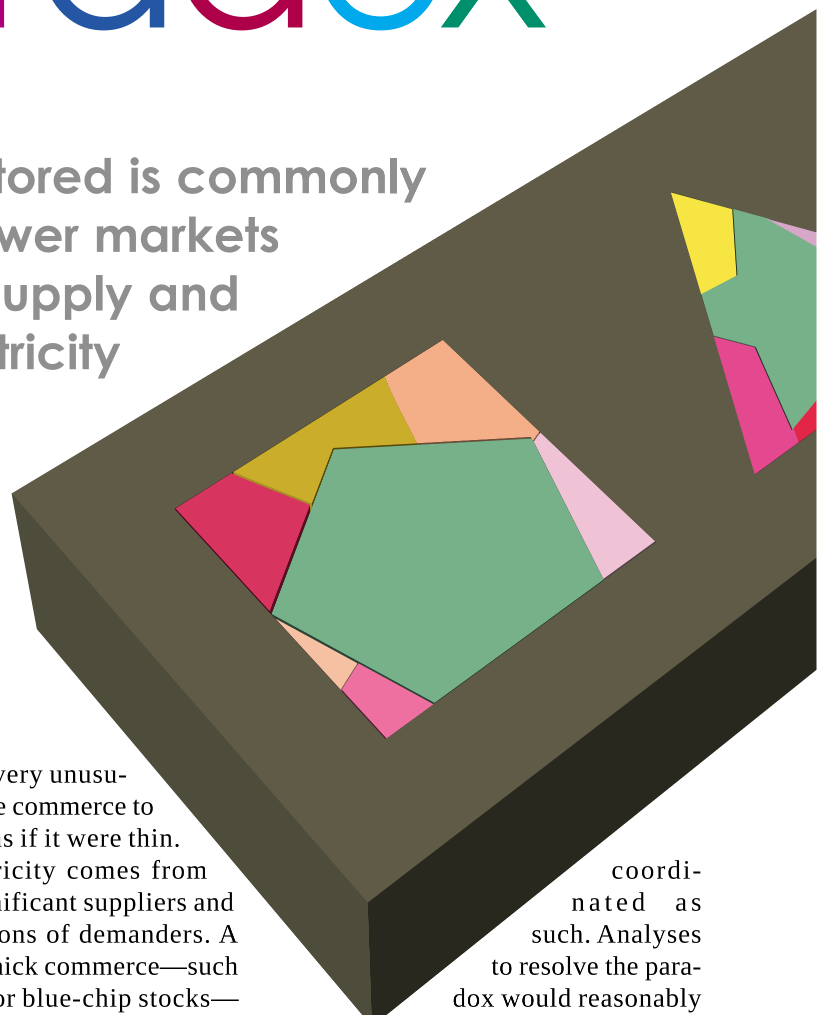
Resolving the electricity paradox

That electricity cannot be stored is commonly cited as the reason why power markets are 'different.' Flexibility in supply and demand should make electricity markets behave like any other commodity market with hundreds of suppliers and demanders. Why isn't that the case?



