GAS STORAGE OPTIMIZATION AND VALUATION

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CEZ TRADING PROVIDES ACCESS TO COMMODITY MARKETS FOR THE WHOLE CEZ GROUP

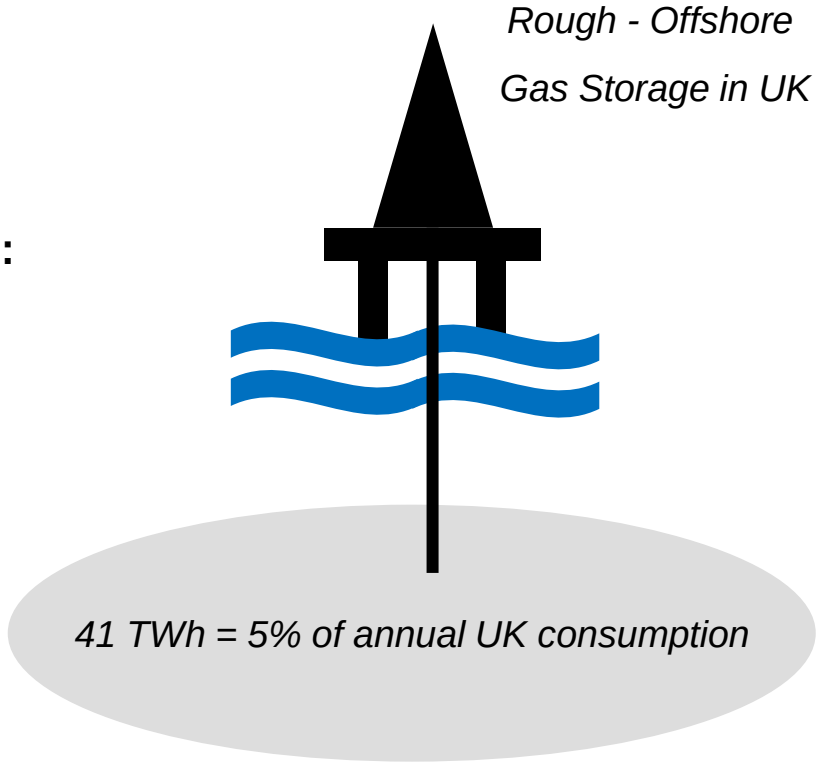
- **CEZ Trading activities:**
  - 30+ traders trade power, gas, coal, oil and emissions
  - Dispatch and optimization of CEZ assets
  - Market access for CEZ group and other companies
  - Marketing of non-standard products
  - Proprietary trading

- **Analytical Team provides:**
  - Meteorological services
  - Fundamental commodity price forecasts
  - Evaluation of trading/hedging strategies
  - Pricing of consumption diagrams and products with optionality

GAS STORAGES SMOOTHEN PRICES ACROSS TIME PERIODS, MAINLY SUMMER WINTER DIFFERENCES

- **Gas storages are:**
  - Depleted gas fields
  - Salt caverns
  - LNG
  - Pipelines

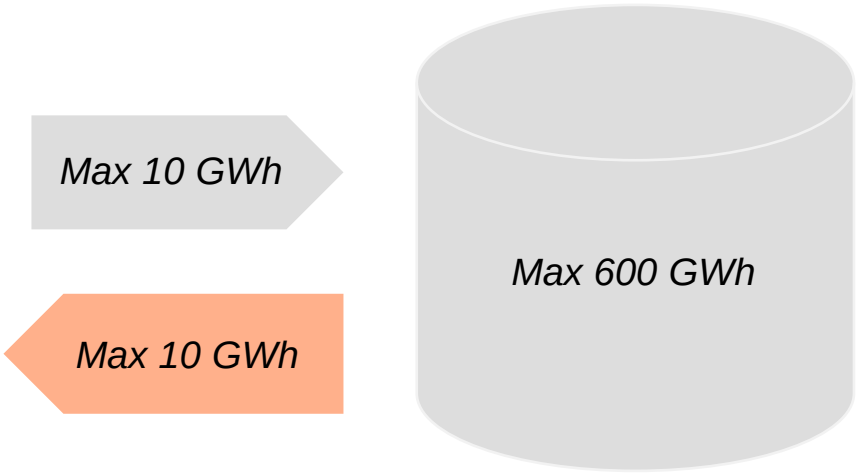
- **Gas storage can serve multiple purposes:**
  - Balancing supply and demand
  - Insurance against shortages
  - Regulatory obligations
  - Speculative trading



