"Powering" the Energy Efficiency Revolution

Wen-Hann Wang
Vice President, Intel Labs
Director, Circuits and Systems Research

Sponsors of Tomorrow.™ intel

Innovations Across the Platform

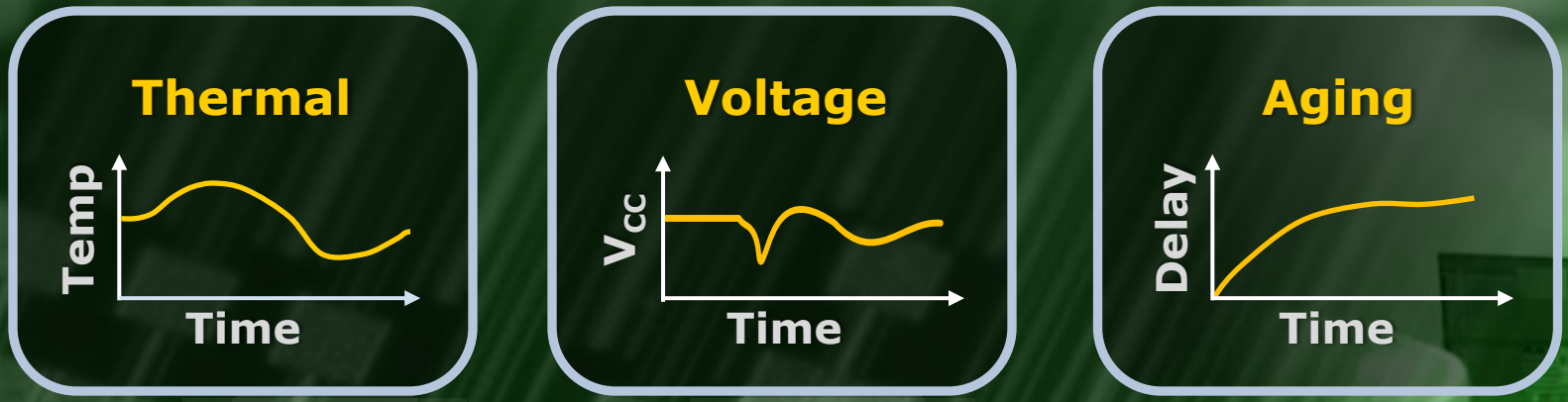
Circuits

Architecture

Platform

Broad set of innovations enable dramatic improvements in energy efficiency

