

Solving the Information Technology Energy Challenge Beyond Moore's Law

*2x transistor/2yrs at same power & cost
Started slowing ~2007*

Now – 2025

Moore's Law continues through ~5nm -- beyond which diminishing returns are expected.

2016

2016-2025

End of Moore's Law
2025-2030?

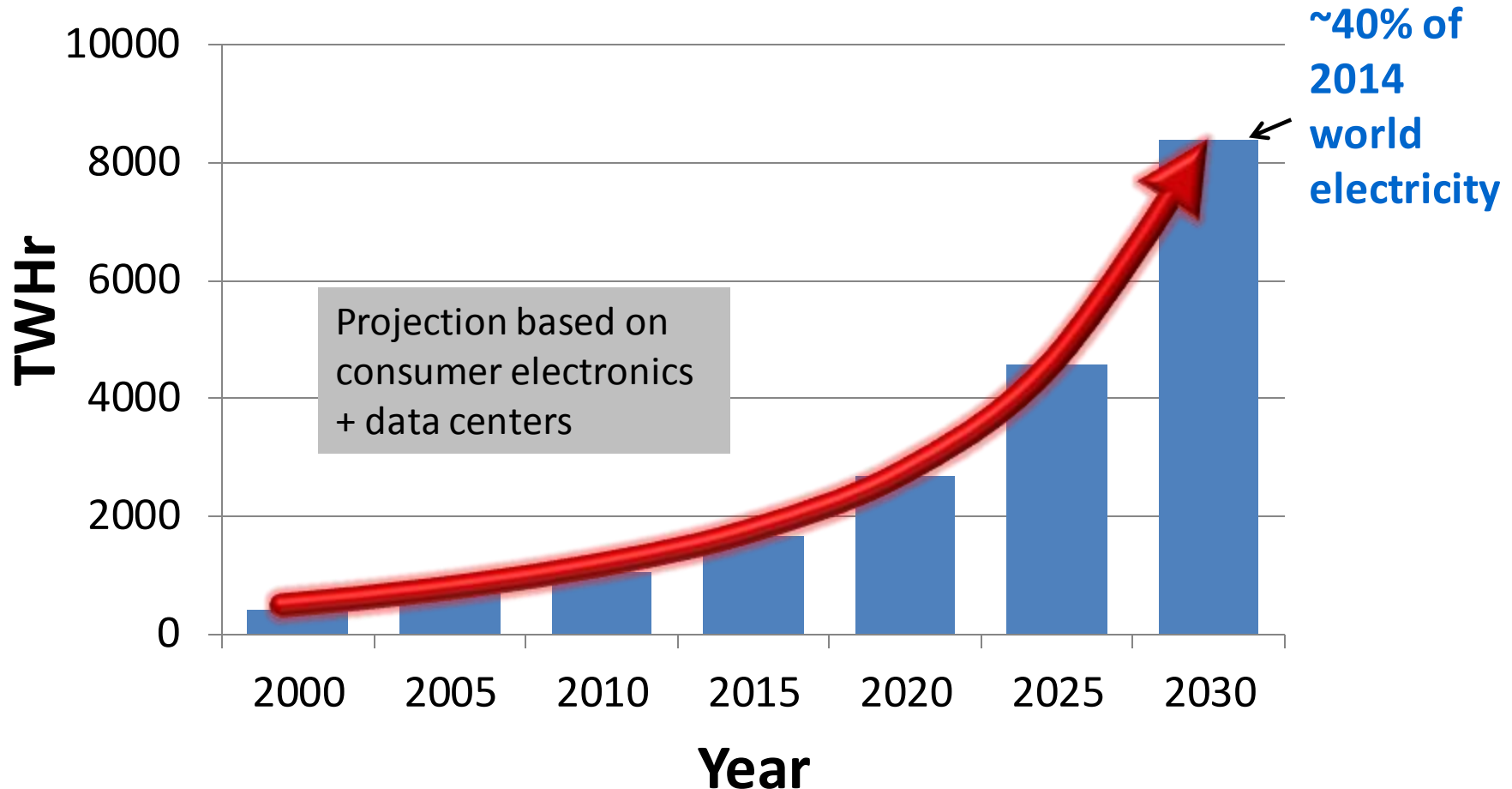
Post Moore Scaling

New materials and devices introduced to enable continued scaling of electronics performance and efficiency.

