FMS 2013
<20nm NAND

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Background

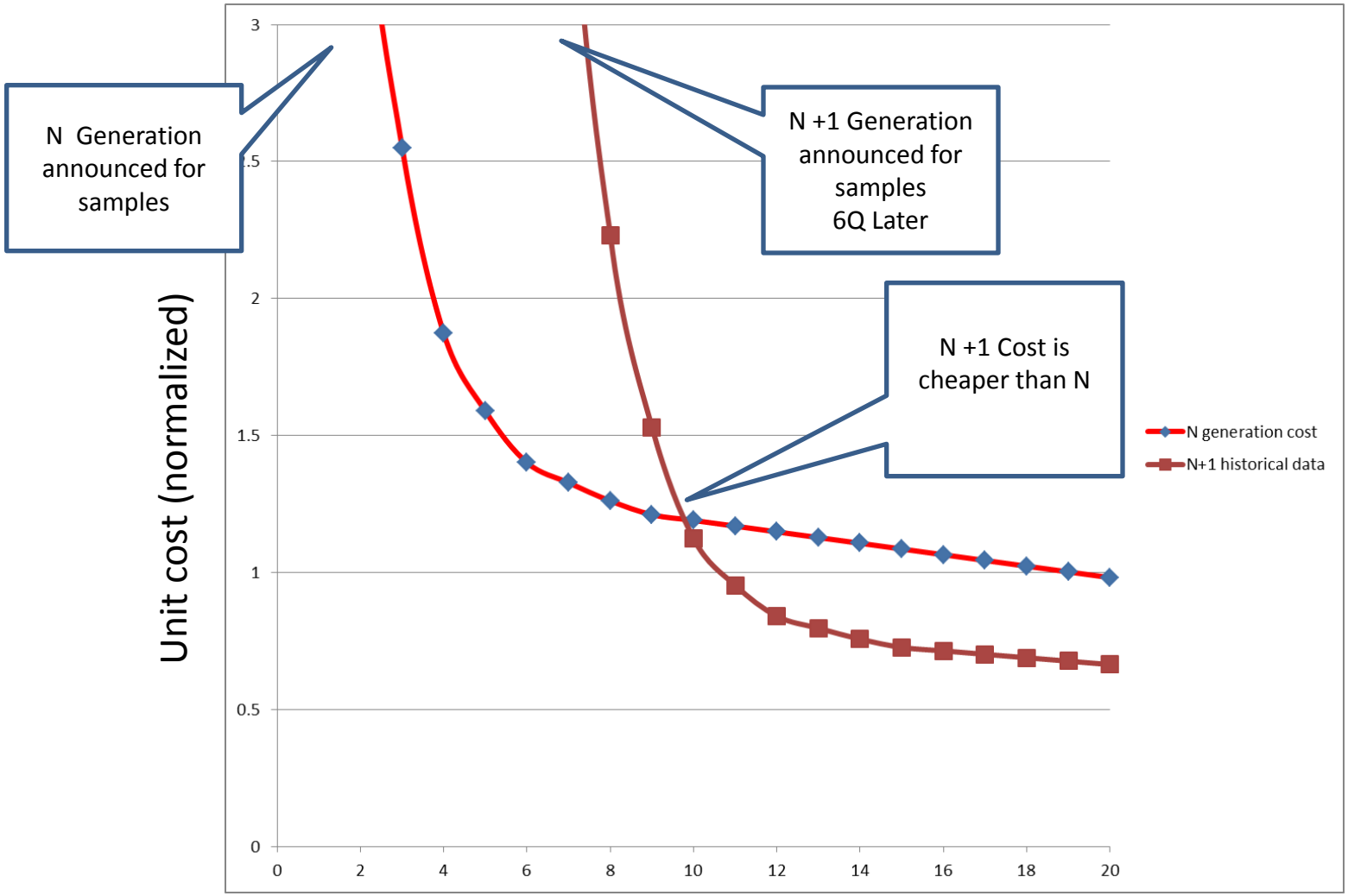
- Post 20nm NAND scaling will be dependent on financial issues and not a physics “brick wall”

- Planar NAND Cost reduction is slowing significantly due to a number of variables.
  - 19-21nm provided less cost reduction to NAND suppliers
  - 15-19nm will show significantly less cost reduction
  - Beyond that, I expect to see little to no cost reduction

- The Cost model shown quantifies impact of what is happening with increasing complexity, greater development cost and slower cost reduction
  - Presentation of data is normalized to current generation

