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stochastic optimization

Increasing Revenues in Gas Storage Operations by using Scenario Tree based Stochastic Optimization

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Date: July 7th, 2017

1 Challenges of gas storage operation today

Managing natural gas storages has become to a difficult task in recent years. Seven or ten years ago, volatility in the gas market prices and thereby lucrative price spreads allowed for sufficient revenues. Today, low volatilities and very uncertain medium to long term movements of the market price levels make hedging of gas storage positions very risky whereby at the same time the perspective of revenues that cover the storage's costs is low. In particular, riskless strategies that apply rolling intrinsic back-to-back trading, are not yielding revenues that cover the costs for the storage.

2 Limitations of conventional gas storage models

There are basically two mathematical approaches established in the industry for gas storage operations:

a) Optimal Control models such as Stochastic Dual Dynamic Programming (action grids) or Least Squares Monte Carlo

b) Rolling Intrinsic

The optimal control models focus on valuing the gas storage against multiple paths for the day ahead price evolution, deriving decision support whether to inject or withdraw today. They do not directly propose which forward market products to use for hedging.

The rolling intrinsic approach is used for decision support in hedging the storage in the forward market. This can be done day by day for the same future hedging period, which motivates the phrase “rolling” intrinsic. If one generates multiple scenarios of the forward curve, the approach can be extended towards “delta hedging”. This strategy always tries to capture the extrinsic value of the storage by offsetting position pairs which yield the same revenue even at changing market prices.

There are several drawbacks of the above mentioned approaches, two of which are:

a) Optimal Control models do not provide decision support for hedging in the forward market.

b) Rolling Intrinsic models only look at one single forward curve at a time, may it be the currently quoting forward curve or one out of a set of scenarios of a forward curve. Decision support for physical gas storage operation taking into account future uncertainty is not provided.

3 Innovative scenario tree based model for gas storage operation

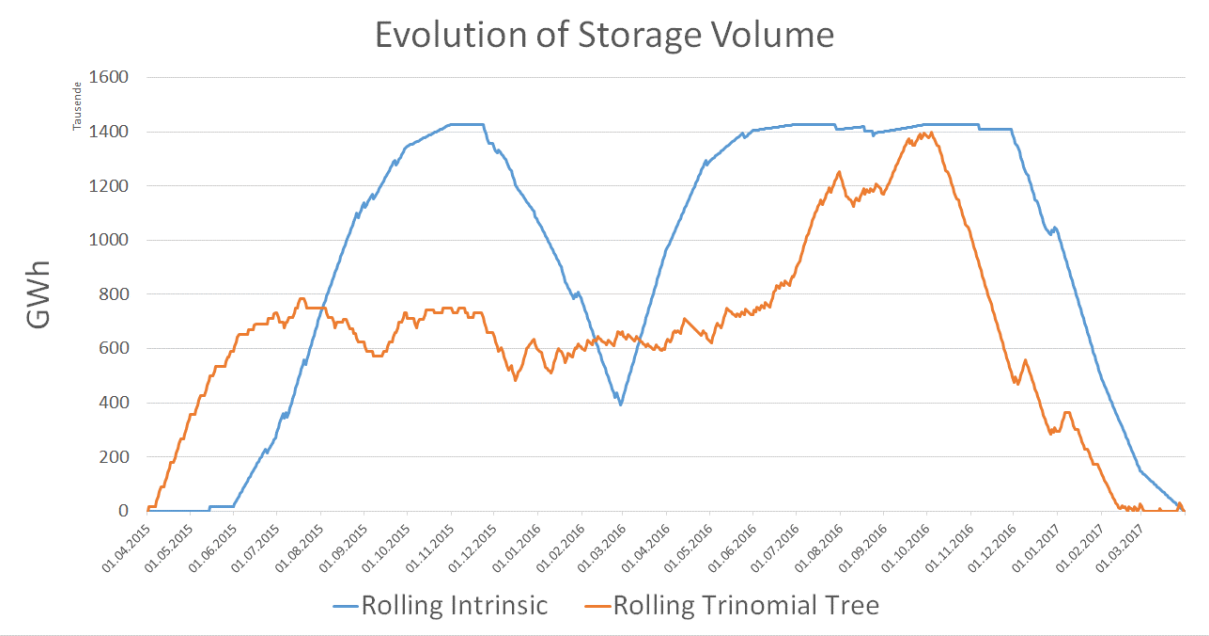
Decision Trees GmbH has developed an innovative stochastic model for gas storage and gas contract operation in close collaboration with a major international oil and gas firm. This model is based on trinomial scenario trees which cover not only future day ahead price scenarios but scenarios of the whole forward curve day by day. The model holds decision variables for both, physical gas storage operation and managing hedging positions. Therefore, decisions for injection/withdrawal and buying/selling different products in the market are proposed by one single stochastic model. Moreover, the model represents reality in gas storage management closer than conventional models:

a) Setting Limits for Overall Open Positions
   Depending on risk aversity or risk affinity of the gas storage operator, financial or physical limits can be set for the overall open position. This is important because most gas storage operators are willing to take some limited risk in order to enhance expected profits. Setting the limit for the overall open position is forcing the model to always set off buys and sells. If open positions up to a certain limit are allowed, the model decides on the hedging portfolio considering the maximum overall open position limit.
b) Not closing positions at low spreads
   Real world gas storage operators do not change the hedging portfolio whenever some minimum positive spread above transaction costs is possible to be locked in, like rolling intrinsic does. Moreover, if spreads are likely to increase, real world traders wait until they lock in. This is represented in the trinomial tree model.
c) Not operating the storage at its edge
   Rolling intrinsic models always use the maximum capacities and maximum volume of the storage. However, often when the maximum injection/withdrawal of the storage is booked by forward positions there is no opportunity anymore to make profit from short term market price movements. The trinomial tree model avoids operation of the storage at its edges in order to leave opportunities open to be captured.