2025+

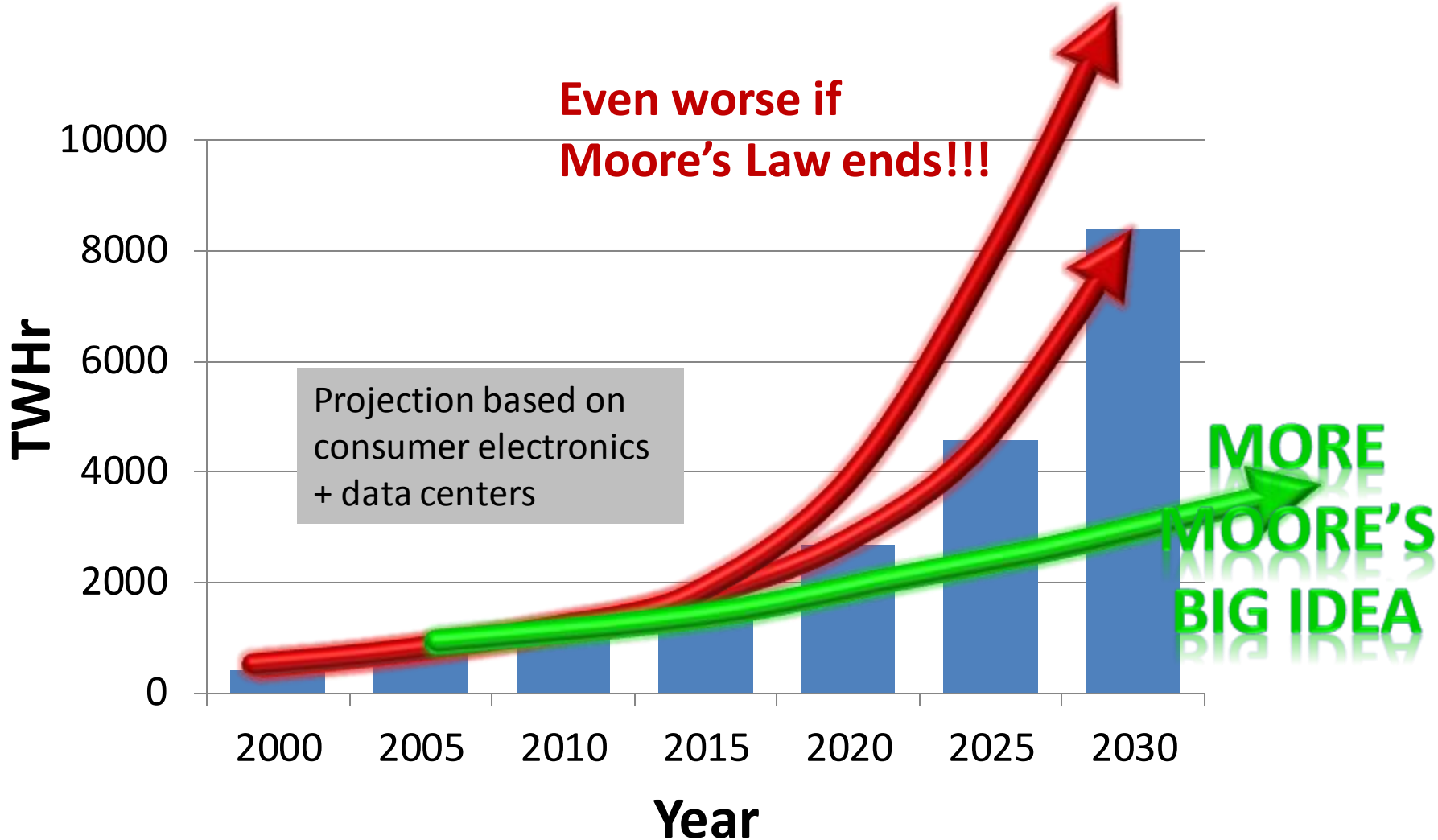
The problem:

