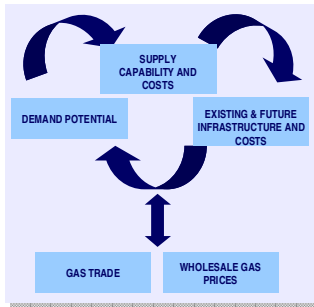


# World Gas Model



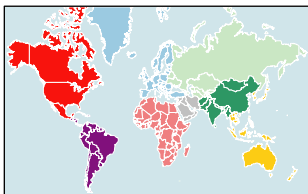
*The World Gas Model (WGM) has been developed by Nexant's Global Gas practice to support our consultancy assignments and multiclient studies and reports.*

The model simulates how interactions between supply availability and costs, transportation and LNG capacity and long term gas contracts interact to produce global, regional and national gas supply demand balances.

Gas prices are projected based on linkages to oil and oil product prices in long term contracts and as the marginal cost of supply, particularly in respect of North America, North-West Europe and the growing spot LNG trade.

The model includes a comprehensive database on gas production, LNG and pipeline infrastructure, as well as long term contracts. Nexant Global Gas team works closely with clients to define scenarios, which can be studied using the model. Clients are encouraged to specify their own assumptions in key areas of interest or to dovetail with internal planning processes, overwriting any in the vast array of existing assumptions included in the model.

## Global Coverage



The model considers every country in the world which either consumes or produces natural gas. Large countries including the USA, Canada and Russia are further segmented by region. The focus is on the growing international trade of natural gas by cross-border pipeline and as LNG.

The model currently includes over 130 countries with space to add new countries as needed.

## Time Periods

The model currently has an outlook period to 2030 which can easily be extended to meet clients' requirements. The model is balanced on a quarterly basis.

## Gas Demand

Energy demand forecasts are built up for each country taking account of trends in population, economic growth and energy intensity. Natural gas contribution to energy supply involves consideration of investment decisions, particularly in the electricity generation market, where gas competes with coal, nuclear and renewable energy. Economic, environmental and political considerations all play a part in determining this mix.

## Infrastructure and Supply

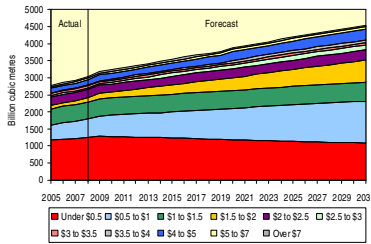
The model includes detailed data on the gas infrastructure and supply needed to support international trade, including production fields and basins, pipelines, LNG liquefaction and regasification terminals and storage facilities, together with associated costs. The inclusion and timing of new infrastructure projects can be controlled, allowing the model to be used to test the impact of individual projects on world trade and pricing. Varied assumptions can be made about which projects go ahead and also as part of developing alternative scenarios which may be of interest to clients.

## Gas Contracts

Long term gas supply contracts play an important role in determining gas flow volumes and prices, particularly in Europe and the Far East. The model includes information on about 400 long-term contracts on gas supply by both cross-border gas pipeline and in LNG form. Volumes are controlled within the range set by Annual Contract Quantity and take-or-pay volumes. Gas prices are simulated in relation to oil prices using relationships derived from modelling historical prices.

The model includes a combination of contracted and uncontracted trade.

## Cost Data



Cost data are included for all facilities in the model including production, pipelines, liquefaction and regasification terminals, storage facilities and LNG shipping. Capital costs for production and infrastructure are represented as unit costs (per MMBtu or per thousand cubic metres - mcm) on a Long Run Marginal Cost (LRMC) basis. Shipping costs are built up from shipping distances and assumed day rates and fuel costs.

## Optimisation

The economically optimum pattern of international trade by both LNG and pipelines is determined within the model taking into account costs of production and transport to the market. Flows are constrained according to the available infrastructure and within the bounds of long term contracts, where appropriate.

## Outputs

The outputs of model runs, focus on wholesale gas prices by country and region and gas trade between countries and regions. Detailed and summary gas supply demand balances are produced for regions and individual countries.

Outputs can be tailored to the individual needs of clients. For example, we are aware that many companies use different geographical regions when looking at international gas markets. WGM is set up so that such regional definitions, and the countries included in each region, can easily be specified and all regional and inter-regional information will be presented accordingly.

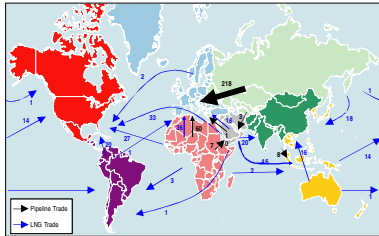
Clients are also able to specify their own choice of units for reporting purposes.

Inputs and output data are all in Excel format allowing for easy interfacing with clients' internal systems.

## Supply/Demand Matches

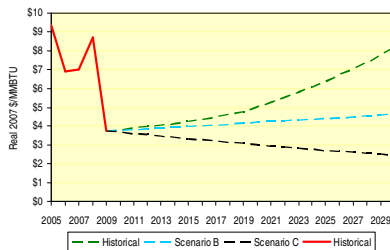
WGM balances supply and demand on a country, regional and global basis. Each supply/demand balance includes indigenous gas production, consumption, imports by LNG and pipeline and exports by LNG and pipeline. Detailed breakdowns of imports and exports are given by origin and destination respectively.

