

# The Economics of the ITRS

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# Outline

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- ITRS Unmet needs
- Objectives and background
- Market assumptions
- Results
- Conclusion

# ITRS Unmet Needs

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- The International Technology Roadmap of Semiconductors (ITRS) provides an industry consensus forecast of semiconductor technology requirements looking ahead 15 years.
- The ITRS provides half-pitch and some structural parameters for MPU/ASIC, DRAM and NAND.
- The ITRS does not provide guidance on the Market for equipment, technology or materials required to meet the ITRS goals.
- The ITRS does not provide guidance on process complexity or cost resulting from the ITRS goals.

# Objectives and Background

# Objective

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- Translates the ITRS into forecast fab configurations with equipment sets, material usage and wafer costs.
- Cover all half-pitches, years and product types defined in the current ITRS (2010).
- Produce a model with clearly defined assumption sets based on the best available industry knowledge at the time. Allow the user visibility into the assumption sets and the ability to change the assumptions.
- Provide forecasted equipment and material demand by type over the ITRS time frame.
- Provide calculated wafer and fab costs by half-pitch, year and product type.

# Model Foundation

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- IC Knowledge produces the most widely used commercial IC Cost Model currently available.
- The commercial model has all of the necessary algorithms for the strategic model and the algorithms are already well vetted on current technologies.
- The key strategic modeling challenge is to define the long term assumption set.
  - Database trend analysis
  - Domain experts
  - Expose assumptions for user adjustment and feedback

# Block Driven Process Approach

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- Define standard process blocks for each product type.
- Define how many times each block is used by half-pitch and product type.
- Underlying each block are standard process steps.
- Summarize process steps by half-pitch.
- Summarize mask levels by half-pitch.
- For each mask level define the pitch based on a ratio to the ITRS half-pitch and use the pitch to determine the required exposure technology.
- Expose the blocks to the user and allow overrides.

# Equipment Approach

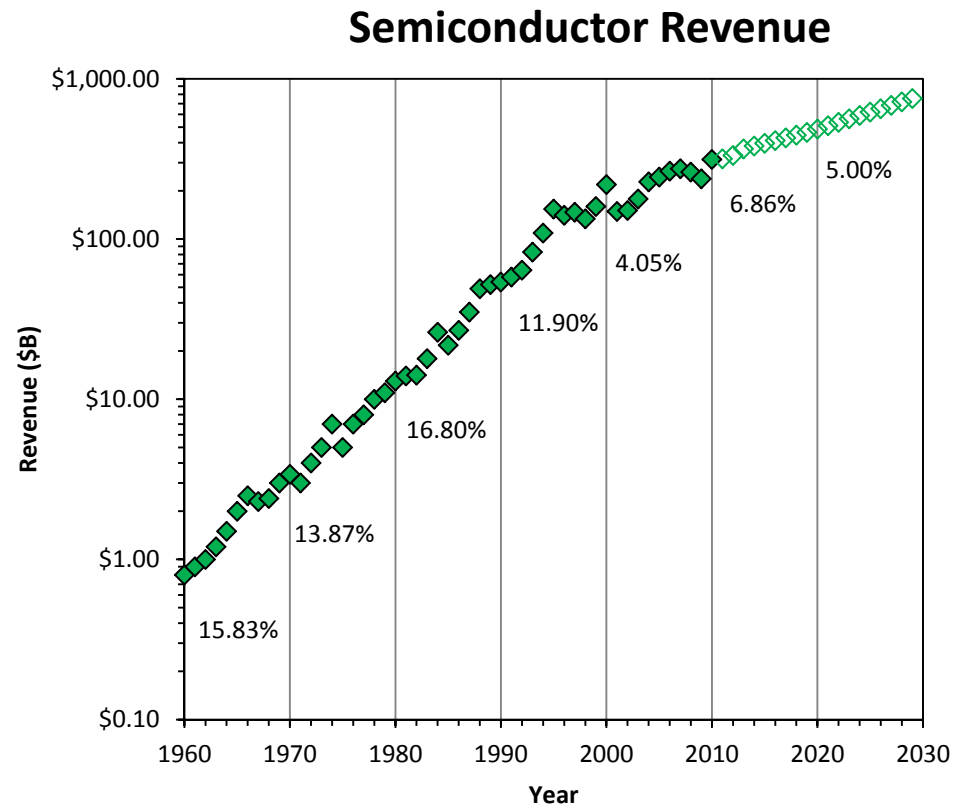
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- Define a group of standard equipment types (64 types).
- Forecast equipment cost per tool by half-pitch and wafer size.
- Forecast throughput by half-pitch and wafer size.
- Forecast footprint by wafer size.
- Forecast OEE.
- Expose all assumptions to the user and allow overrides.
- Based on a selected fab capacity, the number of times each piece of equipment is used (defined by the process blocks), throughput and OEE an equipment set can be calculated.

