SwissQuote Conference

EPFL Lausanne, Switzerland

1 November 2013

Extracting Higher Option Value from Physical Assets

Mahmoud Hamada, PhD, MBA

Agenda

Section 1 — Commodity Trading Optionality

- Time
- Location
- Quality
- Lot Size

Section 2 — Power Plant as a Real Option

- Motivating Example

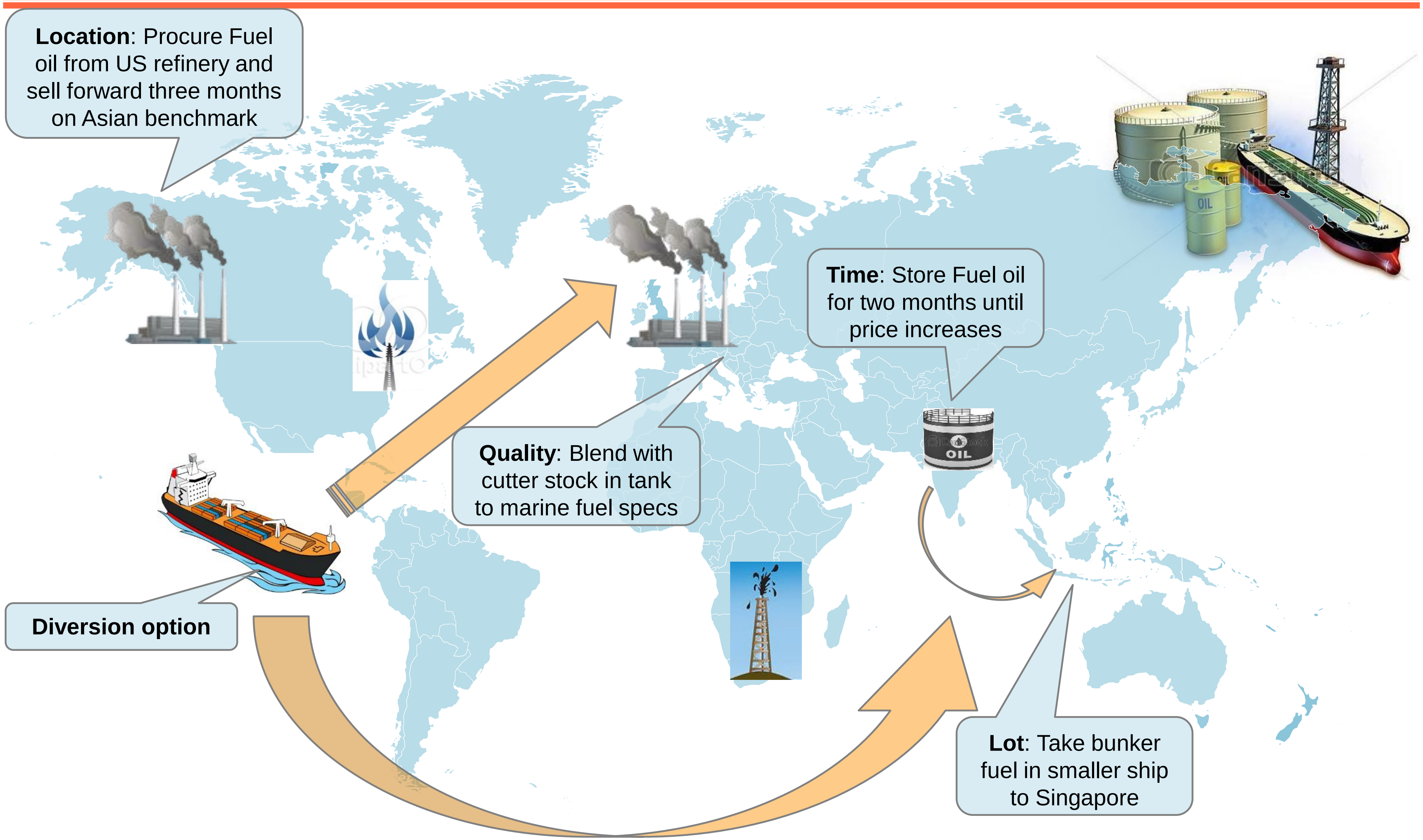
Section 3 — Gas Storage Optimization

- Optimal Control
- Rolling Intrinsic
- Basket of Spread Options
- Comparison

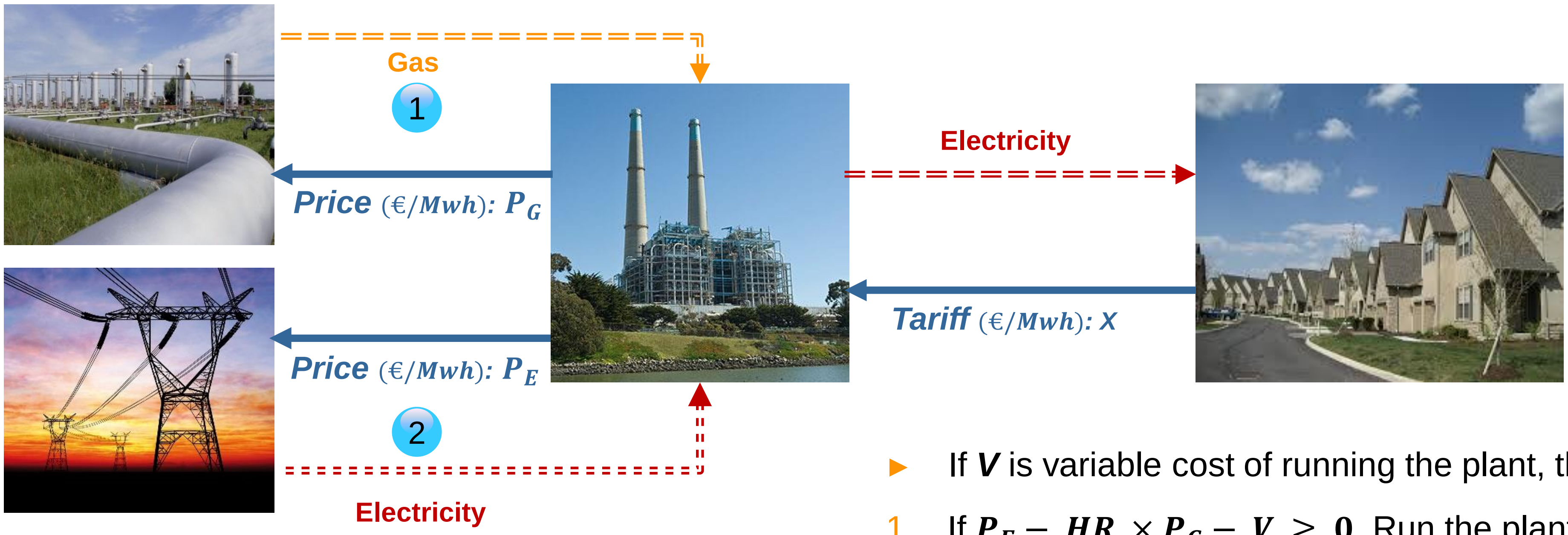
Section 4 — Concluding Remarks

- Towards a robust approach
- Asset-backed trading in worldwide integrated business

Monetizing real optionality through interconnected set of logistical assets



Power plant as a real option – motivating example



1. Plant's P&L: $\Pi 1 = X - HR \times P_G(€/MWh)$
2. Plant's P&L: $\Pi 2 = X - P_E(€/MWh)$

- The difference between the two strategies equals the spark spread:

$$\Pi_1 - \Pi_2 = P_E - HR \times P_G(€/MWh)$$

- If V is variable cost of running the plant, then

1. If $P_E - HR \times P_G - V \geq 0$, Run the plant.
2. If $P_E - HR \times P_G - V \leq 0$, Do NOT run

- The operational margins from running the plant following this strategy as

$$\Pi = max\{P_E - HR \times P_G - V, 0\}$$

- This is payoff of the call option on the spread between power and fuel with the variable cost being the strike.