Historical ROI on NAND Scaling

Follow Moore's/Hwang's law, don't blink

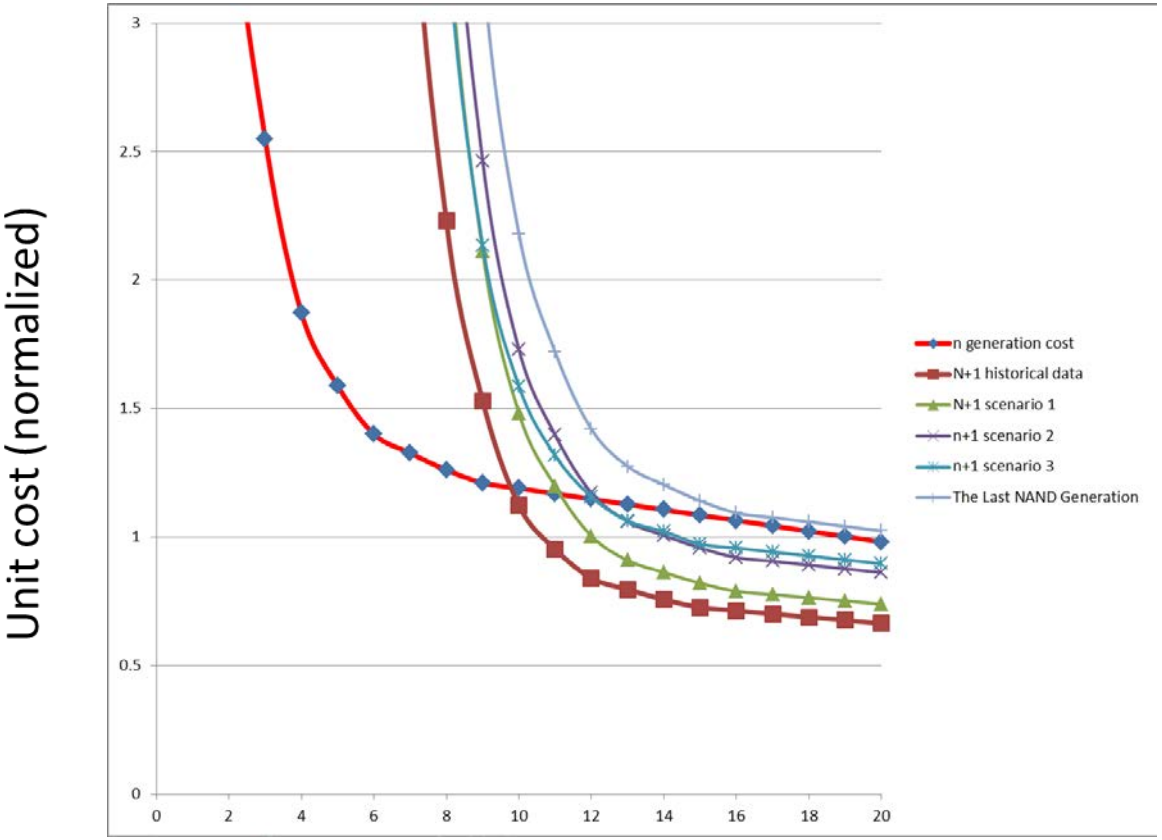


Assumes N+1= 40% area reduction

Slide show

New Scaling Cost Model

What is happening, what will happen



I have similar curves to predict 3D NAND impact

Scenario 1: 10% higher wafer cost, 1Qtr delay in yields, 40% shrink **@19-21nm**

Scenario 2: 10% higher wafer cost, 1Qtr delay, only 30% area shrink **@15-19nm**

Scenario 3: no wafer cost increase or delay , only 20% area shrink **@15-19nm**

The End: only 30% shrink, wafer cost 15% higher, 1Q Delay and 10% lower yields

What will reaction be?

- Summary:
  - Cost savings for 19-21nm introduction is 15-20% less than normal
  - Cost savings for 16-19nm introduction will be half of normal
- You can still make finances work even with half the ROI
  - Slower scaling and slower ramp
- This wouldn't be a problem except Planar NAND has expiration date
  - 3D NAND, if invested is the NAND breakthrough to prevent lower return on investment shown in model.
  - The "right" future answer for system storage is fast, non-volatile, scalable, stackable memory (Alternative) and a low cost, high density storage (Disk/cloud).
- Companies must plan for and invest in these new technologies

Prediction

- Planar continues scaling….1- 2 generations beyond 19-21nm
- 3D is small niche in 2015-2016
  - very high density, lower quality applications.
  - It is not initially lower cost per bit than planar NAND
  - **If** layers increased later and cost/yield breakthroughs happen, it will pass planar bit shipments in 2018
- Alternative memory (choose favorite) enters as small niche in 2016/17
  - High speed, high reliability, high cost
  - **If** it is optimized and leadership companies change storage architecture for industry, it will pass planar bit shipments in 2019
- Only one of the replacements will happen in next 10 years.