

EDHEC Comments on the Amaranth Case: Early Lessons from the Debacle



Hilary Till

Research Associate, EDHEC Risk and Asset Management Research Centre,
and Principal, Premia Capital Management, LLC

Abstract

We examine how Amaranth, a respected, diversified multi-strategy hedge fund, could have lost 65% of its \$9.2 billion assets in a little over a week. To do so, we take the publicly reported information on the fund's Natural Gas positions as well as its recent gains and losses to infer the sizing of the fund's energy strategies. We find that as of the end of August, the fund's likely daily volatility due to energy trading was about 2%. The fund's losses on 9/15/06 were likely a 9-standard-deviation event. We discuss how the fund's strategies were economically defensible in providing liquidity to physical Natural Gas producers and merchants, but find that like Long Term Capital Management, the magnitude of Amaranth's energy position-taking was inappropriate relative to its capital base.



About the author

Hilary Till is the co-founder of Premia Capital Management, LLC, a principal of Premia Risk Consultancy, Inc., and a research associate with the EDHEC Risk and Asset Management Research Centre.

A Chicago-based proprietary trading firm with a focus in natural resources markets, Premia Capital Management, LLC specialises in detecting pockets of predictability in derivatives markets using statistical techniques. Premia Risk Consultancy, Inc. advises investment firms on derivatives strategies and risk management policy. In addition, Ms. Till sits on the advisory board of the Tellus Natural Resources Fund, a fund of hedge funds. Before co-founding Premia Capital, Ms. Till was chief of derivatives strategies at Putnam Investments where her group was responsible for the management of all derivatives investments in domestic and international fixed income, tax-exempt fixed income, foreign exchange, and global asset allocation. Prior to joining Putnam Investments, Ms. Till was an equity derivatives analyst and commodity futures trader with Harvard Management Company, the investment manager for Harvard University's endowment.

Ms. Till has written articles on commodities, risk management, and hedge funds published in the Journal of Alternative Investments, AIMA Journal, Derivatives Quarterly, Quantitative Finance, Risk Magazine, Journal of Wealth Management, and the Singapore Economic Review. She has served as a referee for the Financial Analysts Journal.

Ms. Till has recently authored and co-authored chapters in *The New Generation of Risk Management in Hedge Funds and Private Equity Investments* (Euromoney, 2003), *Intelligent Hedge Fund Investing* (Risk Books, 2004), *Commodity Trading Advisors: Risk, Performance Analysis, and Selection* (Wiley, 2004), *Core-Satellite Portfolio Management* (McGraw Hill, 2005), *Hedge Funds: Insights into Performance Measurement, Risk Analysis, and Portfolio Allocation* (Wiley, 2005), *The Handbook of Inflation Hedging Investments* (McGraw Hill, 2006), *Hedge Fund & Investment Management* (Elsevier, 2006), *Portfolio Analysis: Advanced Topics in Performance Measurement, Risk and Attribution* (Risk Books, 2006), *Fund of Hedge Funds: Performance, Assessment, Diversification and Statistical Properties* (Elsevier, 2006).

Ms. Till is a member of the curriculum and examination committee of the Chartered Alternative Investment Analyst Association® and a member of the hedge fund specialisation exam committee for the Professional Risk Managers' International Association.

Ms. Till has a B.A. in Statistics from the University of Chicago and an M.Sc. in Statistics from the London School of Economics where she studied under a private fellowship administered by the Fulbright Commission.

Introduction

How can a respected, diversified multi-strategy hedge fund, whose size was reportedly \$9.2 billion as of the end of August, lose 65% of its assets in a little over a week?

This analysis will provide some preliminary answers and consider some early lessons from this debacle.

Amaranth Advisors, LLC is a multi-strategy hedge fund, which was founded in 2000 by Nick Maounis and is headquartered in Greenwich, Connecticut. The founder's original expertise was in convertible bonds. The fund later specialized in leveraged loans, blank-check companies, and in energy trading. According to Burton and Leising (2006), as of June 30th of this year, energy trades accounted for about half of the fund's capital and generated about 75 percent of their profits.

Davis (2006) has thus far provided the most complete picture of Amaranth's energy strategies. The following paragraphs quote from her article.

Davis reported that Brian Hunter, Amaranth's head energy trader sometimes held "open positions to buy or sell tens of billions of dollars of commodities." Mr. Hunter was based in Calgary, Alberta.

"Mr. Hunter saw that a surplus of [natural] gas this summer [in the U.S.] could lead to low prices, but he also made bets that would pay off if, say, a hurricane or cold winter sharply reduced supplies by the end of winter. He was also willing to buy gas in even further-away years, as part of complex strategies."

"Buying what is known as 'winter' gas years into the future is a risky proposition because that market has many fewer traders than do contracts for months close at hand."

"Unlike oil, [natural] gas can't readily be moved about the globe to fill local shortages or relieve local supplies."

"Traders like Mr. Hunter make complex wagers on gas at multiple points in the future, betting, say,

that it will be cheap in the summer if there is a lot of supply, but expensive by a certain point in the winter. Mr. Hunter closely watches how weather affects prices and whether conditions will lead to more, or less, gas in a finite number of underground storage caverns."

"Bruno Stanziale, a former Deutsche Bank colleague and now at Société Générale, works with energy companies that need to hedge their [forward] production. In an interview in July, he contended Mr. Hunter was helping the market function better and gas producers to finance new exploration, such as by agreeing to buy the rights to gas for delivery in 2010. 'He's opened a market up and provided a new level of liquidity to all players,' Mr. Stanziale said."

"[Amaranth's energy book] was up for the year roughly \$2 billion by April, scoring a return of 11% to 13% that month alone, say investors in the Amaranth fund. Then ... [the energy strategies] ... had a loss of nearly \$1 billion in May when prices of gas for delivery far in the future suddenly collapsed, investors add. [The energy traders] won back the \$1 billion over the summer ..."

On Monday, 9/18/06, the market was made aware of Amaranth's distress. It turns out the fund lost about 35% of its assets during the week of September 11th. It lost -\$560 million on Thursday, 9/14/06 alone.

The fund scrambled to transfer its positions to third-party financial institutions during the weekend of 9/16 to 9/17, but was unable to do so. On Wednesday, 9/20/06, the fund succeeded in transferring its energy positions to JP Morgan Chase and Citadel Investment Group at an apparent -\$1.4 billion discount to their 9/19/06 mark-to-market value. This meant that the fund's investors had lost about -\$6 billion or -65% since the end of August.

Given these facts, we can draw six preliminary lessons about what happened at Amaranth.

1. Lessons for Investors

Full and timely position transparency would not have been necessary to raise a red flag about the fund's Natural Gas trading.

Since May, investors knew the energy portfolio had typical up or down months of about 11%. The monthly volatility of the energy strategies therefore had been about 12%. Therefore, it would not have been unusual for the fund's energy trades to lose -24% in a single month, corresponding to a two-standard-deviation event.

In summary, an examination of the fund's monthly sector-level p/l would have been sufficient to raise a red flag.

That said, an analysis of the fund's liquidity risk would have benefited from an understanding of the precise positions of the fund.



2. Lessons for Fund-of-Fund Risk Managers

One would expect that the fund did not entirely accumulate its Natural Gas positions through the exchange-traded futures markets; one might assume that a meaningful fraction of its Natural Gas strategies was also acquired through the Over-the-Counter (OTC) derivatives markets.

Even if a substantial amount of the Fund's positioning was through the opaque OTC markets, an examination of the notional value of Amaranth's positions versus the open interest in the back-end of the New York Mercantile Exchange (NYMEX) futures curve would likely have shown that the fund's positions were massive relative to the prevailing open positions in the futures markets. This would have provided a red flag of the liquidity (or lack thereof) of the fund's positions.

