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Would Implementing Responsible Care® Principles Improve the Safety of the Fracking Industry?

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Abstract: Fracking is an industrial activity and like all industrial activities, it can have positive and negative impacts on the environment and society. The debate would benefit from a discussion of the risks and an analysis of the means for their mitigation. To this end, we describe of the principles of ethics of Responsible Care®, first formulated in Canada by the now Chemical Industry Association of Canada, could improve the performance of the industry and gain public trust in the process.

Introduction

Hydraulic fracturing to extract shale gas has been a topic of ongoing public and policy debate (Gosman et al. 2012). Fracking is an "Industrial activity" and like all industrial activities, it can have positive and negative impacts on the environment and society. The debate would benefit from a quantification of the risks and an analysis of the means for their mitigation. We provide a brief overview of the history of hydraulic fracturing, recent technological advancements, policy responses, and recommendations on how to mitigate the actual and perceived risk of fracking.

Hydraulic fracturing operations have been ongoing since the 1940's. Historically fracking operations targeted conventional gas, which is normally located 500 to 2,000 feet below ground level and typically extracted using short vertical wells [1]. Horizontal drilling was introduced in the 1980's, but has not been extensively applied in North America until recent years (Michigan Department of Environmental Quality, 2013; Gosman et al., 2012). With the technological advancements in horizontal drilling, deep shale developments have become financially feasible to access, but the perceived, unknown, and possible risks have received much public scrutiny (Gosman et al., 2012; Mooney, 2011). In Canada there has been over 175,000 wells have been hydraulically fractured, and of those wells approximately 14,000 of them were horizontal systems primarily located in remote locations in Western Canada (Rivard et al. 2013).

Over the last decade there have been federal regulatory changes to energy policy in Canada and the U.S., with the intentions of streamlining the environmental regulatory processes. Regulatory changes place majority of the responsibility for regulating these operations on the individual states and provinces. Many of the states in the US have a long history of hydraulic fracturing and have established strong regulatory protocols to minimize the risk associated with these operations. This has been politically provocative because while Quebec, Nova Scotia, New Brunswick and New York have anti-fracking bans in place (Canadians.org n.d.) , in March 2015 the Liberal government quickly rejected the bill proposing a moratorium on high volume hydraulic fracturing in Ontario (Leslie, 2015); which is closely aligned with Michigan, Ohio and Pennsylvania position to allow deep shale drilling (Gosman et al., 2012).

Anti-fracking bans resulted from environmental campaigning and a strong citizen-based movement (Minkow, 2015). It appears this problem stemmed from lack of transparency, and lack of industry trust. There is clearly public pressure for the hydraulic fracturing industry to focus on earning and maintaining their "social licence to operate" (Smith & Richards, 2015). Since most of the concerns around hydraulic fracturing have stemmed from the chemicals involved in the process, we will propose

[1] http://www.livescience.com/34464-what-is-fracking.html

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that the fracturing industry considers implementing the principles of Responsible Care® to help maintain their social licence to operate. In the 1980s, pressures to regulate Canada's chemistry industry were growing, galvanized by spills, process safety, and transportation incidents in Canada and abroad. Canada's chemistry industry understood that they did not have the public trust. Building public trust would require something above and beyond the law. Between 1985 and 1988, members of the Chemistry Industry Association of Canada (then known as the Canadian Chemical Producers' Association) drafted the first Responsible Care® (RC©) Codes – including stringent guidelines for the safe and environmentally sound management of chemicals[2].

This movement represents a progressive shift within the chemical industry that focuses on the transition from being compliance focused to a more ethically driven framework (Topalovic&Krantzberg, 2014). We elaborate further on RC© and it's approach later in this paper.

Fracturing to extract natural gas is often viewed in one of two ways in terms of environmental impact. One perspective is that fracturing of horizontal systems to extract natural gas is a more environmentally friendly alternative when compared to other fossil fuels. "Natural gas development is acknowledged to have a far smaller land use impact compared to coal mining and thermal coal power plant siting, fewer impacts on safety and occupational health, and smaller pollution impacts in its production compared to coal" (Canadian Council of Academics, 2014, pg 100).