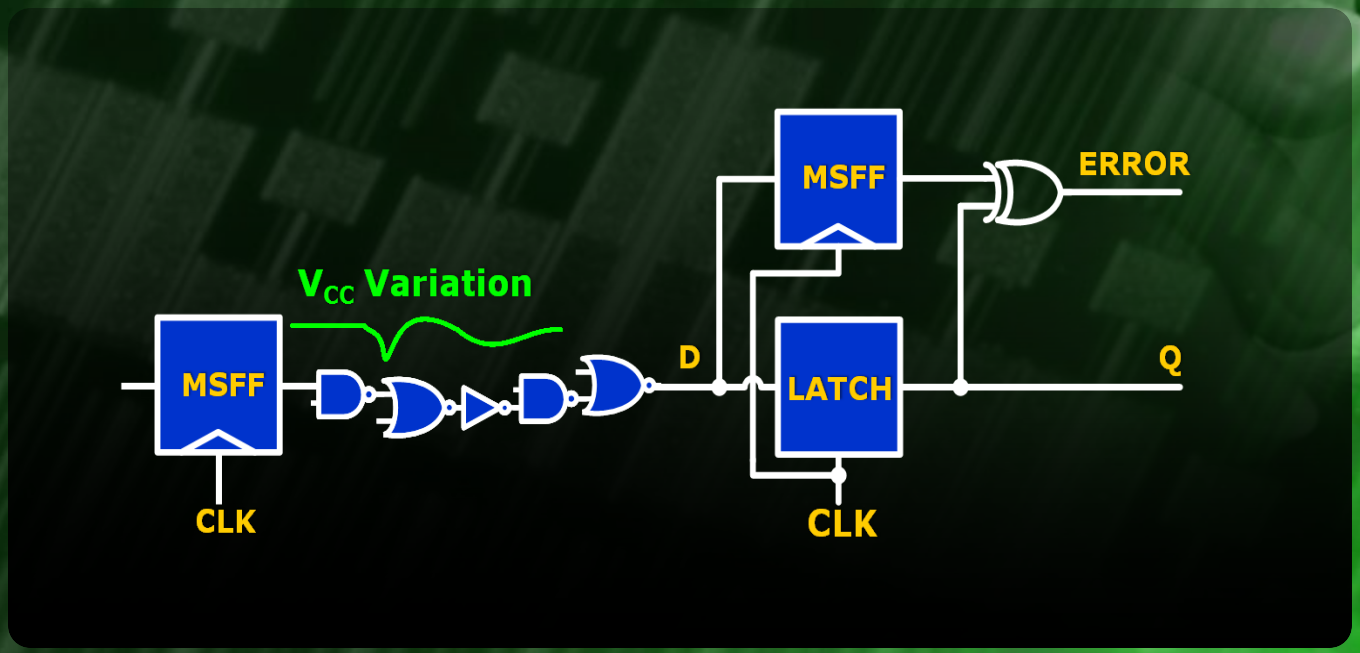
Dynamic Variation Problem



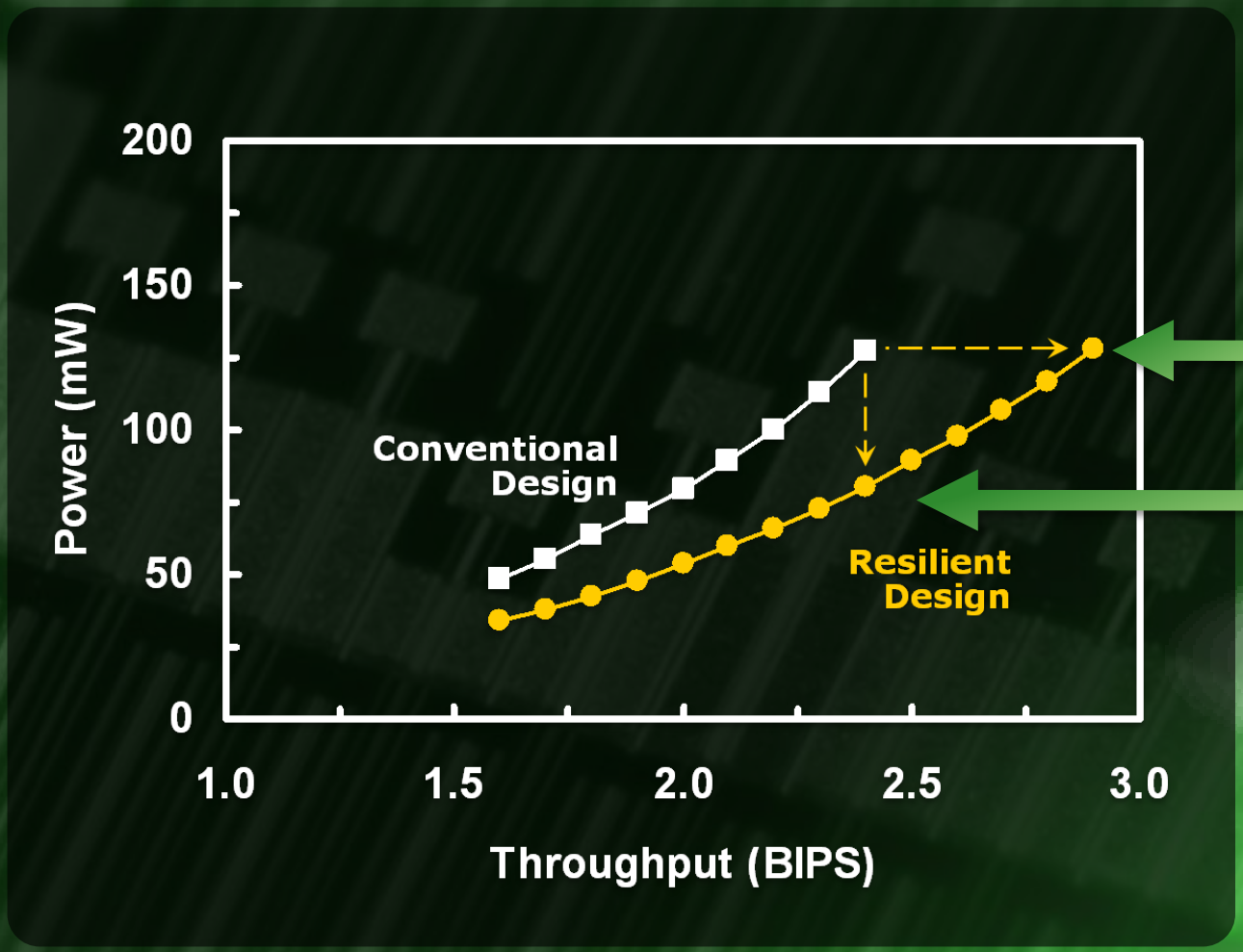
- Multitude of dynamic variations constantly present
- Guardbands must be applied to ensure correct operation
- **Result:** Processors are slowed and run at higher power