After the fact, we can do a returns-based analysis of what the likely sizing of the fund's positions were, based on the publicly reported strategies of the fund, and what the publicly stated path of the strategy's p/l had been since June.

This procedure is described in Appendix A: *Reverse-Engineering Amaranth's Natural Gas Positions*.

We do not represent that our analysis shows the fund's actual positions. Instead, our returns-based analysis shows positions that, at the very least, were highly correlated to Amaranth's energy strategies.

According to our returns-based analysis, the fund's positions were indeed massive relative to the open interest in the further-out months of the NYMEX futures curve.

3. Lessons for the Hedge Fund Industry, Including Analogies to the Long Term Capital Management (LTCM) Debacle

There are at least three analogies to the LTCM debacle.

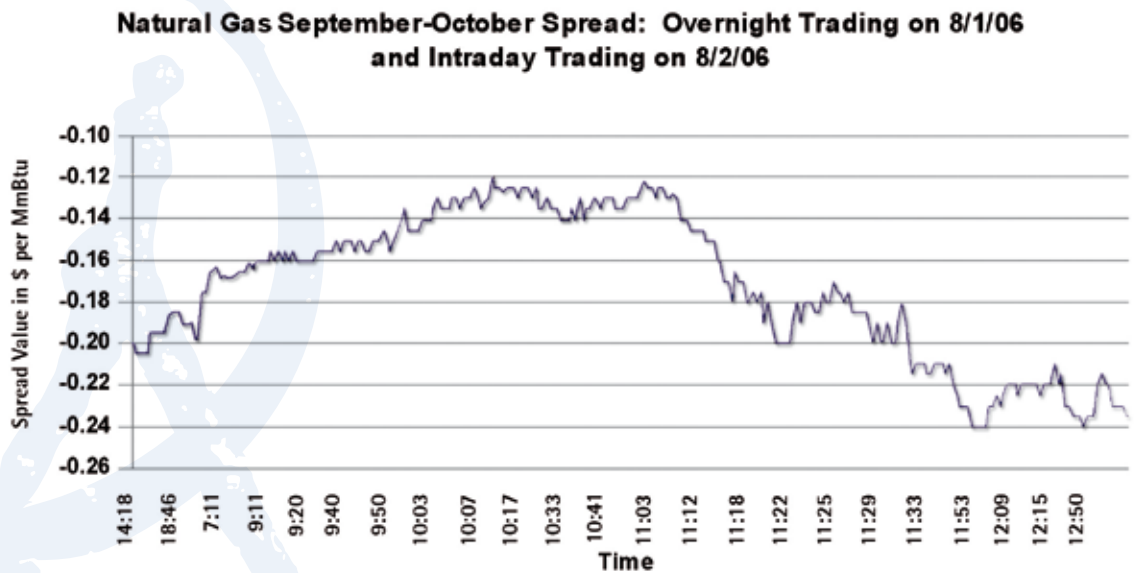
[A] Risk metrics using recent historical data would not have been helpful in understanding the magnitude of moves during an extreme liquidation-pressure event.

There was a preview of the intense liquidation pressure on the Natural Gas curve on 8/2/06, the day before the energy hedge fund, MotherRock, announced that they were shutting down.

This natural-gas-oriented hedge fund had been founded by a former NYMEX President, Robert Collins; and its shutdown sent shock waves throughout the industry.

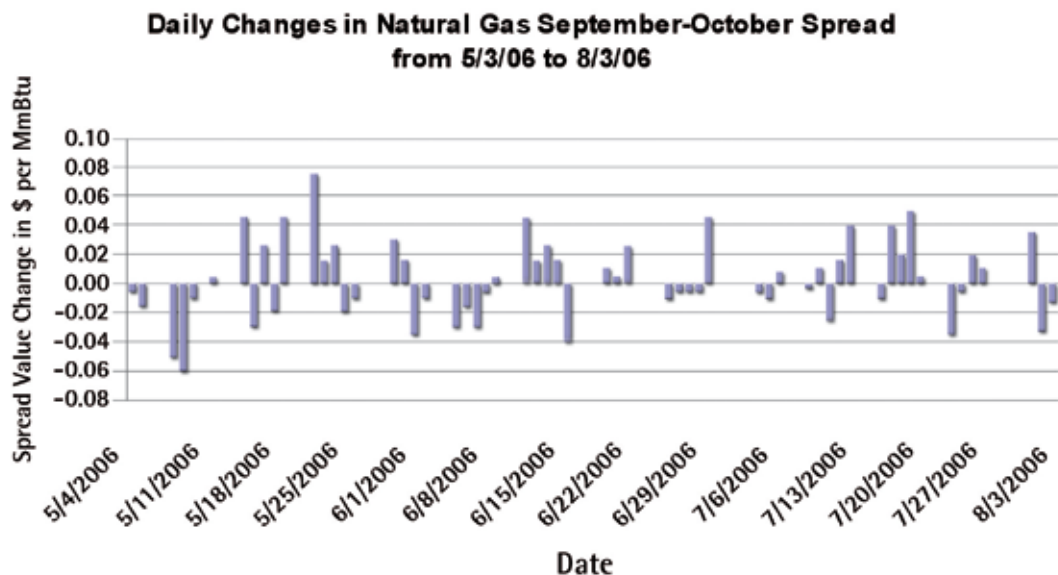
A near-month calendar spread in Natural Gas experienced a 4.5 standard-deviation move intraday before the spread market normalized by the close of trading on 8/2/06. We assume that this move occurred because of MotherRock's distress.

Figure 1 – panel A illustrates the intraday and three-month behavior of the September-vs.-October Natural Gas (NG U-V) spread.



The intraday peak-to-trough move in the NG U-V spread was 12c on 8/2/06

Figure 1 – panel B



As of 8/1/06, the daily standard deviation of the NG U-V spread had been 2.67c based on the previous three months of data. Therefore, the spread's intraday move, which is illustrated in Panel A, was 4.5 (= 12/2.67) standard deviations.

3. Lessons for the Hedge Fund Industry, Including Analogies to the Long Term Capital Management (LTCM) Debacle

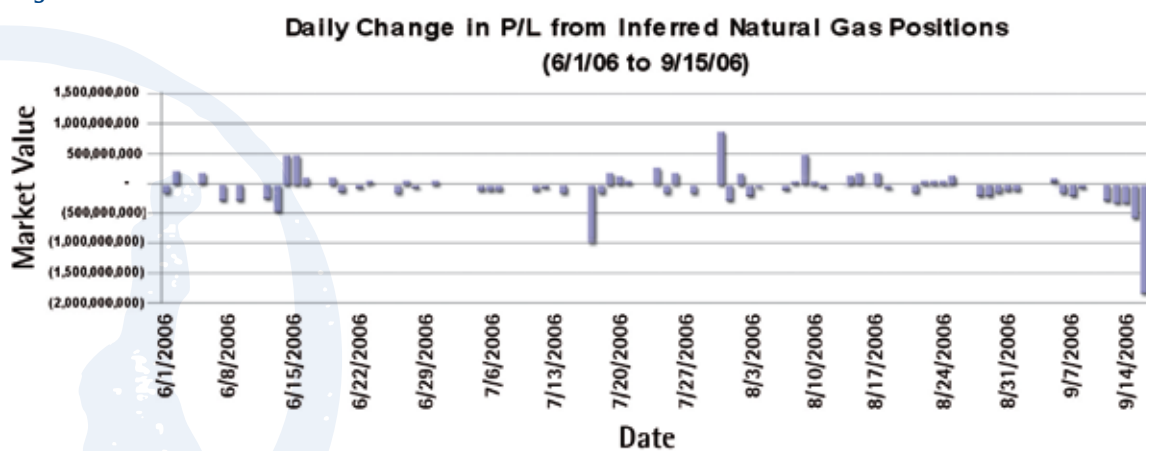
We might assume that MotherRock had been short the NG U-V spread; that is, they were long October and short September. Why make this assumption? The brief intense rally in this spread on 8/2/06 is consistent with the temporary effects of a forced liquidation of a short position in this spread.