4 Proven outperformance of tree based stochastic optimization over rolling intrinsic

Decision Trees has conducted comprehensive analysis in order to quantify the outperformance of the trinomial tree approach over rolling intrinsic in gas storage operations for a major Austrian utility. The result has been impressive,

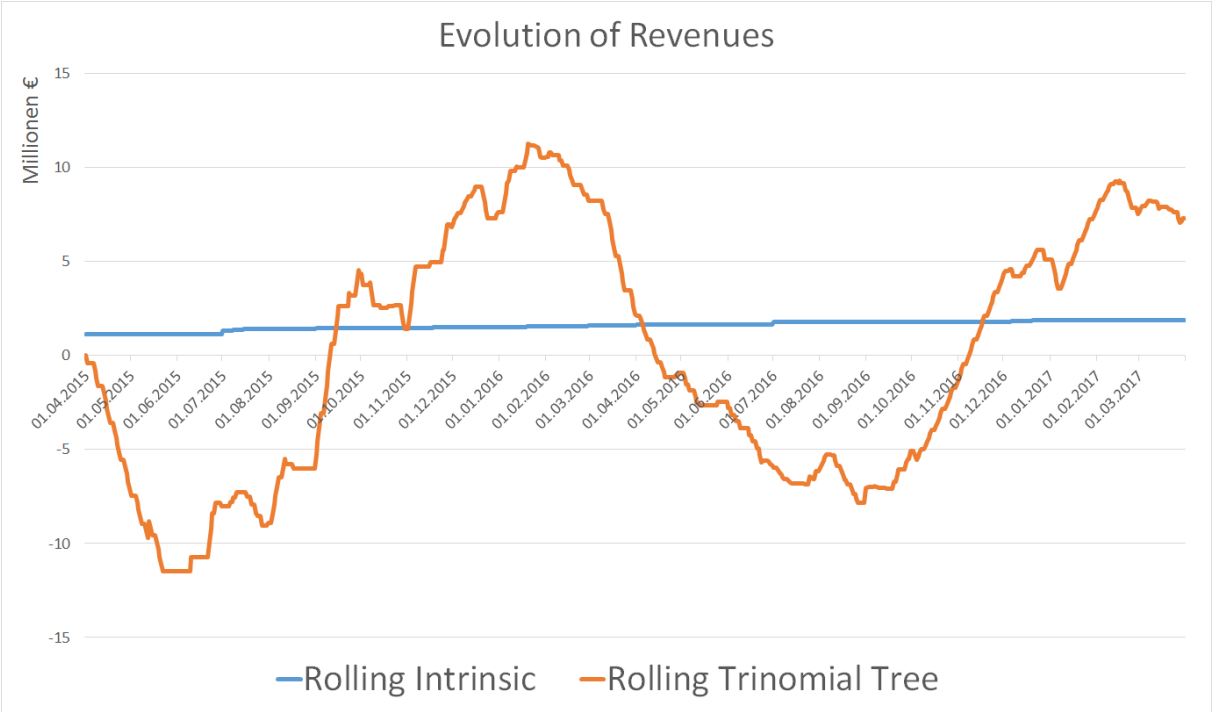
The following chart shows the volume evolution of the gas storage over two storage years, which is very much different between rolling intrinsic and rolling trinomial tree.



The outperformance of the trinomial tree as compared to rolling intrinsic in terms of revenue is impressive. The rolling intrinsic approach basically locks in the summer-winter spreads of the two storage years right at the beginning.

After having booked all injection and withdrawal capacities with seasonal and quarter products, there is not much opportunity afterwards anymore to change the hedging portfolio with lucrative spreads.

As opposed to this, the rolling trinomial tree takes risk to a limited extend and fills the storage with spot buys – without immediately booking the counter positions in the forward market. Of course, substantial risk positions are to be handled, but at the end an impressively higher revenue is achieved, which in this case is more than seven million as compared to only two million with rolling intrinsic.


Evolution of Revenues
Millionen €
15
10
5
0
-5
-10
-15
01.04.2015
01.05.2015
01.06.2015
01.07.2015
01.08.2015
01.09.2015
01.10.2015
01.11.2015
01.12.2015
01.01.2016
01.02.2016
01.03.2016
01.04.2016
01.05.2016
01.06.2016
01.07.2016
01.08.2016
01.09.2016
01.10.2016
01.11.2016
01.12.2016
01.01.2017
01.02.2017
01.03.2017
Rolling Intrinsic
Rolling Trinomial Tree