Resilient Circuits

- All guardbands removed
- Detection circuits applied to select critical timing paths
- Potential errors detected, brief re-execution at slower speed
- Normal operation resumes



Resilient Circuits Prototype

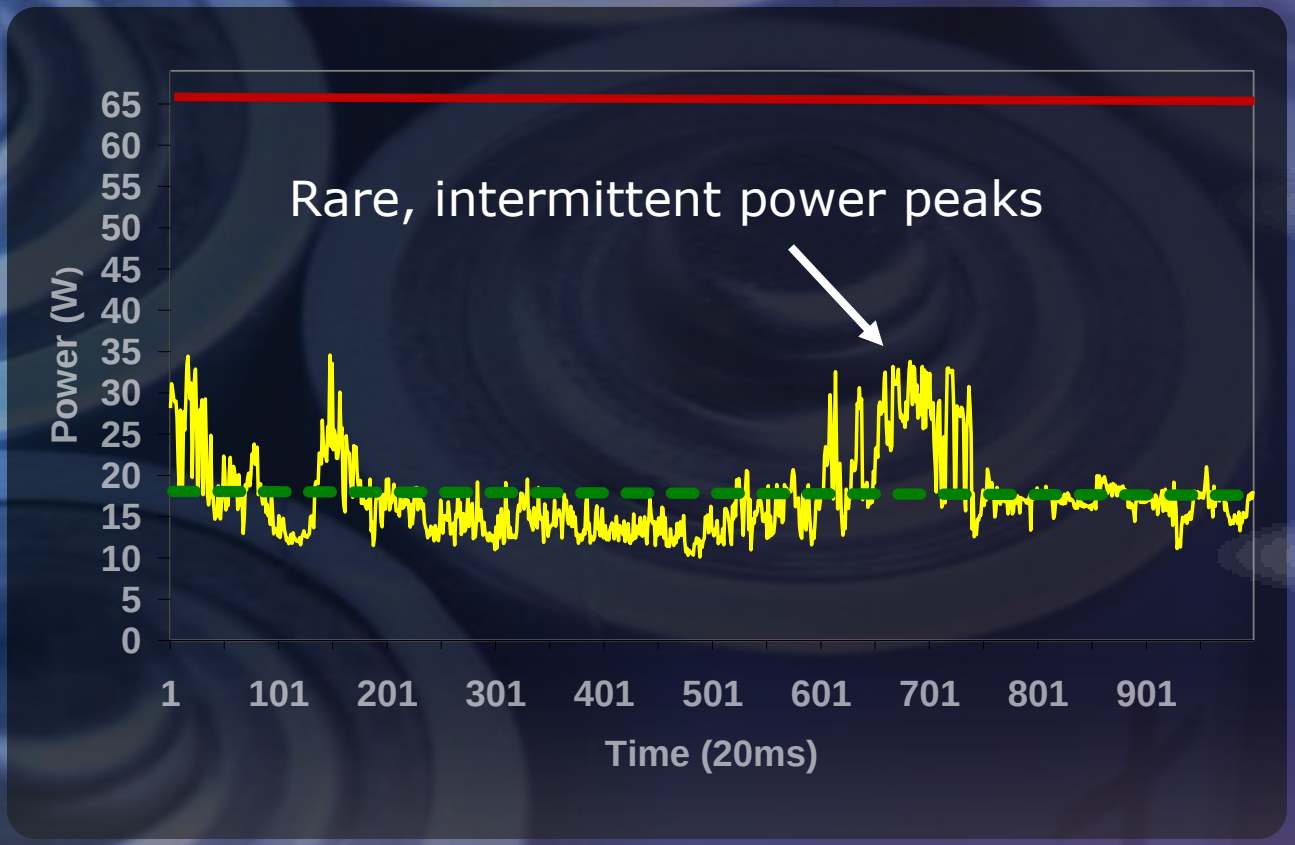


21%
Throughput Gain

– OR –

37%
Power Reduction

Power Demand/Delivery Mismatch

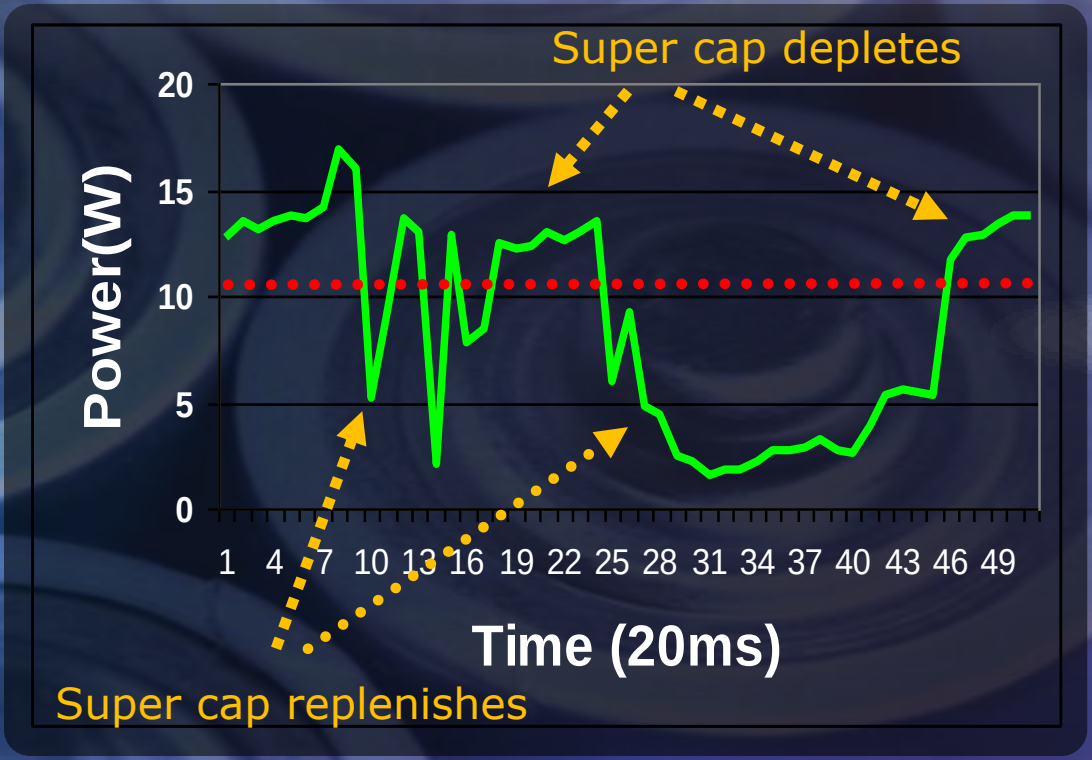


65 W max power from BRIC or battery

17.5 W average power

Power supply and battery designs constrained by peak power

Super Capacitor Augmentation



10 W continuous power source/BRIC