As it turned out, the scale of MotherRock's losses, which were likely up to \$300 million, was small

compared to Amaranth's September experience.

In *Appendix B: Recent Volatility Analysis of Fund's Reverse-Engineered Positions*, we discuss what the volatility of Amaranth's energy trades is likely to have been, based on a returns-based analysis. Figure 2 reproduces one of the graphs in Appendix B.

Figure 2



As of the end of August, the daily volatility of Amaranth's inferred Natural Gas positions was 2% based on the previous three months of trading experience.

The fund's loss on Friday, September 15th (inferred from Appendix A's returns-based analysis) may then have been a 9-standard-deviation event.

Jorion (1999) informs us that based on LTCM's target volatility, the scale of LTCM's losses in August 1998 would have been an 8 standard-deviation event.

[B] The strategies that LTCM and Amaranth employed are and were economically useful.

LTCM's core strategy had been "relative-value fixed-income investing".

Relative-value fixed income hedge funds have

historically allowed international banks to lay off illiquid fixed-income risk. These hedge funds then have traditionally hedged this exposure with highly correlated, but more liquid, instruments (although post-1998, they have no longer done so with Treasuries).

In the case of Natural Gas, there is a natural commercial need for an institution to provide a return for storing Natural Gas for later use during peak winter demand. In the United States, there is also inadequate storage capacity in Natural Gas for peak winter demand. Therefore, the winter Natural Gas contracts have been trading at ever increasing premiums to summer and fall months to (1) incentivize storage; and (2) provide a return in the future for creating more production and storage capacity. The natural commercial position is to lock in the value of storage by buying summer and fall Natural Gas and selling winter Natural Gas forward. There has been no natural

3. Lessons for the Hedge Fund Industry, Including Analogies to the Long Term Capital Management (LTCM) Debacle

other side to this trade in sufficient commercial magnitude, which is where the usefulness of such financial participants as Amaranth comes into play. The hedge fund could have also provided liquidity to commercial participants by buying winter Natural Gas and then hedging itself with spring contracts.

In Appendix C: *Background on the U.S. Natural Gas Market*, we discuss a number of the technical features of the Natural Gas market. We do so in order to provide a better understanding of Amaranth's Natural Gas strategies.

[C] Even If a Strategy is Economically Viable, All Strategies Have Capacity Constraints.

LTCM's well-known strategy of (for example) buying (relatively illiquid) 29.5-year Treasury bonds and shorting 30-year on-the-run Treasury bonds is obviously defensible. But even the Treasury market can come under liquidation-pressure stress when position sizes reach sufficient magnitude, as seen during the LTCM crisis.

For Amaranth (and other energy hedge funds), the benefit of providing liquidity to Natural Gas producers and merchants is as follows. If a trader were long winter Natural Gas versus other sectors of the Natural Gas curve, that trader's portfolio would perform very well during Hurricanes (like 2005's Hurricane Katrina) and also during exceptionally cold winters (such as during February 2003.) In summary, the hedge fund would be positioned for extraordinary gains if such weather shocks occurred. But the issue again becomes one of appropriate sizing relative to a fund's capital base.

4. Lessons for Energy Hedge Fund Risk Managers

Veteran commodity traders do use measures like Value-at-Risk calculated from recent data to evaluate risk. But they also employ scenario analyses to evaluate worst-case outcomes. A natural scenario analysis for Amaranth would

have been to examine what the range of the Natural Gas spread relationships had been in the past. In that case, one would have found how risky the fund's structural position-taking was in its magnitude.

5. Lessons for Multi-Strategy Hedge Fund Managers

The commodity markets do not have natural two-sided flow. For experienced traders in the fixed-income, equity, and currency markets, this point may not be obvious.

The commodity markets have "nodal liquidity". If a commercial market participant needs to initiate or lift hedges, there will be flow, but such transactions do not occur on demand.

For experienced commodity traders, a key part of one's strategy development is a plan for how to exit a strategy. What flow or catalyst will allow the

trader out of a position? In the case of Amaranth, there was no natural (financial) counterparty who could take on their positions in under a week (or specifically during a weekend when the fund initially tried to transfer positions to a third party).

The natural counterparties to Amaranth's trades are the physical-market participants who had locked in either the value of forward production or storage. The physical-market participants would likely have had physical assets against their derivatives positions so would have had little economic need to unwind these trades at Amaranth's convenience.

6. Lessons for Policy-Makers

The derivatives markets are wonderful risk-transfer mechanisms for many economically essential activities. Amaranth was indeed providing an economic service. It is economically desirable for the capital markets to incentivize the creation of sufficient storage capacity of Natural Gas for peak winter demand in the U.S.

But obviously the magnitude of Amaranth's positions was inappropriate for the size of their capital base, as with LTCM. In Appendix D: *The Post-Liquidation Experience*, we note that the assumed Amaranth spreads have (thus far) stabilized since the positions were transferred to two financial institutions.

7. Conclusion

In summary, how could Amaranth have lost 65% of its \$9.2 billion assets under management in a little over a week?

According to published reports, Amaranth Advisors, LLC employed a Natural Gas spread strategy that would have benefited under a number of different weather-shock scenarios. These strategies were and are economically defensible, but the scale of their position-sizing relative to their capital base clearly was not. Using a returns-based analysis to infer the sizing of their positions, we found that their energy portfolio likely suffered an adverse 9-standard-deviation event on the Friday (September 15th) before the fund's distress became widely known.

We can draw six early lessons from this debacle:

(1) Investors would not have needed position-level transparency to realize that Amaranth's energy trading was quite risky. A monthly sector-level analysis of their profits and losses (p/l) would have revealed that a -24% monthly loss would not have been unusual;

(2) If investors did have position-level transparency, they would have likely noted that the fund's over-the-counter Natural Gas positions were massive compared to the prevailing open interest in the exchange-traded futures market, which would have given an indication of how illiquid their energy strategies were;

(3) Risk metrics using recent historical data would have vastly underestimated the magnitude of moves during an extreme liquidation-pressure event;

(4) If the fund's risk managers had employed scenario analyses that evaluated the range of Natural Gas spread relationships that have occurred in the not-too-distant past, they would have realized how massively risky the fund's structural position-taking was in its magnitude;

(5) It is essential for commodity traders to understand how their positions fit into the wider scheme of behaviors in the physical commodity markets: before initiating any large-scale trades in the commodity markets, a trader needs to understand what flow or catalyst will allow a trader out of a position; and

(6) Amaranth was likely indeed providing an economic service for physical Natural Gas participants; this hedge fund provided liquidity for physical-market participants who could then lock in the value of forward production or the future value of storage. But even so, like Long Term Capital Management, the scale of Amaranth's spreading activities was much too large for its capital base.

Endnotes

The author of this article would like to note that the ideas in this article were jointly developed with Joseph Eagleeye, co-founder of Premia Capital Management, LLC, <http://www.premiacap.com>.

The author is also an advisory board member of the Tellus Natural Resources Fund.

The source of the price and inventory data used in this article is from Bloomberg.

