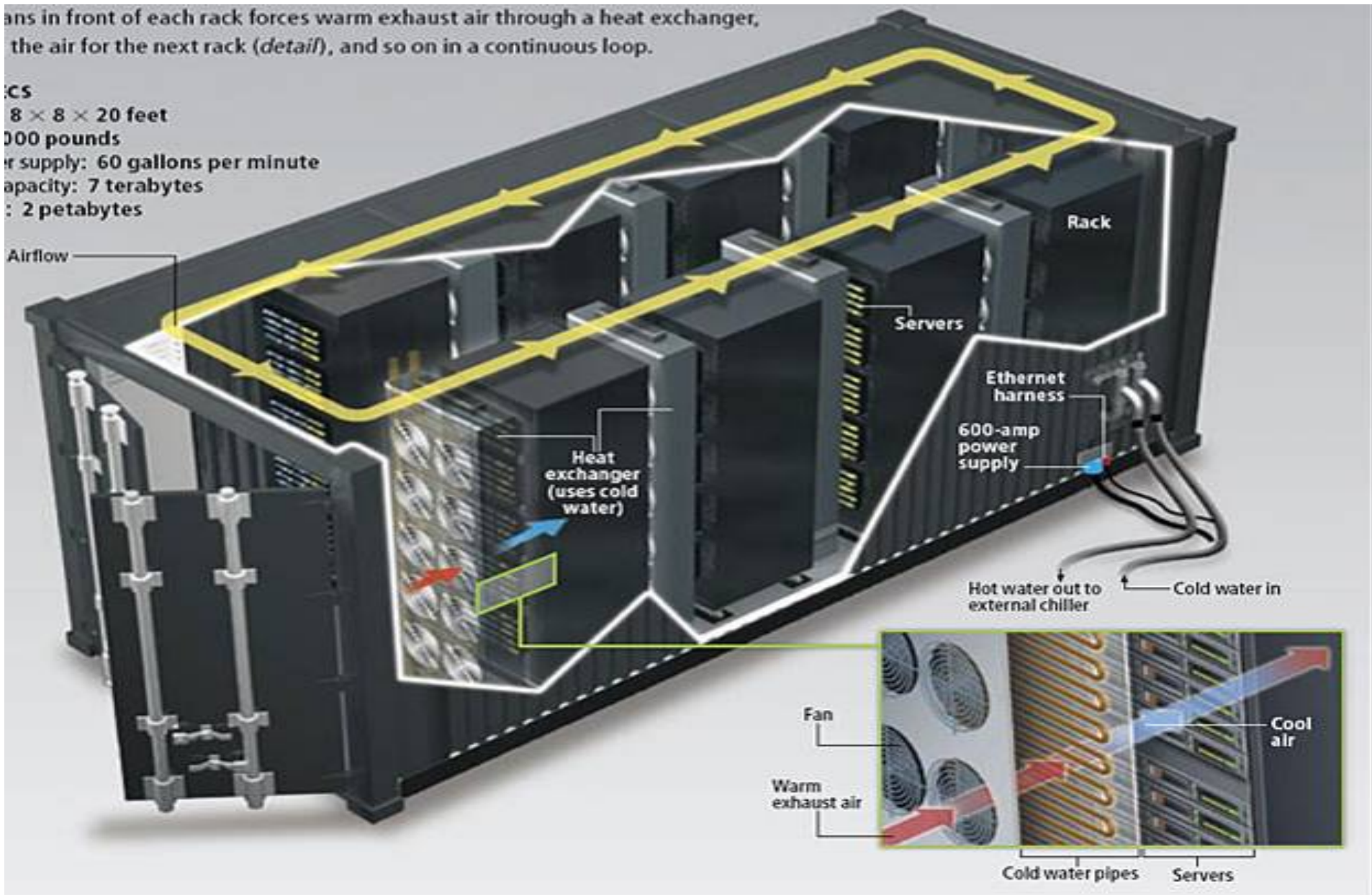


Highly efficient container computer based VLSD

Fans in front of each rack forces warm exhaust air through a heat exchanger, pre-cooling the air for the next rack (*detail*), and so on in a continuous loop.