# Market Assumptions

# Semiconductor revenue

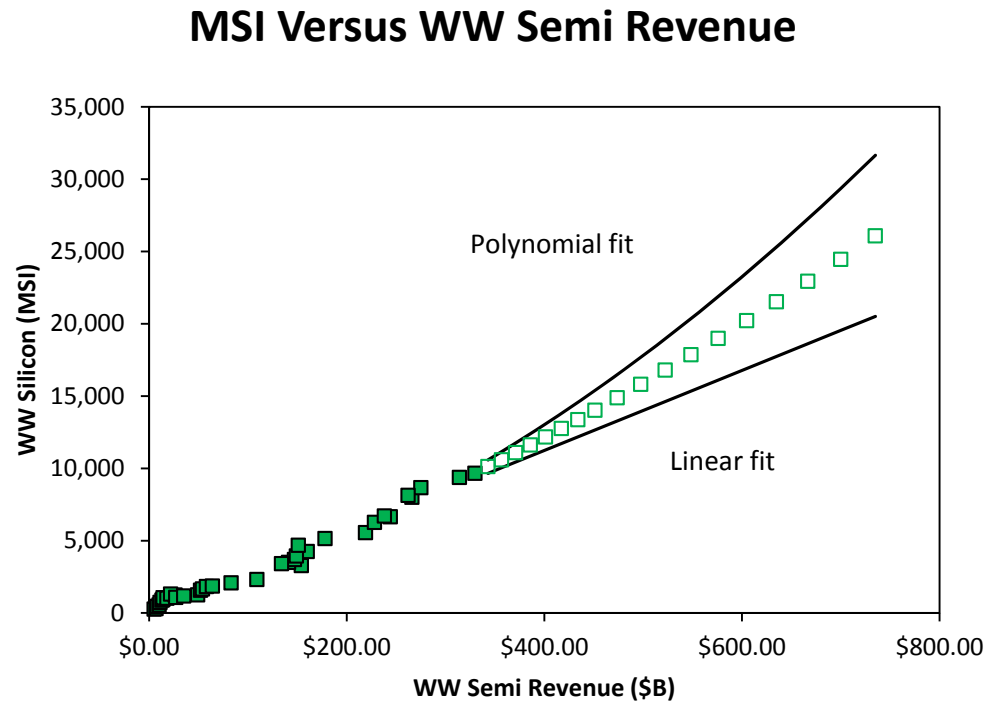
- Percentages are average CAGR for each decade.
- The 2010 decade began with 32% growth and we expect 1% for 2011. Even with weak growth for the rest of the decade we expect ~7% overall.
- The 2020 decade is expected to show slower growth due to industry maturity.
- This is believed to be a conservative forecast.



Source: Semiconductor Silicon Demand Forecast - revision 1107

# Projected silicon demand

- Average of two different forecast views.
  - Polynomial formula based on revenue.
  - Linear formula based on revenue.
- Forecast splits the difference.



