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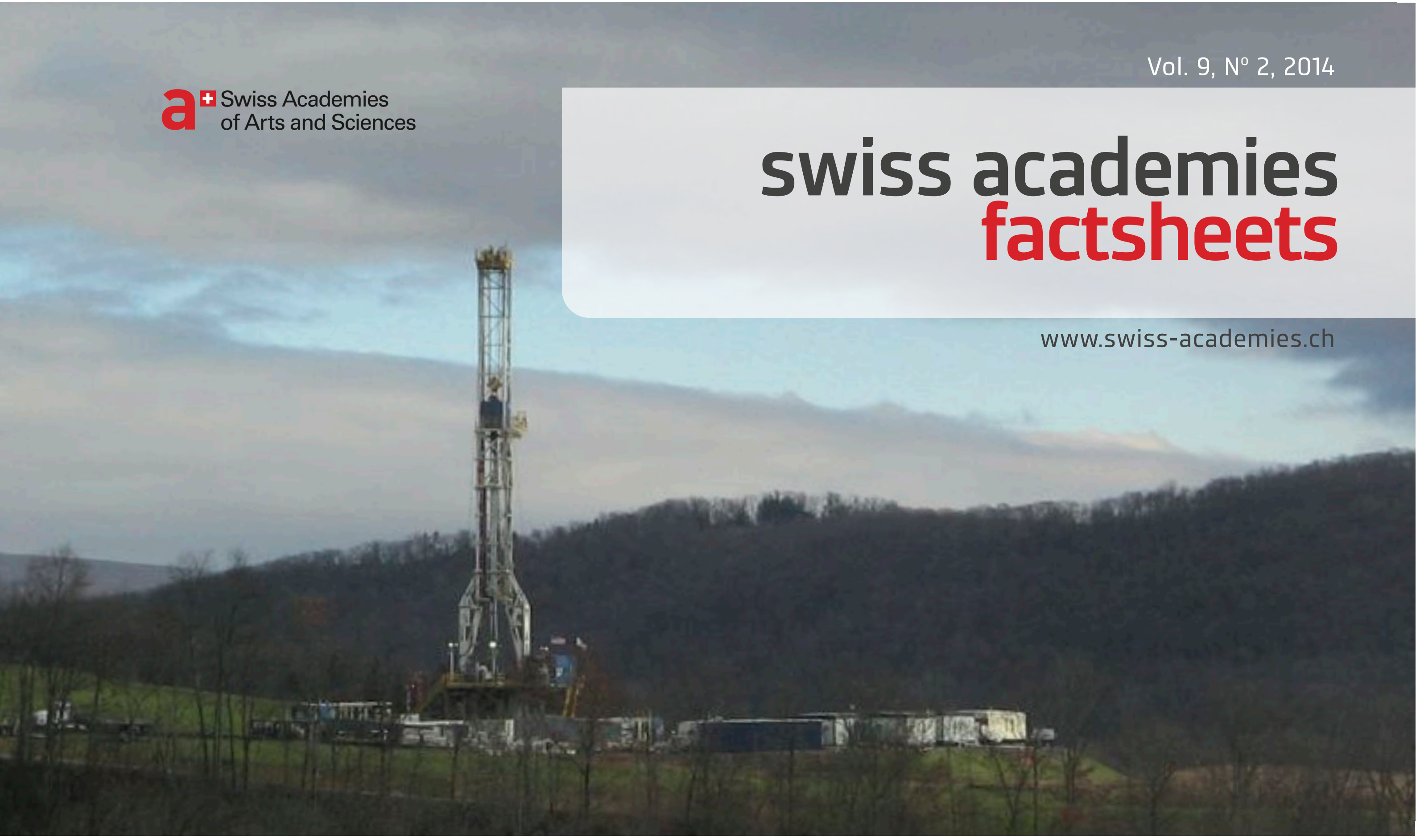