Enables processor turbo mode operation of (70 W) for brief periods

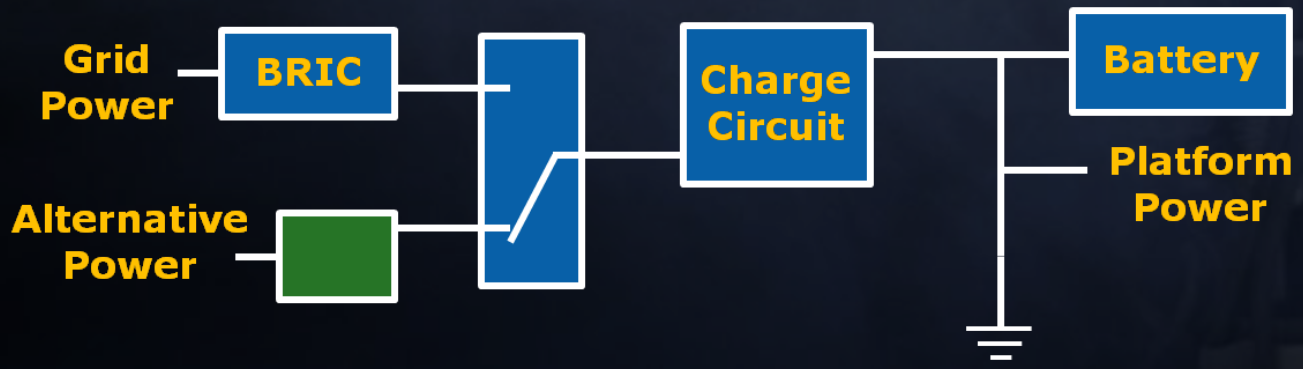
Reduces cost of power source (BRIC) and improves nominal efficiency

Enables use of higher density batteries (typically 20% more storage)

Energy Harvesting

Solar Panel (roll)

- Alternative power sources
- "off the grid" operation



Power Problem: Networked Devices

- 15B internet devices by 2015
- Devices ~50% power efficient
- Devices increasingly left on and in high power idle state

Source: Parks & Associates

Low power "always on" solution needed

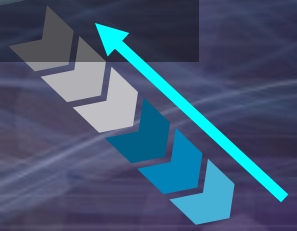
Low Power Network Agent

Intel Wireless PC/Laptop

Step 1: Platform & Security Configured, Sleep Entered

WiFi Access Point

Step 2: Packet Forwarded



Step 3: Packet arrives

Interesting?..YES!

Intel Network Agent

Step 4: Agent maintains Network Access during Sleep (e.g. ARP, mDNS)

Idle power of 22 W reduced to 0.8 W on prototype notebook

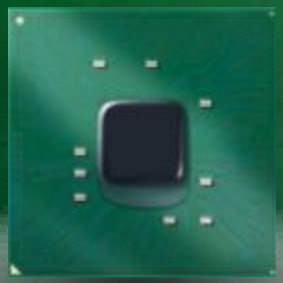
Network Agent Benefit

	Annual Energy
PC left "always on"	430-610 kWh*
PC with Network Agent (70% of time asleep)	150-210 kWh
Annual Energy Savings	400 kWh ($40)
150+ Million PCs	60+ TWh ($6B)

