Last updated: Apr 2014

Methodology and Assumptions[1]

Upstream assets

Introduction

The aim of Wood Mackenzie's upstream asset reports is to provide a detailed review of the key technical, commercial and economic issues surrounding the historic and future development of an oil and gas field or play. Although not all oil and gas fields have cash flows, where applicable, cash flows and economic metrics provide the necessary financial information to indicate Wood Mackenzie's view of the future value of each field, based on the development scenario outlined. In some areas of our unconventional asset research, the development scenario is hypothetical. The key sections in a Wood Mackenzie upstream asset report include:

- Key facts
- Summary and key issues
- Participation
- Location maps
- Geology and exploration
- Reserves and resources
- Production, development and infrastructure
- Costs and fiscal and regulatory
- Economic assumptions and economic analysis

Our upstream asset data is accessible via the Upstream Data Tool (UDT), the Corporate Valuation Tool (CAT) and PathFinder.

Summary

Wood Mackenzie's approach to producing its upstream asset reports is to conduct primary research, supported by a range of data and information available in the public domain and our in-house deep industry and regional knowledge. This allows us to generate high-quality proprietary information and analysis, using our own models, and insightful commentary on all major upstream projects around the world.

Data collection

Data sources

Wood Mackenzie's research analysts conduct extensive and detailed research into their respective focus areas. We use a wide variety of sources, but we do not purchase data other than from entities which own the data and are entitled to sell it to us.

External data sources

The primary external data sources used by Wood Mackenzie to compile field and play reports are shown.

External data sources

Information source	Description
Interviews with energy company and government contacts	Wood Mackenzie aims to interact with operators of upstream assets on an annual basis in all regions and countries. This takes place, most often, on a face-to-face basis in the relevant country or state. Wherever possible, this interaction is extended to all of the other non-operating company participants, sometimes including royalty owners, in any particular asset. Meetings are also held with contacts in the service sector, other investors, and relevant government and regulatory organisations.

[1] WoodMac's website, http://portal.woodmac.com/web/woodmac/methodology-assumptions?pagecontentId=15704486.

Government publications and other regulatory information	In many countries and states, the relevant regulatory authorities publish an annual review of energy activities. This may contain, for example, details of licensing rounds, licences awarded and relinquished, wells drilled and their outcome, production, the status of production and transportation facilities, processing volumes, permit data, completion information, and any new legislation impacting the energy sector. We also review other regulatory authority information, such as websites, press releases, impact studies and historical databases.
Company annual reports and other company documentation	Wood Mackenzie regularly reviews all key energy company annual reports, investor presentations and SEC or other stock exchange (e.g. ASX, SEDAR) filings. In addition, we review other energy company sources of information, such as websites and press releases.
General and industry-specific media	Our analysts regularly review general media and a wide variety of industry-specific publications. We also attend conferences, trade shows, forums, and educational workshops hosted by professional organisations.
Third party commercial data providers	There are occasions when we purchase specific data directly from third parties. NB: Wood Mackenzie has used INCOTEC data to identify locations of specific fields, licence blocks and infrastructure in Russia.
Academic material	Research conducted by universities, trade consortia, and professionally-affiliated groups such as the SPE and AAPG is also used. Where applicable, it can be applied in our models to help develop our asset-specific views.

Source: Wood Mackenzie

Data validation

Our data are subject to a rigorous integrity checking and quality control process. We have developed a comprehensive set of checks, which are carried out on a regular basis, at a field, play, basin, country, region, and global level.

Scope of coverage

Conventional assets

Wood Mackenzie strives to cover all commercial upstream assets in any particular country. However, some assets may not be covered.

The primary reason for exclusion of an asset is its lack of significance to the upstream industry. This may be due to the physical scope and scale of the asset, for example in terms of reserves, production or investment. For example, in the UK we do not cover the onshore conventional oil and gas industry, since it is now insignificant relative to the country's offshore industry. Or, oil and gas fields may be entirely owned and operated by the state, with no possibility of other oil companies being allowed to participate in their ownership and development. Hence, there is usually little interest in detailed analyses of these assets.

Another reason for the exclusion of conventional assets is where insufficient data availability precludes an adequate analysis being undertaken. If it is deemed that inadequate information exists on any particular asset(s), despite the best efforts of Wood Mackenzie's research analysts, then a detailed analysis will not be attempted, although this is, in fact, quite rare.

Unconventional assets

Unconventional assets are viewed by many investors and operators to have less exploration risk. Therefore, our coverage of unconventional plays includes a range of speculative opportunities. Here, proven commercial production does not need to be present for us to construct analogue models and form analytical views. Examples of coverage in areas where no commercial reserves exist in unconventional plays, but there is still considerable resource potential include the Ukraine, Algeria, Indonesia, Brazil, and Vietnam.

Updating process

Updating cycle/publishing schedule

Wood Mackenzie focuses its research updating process with the aim that each upstream asset report is updated at least annually. Generally, we work to quarterly publication deadlines, although our upstream asset reports may be published at any

time throughout the year. We prioritise our updates based on several factors, including the level of client interest, the scale of individual fields, and the last publication date of the report.