The other perspective is that the use of natural gas locks society into fossil fuel dependent infrastructure (Canadian Council of Academics, 2014). In regards to the environmental risks, there are seven main environmental considerations associated with hydraulic fracturing of horizontal wells, which include; water quality, water contamination, fracking fluid and flow back management, radioactive waste, nuisances associated with increased activity in the area, emissions and air quality and seismic concerns (Rivard et. al. 2013).

Water Resource Consumption

One of the main concerns around fracturing horizontal wells is that the process requires considerably more water and sand being pumped at higher pressures, when compared to vertical well fracturing (Rivard et al. 2013; Mielke, et al. 2010). However, since one horizontal well often replaces multiple vertical wells, and there are often multiple horizontal wells on every well pad, the resource consumption rates often results in a lower net water consumption rate compared to other forms of energy. Further, water consumption rates vary considerably from well to well (Jenner & Lamadrid, 2013). Based on Canadian and US statistics, the water-intensity rate is between 0.6 to 1.8 gal/MMBtu. While there is little information comparing the water-intensity between vertical to horizontal wells, there is information comparing shale gas to other fossil fuels, as detailed in Figure 1 (Mielke et al. 2010). Based on Mielke et al's (2010) life cycle assessment, which includes the extraction, transportation and processing of various fossil fuels in North America, Natural Shale Gas has the lowest water consumption per MMBtu.

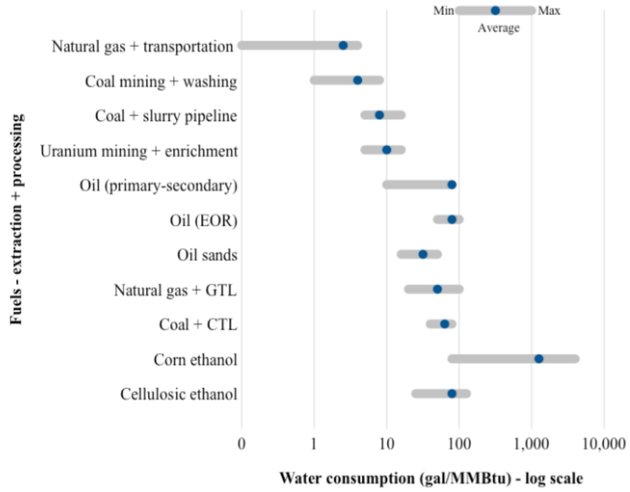

Figure 1.Mielke et al's (2010) life cycle assessment, which includes the extraction, transportation and processing of various fossil fuels in North America.

While the water-intensity per unit of energy is comparatively low, this process requires the water quantity for the life of the well within a time span of two to five days prior to production. This front-loaded water consumption requirement can be problematic based on water availability (Mielke et al. 2010; Rivard et al. 2013). This is a unique problem because most water intensive industrial processes return the process water back into the environment. In this case, since the process water for hydraulic fracturing is either lost in the well or disposed of in a disposal injection wells, it is not returned to the ecosystem it was withdrawn from, which has the potential to have negative impacts on the hydrological cycle (Council of Canadian Academies, 2014). There have, however, been technological advancements to minimize the water requirements for

[2] http://www.canadianchemistry.ca/responsible_care/index.php/en/responsible-care-history

these processes. Companies have now started using brackish and saline water, which minimizes the strain on freshwater resources. In addition, since there are various horizontal wells on each well pad, the fracking fluid can often be recycled for multiple wells (Mielke et al. 2010; Rivard et al. 2013).It is also important to recognize not all shale formations respond well to water such as the Colorado Group in Southern Alberta and Saskatchewan or the Montney Play in Northern BC, therefore water is often substituted by alternative materials such as CO2, nitrogen or a propane and butane mixture (NEB, 2009).

While best practices can mitigate water quantity impacts, there are still risks of potential impacts, including aquifer depletion, interference with wetland and water dependent ecosystems, and disruptions to natural steam flow (Sumi, 2010). As a consequence, most states and provinces require oil and gas companies to obtain surface land access lease agreements and water withdrawal permits (Rivard et al. 2013). Even with some regulatory controls in place; water limitations have been the source of both collaboration and conflict. For example, the Montney gas field near Dawson's Creek BC had approximately 885 wells in 2011, and the surrounding community relies on the Kiskatinaw River for water. This is a positive example of a collaborative effort between industry, academia, government and the community, to properly management water within this watershed (Council of Canadian Academies, 2014). On the other hand, an unfortunate example of conflict that has resulted from water constraints is revealed through the litigation that has occurred between the Fort Nelson First Nations community and the Nexen Inc., EOG Resources Canada Inc. and Devon Canada Corporation. This legal action resulted in a suspension of a water licences to protect the Tsea River Watershed in Fort Nelson BC (BC Environmental Appeal Board, 2012).