IT projected to challenge future electricity supply

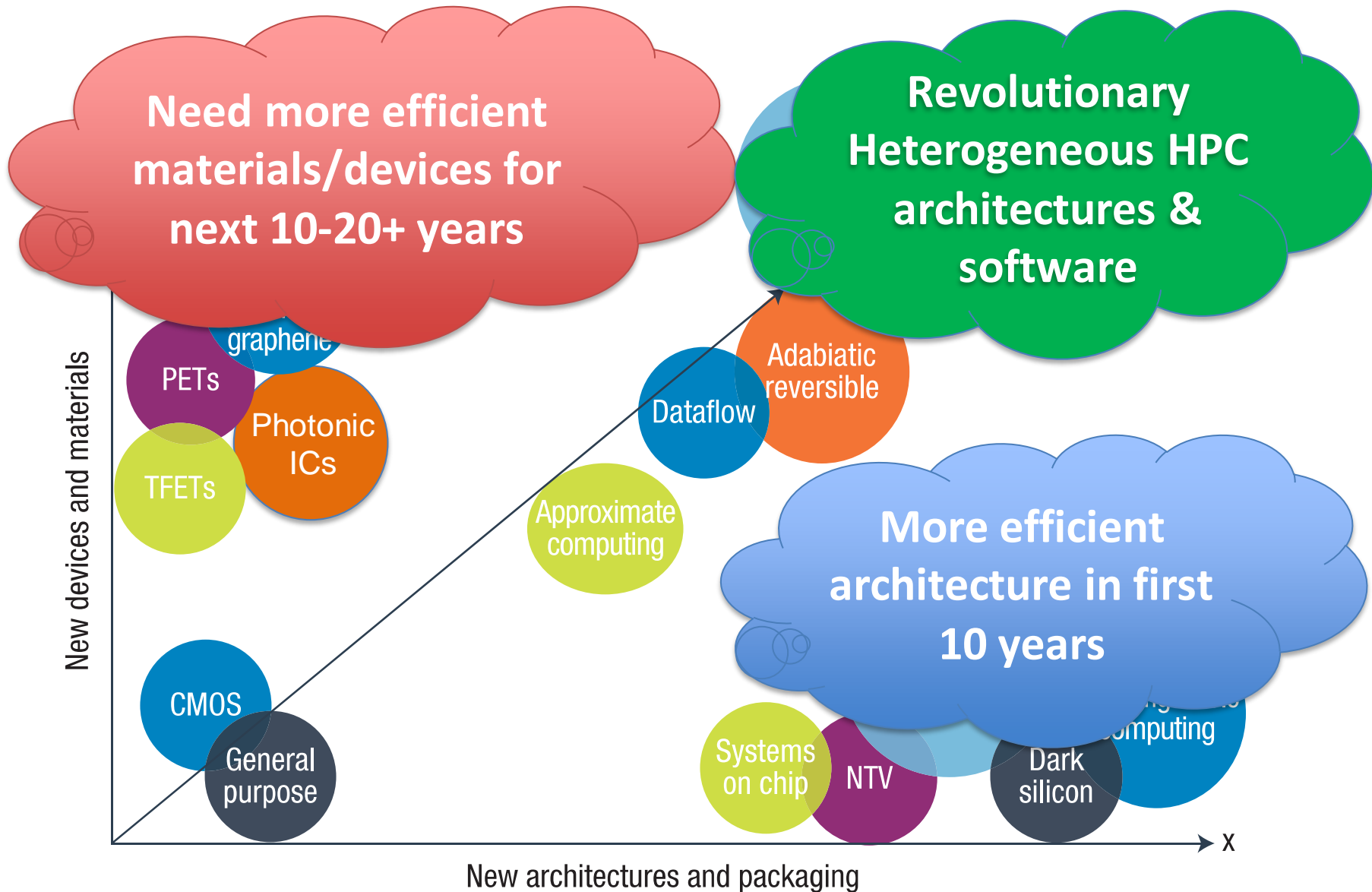


The problem:

