

DOCKETED

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ITI & Technet 9/29 F2F Presentation: WD Hard Disk Drives

Additional submitted attachment is included below.

HDD Drive Idle Power

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HDD Drive Idle Power Agenda

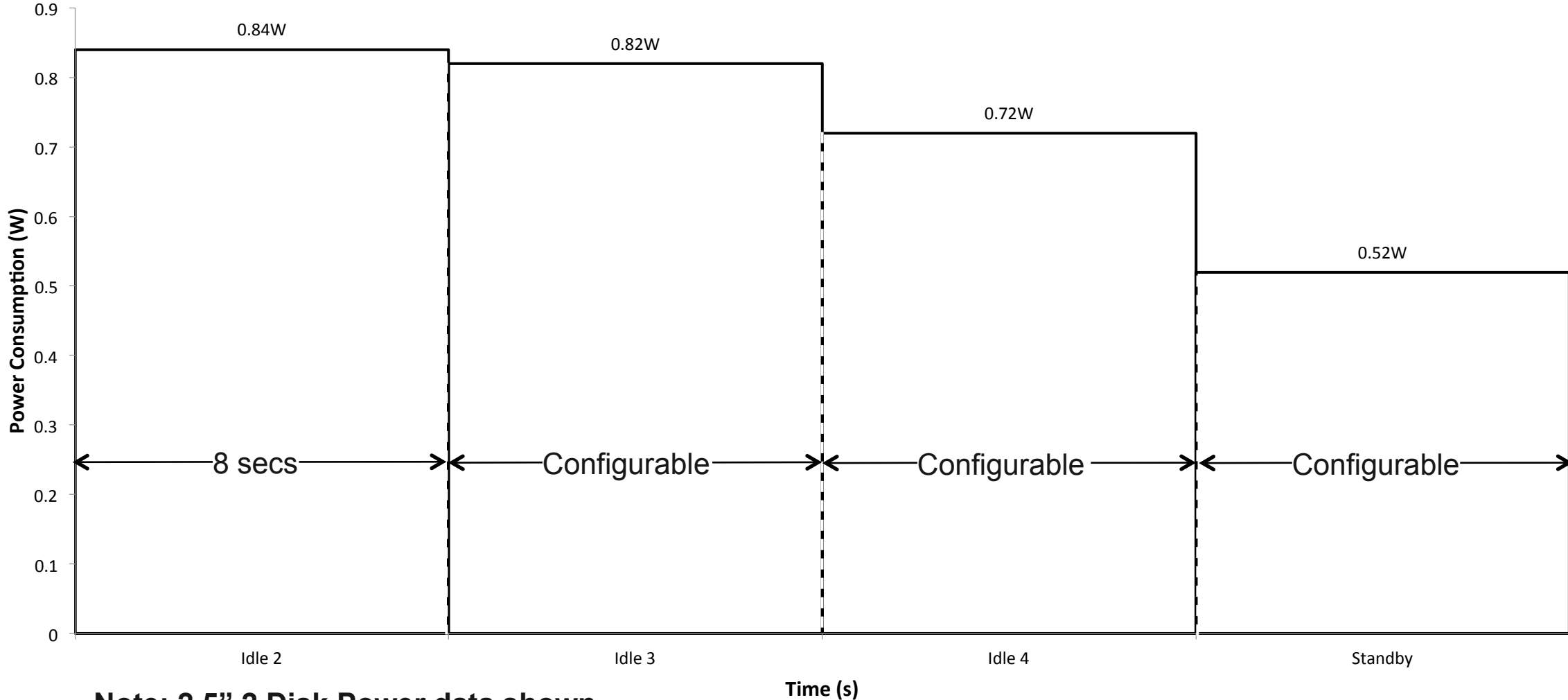
- Idle Power Overview
- Idle Power Profile
- 2.5" Idle Power
- 3.5" Idle Power
- Motor vs Electronics Power
- Potential power reduction enablers
- Summary