Water Contamination

Contamination of surface and ground water has been a growing concern associated with fracking. Approximately 98 to 99.5% percent of fracking fluid is made up of water and sand, with the remaining 2 to 0.5% being composed of chemical additives. While chemical additives only make up a small percentage of the total fracturing fluid, these additives could be particularly potent toxicants. Drilling fluid comprises of a variety of contaminants, which can result in high levels of dissolved solids such as salts and trace metals that can have significant environmental impacts (FracFocus Chemical Disclosure Registry, 2016; Gosman et al. 2012). As well, conceivably one of the biggest risks is the result of having large quantities of undiluted chemical additives stored on site, which require appropriate management and spills response plans.

Ground water contamination can be caused if the integrity of the first vertical section of the well is compromised. The main ground water concern is specifically throughout the first vertical section of the wellbore because this section goes below the ground water zone. Since horizontal wells reach depths normally more than a mile below the water table, and the fracturing process only takes place within the horizontal section, the risk of ground water contamination from this section is possibly rather limited (FracFocus Chemical Disclosure Registry, 2016; Rivard et al., 2013). Most states and provinces have strict regulatory requirements regarding the well composition, construction processes and integrity testing, therefore appropriate regulatory controls are an effective way to minimizes the risk of ground water contamination (FracFocus Chemical Disclosure Registry, 2016; Gosman et al. 2012; Rivard et al., 2013). As an example, in Alberta and British Columbia wastewater is stored in enclosed tanks with secondary containment to minimize the risk of contamination (Rivard et al., 2013), since even double lined ponds are rarely ever free of flaws and precipitation can cause ponds and open top tanks to overflow (Council of Canadian Academics, 2014).

Another significant threat to surface water and ground water is the result of improper fracture fluid management on the surface level, which can occur as a result of a tank failure, compromised pit liners or damaged lines carrying fluid. There are various practices used to minimize these risks depending on the fluid being contained, including: pit liners (compacted clay or synthetic materials), secondary containment, surface water setback limits, and restrictions on pits that intersect with the water table. Regulations regarding pits and water protection requirements vary by state and province (FracFocus Chemical Disclosure Registry, 2016; Rivard et al. 2013) and the selection of the most rigorously protective could be a result of adopting the RC© principles and ethics (Topalovic&Krantzberg, 2014).

Hazardous Waste Management

After the fracturing process takes place there can be a phenomenon known as flowback, fluid that flows out of the well following the well stimulation, that can range from 3 to 80% of the volume pumped into the wellbore. As mentioned earlier this fluid often contains high levels of dissolved solids present within the formation. Technological advancements have been made to recycle and/or treat fracking fluid so it can be reused for additional fracking operations or disposed of in a more environmentally friendly manner. The most common method of disposal is by placing the waste in an injection well or a deep saline aquifer, however the regulations around waste composition and the lining of injection wells varies by state and province (FracFocus Chemic Disclosure Registry, 2016; Gosman et al., 2012). Injection wells are considered the most low risk option because municipal wastewater facilities are unable to properly treat this wastewater because of the unique composition. (FracFocus Chemical Disclosure Registry, 2016; Gosman et al. 2012;Sumi, 2010).Treatment options have also been explored, and include reverse osmosis, thermal distillation and crystallization (Gregory et al., 2011; Council of Canadian Academics, 2014).

