Geosynthetic opportunities in shale gas fracking (revisited)

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Introduction

Energy is clearly the driver of almost every activity that the world and its inhabitants rely on and fully utilize. At issue is “what type of energy?” and the answer (as if there even exists a single answer) is largely geographically dependent.

Currently, the world usage (which is close, in percentages, to that used in the USA) is as follows (data from Wikipedia, 2011): oil–42%, coal–23%, gas–19%, nuclear–10%, hydro–3%, renewables–3%.

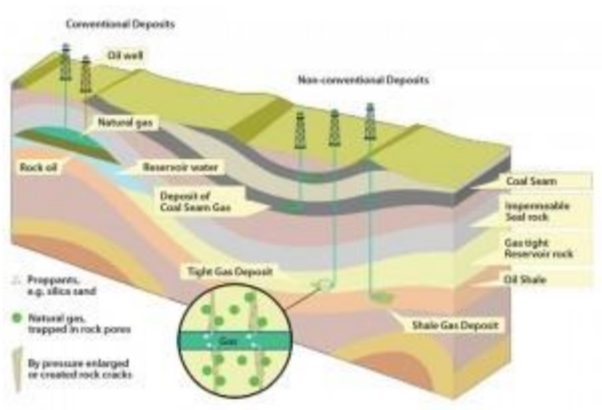

FIGURE 1 Horizontal drilling and hydrofracking of gas and oil. EIA

How this energy balance will change over both the near and far term is unknown (e.g., the recent huge drop in the price of oil will likely have profound implications). Even further, technological advances will result in significant changes in the percentages listed above.

Clearly the advent of horizontal drilling and hydrofracking of gas-bearing (and oil to a lesser extent) shale rock is a major technological advance in this regard. The concept is illustrated in **Figures 1 and 2**.

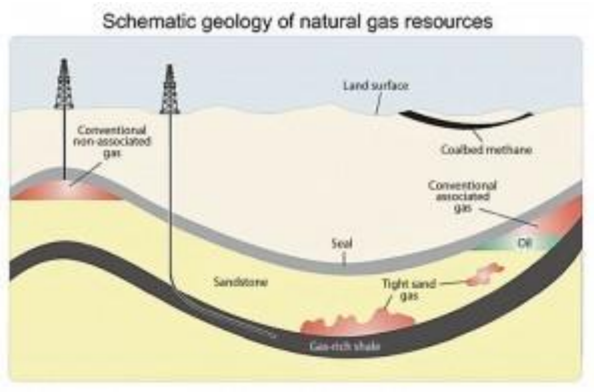

FIGURE 2 Schematic geology of natural gas resources. EIA

The availability of natural gas accessed by horizontal drilling and hydrofracking in gas-rich shale is worldwide in its scope and is available in enormous quantities.

As far as quantities are concerned, **Table 1** is based on the data collected by the U.S. Energy Information Administration (EIA) in 2013. Numbers for the estimated amount of technically recoverable shale gas resources are provided below alongside values for proven natural gas reserves.

Country	Estimated technically recoverable shale gas (trillion cubic feet)	Proven natural gas reserves of all types (trillion cubic feet)	Date of Report
China	1,115	124	2013
Argentina	802	12	2013
Algeria	707	159	2013
United States	665	318	2013
Canada	573	68	2013
Mexico	545	17	2013

TABLE 1 Worldwide availability of shale gas quantities (EIA, 2013)

For the U.S., the EIA estimates (2013) a total “wet natural gas” resource of 2,431 trillion cubic feet, including both shale and conventional gas. Shale gas was estimated to be 27% of the total resource. For the rest of the world, EIA estimates (2013) a total wet natural gas resource of 20,451 trillion cubic feet (579.1 x 1012m3). Shale gas was estimated to be 32% of the total resource.

Clearly, this is an enormous amount by any standard.


FIGURE 3 Site operations at a shale gas extraction wellhead.

