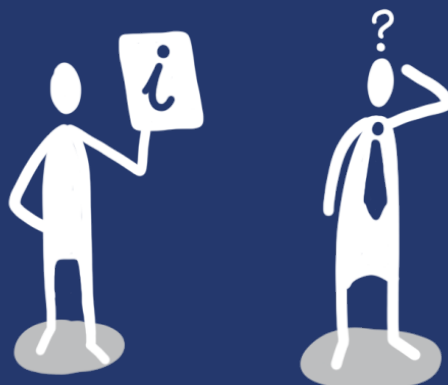




TRAINING COURSE

The PRACTICE of INFORMING POLICY through EVIDENCE



- Simulation Game: Round 1 -

Name:

Simulation Game: Round 1

Note: all data provided for this exercise are fictive and do not reflect reality in the field

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Role 1: Minister of Energy

Round 1

Your role

You are the Minister of Energy in Urland. You must make an informed decision on the application made by Drilling & Co to be granted concessions for exploratory drillings on two sites, Flat City and Boxing Town. In line with current mining legislation, Drilling & Co has enclosed a risk assessment based on its drilling experiences in the United States. The assessment concludes that exploratory drillings near Boxing Town and Flat City involve little environmental risk, and that the company's CSR policies are well equipped to deal with any unlikely calamities that might arise.

Your job is to check whether Drilling & Co's risk assessment does indeed provide sufficient evidence to justify granting the concessions and giving the company permission to start exploratory drillings. You have therefore called a meeting with experts from the government-affiliated Urland's Institute of Technology (UIT), and an expert working at the University of Urland.

The meeting is attended by five experts: three UIT experts, one expert from the University of Urland, and one expert from Drilling & Co. Also present are the Senior Policy Officer of your own ministry, your political advisor and your science advisor.

At the end of the meeting, you will decide whether or not an additional risk assessment is required in order for you to make an informed decision.

Preparation

You will listen to the statements made by the experts. Focus on the uncertainties in their presentations. Do you have sufficient and sufficiently robust evidence to grant the concessions? Do you need additional evidence?

Additional considerations.

- Your department is responsible for issuing the environmental permits currently necessary to undertake shale gas exploration and production.
- Conventional sources of natural gas in the underground are diminishing. The Urland Government therefore takes an upbeat view of the potential of indigenous shale gas resources to contribute to energy security.
- However, Urland's principal aims are to protect and improve the environment, and to promote sustainable development. If a significant amount of shale gas enters the Urland market (whether from domestic sources, imported from another country, or from the global market via LNG) it will probably discourage investment in more-expensive—but lower carbon—renewables. Urland needs to manage this risk in order to achieve its aim of generating more electricity from renewable and other low carbon sources.

Role 2: Senior Policy Officer, Ministry of Energy

Round 1

Your role

You have been working as Senior Policy Officer at the Ministry of Energy for two decades now. You are therefore considered to be an expert when it comes to multi-level and complex issues such as this. You support the minister during this meeting.

In order to properly assess the policy implications of new energy options, such as shale gas, your department has consulted a group of experts. They have focussed on the prospects of shale gas versus renewables. Based on their recommendations, you will deliver these claims:

Your claims

- Shale gas has the potential to diversify and secure energy supplies in Urland. Domestic prospects—onshore and potentially offshore—could reduce Urland's dependence on imports, but the effect on energy security is unlikely to be enormous. Energy security considerations therefore should not be the main driver of policy on the exploitation of shale gas.
- Shale gas has the potential to shift the balance in the energy markets away from low carbon electricity generation. The exploitation of large amounts of shale gas could undermine investment in renewable energy.