Nuisances, Emissions and Air Quality

One of the major sources of nuisances and air emissions is attributed to the large amount of equipment activity required for the process. The equipment required for the fracturing process includes fracture fluid storage tanks, chemical additive trucks, sand storage units, a blending unit, pumping equipment and the data monitoring van. In addition, large amounts of fugitive air emission are generated during the fracturing process and flowback containment phase .After a system is hydraulically fractured there is often a large amount of GHG emissions released with flowback fluids (Osborne et al. 2011). Often flowback is stored onsite in either tanks or in lined or unlined ponds, where the gas released from the waste fluid is typically vented or flared. However, with technological advancements related to reduced emissions completions, gas emission reductions of 90% can be achieved (Council of Canadian Academics, 2014). In addition, there have been reports of methane contaminating private water supplies and flowing up through the ground, as the result of abandoned wells and newly fractured systems (Sumi, 2010; Jackson et al. 2013).

There is conflicting evidence associated with air emission related to shale gas production and utilization. Every well and shale gas formation has different characteristics; therefore the environmental impact of wells varies considerably based on the unique site conditions. There are two main perspectives taken regarding the shale gas GHG emission (methane in particular) debate. From one perspective shale gas produces less GHG emission when compared to coal and oil, therefore it can be viewed as a more sustainable alternative to more traditional fossil fuels. The other perspective is that it may produce less emission than traditional fossil fuels; but it also promotes the development of high-carbon infrastructure, which displaces other alternative energy sources (Council of Canadian Academies, 2014). Since there is significant variability between each well, the shale formation characteristics, fracturing fluids composition and regulatory practices, the research on GHG emissions is inconstant and limited. However, methane has a Global Warming Potential that can be as high as 72 times more potent than CO2 over a 20 year timeframe (Peduzzi et al., 2012).

The British Columbia government has been encouraging shale gas extraction companies to implement carbon capture and sequestration strategies. Strategies include disposing of CO2 in deep formation or using it for enhanced oil recovery projects in close proximity (NEB, 2009). In Canada there are strong federal and provincial regulations governing industrial air emissions, however these regulations are not specific to shale gas (Rivard et al., 2013). The shale gas industry could use the principles and ethics of RC© (doing the right thing) to drive continuous improvement with regards to air emission initiatives (Topalovic&Krantzberg, 2014).

Seismic Concerns

Lastly there are concerns related to micro-seismic events induced by hydraulic fracturing activities. It has been proven hydraulic fracturing and wastewater injection can result in seismic activity, though no damage has been reported as a result of the seismic activity (Rivard et al., 2013). Minor-seismic events is a low risk concern, the risk can be further minimized by careful site selection, management and monitoring (Council of Canadian Academies, 2014).

Current Policy Situation

In eastern Canada, regulations are promulgate by the Departments of Mines and Energy for New Brunswick, by Natural Resources for Quebec, and by Energy for Nova Scotia, related to exploration and drilling activities and through the Environment and Climate Change Canada regarding environmental issues, including water withdrawals, water and air quality, gas flaring and authorization or permits for fracking operations. In the British Columnbia and Albera, regulated authority has been delegated to single institutions (BC Oil and Gas Commission and Alberta Energy Regulator, formerly ERCB) (Rivard et al., 2013)

In keeping with the Energy Policy Act of 2005, the U.S. Environmental Protection Agency (EPA) published a final rule in 2006 that exempts stormwater discharges of sediment from construction activities at oil and gas exploration and production operations from the requirement to obtain a National Pollutant Discharge Elimination System (NPDES)

."(FracFocus Chemical Disclosure Registry, 2016) as long as stormwater runoff to waters under the jurisdiction of the CWA are not contaminated with oil, grease, or hazardous substances. With this exemption, EPA in effect encouraged the oil and natural gas industry to develop and implement Best Management Practices (BMPs) to minimize the discharges of pollutants to stormwater both during and after construction activities.

Social Considerations

The public has a right to be informed about industrial activities that have the potential to impact their health and environment. The Council of Canadian Academies (2014) call for the consideration of potential impacts of shale gas development, as well as strategies to manage these impacts, in the context of local concerns and values. The manner in which residents are engaged in decisions concerning shale gas development will be an important determinant of their acceptance or rejection of this development. Public acceptance of large-scale shale gas development will not be gained through industry claims of technological prowess or through government assurances that environmental effects are acceptable. It will be gained by transparent and credible monitoring of the environmental impacts (Council of Canadian Academies, 2014)

In the US, Texas Governor Rick Perry in his ''Energy Plan'', stated his desire to expand drilling as soon as possible. Governor Romney, former presidential candidate also supported shale gas development. By contrast, the State of New York has a moratorium in place (Oppel, 2011). Likely, the solution lies somewhere between these extremes (Jenner &Lamadrid, 2013).

