Energy Trading and Risk Management

Certificate in Quantitative Finance Programme

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Notebook II

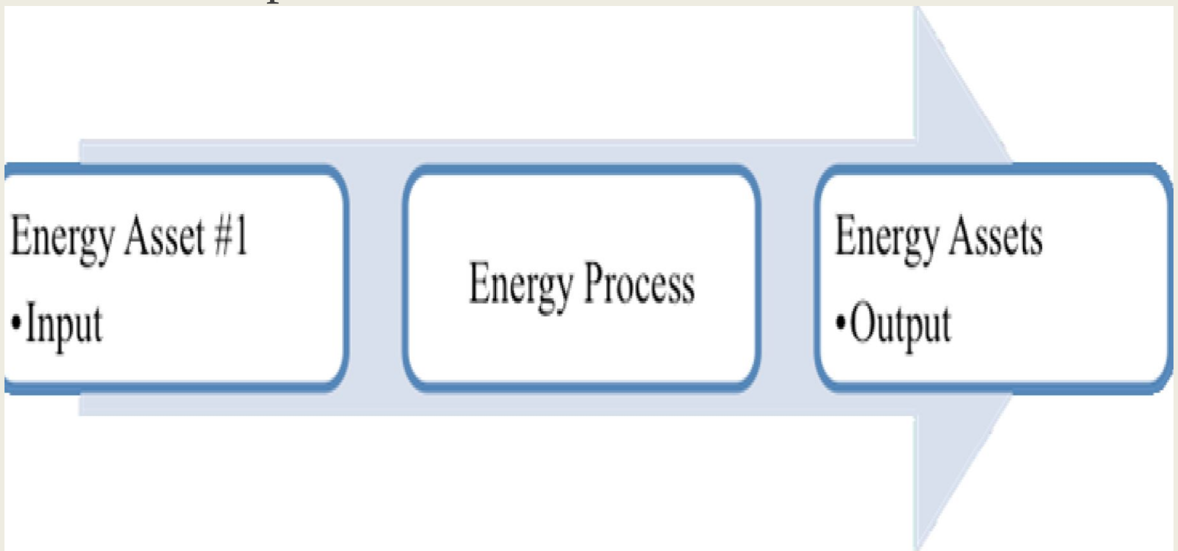
Inter-commodity Spreads in the Energy Markets

Inter-Commodity Spreads in the Energy Market

Energy producers are often concerned with the difference between the inputs and outputs of energy processes, rather than the level of these prices.

Example:

Oil refiners' profits are tied directly to the spread between the price of crude oil and the prices of refined products.



Inter-Commodity Spreads in the Energy Market

	Input	Output	Inter-commodity Spread
Crack Spread	Crude Oil	Refined Petroleum Products	Price of Refined Petroleum Products – Price of crude oil
Heat Spread	Crude Oil	No. 2 Heating Oil	Price of No 2 heating oil – Price of crude oil
Gasoline Spread	Crude Oil	Unleaded Gasoline	Price of unleaded gasoline – Price of crude oil
Resid Spread	Crude Oil	No. 6 Fuel Oil	Price of No 6 fuel oil – Price of crude oil
Frac Spread	Natural Gas	Gas Liquids	Price of gas liquids – Price of natural gas
Spark Spread	Natural Gas	Electricity	Price of electricity – Price of natural gas burned to generate electricity
Dark Spread	Coal	Electricity	Price of electricity – Price of coal used to generate electricity

Examples:

Use the TradeStation *Symbol Lookup* to observe the many inter-commodity spread products listed.

Note: As we will discuss when we get to the topic of *hedging*, one can also trade options on inter-commodity spreads.

Inter-Commodity Spreads in the Energy Market

The ***spark spread*** is the theoretical gross margin of a gas-fired power plant from selling a unit of electricity, having bought the fuel required to produce this unit of electricity.

All other costs (operation and maintenance, capital and other financial costs) must be covered from the spark spread.

Spark Spread

= Output price – Input price
= (Price of power) – (Price of fuel burned to generate power)
= (Electricity price - Gas price) / Power plant efficiency
= Price of Electricity - [(Cost of Gas) * (Heat Rate)]
= $/MWh - [($/MMBtu) * (MMBtu / MWh)]

The ***heat rate*** is a measure of the thermal efficiency of a power generating unit.

$$K_H = \text{Heat rate} = \frac{\text{Btu content of fuel consumed in power production}}{\text{KWh generation of facility}}$$

The spark spread can be used as a trading strategy based on the differences in the price of electricity and its cost of production.

Traders can profit from changes in the spark spread through OTC trading in electricity contracts.

The spark spread is sometimes referred to as a ***paper plant***.

Inter-Commodity Spreads in the Energy Market

- The spark spread helps utilities determine their bottom lines.

- If the spark spread is small on a particular day, electricity production might be delayed until a more profitable spread arises.

Spark spread > 0

Utility makes money

Spark spread <= 0

Utility loses money

Energy Trading & Risk Management with MATLAB

An electricity portfolio can include

- *Financial contracts*
- *Fuel sources for power generation*
- *Technology for power generation*
- *Power contracts for delivery*
- *Power contracts for purchase*
- …

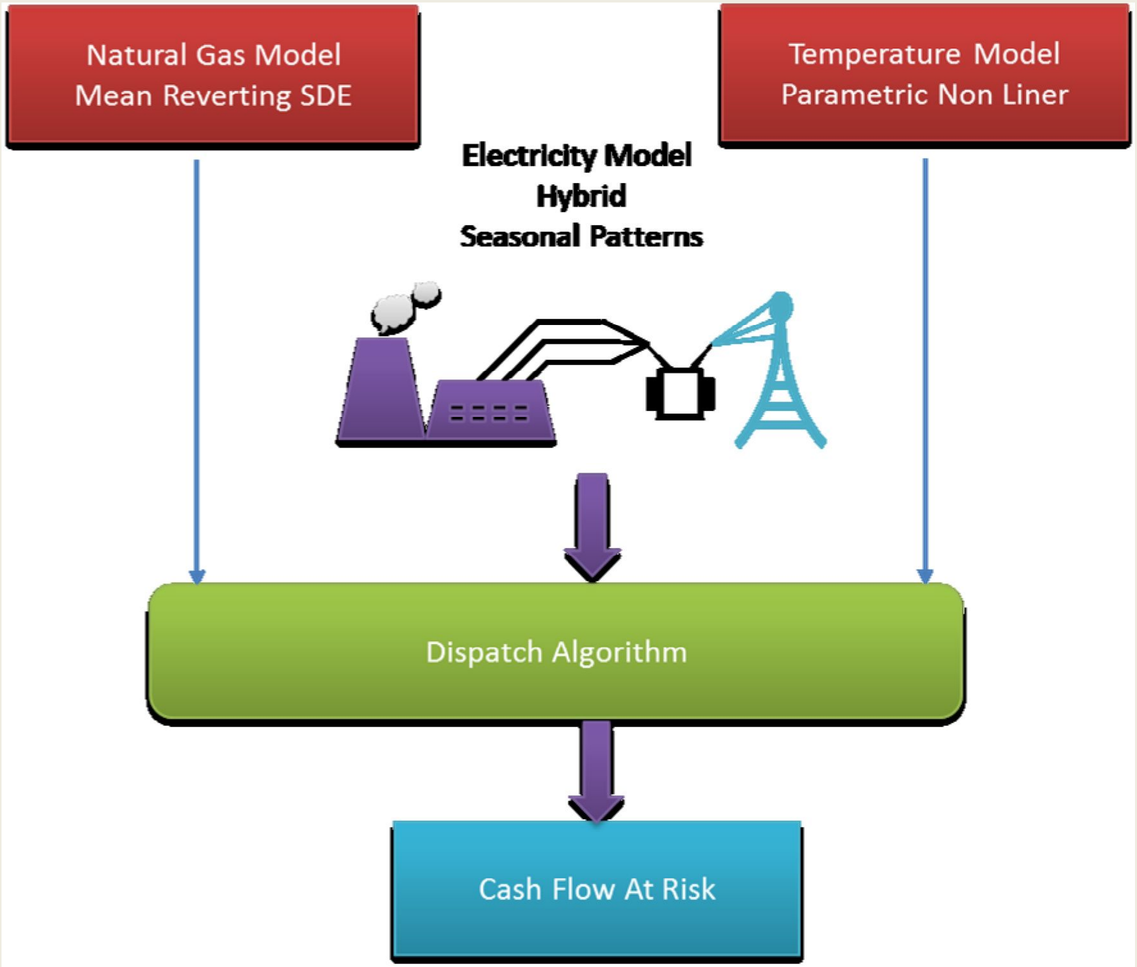
In this case study you will learn how MATLAB can be used to streamline the development of energy trading and risk management applications from inception to deployment.

This webinar presents an example of computing cash-flow-at-risk and expected profit from operating a portfolio of gas-fired power plants.

Highlights of this MATLAB Case Study:

- Model and simulate natural gas prices, temperature, electricity prices
- Calculate optimal dispatch
- Compute cash-flow-at-risk for a portfolio of gas-fired power plants
- Deploy an energy trading application as an Excel add-in
- Energy Data Sources

Energy Case Study: Energy Trading & Risk Management with MATLAB



- Suppose a power generator has a certain number of generating units online.

- The ***economic load dispatch (ELD)*** *problem* involves finding the optimal allocation of power generation that minimizes the total generating cost while simultaneously satisfying the total required demand.

Objective Function for ELD Electricity Portfolio optimization:

$$C = \sum_i \left(a_i + b_i P_i + c_i P_i^2 \right)$$

where

C = Cost function for each generator

a_i, b_i, c_i denote the cost coefficients of the ith generator

P_i = Power generated from the ith generator

Constraints for ELD Electricity Portfolio Optimization:

$$D + L = \sum_i P_i \quad \left(\text{Power Balance Equation}\right)$$

$$P_{i,\min} \le P_i \le P_{i,\max}$$

where

$D =$ the total load

$L = \sum_i \sum_i a_{ij} P_i P_j$ denotes the transmission loss

a_{ij} denotes the transmission loss coefficient

$P_{i,\min}$ denotes the minimum generation power

$P_{i,\max}$ denotes the maximum generation power

Definitions of terms used in this energy case study:

Dry-bulb Temperature:

The ***dry-bulb temperature*** is the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture.

Dry bulb temperature is the temperature that is usually thought of as air temperature, and it is the true thermodynamic temperature. It is the temperature measured by a regular thermometer exposed to the airstream.

Unlike ***wet bulb temperature***, dry bulb temperature does not indicate the amount of moisture in the air.

Disclaimer

- Mathwork has granted permission to use this case study in this lecture.
- More details on this case study may be found in Chapter 8 of the textbook.
- The techniques and methods described in this case study illustrate best practices.
- References for this MATLAB case study are as follows:
  - http://www.mathworks.com/videos/energy-trading-risk-management-with-matlab-81745.html?form_seq=conf1050&confirmation_page&wfsid=5647097
  - http://www.mathworks.com/company/events/webinars/wbnr50145.html?id=50145&p1=789805758&p2=789805770

Crude Oil Benchmarks

Crude Oil Benchmarks

- *Brent*
- *WTI*
- *Asian*
- *Importance of Brent and WTI to Futures Market*
- *China's new oil contract signals shift from Brent and US dollar (aka petrodollar)*