More details:

Renewables versus Shale Gas Some experts are concerned that the exploitation of large amounts of shale gas will undermine investment in renewable energy, adding that gas is "already threatening renewable investment, even before shale gas is considered". The Trident Centre agrees: "if money is invested in shale gas then there is a real risk that this could delay the development and deployment of zero-carbon technologies". While the Energy Committee argues that if unconventional gas production displaces high carbon fuels such as coal, there could be "reduced emissions in the short- to medium-term", it also admits that this could reduce the incentive for investment in "the low-carbon alternatives required to meet longer-term emission goals". Professor Stream of University of New City poses the question "who will commit large sums of money to expensive renewables" in a world where low carbon gas is abundant and cheap. The Energy Committee believes that if gas was to play a long-term role in Urland energy policy, this would "suggest a greater need for effective CCS [carbon capture and storage] technology for gas plants". It adds that, alongside "tighter national emission targets and policies to support innovation and deployment of low-carbon technologies", gas could be an "effective bridge to help deliver greater near- term [emissions] reductions". Professor Ken Carson, Director of the Trident Centre, questions whether shale gas could act as a "bridge" to a low-carbon economy: "We need to make that transition to renewables as a matter of some significant urgency. If that is the case, then any mechanism that takes away the incentives to move towards renewables cannot be a good deal". However, Rick Greavy—of the gas-commentary blog *No Hot Air*—claims, "Gas is low carbon. It is not zero carbon [...] we can't make the perfect the enemy of the good". The Urland Energy Company makes the case that Urland Government's commitment to

renewable energy sources would require "new, low-carbon, flexible gas-fired power plants to compensate for the intermittency of wind generation". However, they also acknowledge that this would also lock carbon into the Urland's energy system for a number of decades. As to whether shale gas and renewables could be used in parallel in order to meet climate change targets, Professor Atkins believes that it was not possible to use a fossil fuel to meet the Urland's 2°C

target. He claims that "shale gas would take about as long to deliver the Urland's targets as a lot of the renewables", while at the same time locking carbon into the energy mix. The Minister has previously stated he was "wary" about referring to gas as a "transition fuel", adding that "we have to start explaining what is going to be required in terms of emission levels and what is going to be required in terms of CCS retrofitting, so people can make investment decisions".

Role 3: Minister's political advisor

Round 1

Your role

You are the Minister's political advisor. Since elections will be held within three months from now, you are present at the meeting, to make sure that the Minister also takes into account the particular interests of his/her political party.

It is your duty to remind the Minister of the possible political sensitivities in his/her decision, given that it is election time in Urland.

The minister is a leading member of Urland's liberal democratic party. This party favours:

- Economic strategies that advocate diversification away from declining and lower value sectors, and prioritise actions that will attract higher value industries with strong growth potential.
- Enlargement of job opportunities. Since shale gas extraction is a highly sophisticated process, involving large volumes of skilled labour, the need for specialist suppliers and costly capital equipment has been proven to increase in the US. Shale gas extraction therefore offers profitable prospects to the labour market.

You claim:

The Minister should focus on the beneficial (economic) impact of shale gas exploitation. It might also lead to an increase in job opportunities.

In the US shale gas exploitation has become a major industry where a number of substantial shale plays have been exploited in the last decade.

The jobs estimates includes those directly employed within drilling/production companies, indirect jobs in the immediate supply chain and those which are induced via the expenditure of staff employed by the lead producers and their suppliers. All impacts are measured at the state level.

Various studies have researched the issue of employment and supply chain impacts in the US shale plays. The available evidence points to large scale employment creation based on the substantial US shale plays. The total number of full time equivalent jobs range from 13,000 across the state of West Virginia to 83,000 FTEs in Texas. FTE jobs in Pennsylvania is estimated at 41,000.

Role 4: Minister's science advisor

Round 1

Your role

Your task is to give the Minister of Energy strategic and operational advice on science and science policy issues.

As the Minister's scientific advisor, it is your job to try and present concepts of complexity, risk and probability in a clear, unbiased and matter of fact way so that both the public and policy maker can reach their decisions amongst options which, in the case of shale gas, are clearly about the level of risk and cost of hazard reduction.

You know that the shale gas dossier has immense complexities; indeed it is a classic example of what you call complex rather than linear science. Linear science can generate certainty; what is the speed of light, are birds the descendants of dinosaurs etc; but in climate change, in much of biology, and within the extraction of nonconventional hydrocarbons we are dealing with something very different. Precision as to any particular event or outcome cannot be achieved, what is likely to happen can only be described in terms of risk and probabilities. Science operates to try and reduce the level of uncertainty so that decisions can be made.

However, there are some facts, beyond dispute, and worth considering.