Wood Mackenzie aims to update a proportion of its field or play reports more frequently than annually. These updates will usually focus on, for example, assets that have been materially affected by a significant event. Instances could include a change to the licensing terms or regulatory environment, removal of price controls, or an M&A deal that brings new operator experience or expertise to the asset.

To support our updates, research activities occur continually throughout the 12-month period to coincide with access to the research sources we use. For example, information contained in company annual reports and government publications is collated as and when those documents are published. Hence, at the start of a particular update, a certain amount of information on individual assets will have already been gathered.

Analysis validation

Using all possible publicly available information, together with information gathered from energy company interviews, Wood Mackenzie's analysts complete a draft of each upstream asset report. In an important part of the updating process, where possible, these drafts are forwarded to operators and other stakeholders in any particular asset for comment.

This stage of the process is designed to ensure that each report is as accurate as possible, within the limits of what may be differing interpretations of a development among the various equity holders. The final analysis produced is always Wood Mackenzie's view of the most likely development scenario, set of operating conditions, and performance metrics in an asset. It may not necessarily reflect the view of the operator, partners or other parties.

Type of analysis performed

Upstream asset analysis types

Analysis type	Description
Stand-alone field	This is the most common type of report published. It is based on a single field which is distinctly separate (geologically and/or geographically) from any other field, and whose development forms an individual project. Separation from other fields often implies individual tax treatment. Report sections including Reserves and resources, Production and Costs relate only to that field.
Field grouping	When a development encompasses a group of fields, or a single licence covers several discoveries, which is the case for many PSC-type contracts, we present this type of analysis. In this instance, many field development details, such as production, expenditure and fiscal terms relate to the fields collectively. Information by field (e.g. reserves or production) may or may not be available. A version of this approach is applied for onshore US assets.
Other fields / discoveries	A very small proportion of our oil and gas field coverage is less detailed, for example, where fields are undeveloped and have no development plan in place, where field production is very low in small, mature onshore fields, or where only extremely limited information is available. In these cases, less detailed information is presented.
National oil company	In some countries the existing or former national oil company is the dominant equity holder in the upstream sector. Details of its operations and results may be available in variety of formats, not necessarily on a field-by-field or block-by-block basis. Where field-specific analysis is not possible, Wood Mackenzie presents an analysis for the national oil company.

Onshore North America company and basin	In most onshore North America regions, companies hold interests in a vast number of relatively small fields or geologically similar reservoirs (plays). Due to the unique nature of licensing and the law of capture applying, it is often not possible to define company interests by field. For this reason, we present company analyses, broken down by play, in the US Lower 48 states and Western Canada.
	For the US Lower 48, we evaluate companies play positions further by state to calculate fiscal take accurately. Sub-division of the data can also reflect the location of fields on federal or non-federal acreage. We derive a company-play-state cash flow analysis and roll this up by company-region (e.g. all of EOG s combined assets in the US Gulf Coast region).
	In the US Lower 48, we also provide reserve, production and cost forecasts by basin. We do this by rolling up all the companies modelled in that particular basin. The basin analyses contain company ranking tables, which can be used to assess the relative performance and attractiveness of individual portfolios.
	In Western Canada we have built company analyses using a relatively standard methodology that consolidates a company s interests in a large number of modelled assets. However, the company interests in these assets are often only estimated based on current production, rather than being actual interests (as in other regions of the world).
Unconventional plays	For unconventional plays, exploration and development can span an area much larger than conventional fields. Play boundaries are not always defined by structure or stratigraphy. Boundaries are often commercial limits that can move with fluctuating economic conditions or changes in well productivity.
	Our analysis of coalbed methane, tight gas, shale gas, and light tight oil plays takes this into account and our view is presented by play. A play is defined as a similar set of strata.
	For areas in the world where plays are still being defined, unconventional analysis may be performed by basin or even country.
Pipelines and terminals	Wood Mackenzie endeavours to provide analyses for pipelines that are the primary delivery mechanism from an oil or gas field to the terminal at which the product is either sold or distributed further. This may include major export pipelines routing from one country to another.

Source: Wood Mackenzie

Classification of discoveries

Wood Mackenzie sub-divides discovered reserves, based upon the potential to exploit those reserves commercially, into commercial and technical reserves. Commercial fields are sub-divided further depending on their development status.

Commercial

Commercial fields are defined as those in production, under development or likely to be developed in the near future. Certain commentators might regard the third category, which Wood Mackenzie terms probable developments, as being potentially commercial rather than commercial. Probable developments are included in the partner's long-term plans; therefore we expect them to be developed under our base case assumptions. Detailed coverage of commercial fields that are depleted and/or abandoned will usually stop one or two years after abandonment, although the details of these fields are retained in our databases.