Such enormous quantities when used directly or converted into liquefied natural gas (LNG) result in major shifts in energy balances that are already being implemented. In turn, this new energy source has implications for truck, railroad, and pipeline transportation; new terminals, pumping stations, and tank farms; and new ports and ocean shipping terminals, all of which are traditional industries served by geosynthetics in many of its varied forms. At the gas wellhead (Figure 3), and nearby vicinity there are many new geosynthetics opportunities.

This article presents these geosynthetic opportunities in three categories:

- at the wellhead.
- at permanent nearby locations.
- at temporary nearby locations.

Opportunities at the wellhead

Activities at, or near, the wellhead have major and immediate needs for the use of geosynthetic materials in the following applications.


FIGURE 4 Example of freshwater above-ground containment system. Authors' photo

Geomembranes for freshwater containment

There is an obvious opportunity in the use of geomembranes for freshwater containment and subsequent use in the well-drilling activities (Figure 4). The design stages of such liners for surface impoundments are well known and consist of the following sequential steps: geometry (length, width, depth), cross section materials, geomembrane type, geomembrane thickness, subgrade soil stability, cover soil stability, and run-out and anchor trench details.

Perhaps the most overlooked design detail is the requirement of providing an underdrain system beneath the geomembrane. There are the all-too-common "whales" or "hippos" lifting up the geomembrane via rising gases from the underlying soil subgrade. Various underdrain solutions that should be considered are:

- thick needle-punched nonwoven geotextiles.
- drainage geocomposites (complete coverage or strips).
- geotextiles with small perforated pipes.
- sand bedding layer.
- interconnected perforated pipe systems.

Geomembranes for flow back and production water containment

Also an obvious opportunity is the containment and re-use of the flow-back water from drilling as well as production water from both operations, which is quite contaminated. Currently, this contaminated liquid is often being held in mobile holding tanks; however, geomembrane lined ponds or even underground storage systems offer attractive alternatives. Both strategies should be considered in contrast to hundreds of interconnected holding tanks with possible spills and leaks occurring, thus contaminating the surrounding soil subgrade.

Still another opportunity for geosynthetics is the containment of cuttings from the drilling operation itself insofar as proper safe and secure long-term disposal is concerned. In this regard, it should be mentioned that each well produces about 1,000 tons (~75 truckloads) of contaminated cuttings.

This type of waste is generally accepted by municipal solid waste landfills but they are often located considerable distances from these remote drilling sites (Figure 5). Having large trucks on rural roads can be an issue for local municipalities and residents. Also, the waste itself can contain a radioactive component that is currently under investigation by several state environmental agencies.

Geotextile tubes for dewatering and decontamination of well drilling cuttings

Instead of placement in a landfill, drill cuttings can be placed in geotextile tubes at the site and have a decontaminant added such that the now-treated effluent can be released to the environment. The addition of charcoal, activated carbon, phosphoric rock, or organoclays is necessary and all are within decontamination technology that is associated with geotextile flexible bags, containers, and tubes (Koerner, et al. 2013).

Drill pad liner and support systems

The drill pad itself must be made both impermeable and stable to support the massive drilling equipment shown earlier and related auxiliary equipment. Obviously, the site-specific soil subgrade must be adequate and investigated accordingly.

Once subgrade stability is assured, the minimum requirement for a spill containment liner is generally a geomembrane and/or geosynthetic clay liner. Other systems that have been proposed include a geomembrane liner overlaid by a cushioning geotextile and then topped with geocells or other specialty mat or support system (Figure 6).

Opportunities at permanent locations

Considering that a typical well delivers gas for up to three years and is refracked up to six times, a wellsite can function for about 20 years. If, however, there is a lower bearing shale gas layer the site could be functioning for twice that time. This certainly might be the case for the Utica Formulation underlying the Marcellus Formation in many northeastern states in the U.S. In this context we consider 40 years to be “permanent.”

Figure 6 A well pad system that consists of a 1.5mm (60-mil) HDPE textured geomembrane, a 340 g/m2 (10 oz/yd2) cushion geotextile, a 50mm (2in.) recycled foam product and a durable, reusable specialty mat product. Andrejack-Loux and Filshill, 2013

Access roadway construction

Of major priority in this category are stable and durable roadways into and out of the drilling site, which are necessary for the decades-long lifetime of wellhead operations. Geotextiles and geogrids have been shown to save from 10% to 50% of the crushed stone thickness of base courses placed on soil subgrades.