Holistic Approach

Managing power across the platform

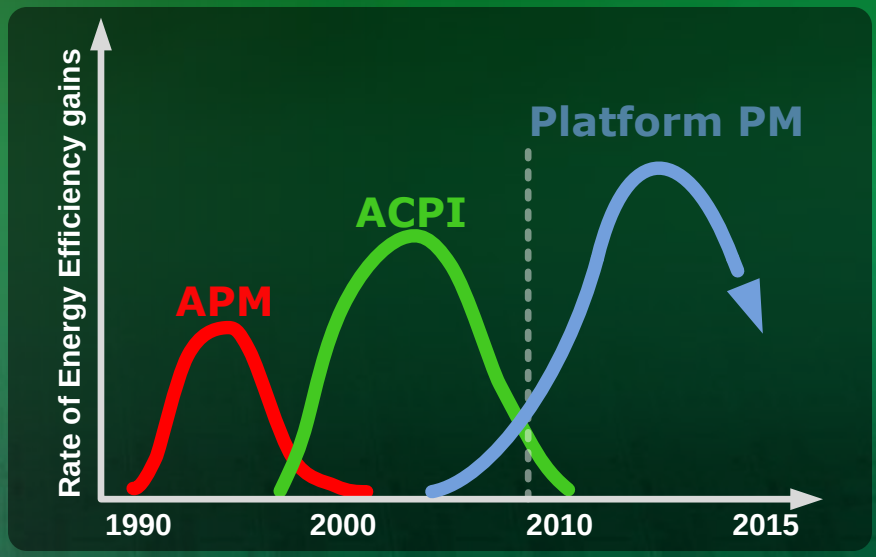
- Core Logic
- Operating Systems and VMMs
- Manageability
- Interconnects and Peripherals
- Telemetry
- Power Delivery and Cooling



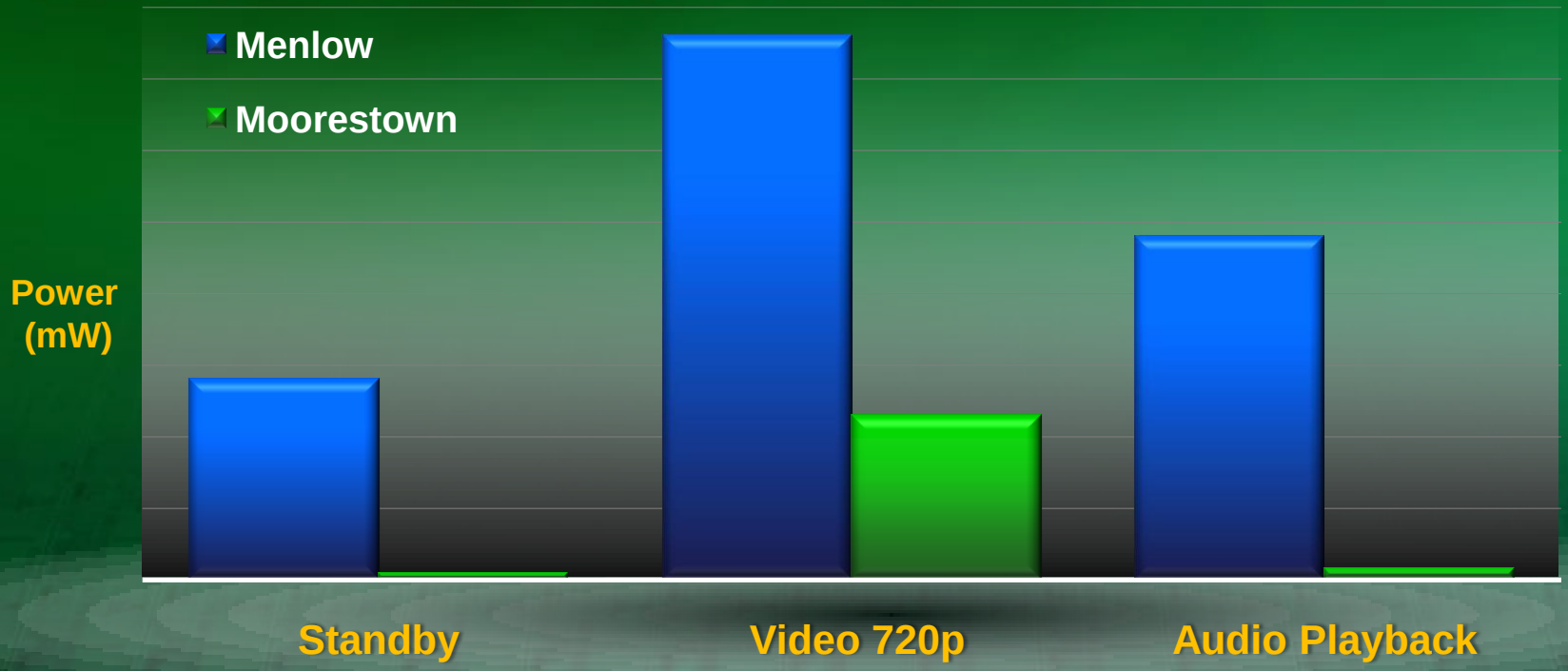
PLATFORM
POWER MANAGEMENT

Platform Power Management

- Fundamentally new framework
- Introduces HW power management
- Fine grain control at HW speeds
- Sustainable improvements in energy efficiency