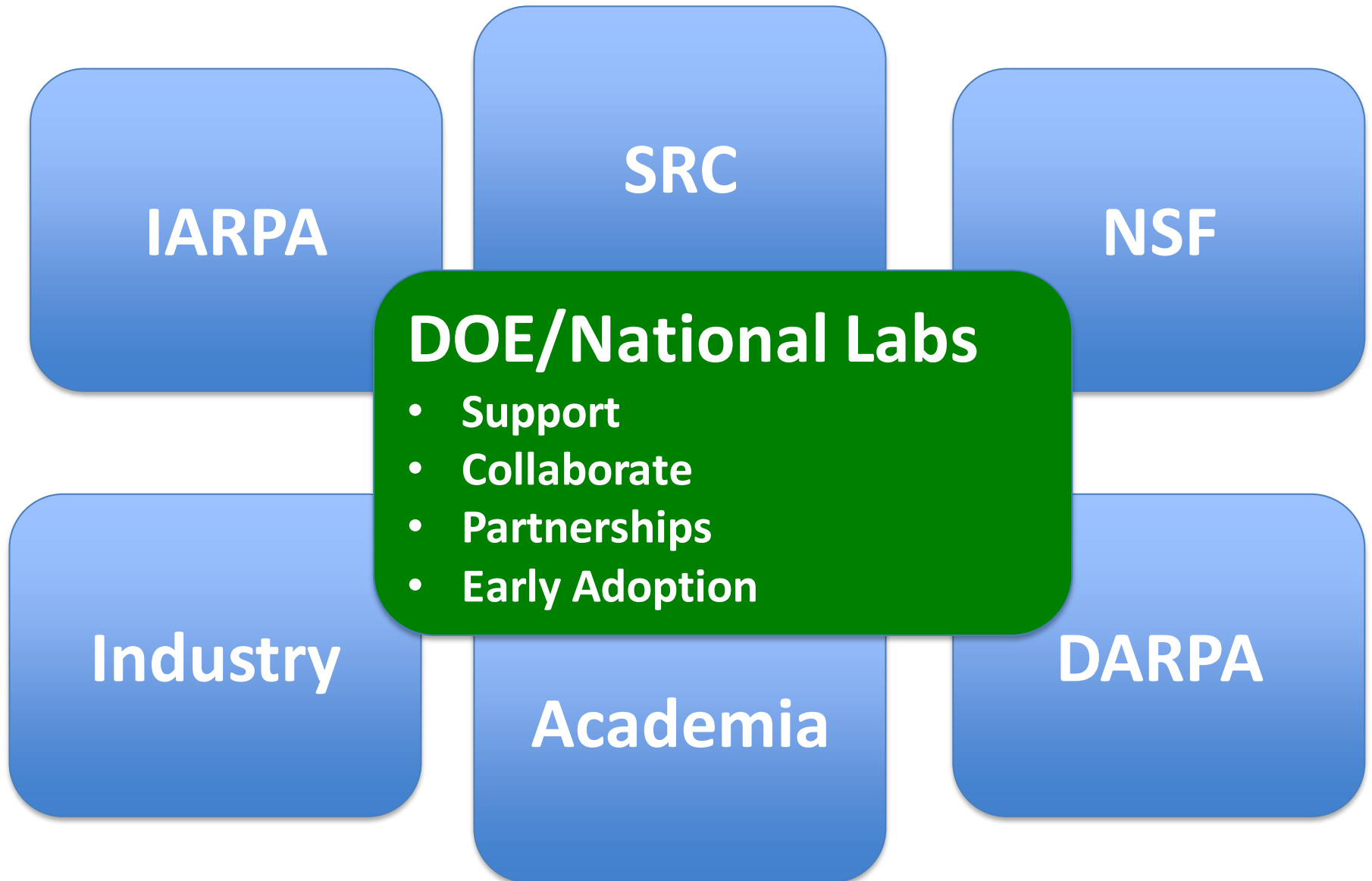
IT projected to challenge future electricity supply



The path: near and long term



Complex Landscape



The Opportunity

Fundamental Science

- Leverage unique capabilities in material science
- Scientific user facilities
- Computational approaches to materials design
- Grand challenges driven research

Computing Science

- Advanced computing
- Multiscale computing benchmarking and modeling
- Next-generation heterogeneous architectures
- New programming models and application software

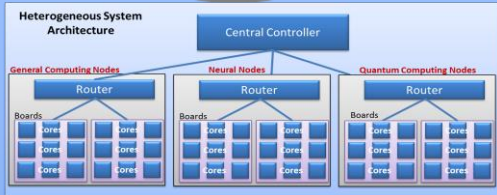
Manufacturing Science

- Move revolutionary low energy devices and architectures from Lab to Fab
- Accelerate development and manufacturing base for semiconductor devices
- Create public-private partnerships with electronics industry



Multiscale Multi-Lab Effort

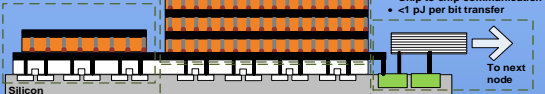
Multiscale Evaluation Framework



- Stacked ReRAM
- Petabit cm^2 Densities
- Replaces DRAM & flash
- <1 pJ per write/read

