



Modernizing the Energy Infrastructure in the HPCMP



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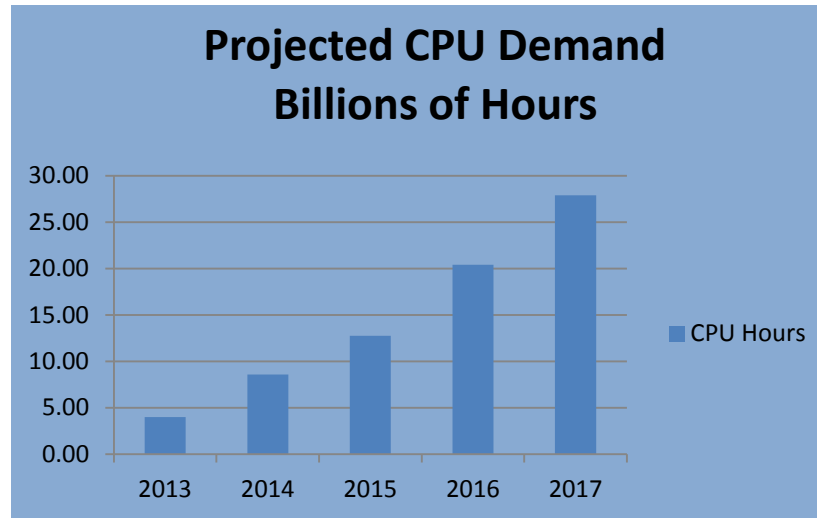
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Modernizing the Energy Infrastructure

- **Projected Growth**
- **Options**
- **Challenge Ahead**
- **Maui Energy Efficiency Demonstration Site**

Projected Growth

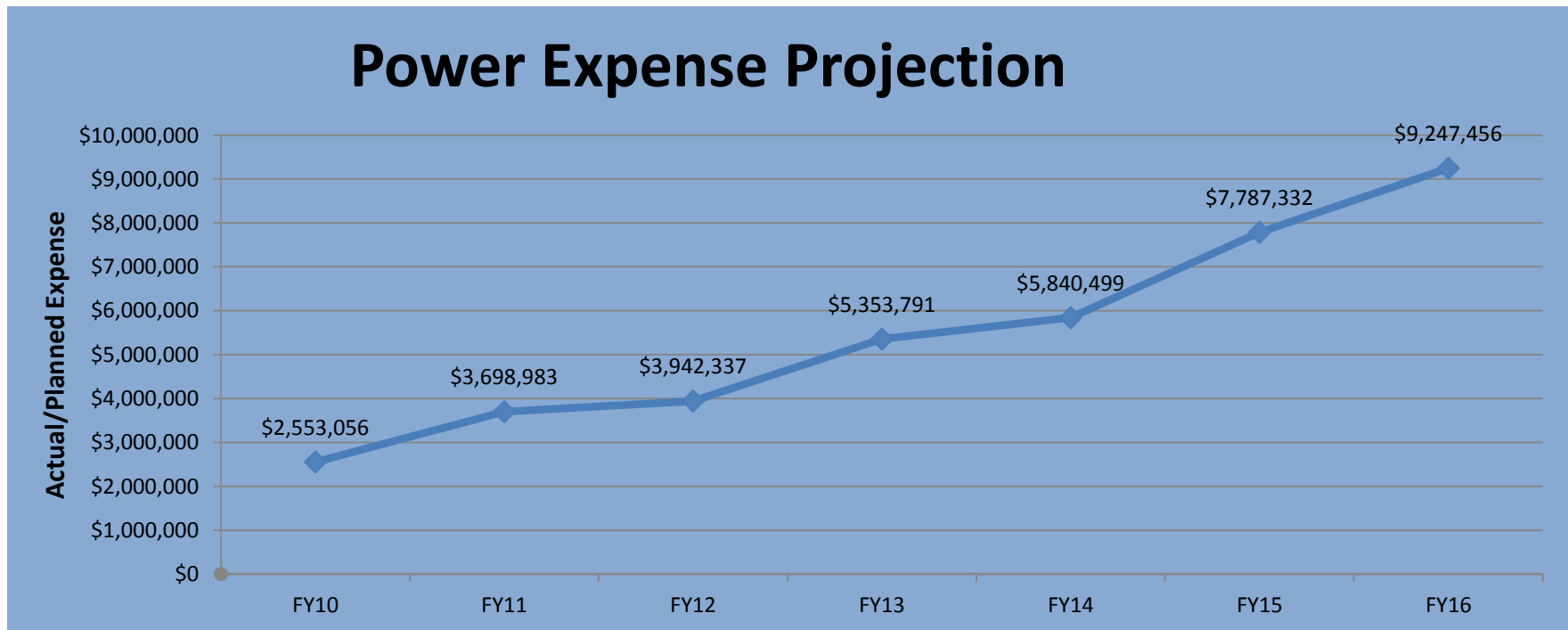
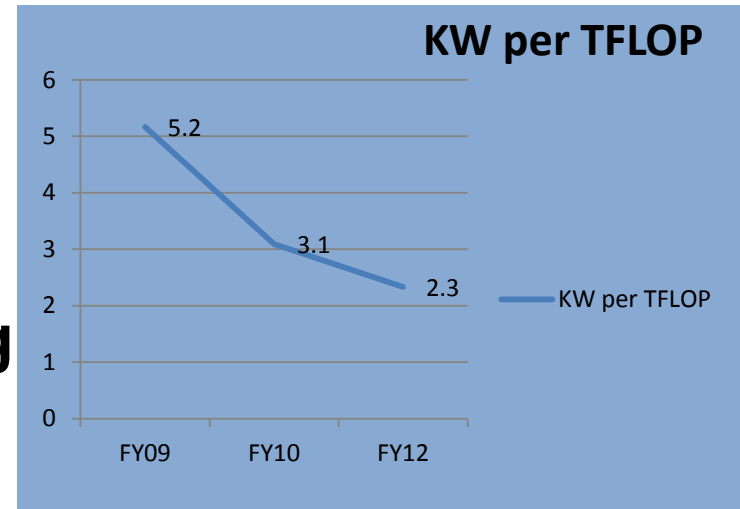
- **Demand Continues to Increase**