Kralovic (2011) asserts that while fracking is a very important component in the development of shale gas availability, it is also a politically-charged topic. While shale gas is often perceived as an unknown entity, as are the technologies used to produce the resource, he contends that the perception is incorrect.

Economic Considerations

Producing petroleum products in close proximity to where they will be used reduces the dependence on foreign imports and reduces the environmental impacts and risks associated with those operations. Since the significant increase in fracking that started in 2013, gas prices dropped by 47% in the US. Since 2013 energy consumers in the US have experienced economic gains of $74 billion per year (Brooking Institute, 2015).

Early adopters including Texas, Oklahoma, and Pennsylvania put emphasized economic development, job creation, and state income. Yet empirical evidence for the economic benefits so far remains thin. A study on the economic impacts of the Marcellus shale in Pennsylvania indicated that benefits were not as high as earlier predicted. Furthermore, only half of the benefits remained in the hands of local citizens, the other part flowing to landowners living elsewhere and the state (Kelsey, Shields, Ladlee, & Ward, 2011). We note that even among big-time producing states, significant differences in environmental regulation have been reported, e.g., between Texas and Colorado (Davis, 2012). States such as New York, Delaware, and Vermont, have been reluctant to let the industry steer the process, with New Jersey passing and Vermont discussing an outright ban on shale gas exploitation. These states emphasize heavily contested environmental concerns over polluted drinking water, anthropogenic seismicity, and the overall carbon footprint of shale gas. A Cornell study concluded that shale gas has a significantly larger footprint than conventional gas due to methane emissions with flowback fluids and from drill-out of wells during well completion (Howarth, Santoro, &Ingraffea, 2011). Yet these conclusions have been disputed, notably by scholars of that same university, who pointed out that the analysis was "seriously flawed" and "overestimated the fugitive emissions associated with unconventional gas extraction" (Cathles, Brown, Taam, & Hunter, 2011). It is worth keeping in mind that "fugitive methane" is gas that escapes because of faulty application of long-used oil and gas drilling technologies (e.g., cracked well casings).

Still, natural gas plays an important role in the Canadian economy, meeting over 30 per cent of Canada's energy needs and representing a large source of export revenues (Statistics Canada, 2012). It is used extensively in residential, commercial, and industrial markets and, to a lesser extent, for power generation. Natural gas burns more cleanly than do other fossil fuels, emitting fewer air pollutants and less carbon dioxide (about half that of coal), thus contributing less per unit of energy to the GHG emissions (EIA, 1998). (Council of Canadian Academics, 2014).

Responsible Care

While technology is still well in the development phase, we argue that now is the time to adopt the principles of doing no harm, as exemplified by the chemical industry ethic of "Responsible Care©". This initiative would help the fracking industry increase its attention to best practices, continuous improvement, and transparency and help build-up stakeholder trust.

Responsible Care© is the chemical industry's global initiative to drive continuous improvement and achieve excellence in environmental, health, safety and security performance (Topalovic&Krantzberg, 2014). Since there is a great deal of ambiguity around chemical additives in the fracking industry, the principles of responsible care could be help the industry establish a stronger "social licence to operate". The Responsible Care® Ethic and Principles for Sustainability are as follows (http://www.canadianchemistry.ca/responsible_care/index.php/en/our-commitment)

We are committed to do the right thing, and be seen to do the right thing.

We dedicate ourselves, our technology and our business practices to sustainability - the betterment of society, the environment and the economy. The principles of Responsible Care® are key to our business success, and compel us to:
work for the improvement of people's lives and the environment, while striving to do no harm;
be accountable and responsive to the public, especially our local communities, who have the right to understand the risks and benefits of what we do;
take preventative action to protect health and the environment;
innovate for safer products and processes that conserve resources and provide enhanced value;
engage with our business partners to ensure the stewardship and security of our products, services and raw materials throughout their life-cycles;
understand and meet expectations for social responsibility;
work with all stakeholders for public policy and standards that enhance sustainability, act to advance legal requirements and meet or exceed their letter and spirit;
promote awareness of Responsible Care, and inspire others to commit to these principles

