for the system to function, coins should be fungible, which is to say that each coin should be indistinguishable from the next. When a coin carries the history, and potentially the smear, of every past transaction—as bitcoins do—this can be difficult to achieve.

"The laws of economics are almost as immutable as the laws of physics. And good money means that every unit of that money is the same as any other unit of that money. The only way to have that be the case for digital currencies is to have it be private," says Roger Ver, a Zcash investor who considers fungibility a central concern.

But perhaps the most intriguing feature of Zcash is that users can toggle the level of privacy it provides. Although the Zcash protocol encrypts all information about transactions by default, people can selectively disclose this data, and they have control over what parts get revealed as well as who gets to see them.

Let's say I'm in college and my parents are funding my studies. They could send me Zcash, and then I could lift the veil on all the transactions I make with that money in a way that only they could see.

Adam Back, a cryptographer who has himself endeavored to strengthen Bitcoin's privacy guarantees with a scheme called Confidential Transactions, says that Zcash is able to offer this degree of flexibility because, unlike Bitcoin, it starts with the strongest privacy-guarantee tools available.

"It's very hard to build something stronger on something that's weak," he says. "If you start with a perfect electronic cash system building block, then you can build an electronic cash system with selective weakening in a way that makes sense for society."

But cryptographers like Back do have reservations. There is, of course, the problem of requiring that one moment of infallibility on the part of human beings—the destruction of the key fragments—to guarantee its security.

Also, the zk-SNARK computations that validate transactions are quite exotic, at least compared with the well-worn standards used in Bitcoin. "The number of people who understand and have read the math and could develop an attack would be very small, maybe a dozen researchers worldwide. And so you run the risk that maybe not enough people have looked at it to have the insight of what's wrong with it," says Back.

The Zcash company, which developed the open-source software, is itself a bit of an experiment. It has a direct stake in the coins that are generated by the Zcash protocol. As with Bitcoin, miners periodically create new coins. But with Zcash, the miners get to keep only 90 percent of those coins. The rest gets dumped into accounts controlled by the Zcash company, which has stated that it will divvy up these earnings among founders, private investors, and a nonprofit foundation responsible for working on future versions of the protocol. But it is up to the company to transparently report on where that money flows.

One of the biggest unknowns is whether enough people care deeply enough about privacy to bring Zcash into the mainstream. When DigiCash declared bankruptcy in 1998, the failure was attributed partially to a lack of interest in financial privacy on the part of the everyday consumer. Buoyed by unsolicited encouragement both online and in person, Wilcox is confident that it will be different this time around.

—MORGEN E. PECK

WHY SOUTHERN CHINA BROKE UP ITS POWER GRID

An abundance of high-voltage DC makes big AC grids unstable

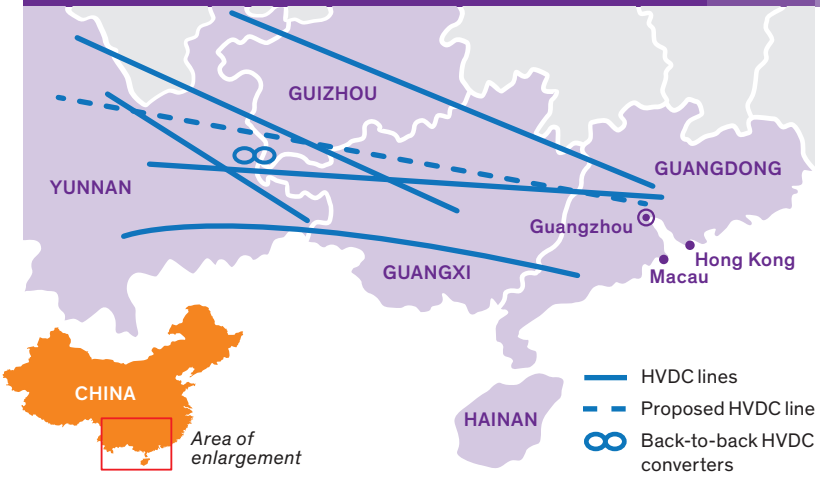
Throughout the 20th century, utilities merged transmission systems with neighboring grids, creating ever-larger AC electricity grids. Some, such as Europe's and North America's, now approach continental scale. But a recent move in China to break up an AC grid suggests that growing use of DC transmission technology may turn back the clock.

Grid operators have synchronized their AC power grids with neighboring systems to take advantage of electricity trading opportunities and mutual support. When a storm knocks out a high-voltage line or power station, for example, larger AC grids offer the resources and electrical inertia to absorb the loss.