The functions of separation, stabilization, and/or replacement are clearly indicated in the literature (e.g., Koerner 2012) since this application has been ongoing since the beginning of geosynthetics. Not only is there a savings in stone base material, the distance from the nearest large quarry is significant where total cost and localized environmental impacts are concerned.

Geocells for roads and staging areas

Another way of reducing crushed stone thickness that has considerable economy is offered by using geocells. They are filled with gravel, sand, or locally available soil and their design (which uses a geotextile beneath them) is well established. Thicknesses saved are from 50% to 100% over the use of gravel by itself. These same geocells, in a somewhat less-thick format, are ideal for parking and staging areas located adjacent to the drill pad.

Locally available soils stabilized by geosynthetic inclusions

Locally available soils (e.g., silt and clay soils) can be meaningfully strengthened by the addition of discrete fibers or microgrids. Both types lead to major increases in shear strength of the reconstituted soil. This technology is well advanced and mature.

Mechanically stabilized earth walls and slopes

The drill pad site along with adjacent parking and staging areas must be level. To accomplish this in hilly or mountainous terrain (as is typical in many shale areas) one needs to create stable soil slopes or even vertical walls. The concept of mechanically stabilized earth (MSE) slopes and walls using geogrid or geotextile reinforcement is ideal in this regard. Not only are these situations the least expensive of all types of retaining structures, they are straightforward to construct; have no limitations as to curvature, height, or orientation; and have proven stable even under extreme surcharge loads as well as in seismic areas.

Use of a plastic pipe

Natural gas operations are replete with plastic pipe. Such pipe is used for many purposes such as freshwater transmission, frackwater transmission, gas transmission, surface water drainage, etc. The pipe is generally HDPE or PVC and can be solid wall (for transmission) or corrugated with slots or holes (for drainage). Whatever the case, natural gas plays require the use of plastic pipe in a major way.

Opportunities at temporary locations

By temporary, we mean time frames for up to a few years but clearly much less than the permanent applications of decades just presented.

Temporary and reusable roadways

Temporary roadways for weeks or months of service are necessary in connection with setup and eventual demobilization at natural gas wellhead sites.

The geosynthetics industry has the capability of providing temporary wearing surfaces placed directly on the ground, such as various roadway systems developed by the Dutch military for rapid deployment of heavy vehicles and equipment. These systems are typically 18m (60ft) long and 3m (10ft) wide and the weight varies with type. They can be removed and redeployed as often as necessary.

Temporary dams for surface water control

Temporary dams have been used for surface water control or for accidental spills associated with drilling and containment operations. Geomembranes can readily provide such temporary containment and be adaptable to myriad situations. They are often reusable.

Use of silt fences

On sloping surfaces, soil erosion is an ongoing concern and must be avoided to prevent silting of off-site areas and local streams and rivers. Geotextile silt fences have played an economical role in this regard for decades.

Use of rolled erosion control materials

Rather than containing the site’s erosion after it occurs, it is better to control and stabilize the site before erosion starts. This has been traditionally provided by a variety of geosynthetic erosion control materials. The two major categories are slopes and channels/ditches. Designs are well advanced in both cases.

Closing comments

Natural gas plays (including the actual drilling, the well pad, staging and parking areas, permanent and temporary roadways, and access areas) are extremely large construction projects with enormous natural gas potential. They also have attracted public and regulatory scrutiny.

That said, once permits are obtained, fast mobilization, deployment, and operations are necessary. Within the entire activity, a low profile and exposure is always an advantage. All of these aspects can capitalize on geosynthetics in a major way. This paper describes many, but certainly not all, of these opportunities.

Of course, and within acceptable environmental criteria, benefit/cost analyses are always required for alternative and competing systems. We feel that in so doing, geosynthetic materials will be the obvious choice for many of these applications.

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