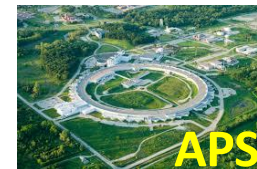
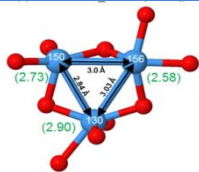
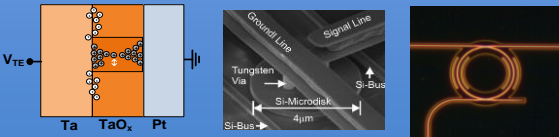
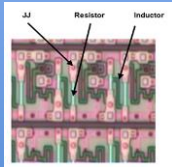
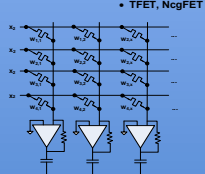
On-Chip Memristor Accelerator:

- Vector or matrix operations
- fJs per operation

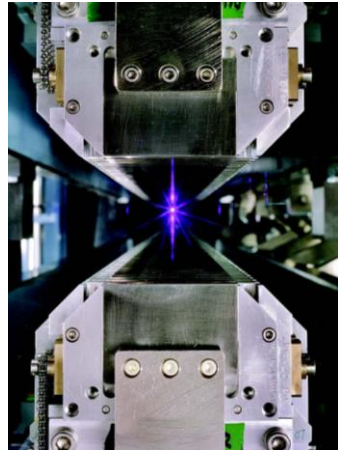
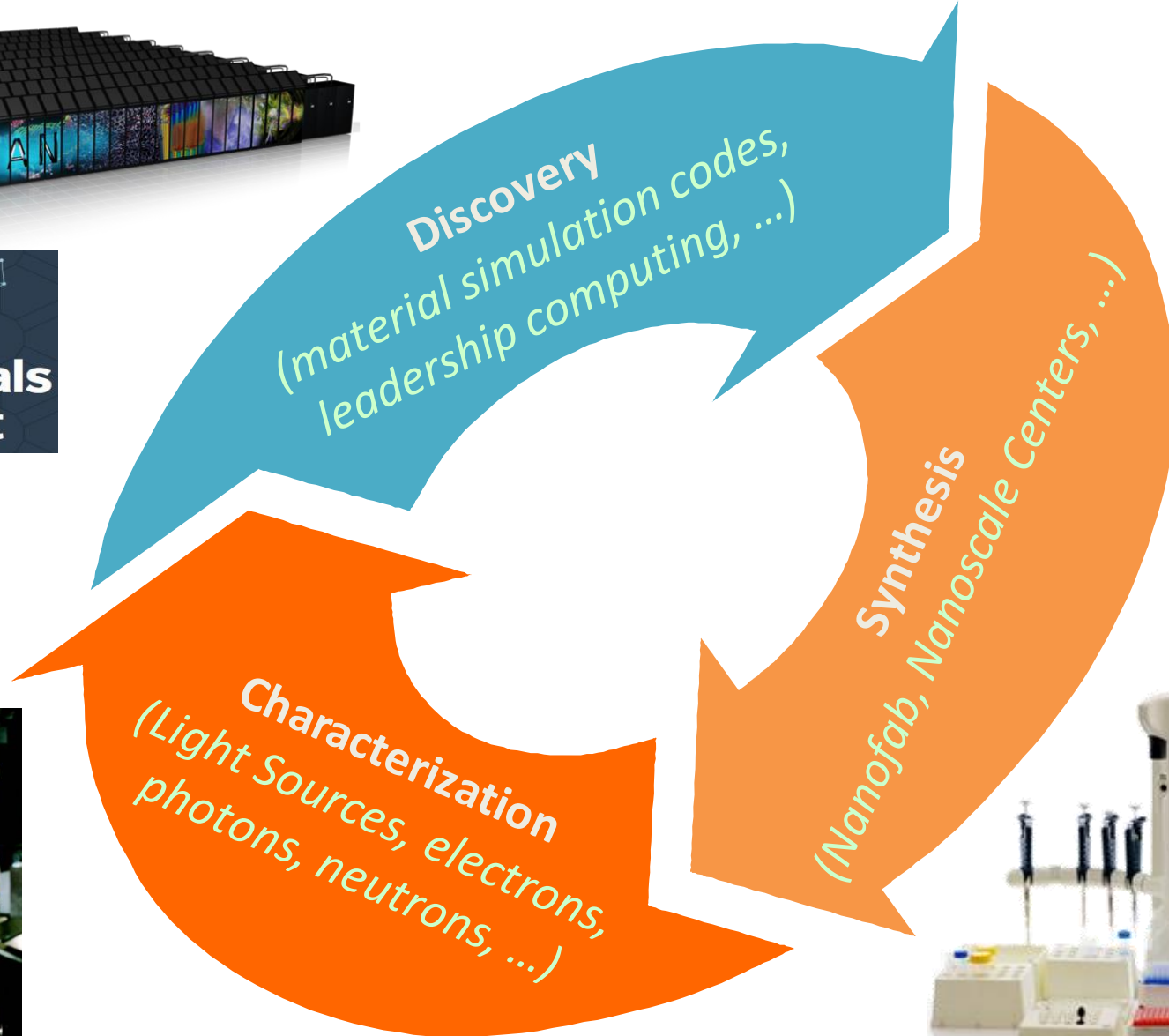