By Charles W. Polk

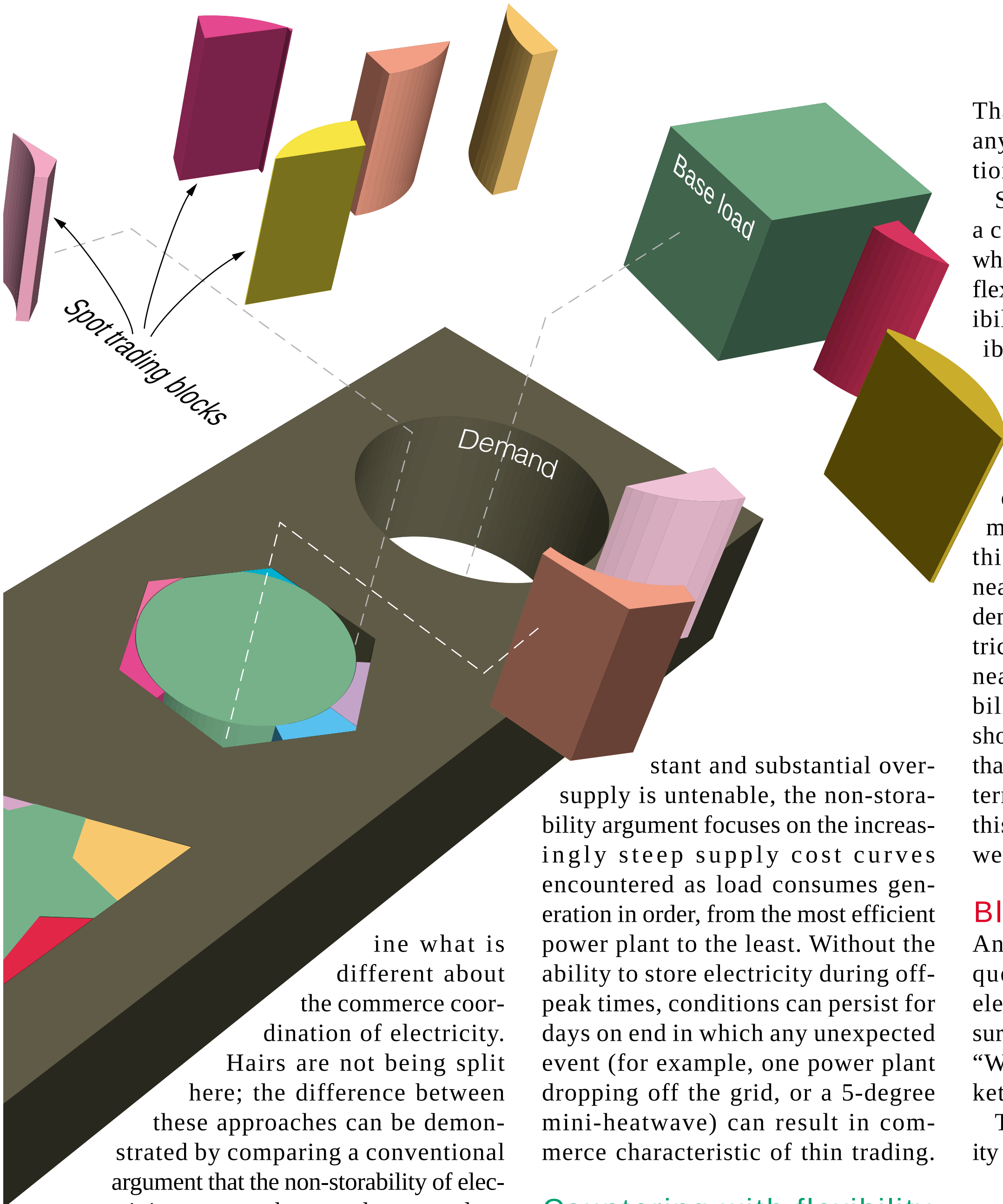
Electricity has a huge commerce, yet its trade has the characteristics of "thin" markets. That's paradoxical. In a thin market, even modest efforts to transact commerce can be complicated or even scuttled by unanticipated prices and various other risks. Classic characteristics of thin market trading include:

- Price volatility.
- The prevalence of brokered vs. exchange-like deal making.
- The costs and illiquidity of risk management instruments.

Though this may sound normal for electricity, it is very unusual for such a huge commerce to be coordinated as if it were thin. After all, electricity comes from hundreds of significant suppliers and is used by millions of demanders. A fundamentally thick commerce—such as in oil, grain, or blue-chip stocks—usually reaps the benefits of being organized by thick markets, whose characteristics are the opposite of thin markets.

So the electricity paradox is really one of comparison: A thick commerce coordinated as if it were thin, compared to other thick commerces coordinated as such. Analyses to resolve the paradox would reasonably include coming up with an answer to the question: What is different about electricity commerce?

A conventional approach to this question would first look at what is different about electricity. However, a less conventional—but arguably more productive—approach would exam-



ine what is different about the commerce coordination of electricity. Hairs are not being split here; the difference between these approaches can be demonstrated by comparing a conventional argument that the non-storability of electricity causes the paradox, to a less conventional one that the markets available to coordinate the commerce of electricity are poorly designed for that purpose.

Blame non-storability

Let's start with the conventional argument. Although electricity is not storable, the inputs to power plants that generate it—coal, gas, oil, water—are. However, the ready maintenance of sufficient generating reserves to accommodate any conceivable demand would remain very expensive even if capacity to transmit and distribute power from plant to loads were to be eliminated as a constraint.

Recognizing that a condition of constant and substantial oversupply is untenable, the non-storability argument focuses on the increasingly steep supply cost curves encountered as load consumes generation in order, from the most efficient power plant to the least. Without the ability to store electricity during off-peak times, conditions can persist for days on end in which any unexpected event (for example, one power plant dropping off the grid, or a 5-degree mini-heatwave) can result in commerce characteristic of thin trading.