Source: Semiconductor Silicon Demand Forecast - revision 1107

# Results

# Fabs required

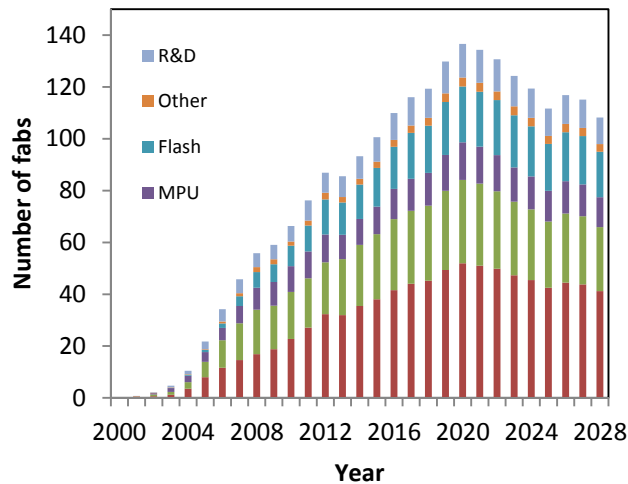
Source: Semiconductor Silicon Demand Forecast - revision 1107

**300mm**  
 R&D = 5k wpm  
 Other = 25k wpm  
 Flash = 100k wpm  
 MPU = 30k wpm  
 DRAM = 60k wpm  
 ASIC = 30k wpm

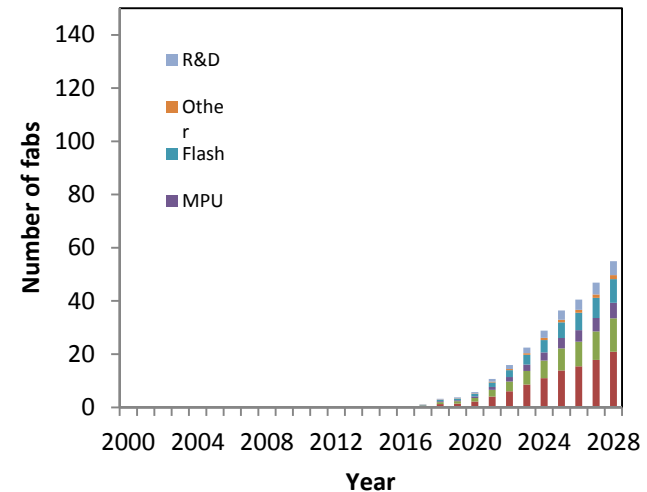
**450mm**  
 R&D = 7.5k wpm  
 Other = 27.5k wpm  
 Flash = 150k wpm  
 MPU = 45k wpm  
 DRAM = 90k wpm  
 ASIC = 45k wpm