HDD Drive Idle Power Idle Timers Overview

- Idle1
 - Track following
 - Channel powered up
- Idle2
 - Head floating
 - Channel powered down
- Idle3
 - Heads parked on ramp
 - Disk at 5400 RPM
 - Read/Write cmd latency ~ See Slide 6
- Idle4
 - Heads parked on ramp
 - Disk at reduced RPM, full current recovery
 - Read/Write cmd latency ~ See Slide 6
- Standby
 - Heads parked on ramp
 - Disk spindle down, full current recovery
 - Read/Write cmd latency ~ See Slide 6

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HDD Drive Idle Power Idle Timer Profile



Note: 2.5" 2 Disk Power data shown

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HDD Drive Idle Power

2.5" – 5400 RPM Idle power comparison by platter count

2.5" - 5400 RPM	1 Disk*			2 Disk		
Mode	5V Current (mA)	5V Power (W)	Recovery Time (s)	5V Current (mA)	5V Power (W)	Recovery Time
Idle 3	163	0.82	0.31	167	0.84	0.33
Idle 4**	143	0.72	0.82	145	0.73	1.09
Standby	103	0.52	1.757	100	0.50	2.13

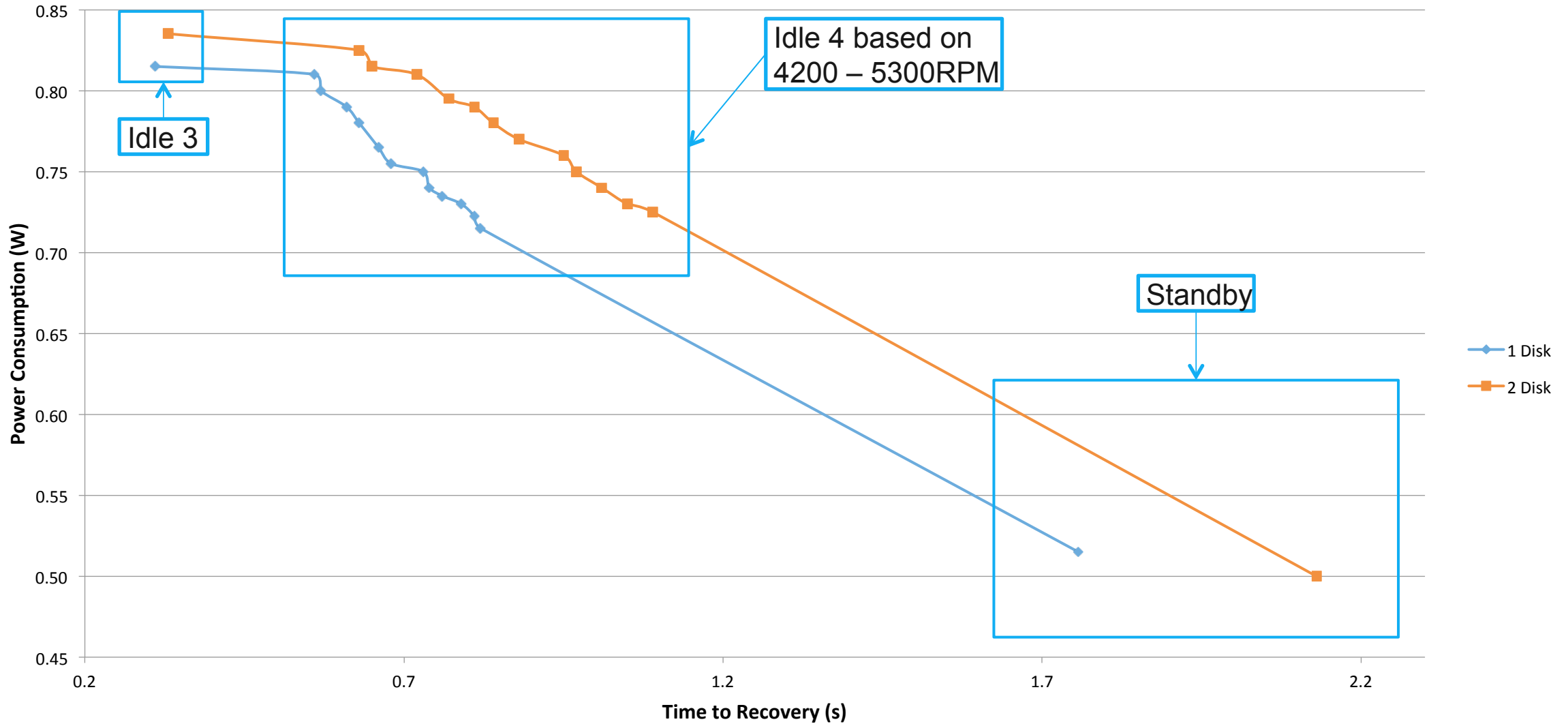
- 1 Disk Platter represents the majority of the volume; all 2.5" products are 5400 RPM
- **Idle 4 Power is based on 4200RPM
- Cold start time is similar to Standby recovery time
- All power and recovery times are an approximation