Platform Power Management in Product

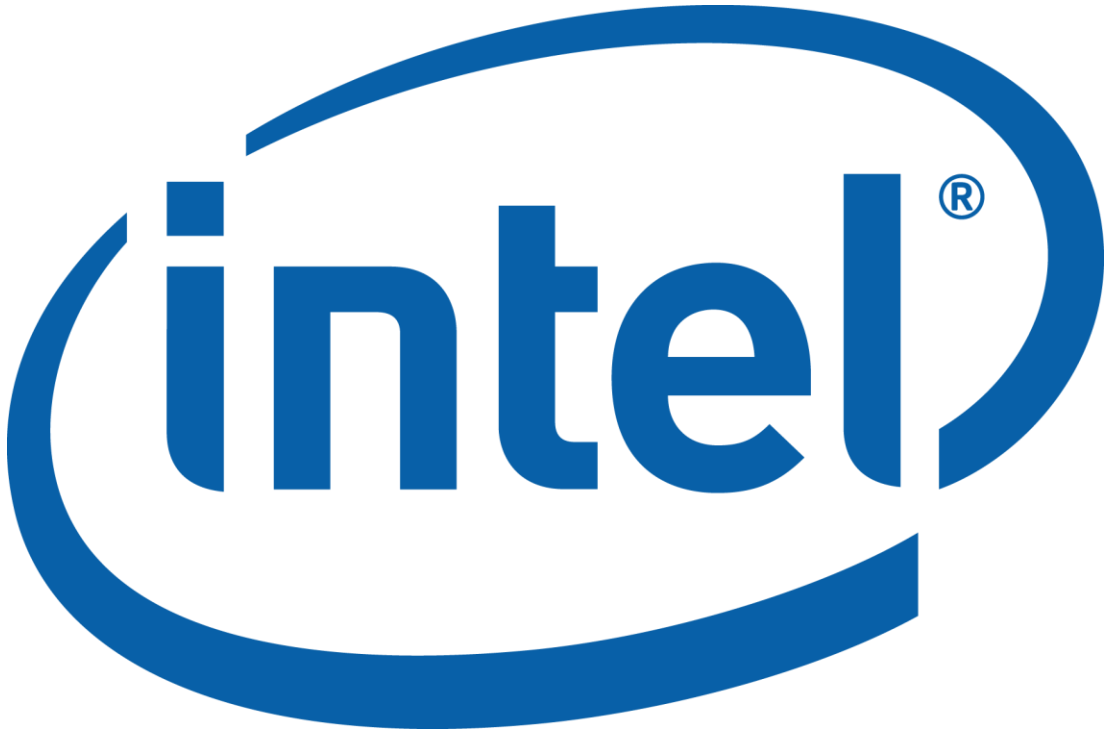


50x
Standby Power Reduction

3x - 30x
Active Power Reduction

Dramatic Innovations Bring Dramatic Benefits

Circuits	**37%** Active Power Reduction
Architecture	**60+ TWh** Annual Power Savings
Platform	**50x** Idle Power Reduction


intel

Legal Disclaimer

- INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH INTEL® PRODUCTS. NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. EXCEPT AS PROVIDED IN INTEL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, INTEL ASSUMES NO LIABILITY WHATSOEVER, AND INTEL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO SALE AND/OR USE OF INTEL® PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT. INTEL PRODUCTS ARE NOT INTENDED FOR USE IN MEDICAL, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS.
- Intel may make changes to specifications and product descriptions at any time, without notice.
- All products, dates, and figures specified are preliminary based on current expectations, and are subject to change without notice.
- Intel, processors, chipsets, and desktop boards may contain design defects or errors known as errata, which may cause the product to deviate from published specifications. Current characterized errata are available on request.
- Performance tests and ratings are measured using specific computer systems and/or components and reflect the approximate performance of Intel products as measured by those tests. Any difference in system hardware or software design or configuration may affect actual performance.
- Intel, Core i7 and the Intel logo are trademarks of Intel Corporation in the United States and other countries.
- *Other names and brands may be claimed as the property of others.
-