A Focus on Fracking

Potentials, opportunities and risks

Fracking has been used for decades to improve the exploitation of conventional oil and gas reservoirs. In recent years, enhanced conveyance technology and rising gas prices have enabled an economic use of fracking in the case of unconventional gas resources, that is resources which are hard to recover. Fracking is also used in deep geothermal energy systems. Both applications are under controversial discussion. Gas fracking and fracking to tap geothermal resources are different not only with regard to environmental aspects. Assessing the use of fracking to exploit these two energy sources also requires considering sustainability, potentials and cost-effectiveness. Apart from the general opportunities and risks, there are specific questions regarding the application of fracking in Switzerland.

Technology

Basically fracking means to pump liquid at high pressure into the ground in order to enlarge the pores, to create new pore space by generating cracks and breaks and to connect them. This increases the permeability of the rock. After the process of crack formation, the overpressure in the deep ground is relieved by pumping the fracking fluid to the surface. Part of the fracking fluid usually remains in the stimulated formations. Nowadays, fracking is used for the exploitation of conventional and unconventional gas resources as well as in geothermal systems. The respective procedures differ with regard to various aspects. These differences concern environmental impacts, water requirements and the risk of earthquakes.

Fracking for gas

Already since the end of the Second World War, fracking has been used to improve the exploitation of existing conventional oil and gas deposits. In addition, fracking was also used at a relatively early stage for the production of tight gas.

With improvements in mining and drilling technologies and rising gas prices, interest in the exploitation of extensive shale gas deposits increased. Their economic exploration was enabled particularly by the possibility to accurately deflect boreholes horizontally. However, the exploration of shale gas is considerably more costly than the exploration of tight gas, since shale gas is adsorbed in less permeable rock.

The main component of the fracking fluid used for the exploitation of unconventional gas deposits is water. A proportion of 5 per cent of sand serves as a proppant and prevents the fractures from closing again after pressure decrease. Chemical additives account for below 1 per cent and serve different purposes, including transporting and distributing the proppant, hindering bacterial growth, preventing corrosion of production facilities and regulating the pH value.

At first the so-called gas boom spread across North America and revolutionised its power economy. Already in 2009 the US became the leading gas-producing country (ahead of Russia and Canada). Should the development continue, the US could become a net natural gas exporter in the very near future.

Drilling site for gas fracking in the US.

However, there are also critical voices referring, in particular, to the environmental impacts of gas fracking. They include the risk of groundwater pollution, the land requirement for borehole fields, the water requirement for hydraulic fracturing, particularly in arid environments, the use of chemical additives and wastewater treatment.

There are unconventional gas resources in Europe as well, but they are much less significant than in the US. In Poland, a traditional coal and gas country, the exploration of shale gas is being advanced. The situation is entirely different in France where the exploitation of unconventional gas resources has been banned. Hydraulic fracturing is also forbidden in Bulgaria, whereas Romania, the Czech Republic and the Netherlands decided to adopt a moratorium. In Germany, a draft bill is currently under discussion.

Fracking in deep geothermal system

The use of hydraulic fracturing in deep geothermal systems is similar to its use for the exploitation of unconventional gas resources. In hydrothermal systems, that is if there is a thermal aquifer, the development of the resource requires at least one borehole. Usually, a cycle is created by means of two boreholes. Stimulation, that is the injection of water, enables or improves access to the geothermal reservoir. Whereas hydraulic fracturing is not necessarily required for hydrothermal systems, petrothermal systems can be exploited economically only by using stimulation, which increases rock permeability. Since the stimulation of petrothermal systems increases the risk of earthquakes, the vicinity to (known) fault zones is avoided in current projects.

Hydraulic fracturing for the use of petrothermal systems requires at least two boreholes. Water is injected under high pressure through one of the boreholes into the hot, dry, mostly crystalline rock. This creates a system of cracks and fissures with a volume of several square kilometres. Fracking for the exploitation of geothermal resources does not necessarily require the use of proppants or chemical additives; this depends on the specific geological conditions.