References

- Barr, Alistair, "Amaranth Sells Energy Portfolio to J.P. Morgan, Citadel," *MarketWatch*, 9/20/06.
- Burton, Katherine and Matthew Leising, "Amaranth Says Funds Lost 50% on Gas Trades This Month," *Bloomberg News*, 9/18/06.
- Burton, Katherine and Jenny Strasburg, "Amaranth Plans to Stay in Business, Maounis Says," *Bloomberg News*, 9/22/06.
- Chambers, Matt and Cassandra Sweet, "Amaranth Debacle Raises Regulation Issues," *Dow Jones Newswires*, 9/22/06.
- Davis, Ann, "How Giant Bets on Natural Gas Sank Brash Hedge-Fund Trader," *Wall Street Journal*, 9/19/06.
- Goldstein, Matthew, "Heat is On at ICE," *TheStreet.com*, 9/22/06.
- Jorion, Philippe, "Risk Management Lessons from Long-Term Capital Management," University of California at Irvine, Graduate School of Management Working Paper, June 1999.
- Lammey, Alan, "Choppy Winter Forecasts Suggest Healthy 1 Tcf End to Drawdown," *Natural Gas Week*, 12/5/05, pp. 2-3.
- Trincal, Emma, "Amaranth is Bleeding Assets, But Keeps Talking to Investors," *HedgeWorld*, 9/21/06.
- Trincal, Emma, "Amaranth Advisors: Who is to Blame?," *HedgeWorld*, 9/26/06.
- Weisman, Andrew and Jerome Abernathy, "The Dangers of Historical Hedge Fund Data," *Risk Budgeting* (Edited by Leslie Rahl), Risk Books, London, 2000.
- White, Ben, "Amaranth Chief Defends Policies," *Financial Times*, 9/23-24/06.

Appendix A: Reverse-Engineering Amaranth's Natural Gas Positions

One would expect that the exact Natural Gas positions that were held by the Amaranth Multi-Strategy Funds will (and should) be confidential for an extended period of time.

According to Barr (2006), Amaranth sold its entire energy-trading portfolio to J.P. Morgan Chase and Citadel Investment Group on Wednesday, September 20th. Amaranth apparently did so at a significant discount to the portfolio's then mark-to-market value. Until JP Morgan and Citadel have comfortably unwound or materially restructured the risk of this portfolio, one would expect that these positions will remain confidential. Therefore, detailed post-mortems on Amaranth's energy strategies will correspondingly have to wait until the exact positions in this portfolio are made public.

Nonetheless, a substantial amount of information has thus far been made public regarding this debacle. Two of Amaranth's Natural Gas spread strategies have been frequently mentioned in press reports. The size and timing of the fund's gains and losses in energy trading have also been exhaustively detailed in the public domain. We therefore have enough information to perform a simple returns-based analysis on the fund's energy strategy.

Returns-based analysis is a well-known technique in the hedge-fund industry since investors and risk managers frequently are not provided with

position-level transparency. Instead, investors have to infer the exposures of a hedge fund from the fund's return data.

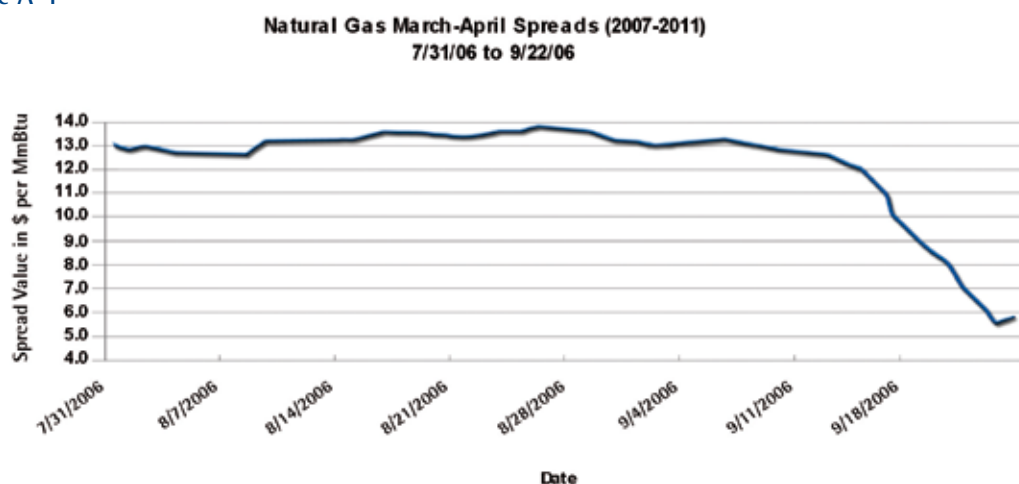
In our analysis, we draw from the spirit of Weisman and Abernathy (2000), who discuss a clever way to infer a hedge fund's key risk factors and leverage level from performance data. The following analysis draws from the publicly reported information that was available as of Monday, 9/25/06. If any of the publicly available information becomes revised or updated, then this analysis will need to be correspondingly revised.

From Davis (2006) and Burton and Strasburg (2006), we note that Amaranth apparently held Short Summer /Long Winter Natural Gas spreads as well as Long March / Short April Natural Gas spreads, including in deferred-delivery years, possibly through 2011.

We can create two spreads: (1) a Natural Gas spread combination in the March-April contracts for delivery in 2007, 2008, 2009, 2010 and 2011; and (2) a Natural Gas spread combination of Long Winter (December, January, February, and March) and Short Summer (June, July, August, and September) for delivery in 2007/8 through 2010/11.

Let's examine how each spread has performed since the end of July.