Gas storage – a profitable real option

- Storage facilities are time machines that let the operator move production capacity from one point in time to a later one.
- This mechanism enables smoothing of the supply response to demand fluctuations.

Type		Working gas capacity	Cushion gas	Injection period	Withdr. period	Operation
Underground	Depleted field	≈ 300 mcm	≈ 50% (already present)	150 - 250 days	50 - 150 days	Seasonal
Underground	Aquifer	≈ 300 mcm	Up to 80%	150 - 250 days	50 - 150 days	Seasonal
Underground	Salt cavern	≈ 150 mcm	≈ 25%	20 - 40 days	10 - 20 days	Peak shaving, balancing
Surface	LNG tank	≈ 500.000 m^3 Compression $^{1}/_{600}$	none	1 - 2 days	1 - 10 days	Short term balancing
Surface	Gaso-meter	≈ 50.000 m^3	none	1 - 2 days	1 - 2 days	Daily / weekly balancing
Surface	Line pack	varying	none	≤ 1 day	≤ 1 day	Intraday balancing

Three main approaches to gas storage valuation

Approach	Characteristics
Optimal Control	▶ Rigourous mathematical formulation of the poblem. ▶ Stochastic Dynamic Programming (SDP) ▶ Least Squares Monte Carlo (LSMC) ▶ Solving Stochastic Differential Equations (SDE)
Rolling Intrinsic	▶ Most transparent and intuitive methodology ▶ Flexibility value is managed by locking-in observable forward curve spreads and then making (risk-free) adjustments to hedge positions as prices move, in order to monetise market volatility
Calendar Spread Options	▶ Considers a storage contract as a series of time spread options to swap gas from one period to another in the future ▶ The volume of available spread options is constrained by the physical characteristics

Solving the optimal control

$$V\big(t_0,S,I(t_0)\big)=\max_{c(S,I,t)}\mathbb{E}^*_{t_0}\left[\int_{t_0}^{T} e^{-r(\tau-t_0)}\big(c-a(I,c)\big)S\,d\tau\right] \quad (1)$$

$$c_{min}(I)\le c\le c_{max}(I) \quad (2)$$

$$dI=-(c+a(I,c))dt \quad (3)$$

$$dS=\mu(S,t)dt+\sigma(S,t)dW+\sum_{k=1}^{N}\gamma_k\,(S,\mathrm{t},J_k)dq_k \quad (4)$$

$$dq_k=\begin{cases}1\ with\ probablity\ \lambda_k(S,t)dt\\ 0\ with\ probablity\ (1-\lambda_k(S,t)dt)\end{cases} \quad (5)$$

$$V(t,S,I)=$$

$$\max_{c(S,I,t)}\mathbb{E}^*_{t}\left[\int_{t}^{t+dt} e^{-r(\tau-t)}\big(c-a(I,c)\big)S\,d\tau+V(t+dt,S+dS,I+dI)\right]$$

- S= current price per unit of natural gas.
- I = current amount of working gas inventory.
- c = amount of gas currently being released from (c > 0) or injected into (c < 0) storage.
- I_{max} = maximum storage capacity.
- $c_{max}(I)$ = maximum deliverability rate
- $c_{min}(I)$= maximum injection rate
- $a(I,C)$= amount of gas lost given c units of gas being released or injected into storage.

Least Square Monte Carlo

1. Simulate N independent price paths $S_1^n, S_2^n, \cdots, S_T^n, n = 1, \ldots, N$
2. Carry out backward induction:

For $t = T, \ldots, 1$

For each simulation n = 1, ⋯, N

For each storage level I_t^m $(\mathbf{m} = 1, \ldots \mathbf{M})$

Solve the one stage problem and find a decision rule,

$$V_t^n = \max_c \{ (c - a(c)) S_t^n + e^{-rt} E[V_{t+1}^n \mid \mathcal{F}_t] \}$$

subject to: storage physical constraints

Next

Next

Next

- Longstaff and Schwartz (2001)

$$V_{t+1} = \gamma_0 + \gamma_1 S_t + \gamma_2 S_t^2 + \varepsilon_t$$

For n=1, ⋯, N

Compute the present value of the storage by summing the discounted future cash flows following the decision rule