Following the fracking process, the water circulates through the two boreholes: it is injected into the ground through one borehole and pumped to the surface through the other. There, the water is used for electricity and/or heat production.

Potentials in Switzerland

Knowledge about the geological underground in Switzerland is limited. Efforts are being undertaken to find out more about the structure of the underground. Switzerland participates in European research projects (GeoORG, GeoMol), and exploration of the underground is also demanded on the political level in a number of parliamentary motions.

Potential of unconventional gas resources

Based on the above-mentioned limited knowledge, the potential of unconventional gas resources is difficult to estimate. Shale gas and tight gas resources are likely to be found in Switzerland whereas coal beds are probably located too deep underground for economic exploration.

Potential of deep geothermal resources

Of all renewable energies, deep geothermal resources have the largest theoretical potential in Switzerland. The potential of petrothermal resources is considerably larger than that of hydrothermal resources. Estimates of the technical and economically usable amount of energy depend on the state of the art and the associated costs.

For Western Switzerland and the northern part of the Swiss plateau, the theoretical thermal potential is estimated at 7200 TWh per year down to a depth of 5000 metres. This would mean electricity generation of 240 TWh per year (current Swiss electricity consumption: about 64 TWh per year). The economically realisable potential for the production of electricity from geothermal resources is much lower and amounts to 1 TWh per year until 2035, and to 4 or 5 TWh per year until 2050.

Legal basis

In Switzerland the use of the underground is under cantonal sovereignty. The corresponding legal provisions can mostly be found in the medieval mining rights of the cantons and often date back to the 19th century. A new legal basis has been established in the canton of Aargau. It takes into consideration new developments in the energy sector by defining, for instance, authorisation requirements for exploring or using natural resources in the deep ground. The canton of Lucerne intends to adopt a legal basis similar to the one of Aargau. Nine cantons in Eastern Switzerland (AI, AR, GL, SG, SH, SZ, TG, ZG, ZH) plan to establish a joint legal basis.

The cantons differ a great deal in their attitudes towards gas exploration. The cantons of Fribourg and Vaud have decided in favour of a moratorium with respect to the exploration and exploitation of gas. The canton of Bern, on the other hand, has approved gas explorations between the towns of Aarberg and Bienne.

On the national level, there are demands for spatial planning principles as to the use of the underground. The Federal Geological Commission (FGC) stated in 2009 that there was an urgent need for coordinating the various claims laid to the ground. It proposed to formulate goals, give priorities to uses based on criteria, define risks and establish 4-dimensional spatial planning, that is to extend today's surface-oriented planning with the dimensions «depth» and «time». In 2013 the Swiss Association of Geologists recommended that the different regulations of the cantons be harmonised. The topic is also on the political agenda: a corresponding postulate was adopted in 2010. It calls for clarification as to the legal regulations on the national and cantonal levels. Moreover, the possibilities of a sustainable use of the underground are to be shown. In response to this postulate, the Federal Office for Spatial Development is preparing a report as part of the 2nd revision of the Swiss Spatial Planning Act.

Summary

Legal regulations

In Switzerland the priority is to establish legal regulations or a legal framework for concessions, licensing and supervising procedures – independently of agreeing or disagreeing with fracking. The requirements of spatial planning have to be determined. This is urgent in view of the increasing claims laid to both space and ground. There are no borders underground between cantons and countries. Coordination of cantonal regulations or the establishment of a common framework therefore seems reasonable.

Insufficient knowledge

Knowledge about the underground is currently insufficient in Switzerland, in particular on the Swiss plateau at a depth of below 1000 metres. Thus it is difficult to estimate the potential for exploiting gas and geothermal resources. On the political level, it has been decided to undertake nationwide exploration, but it is not clear how this should be financed.

Drilling for hydrocarbon prospection in Noville (VD, Switzerland).

