



# What if the Energy Grid Where Designed Like the Internet?

Randy Katz,  
David Culler, Seth Sanders

University of California, Berkeley  
Hot Power '08 Workshop  
December 7, 2008

*LoCal*

# Machine Age Energy Infrastructure

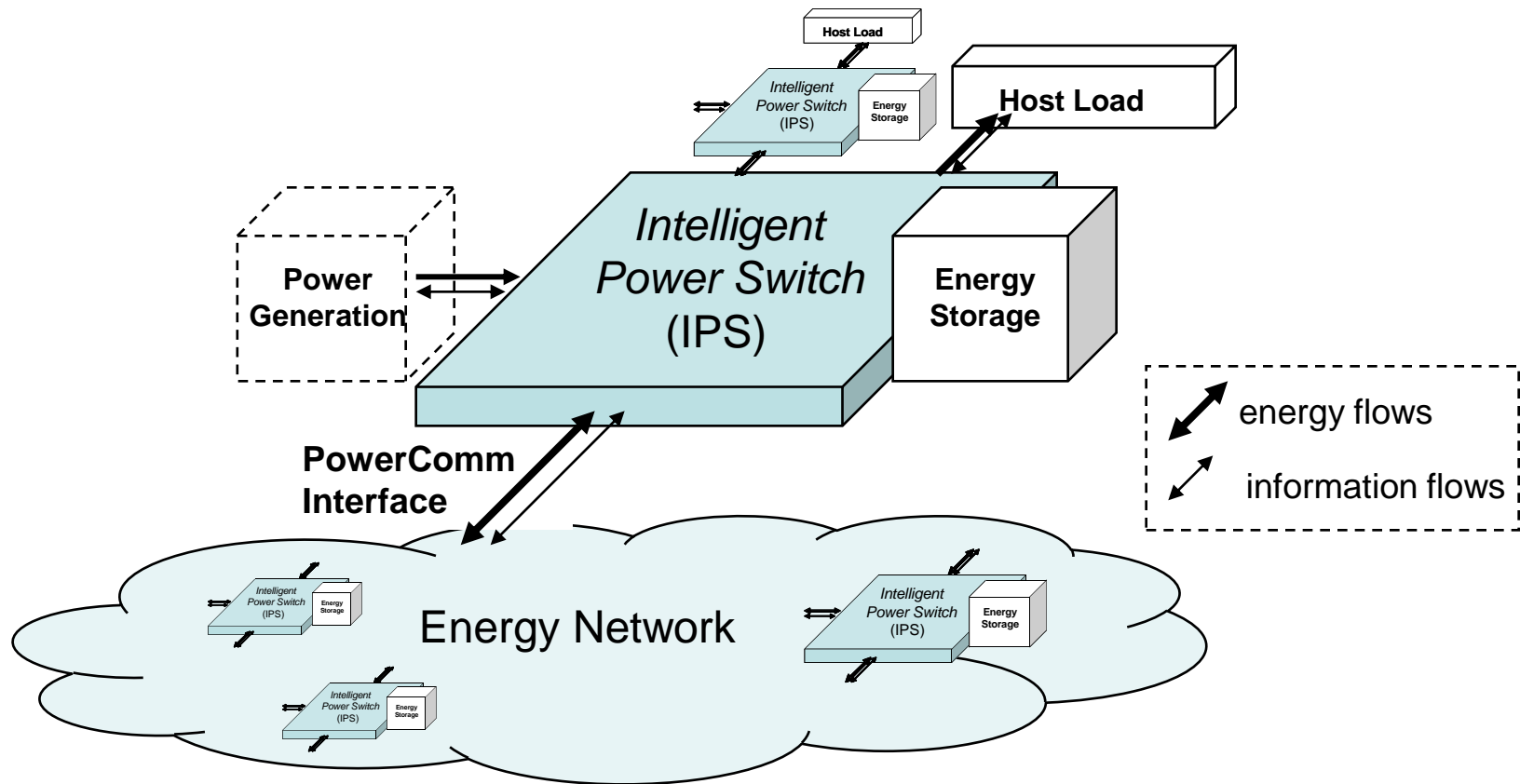




# Information Age Energy Infrastructure

- Energy: *the* limited resource of the 21st Century
  - Intelligence pushed to the edges, interconnection of intermittent sources, incentives for localized energy sharing to reduce long distance transmission losses
  - Lower cost, incremental deployment, suitable for developing economies
  - Enhanced reliability and resilience to wide-area outages, such as after natural disasters
- *Packetized Energy*: discrete units of energy locally generated, stored + forwarded to where needed; enabling a market for energy exchange