In relation to these principles, the Council of Canadian Academies (2014, pg xix) note:
"The shale gas industry has made considerable progress over the past decade in reducing water use by recycling, reducing land disruption by concentrating more wells at each drilling site, reducing the volumes of the toxic chemicals it uses, and reducing methane emissions during well completions. Other impacts, however, such as cumulative effects on land, fugitive GHG emissions, and groundwater contamination, are more problematic. This is the case because available mitigation technologies are untested and may not be sufficient; scientific understanding is incomplete; and the design of an adequate regulatory framework is hampered by limited information. Shale gas development poses particular challenges for governance because the benefits are mostly regional whereas adverse impacts are mostly local and cut across several layers of government."

An effective framework for managing the risks posed by shale gas development, linked to the RC ® ethic and principles would include that:
(i) Technologies to develop and produce shale gas employ equipment and products that adequately designed, installed, tested and maintained for reliability to improve the pursuit of "doing no harm"
(ii) The safety of equipment and processes associated with the development and operation of shale gas sites be comprehensive and rigorous as a demonstration of preventative action to protect health and the environment.
(iii) Rules to govern the development of shale gas be based on science-based and, outcome-based principles, with the requirement for measuring and reporting on performance, inspection, and enforcement of RC principles.
(iv) Public engagement be of a nature to go beyond informing local residents, but real consultation to reflect and address their concerns, and to earn their trust, not only do the right thing, but to be seen to be doing the right thing in a transparent manner.

We now provide specific examples of where the ethic of doing no harm would apply.

Actual vs Perceived Risks -

One of the primary societal concerns is the perceived risk of chemical additives in the fracturing fluid contaminating ground water. This perceived risk is heightened because of the ambiguity around the drilling and fracking process, the chemical additives being used and the safety precautions being taken to minimize the risk. The perceived risk could be lowered when one considers wells are being drilled to target shale gas between 2000 feet to 9000 feet below ground level. The vertical section of the well that is within the groundwater zone has two metal casings, with a dividing layer of concrete. While there are thousands of chemical additives with various effects used to make fracking fluid, it is the potency of these chemicals and the potential to penetrate drinking water though cracks in the well casings that needs to be clarified and addressed using the ethic of doing no harm, under RC®.

Well Construction Process

To properly understand the actual and perceived levels of risk from hydraulic fracturing, requires an understanding of the well construction process.

Modern wells in North America are often constructed out of steel casings and cement. Casings, sometimes referred to as casing strings, are hollow steel pipes that line the hole being drilled. The American Petroleum Institute has established industry standards that specify the length, thickness, tensile strength and composition of steel castings based on the specific situational characteristics. The American Petroleum Institute has also established industry standards for cement types, however Class A Portland cement is the most common. Casing requirements and cement composition can vary based on the well section, site-specific characteristics, and regulatory requirements (FracFocus Chemical Disclosure Registry, 2016). Mechanisms are needed to ensure such standards are stringently enforced. The RC® ethic would push companies to go beyond such standards. The RC© ethic would require an objective evaluation of the most protective approach and require that as the industry standard.

Fracturing Fluid

To support the well stimulation phase a variety of equipment is arranged on the well pad, including; fracture fluid storage tanks, chemical additive trucks, sand storage units, a blending unit, pumping equipment and the data monitoring van. Fracturing fluid is often contained in tanks, but on occasion can be placed in a lined or unlined pit. The biggest threat to surface water and ground water is the result of improper fracture fluid management on the surface level, which can occurs as a result of a tank failure, compromised pit liners or damaged lines carrying fluid. There are various practices used to minimize these risks and the selection of the most rigorously protective could be a result of adopting the RC© principles and ethics.

Conclusions

Anti-fracking bans have emerged from resulted from environmental campaigns based on strong citizen-based concerns. This perceived risks are in part due to a lack of transparency resulting in a lack of industry trust. There is clearly public pressure for the hydraulic fracturing industry to focus on earning their “social licence to operate”. Since most of the concerns around hydraulic fracturing have stemmed from well construction, chemicals, and the potential to compromise drinking water in particular, we will propose that the fracturing industry considers implementing the principles of Responsible Care® to help secure and sustain their social licence to operate.

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