Crude Oil Benchmarks

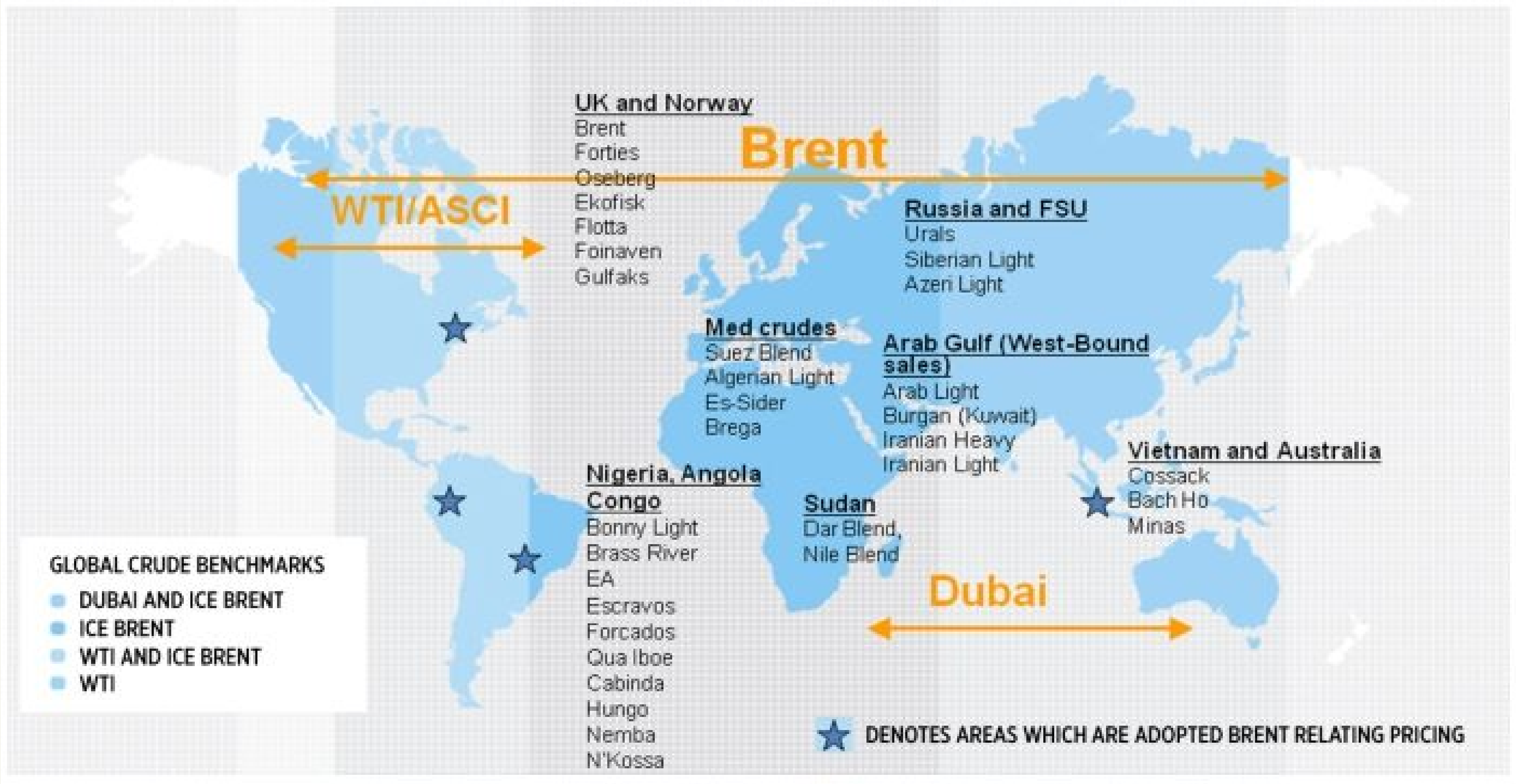
As indicated in the next slide, there are many different grades of physical crude oil.

Two most popular traded grades of crude oil:

- ❖ *Brent*
- ❖ *West Texas Intermediate (WTI)*

http://www.investopedia.com/articles/investing/102314/understanding-benchmark-oils-brent-blend-wti-and-dubai.asp

Crude Oil Benchmarks



"ASCI" = Argus Sour Crude Index

http://www.cmegroup.com/trading/energy/crude-oil/argus-sour-crude-index-asci-vs-wti-diff-spread-trade-month-swap-futures_contract_specifications.html

http://www.investopedia.com/articles/investing/102314/understanding-benchmark-oils-brent-blend-wti-and-dubai.asp

Brent

Brent Crude Oil refers to oil that is produced from 4 oilfields in the North Sea: *Brent, Forties, Oseberg, Ekofisk*

http://en.wikipedia.org/wiki/Brent_Crude#mediaviewer/File:Brent_crude_oil_map.png

Brent

Brent Crude is a major trading classification of *sweet light* crude oil that serves as a major benchmark price for purchases of oil worldwide.

Key characteristics of Brent:

- *Light* - relatively low density
- *Sweet* - low sulfur content (~0.37%)
- The lower the sulfur content, the easier and cheaper Brent is to refine into gasoline, diesel fuel, ...
- *Water-borne*: Relatively easier to transport to distant locations.
- ~2/3 of all crude contracts around the world reference Brent Blend

WTI

West Texas Intermediate (WTI) (aka ***Texas light sweet***) is a grade of crude oil used as the benchmark crude for North America.

WTI refers to oil extracted from wells in the U.S. and sent via pipeline to Cushing, Oklahoma.

http://blogs.ft.com/energy-source/2009/02/13/wti-woes-what-will-nymex-do/
http://www.sec.gov/Archives/edgar/data/1510295/000119312513461395/d635310dex991.htm

WTI

Key characteristics of WTI

- *Sweeter than Brent* (less sulfur)
- *Lighter than Brent* (lower density)
- Better grade of oil for the production of gasoline
- *Land-locked*: One of the drawbacks to WTI crude – it's relatively expensive to ship to certain parts of the globe.
- Main benchmark for oil consumed in the U.S.

Asian Crude Benchmarks

Many Asian countries use a combination of Brent and WTI benchmarks to price their crude oil.

Importance of Brent & WTI to the Futures Market

There was a time when buyers would primarily purchase crude oil on the ***spot market*** – i.e., pay the current price and accept delivery within a few weeks.

After the oil crisis of the late 1970s, refiners and government buyers began looking for a way to minimize the risk of sudden price increases.

Importance of Brent & WTI to the Futures Market

The solution came in the form of the crude oil futures, which are tied to a specific benchmark crude.

With futures, buyers can lock in the price of a crude oil for several months, or even years, in advance.

Importance of Brent & WTI to the Futures Market

Buyers and traders of crude oil need an easy way to value the commodity based on its quality and location.

Benchmarks such as Brent and WTI serve this important purpose.

When refiners purchase a WTI futures contract, they have a good idea of how good the oil will be and where it will come from.

Importance of Brent & WTI to the Futures Market

Brent futures contracts are traded on the Intercontinental Exchange, Inc. (ICE) Futures Europe - https://www.theice.com/futures-europe

WTI contracts futures are traded chiefly on the New York Mercantile Exchange (NYMEX) – a commodity futures exchange owned by the CME Group.

China's new oil contract signals shift from Brent and US dollar

China intends to oust dollar from oil trade (video)
http://www.wilmott.com/blogs/irismack/index.cfm/2015/9/8/China-Intends-to-Oust-Dollar-from-Oil-Trade

❖New Chinese oil contract will challenge the dollar's dominance as the primary currency for trading commodities.

❖ Brent crude has been the global benchmark against which most oil is measured ever since the field from which it draws its name was discovered in the 1970s.

❖ Brent's role as the preferred global benchmark is soon to be challenged by a new Chinese futures contract.

❖ China is thought to be "plotting" the downfall of Brent and its US cousin, West Texas Intermediate (WTI), as the world's second largest economy seeks to gain more control over the pricing of its main source of energy.

❖ **China's planned crude oil futures could become global benchmark: Expert**

http://globalenergypost.com/?s=china%27s+futures
https://www.indiegogo.com/projects/mathqed-math-help-for-all/x/3935134#/
http://globalenergypost.com/?s=china+dollar

China's new oil contract signals shift from Brent and US dollar

❖ Unlike Brent and WTI, the new contract will be priced in China's yuan instead of US dollars.

❖Shanghai International Energy Exchange sent a draft futures contract to market players in August (Reuters).

❖ Oil futures will be the first Chinese contract to permit direct participation of foreign investors.

❖However, this is not the first step for greater oil market openness in China.

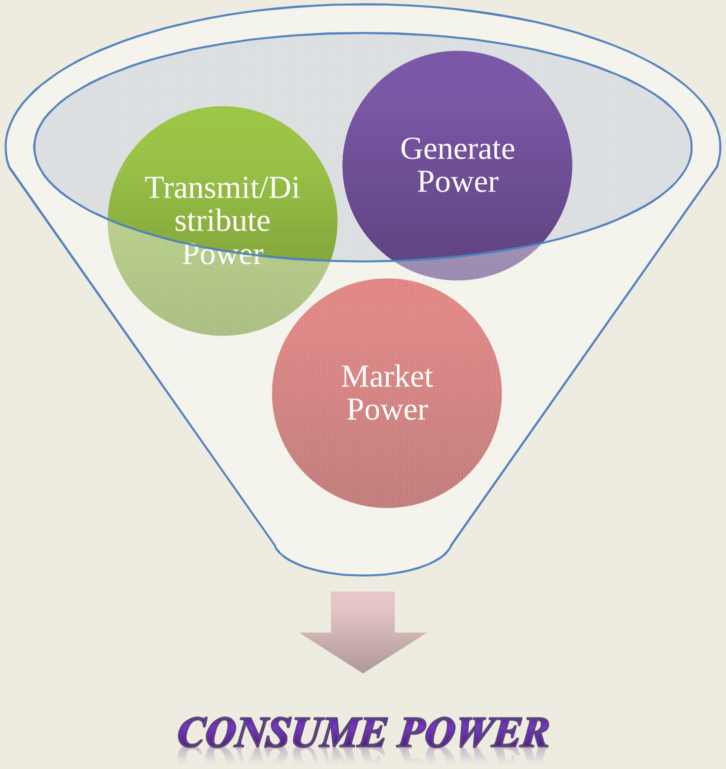
❖ In July, Beijing allowed private companies to import crude.

❖Previously importing was only done by state-run majors such as Sinopec, China National Petroleum Corporation and China National Offshore Oil Corporation (Xinhua news).

Risk Management

Electricity Markets Participants' Risk Exposure

Participants in the electricity markets perform one or more of the following functions:



Energy Markets Participants ' Risk Exposure

Some potential risks faced by participants in the energy markets are:

- "Acts of God" (earthquakes, fire, blizzards,…)risks
- Basis risks
- Budgeting/financial risks
- Business continuity/IT security risks
- Capacity
- Compliance breaches
- Consumption risks
- Corporate risks
- Correlation risks
- Counterparty risks
- Credit risks
- Data risks
- Delivery
- Fuel prices
- Generation risks
- Geopolitical risks
- Governance
- Hazard or insurable risks
- Interest rate risks
- Legal risks
- Liquidity risks
- Management risks
- Market risks
- Operational risks
- Price volatility
- Privacy risks
- Quantitative modeling risks
- Regulatory risks
- Reputation risks
- Safety
- Storage
- Strategic risks
- Trading risks
- Transmission/distribution risks
- Vendor risks
- Others (Environmental, Operations, Human Resource, Physical, Infrastructure)

An "optimal" risk management practice identifies risks pertaining to these categories.

Electricity Markets Participants' Risk Exposure

Market Participant	Risk Exposure	Power Position
Generators	▪ Generators include utilities, federal power authorities, qualifying facilities (small power production and cogeneration facilities), merchant power plants, and on-site industrial plants. ▪ These entities own a power plant. Hence, they have a "long" electricity position. ▪ When power prices increase (decrease), the value of the generator increases (decreases).	***Long***
Marketers	▪ Marketers buy and resell power. ▪ A marketer can have either a "long" or "short" position. Marketers that buy (sell) fixed-price power before finding a market for that power have a "long" ("short") position. ▪ *San Diego Gas & Electric* and *Portland General Electric* are examples of utilities that also serve as marketers. Each of these utilities has greater load than generating resources. Hence, they buy power in the wholesale market and resell it at the retail level. Their obligation to serve retail loads give them a "short" position, since they must buy power in the wholesale markets in order to meet their obligations to customers. ▪ *Enron* was initially a power generator that evolved into a marketer. Jeff Skilling and several other executives decided it was a great idea for Enron to become asset-lite and eventually asset-free.	***Long or Short***
End Users	▪ End users may be industrial, commercial, or residential customers. ▪ An electricity end user has a "short" position. Consumers benefit when prices decrease and are hurt when prices increase.	***Short***

FERC* =: Federal Energy Regulatory Commission

Price Volatility in Electricity Markets

Price Volatility in Electricity Markets

- Electricity generation costs and demand fluctuations are translated into ***price volatility***.
- ***Energy derivatives*** are utilized by market participants to manage price volatility.
- Daily fluctuations in electricity prices are the most dramatic manifestation of price volatility.
- Customers on real-time rates can face prices that may fluctuate by more than 100% over several hours.
- These fluctuations don't constitute a serious risk because
  - It's easy for customers to time average on a daily basis.
  - The amount of money spent on energy in one day is relatively small.
- Hence, energy derivatives aren't typically designed to mitigate risks associated with daily price fluctuations.

Price Volatility in Electricity Markets

Price volatility alone does not create serious risk.

But firms can face significant risks in its financial operations.

Volatile input Price	Fixed Output Price

Price Volatility in Electricity Markets Examples

Example: 1. Marketer's Volatile Input/Fixed Output Price Risks

- Suppose a marketer buys power from generators in a spot market and sells power through fixed price contracts.
- The marketer's markup is likely to be small (e.g., less than 10% above the spot price)
- Most of the markup goes towards marketing and overhead cost - leaving only a small profit.
- If the spot price jumps 25% in a given year due to a supply shortage, the marketer could lose several years worth of profits.
- This is an unacceptable risk, and the marketer would be interested in hedging it.