CS
8 × 8 × 20 feet
1000 pounds
Power supply: 60 gallons per minute
Capacity: 7 terabytes
Storage: 2 petabytes

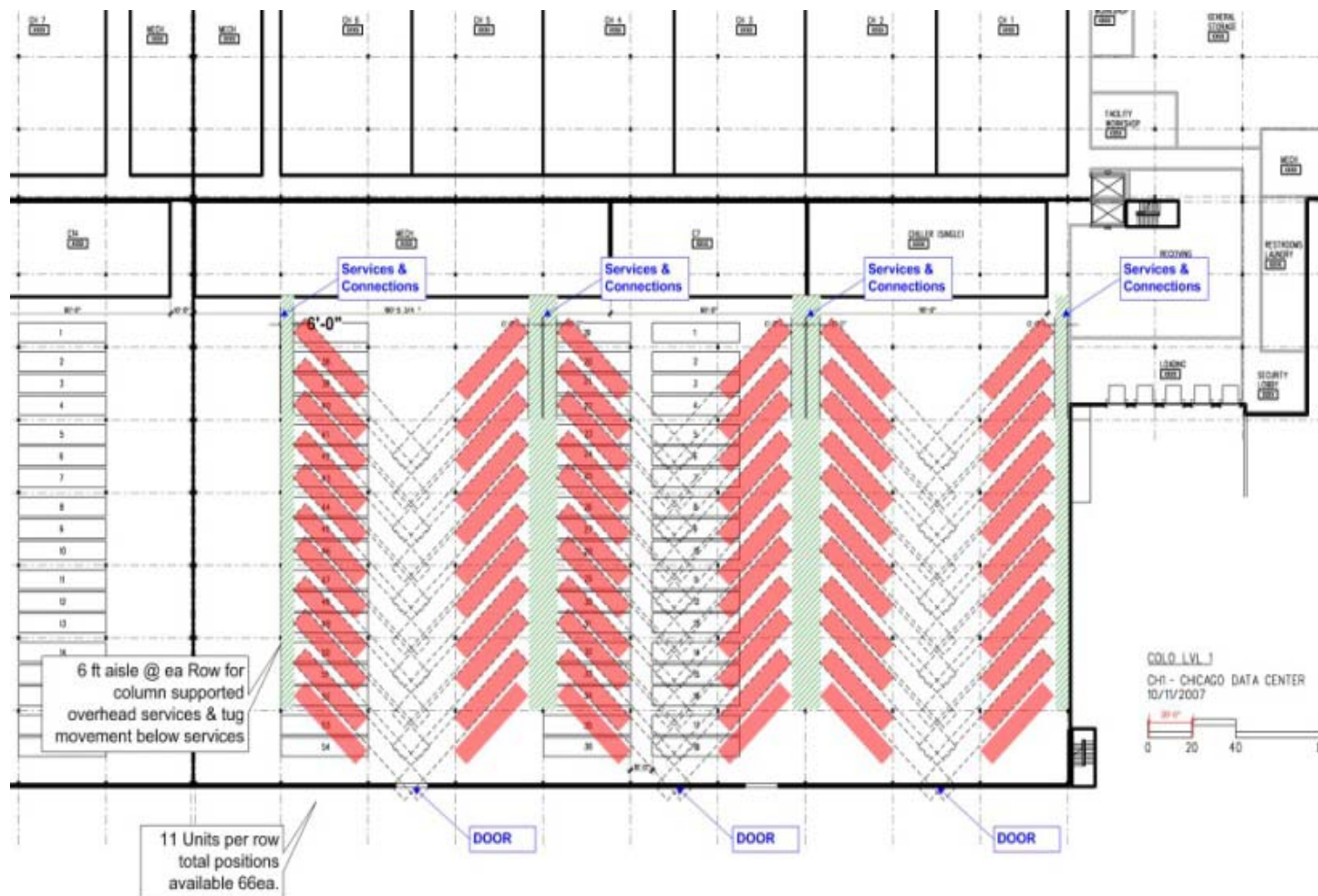
Airflow



Container based Very Large Scale Datacenter (VLSD)



Microsoft Chicago VLSD



微軟投資五億美金於芝加哥打造貨櫃型雲端資料中心



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Cooling is a BIG problem in VLSD (Phoenix ONE datacenter)