Claims:

- The knowledge of fracking is as good as it gets. The Ureland Institute of Technology has a long well respected history. It is well connected to major offshore expertise such as the US Geological survey.
- Ureland engineering science is also world class and has led the world in many life-saving and building-saving innovations.
- While there is considerable effort going in to understanding more about fracking in the United States, enough is known now to inform policy makers in terms of risk and probabilities for planning for the future.
- There is no scientific controversy about what is going on. Like any complex science, there will be large areas of absolute agreement and academic discourse about detail as clearly we still have much more to learn about the effects of fracking.

Role 5: UIT expert on impact on groundwater

Round 1

Your role

You are an expert on applied ecotoxicology from the Urdland Institute of Technology (UIT), a government laboratory. In the past, you have studied the risk of groundwater pollution caused by hydraulic fracturing. Your information is based on studies you conducted in the United States.

Your claims:

- Cementation of the steel casing in the borehole offers good protection against groundwater contamination
- While there might have been cases of well integrity failure on some US shale wells, you don't believe that such a situation would occur in Urdland. The operator is obliged to ensure that the well design is safe and fit for purpose. This obligation is checked very carefully by the Health and Safety Executive.
- How far fracturing fluids are transported laterally in aquifers lying above the gas-bearing shale formation depends on various parameters. It is not impossible that the 'leaking' of fracturing fluids might occur in Urdland. However, since groundwater is being retrieved at a maximum of 300 meter below surface, and the fracking occurs at a depth of 3.500 meter, the leaking of fracturing fluids through the artificially created fractures to other areas is highly unlikely.

More details:

(Eco)toxicological relevance of substances used

A list of chemicals used in fracturing fluids in the US was compiled for an Environmental Protection Agency (EPA) project studying the potential impacts of hydraulic fracturing on drinking water resources. It includes several hundred items.

However, only a limited number of additives are used at each site. In Northland, Outer Co. is using fracturing fluids in test-drilling operations – around 20 chemicals selected to meet the needs of each particular site. According to the EPA, hydraulic fracturing with a water volume of 11.5 million litres requires the use of 55–230 tonnes of chemical additives. This estimate matches the fracturing fluid compositions published by Outer Co.

Some of these substances are of (eco)toxicological concern: they are classified as toxic to the aquatic environment, toxic to humans, carcinogenic, mutagenic and/or toxic to reproduction. In a statement issued in 2011, the Northland Federal Environment Agency (NFEA) focuses, by way of example, on two additives used in Northland (octylphenol ethoxylates and petroleum). At wastewater treatment plants and in the environment, octylphenol ethoxylates (used as surfactants) are partly converted to octylphenol, which can disrupt the endocrine system in fish and adversely affect reproduction. Petroleum distillate

hydrotreated light is a substance of variable composition, whose risk potential varies accordingly. Other substances used – biocides (e.g. isothiazolinones), cross-linking agents (e.g. borates or methanol) and breakers (e.g. sodium bromate) – may also be toxic to humans and the environment. However, given the low percentage of additives in fracturing fluids, the mixtures themselves are not generally to be classified as hazardous.

In general, only limited information is available on the additives; the biocides used in the US have not yet been registered for this application under IC chemicals legislation.

Potential for groundwater contamination

In hydraulic fracturing – as in conventional gas production – operational failures may lead to contamination of groundwater or surface waters. There are three possible sources of contamination:

- the fracturing fluids described above
- extracted shale gas itself
- water returned to the surface during production, known as “produced water” (containing dissolved, in some cases toxic, substances occurring naturally in the target formations, e.g. uranium, radium, arsenic, sulphur) and salts.

Contaminants from all three sources may reach aquifers by passing through leaks in the casing or flowing upwards outside the casing – the most likely pathway for groundwater contamination according to you. Cementation of the steel casing in the borehole offers good protection against contamination via this pathway. The US EPA has stated that proper well construction is "essential for isolating the production zone from USDWs [underground sources of drinking water], and includes drilling a hole, installing a steel pipe [casing] and cementing the pipe in place". In the US, this has not been implemented at all shale gas drilling sites, and contamination of drinking water with methane has occurred via this route.

While there might have been cases of well integrity failure on some US shale wells, the Energy Committee "does not believe that such a situation would occur in Urland". The operator is obliged to ensure that the well design is "safe and fit for purpose". This obligation is "checked very carefully by the Health and Safety Executive".