Example: 2. Utility's Volatile Input/Fixed Output Price Risks

- Suppose an electric utility has more load than generation capabilities.

- So the utility needs to purchase power in the spot market.

- The utility may encounter price volatility risks if it is under a price-cap regulation or unable to pass costs on to customers.

Price Volatility in Electricity Markets Examples

Example: 3. Generator's Volatile Input/Fixed Output Price Risks

- Generators may encounter price volatility risks if they sell in a market dominated by generation from another fuel.

- Suppose a generator's fuel costs increases more than the fuel costs of other types of generation.

- Hence it is likely that spot power prices will not completely cover their increased fuel prices and their profits will suffer.

Factors That Cause Electricity Production Costs to Fluctuate

Cause of Fluctuation	Relevant Time Period	Role of Energy Derivatives
Demand	***Daily, Seasonal***	▪ Energy derivatives aren't typically used to hedge risks associated with daily price fluctuations. ▪ They're used to hedge risks associated with seasonal price fluctuations.
Generation Availability	***Daily, Yearly***	▪ A source of cost fluctuation is a function of available generation – e.g., 1. inexpensive hydro power (if there is plentiful rainfall) 2. fossil plants 3. … ▪ Derivatives play a useful role in hedging fluctuations associated with generation.
Fuel Cost	***Seasonal and longer***	▪ Perhaps the most important source of electricity price volatility is that of the cost of fuel. ▪ Fuel cost is affected by seasonality, geo-political events and changes in global market conditions. ▪ Derivatives play a useful role in hedging fluctuations associated with fuel cost.
Other Production Costs	***Years to Decades***	▪ Sources of cost fluctuations are changes in the production technology. Technological progress reduces the cost of production. ▪ Production costs may also be affected by environmental and labor costs. ▪ These cost fluctuations may be very important over the life of multi-year contracts, but are generally beyond the time scope of hedging strategies based on energy derivatives.

Exercises: How to Hedge Using Futures Contracts

Hedging Exercises from the following perspectives

1. Generator
2. Consumer
3. Marketer

Hedging

A ***hedge*** is an investment that reduces the risk of adverse price movements in an asset.

- Normally, a hedge consists of taking an offsetting position in a related security.
- Energy market participants use hedging strategies to deal with market uncertainties.
- There are differing opinions on why, how, and when companies should hedge?
- A few consistent themes have emerged like fixed-price swaps and/or costless collars to hedge.

1. How Generators Use Futures to Hedge

How Generators Use Futures to Hedge

Example

Example

A generator expects to sell electricity into the spot market in 6 months.

The generator's cost of production = $20/MWh.

The current electricity spot price = $20/MWh.

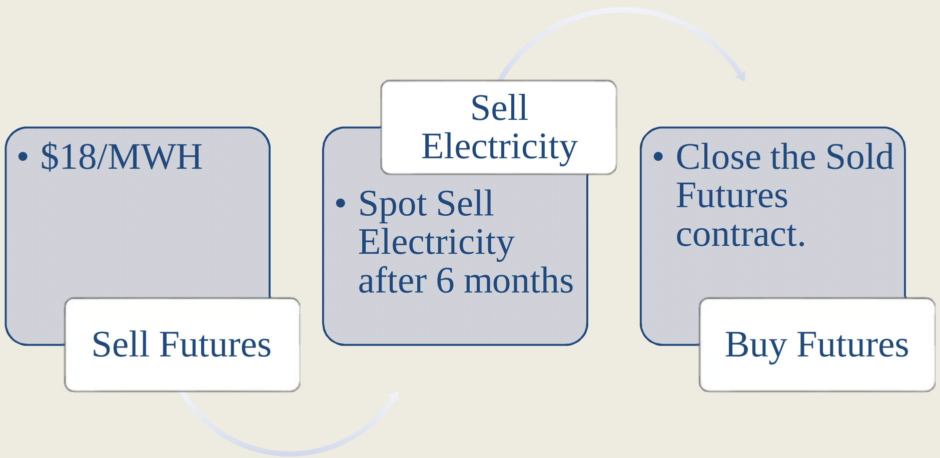
The futures price for delivery in 6 months = $18/MWh.

Since the generator is long electricity, it will break even if the spot price remains constant.

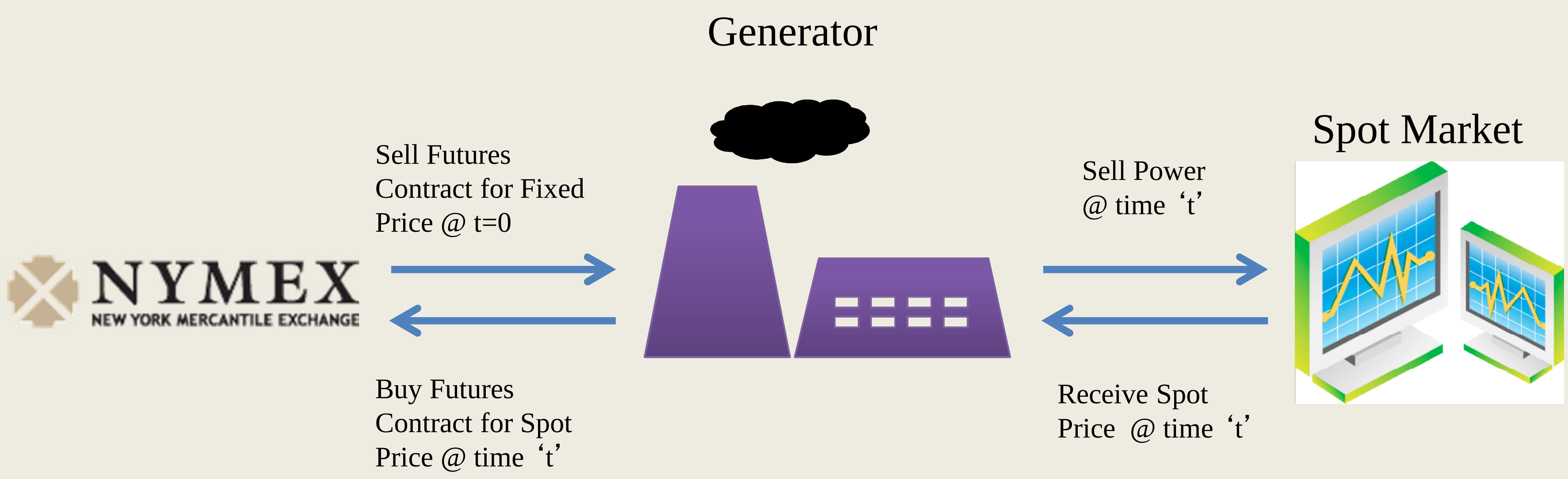
Make money if the spot price increases	Lose money if the spot price falls

How Generators Use Futures to Hedge

- To mitigate this price risk, the generator could sell futures contracts for \$18/MWh.
- In 6 months, the generator would then sell electricity for the spot price and buy futures contracts to close out its financial position.
- We have assumed that the futures price converges to the spot price as the delivery date approaches and equals the spot price when the position is closed.
- In this case, the generator would be perfectly hedged.



How Generators Use Futures to Hedge



How Generators Use Futures to Hedge

Spot Price	↑ $30/MWh	↓ $10/MWh
	Generator	
	Receives $30/MWh for its electricity	Receives $10/MWh for its electricity
	Pays $30/MWh to close out its futures positions.	Pays $10/MWh to close out its futures positions.
	Receives $18/MWh for its original futures positions.	Receives $18/MWh for its original futures positions.

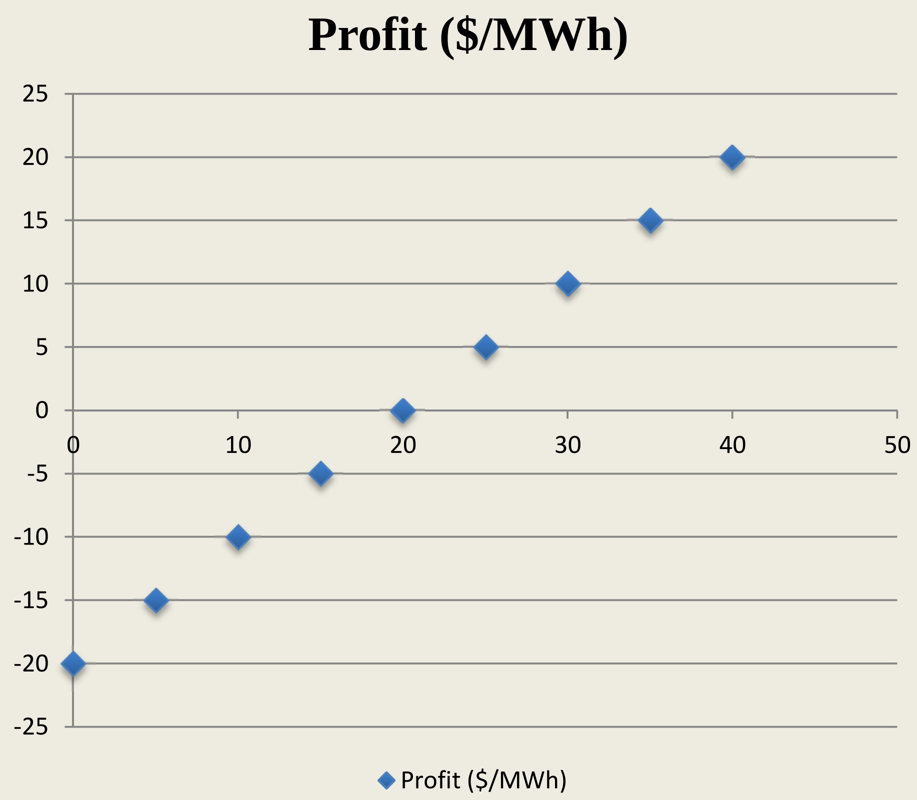
In both instances, the generator ultimately receives $18/MWh for delivering electricity and is unaffected by price changes and, therefore, price risk.

How Generators Use Futures to Hedge

This payoff diagram illustrates the potential profits and losses associated with the **generator's physical position.**

If the spot price in 6 months falls to \$10/MWh, the generator would lose \$10/MWh because its production costs (\$20/MWh) would exceed its payment (\$10/MWh).

But if the spot price rises to \$30/MWh, the generators would make \$10/MWh.

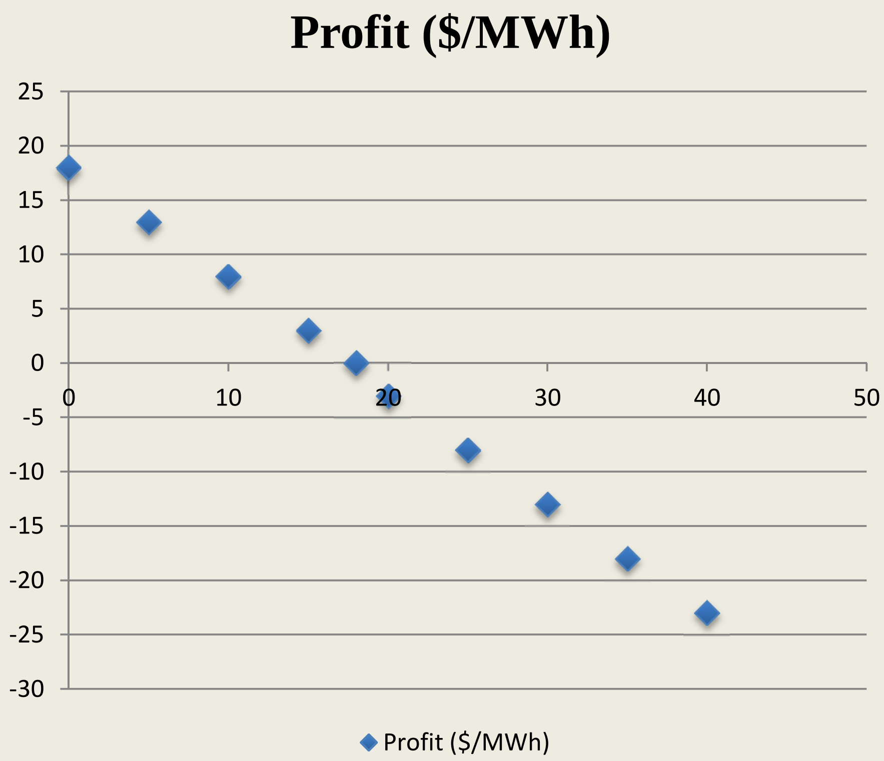


How Generators Use Futures to Hedge

This payoff diagram illustrates the potential profits and losses associated with the **generator's financial position.**

If the spot price in 6 months falls to $10/MWh, the generator would profit by $8/MWh because it sold futures contracts for $18/MWh, but to close out this position, it bought futures contracts for $10/MWh.