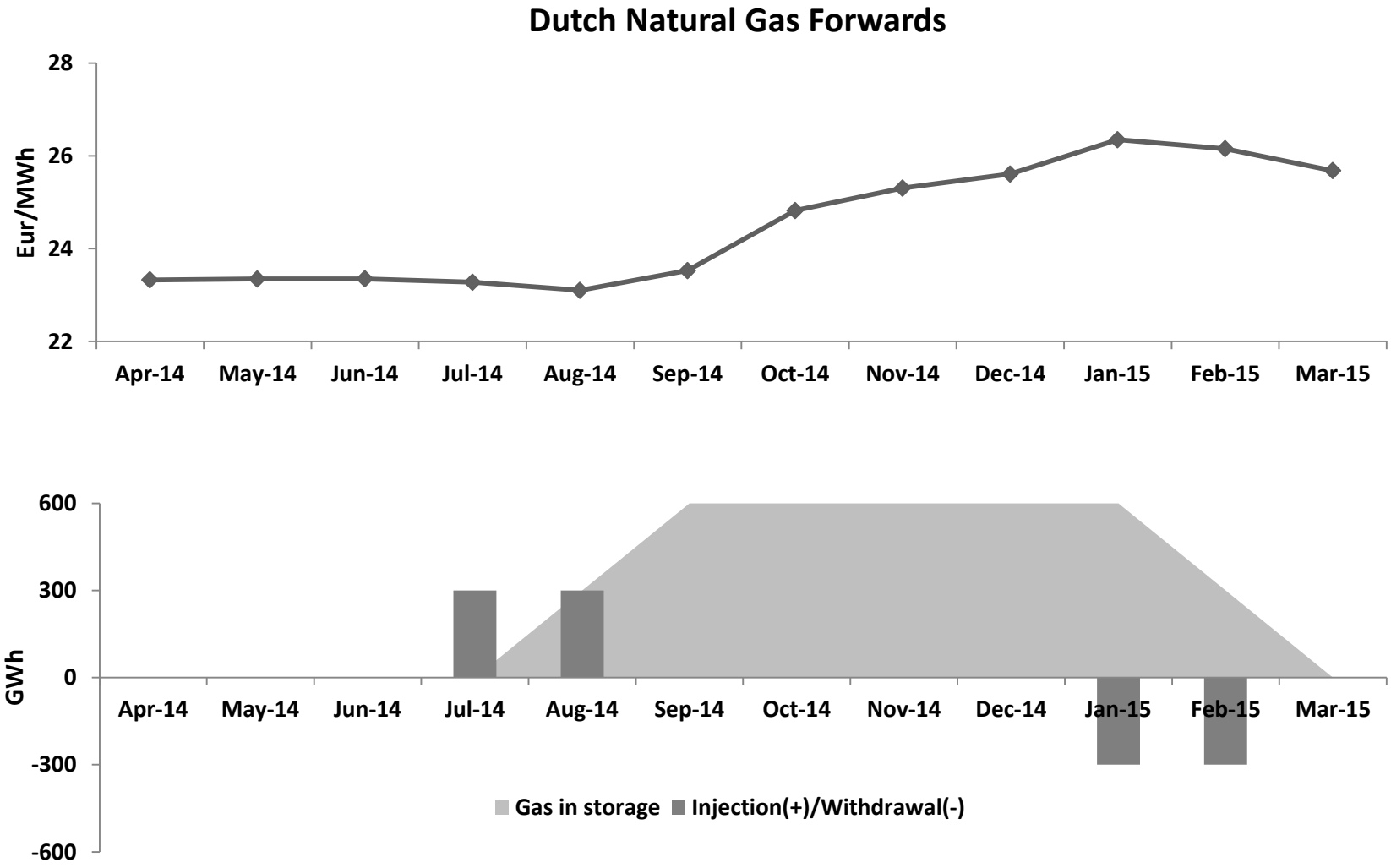
EACH GAS STORAGE HAS DIFFERENT OPERATIONAL CONSTRAINTS