Fracking for gas

Based on the current (insufficient) data, there are gas resources in Switzerland that might be worth exploiting. They could contribute to the security of energy supplies and to the diversification of domestic energy sources. However, the exploration of unconventional gas resources gives rise to questions regarding environmental impacts. Firstly, gas is a non-renewable energy resource. Its exploration and use potentially involves emitting considerable amounts of CO_2. Secondly, such exploration is associated with a relatively large land requirement, which is likely to lead to conflicts of use in a country as small as Switzerland. Further negative environmental impacts should also be considered, as well as the fact that both economic exploration and public acceptance are questionable.

Fracking in deep geothermal systems

Geothermal systems are renewable resources with low CO_2 emissions. Their use is in agreement with Switzerland's climate targets and is part of the Swiss energy strategy 2050. The theoretical potential is enormous but the economically realisable potential remains very vague. Environmental impacts, in particular the increased risk of earthquakes, are to be considered.

Whereas the land requirement is relatively small for geothermal systems in comparison to the exploration of unconventional gas, other environmental impacts, such as noise emissions during drilling or the risk of water pollution, must also be taken into account.

Long version

This fact sheet is a short version of the report «Eine Technik im Fokus: Fracking. Potenziale, Chancen und Risiken» (2013). Available in German only.
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FURTHER READING

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Energy sources in the ground

Coal		
Oil	Conventional and unconventional	
Natural gas	Conventional	
	Unconventional	**Shale gas** **Tight gas** Coal bed methane
		Aquifer gas Gas hydrates
Geothermal energy	Shallow geothermal energy	
	Deep geothermal energy	**Hydrothermal systems**
		Petrothermal systems

Overview of energy sources in the ground. This factsheet focuses on fracking for the exploration of the unconventional gas resources of shale gas and tight gas, as well as for the use of deep geothermal resources (highlighted in bold type).

Box 1: Natural gas resources

Conventional gas resources

Conventional gas resources result from the thermochemical splitting of organic materials in sedimentary rock, the so-called host rock. Depending on the geology and structure of the host rock, the gas moves upwards or sideways into porous layers. If these layers are topped by impermeable rock, the gas accumulates in the porous layers.

Unconventional gas resources

Unconventional gas resources are characterised by the greater difficulty in opening them up compared with conventional gas resources. Unconventional gas resources exist in the following forms:

Tight gas accumulates in rock with low porosity and permeability. Reservoirs are at a depth of at least 3500 metres and are comparable to conventional gas resources in rock with low permeability.

Shale gas forms in situ and results from the decomposition of organic material at increased temperatures and pressures. The rock to which the gas is adsorbed is fine-grained, usually contains clay minerals and shows very low permeability. Shale gas can be found at a depth of between 1000 and 5000 metres.

Coal bed methane is stored in the pores of coal beds. It forms with the transformation of organic material. The largest part of the gas is adsorbed to coal particles. Usable coal beds are located at a depth of between 200 and 1500 to 2000 metres at most.

Box 2: Geothermal energy

In the field of geothermal energy, a distinction is made between deep and shallow geothermal energy. Shallow geothermal energy uses heat reservoirs in the uppermost 400 metres of the earth for heating. This use is widespread in Switzerland, and the technology involved is mature. In most cases heat pumps are used. In order to reduce the consumption of electricity for heating purposes, deep thermowells should be used more often.

Geothermal power plant in Iceland.

Deep geothermal energy makes use of either hydrothermal or petrothermal systems. Hydrothermal systems consist of thermal aquifers and enable the use of hot water resources. To be used for heat and electricity production, the water must have a temperature of at least 80 to 100 °C. On the Swiss plateau this means water at a depth of about 3000 metres or more.

Petrothermal systems consist of hot, largely dry rock with low permeability. For electricity production, such systems are used at a depth of 5000 metres or more, where temperatures in excess of 200 °C ensure significantly higher efficiency.