If the spot prices rises to $30/MWh, by contrast, the generator would lose $12/MWh ($18/MWh - $30/MWh).

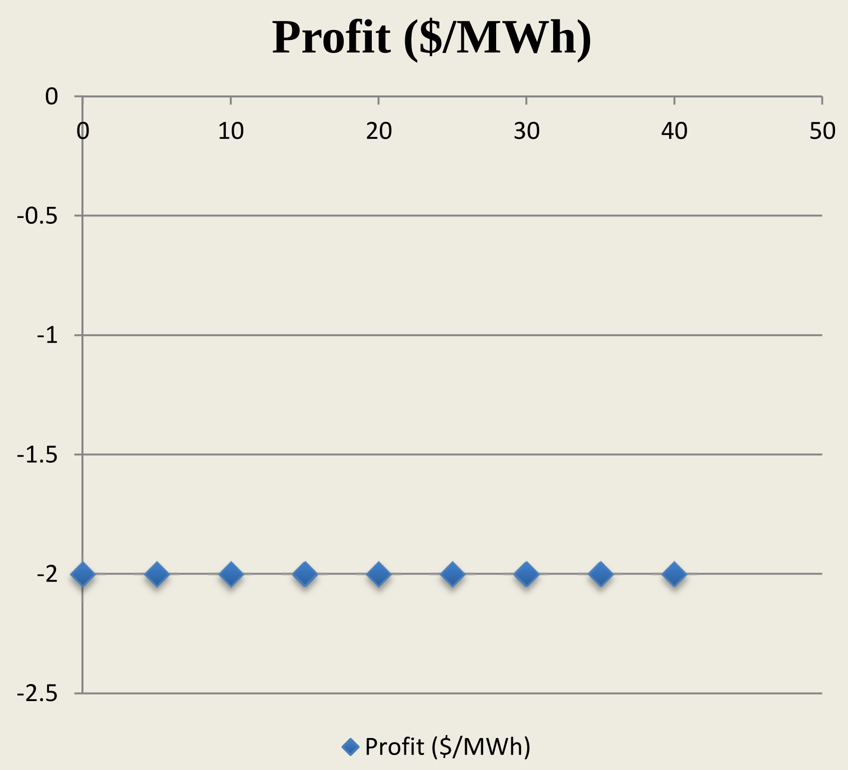


How Generators Use Futures to Hedge

This payoff diagram illustrates the potential profits and losses associated with the **generator's hedged position.**

At each spot market price, the hedged profit is the sum of profits from the physical and futures position.

By hedging, the generator has locked in an electricity price of $18/MWh and a loss of $2/MWh.



Risks Associated with Hedging

- The futures price does not converge to the spot price on the delivery date.
- The monthly futures does not match the daily spot market (i.e., the generator would be hedging daily price risk using a monthly instrument).
- The generator miscalculated and had less (or more) electricity than initially anticipated.

2. How *End Users* Use Futures to Hedge

How *End Users* Use Futures to Hedge

Example

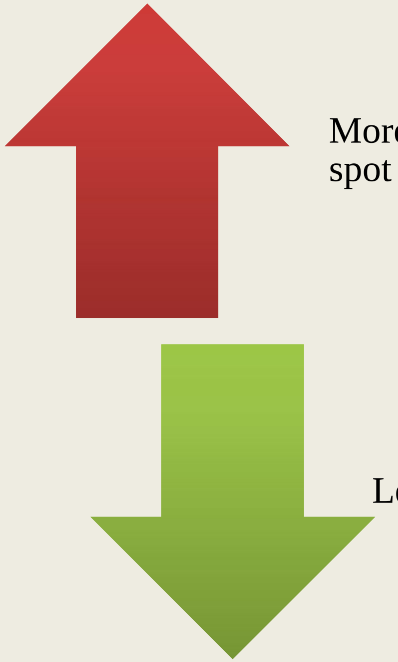
The end user is short electricity. It pays

An end user/consumer (e.g., a large manufacturer) anticipates needing electricity in 6 months.

The end user intends to buy the electricity in the spot market at that time.

The current electricity spot price = $20/MWh.

The futures price for delivery in 6 months = $18/MWh.



More for electricity if the spot price increases

Less if the spot price decreases

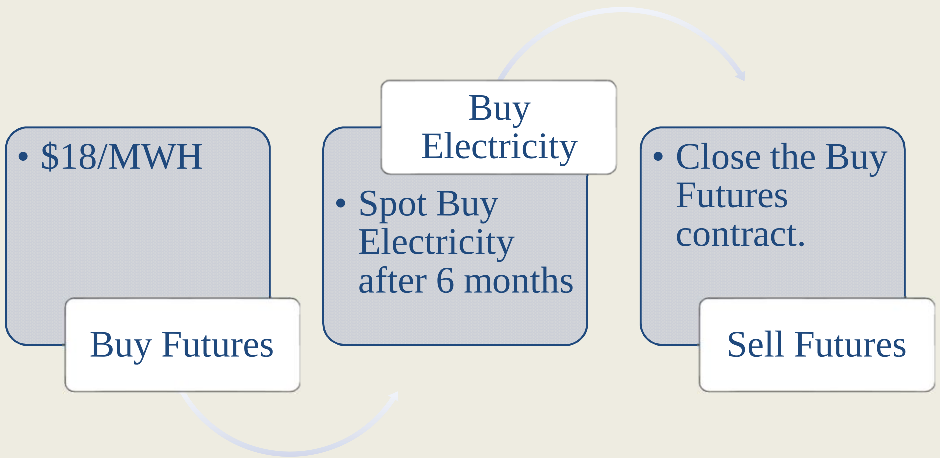
How End Users Utilize Futures to Hedge

- To mitigate this price risk, the end user could buy futures contracts for $18/MWh to lock in electricity prices.

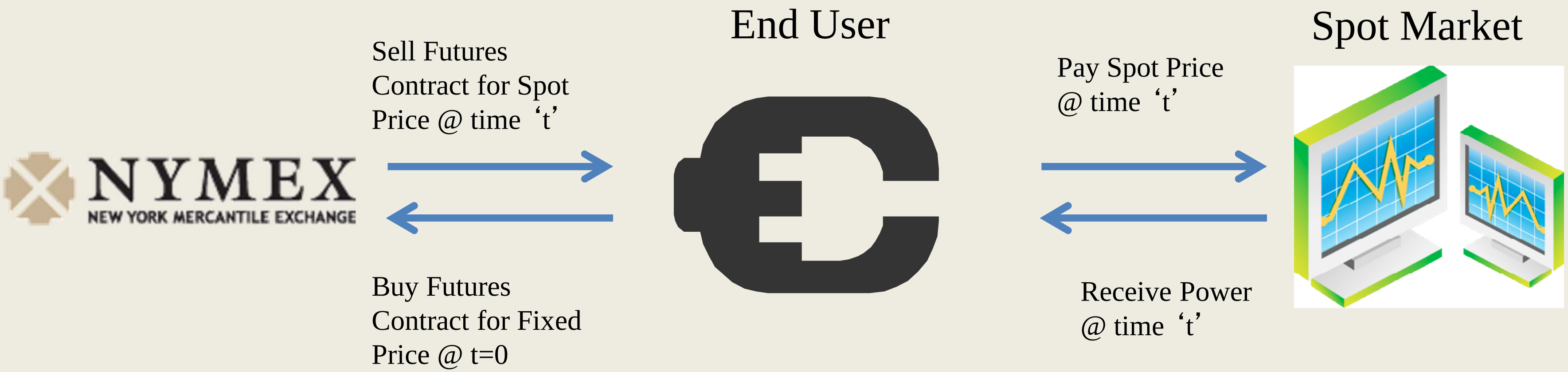
- In 6 months, the end user would then buy electricity for the spot price and sell futures contracts to close out its financial position.

- For purposes of this example, we have assumed that the futures price converges to the spot price as the delivery date approaches and equals the spot price when the position is closed.

- In this case, the end user would be perfectly hedged.



How End Users Utilize Futures to Hedge



How End Users Utilize Futures to Hedge

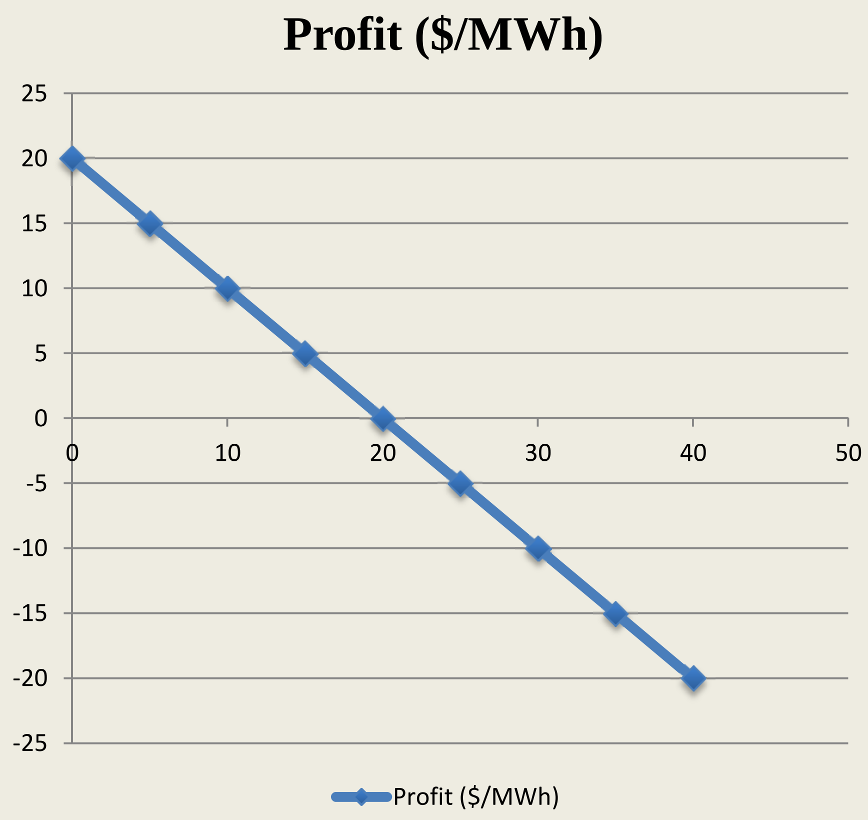
Spot Price	↑ $30/MWh	↓ $10/MWh
	End User	
	Pays $30/MWh for its electricity	Pays $10/MWh for its electricity
	Receives $30/MWh to close out its futures positions.	Receives $10/MWh to close out its futures positions.
	Pays $18/MWh for its original futures positions.	Pays $18/MWh for its original futures positions.

In both instances, the end user ultimately pays $18/MWh for purchasing electricity and is unaffected by price changes and, therefore, price risk.

How End Users Utilize Futures to Hedge

This payoff diagram illustrates the potential profits and losses associated with the **end user's physical position.**

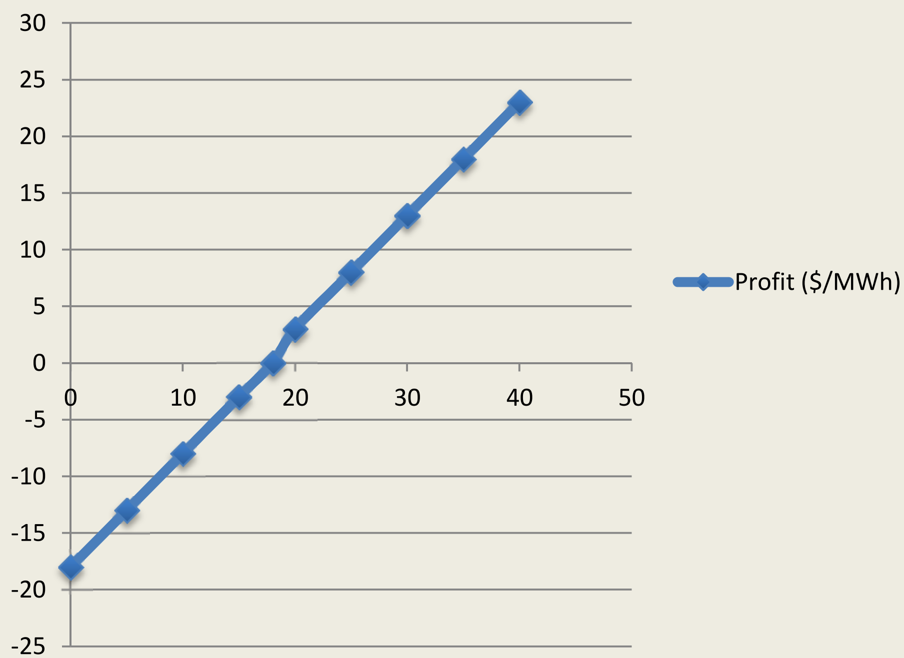
We assume that the end user has fixed output prices and can pass on only $20/MWh to its customers.