Contamination of aquifers may also occur via disused boreholes. Even under high pressure, the spread of fracturing fluids and produced water during the fracturing process only amounts to tens of metres. Thus, unlike shale gas itself, vertical transport beyond these distances is not to be expected during hydraulic fracturing.

How far fracturing fluids are transported laterally in aquifers lying above the gas-bearing shale formation depends on the usual parameters, such as the porosity of the strata, or on exchange processes between the aquifer and solid rock. It is therefore not impossible that the ‘leaking’ of fracturing fluids might occur in Urland. However, since groundwater is being retrieved at a maximum of 300 meter below surface, and the fracking occurs at a depth of 3.500 meter, the leaking of fracturing fluids through the artificially created fractures to other areas is highly unlikely.

Role 6: UIT expert on shale gas estimates

Round 1

Your role

You have worked in the statistical department of the Urland Institute of Technology (UIT), a government laboratory, for seven years. Three weeks ago, the Ministry of Energy asked your team to provide an estimate of the amount of shale gas that it would be economically viable for Urland to extract. It turns out, however, that very little evidence is available.

You have therefore made a quick summary of the evidence concerning shale gas estimates worldwide.

Your claims:

- shale gas could increase Urland's gas reserves with approximately 37 %
- however, there is no clear consensus on these numbers; it is very hard to work out precisely how large the reserves are

More details:

Urland Shale Gas Estimates

There have been estimates that Urland could be producing 10% of its current gas needs from shale gas if it could be extracted at a commercial rate.

The Urlish Geological Survey (UGS) on the other hand, noted that this figure was based on figures from the US a year ago, when "shale gas contributed about 10% of their needs", which in 10 years' time would be "30% or more". More recently they estimated that—by analogy with similar producing shales in the US— Urland's shale gas reserve potential could be as large as 150 bcm (billion cubic metres). This is equivalent to approximately 1.5 years of Urland's current gas consumption, or 15 years of Urland's current LNG (liquefied natural gas) imports. This would imply an increase in Urland's gas reserves with approximately 37%.

However, the Barnett Shale in the US—which was used as an analogy for Urland shale potential in the UGS's calculation—is described by the Trident Centre as "an above-average producer due to its low clay content which allow fractures to form more easily".

In April 2011 the US Department of Energy's independent statistical and analytical agency, the Energy Information Administration (EIA) published their report *World Shale Gas Resources: An Initial Assessment of 14 Regions around the United States*. This report estimated that Urland had 20 trillion cubic feet of technically recoverable shale gas resources, or 560 bcm. This is equivalent to 5.6 years' of Urland's current gas consumption, or 56 years' worth of LNG imports. The EIA estimated that in the Inside Countries, the two most promising countries were Coland (3,740 bcm) and Middle Land (3,600 bcm), while globally the US (17,240 bcm) and Old Land (25,500 bcm) have the largest estimated technically recoverable shale gas resources. The report estimate that shale gas could increase world technically

recoverable gas resources by 40% to approximately 452,000 bcm.

However, the Geological Society of New City admitted that "there is currently no clear consensus within the Earth Science community regarding the quantity of these [unconventional] resources" either in Urland or the Inside Countries.

Professor Seldon of Colonial College New City claims that one of the problems with a lot of non-conventional petroleum—oil and gas—is it is very hard to work out the reserves. The Geological Society believed that further research will improve understanding, "for example, by helping identify 'sweet spots' in gas plays".

The Urlish Geological Survey (UGS) believed that the lowest shale gas exploration risk lies where "source rocks have accompanying conventional hydrocarbon [oil and gas] fields". An inventory shows that there are a number of formations with shale gas potential in Urland. Shales in the Carboniferous (Epen shale) and the Jurassic (Posidonia and Kimmeridge shale) are thought to have the highest potential. It is assumed that the gas occurs adsorbed (in clay minerals and organic matter) and as free gas (in fractures and pores).

Drilling & Co pointed out that "these same shales are the source of hydrocarbons found in most of Urland's conventional oil and gas". With regard to this, the UGS noted that as conventional and unconventional sources of oil and gas both derive from the same source rocks, there will be some relationship between their productions.

