

UNCONVENTIONAL GAS SERVICES



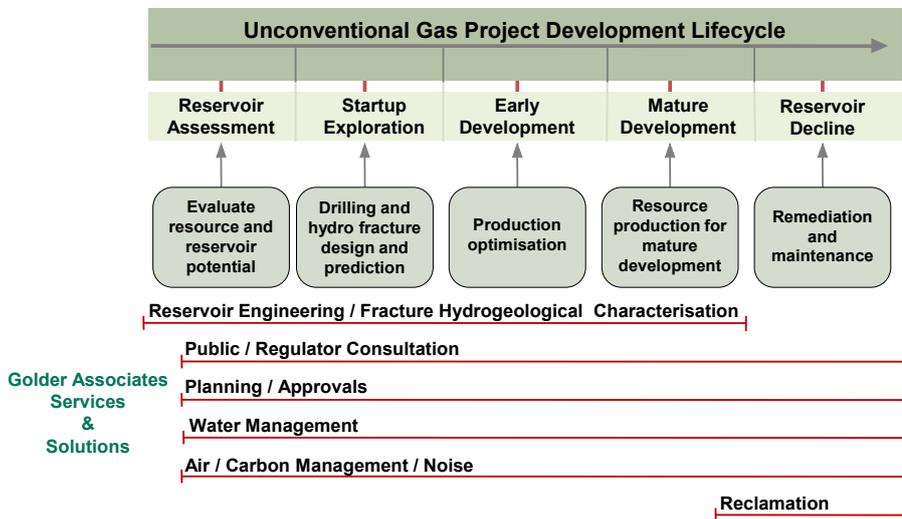
Around the world
Under the earth
Above & beyond

GOLDER PROVIDES INNOVATIVE SOLUTIONS FOR UNCONVENTIONAL GAS RESERVOIRS:

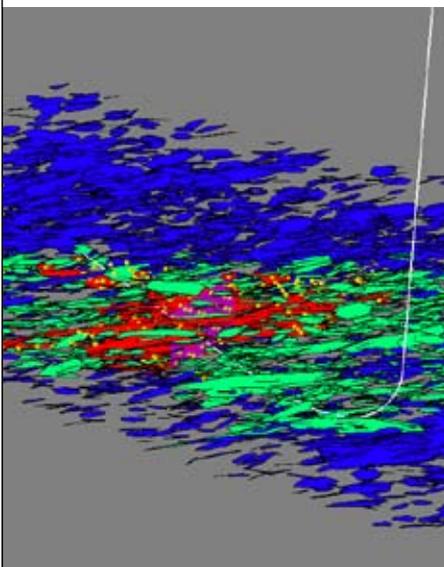
The exploitation and development of the reserves of unconventional gas reserves in both Europe and North America has major implications on the long term global supply of natural gas. This includes the supply source and pricing, the growth of gas markets, and pipeline infrastructure and climate change strategies. In addition, local and regional specific issues relating to unconventional gas exploration and production are also of primary importance.

At Golder, we understand the criteria, challenges, and regulatory environment required for a successful Unconventional Gas development, whether this be in shale gas, tight gas, or coal bed methane formations.

We offer an innovative, multidisciplinary approach to unconventional gas development, bridging the gap between engineering design and environmental planning and permitting. We provide solutions for the full cycle of development for exploration, characterisation and production, through regulatory and permitting services, reserve assessment, reservoir and hydraulic fracture engineering, production optimisation, water disposal, and pipeline infrastructure. Our integrated unconventional gas team can assist with project approvals and can help maximise production and reduce costs.



FRACMAN®



Above: Results of hydraulic fracture simulation in FracMan

FRACMAN TECHNOLOGY GROUP RESERVOIR ENGINEERING AND GEOLOGY

Unconventional gas production depends on flow controlled by the combination of hydraulic fractures and reactivated natural fracture networks. With over 25 years of experience, Golder's FracMan Technology Group is the world leader in analysis and evaluation of fracture-controlled oil and gas production. Golder applies this experience to unconventional gas formations using our integrated FracMan® technologies, which simulates hydraulic fracturing within the unconventional, including interaction with the natural fracture network.

Golder's geologists and engineers develop geologically realistic models of the natural and hydraulic fracture system through a quantitative integration of geological, geophysical and engineering data.