Countering with flexibility

Just as the means to produce electricity are flexible, so too are most of its uses. The air-conditioning requirements of all but the smallest commercial buildings involve their thermal sink properties. They allow a flexibility in electricity consumption that is finer than just the ability to reset the thermostat by a few degrees during the day. By cooling more heavily in the morning and less heavily in the afternoon, demand during peak hours can be decreased with a less than proportional increase in building discomfort. Similarly, in most industrial operations, there is a price at which certain production processes can be shifted to non-peak hours. That price is lower than the cost of any steady-state reduction in production caused by the shift.

So in electricity, the commerce is in a commodity that is non-storable, but whose near-term demand and supply are flexible. Further, the incidences of flexibility and the willingness to use flexibility vary among demanders and suppliers. Given the large numbers of demanders and suppliers—and given that the long-term base load of electricity commerce is as predictable as that of other thick commerces—it should be possible to use this flexibility to "smooth out" the near-term organization of supply and demand. Granted, an inventory of electricity cannot be maintained to buffer near-term turbulence. But the flexibility on all sides of the commerce should be able to give the system more than enough "slack" to buffer the near-term turbulence that otherwise causes this thick commerce to behave as if it were thin.

Blame electricity markets

An unconventional approach to the question, "What is different about electricity commerce?" produces this surprising but supportable conclusion: "We're using the wrong kinds of markets to trade electricity."

The demand flexibility of electricity can be exemplified by shaped power.

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Computational combinatorial markets in other industries

One-to-many combinatorial procurement markets:

Date	Application	Developer	Client
1993	Trucking, long-term contracts[1]	Net Exchange	Sears
1997	Trucking, long-term contracts	Logistics.com[2]	Various
2001	Contracts for ingredients[3]	IBM	Food products manufacturer
2001	Packaging material	TradeExtensions[4]	Major auto manufacturer
2001	Road service contracts	TradeExtensions	Swedish Road Administration

Many-to-many combinatorial markets:

Date	Application	Developer	Client
1996	Emissions credits in Los Angeles[5]	Net Exchange	ACE Emissions Market
1999	Bond Connect	Net Exchange	State Street Bank
2001	Trucking, spot contracts	Net Exchange	Schneider Logistics

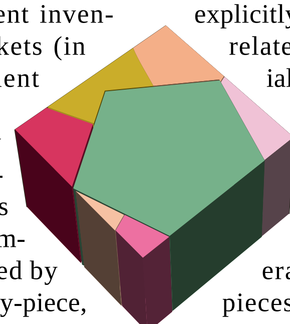
[1]www.nex.com/nex_about.htm. Operated from 1993 to 1996, saving Sears $80 million off expectations (13%) while providing savings and increased asset utilization to trucking firms. [2]Initially a part of Sabre. [3]www.research.ibm.com/auctions/index.htm. [4]www.tradeextensions.com. [5]See article on p. 23 of July/August 2001 Global Energy Business and www.nex.com/nex_about.htm.

Storability allows each demander, seller, and intermediary the means to buffer its business from temporary mismatches produced by markets that transact piece-by-piece

Demanders of load care about the temporal pattern of power they consume; hourly increments are usually fine enough to service their concerns for interrelated periods of use. Similarly, the supply flexibility of electricity can be exemplified by unit commitment. Suppliers of generation strongly prefer to run a unit continuously rather than bring it up and down. As in load demand, an hourly increment seems sufficiently fine to satisfy a generator's desire for interrelated periods of operation. The commerce of electricity can therefore be phrased in terms of hourly pieces. However, the business value of hourly pieces is interrelated, and the valued interrelationships vary between and among demanders and suppliers.

That a firm has interrelated value among pieces of its business is not rare. In fact, it is a very rare commerce indeed in which such interrelatedness does not predominate. Each sort of commerce has its own language to express the interrelated values held by the firms in the commerce—portfolio, scheduling, input tradeoffs, etc.

Many markets that organize thick commerce thickly do not explicitly deal with interrelated values among the pieces of the commerce they organize. However, these markets organize commerce in commodities that are storable: grain (in silos), oil (in tank farms, tankers, pipelines, or salt domes), capital goods (in component inventories), and financial markets (in letters of credit, government debt, short selling, or securities lending). Storability allows each demander, seller, and intermediary the means to buffer its business from temporary mismatches produced by markets that transact piece-by-piece, rather than in interrelated groups or patterns of pieces.



Do existing electricity markets transact hour-piece patterns of electricity generation and load? The answer is yes and no: Yes for long-term structured deals, and no for spot trades. Spot trades are conducted in hourly blocks, not in customized shapes. The ramifications of fragmenting term and spot in this manner are at the heart of the electricity paradox. With the liquidity of term commitments locked up in structured deals and the spot trade unable to deal in patterns, nonstorability can render the physical commerce thin. This risk of thinness ripples through the associated financial commerce, reducing the access to and increasing the cost of risk management instruments. But this is jumping to the end of the story; let's return to the middle and build the argument.