- **Gas storage often come with limits such as**
  - Maximum daily injection and withdrawal
  - Maximum and minimum level of gas in the storage
  - Maximum number of injection and withdrawals…

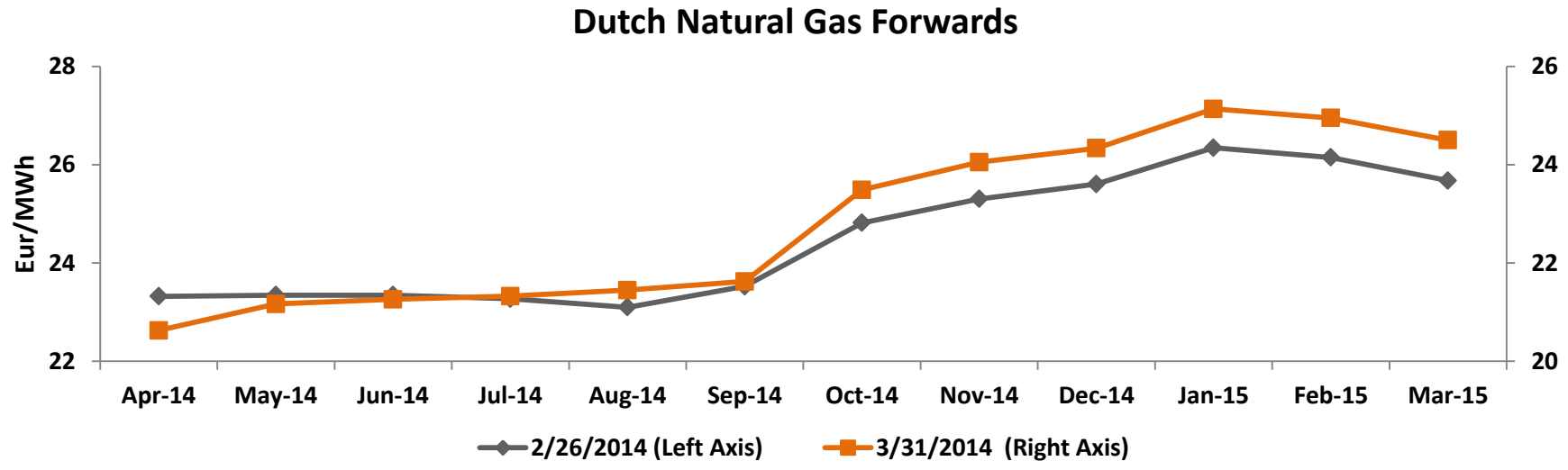
- **Simple storage contract might look like:**
  - Available April through March
  - Capacity 600 GWh
  - Max daily injection 10 GWh
  - Max daily withdrawal 10 GWh