High Performance Logic:

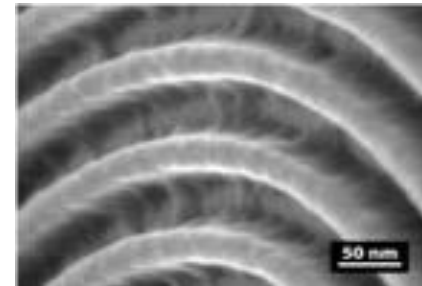
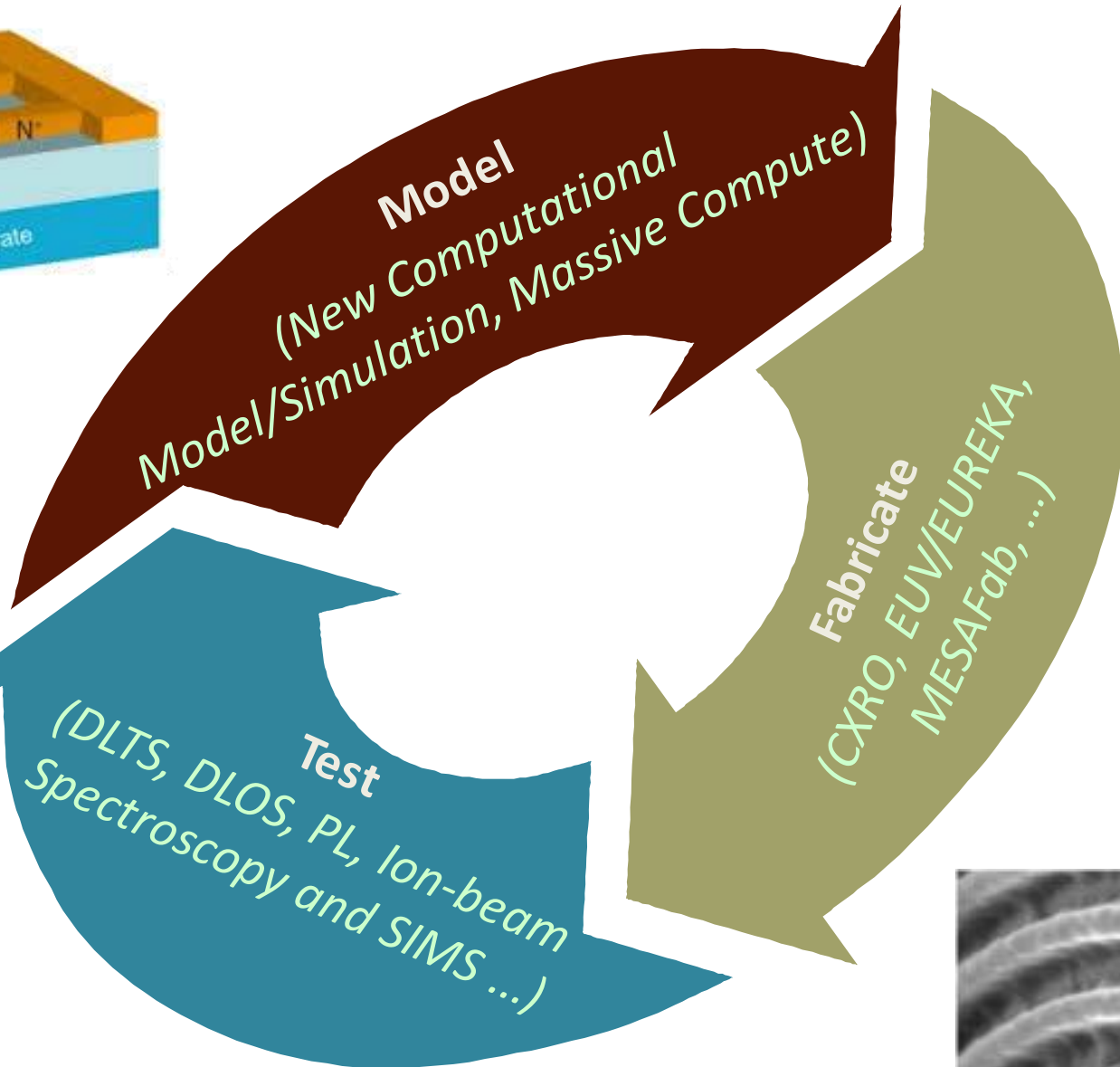
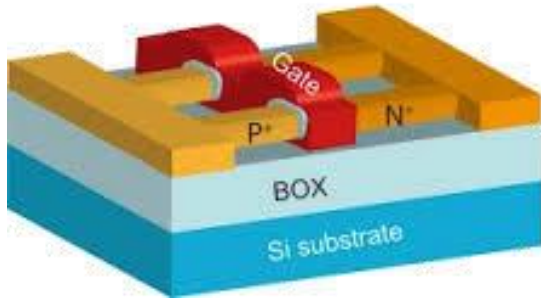
- TFET, NcgFET