How End Users Utilize Futures to Hedge

Profit ($/MWh)

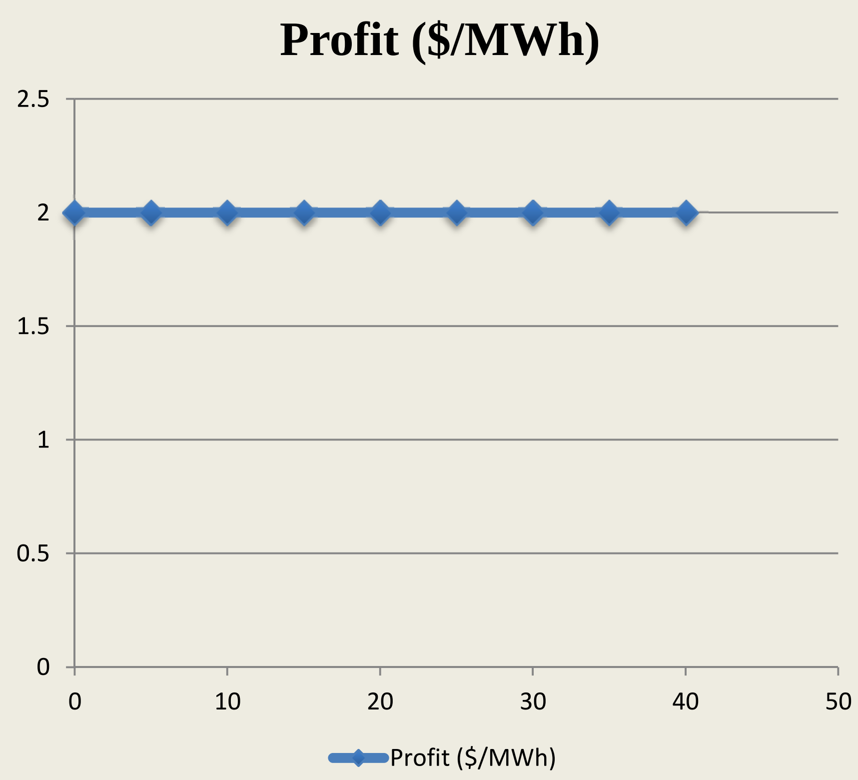
This payoff diagram illustrates the potential profits and losses associated with the **end user's financial position.**



How End Users Utilize Futures to Hedge

This payoff diagram illustrates the potential profits and losses associated with the **end user's hedged position** if the spot price in 6 months falls to zero or increases to $40/MWh.

If the end user locks in a price of $18/MWh and is able to pass on electricity prices of $20/MWh, it stands to make a profit of $2/MWh.



How End Users Utilize Futures to Hedge

- If the spot price converges to the futures price, the end user will be perfectly hedged and unaffected by price changes.

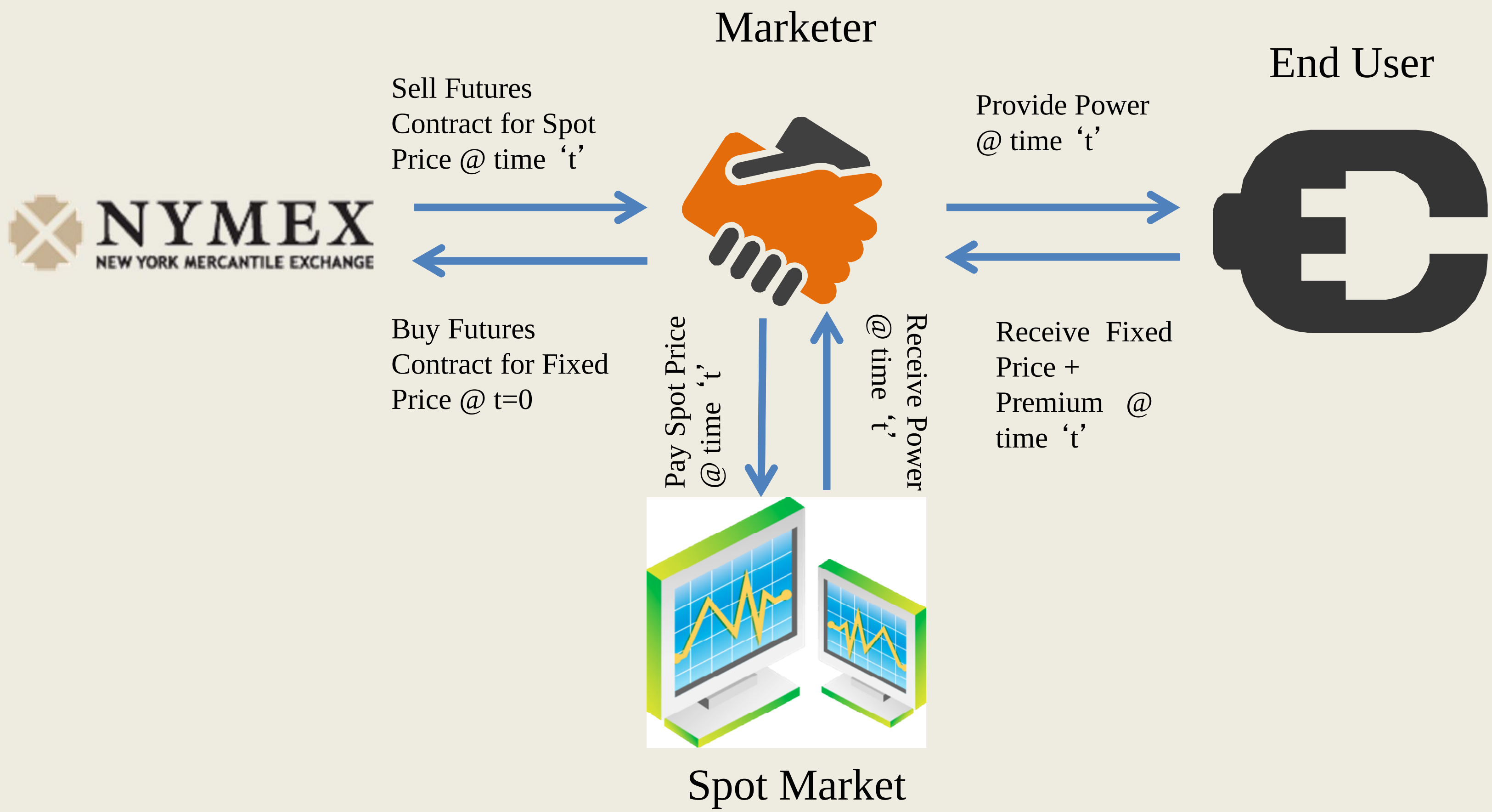
- This is because the gains (losses) in the physical market are exactly offset by the losses (gains) in the financial market.

- The risks associated with hedging for the end user are similar to those faced by the generator.

3. How Marketers Use Futures to Hedge

How Marketers Use Futures to Hedge

Marketer's Long Hedge



How Marketers Use Futures to Hedge

Marketer's Long Hedge

Assume that a marketer has guaranteed customers that it will deliver electricity to them in 6 months.

.

The marketer can buy futures contracts for $18/MWh and sell electricity to the end-user for a small mark-up, say $18.10/MWh.

If the spot price rises to $30/MWh in 6 months, the marketer would buy electricity in the spot market for $30/MWh and deliver it to the customers for $18.10 (for a loss of $11.90 on the physical transaction).

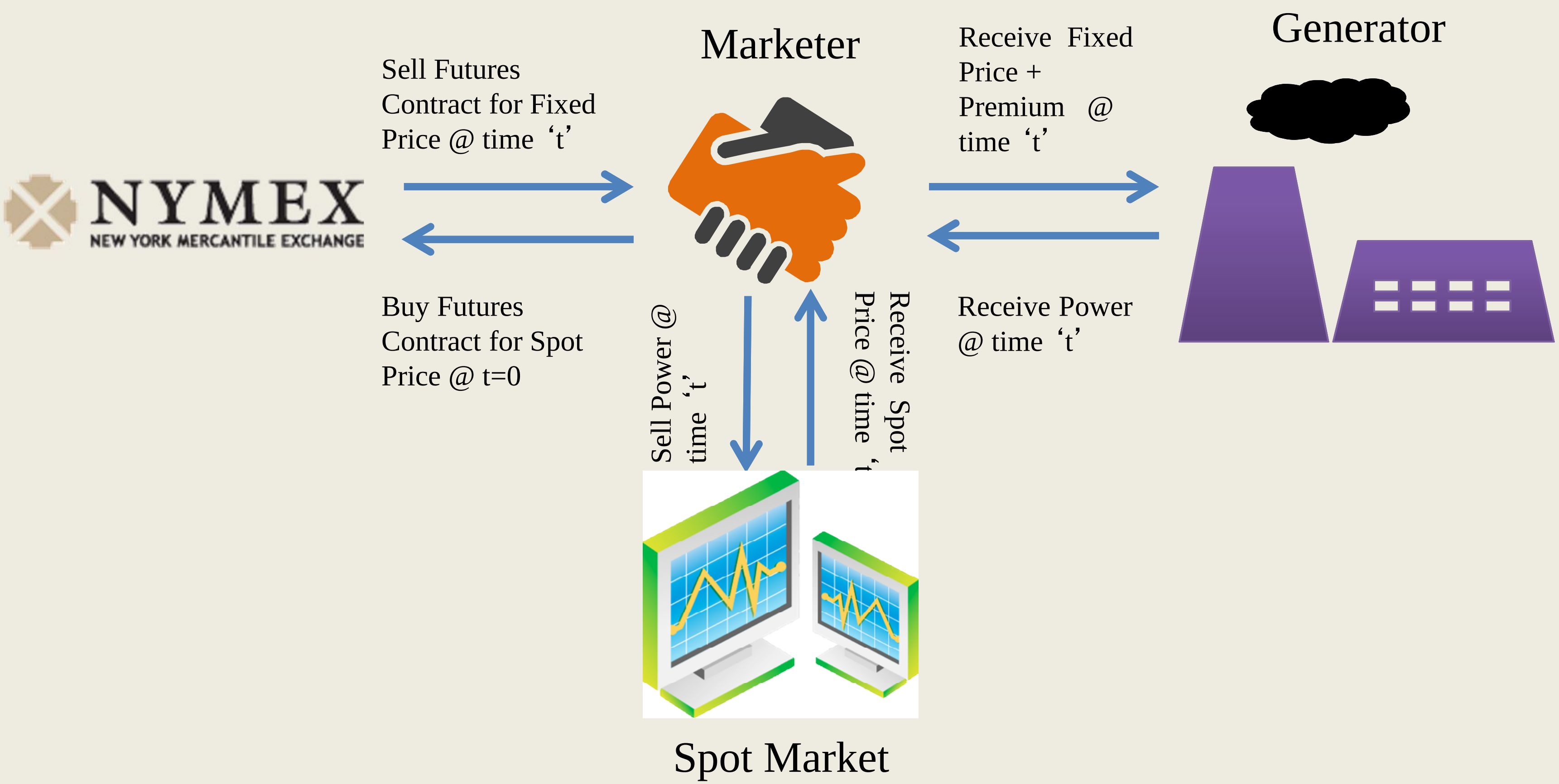
Simultaneously, the marketer can close out its futures position by selling futures contracts for $30/MWh (for a gain of $12/MWh over the original purchase price of $18/MWh).

This transaction guarantees the end user fixed price power at $18.10/MWh.

In addition, if the spot price converges to the futures price, this transaction guarantees the marketer a profit of $0.10/MWh

How Marketers Use Futures to Hedge

Marketer's Short Hedge



How Marketers Use Futures to Hedge

Marketer's Short Hedge

Assume that a marketer has agreed to buy electricity from a generator in 6 months.

The marketer can buy electricity for \$17.90/MWh and sell electricity futures for delivery in 6 months for \$18, thus locking in the fixed price and a profit.

In six months, if the spot price has increased to \$30/MWh, the marketer would pay the generator \$17.90/MWh for the power, sell the power on the spot market for \$30/MWh, making \$12.10/MWh on the physical transaction.

At the same time, the marketer can close out its futures position by buying futures contracts for \$30/MWh, thus losing \$12/MWh on its financial position.

The combined physical and financial positions leave the marketer with a profit of \$0.10/MWh.

Risks Associated With Hedging With Futures Contracts

Risks Associated With Hedging With Futures Contracts

Basis risk **is the primary risk associated with using futures contracts to hedge commodity risks.**

Basis is the difference between the futures price and the spot price of the commodity being hedged.