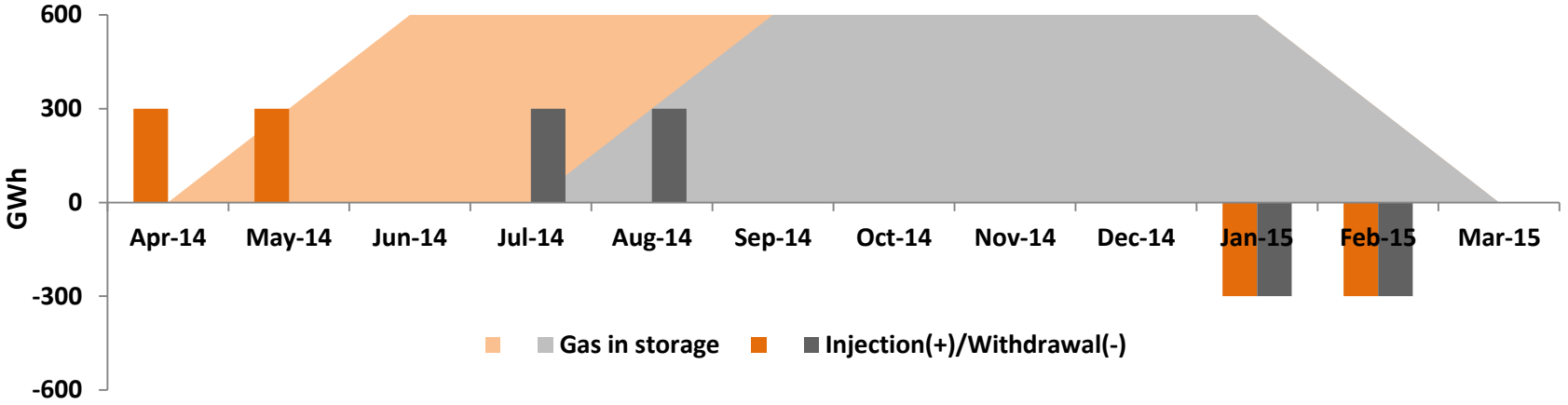


GAS STORAGE PROFITS FROM DIFFERENCES BETWEEN HIGH AND CHEAP PERIODS



VOLATILITY OF PRICES BRINGS OPPORTUNITY TO REOPTIMIZE STORAGE AND EARN HIGHER VALUE





ESTIMATION OF RETURNS FROM DAILY REOPTIMIZATION REQUIRES STOCHASTIC METHODS

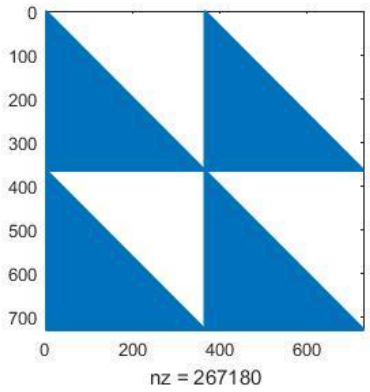
- **Forward curve is simulated by Monte Carlo methods.**
  - Summer – Winter spread is greater than zero
  - Forwards are correlated and cointegrated
  - Volatility increases as delivery approaches
- **Optimal decision is LP problem for each trading day and each simulation**
- **With large number of simulations and trading days speed matters**
  - Sparse *linprog* reduce calculation time if the problem is properly formulated