## Gas and LNG Flow Projections



Detailed flows of gas by cross-border pipelines and by LNG are included in the outputs. Flows are shown from individual pipelines connecting countries. In respect of USA, Canada and Russia internal flows are also shown. LNG flows are also shown along approximately 700 different routes.

## Gas Prices



Contract prices can be calculated within the model based on assumed oil and oil product prices in Europe and Asia.

Spot prices for gas in North America, Northern Europe and LNG are determined in relation to the marginal cost of supply.

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## Frequently Asked Questions

Q *How do clients access the World Gas Model?*

A WGM is currently used by Nexant staff to support clients. The model can be run with assumptions specified by the client, proposed by Nexant Global Gas or typically by a combination of the two depending on clients' specific interests.

Q *Is the model available for licensing?*

A The model is now available for licensing to clients to use at their own premises. Please contact us to discuss this option

Q *How many countries are included in the model?*

A The model includes every country which produces, consumes or transits gas. Larger countries including USA, Canada and Russia are sub-divided. In total there are currently over 140 nodes, each of which represents a country or part of a country.

Q *Are results summarised by region?*

A Results can be provided at both country and regional levels. The regions used to summarise results are not hard coded into the model allowing clients to specify their own regional definitions.

Q *What Units does the model work in?*

A Inputs are provided in billion cubic meters (bcm) with costs in USD and \$/MMBtu. Outputs can be converted within the model to any units specified by the client.

Q *What is the format of outputs?*

A All outputs are in Excel format so can be provided as tables or charts or linked to other Excel systems.

Q *What if we need to include new countries in the model?*

A New nodes can be added to the model easily to represent additional countries.

Q *What happens if we want to add new pipelines or LNG plants?*

A The model has been developed with sufficient space to add new facilities such as pipelines, LNG liquefaction and regasification plant and storage facilities simply by adding appropriate data.

Q *What is the time horizon of the model?*

A The model is currently set up with data to 2030, but it can easily be extended.

Q *How much detail is provided on seasonal variations in supply and demand?*

A The model considers quarterly time periods. Seasonal patterns of demand are estimated based on historical data.

Q *How are pipelines included in the model?*

A The model includes all existing international pipelines as well as proposed new pipelines. The timing of new projects is a parameter in the model which can be used to defer project start-up (possibly beyond the outlook period) depending on the scenario being considered.

Q *How are pipelines modelled?*

A Pipelines are modelled as links between two nodes. Pipeline capacity and unit costs/tariffs are specified in the data set.

- Q *What about bi-directional pipelines?*
- A Pipelines may be bi-directional. That is flow may be allowed in either the forward or reverse directions. Generally the model does not produce flows in both the forward and reverse directions in the same quarter because that would incur unnecessary transport costs. Rather the net flow volume is given.
- Q *How are LNG plants included in the model?*
- A The model includes all existing liquefaction and regasification plants as well as proposed new plants. The timing of new projects is a parameter in the model which can be used to defer plant start-up (possibly beyond the outlook period) depending on the scenario being considered.
- Q *How are LNG plants modelled?*
- A Each plant is included in the database with a maximum capacity and unit costs for liquefaction and regasification.
- Q *How is storage capacity modelled in Europe and elsewhere?*
- A The model includes a database of almost 280 gas storage sites or groups of sites including existing facilities and planned facilities taking into account the projects listed by Gas Storage Europe. For USA storage sites are grouped by state based on the US Department of Energy information.
- Q *How are gas contracts simulated in the model?*
- A The model includes information on over 400 long term supply contracts involving delivery by pipeline and as LNG. The start date and end date of contract is specified as well as the annual contract quantity and minimum take (take-or-pay) levels.
- Q *Can deliveries under gas contracts be reduced if uncontracted gas is cheaper?*
- A The model minimizes total costs of supply and contract deliveries will be reduced to minimum take levels if the delivered cost of alternative supplies is lower.
- Q *Does the model recognize portfolio LNG contracts?*
- A Yes. The model can allow for contracts which involve specified sources but not the destination. This simulates the real world situation in which a portfolio LNG company may have a contractual obligation to take LNG from a particular project but is free to sell the LNG on to any destination.
- Q *How does the model determine gas contract prices?*
- A Long term gas contract prices are determined in relation to oil prices and/or spot prices as appropriate. The gas and oil price relationships in contracts are estimated based on statistical analysis of historical gas, oil and oil product prices as appropriate.
- Q *Can varying price structures in LNG contracts be simulated?*
- A Yes. The formula linking gas and oil prices can be adjusted for each contract. Floors ceilings and 'S' curves can be represented in the formula. Contract prices can also be linked to spot indices such as Henry Hub and NBP.
- Q *How does the model deal with competition between pipeline supplies and LNG into Europe?*
- A The model seeks to minimise the total cost of supply to meet demand in all international gas markets. For example, the balance between pipeline and LNG supplies into Europe will be determined by the relative costs of supply and competition for LNG from North America, the Far East and elsewhere. Naturally, long term contracts also have an important influence on how gas flows from producing areas to markets.
- Q *How does the model determine spot gas prices?*
- A Unlike other models, which often treat gas price as an input assumption, WGM projects spot prices as an output of the model. Spot prices are projected for North America, North-West Europe and LNG spot trade.