Figure A-1



Appendix A: Reverse-Engineering Amaranth's Natural Gas Positions

Figure A-2

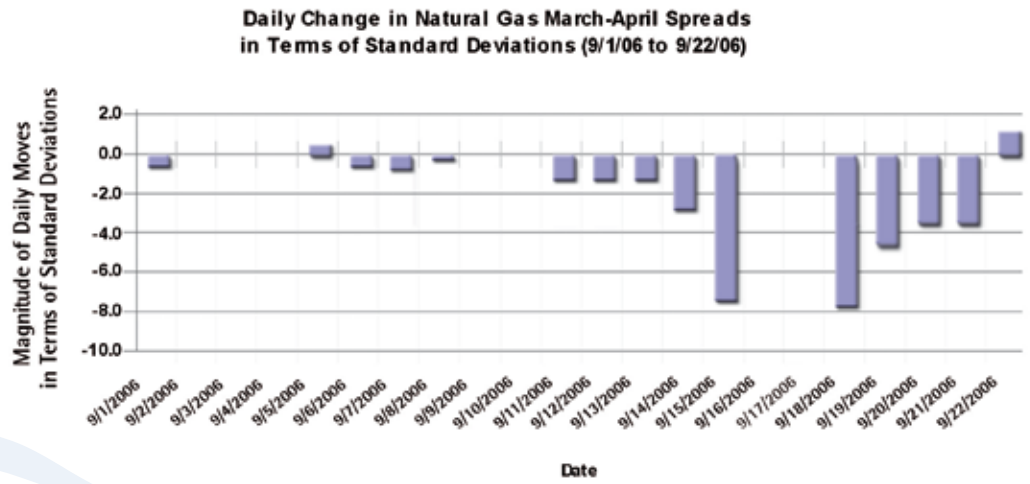


Figure A-3

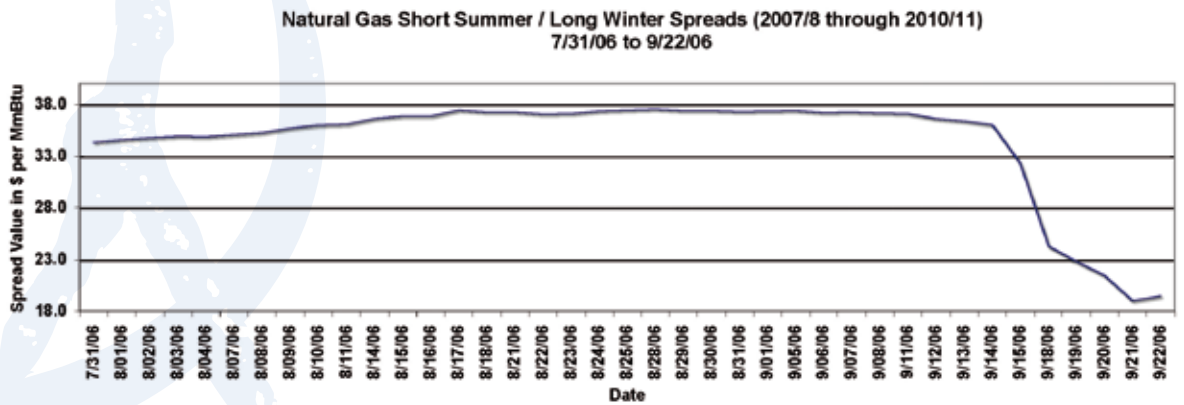
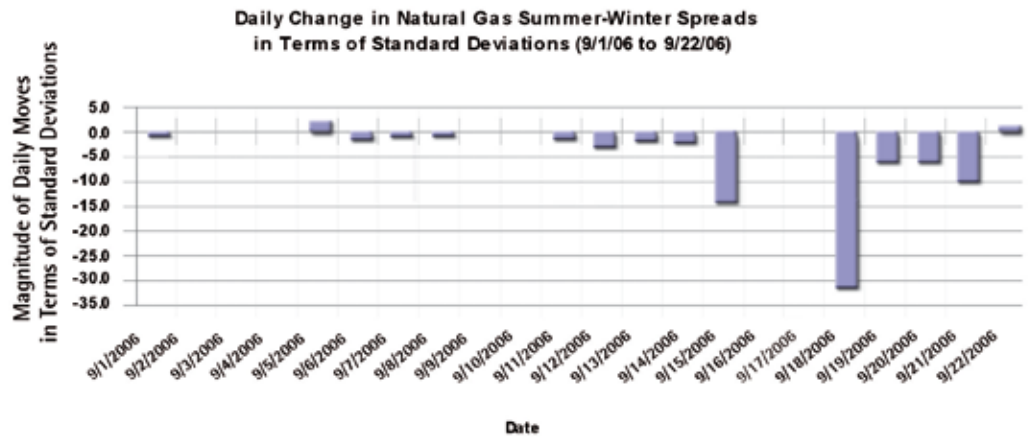


Figure A-4



Note: The spread combination's standard deviation was calculated from three months of daily data from 5/31/06 to 8/31/06.

Appendix A: Reverse-Engineering Amaranth's Natural Gas Positions

We cannot represent that Spread (1) and Spread (2) were Amaranth's actual positions, but given the magnitude of the moves illustrated in Figures A-1 through A-4, we can say that at the very least, their positions were likely highly correlated to those in this analysis.

Note particularly, Figures A-2 and A-4. If one used daily data from 5/31/06 to 8/31/06 to calculate the historical standard deviations of Spread (1) and Spread (2), the moves on 9/15/06 and 9/18/06 were massive in their magnitude. This is summarized in Figure A-5.

Figure A-5

Magnitude of Moves Based on Recent Three-Months of Data in Standard Deviations

	9/15/2006	9/18/2006
<u>Spread 1: Natural Gas March - April Spreads:</u>	-7.3	-7.9
<u>Spread 2: Natural Gas Summer - Winter Spreads:</u>	-14.5	-30.7

We can now infer the size of Amaranth's positions in Spreads (1) and (2) based on the gains and losses for the fund's energy book. Drawing from Burton and Strasburg (2006) and White (2006), (a) the fund lost -\$560 million on September 14th, and (b) lost about -35% during the week of September 11th. According to Trincal (2006), the fund had approximately \$9.2 billion in assets, as of the end of August. Therefore, the losses during the week of September 11th may have been about -\$3.2 billion.

Spread (1) declined -\$0.60 on 9/14/06, or -\$6,000 per spread combination. (The contract size for Natural Gas futures contracts on the New York Mercantile Exchange (NYMEX) is 10,000 MmBtu; we also say that the contract multiplier for this commodity is 10,000.) During the week of September 11th, this spread declined -\$3.065, or -\$30,650 per spread combination.

Spread (2) declined -\$0.372 on 9/14/06, or -\$3,720 per spread combination. During the week of September 11th, this spread declined -\$4.895, or -\$48,950 per spread combination.

We can solve for the sizing of the fund's spread positions because we now have two equations with two unknowns. Let n = the number of NYMEX-equivalent contracts for Spread (1); and let q = the number of NYMEX-equivalent contracts for Spread (2). Solve for n and q based on:

$$560 \text{ million} = (n * -6,000) + (q * -3,720);$$

and

$$3.2 \text{ billion} = (n * -30,650) + (q * -48,950).$$

$$n = 86,308 \text{ spreads};$$

and

$$q = 11,331 \text{ spreads}.$$

Appendix A: Reverse-Engineering Amaranth's Natural Gas Positions

Again, no representation is being made that these were the fund's actual positions. But these inferred positions are very consistent with the publicly known facts of this debacle.

We can double-check whether this position-sizing is consistent with other known facts about the fund's energy portfolio. The energy portfolio apparently made about \$1.3 billion from June through August. Would the position-sizing solved for above provide such trading gains?

The answer is approximately. This spread combination would have made \$1.2 billion from the end of May through the end of August. This is shown in Figure A-6. We would expect that the fund's positions were not static this summer, but given how close our derived portfolio's profits and losses (p/l) are to the fund's actual energy-book p/l, we may conclude that our derived positions are similar (or highly correlated) to what the fund's core energy positions were this summer.