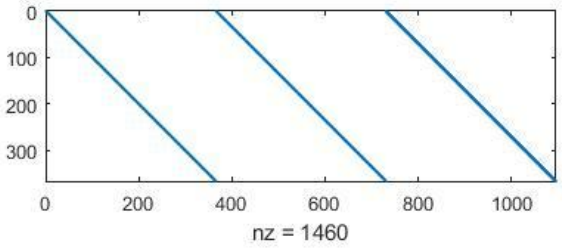
Calculation time

2.50 s

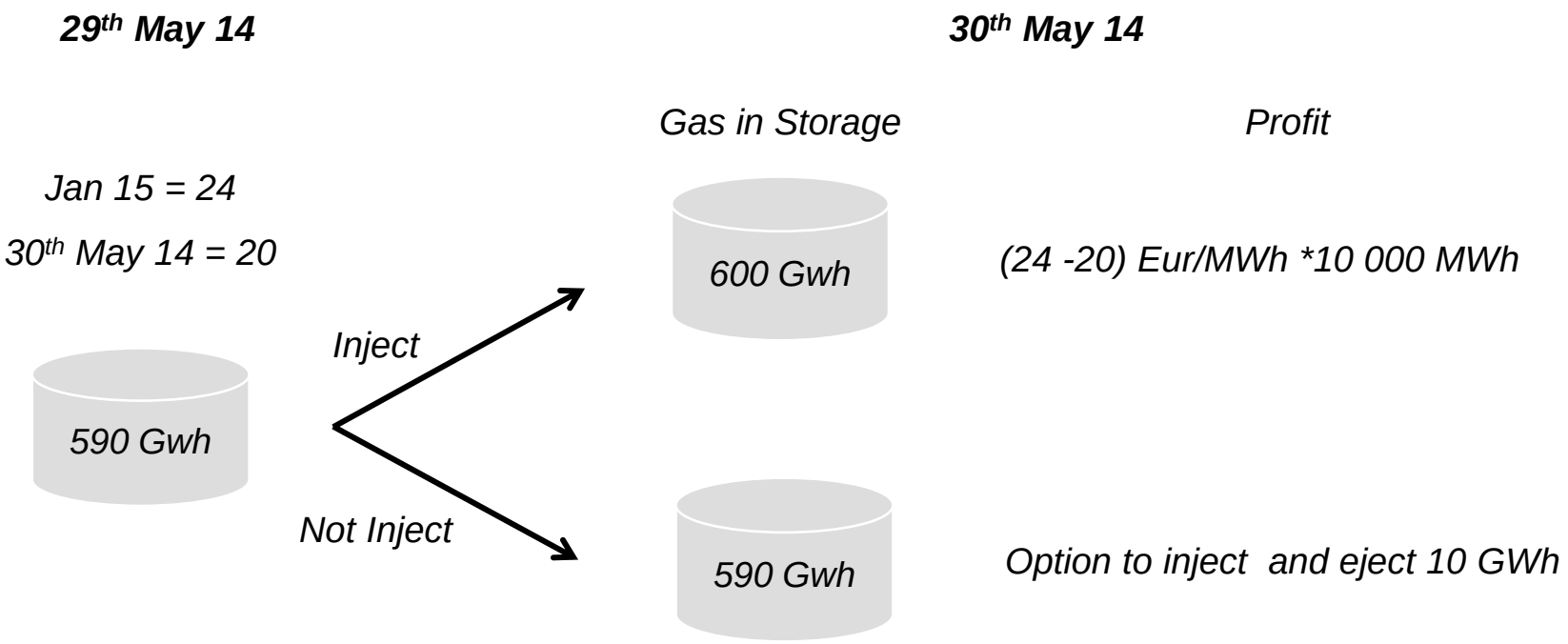
0.04 s

Non-zero entries of constraints matrices



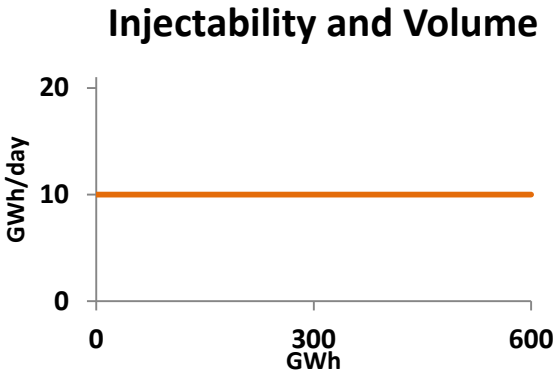


CHALLENGES: MAXIMIZATION OF CURRENT PROFIT REDUCES PROFITABLE OPPORTUNITIES IN FUTURE

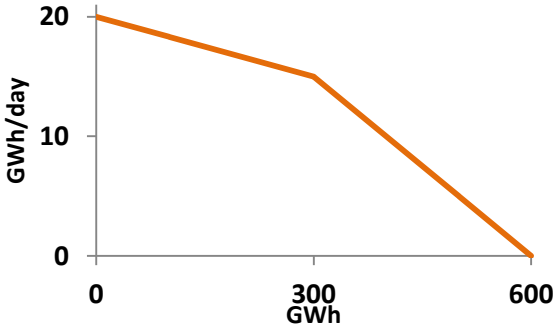


- **Full value of optionality can be valued by dynamic programming**
- **Value function can be estimated by:**
  - Binominal trees
  - Least squares Monte Carlo

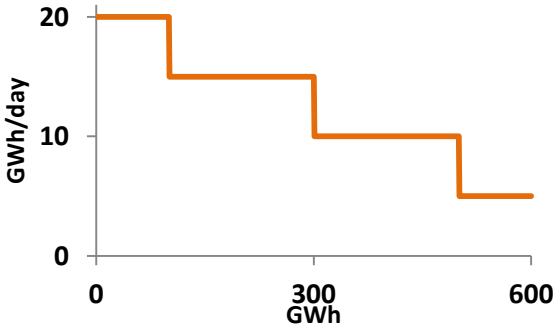
CHALLENGES: INJECTION AND WITHDRAWAL CONSTRAINTS ARE OFTEN VOLUME-DEPENDENDENT



- Feasible volume and injection form **convex** set
- Simple linear program - ***linprog***