# Intelligent Power Switch



- PowerComm Interface: Network + Power connector
- Scale Down, Scale Out

# Datacenters





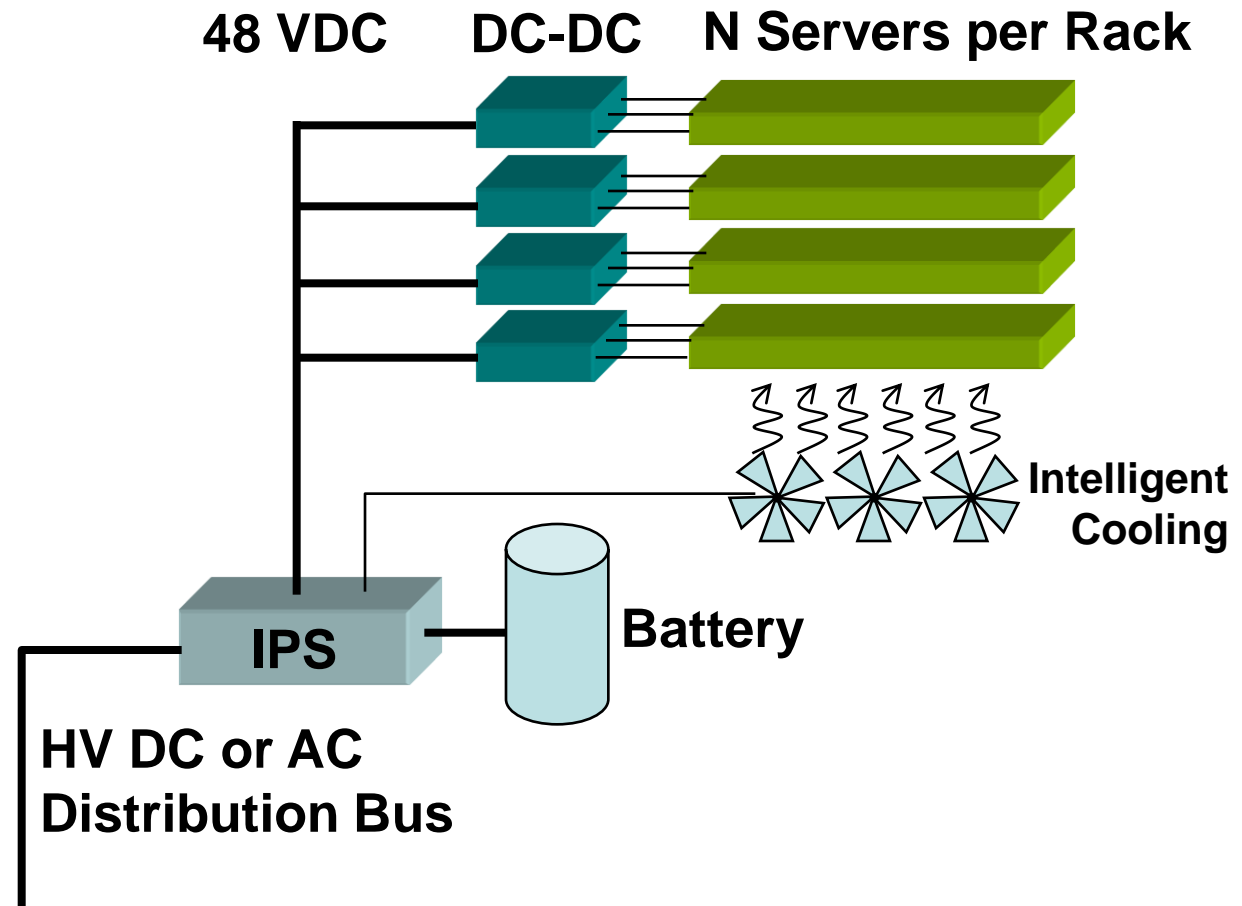
# “Doing Nothing Well”