Regarding the potential amounts available, Rick Greavy—of gas policy website *No Hot Air*—states,

"I do not think people really quite understand the amounts of gas that are available [...] the United States, from 2007 to 2009, increased their estimates of available resources by 40% over two years [...] we may even be looking to an increase on that".

An expert of the University of New City claims that, "In terms of the global impact of shale [...] it is a know at the moment".

Box 1—Units and Equivalents

The UGS estimated that—by analogy with similar producing shales in the US—Urland's shale gas reserve potential could be as large as 150 bcm [billion cubic metres]. This is very large compared with the 2-6 bcm estimate of undiscovered onshore conventional petroleum.

In 2009 Urland total demand for natural gas was approximately 1,000,000 GWh [giga/billion Watt-hours] of energy. This was equivalent to approximately 100 bcm. So Urland shale gas reserve potential was equivalent to approximately 1.5 years of Urland's current gas consumption.

National statistics stated that in 2009 Urland imported 110,579 GWh of liquefied natural gas [LNG]. This was equivalent to approximately 10 bcm. So Urland shale gas reserve potential could replace LNG imports for approximately 15 years.

Current wholesale gas prices are approximately 53p/therm. This would mean that 150 bcm of gas was worth approximately £28 billion. If the Government takes approximately one third of this in tax, Urland gets about £9 billion.

1 tcm = 1 trillion cubic metres = 1000 bcm 1tcf = 1 trillion cubic feet = 28 bcm

Role 7: Drilling & co Chief scientist

Round 1

Your role

You are the chief Scientist of Drilling and co. You are a member of the top management of the company. You have a strong scientific background. You are a strong proponent of shale gas.

Your main objective is to ensure that your Drilling and co is allowed to explore and ultimately exploit shale gas in Urland as it is a huge business opportunity for Drilling & co and you expect an important profit stream.

One of the issues on the table are seismic risks and you happen to have started your career in the company as a seismic engineer. But now you are in a strategic management position.

In April, a tremor measuring 2.3 on the Richter scale was felt in the Whitewell seaside resort, followed by an event in May that measured 1.5 on the scale. Immediately the question arose whether these ‘minor seismic events’ (as you called them) were triggered by the hydraulic fracturing of Drilling & Co’s Preese Hall-1 well. You decided that drilling would not restart until the events in Whitewell had been investigated.

Drilling and co set up an internal research team that was set up to investigate the tremors and which reported to you as Chief Scientist.

Your claims:

- Shale gas is a huge opportunity for Urland.
- Drilling & co is the ideal partner for Urland's government in the development of shale gas exploration and exploitation. It is a big company, with a long history and demonstrated track record in fossil fuel extraction, in particular shale gas.
- On seismic risks: The seismic events were due to an unusual combination of geology at the well site coupled with the pressure exerted by water injection as part of operations. This combination of geological factors was extremely rare and would be unlikely to occur together again at future well sites.

More details

This is a summary of the results. (Source: *Drilling & Co – synthesis report “Geomechanical study of Shale seismicity”, 2011*)

Over the past decades, experience gained from mapping hundreds of hydraulic fracture treatments with downhole geophones has shown that seismic events induced by these fracture treatments normally have a magnitude much lower than 0 on the Richter scale. That is the reason for using downhole receivers, since these events are hard to detect at the surface.

Stronger events occur when some of the fluid penetrates into faults and in rare cases, events with magnitude up to 0.8 ML have been detected. Another observation is that injection volume has an influence on micro-seismic magnitude: larger injected fluid volumes tend to yield stronger events. However, even mapping of many treatments in US shale plays has only shown events up to 0.8 ML for a treatment volume of 15,000 bbls. There are only two documented cases of a hydro-frac treatment causing events up to magnitude 1.9 ML and 2.8 MD, respectively (from massive hydro-frac treatments in Oklahoma).

The seismic events observed after two treatments in the Preese Hall well are therefore quite exceptional. Two events reported by BGS (magnitudes 2.3 and 1.5) and 48 much weaker events have been detected, and it is therefore hard to dismiss them as an isolated incident. The observed events are already 2 orders of magnitude stronger than normally observed from hydraulic fracturing induced seismicity and if future stimulation treatments again induce seismicity, it is imperative that the maximum magnitude can be estimated. It only appears feasible to establish an upper bound on the seismic magnitude if the estimation of that bound can be based on a clear understanding of the mechanism behind the past events.