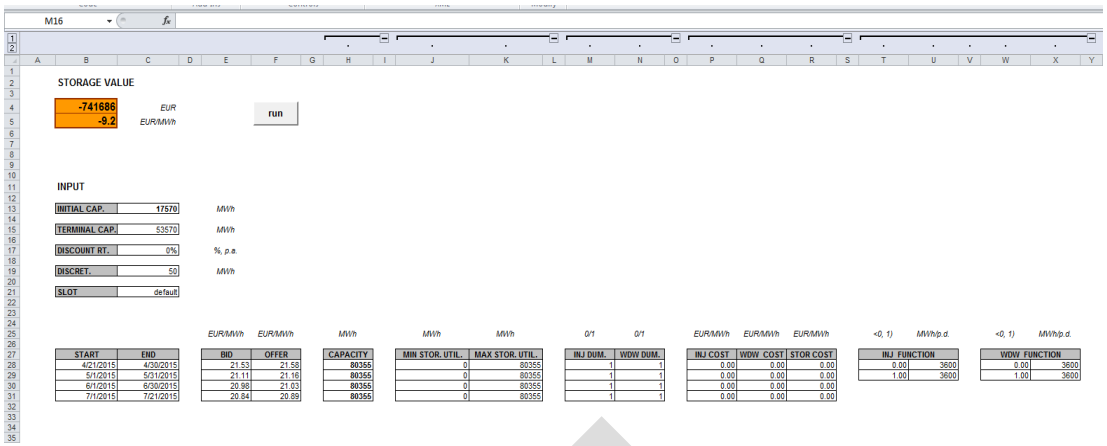


- Feasible volume and injection form **convex** set
- Linear program with multiple linear constraints



- Feasible volume and injection form **non-convex** set
- Need to use mixed-integer programming - ***intlinprog***
- Slower and in many cases computationally infeasible

IMPLEMENTATION OF GAS STORAGE OPTIMIZATION TOOLS IN MATLAB



STORAGE VALUE

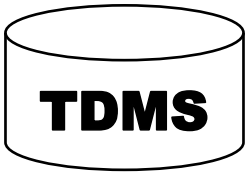
-741686 EUR
-9.2 EUR/MWh

run

INPUT

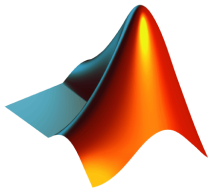
INITIAL CAP.	17570	MWh
TERMINAL CAP.	53570	MWh
DISCOUNT RT.	0%	%, p.a.
DISCRET.	50	MWh
SLOT	default	

START	END	BID (EUR/MWh)	OFFER (EUR/MWh)	CAPACITY (MWh)	MIN STOR. UTIL. (MWh)	MAX STOR. UTIL. (MWh)	INJ DUM. (0/1)	WDW DUM. (0/1)	INJ COST (EUR/MWh)	WDW COST (EUR/MWh)	STOR COST (EUR/MWh)	INJ FUNCTION (<0, 1)	INJ FUNCTION (MWh/p.d.)	WDW FUNCTION (<0, 1)	WDW FUNCTION (MWh/p.d.)
4/21/2015	4/30/2015	21.53	21.58	80355	0	80355	1	1	0.00	0.00	0.00	0.00	3600	0.00	3600
5/1/2015	5/31/2015	21.11	21.16	80355	0	80355	1	1	0.00	0.00	0.00	1.00	3600	1.00	3600
6/1/2015	6/30/2015	20.98	21.03	80355	0	80355	1	1	0.00	0.00	0.00				
7/1/2015	7/21/2015	20.84	20.89	80355	0	80355	1	1	0.00	0.00	0.00				



VBA API

JAVA API



VBA

VBA