Technical

Technical reserves are defined as discovered volumes of petroleum that are potentially, but are not yet considered to be, commercial. This may be due to a number of reasons, for example, a lack of development plans, low resource volumes, technical constraints, low product quality and the lack of accessible markets (e.g. stranded gas deposits) or of viable price regimes. Wood Mackenzie further sub-classifies technical reserves as:

- Good (or potentially economic): these are fields that could be economic under our current costs/price projections, but significant uncertainty remains over the nature and timing of their development.
- Contingent (or uneconomic): these are fields that we do not expect to be developed under our current costs/price projections. To become potentially economic these fields may require a breakthrough in technology, a step-change in prices, new fiscal terms or access to, as yet, unplanned infrastructure.

Resource potential in unconventional plays

This is a measure of the technical potential of the play if all the accessible and prospective land is drilled up and produced. We use no economic or time constraints in our development model to calculate these volumes. Key variables that influence this metric include our view on average well recovery (expected ultimate recovery), well spacing, and the ultimate size of the area suitable for drilling. The drillable area accounts for both surface and subsurface constraints. Resource potential does not include gas volumes already produced or those classified as commercial.

Key steps - asset modelling

Commercial assets

Wood Mackenzie's oil and gas reserves and production estimates are based on our view of likely future production. We do not conduct independent reservoir studies or engineering assessments. However, we do use data related to such studies to form our view of individual well performance in unconventional plays.

More often than not in conventional plays, we make an independent analysis of production forecasts provided by operators and/or partners, integrated with our own view of other commercial factors such as demand, infrastructure availability and costs. We validate this assessment by comparing this to data from analogous fields in the same basin or region. In unconventional plays, production and reserves volumes are built up by modelling individual wells and extrapolating that assumption over a wider development plan. Our estimates are broadly equivalent to company proved plus probable reserves and production estimates. We take this approach, as opposed to basing asset modelling on proved reserves, because proved plus probable reserves are believed to represent the most likely future outcome for each field. For those fields where reserves upside is known to exist, for example where isolated sections of a reservoir have yet to be drilled, this will be noted in the report (such reserves are usually classified as possible reserves by companies). Any forecast costs and resultant reserves and production profiles associated with possible reserves will not, however, be included in our economic analysis.

Wood Mackenzie's reserve estimates cover all fields regarded as commercial: fields in production or under development, as well as fields which Wood Mackenzie classes as probable developments. In many cases, Wood Mackenzie will class a discovery as a probable development before a company has booked the reserves under the applicable stock exchange rules, for example the SEC in the United States. This is particularly true for gas discoveries, which Wood Mackenzie may classify as commercial before a gas sales contract has been agreed. In light of this, and the fact that SEC/annual report figures generally report proved reserves, Wood Mackenzie's published entitlement reserves are likely to exceed SEC reported reserves.

Capital and operating costs

Wood Mackenzie uses capital and operating expenditure forecasts associated with our proved plus probable reserves and production for a field or group of fields. In unconventional play reports, these metrics are calculated under two scenarios, individual development wells and multi-well, full-cycle projects.

Capital costs: these include, where relevant, costs for production facilities (including water management), processing equipment, subsea facilities, pad construction, development drilling, completion and well stimulation, pipelines, offshore loading facilities, terminals, abandonment costs and any other costs that are typically capitalised.

Exploration and appraisal (E&A) costs: in many cases in conventional fields, cash flows do not include E&A costs, and hence the economics presented represent project economics, not full life-cycle economics. In these cases, the exploration history and costs

incurred are discussed in the field report, and the E&A costs may be included in the corporate files within our model for each company. However, in some regions, E&A costs are included in the field cash flows, usually in PSC-type regimes, since they have an impact on the tax calculation. In our full-cycle economic models for unconventional projects, access costs, pilot wells, and seismic fees are also included.

Operating costs: these include, where appropriate, fixed and variable costs for field operations, transportation (non-tariff), equipment leasing, insurance and G&A costs. Additionally, they include any tariffs paid for transportation and/or production processing.

Technical fields

Wood Mackenzie calculates indicative values for good technical reserves based on an analogue approach using a number of simple inputs. The key driver of value is the potential development solution chosen, and the reserves believed to be potentially recoverable. Using these, our model interpolates between sets of model asset production profiles for liquids and gas streams, and capital investment profiles, for that specific development solution type at different reserves levels.

Capital costs are based on the two key inputs of development solution and reserves, and a number of other controls around water and reservoir depths, well costs and recoveries, distance to any infrastructure likely to be used, and local cost environments. Operating costs are based on assumed costs for the development solution indicated, adjusted for local costs and the inclusion of any tariffs likely to be paid, if appropriate. Tax terms, and liquids and gas price streams, are assigned as appropriate. Our indicative valuation is derived from a discounted cash flow produced in Wood Mackenzie's Global Economic Model (GEM), under our standard economic assumptions.

Our indicative valuations for good technical reserves therefore represent those resulting from a successful development of the type indicated. They do not include any assessment of risk or the likelihood of any development proceeding, or any additional interim costs likely to be incurred before project sanction is achieved, such as further appraisal costs or FEED studies, for example.

Models

Global Economic Model (GEM)

Wood Mackenzie's research analysts use our proprietary upstream model (GEM) to generate cash flows for upstream assets. Production, capital and operating costs, prices and fiscal terms are input into the model and used to produce the standard cash flows and Wood Mackenzie valuations shown in the upstream asset reports.