Next

4. Storage value is the average of the present values under n paths

Rolling Intrinsic

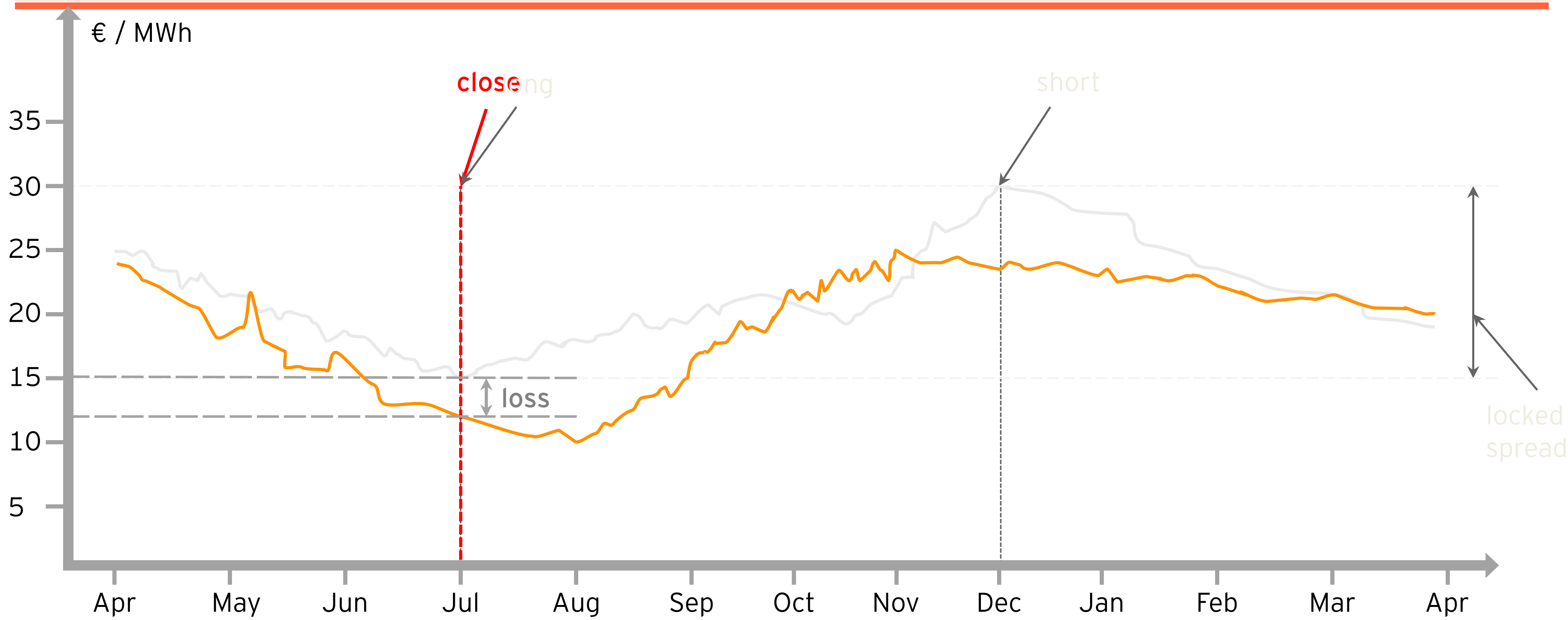
April 1st

Net Position	P&L	Market Value
+ long Jul at 15 - short Dec at 30	0	
= short highest spread € 15 / MWh		€ 15 / MWh