However, a DC-power comeback has been brewing for decades, spurred on by

EASTWARD-FLOWING POWER: Hydropower projects feed China's eastern megacities using HVDC technology.

CHINA SOUTHERN POWER GRID



WHEN HVDC ATTACKS: This entire area was once one synchronous AC grid, but the concentration of HVDC lines to the east meant it was safer to separate Guangdong.

advances in solid-state power electronics. Solid-state conversion between AC and DC has enabled high-voltage direct current (HVDC) transmission lines that move electricity farther and more efficiently than AC lines. And, when paired, "back-to-back" DC converters allow the electrical exchange of power between nonsynchronized AC grids.

No country has gone as far with HVDC as China has. It operates more than 20 HVDC lines that deliver hydro, coal, and wind power from the nation's interior to its eastern megacities. In southern China, five HVDC lines carry about 26 gigawatts of hydropower from mountainous Yunnan province to the coastal factories of Guangdong, meeting more than one-quarter of that province's electricity demand.

It was this concentration of HVDC transmission that prompted the regional grid operator, Guangzhou-based China Southern Power Grid Co. (CSG), to take an unprecedented step: breaking up its AC grid.

Before last July, Yunnan and Guangdong were the western and eastern flanks of a CSG grid that served 248 million people living and working in a million-square-kilometer area. It was one large AC zone, augmented by HVDC lines, and it worked. System reliability was consistently improving, according to Mo Weike, a CSG control center engineer pursuing a Ph.D. at South China University of Technology, in Guangzhou. However, says Mo, the hybrid AC-DC system harbored a "unique risk" of systemwide blackouts.

Essentially, the HVDC lines converging on Guangdong were too big for the AC grid. When an HVDC line from Yunnan tripped off-line, up to 6.4 GW of power instantly surged onto the underlying mesh of AC lines. To counter this, CSG used preprogrammed security schemes to quickly reduce output from Yunnan.

But if those countermeasures had failed, the AC lines could overload and disrupt the electronic power switching in other HVDC converters. The latter threatened to knock more transmission off-line and collapse the entire CSG grid.

In July, CSG neutralized this threat by shutting off Yunnan's AC links to the rest of its grid, turning the province into its own distinct synchronous zone. Power exchanges continue between Yunnan and the rest of the CSG grid (in fact, they have increased since July) via the HVDC lines and newly built back-to-back HVDC links on Yunnan's eastern border.

CSG's breakup marks the first reversal in AC's inexorable expansion trend in over 40 years, according to international power experts. "I haven't heard of anyone splitting grids in that way," says Ian Dobson, an expert in grid stability at Iowa State University. But such compartmentalization could become a trend, according to Dobson and others. An optimization study that Dobson coauthored in 2014 suggested that, for the biggest grids, AC connectivity is a net liability in terms of reliability.

What's more, says Gregory Reed, a DC expert at the University of Pittsburgh, HVDC can act as a firewall against cascading failures such as the Northeast blackout, which plunged 50 million people from Ontario to New Jersey into darkness in 2003. CSG's AC breakup, he says, is pointing the way toward more resilient power systems. "They are doing what we should have embarked on in the [United States] and Canada a long time ago. Our AC synchronous networks are huge—way too large, in my opinion."

CSG's experience could also accelerate a shift toward more resilient HVDC technology. Southern China's big HVDC lines overpowered its AC grid partly due to its thyristor-based converters, which require voltage support from the AC grid. CSG expects future HVDC projects to make greater use of newer, transistor-based voltage-source converters (VSCs), which manage their own voltage. VSCs are already favored for lines carrying the variable power produced by wind and solar farms. [See "Germany Jump-Starts the Supergrid," *IEEE Spectrum*, May 2013.]

CSG installed VSCs in its Yunnan-Guangxi back-to-back station. It is now considering them for the second stage of its AC breakup plan: cutting off eastern Guangdong from the main grid.

Mo says the timing of that move will depend, in part, on how the Yunnan desynchronization experiment pans out. Its biggest challenge is balancing Yunnan's AC supply and demand in real time, and thus keeping the grid frequency locked to its 50-hertz standard.

CSG has made it work so far, says Mo, by reprogramming Yunnan's HVDC converters to lean on the larger CSG grid for help. Yunnan's converters track the regional grid's AC frequency and modulate its exports accordingly. When Yunnan has excess power, the overage is shunted to the larger CSG grid (and vice versa). But it is a balancing act that will grow only more challenging as the region installs more wind and solar power. —PETER FAIRLEY

ILLUSTRATION BY Erik Vrielink