Figure A-6

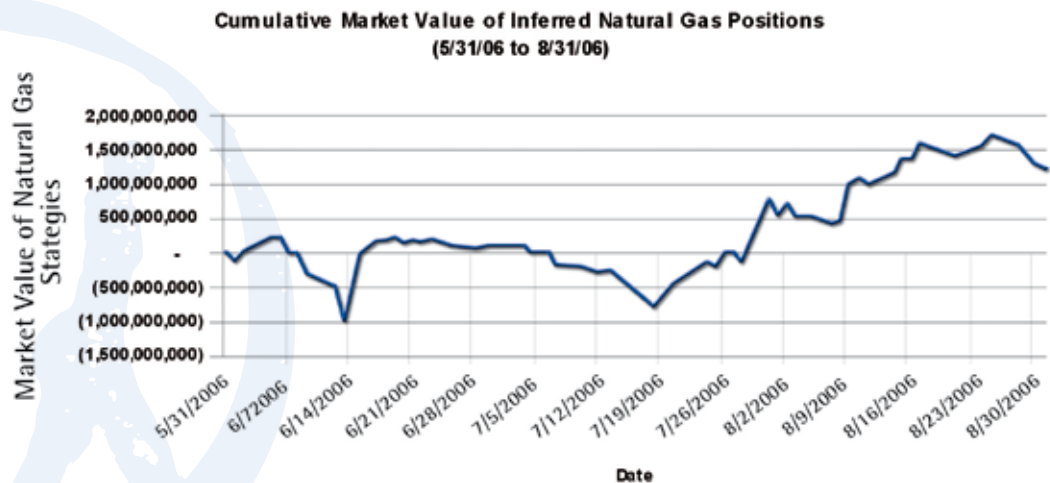
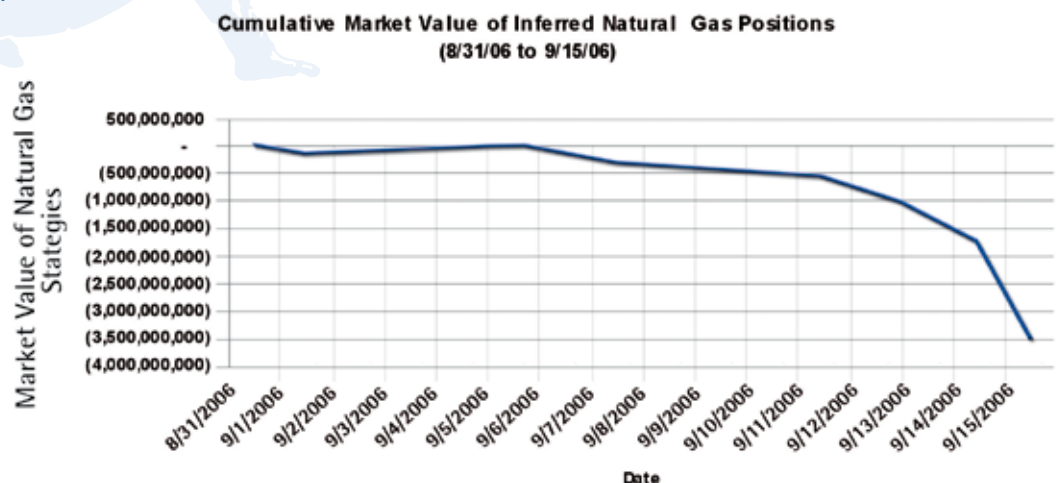


Figure A-7 shows how the inferred Natural Gas positions performed during the first two weeks of September.



Experienced Natural Gas participants will note that the magnitude of the inferred positions is greater than what would be expected from an examination of the futures open interest on the NYMEX. Write Chambers and Sweet (2006), "Amaranth's trades are thought to have involved

extensive over-the-counter bets ..." Goldstein (2006) adds that it is expected that Amaranth's over-the-counter Natural Gas trades were executed via the InterContinental Exchange (ICE). In other words, Amaranth's positions were not (entirely) accumulated via NYMEX futures positions.

Appendix B: Recent Volatility Analysis of Fund's Reverse-Engineered Positions

Appendix A attempts to reverse-engineer Amaranth's Natural Gas positions. We cannot say that we have identified their actual positions. Instead, we can say that at the very least, their positions were highly correlated to those in this analysis.

We can now attempt to come up with some explanations for how Amaranth and its risk

managers might have become so wrong-footed in evaluating the risk of their energy trading.

A simple Value-at-Risk / recent volatility analysis as of the end of August probably would have vastly underestimated the risk of their strategies during a liquidation-pressure event. Figure B-1 shows the daily P/L from 6/1/06 through 9/15/06 of the fund's inferred Natural Gas positions.

Figure B-1

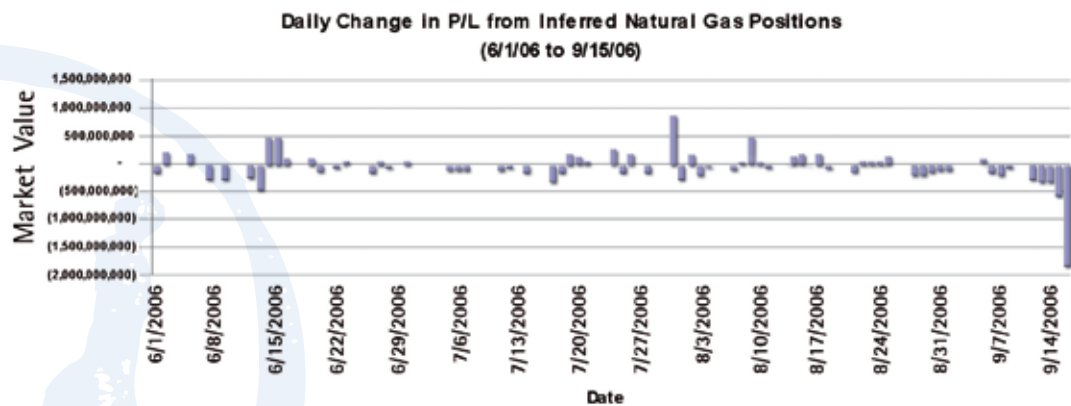
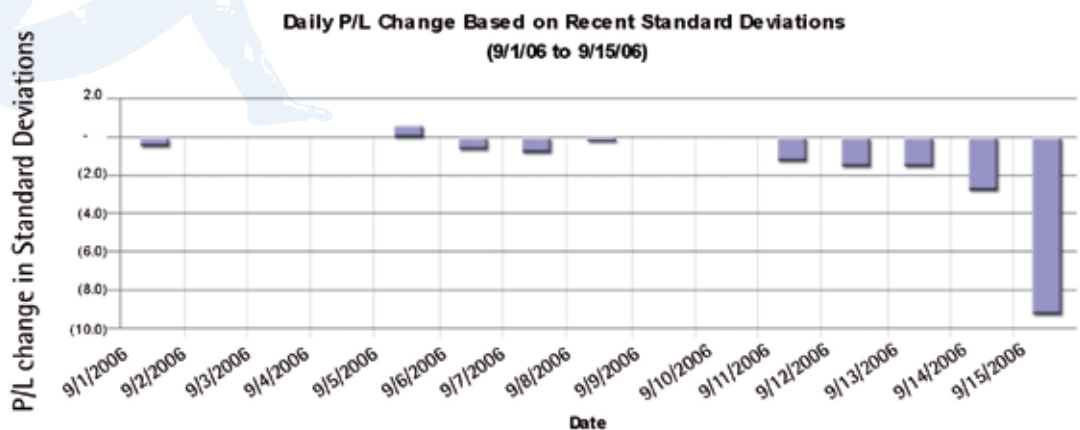


Figure B-2 shows the progression in the fund's p/l in standard-deviation terms, which reached an extreme on Friday, September 15th.



Note: The standard deviation of the inferred energy portfolio's p/l was calculated from three months of daily data from 5/31/06 to 8/31/06

As of the end of August, the fund's risk managers may have expected that a one standard-deviation move in the energy strategy's p/l was 2%. This translates into a monthly standard deviation

in p/l of 10%. Such a monthly volatility is consistent with the p/l swings reported by Davis (2006).

Appendix C: Background on the U.S. Natural Gas Market

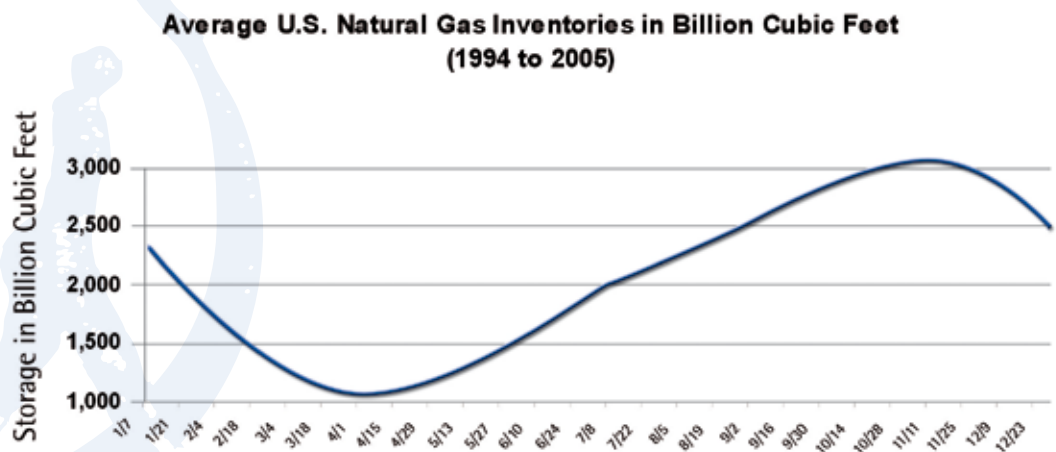
Natural Gas derivatives trading has offered hedge funds a potentially alluring combination of scalability and volatility, and also at times, pockets of predictability. Traders can access these markets through the transparent New York Mercantile Exchange (NYMEX) for exchanged-traded exposure, or they can do so through the opaque InterContinental Exchange (ICE) for over-the-counter exposure.