INTEGRAL ENERGY CONSULTING
ENERGY RISK MANAGEMENT SOLUTIONS

Rolling Intrinsic

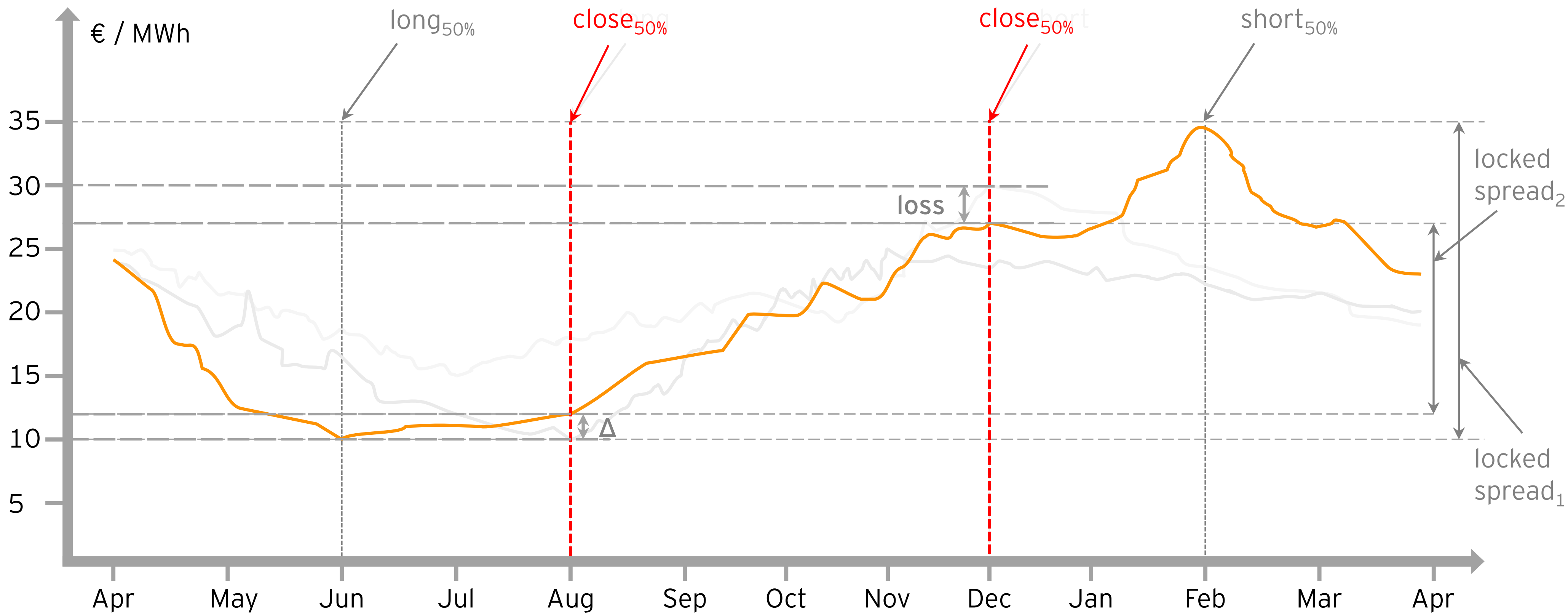
April 2nd



Net Position	**P&L**	**Market Value**
+ long Jul at 15 - short Jul at 12.5	loss of € 2.5 / MWh	
+ long Aug at 10 - short Dec at 30		
= short highest calendar spread € 20 / MWh	- €2.5/MWh	€20/MWh

Rolling Intrinsic

April 8^{th}



Net Position		P&L	Market Value
+ $long_{50\%}$ Jun at 10 - $short_{50\%}$ Feb at 35	+ $long_{50\%}$ Aug at 10 - $short_2$ Aug at 12.5 - $short_{50\%}$ Dec at 30 + $long_{50\%}$ Dec at 27	profit of € 2.5 / MWh loss of € 3 / MWh	
= short highest spread (at 25) for 50% of capacity + short highest spread (at 14.5) for 50% of capacity		- € 0.5 / MWh	€ 19.75/MWh