Risk Factors

The above statements and any others in this document that refer to plans and expectations for the third quarter, the year and the future are forward-looking statements that involve a number of risks and uncertainties. Many factors could affect Intel's actual results, and variances from Intel's current expectations regarding such factors could cause actual results to differ materially from those expressed in these forward-looking statements. Intel presently considers the following to be the important factors that could cause actual results to differ materially from the corporation's expectations. Ongoing uncertainty in global economic conditions pose a risk to the overall economy as consumers and businesses may defer purchases in response to tighter credit and negative financial news, which could negatively affect product demand and other related matters. Consequently, demand could be different from Intel's expectations due to factors including changes in business and economic conditions, including conditions in the credit market that could affect consumer confidence; customer acceptance of Intel's and competitors' products; changes in customer order patterns including order cancellations; and changes in the level of inventory at customers. Intel operates in intensely competitive industries that are characterized by a high percentage of costs that are fixed or difficult to reduce in the short term and product demand that is highly variable and difficult to forecast. Additionally, Intel is in the process of transitioning to its next generation of products on 32nm process technology, and there could be execution issues associated with these changes, including product defects and errata along with lower than anticipated manufacturing yields. Revenue and the gross margin percentage are affected by the timing of new Intel product introductions and the demand for and market acceptance of Intel's products; actions taken by Intel's competitors, including product offerings and introductions, marketing programs and pricing pressures and Intel's response to such actions; and Intel's ability to respond quickly to technological developments and to incorporate new features into its products. The gross margin percentage could vary significantly from expectations based on changes in revenue levels; capacity utilization; start-up costs, including costs associated with the new 32nm process technology; variations in inventory valuation, including variations related to the timing of qualifying products for sale; excess or obsolete inventory; product mix and pricing; manufacturing yields; changes in unit costs; impairments of long-lived assets, including manufacturing, assembly/test and intangible assets; and the timing and execution of the manufacturing ramp and associated costs. Expenses, particularly certain marketing and compensation expenses, as well as restructuring and asset impairment charges, vary depending on the level of demand for Intel's products and the level of revenue and profits. The current financial stress affecting the banking system and financial markets and the going concern threats to investment banks and other financial institutions have resulted in a tightening in the credit markets, a reduced level of liquidity in many financial markets, and heightened volatility in fixed income, credit and equity markets. There could be a number of follow-on effects from the credit crisis on Intel's business, including insolvency of key suppliers resulting in product delays; inability of customers to obtain credit to finance purchases of our products and/or customer insolvencies; counterparty failures negatively impacting our treasury operations; increased expense or inability to obtain short-term financing of Intel's operations from the issuance of commercial paper; and increased impairments from the inability of investee companies to obtain financing. The majority of our non-marketable equity investment portfolio balance is concentrated in companies in the flash memory market segment, and declines in this market segment or changes in management's plans with respect to our investments in this market segment could result in significant impairment charges, impacting restructuring charges as well as gains/losses on equity investments and interest and other. Intel's results could be impacted by adverse economic, social, political and physical/infrastructure conditions in countries where Intel, its customers or its suppliers operate, including military conflict and other security risks, natural disasters, infrastructure disruptions, health concerns and fluctuations in currency exchange rates. Intel's results could be affected by adverse effects associated with product defects and errata (deviations from published specifications), and by litigation or regulatory matters involving intellectual property, stockholder, consumer, antitrust and other issues, such as the litigation and regulatory matters described in Intel's SEC reports. A detailed discussion of these and other risk factors that could affect Intel's results is included in Intel's SEC filings, including the report on Form 10-Q for the quarter ended June 27, 2009.