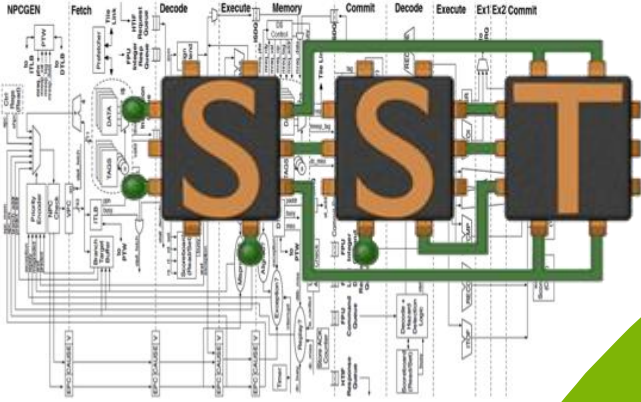
Advanced Materials



Advanced Devices and Manufacturing



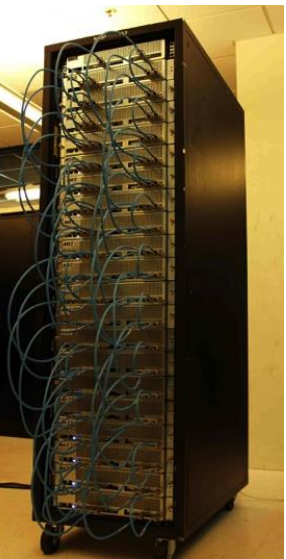
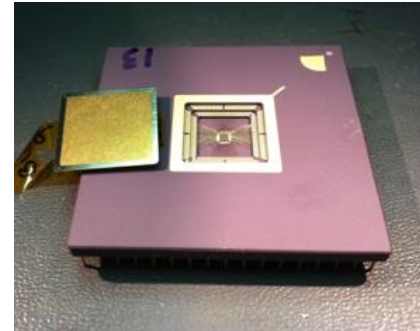
Architecture & Algorithms



Architectural Simulators
(SST, Chisel, models, codesign...)

Synthesis/Prototype
(OpenSOC, MESA Fab)

Benchmarking
(Benchmark, analyze,
applications)



Multi-Lab Engagement

Ramamoorthy Ramesh
Patrick Naulleau
John Shalf
Horst Simon



Jeff Nichols



Supratik Guha
Rick Stevens



Gary Grider
John Sarrao
Toni Taylor



Pacific Northwest
NATIONAL LABORATORY

Lou Terminello
Nathan Baker
Malin Young

(F.B.) Rick McCormick
Bruce Hendrickson
Dave Sandison
Rob Leland



Trish Damkroger

Building the Public-Private Partnership

Date: Thursday, March 24, 2016

Location: LBNL 66-Auditorium

Arrival and continental breakfast

8:00 – 8:30

Motivation session

8:30 – 8:50	M. Witherell, LBNL	Welcome
8:50 – 9:20	M. Johnson, AMO	AMO Overview and Perspective on semiconductor
9:20 – 9:50	W. Harrod, ASCR	ASCR Overview and Perspective on semiconductor
9:50 – 10:10	R. McCormick, Sandia	Opportunities for a DOE program in energy efficient electronics
9:10 – 10:30		Break
10:30 – 11:00	J. Golda, Intel	DOE Lab's and advanced semiconductor manufacturing research
11:00 – 11:30	T. King-Liu, UCB	Device challenges and opportunities talk
11:30 – 11:50	R. Nair, IBM	System challenges and opportunities talk, Part 1
11:50 – 12:10	S. Borkar, Intel	System challenges and opportunities talk, Part 2
12:10 – 1:30		Working lunch