INTEGRAL ENERGY CONSULTING
ENERGY RISK MANAGEMENT SOLUTIONS

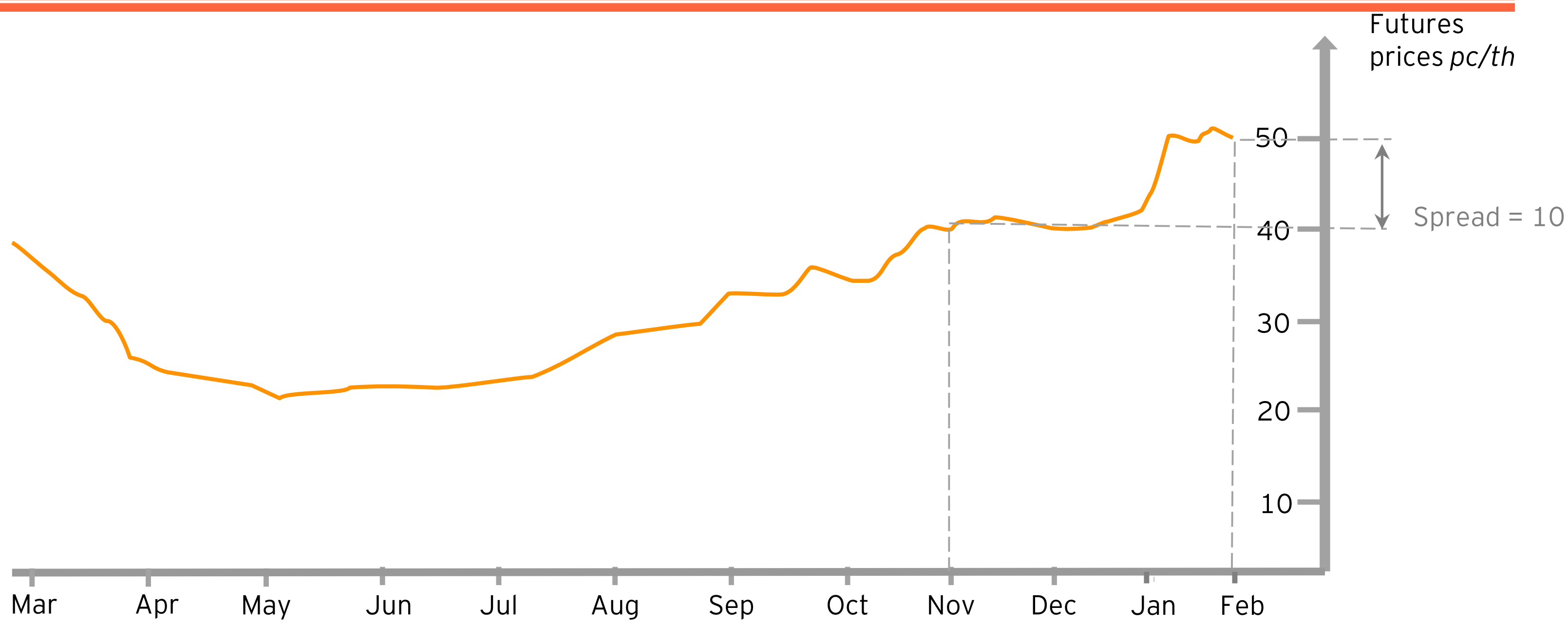
Valuation using the rolling intrinsic approach

- This is the most transparent and intuitive methodology and thus is often favoured by asset managers and traders.
  1. We enter into the forward positions suggested by the optimal injection/withdrawal schedule for this forward curve.
  2. If the forward changes favourably, we readjust our positions to capture the positive difference. If the curve moves in an unfavourable way, we do nothing.
- A simulation based methodology can be implemented based on the following logic:
  - t = 0: Optimise the storage facility against the currently observed forward curve and execute hedges to lock in intrinsic value.
  - t = 1 to T: Simulate the movement in the forward curve and re-optimise storage contract.
  - Calculate the value of unwinding existing hedges and placing on new hedges against re-optimised profile and execute profitable hedge adjustments.
- At any point in time the hedge position matches the planned injection and withdrawal profile and the outturn margin will always be higher than the initial intrinsic hedge as adjustments are only made if it is profitable to do so