The key economic function for Natural Gas is to provide for heating demand during the winter in

the northern states of the United States. Natural gas is also a key energy source for air-conditioning demand during the summer.

There is a long "injection season" from the spring through the fall in which Natural Gas is injected and stored in caverns for later use during the long winter season.

Figure C-1 illustrates the normal seasonal pattern of builds and draws in Natural Gas throughout the year.



This graph specifically shows the U.S. Department of Energy's total estimated storage data for working natural gas inventories averaged over the period, 1994 to 2005.

Several technical points make Natural Gas an especially volatile commodity market:

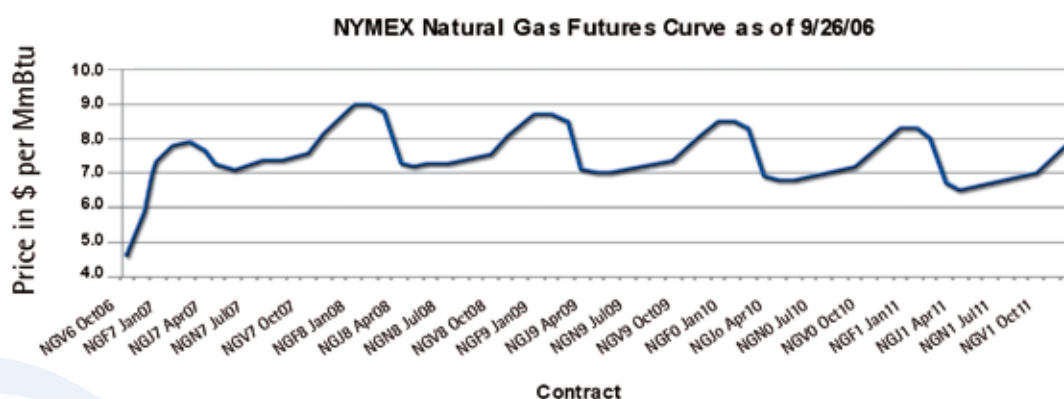
- Natural Gas production has not kept pace with increasing demand for this commodity;
- The U.S. Natural Gas markets are largely insulated, at least in the short-term, from global energy factors, since only a small amount of U.S. Natural Gas needs are met through imports of Liquid Natural Gas (LNG);
- There is insufficient storage capacity of Natural Gas to meet peak winter demand; and
- At the end of winter, inventories have to be cycled out of storage, regardless of price, in order to maintain the integrity of storage facilities.

In essence, the technical issues with Natural Gas mean that it is only a quasi-storable commodity.

This has a direct impact on the pricing relationships between different delivery months for Natural Gas.

In all commodity futures markets, there is a different price for a commodity, depending on when the commodity is to be delivered. For example, a futures contract whose delivery is in October will have a different price than a contract whose delivery is in December. Commodity traders will frequently specialize in understanding the factors that impact the spread between two delivery months; this is known as *calendar-spread* trading. In our example, a futures trader may trade the spread between the October vs. December futures contracts.

Figure C-2 shows the futures curve for Natural Gas as of 9/26/06. We refer to the term structure of a commodity futures market as a curve since each delivery-month contract is plotted on the x-axis with their respective prices on the y-axis; thus, a curve is traced out.



When the near-month futures contracts trade at a discount to further-delivery contracts, one says that the futures curve is in *contango*. When the near-month futures contracts instead trade at a premium to further-delivery contracts, one says the futures curve is in *backwardation*.

One can note that the yearly futures curves for Natural Gas in Figure C-2 mirror the average inventory build-and-draw pattern of Figure C-1. The prices of summer and fall futures contracts typically trade at a discount to the winter contracts. The markets thus provide a return for storing Natural Gas. An owner of a storage facility can buy summer Natural Gas and simultaneously sell winter Natural Gas via the futures markets. This difference will be the storage operator's return for storage. When the summer futures contract matures, the storage operator can take delivery of the physical Natural Gas, and inject this Natural Gas into storage. Later when the operator's winter futures contract matures, the operator can make delivery of the physical Natural Gas by drawing physical Natural Gas out of storage for this purpose. As long as the operator's financing and physical outlay costs are under the spread locked in through the futures market, then this operation will be profitable.

The example provided above is actually a simplified version of how storage operators can choose to monetize the value of their physical assets. Sophisticated storage operators actually value their storage facilities as an option on calendar-spreads. Storage is worth more if the calendar spreads in Natural Gas are volatile. As a calendar spread trades in steep contango, storage operators can buy the near-month contracts and sell the further-out month contracts, knowing that they can ultimately realize the value of this spread through storage. But a preferable scenario would be for the spread to then tighten, which means that they can trade out of the spread as a profit. Later if the spread trades in wide contango again, they can reinitiate a purchase of the near-month versus far-month Natural Gas spread. As long as the spread is volatile, the operator/trader can continually lock in profits, and if they cannot trade out of the spread at a profit, they can then take physical delivery and realize the value of their storage facility that way.

It is our expectation that both storage operators and Natural Gas producers were the ultimate counterparties to Amaranth's sizeable spread trading.

Why are Natural Gas spreads so volatile? It is only when a commodity is fully storable that commodity spreads can be predictably stable. In that case, the determining factor between the value of one contract versus a later-month contract is the cost of storing and financing the commodity from one period to the next.

With U.S. Natural Gas, storage capacity has actually declined since 1989. Further, domestic production has not kept pace with demand. These factors have caused massive volatility in the outright price of Natural Gas and in the price relationships between different sectors of the Natural Gas curve. To give one an idea of Natural Gas' volatility, as of 9/26/06, the implied volatility of one-month, at-the-money Natural Gas options is 92.5%. This is the case even though there are no hurricanes, heat-waves, or cold-shocks presently confronting this market.

The outright price of Natural Gas as well as the spread relationships in this market are highly sensitive to the prevailing storage situation for the commodity.

During the summer if there are hurricanes in the U.S., concerns emerge that not enough Natural Gas will be produced and stored for winter needs. In that scenario, the front-month contract's price has exploded to discourage

current demand, and the futures curve has traded in steeper contango to provide a further enhanced return for storage. This occurred in the aftermath of Hurricane Katrina in 2005.

At the start of the winter, if there are predictions of an exceptionally cold winter, the winter contracts trade at a large premium to spring contracts in order to encourage supplies to be brought out of storage immediately, and to discourage any non-essential use of Natural Gas. This occurred in December of 2005, even though storage at the start of the season was quite high.

At the end of the winter, if there is a cold shock and inventories are at their seasonal low, the end-of-winter contracts can also explode relative to later-month contracts in order to limit current use of Natural Gas to absolutely essential activities. This scenario occurred in the winter of 2002/3 and is illustrated in Figure C-3. Lammey (2005) quotes a futures trader regarding the extremely cold winter of 2002-3: "I remember that season well, because we started off the winter with intense cold, and ended the season late with intense cold – and many participants in the industry were seriously worried that there might not be enough gas to get us across the finish line."