Combinatorial markets

The technical term for markets that explicitly transact patterns of interrelated pieces is "combinatorial." The term—from the science of market design, a branch of economics—comes from the need to combine into one transaction process the several markets that trade the pieces of a pattern. Without the ability to combine markets, patterns cannot be explicitly transacted.

On a practical basis, then, if we think of each hour of electricity use and generation as a separate market, then a combinatorial electricity market is one into which demanders can submit their load profiles and suppliers can submit their unit commitment schedules. The market's purpose/function then becomes one of directly matching these patterns. A combinatorial market must include and combine considerations of transactions across all of the hours in which suppliers and demanders express interest in the commodity. It is a multilateral and multi-item process through which a participant's valued pattern (multi-item, where each item is a volume of power in an hour) may be filled by many counterparties across the hours involved.

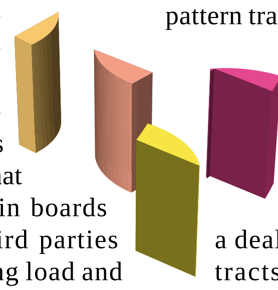
A combinatorial electricity market is therefore quite different—and more productive and efficient—than an electricity marketplace in which a demander or supplier must pursue patterns piece-by-piece. For a good analogy, consider two options you have for buying ingredients for making a dinner. You could get its components (a pattern) by visiting in turn several specialty food stores (a fruit market, a bakery, a butcher, a wine shop), each with its own proprietor. Or you could create the pattern more conveniently by going to a single source—a supermarket. A supermarket exemplifies a combinatorial market. Note that an electricity market that offers standardized shape contracts to demanders is not a combinatorial market. Rather, in the dinner analogy, it would play the same role as a McDonald's—whose Big Mac is a standardized, structured product. Note further one big difference between piecing together the parts of a dinner and piecing together the parts of an electricity pattern, the refrigerator provides a means of inventorying parts of dinner not shared in the electricity case.

Combinatorial electricity markets are common for organizing long-term trade. A classic example is the brokerage of long-term, structured deals. In any commerce, a broker is an intermediary who assembles deals among multiple counterparties and involving multiple items. To do that, some brokers carry transition inventory while others are purely information brokers (dating services, for instance).

Structured deals for long-term electricity supply can become highly customized, as each of the parties to the deal seeks forms of optionality to reduce the risks inherent in long-term commitments. The value placed on this embedded optionality reflects the parties' expectations that they cannot easily unwind pieces of the commitment in any intermediate or spot market as their performance on the deal gets closer. Were there effective secondary electricity markets for spot trading, then structured deals would not need to be so customized. But effective implies combinatorial, and human brokers cannot rebalance old deals nor cobble together supplemental ones fast enough to provide a combinatorial secondary market in electricity.

Why today's spot markets can't do patterns

All the bid/ask markets prevalent in electricity spot-market commerce do little or nothing to facilitate pattern trading—with the exception of EnronOnline. Before examining the EnronOnline exception, it's instructional to consider what happens at bid/ask bulletin boards (BABBs) operated by third parties for the purpose of matching load and generation.



When traders come to a spot market, they're looking to reshape load or rebalance generation from a level of intended use or generation that has been set by past agreements. Depending on the total price of adjusting from that level, a trader is usually willing to accept one of several reshapings or rebalancings. But any of these acceptable alternatives is likely to involve more than one hour of electricity.

When using a BABB, a trader must pick which of these several acceptable alternatives to pursue and then attempt piece-by-piece execution, haggling over each until a quantity and price are agreed upon for each hour-piece. Meanwhile, all of this trader's potential counterparties are engaged in a similar process. Therefore, it is highly unlikely that any trader will be able to acquire all of his or her pieces and know whether the alternative they are pursuing can be obtained at an acceptable price—if at all.

The trading risks of the BABB process are substantial and promote conservative offers by all traders, which in turn reduces the chances of closing any single negotiation; this puts a damper on the whole process. BABBs can work nicely in thick financial markets—but those are markets whose commodities are storable.

EnronOnline is a BABB of a different sort. Although it is not explicitly combinatorial, it does facilitate pattern trades to a much greater degree than do other BABBs. As the sole counterparty to—and the clearing agent for—every trade, Enron can offer a trader terms that are firm and certain for all pieces of a deal. With a huge book of contracts over which to distribute potential losses, with substantial access to demander and supplier information, and with significant means to address short selling, Enron can be more risk neutral than can a counterparty participating in a traditional BABB. Enron's risk neutrality reduces the impact of haggling. A trader can cobble together a pattern using EnronOnline much more effectively than on another BABB.