Valuation of Gas Storage using basket of Calendar Spread Options

Feb. 15th

Trader



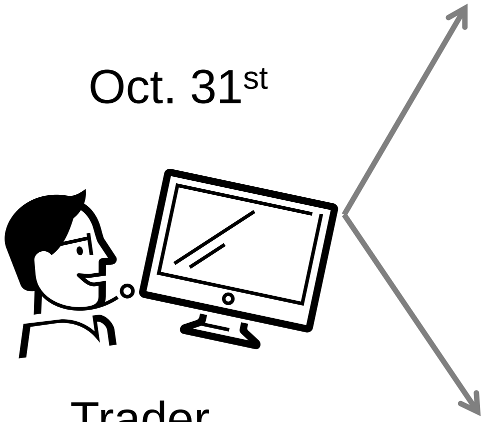
Sell Calendar Spread option:	
Payoff	$\max(F_{Feb} – F_{Nov}, 0)$
Expiry	October 31st
Intrinsic Value	10 pc/th
Time Value	7 pc/th

Total Value = 17pc/th

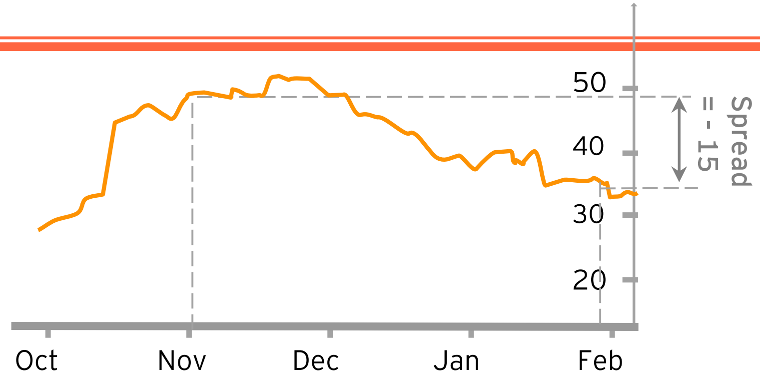
INTEGRAL ENERGY CONSULTING
ENERGY RISK MANAGEMENT SOLUTIONS

Valuation of Gas Storage using basket of Calendar Spread Options

Oct. 31st

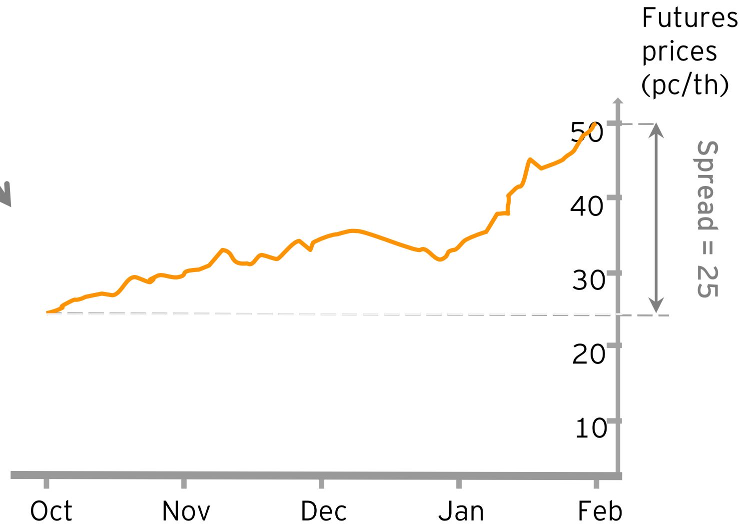


Trader



Spread decreasing

- The option is worthless
- Trader keeps the premium.