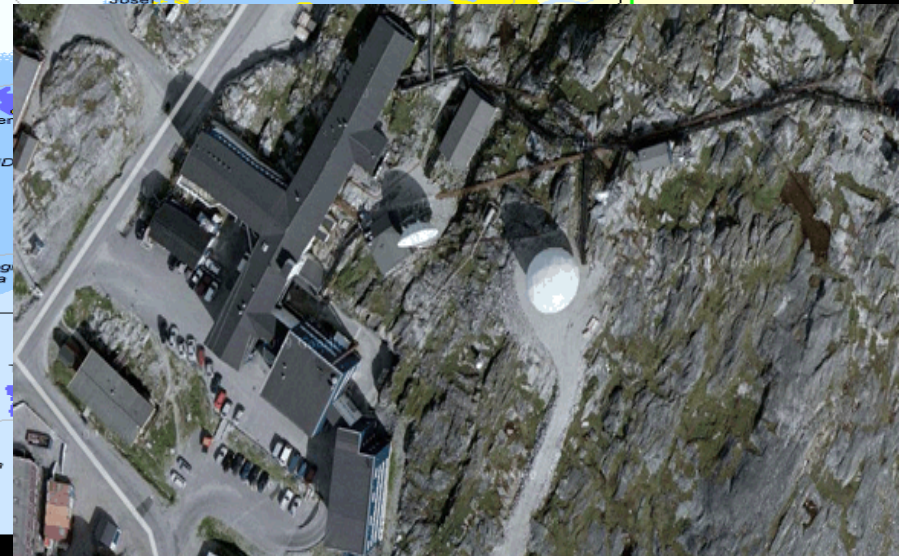


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Today's VLSD needs a lot of Power + Water

Google Datacenter at Columbia river,
Oregon







Interesting ideas for building “Green” VLSD

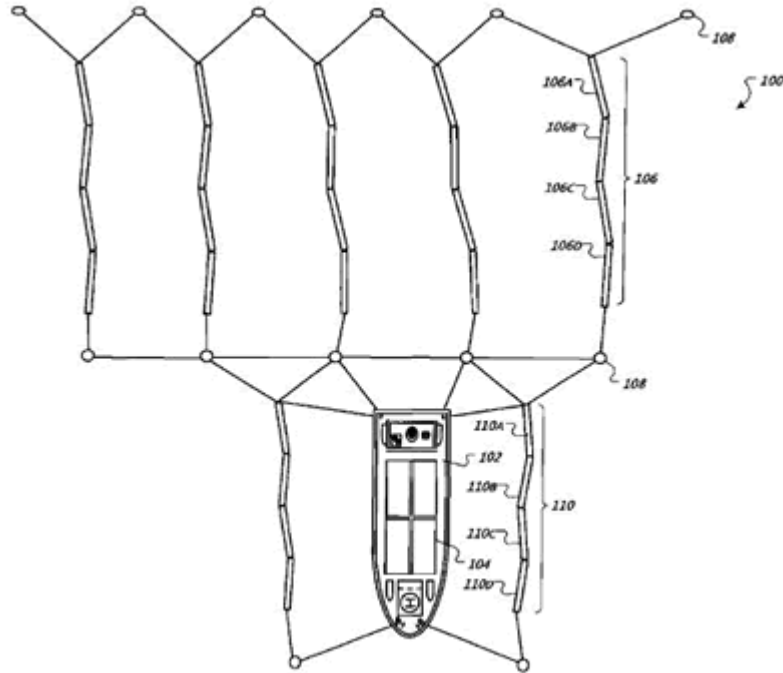


Interesting ideas for building VLSD





Interesting ideas for building “green” VLSD



([Google Navy floating data centers](#))

The sea-going computer platforms will be sustainably powered by Pelamis wave energy converters.

Interesting ideas for building “green” VLSD

Google Navy floating data centers

The sea-going computer platforms will be sustainably powered by wave energy converters.

USPTO PATENT FULL-TEXT AND IMAGE DATABASE



United States Patent
Clidas, et al.

Water-based data center

Abstract

A system includes a floating platform-mounted computer data center comprising a plurality of computing units, a sea-based electrical generator in electrical connection with the plurality of computing units, and one or more sea-water cooling units for providing cooling to the plurality of computing units.