Based on a careful technical analysis of all available data, we conclude that many factors coincided to induce these seismic events, which are unusual for stimulation treatments. Since the chance for any single factor to occur is small, the combined probability of a repeat occurrence of a fracture induced seismic event with similar magnitude is quite low.

Seismic data interpretation

A catalogue of all seismic activity has been compiled consisting of 50 events. The timing of the events shows that the process driving the events has a time scale of many hours. So, it is unlikely that the actual opening of the hydraulic fractures induced the events, since the elastic response would be immediate. Fluid pressure on the fault, however, has a natural time scale, depending on fault transmissibility and storage, which does fit the observed time delay.

Seismic magnitude and hazard

Based on the physical model, which is calibrated on the observed seismicity, the maximum magnitude which can be expected for future treatments can be estimated; that is to say, treatments that would be repeated under almost the same geologic conditions as encountered in the Preese Hall well. For instance, it is unlikely that another well will encounter a similar fault with the same critical stresses and high transmissibility into which fluid can be pumped. However, even with such an unlikely scenario the maximum magnitude is likely to not exceed ML=3, based on the modelling of the seismicity. Based on the ground motion observed in the Preese Hall seismic events, the ground motion which could be expected for future events can be accurately predicted.

This analysis provides the basis for a traffic light system that can be used for mitigating the chance of an earthquake exceeding the safe limit.

Conclusions

It is highly probable that the hydraulic fracturing of Preese Hall-1 well did trigger a number of minor seismic events.

- None of the events recorded, including one in April of 2.3 and one in May of 1.5 on the Richter scale, had any structural impact on the surface above.
- The seismic events were due to an unusual combination of geology at the well site coupled with the pressure exerted by water injection as part of operations.
- This combination of geological factors was extremely rare and would be unlikely to occur together again at future well sites.
- If these factors were to combine again in the future local geology limits seismic events to around magnitude 3 on the Richter scale as a “worst-case scenario”.
- water injection operations take place very far below the earth’s surface which significantly reduces the likelihood of a seismic event of less than 3 on the Richter scale having any impact at all on the surface.

Role 8: Expert on economic impacts of shale gas

Round 1

Your role

You are professor of Economy at the University of Urland. You have studied the economic impact shale gas exploitation might have on the Urland economy.

Your claims:

- The impacts of international shale gas developments on Urland are expected to be limited and gradual, and not similar to the recent shale gas boom in the United States.
- It is not certain that there will be a positive business case for shale gas production in Urland. The potential volume and quality of production can only be estimated after exploratory drilling.
- Current trends in the Urland electricity sector (a shift from gas to coal) and in the chemical industry (deteriorating competitive situation) can only be linked to shale gas developments to a limited extent. Other drivers, such as lower volatility in gas market prices, a low carbon price and geographical shifts in demand for chemical products are likely to be more important.
- If the United States starts exporting shale-gas in larger volumes, the most likely destination for this gas is Asia (and in particular Japan) - as the business case for export to Asia in the foreseeable future is much stronger than for export to Urland.
- The cost and revenue assumptions on shale gas production in Urland are very uncertain. Available evidence cannot confirm, nor deny a positive business case for production. Shale gas will produce positive short terms incomes for the Urland state treasury. This income is countered by a variety of potential social costs and the decision of the relative benefits of these is political.
- Shale gas production in Urland will have a direct positive impact on the Urland treasury through the participation of state-owned EBN in any production activities.
- An indirect positive impact will occur as a result of the taxation of the profits of commercial activities. In addition to this shale gas production will induce some direct and indirect employment, although there is substantial variation between sources on the estimated scale of this.
- On the other side, shale gas production can lead to additional CO₂ emissions (depending on with which 'baseline' shale gas is compared), as well as to additional land and water use.
- The Urland government needs to take a sovereign national decision on whether or not to allow shale gas exploration and production in Urland. Such a decision can only be taken in the wider context of energy and socio-economic policies, including considerations about longer- term energy transition and green growth strategies.