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HDD Drive Idle Power 2.5" 5400 RPM Drive Power Consumption (W) vs Time to Recovery (s)



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HDD Drive Idle Power

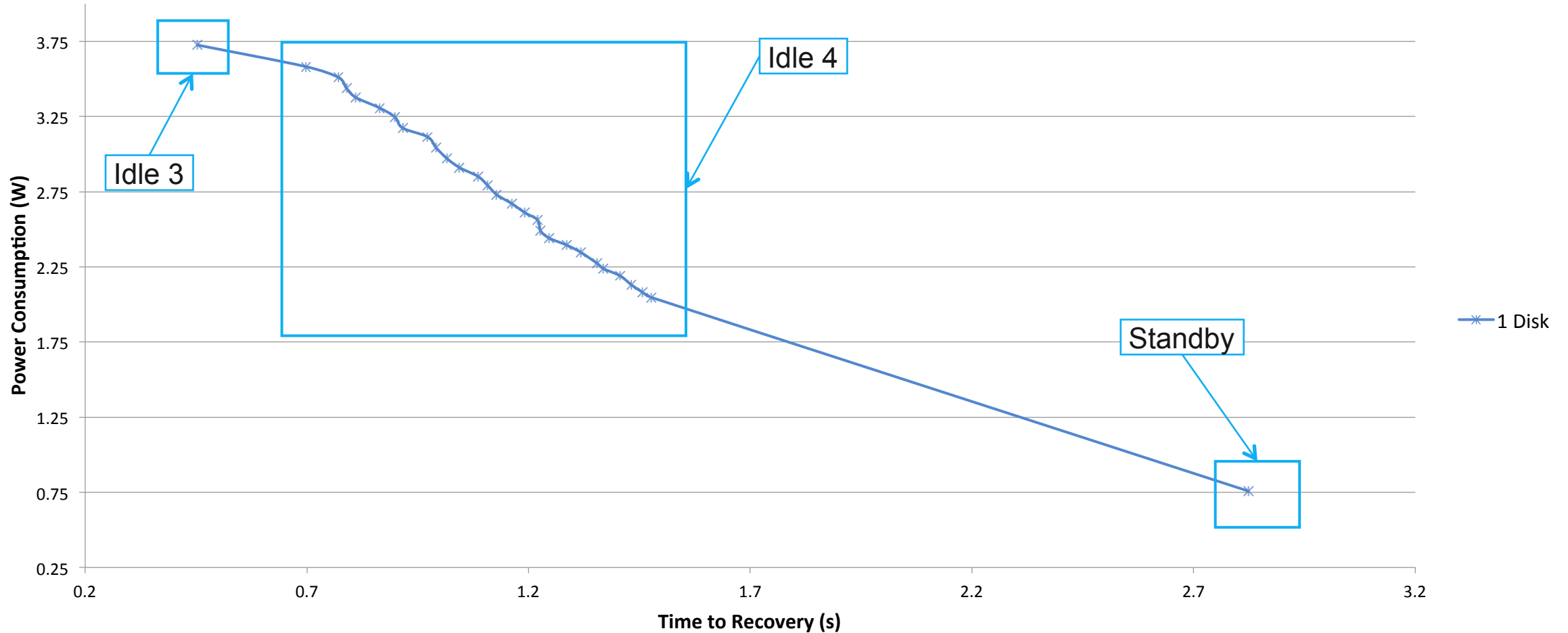
3.5" – 7200 RPM Idle power comparison by platter count