- **Acquire the Best and Most**
- **Energy Demands Rise with Growth**
- **How Do We Flatten the Growth Curve of Energy Consumption**

Impact to Program

- More Work per KW
- Budget Flat
- Energy Consumption Increasing
- Where Do We Reduce Costs



Options

- **Constrain Growth**
- **New Construction**
- **Modify Existing**
- **Increase Efficiency**



Constrain Growth

- **Nonstarter**

- Physics-Based Computational Modeling Is a Proven Money Saver. We Need to Deliver More Computational Power to Our Scientists and Engineers

New Construction

- **Cost to Build**

- Varies with Redundancy Requirements and Geography

Source	Estimated Cost
Uptime Institute (2006)	\$12-25/W
Microsoft (2007)	>\$10/W
Dupont Fabros (2007)	\$10-14/W

- **30 MW HPC Center**

- Capital Costs \$360M-\$750M
 - Level of Redundancy
- Operational Expenditures (No Land Purchase)
 - Non-Electrical Costs \$72M-\$150M
 - Utility Charge (\$0.10/ KWh) \$36.8M
- Operations Cost 25-30% of Capital Costs

New Construction

- **Challenges Beyond Money**
 - Time to Design
 - Time to Construct
 - Time to Commission

Modify Existing

- **Executed Efforts (Reduced PUE from Near 2.0 to 1.4)**

- Line Interactive Medium Voltage UPS
 - Less Loss Due to Conversion
- Higher Voltage Equipment
 - Radiator Doors
 - Phase Change
- Water-Based Cooling
 - Operate Computers at Maximum Allowable Air Temp
 - Move Heat Sources Out of Computer Space
 - Move UPS and Transformers Outside
- Increase Efficiency of Infrastructure Components
 - UPS, Transformers, Highest Possible Voltage
- Raise Water Temperatures in Water Chiller
 - Operate Chillers at Highest Temperature to Allow Thermal Transfer
- Air Flow Containment



Modify Existing

- **New Technology Now (Reduce PUE To 1.1)**
 - Water-Side Economizer with Load-Based Controls
 - Magnetic Bearing Chillers
 - Photovoltaic Arrays
 - High Temperature Direct Water Cooling
 - Advanced Job Scheduler



Challenge Ahead

- **Improve Metrics**

- Better Monitoring
- Rules-Based Analytics
- Automated Control

- **Acquire Wisely**

- Require Recordable Operational Information from HPC Vendors
- Interface to Infrastructure Controls

- **Integrate Monitoring and Control**

- Develop Monitoring and Control Interface Between Infrastructure and Compute Systems
- Develop Rules-Based Operational Control

Maui Energy Demonstration Site

- **Best ROI**
- **Early Adopter**
- **Migrate to Other Centers**



Spare Slides

Continuous Change

- **Water Cooling**
- **Warm-Water Cooling**
- **Early Detection and Sensing Systems**





Continuous Change