- Characterisation of the natural fracture network;
- Three dimensional modelling of hydraulic fracture, including both reactivation and new fracture creation in quasi brittle rock types;
- Spatial mapping of fracture characteristics throughout the reservoir;
- Geomechanics and Hydrodynamics based assessments;
- Appraisal of down-hole disposal options for waste water;
- Assessment of reserves, recovery optimisation, connectivity, and compartmentalisation; and
- Up-scaling of DFN data to cellular grid based multiphase flow simulators.

ENVIRONMENTAL PERMITTING

- Permitting for seismic exploration, well pad siting and development infrastructure;
- Development of bid specifications, well design and construction;
- EIA based regulatory process management and permitting;
- Terrestrial and aquatic habitat surveys and monitoring;
- Mitigation and reclamation design, oversight, and monitoring;
- Groundwater withdrawal permitting;
- Permitting of surface water intake, surface discharge and re-injection;
- Aquifer testing in fractured bedrock and coastal plain aquifers; and
- Water quality testing, treatment alternative analyses and selection and well system engineering.

WATER MANAGEMENT SERVICES

- Planning and Regulatory;
- Hydrology and hydraulic studies;
- Water treatment, reuse and conservation;
- Water supply siting and permitting;
- Water disposal assessment;
- Water quality assessment; and
- Permit application and regulatory liaison.

Design and Construction:

- Pipelines, pump stations, hydraulic transient analysis;
- Dams and on and off stream reservoirs; and
- Water intakes.

Combined Hydrological and Geological Characterisation Services:

- Aquifer and aquitard characterisation;
- Production and injection well design;
- Well-head protection analyses;
- De-watering design and analysis;
- Groundwater modelling;
- Pathway analysis;
- Contaminant assessment;
- Hydraulic and tracer testing, including two phase flow, low-permeability, at depths up to 2km;
- Baseline and long-term groundwater quality monitoring;
- In situ stress measurement;
- Water balance;
- Acid rock drainage implications; and
- Tool design including supply and use of our own equipment.



AIR QUALITY MANAGEMENT, NOISE AND ACOUSTIC ENGINEERING

- Atmospheric dispersion modelling (AERMOD, ADMS, ADMS-Roads);
- Air quality assessments for major infrastructure (DMRB & TAG);
- Gas risk assessments (GasSim and VapourT);
- Air quality impact assessments of ecosystems and habitats;
- Human health risk assessments;
- Nuisance risk assessments for odour, dust and bioaerosols;
- Environmental permitting (H1 assessments);
- Calculation of process air emissions (combustion, incineration);
- Design assistance (including stack height calculations, location options and BPEO);
- Process air emissions control technology, mitigation and options appraisals;
- Ambient air quality monitoring and data interpretation;
- Air emissions management and monitoring plans;
- Applied meteorology (monitoring and analysis) and atmospheric science;
- Wind tunnel air flow experiments and assessments; and
- Expert advice and witness testimony.

SUSTAINABLE SOLUTIONS

At Golder, we work with our clients to mediate the interaction between people, nature, and governments to arrive at sustainable solutions with which we can all live. Golder's social and stakeholder engagement specialists have wide ranging experience in achieving social and economic project outcomes to maximise community benefits in often contentious and technically complex projects. Golder has a proven track record and excellent understanding of the social, economic, environmental, political and cultural needs associated with sustainable development. We have developed a number of practical decision-support approaches, methods and tools that facilitate the implementation of sustainable practices in organisations. Golder has developed a network of contacts within corporate, public and voluntary sectors with an involvement in sustainable development. At Golder we have a team of consultants with a broad set of sustainability skills that include:

- International sustainable development;
- Sustainable development policy and planning, audits and certification;
- Stakeholder engagement;
- Environmental impact assessment;
- Environmental and social sustainability; and
- Socio-economic issues.

Golder provides seasoned experience, proven technologies, and a commitment to bringing your gas from unconventional to market.



Engineering Earth's Development, Preserving Earth's Integrity.

Global Issues

At GOLDER ASSOCIATES, we strive to be the most respected global company specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organisational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Local Solutions

Your organisation will find it effective and convenient working across borders and continents with Golder Associates. Contact us today to find out how you can take advantage of our capacity.

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- ▶ Africa + 27 11 254 4800
- ▶ Asia + 91 12 4472 8700
- ▶ Australia / New Zealand + 61 7 3721 5400
- ▶ Europe + 356 21 42 30 20
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