**2018 - 450mm  
 production ramp**

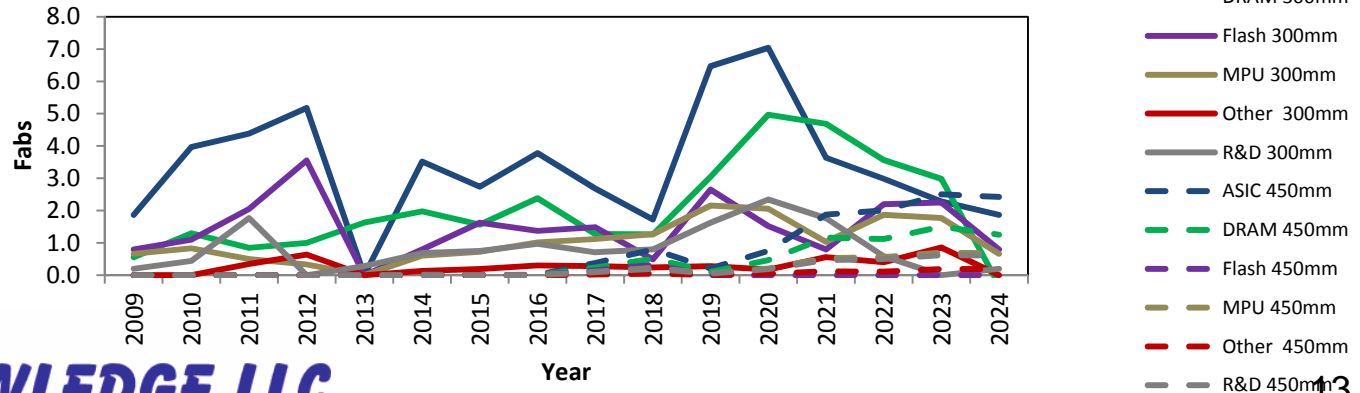
**300mm fabs**



**450mm fabs**

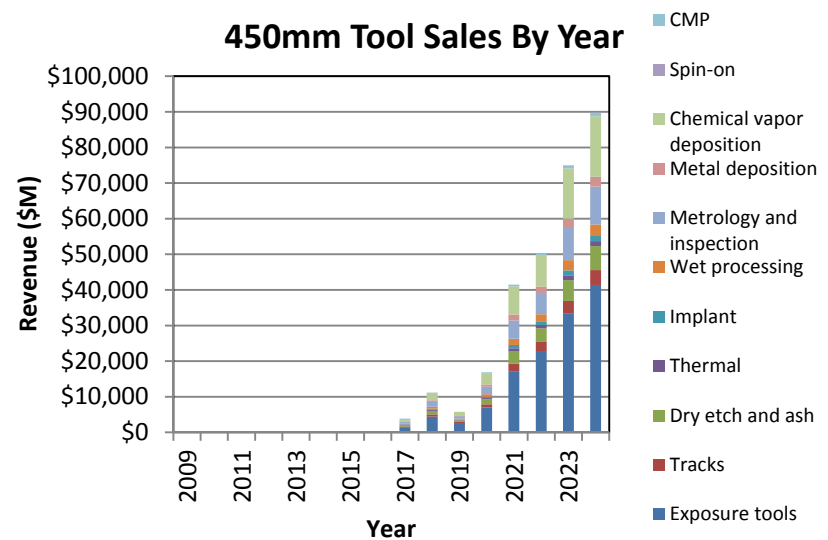
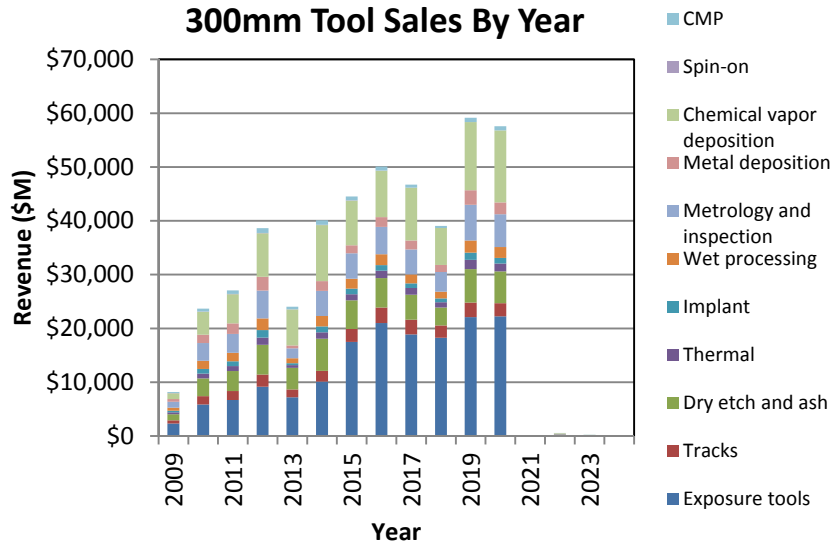