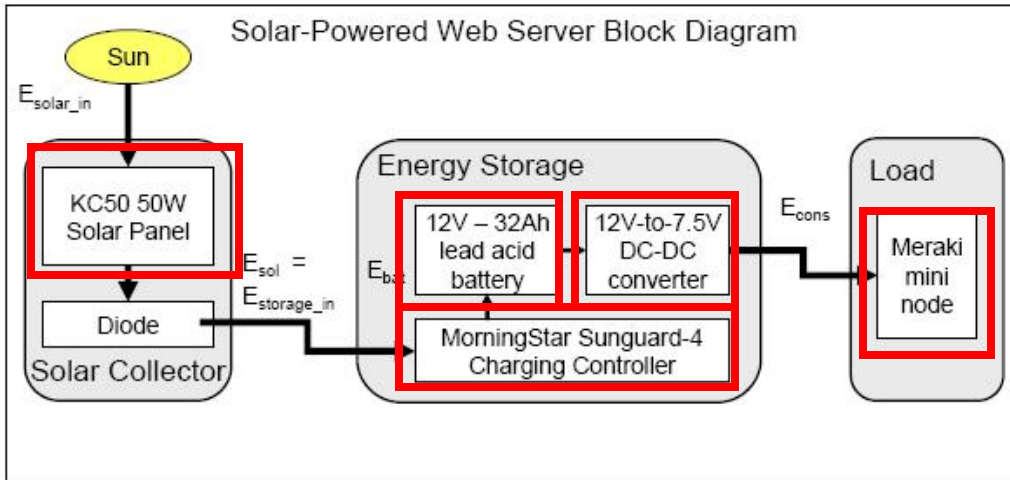
## Existing Systems Sized for Peak

- Exploit huge gap in datacenter peak-to-average processing/energy consumption
- Demand response
  - Challenge “always on” assumption for desktops and appliances
  - Realize potential of energy-proportional computing
- Better fine-grained idling, faster power shutdown/restoration
- Beyond architecture/hardware: pervasive support in operating systems and applications

## Rack Unit

- Replace AC power supply in servers with DC-DC converters to generate required voltages
- Battery capacity per rack to simplify design of the DC-DC converter, centralizing the charge controller and energy sharing function in the IPS
- Distributed DC-DC converters provide regulation at the load

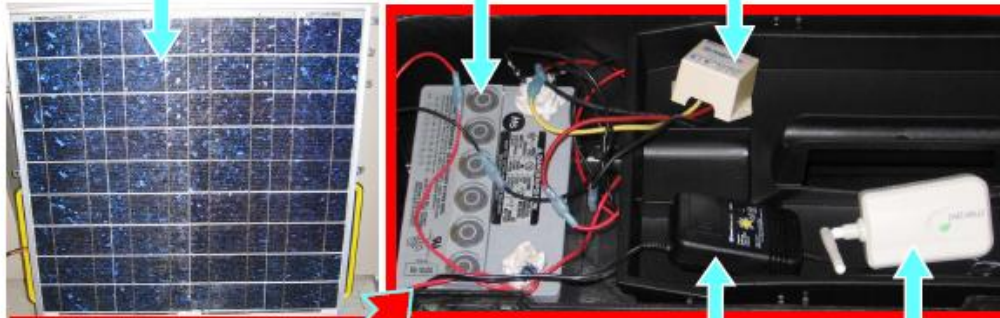




**Kyocera KC50 Solar Panel**

**12V-32Ah Sealed Lead Acid Battery**

**MorningStar Sunguard-4 Charging controller**



**PowerStream DC-292 DC-DC converter**

**Meraki Mini Node**

	Description
Solar Panel	<b>50W panel</b>
Input Regulator	<b>Efficiency 89%-97%</b>
Energy Storage	<b>12V-32Ah lead acid</b>
Output Regulator	<b>Efficiency 80%-82%</b>
Load	<b>2.25W average</b>





# Summary and Conclusions

- New scalable infrastructure
- Integrated energy generation and storage
- IPS and PowerComm Interface
- Energy marketplace
- Demand response: doing nothing well
- Testbeds: datacenter, villages (energy sharing), campground (plug and play)