Critical aspects of fracking

	Use of unconventional gas resources	Use of deep geothermal energy
Water pollution	The risk of water pollution is due to the fracking fluid, the extracted gas and the reservoir water produced with partly toxic or naturally radioactive substances from the reservoir. Water pollution may also occur at the surface, in the case of borehole leaks, gas leaking from the reservoir or inadequate disposal of the fracking fluid. The backflow is recycled or roughly cleaned and disposed of. The fast decline rate requires a large number of ever new boreholes, the leak tightness of which has to be secured in the long term.	The risk of ground- and surface water pollution is similar to the risk in the case of unconventional gas resources. Applying fracking for the exploitation of geothermal resources does not necessarily require the use of proppants or chemical additives. Geothermal fluids that reach the surface are reinjected into the deep ground. Thus there is usually no backflow to dispose of.
Land requirement	During borehole drilling and the fracking phase, an area of up to 20 000 m^2 is required. During the production phase this area decreases to between 5000 and 10 000 m^2. The wastewater ponds that collect the backflow before its removal may double the required area. The exploitation of unconventional gas resources necessitates a large number of drilling sites. By «cluster drilling», that is the radial opening-up of an area using a single drilling site, the land requirement can be reduced.	The entire industrial area of a geothermal power plant amounts to about 5000 m^2 during borehole drilling. After the drilling phase the required area is relatively small. The specific land requirement per energy unit produced is smaller than for any other renewable energy source.
Water consumption	The amount of water used for fracking depends on rock permeability, the size of the crack system and the number of boreholes. On a drilling site 20 to 30 boreholes are required, with each borehole consuming between 9000 and 29 000 m^3 water. 20 to 80 per cent of the water used can be recovered and partly be reused as fracking fluid.	The creation of a petrothermal reservoir requires between 10 000 and 20 000 m^3 water. During the production phase of a geothermal plant, the water circulates. In the case of petrothermal systems, the amount of water produced is usually smaller than the amount of water reinjected. This means that water needs to be added. Ideally the amount of water produced corresponds to the amount of water reinjected.
Greenhous gas balance	Unconventional gas is a non-renewable fossil energy source causing considerable CO_2 emissions. Total greenhouse gas emissions from production, distribution and burning vary considerably, depending on the efforts required for site development, the production rate per borehole and the amount of methane released. In reference cases, emissions are within the range of conventional gas resources.	Geothermal energy is a renewable energy source with low CO_2 emissions. CO_2 emissions are caused primarily during the drilling process. The production phase and deconstruction of the plant account for only about 10 per cent of environmental impacts. CO_2 emissions are comparable to those of other new renewable energy sources.
Induced earthquakes	For shale gas and tight gas resources, the drilling is carried out in sedimentary rock, that is usually able to absorb the energy and deform. If the fracking fluid which is not used any more, is reinjected into the ground, this may also result in earthquakes.	Drilling is carried out in crystalline rock. The risk of inducing earthquakes is bigger than in the case of gas drilling sites. Experience regarding the stimulation of petrothermal systems is very limited. Based on new and unproved assumptions, from now on, rock stimulation by drilling should be carried out stepwise in order to reduce the risk of earthquakes. The vicinity to known fracture zones should be avoided in future projects.
Sustainability	Gas resources are fossil non-renewable resources. The typical production profile for unconventional gas resources shows a steep increase and a sharp decrease. Decline rates are about one magnitude higher than for conventional resources. They amount to a few per cent per month and 50 per cent or more within the first year. The amount of energy produced remains constant only by continuously drilling new boreholes.	Geothermal energy is a renewable energy source. Nevertheless the ground will cool down in the course of use. Therefore, a period of use has to be followed by a period of regeneration. According to studies the period of regeneration is about as long as the period of production. The exact time required for regeneration depends on the underground.
Other environmental aspects	Further negative environmental aspects include air pollution and noise due to drilling as well as due to traffic during construction, the fracking phase and deconstruction of the plant.	Noise emissions are strongest during drilling. There is no transport of energy carriers to and from the plant.