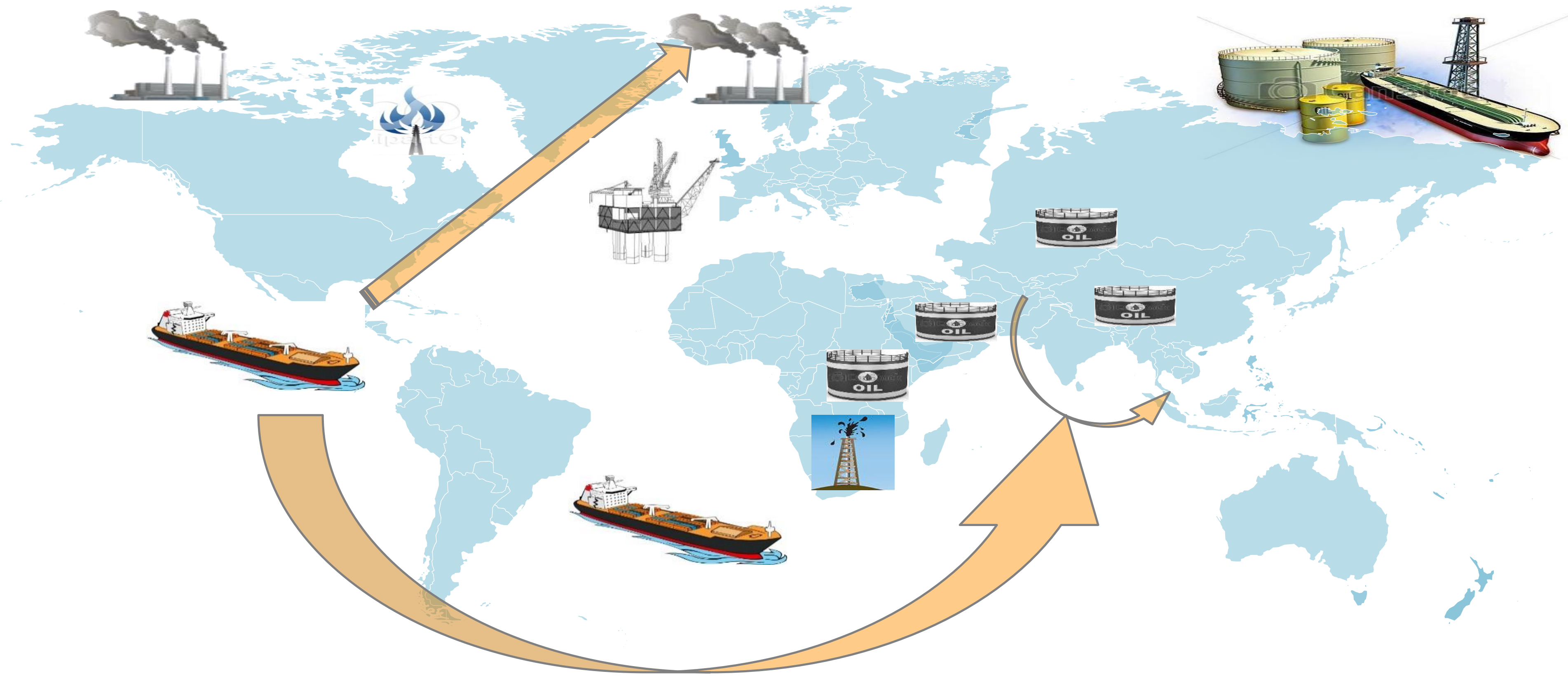
Spread increasing

- Option exercised
- Spread option loss = 25p/th
- However, the availability of storage allows him to buy October gas at 25p/th and short forward the Feb. at 50p/th
- He stores the Oct. gas, keep it until 1st Feb, and sells it using Feb. contract at 50p/th.
- From this position Trader's profit= 25p/th.
- Trader's net position is: -25p/th (CS option loss) + 25p/th (storage and futures spread) + 17p/th (CS option premium) = **17p/th (the premium).**

INTEGRAL ENERGY CONSULTING ENERGY RISK MANAGEMENT SOLUTIONS

Concluding Remarks

- The example of storage shows the complexity of the optimizing a physical asset
- Taking a macro view, can we optimize the portfolio of power plants, gas storage, pipeline capacity, shipping .. for a large scale commodity trading?



Thank You!