But the EnronOnline model is that of one really big counterparty, which

A combinatorial market must include and combine considerations of transactions across all of the hours in which suppliers and demanders express interest in the commodity raises a number of issues. Among them are:

- Although it might be financially feasible for a single counterparty to aggregate the entire spot market in electricity, doing so may require carrying so much risk that costs are imposed on trading that would not be imposed if the risks could be spread differently.
- From an economy-wide perspective, it's probably not a good idea to have a single counterparty be the aggregator of the entire spot market for a commodity as vital as electricity.
- Though a completely dominant EnronOnline might well serve to dampen the instability that affects electricity commerce, the disincentives of dealing with a total information monopolist may prevent a full transition to thick markets.

Given these issues, the EnronOnline model falls short of fully resolving the electricity paradox. But none of these issues would be particularly relevant were there a spot market in electricity that could compete with EnronOnline in facilitating pattern trades.

Combinatorial means computational

An explicit combinatorial spot electricity market that is designed to make pattern trading easy and natural for load demanders, generation suppliers, and commerce intermediaries would be a first step toward solving the electricity paradox. The ability to efficiently reshape load and rebalance generation in response to current conditions—including price—would go a long way toward eliminating the "thin-like" price volatility that stymies the use of financial risk management instruments. Further, there is no reason to limit the time horizon of such a market to the spot, once it is functioning for the spot. Demanders and suppliers of electricity may have sufficient information to reshape and rebalance several weeks prior to performance, and intermediaries may wish to "place bets" even more in advance of the spot.

Now we're really talking about a secondary market that can transact the deals that are valued by the participants in the commerce. Whenever there exists an effective way of retrading a commitment, the risks of entering into that commitment in the first place are reduced. In other words, if you know you can get out of a deal easily, you can be more willing to get into it in the first place. With access to an effective secondary market in electricity, load demanders and generators would be more willing to commit a greater portion of their business to longer-term contracts. What's more, longer-term contracts would not require the sorts of embedded options that currently make them so customized that they cannot easily be retraded.

Unlike classic brokerage, this sort of combinatorial electricity market would necessarily have to be controlled by computational algorithms rather than humans. Human intermediaries would still play a substantial role, in participation management and risk spreading. But only computers would be fast enough to identify deals and then price and process the trades that constitute the deals. Such computer-driven combinatorial markets have been used in other industries for nearly a decade (see table).

Visit these Web sites for more information

Net Exchange	www.nex.com
Glossary of market design terms	www.nex.com/nex-glossary.htm
Papers of Prof. John O. Ledyard	www.hss.caltech.edu/~jledyard/ledyard.html
Tabor Caramanis & Associates publications	www.tca-us.com/publications/pub1.html
Hewlett-Packard's information dynamics laboratory	www.hpl.hp.com/shl

Resolution and revolution

If a broad combinatorial secondary market for electricity were to evolve from spot to intermediate term and beneficially affect—if not subsume—longer-term power contracting, that would pretty much resolve the electricity paradox; the physical commerce in electricity would become thick. But the effect on the financial commerce in electricity might well justify the description "revolution."

A market that allows for generation and use patterns to be explicitly revised must necessarily be able to process single orders that contain buy and sell expressions—"swaps," as single expressions of trading intent, are a necessary part of a combinatorial secondary market. In financial trading, a swap is the essence of a derivative (for example, a bet on the difference between seasonal electricity prices is equivalent to a spread price between a buy in one month and a sell in another month).

But unlike derivatives that rely on separate markets for the price indices of the items on which they are structured, a derivative in a combinatorial secondary market (1) is embedded in the physical trade, (2) is custom-specified by a trader without the involvement of any intermediary, (3) can be filled by more than one counterparty, and (4) is not subject to basis price risk.

The liquidity of the financial derivatives commerce could be directly added to the physical commerce without restrictions on the number or types of derivatives or the requirement that the counterparties to derivative trades be derivative traders—this is the stuff of revolution.

Electricity market mechanisms such as brokerage and EnronOnline allow load demanders and generation suppliers to trade the patterns that constitute their businesses, but with insufficient flexibility to resolve the paradox of a thick commerce traded thinly. A computational combinatorial market for electricity offers the prospect of completely eliminating the electricity paradox. ■

Charles W. Polk is president of Net Exchange, a San Diego-based company that pioneered the commercial use of combinatorial markets in the early 1990s.