3.5" - 7200 RPM	1 Disk				2 Disk			
Mode	5V Current (mA)	12V Current (mA)	Power (W)	Recovery Time (s)	5V Current (mA)	12V Current (mA)	Power (W)	Recovery Time (s)
Idle 3	138.00	253.00	3.73	0.48	273.00	282.48	4.75	0.50
Idle 4*	138.00	113.00	1.36	2.05	273.00	102.82	2.60	6.00
Standby/Sleep	128.00	9.80	0.76	2.82	260.00	6.30	1.38	NA

- Cold start time is similar to Standby recovery time
- *Idle 4 Power is based on 4500RPM
- All power and recovery times are an approximation

HDD Drive Idle Power 3.5" 7200 RPM Drive Power (W) vs Time to Recovery (s)

3.5" Drive Power (W) vs Time to Recovery (s)



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HDD Drive Idle Power

3.5" – 5400 RPM Idle power comparison by platter count

3.5" - 5400 RPM	1 Disk				2 Disk				3 Disk			
Mode	5V Current (mA)	12V Current (mA)	Power (W)	Recovery Time (s)	5V Current (mA)	12V Current (mA)	Power (W)	Recovery Time (s)	5V Current (mA)	12V Current (mA)	Power (W)	Recovery Time (s)
Idle 3	150.75	135.00	2.37	0.44	125.00	192.00	2.93	0.61	125.00	202.00	3.05	0.65
Idle 4*	150.75	92.51	1.86	1.70	125.00	143.00	2.34	1.71	125.00	144.00	2.35	1.87
Standby	142.00	11.00	0.84	4.59	115.00	17.00	0.78	4.50	115.00	17.00	0.78	5.84