Figure C-3 Panel A: February 2003's Near-Stock-Out Scenario

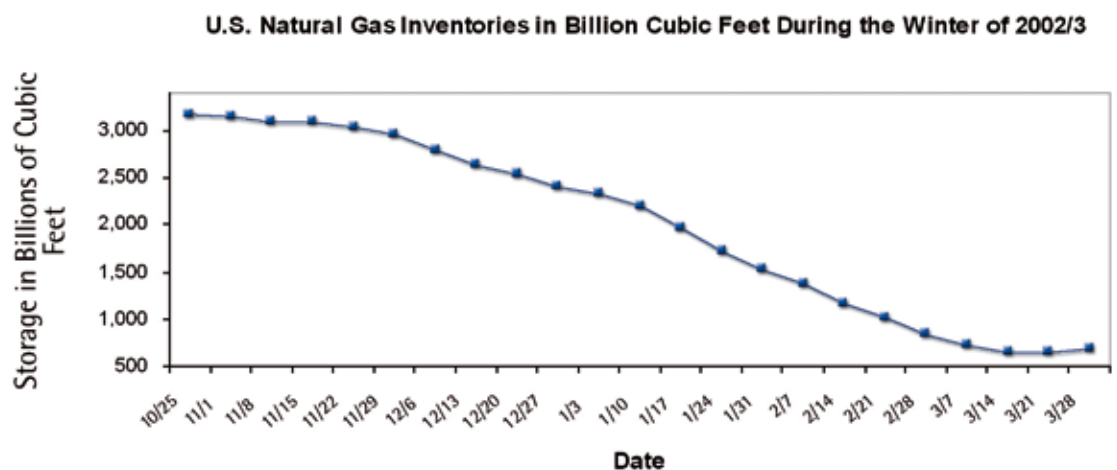
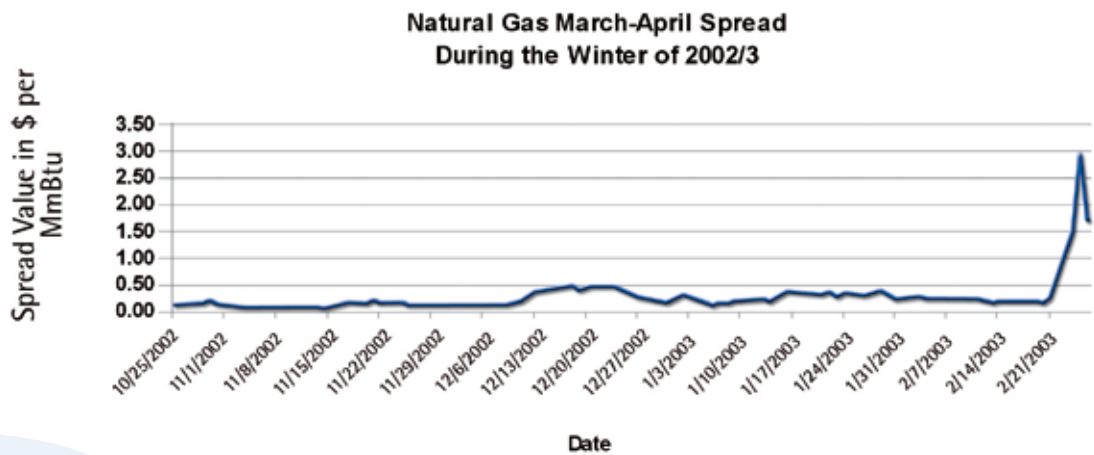


Figure C-3 Panel B



Instead, if the winter is unexpectedly mild, and there are still massive amounts of Natural Gas in storage, then the near-month price of Natural Gas plummets to encourage its current use and the curve trades in contango in order to provide a return to any storage operator who can still store gas. This occurred during the end of the winter in early 2006.

As one may surmise for the above scenarios, the U.S. Natural Gas markets provide many spreading

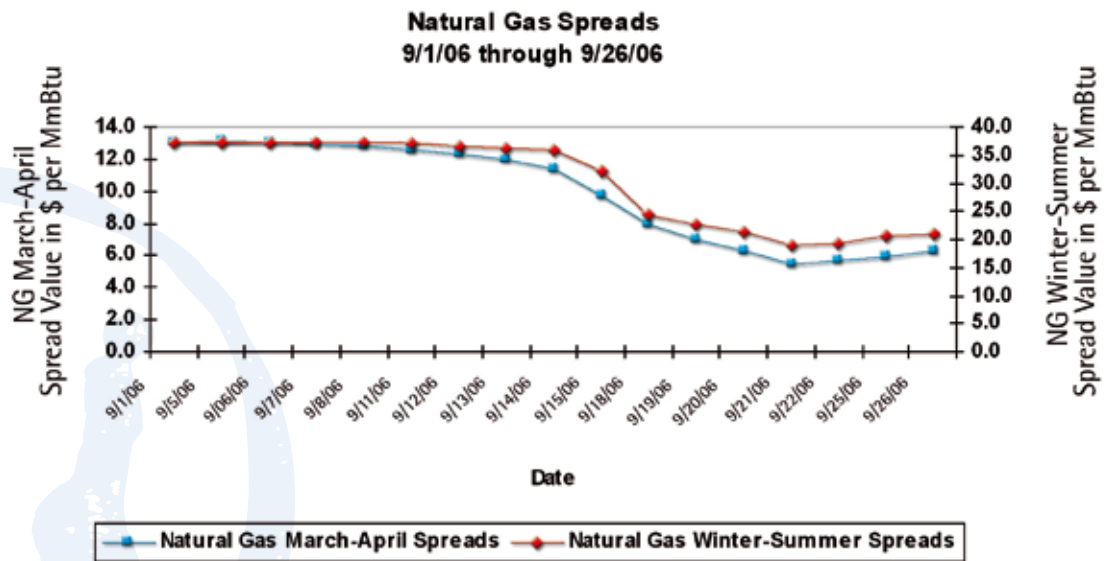
opportunities around seasonal inflection points for Natural Gas use. The summer/fall injection season creates opportunities in the summer/fall versus winter Natural Gas spread relationship. The end-of-winter period creates opportunities in the March-versus-April Natural Gas spread. As discussed in Appendix A: *Reverse-Engineering Amaranth's Natural Gas Positions*, it appears that Amaranth was precisely involved in these sorts of opportunities on a massive scale.

Appendix D: The Post-Liquidation Experience

The assumed Natural Gas positions in the Amaranth energy book are discussed in Appendix A: *Reverse-Engineering Amaranth's Natural Gas Positions*. We note that these positions appeared to have reached their trough on Thursday, 9/21/06, one

day after the announced transfer of Amaranth's energy book to two financial institutions. This is illustrated in Figure D-1. Since that time, the assumed Amaranth spreads have stabilized and slightly recovered (thus far.)

Figure D-1



EDHEC is one of the top five business schools in France owing to the high quality of its academic staff (100 permanent lecturers from France and abroad) and its privileged relationship with professionals that the school has been developing since its establishment in 1906. EDHEC Business School has decided to draw on its extensive knowledge of the professional environment and has therefore concentrated its research on themes that satisfy the needs of professionals.

EDHEC pursues an active research policy in the field of finance. Its **Risk and Asset Management Research Centre** carries out numerous research programs in the areas of asset allocation and risk management in both the traditional and alternative investment universes.

Copyright © 2006 Edhec