**New Fabs By Year**



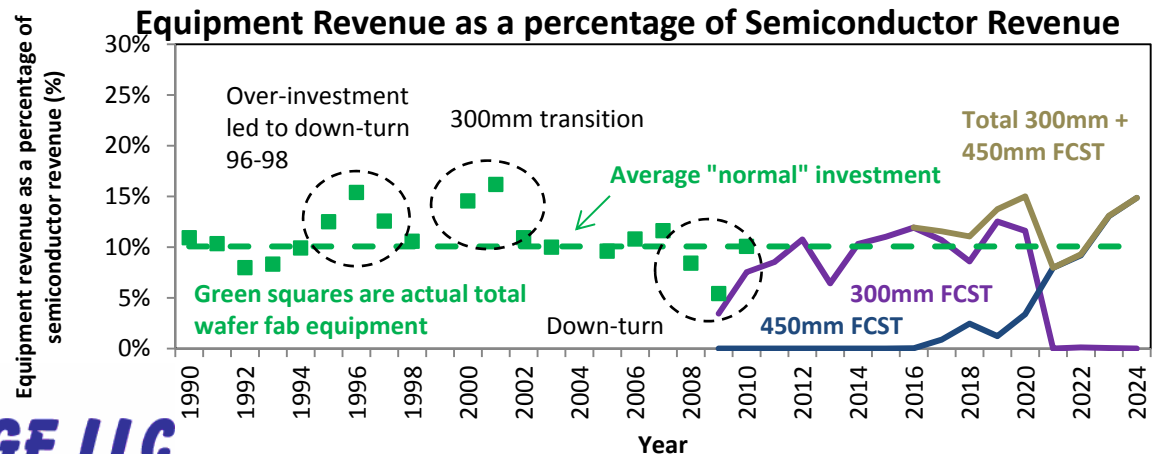
# Fab tool revenue

Source: 300mm and 450mm Equipment Forecast - revision 1104



Missing post 2020 300mm replacement

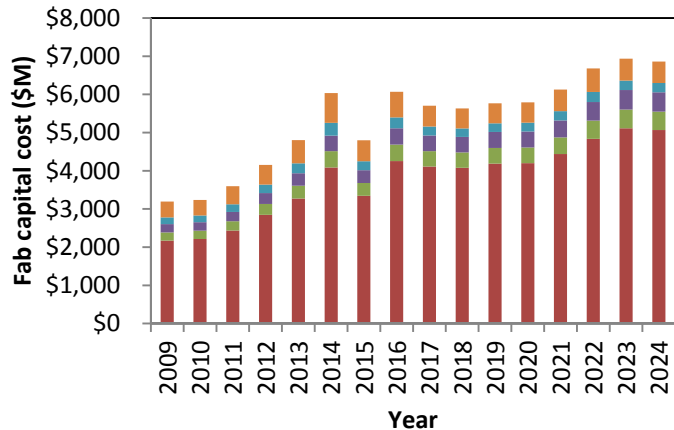
2018 - 450mm production ramp



# Fab capital costs

Source: Strategic Cost Model  
- revision 1108

### 300mm MPU Fab Capital Cost

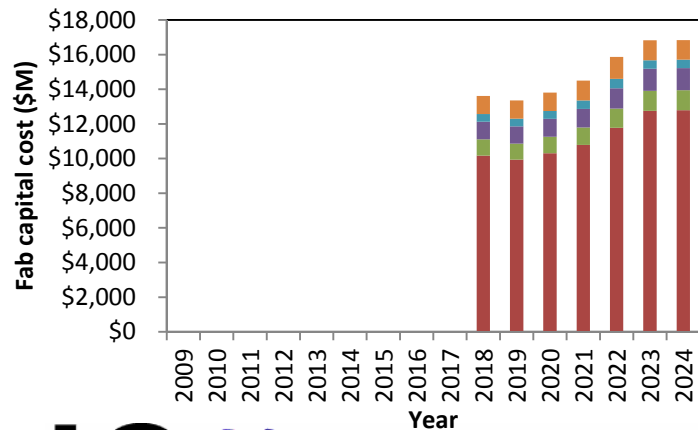


**30K**

- Building systems
- Building
- Automation
- Installation
- Equipment