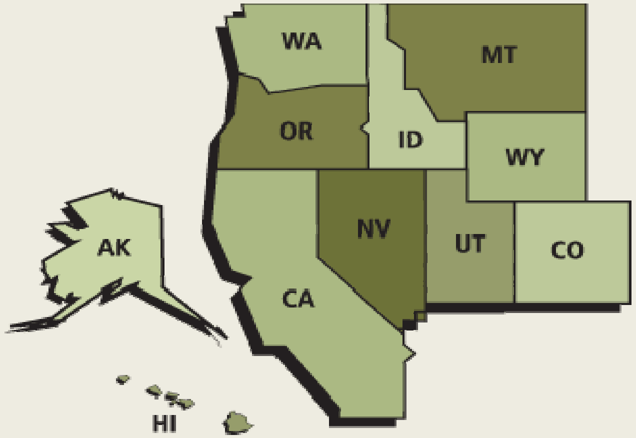
Basis risk is the risk that offsetting investments in hedging strategies will not experience price changes in entirely opposite directions from each other.

Risks Associated With Hedging With Futures Contracts

One type of basis risk occurs because of **location-specific factors**

- Pipeline constraints
- Differences in transportation costs
- Differences in transmission costs

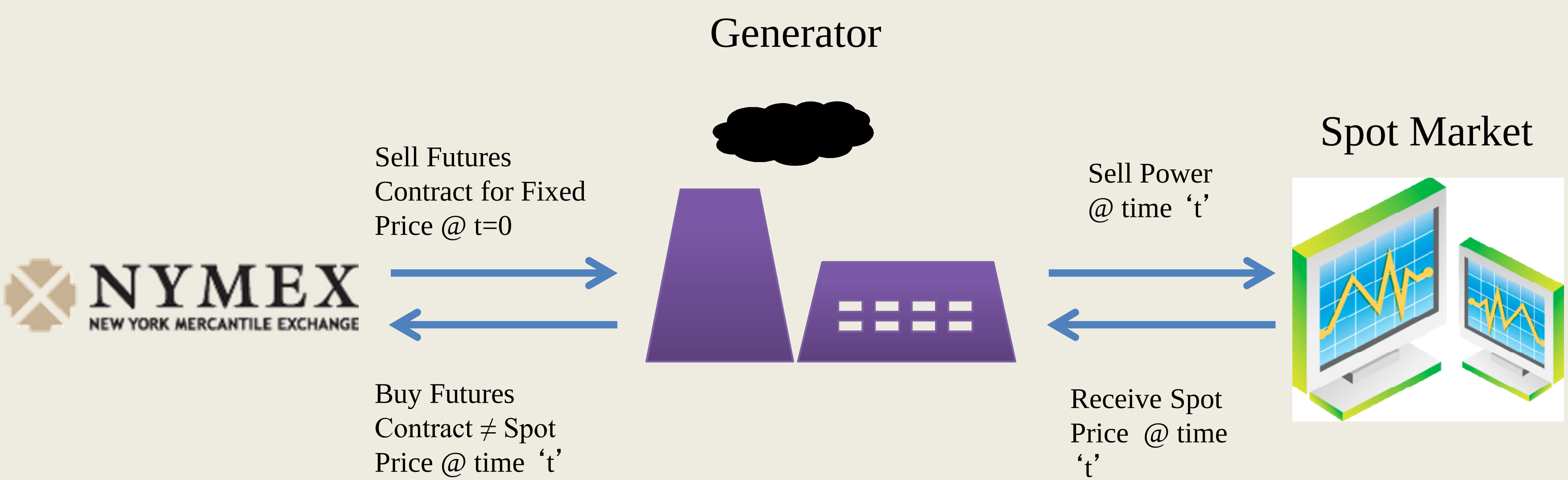
The price of electricity in Denver, Colorado is not likely to be the same as the price at the California-Oregon Border (COB) – even though they're all part of NERC's WECC region. Hence using a futures contract for the COB may not perfectly hedge price risk in Denver.



NERC =: N. American Electric Reliability Corporation
WECC =: Western Electric Coordinating Council

Risks Associated With Hedging With Futures Contracts

Spot Price Doesn't Equal Futures Contract Price



Risks Associated With Hedging With Futures Contracts

Other risks associated with using futures contracts to hedge commodity risks:

The procedures for determining the optimal hedge size are specific and well defined. However, the correlation is an important quantity in the valuation. Eydeland (2003)
The futures contract commodity might be different from the spot price commodity (i.e., product quality or definition). This could be a problem if the spot market sells electricity on a daily rather than a monthly basis because futures contracts call for delivery over an entire month.
The generator, end user, or marketer miscalculates the amount of energy to generate or consume.

Long-Term Hedging via "Stack and Roll"

Long-Term Hedging via "Stack and Roll"

The ***stack and roll*** method is used to hedge a long term physical position with short term futures contracts.

Metallgesellschaft Case: *Stack and Roll* Hedging Disaster

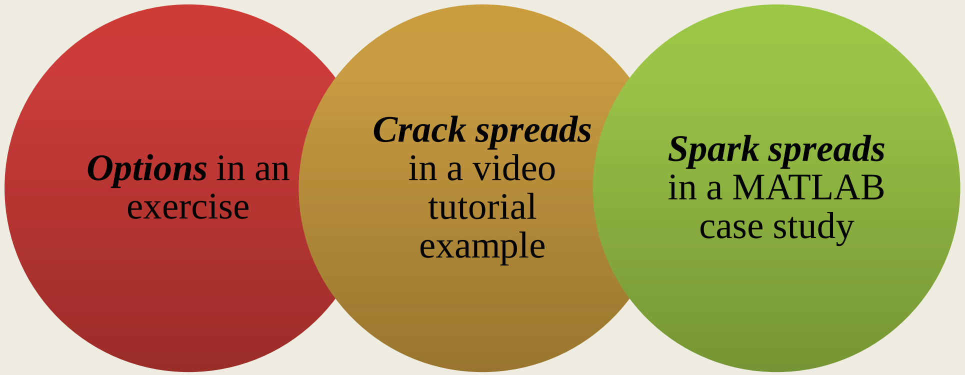
At MG, the underlying's were short positions in long-term forward contracts to deliver oil. A *stack and roll* hedge was utilized: long positions in short-term futures contracts that were rolled over consecutively. The strategy depended on

- Continuation of stable or gently increasing spot oil prices
- Backwardation (Notebook 1)
- **http://www.youtube.com/watch?v=bBuF4RGJKDk**

Hedging With Other Types of Derivatives

Hedging With Other Types of Derivatives

In the next slide you can find a list of other types of derivatives that are commonly used in energy markets. I introduce some of these other hedging strategies with



In addition, I discuss many more of these derivatives hedging strategies in my book:

Energy Trading and Risk Management: A Practical Approach to Hedging, Trading, and Portfolio Diversification

http://www.amazon.com/Energy-Trading-Risk-Management-Diversification/dp/1118339339/ref=tmm_hrd_title_0?ie=UTF8&qid=1398773658&sr=8-1

Hedging With Other Types of Derivatives

- European Options
- American Options
- Asian Options
- Fixed Strike Asian Call Options
- Average Price Options
- Swing Options
- Barrier Options
- Digital Options
- Exotic Options
- Swaps
  - Price Swaps
  - Basis Swaps
- Swaptions
- Refineries as Real Options

Hedging with different types of derivatives

- Multi-asset Options
- Compound Options
  - Baskets
  - Best-of
  - Worst-of
  - Spread Options
    - Spark Spreads
    - Crack Spreads
    - Basis Spreads
    - Natural Gas Transportation as a Locational Spread
    - Generation Assets as Strips of Spark Spreads
    - Natural Gas Storage as a Basket of Calendar Spreads
- Weather Derivatives

Hedging With Electricity Options

- In 1996, NYMEX introduced options for electricity.

- Generators and end users can use combinations of calls and puts to ensure a particular price range.

Put Option

The buyer of an electricity put option ("floors") pays a premium for the right, but not the obligation, to sell electricity at a specified price, the strike or exercise price, at a specified point in time.

Call Option

End users utilize call options ("caps") to place a maximum ceiling price (relative to an indexed price) that they will pay for electricity at a specified point in time.

The **TradeStation options symbols** consist of

- An underlying symbol root
- Followed by a 2-digit expiration year
- Followed by a 2-digit expiration month
- Followed by a 2-digit expiration day
- Followed by one character (either C or P) indicating the option type (Call or Put)
- Followed by the strike price
- Followed by an optional regional exchange designation.

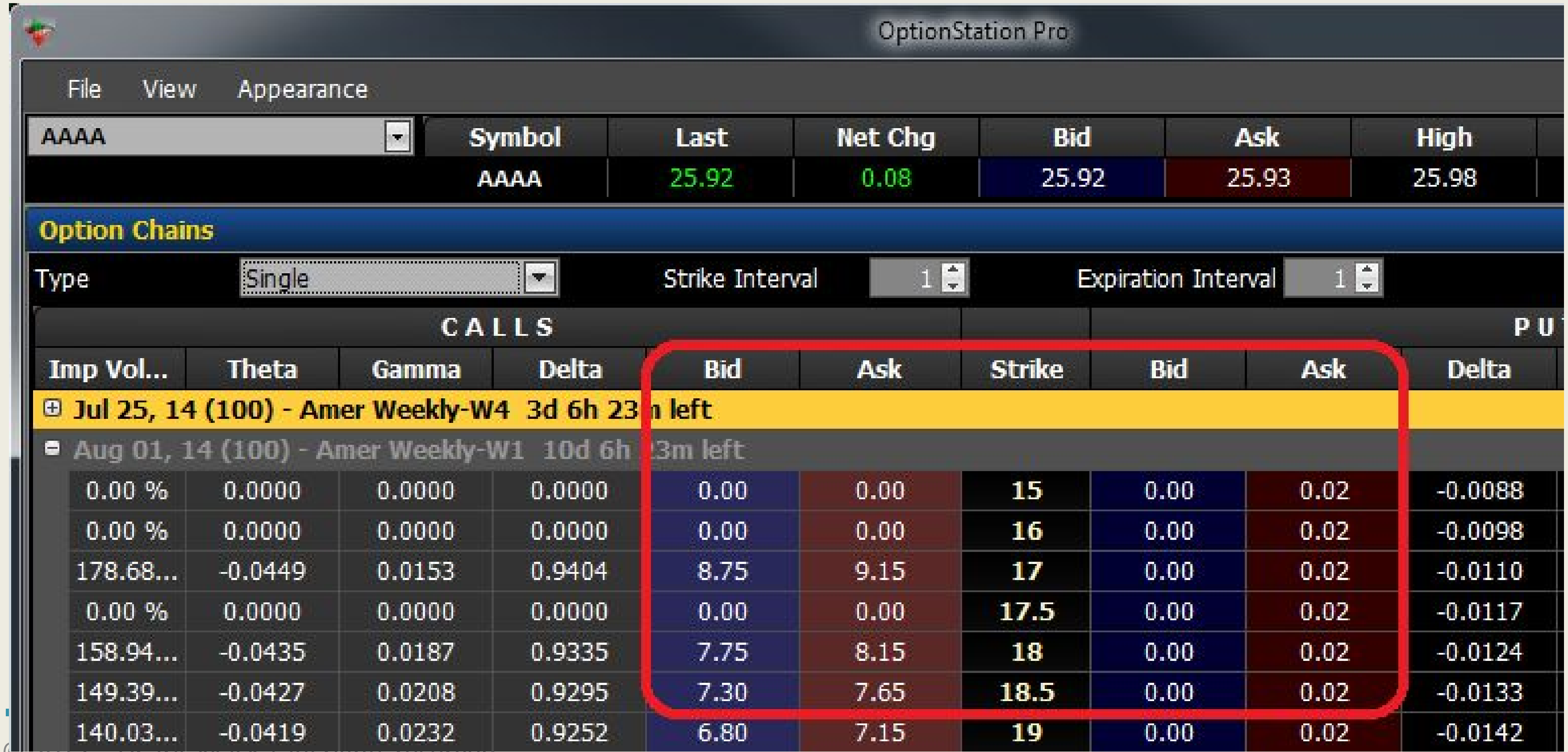
Examples: Call Options on Royal Dutch Shell (RDS.A)

Composite Symbol Attributes	Composite Symbol
RDSA, 11/22/2015 expiration, $67.50 Call	RDSA 151122C67.5
RDSA, 11/22/2015 expiration, $70.00 Put	RDSA 151122P70

Regional Symbol Attributes	Regional Symbol
RDSA, 11/22/2015 expiration, $67.50 Call, CBOE	RDSA 151122C67.5-CO
RDSA, 11/22/2015 expiration, $70.00 Put, CBOE	RDSA 151122P70-CO

Options Chains

The TradeStation OptionStation Pro Option Chains (accessed via TradingApps)



Symbol	Last	Net Chg	Bid	Ask	High
AAAA	25.92	0.08	25.92	25.93	25.98

CALLS							PU		
Imp Vol...	Theta	Gamma	Delta	Bid	Ask	Strike	Bid	Ask	Delta
⊞ Jul 25, 14 (100) - Amer Weekly-W4 3d 6h 23m left									
⊟ Aug 01, 14 (100) - Amer Weekly-W1 10d 6h 23m left									
0.00 %	0.0000	0.0000	0.0000	0.00	0.00	15	0.00	0.02	-0.0088
0.00 %	0.0000	0.0000	0.0000	0.00	0.00	16	0.00	0.02	-0.0098
178.68...	-0.0449	0.0153	0.9404	8.75	9.15	17	0.00	0.02	-0.0110
0.00 %	0.0000	0.0000	0.0000	0.00	0.00	17.5	0.00	0.02	-0.0117
158.94...	-0.0435	0.0187	0.9335	7.75	8.15	18	0.00	0.02	-0.0124
149.39...	-0.0427	0.0208	0.9295	7.30	7.65	18.5	0.00	0.02	-0.0133
140.03...	-0.0419	0.0232	0.9252	6.80	7.15	19	0.00	0.02	-0.0142

Options Chains

Definition of an ***Option Chain***

❖A form of quoting options prices through a list of all of the options for a given underlying asset.
❖An option chain is simply a listing of all the put and call option strike prices along with their premiums for a given maturity period.
❖The majority of online brokers and stock trading platforms display option quotes in the form of an option chain.
❖Option chains are probably the easiest form of presentation for most retail investors to understand when observing option quotes.
❖Much like a mathematical matrix, traders can simply find an options premium by locating the corresponding expiration dates and strike prices.
❖Bid, ask and/or mid quotes maybe displayed within an option chain, depending on the presentation of the data.

