Was it really necessary for Apple to slow down old iPhones?

Apple yesterday confirmed that a long-held and controversial conspiracy theory actually contains some truth. The company says that, starting last year, it started slowing down older iPhones with lower-capacity batteries, mainly to prevent accidental shutdowns. The news set off a wide-ranging debate about smartphone reusability and longevity. But why does Apple need to do this in the first place?

First off, think of a battery like a system of pipes with water, says Marca Doeff, a battery expert at Lawrence Berkeley National Laboratory. Over time, natural side reactions between battery chemicals cause these pipes to clog up, so the water can't flow as quickly and gets stuck. This causes batteries to deliver less power, and a single charge doesn't last as long. Cold weather is harmful too because it slows everything down. Battery charging is dependent on lithium ions being able to move back and forth between the two sides of the battery. When the temperature drops, that movement gets slower; when the water stops moving completely, the phone shuts down.

Unexpected shutdown is especially common during what Apple calls "peak current demands." This is when the system draws on high power for a short amount of time, according to Venkat Srinivasan, a battery expert at the Argonne National Laboratory. "Say you went to the app store and hit 'update' all on the apps, then you clicked on a few unopened apps and opened them, then the system is pulling a lot of juice to do all this," Srinivasan wrote in an email to *The Verge.*

To prevent such shutdowns, Apple's fix is basically to lower the amount of water being pushed through the clogged pipes, to

avoid slowing the entire process down. (All lithium-ion batteries contain a battery management system that tracks battery capacity, according to Srinivasan. This is how Apple knows what's going on.) "You're slowing things down enough so that you can get through, but you're not draining as much current from the battery," says Doeff. Using an external battery would add capacity to the battery, she adds, but it's unclear whether this would cause the phone itself to run more quickly.

It's possible that this could have been avoided, according to Gerbrand Ceder, a professor of materials science at UC Berkeley. The amount that batteries degrade over time and in cold weather is quite predictable and can be tested ahead early, he wrote in an email to *The Verge*.

Battery designers make a trade-off between energy density and lifetime. The more energy you store, the more quickly it degrades. Being able to store a lot of energy at first is "highly desirable from a commercial perspective as this is when critics review the phones, and when users calibrate their experience," writes Ceder. "But this clearly came with intolerable performance decay."

Batteries are gaining a little bit of capacity every year, says Doeff. So newer phones probably have more efficient and better-designed batteries — and of course, the batteries in newer phones are newer to begin with. "It's difficult, though, because we're really pushing the demand for the battery to the maximum," says Doeff. One solution could be over-engineered batteries, or batteries that have more capacity than necessary. The downside is that you're carrying around a bigger phone, which few people want.

"We want more and more, and companies are trying to thread a pretty fine needle," adds Doeff. "Having said that, Apple could make it easier to swap out the battery." (Here's how to do that.)

Additional reporting by Ashley Carman.

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