Inventors: Clidas; Jimmy (Los Altos, CA), Stiver; David W. (Santa Clara, CA), Hamburg; William (Palo Alto, CA)
Assignee: Google Inc. (Mountain View, CA)
Appl. No.: 11/679,013
Filed: February 26, 2007

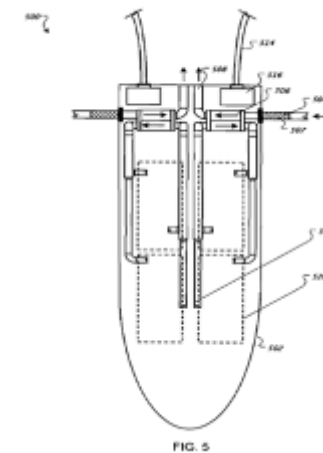
Current U.S. Class:

Current International Class:

Field of Search:

290/43 ; 290/42; 290/53; 290/54
F03B 13/10 (20060101); H02P 9/04 (20060101)
290/42, 43, 44, 53, 54, 55 415/2

Patent Application Publication Aug. 26, 2008 Sheet 7 of 7 US 2008/0209234 A1



(1 of 1)

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1 28, 2009

Green Datacenter + swimming pool



cwe4191 www.fotoresearch.com

- Heat generated by VLSD is used to heat the swimming pool
- Cold water from the swimming pool is used to cool the VLSD



Interesting ideas for building “Green” Power generation for VLSD



Interesting ideas for building "Green" Power generation for VLSD

United States Patent [19] Hampel

[11] Patent Number: 4,851,183
[45] Date of Patent: Jul. 25, 1989

- [54] UNDERGROUND NUCLEAR POWER STATION USING SELF-REGULATING HEAT-PIPE CONTROLLED REACTORS
- [75] Inventor: Viktor E. Hampel, Pleasanton, Calif.
- [73] Assignee: The United States of America as represented by the United States Department of Energy, Washington, D.C.
- [21] Appl. No.: 194,772
- [22] Filed: May 17, 1988
- [51] Int. Cl.⁴ G21C 13/10
- [52] U.S. Cl. 376/274; 376/367; 376/911
- [58] Field of Search 376/272, 273, 274, 275, 376/276, 367, 911, 914

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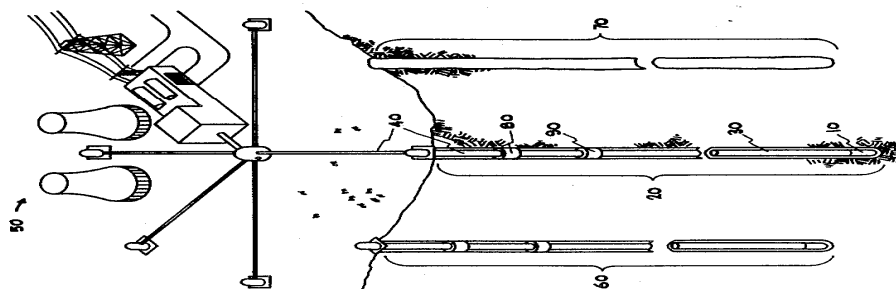
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Primary Examiner—Deborah L. Kyle
Assistant Examiner—Richard W. Wendtland
Attorney, Agent, or Firm—Michael Lee; L. E. Carnahan; Judson R. Hightower

[57] ABSTRACT

A nuclear reactor for generating electricity is disposed underground at the bottom of a vertical hole that can be drilled using conventional drilling technology. The primary coolant of the reactor core is the working fluid in a plurality of thermodynamically coupled heat pipes emplaced in the hole between the heat source at the bottom of the hole and heat exchange means near the surface of the earth. Additionally, the primary coolant (consisting of the working fluid in the heat pipes in the reactor core) moderates neutrons and regulates their reactivity, thus keeping the power of the reactor substantially constant. At the end of its useful life, the reactor core may be abandoned in place. Isolation from the atmosphere in case of accident or for abandonment is provided by the operation of explosive closures and mechanical valves emplaced along the hole. This invention combines technology developed and tested for small, highly efficient, space-based nuclear electric power plants with the technology of fast-acting closure mechanisms developed and used for underground testing of nuclear weapons. This invention provides a nuclear power installation which is safe from the worst conceivable reactor accident, namely, the explosion of a nuclear weapon near the ground surface of a nuclear power reactor.

13 Claims, 6 Drawing Sheets



Wind “Green” Power generation for VLSD



Summary

- **IT Datacenter is at crossroad**
 - **Cloud Computing is driving VLSD demand**
- **Today's cooling approaches are lacking**
 - **Especially in sub-tropical climates (China/Taiwan)**
- **Today's power generation is expensive**
- **Many new ideas – May the best man win**