Options Chains

The ***TradeStation Option Chains*** panel contains the following real-time information required for theoretical options pricing models, trading and risk analysis:

❖Premiums for options and spreads (bid and ask prices)
❖Volatilities
❖Expiration Dates
❖Strike prices (listed down the middle: calls on left, puts on right)
❖"Greek" price risk measures (delta, gamma, theta, vega, rho,…)
❖…

Note: If you right click on the *Options Chains* panel you will find additional options information and data. Feel free to add more tabs – depending on what information you think will help you trade and manage the risk of options.

Options Trading Strategies

- A ***Covered Call Write*** is a slightly bullish or neutral position taken when the price of the underlying asset is expected to remain at its current level or rise slightly.

- The purpose is to collect the premium of the Call written to generate additional returns on an underlying asset owned.

- *A Covered Call Write* is made up from two positions:
    1. Owning shares or contracts of the underlying asset
    2. Writing Call options in the correct ratio - generally one option for each 100 shares of stock owned.

- Covered Call writing requires no margin since the underlying asset covers the options sold.

Why Don't More Investors Write Covered Calls?
by Alan Ellman

Covered Call Writing seems to have so many advantages. Why do so few use this strategy?

In this 7 minute video, an experienced trader discusses some of the pros and cons of writing covered calls.

https://www.youtube.com/watch?v=MfQ-sila11w

Example: Covered Call Write Options Strategy

Long 100 shares of XYZ @58.00, $5,800.00 paid (debit to your account).
Short 1 XYZ OCT 60 Call @3.25, $ 325.00 premium collected (credit to your account).

Results:

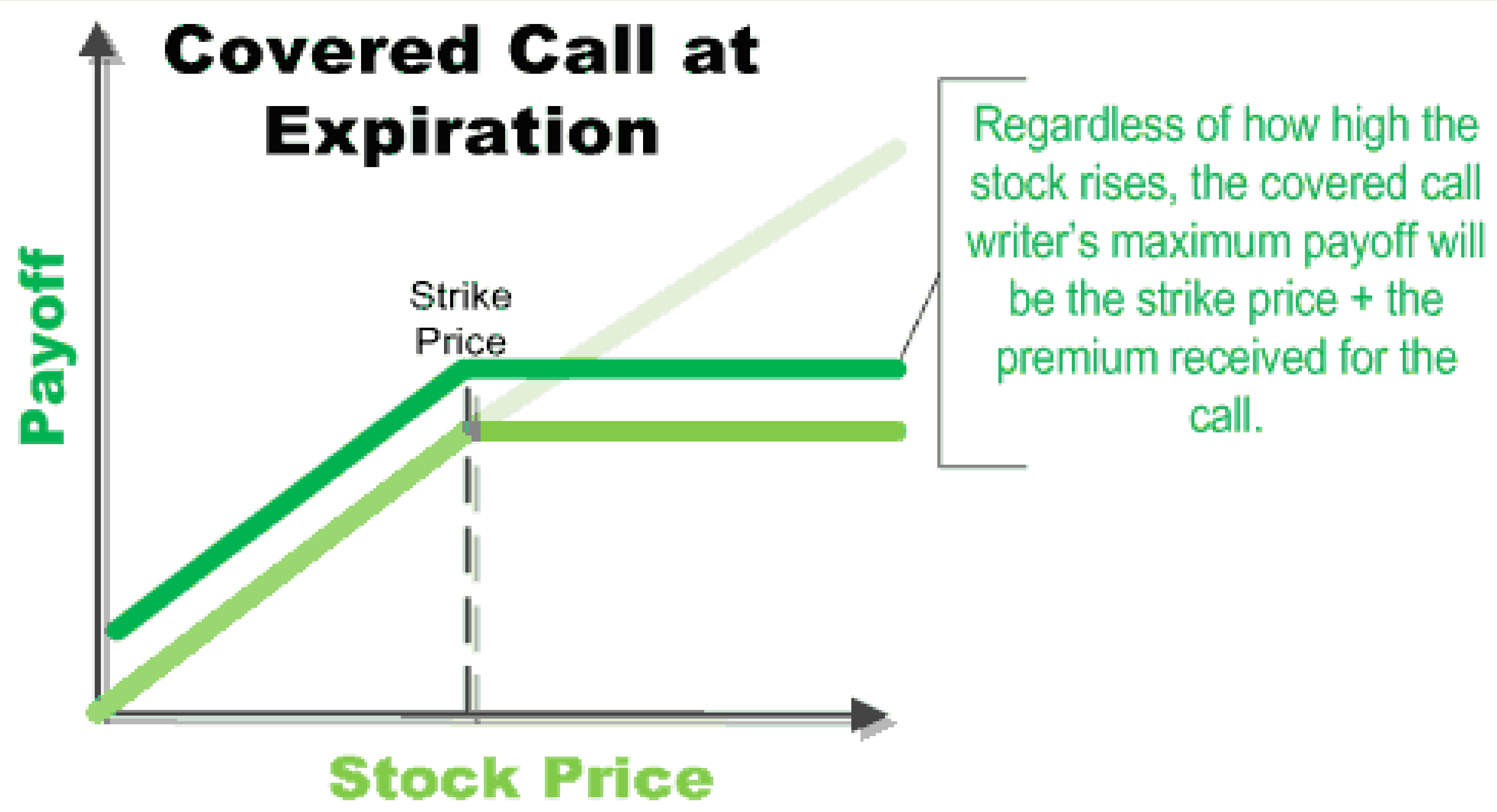
New cost basis for stock is lowered to $54.75.

Maximum Loss can range from zero to unlimited.

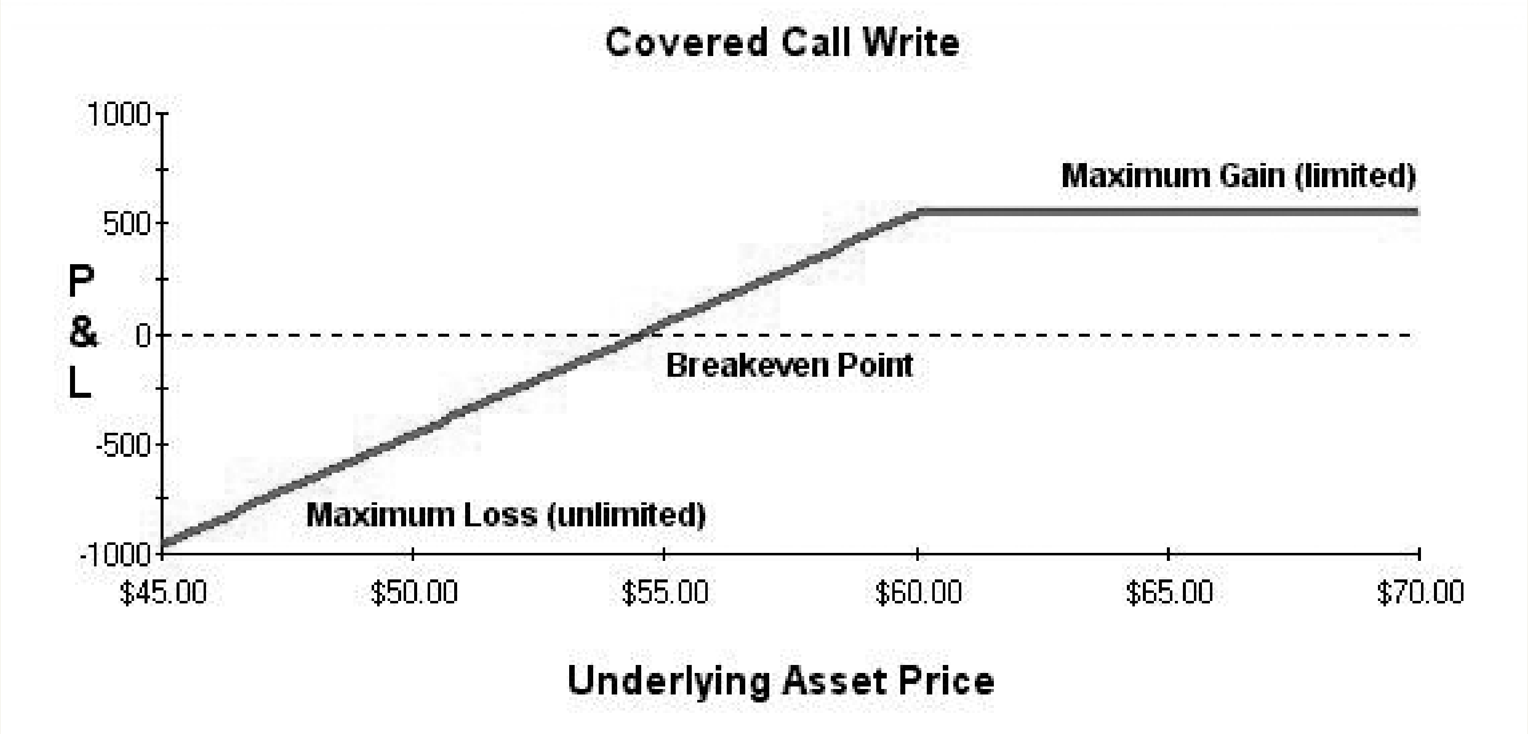
Maximum Gain is is the premium collected and the difference between the strike price and the stock price ($60-$58+$3.25)*100=$525

The breakeven point for a Covered Call is calculated by subtracting the premium collected from the cost of the underlying asset.
$58 cost of asset - $3.25 premium collected = **$54.75** breakeven price

Payoff Diagram for a "Covered Call Write" Position



Payoff Diagram for a "Covered Call Write" Position



Example: Covered Calls on TradeStation's OptionStation Pro

Let's experiment with covered calls on your favorite underlying energy assets.

Please click on the "Type" dropdown box in the Options Chains panel.

Next click on "Covered/Married Stock"

How do the characteristics of the greeks for the covered calls compare to the characteristics of the greeks we previously discussed for plain vanilla calls and puts?

Take a look at the 2D and 3D graphs. What do you observe?

Creating Monthly Cash Flow With Covered Call Writing

Speaker Alan Ellman
Presented by TraderInterviews.com

Alan Ellman of TheBlueCollarInvestor.com explains how to generate monthly income from a covered call strategy.

https://www.youtube.com/watch?v=LBPu694h-q4

Hedging With Electricity Options

Exercise

- Generators use put options ("floors") to guarantee a minimum price for their electricity in conjunction with the physical sale of electricity.

- A generator would still benefit from increases in electricity prices but would avoid the risk of lower prices.

- Assume that the futures contract price is $18/MWh and the generator would like to receive at least that amount.

- How can the generator use electricity options to develop a hedge?

Solution

Energy Trading and Risk Management: A Practical Approach to Hedging, Trading, and Portfolio Diversification

http://www.amazon.com/Energy-Trading-Risk-Management-Diversification/dp/1118339339/ref=tmm_hrd_title_0?ie=UTF8&qid=1398773658&sr=8-1

Hedging with Crack Spreads

A petroleum refiner producing gasoline and heating oil could use a futures ***crack spread*** to lock in both the cost of oil and output prices.