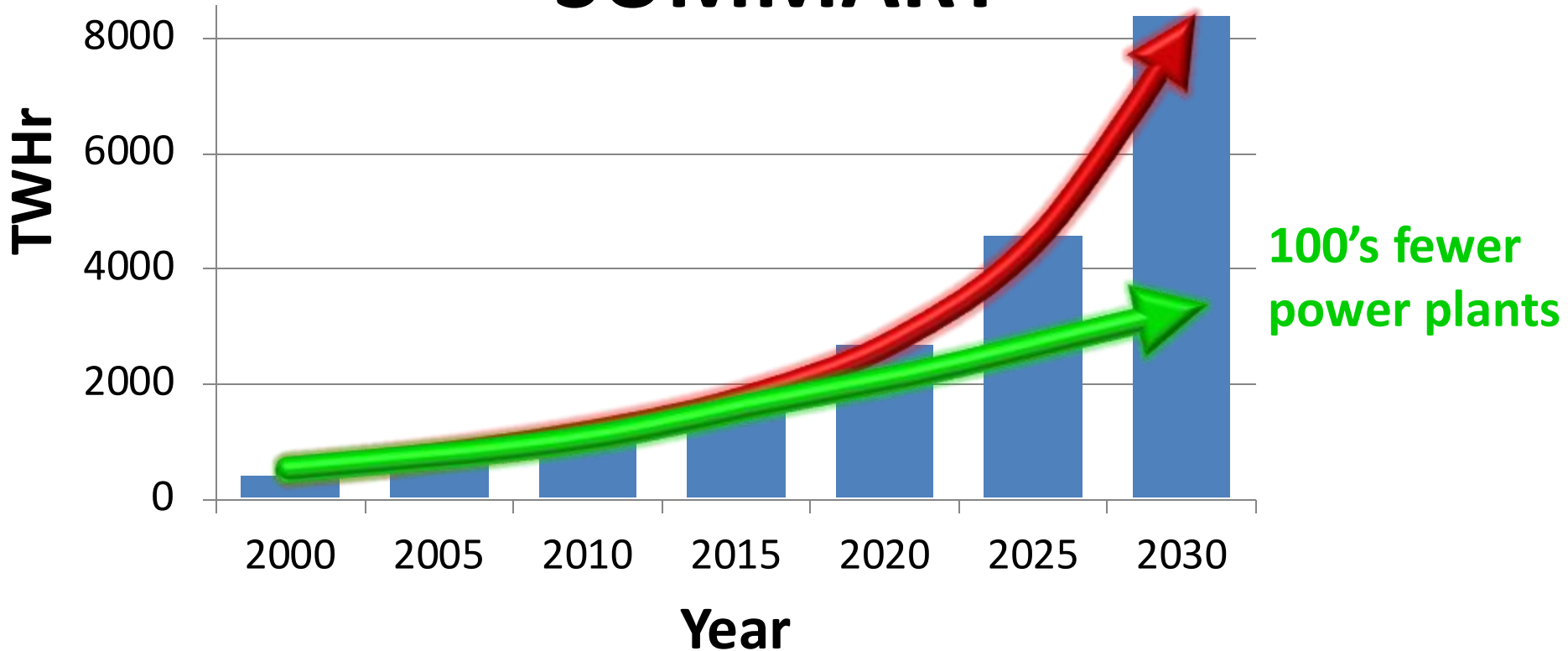
Focus group session

1:30 – 3:00	D. Armburst, Silicon Catalyst	Session A: Precompetitive manufacturing challenges
	S. Salahuddin, UCB	Session B: Device technology impact on energy
	S. Borkar, Intel	Session C: Information technology impact on energy
3:00 – 3:30	D. Armburst	Report out and discussion from Focus Group A
3:00 – 3:30	S. Borkar	Report out and discussion from Focus Group C
4:00 – 4:30	S. Salahuddin	Report out and discussion from Focus Group B

Closeout session

4:30 – 5:30		Wrap up discussion
6:00 – 8:00		Working dinner

SUMMARY



- Looming end of Moore's Law creating **rapidly growing energy gap**
- Coordinated **public-private partnership** will drive breakthroughs by leveraging multiple DOE Office leadership and Lab capabilities

These breakthroughs will enable continued affordability of our information economy, saving construction of 100's of power plants