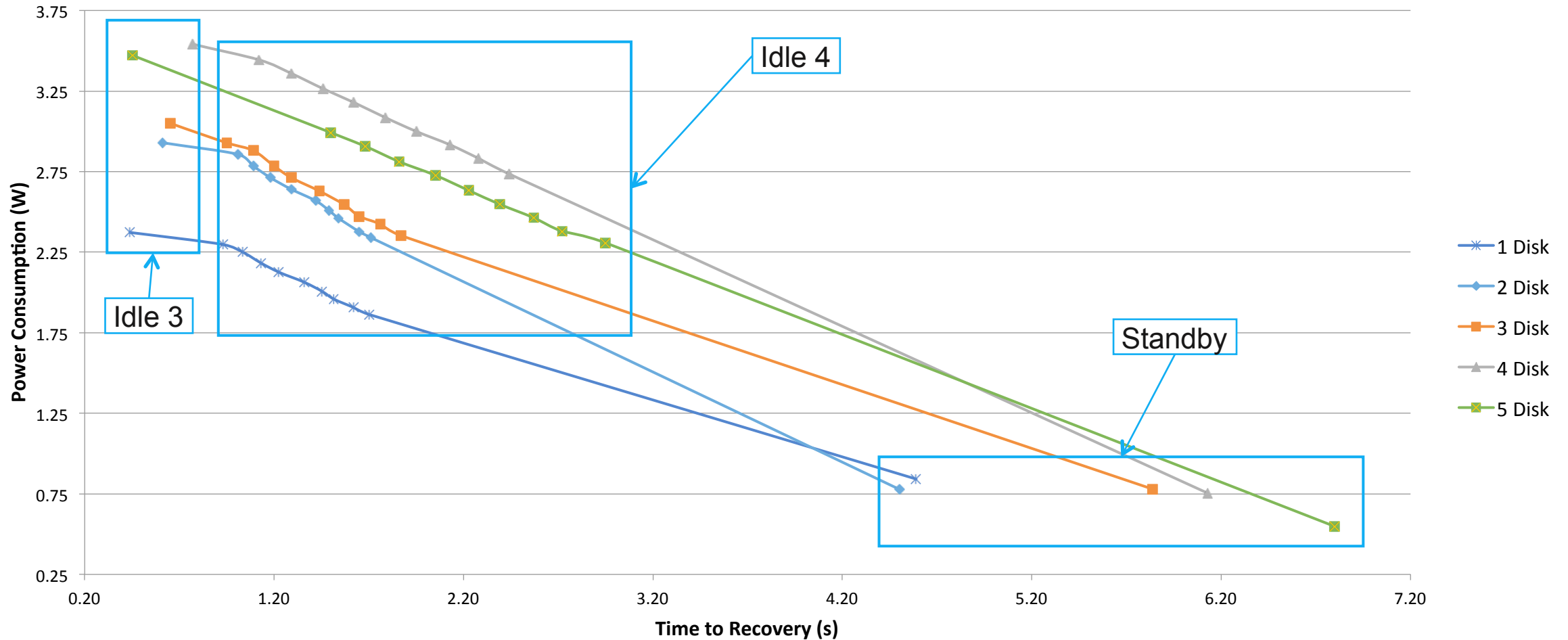
3.5" - 5400 RPM	4 Disk				5 Disk			
Mode	5V Current (mA)	12V Current (mA)	Power (W)	Recovery Time (s)	5V Current (mA)	12V Current (mA)	Power (W)	Recovery Time (s)
Idle 3	120.00	245.00	3.54	0.77	92.00	251.00	3.47	0.45
Idle 4*	120.00	178.00	2.74	2.44	92.00	154.00	2.31	2.95
Standby	110.00	17.00	0.75	6.13	88.00	17.00	0.55	6.80

- 1, 2 and 3 disk platter represents the majority of the 3.5" 5400 RPM client market.
- *Idle 4 Power is based on 4500RPM
- Cold start time is similar to Standby recovery time
- All power and recovery times are an approximation

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HDD Drive Idle Power 3.5" 5400 RPM Drive Power (W) vs Time to Recovery (s)

3.5" Drive Power (W) vs Time to Recovery (s)