The refiner buys crude oil as an input, that is the long futures position in the crack spread.

The refiner sells gas and/or heating oil, that's the short position.

http://www.youtube.com/watch?v=n-QV4tuK2tg

Hedging with Crack Spreads

The ***crack spread*** is the differential between the price of crude oil and petroleum extracted from it.

It is the profit margin that an oil refiner can expect to make by refining (*cracking)* crude oil.

Crack spreads are often called ***paper refineries***.

Hedging with Crack Spreads

Some commonly used crack spreads:

1:1 Crack Spread	**Buy: 1 crude oil futures contract** **Sell: 1 refined product futures contract**
3:2:1 Crack Spread	**Buy: 3 crude oil futures contracts** **Sell: 2 gasoline futures contracts & 1 heating oil futures contract**
5:3:2 Crack Spread	**Buy: 5 crude oil futures contracts** **Sell: 5 refined products futures**

Hedging with Crack Spreads

A ***long crack put*** (or a ***short crack call***) option is defined as the assignment of futures positions which, at exercise, involve selling one underlying heating oil or gasoline futures contract and buying one underlying crude oil futures contract.

Example: A long crack put option may be appropriate for a refiner looking to hedge its profit margin.

Example: Hedging with Crack Spread Options

Suppose an oil refiner

- Buys crude oil for $110.00 per barrel
- Sells gasoline at $3 per gallon ($3/gallon x 42gallon/barrel = $126 per barrel)

Then the crack spread = ($126-$110) per barrel = $16 per barrel.

Hedging with Crack Spreads

- Of this spread, \$6.00 may be fixed and operating costs. This leaves the refiner with a net refining margin of \$10.

- Now suppose the refiner buys fifty (50) *April RBOB gasoline crack spread puts* with a strike price of K = \$16 per barrel.

- An RBOB gasoline put option traded on an exchange represents an option to assume a short position in the underlying futures contract traded on the exchange.

Note: RBOB = *Reformulated Blendstock for Oxygenate Blending* (gasoline production)

Hedging with Crack Spreads

- The underlying assets of the crack spreads options are futures contracts representing 1,000 barrels of crude oil and 42,000 gallons (1,000 barrels) of refined products.

- Hence by purchasing 50 crack puts, the refiner has effectively hedged the cost of purchasing 50,000 barrels of crude oil and the revenue from the sale of 50,000 barrels of gasoline.

Hedging with Crack Spreads

- Suppose the crack put is exercised at expiry.
- Then the refiner will sell gasoline for $16 per barrel over crude oil.
- This hedge guarantees that neither a rise in crude oil prices nor a fall in gasoline prices can decrease the refining margins below $16.
- Hence, for the cost of the crack put options premium, a profit margin has been locked in for 50,000 barrels of refined products.

Speculation

Wholesale Energy Trading

- Process of buying and selling in the energy markets to connect supply and demand at realistic price levels

- Provides an efficient means to manage physical and financial risks associated with the supply of energy assets

Speculation

Energy traders buy, sell, and/or hold assets for periods of time to make a profit (or prevent loss) on the difference between the assets' acquisition cost and the market price at time of sale of the assets.

Common Trading Strategies	
Hedging	Act of taking offsetting positions in a derivative in order to balance any gains and losses to the underlying asset.
Market Making	A market maker is an individual or firm that accepts the risk of holding a certain quantity of a particular security in order to facilitate trading in that security. **Examples**: RWE Supply and Trading GmbH, EDF Trading Limited, Enron Online
Speculating	Speculation is a bet on the future direction of price movements of assets. A key motivation to speculate is that the risk of loss is offset by the possibility of a huge gain.

Speculation

- Speculators use energy derivatives to profit from the changes in the underlying price of energy assets and to amplify those profits through the use of leverage.

- Speculators also provide liquidity that allows market participants to match their buy and sell orders.

- Energy market participants can
  - ***Intentionally speculate*** in an effort to make a profit. In this case speculation requires that the market participant not have a position in the underlying commodity market.

  - ***Unintentionally speculate*** if, for example, they bought futures contracts to hedge their purchase of electricity in 6 months, but found that they did not need the electricity at that time.

Speculation

Energy Product Trading Codes		
Product Subgroup	**Code**	**Product Name**
Oil	AO	WTI Average Price Options
	CL	Light Sweet Crude Oil Futures
	LO	Crude Oil Options
	QM	E-mini Crude Oil (Financial) Futures are an outright crude oil contract between a buyer and seller. The contract is half the size of the standard Light Sweet Crude contract.
Electricity	B6	PJM Northern Illinois Hub Real-Time Off-Peak Calendar-Month 5 MW Futures
	E4	PJM Western Hub Day-Ahead Off-Peak Calendar-Month 5 MW Futures
	N9	PJM Western Hub Real-Time Off-Peak Calendar-Month 5 MW Futures
Natural Gas	LN	Natural Gas European Options
	NG	Henry Hub Natural Gas Futures
	NN	Henry Hub Swap Futures
	NP	Henry Hub Penultimate NP Futures
	QG	E-mini Natural Gas Futures are an outright natural gas contract between a buyer and a seller. The contract is about one-quarter the size of the standard Natural Gas futures contract.

Speculation

Note: ***E-minis*** futures contracts represents a fraction of the value of a normal S&P futures contract.

E-minis futures are traded primarily on

- CME's electronic trading platform
- New York Board of Trade

Options on E-minis exist for the E-mini S&P 500 and the E-mini NASDAQ-100

http://www.investopedia.com/terms/e/emini.asp
http://en.wikipedia.org/wiki/E-mini

Speculation

Advantages to trading E-minis

- Liquidity
- Greater affordability for individual investors due to lower margin requirements than the full-size contracts
- Around-the-clock trading 23.5 hours a day (Sunday to Friday afternoon)
- Benefit from several tax advantages

http://www.investopedia.com/terms/e/emini.asp
http://en.wikipedia.org/wiki/E-mini

Speculation

Examples of E-mini Futures Contracts	
E-mini S&P 500	1/5 the size of the standard S&P 500 futures contract
E-mini Light Sweet Crude Oil	1/2 the size of the standard light sweet crude contract
E-mini Natural Gas Futures	~1/4 the size of the standard natural gas futures contract

Speculation

Note: ***PJM Interconnection*** is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia, an area that includes more than 51 million people.

States covered**:** All or most of Delaware, District of Columbia, Maryland, New Jersey, Ohio, Pennsylvania, Virginia and West Virginia. Parts of Indiana, Illinois, Kentucky, Michigan, North Carolina and Tennessee.

Started in 1927, the pool was renamed the *Pennsylvania-New Jersey-Maryland* Interconnection (PJM) in 1956.

PJM, headquartered in Valley Forge, Pennsylvania, is currently the world's largest competitive wholesale electricity market.

http://www.ferc.gov/market-oversight/mkt-electric/pjm.asp

Speculation

Note: The ***Henry Hub*** is a natural gas pipeline located in Erath, Louisiana. As of June 2007, the hub connects to four intrastate and nine interstate pipelines.

Henry Hub serves as the official delivery location for futures contracts on the NYMEX.

The NYMEX contract for deliveries at Henry Hub began trading in 1990 and are deliverable 18 months in the future.

The settlement prices at the Henry Hub are used as benchmarks for the entire North American natural gas market.

Speculation

Futures tickers are defined in the table on the next slide.

- Contract months are identified by a month code abbreviation to indicate the month in which a futures contract expires (the delivery month).
- Each futures market has a ticker symbol that is followed by symbols for the contract month and the year.

Example: The natural gas futures have a ticker symbol “NG.” The complete ticker symbol for April 2013 natural gas futures is NGJ13.

- “NG” denotes the underlying futures contract.
- “J” denotes an April delivery month.
- “13” denotes the year 2013.

Speculation

Futures Month Code Abbreviation		
Month	**Abbreviation (1st Year)**	**Abbreviation (2nd Year)**
January	F	D
February	G	E
March	H	I
April	J	L
May	K	O
June	M	P
July	N	T
August	Q	R
September	U	B
October	V	C
November	X	W
December	Z	Y

Politics of Speculation & Dodd-Frank Act

Stop Oil Speculation Now

http://www.youtube.com/watch?v=h8_cqQIpYHc

Oil Speculation: As Explained by "Trading Places"

http://www.youtube.com/watch?v=ssfBVKrobYI

Dodd Frank Act

Core theme of Dodd-Frank Act in Electricity Markets

1. Collateralize forward contracts using secured type of collateral.

1. Limit exposure to one issuer.

1. Shorter settlements life cycle.

CFTC Public Meeting on Automated and High Frequency Trading

Meeting focused on 3 significant issues facing the futures and swaps industries as the Commission continued to finalize rules under the **Dodd-Frank Financial Regulations Act**:

1. Automated and HFT
2. Final recommendations from the *Subcommittee on Data Standardization*
3. Credit limit checks: market structure and technology issues.

http://www.youtube.com/watch?v=eXcMiZhDrDo

High Frequency Trading

"High frequency trading is going to transform many once bespoke markets, just the way it changed equities," says Ciamac Moallemi, associate professor of decision, risk and operations at Columbia's Graduate School of Business. (Rosenbush, 2012)

Although the equity markets were the first to embrace AT methods on a large-scale, these practices migrated quickly to

- Commodities
- Forex
- Futures
- Derivatives
- Energy
- Fixed Income
- Swaps

High Frequency Trading

Futures markets are considered fairly easy to integrate into algorithmic trading (AT). The proportion of AT is generally highest in CME currency futures such as EuroFX. Commodities such as crude oil display the least amount of AT activity.

HFT in the Futures Markets	
	% from AT
	Volume
EuroFX Futures	69.32%
E-mini S&P 500 Futures	51.66%
Eurodollar Futures	51.29%
10-Year T-Note Futures	49.88%
Crude Oil Futures	**35.34%**

HFT Example 1:

HFT is playing an ever-larger role in energy markets.

Quantitative spread trading on crude oil and refined products markets is investigated over 2003–2010, with a focus on

1. West Texas Intermediate (WTI) - a benchmark in oil pricing.
2. Brent (sweet light crude oil)
3. Heating oil
4. Gas oil

A statistical arbitrage trading model has been applied to a total of 861 oil spreads. (Cummins, 2012)

HFT Example 2:

Legal case surrounding the alleged manipulation of Brent crude oil prices and potential role of the HFT firms.

Four longtime traders in the global oil market claim in a lawsuit that the prices for buying and selling crude are fixed -- and that they can prove it.

*Some of the world's biggest oil companies including **BP Plc** (BP/), **Statoil** ASA (STL), and **Royal Dutch Shell** Plc conspired with **Morgan Stanley** and **energy traders including Vitol Group** to manipulate the closely watched spot prices for Brent crude oil for more than a decade, they allege. The North Sea benchmark is used to price more than half the world's crude and helps determine where costs are headed for fuels including gasoline and heating oil.*

High Frequency Trading

HFT Example 2, *cont'd*:
The plaintiffs describe how the market allegedly showed that a crude oil benchmark spot price was manipulated by the defendants, depending on what would profit them most in swap, futures or spot markets.

•They allege the defendants used methods including ***spoofing*** - placing orders that move markets with the intention of canceling them later.
•***Layering*** is a spoofing tactic where rather than placing one large bid, the spoofer places several orders a few ticks apart to give the appearance of buying/selling interest on the book.

HFT Example 2, *cont'd*:

The lawsuit provides an insight into one of the less-transparent corners of global trading -- the $5.7 trillion-a-year market in physical commodities.

"It's a very obscure market," David Kovel, a lawyer for the traders, said of oil traded outside of exchanges such as the Nymex. "To outsiders, it can seem impenetrable. Specialists and specialty traders in the market can take advantage of this obscurity."

Brent Crude Traders Claim Proof BFOE Boys Rigged Market
http://www.bloomberg.com/news/2013-11-06/brent-crude-traders-claim-proof-bfoe-boys-rigged-market.html

Why Are Gas Prices So High? Energy Market Manipulation and Oil Prices (2008)
http://www.youtube.com/watch?v=Vdjr0uQ2BuY

Third Largest Futures Broker Gets Record Fine For HFT Stock Market Manipulation
http://www.zerohedge.com/news/2013-07-11/third-largest-futures-broker-gets-record-fine-hft-stock-market-manipulation

HFT Example 3:

It is alleged that some HFT firms also engage in multiple ***wash trades***.

- Acts as buyer and seller in the same trade to distort market activity
- Creates the illusion of heavy trading

'Wash Trades' Scrutinized: Issue Is Whether High-Speed Firms Illegally Buy, Sell Futures in Same Deals

http://online.wsj.com/news/articles/SB10001424127887323639604578366491497070204

Thank You