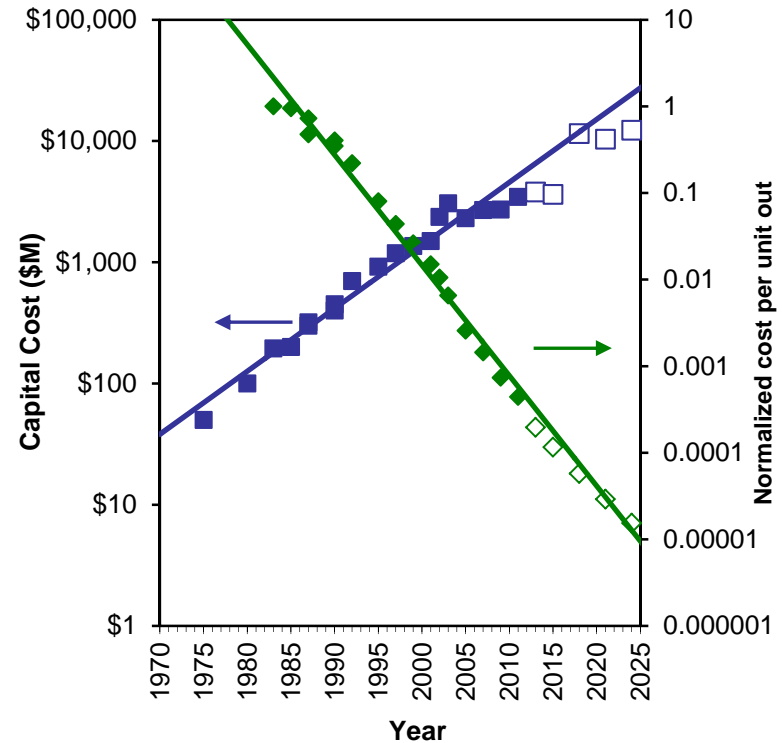
↓ **3.4x**

### 450mm MPU Fab Capital Cost



**45K**

- Building systems
- Building
- Automation
- Installation
- Equipment



14012.3

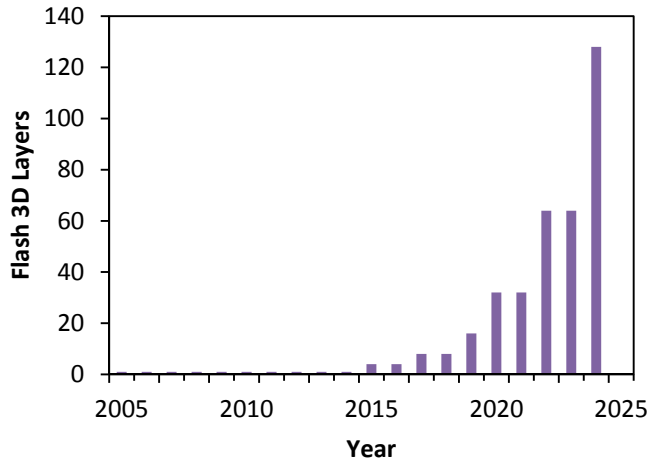
Capital productivity is normalized based on:  
wafer area, fab capacity and half-pitch.

# Flash Costs

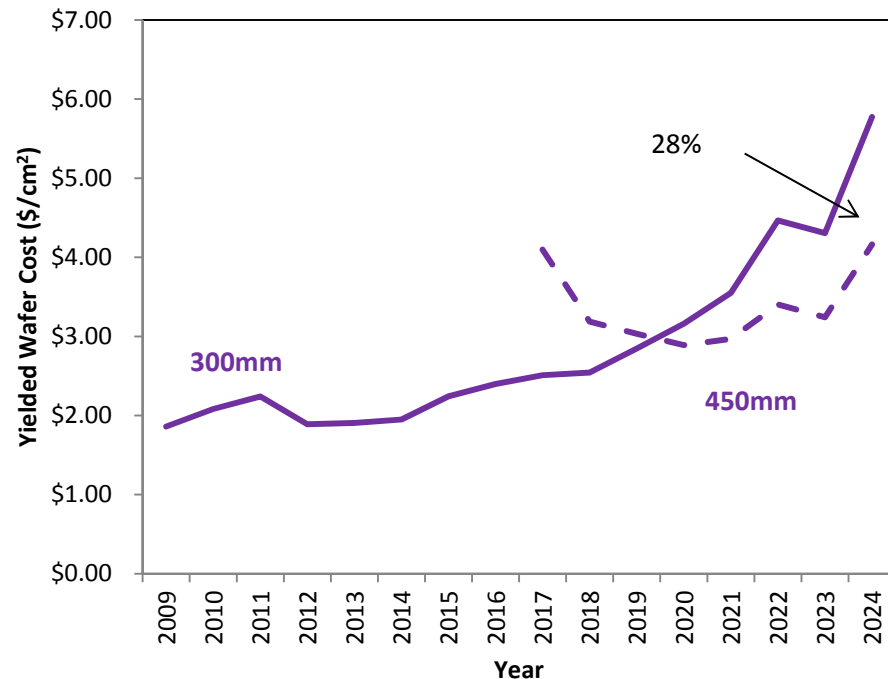
Source: Strategic Cost Model  
- revision 1108

- The large number of 3D layers forecast in the ITRS have cost implications.