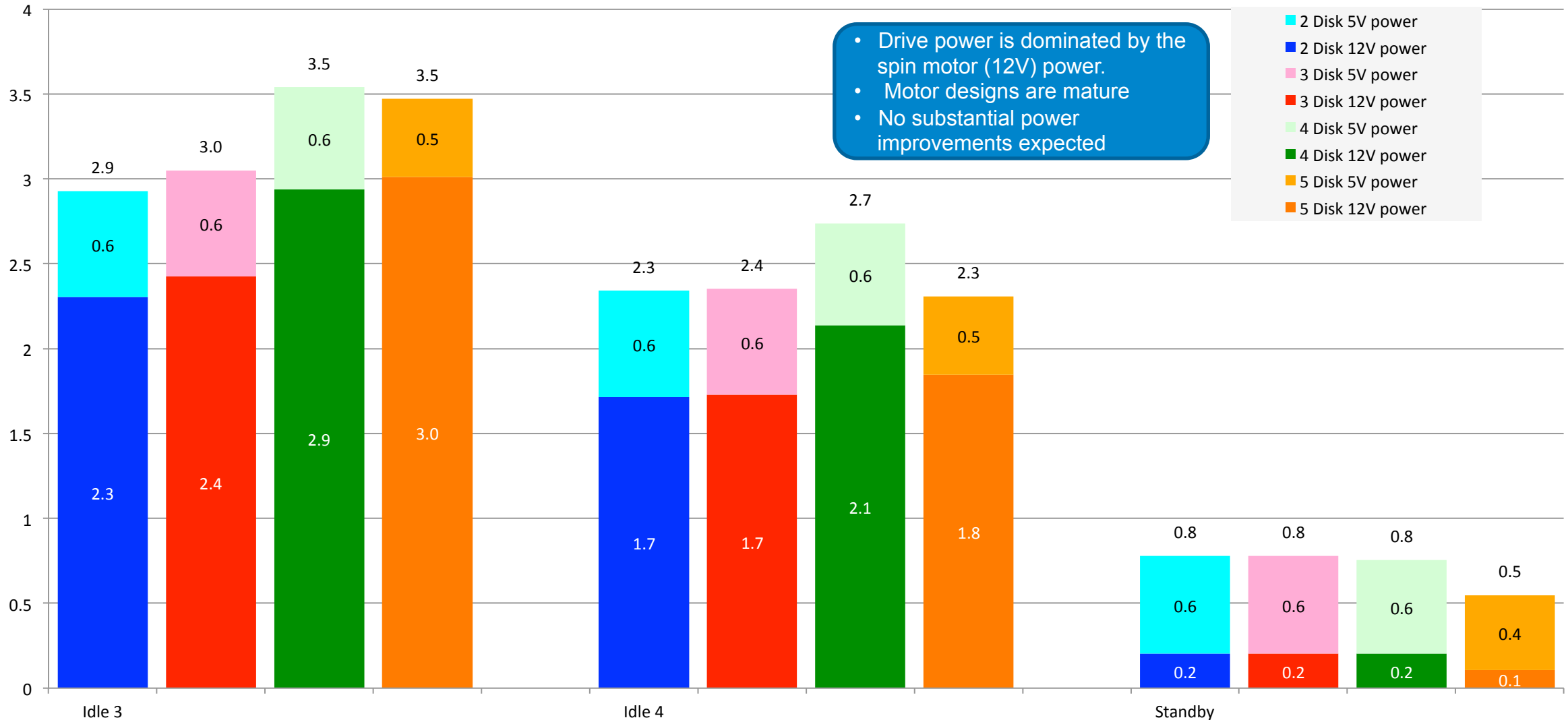


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HDD Drive Idle Power

3.5" 5400 RPM Motor vs Electronics Power



- Drive power is dominated by the spin motor (12V) power.
- Motor designs are mature
- No substantial power improvements expected

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HDD Drive Idle Power

Potential power reduction enablers

- Helium – Helium allows for a lower friction environment for larger platter count drives (4 and 5) provide ~24% power reduction in IdleC/Idle4. This however will not give a total 1 watt idle with a modest recovery time
 - Additional cost associated
- Hybrid – Hybrid drive can provide an always on, always connected user experience while the spindle system is spun down or spinning at a lower RPM. This only helps if the desired information is cached in NAND.
 - Separated caching solution is another option
 - Hybrid is the most expensive
- Advanced power control feature allows the spindle driver to control the spindle motor autonomously without high power SOC functionality
 - Integration effort required, but only 100-200mW savings anticipated

HDD Drive Idle Power Summary

- Platform “Idle” State -> HDD “Idle” State
- Although we have discussed Idle and Standby drive states, it is not possible to achieve platform standby state power levels with the drive in “Idle” state
- **Main Takeaway**
 - 2.5” drives will be able to meet a 1W idle power goal
 - 3.5” drives **will not** be able to meet a 1W idle power goal
 - Motor technology is very mature such that further power reductions are unlikely
 - Larger disk mass, higher motor bearing friction and windage contribute to higher motor power at idle when compared to 2.5” drives
 - None of the power reduction enablers discussed previously will allow us to reach the 1 W power goal