### Flash 3D Layer



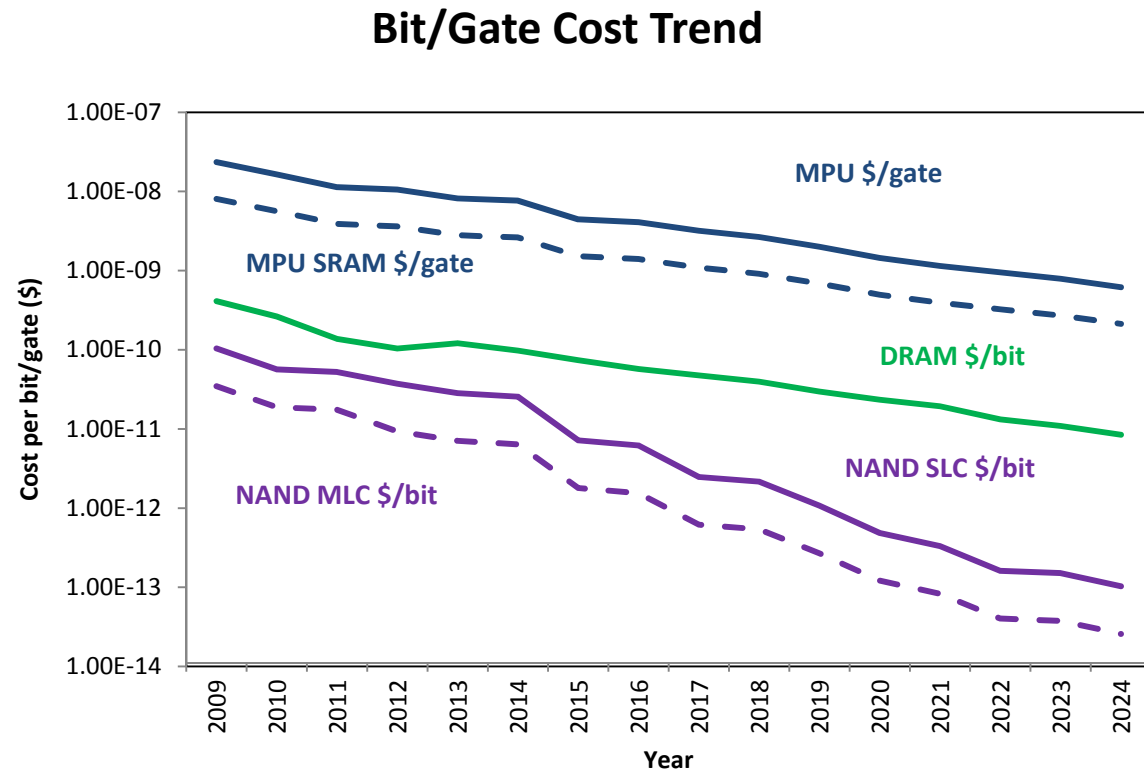
### Flash Wafer Cost Trend



# Cost per bit/gate trend

Source: Strategic Cost Model  
- revision 1106

- Minimum cost per square centimeter at each half-pitch divided by the bits or gates per square centimeter.
- Includes 450mm size ramp in 2018.



# Conclusion

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- IC Knowledge has developed three unique tools that allow a fully self consistent long term view of the semiconductor industry based on the ITRS to be produced.
- The three tools are:
  - **Strategic Cost Model**
  - **Semiconductor Silicon Demand Forecast**
  - **300mm and 450mm Equipment Forecast**
- License holders to the tools have the ability to customize the settings and develop other scenarios.