On a Possible Sustainable Petroleum Asssociated Gas Utilization in the Kashagan and Tengiz Regions, Kazakhstan

Ch. Lee[1], K. Kuchshenko[1] and L. Carlsen[1,2]*

[1] Department of Chemical Engineering, Kazakh-British Technical University, Almaty, Kazakhstan
[2] Awareness Center, Linkøpingvej 35, Trekroner, DK-4000 Roskilde, Denmark

Abstract

Associated petroleum gas (APG) is a form of natural gas, which is found associated with oil deposits. These gasses have traditionally been considered as unwanted byproducts in connection with oil exploitation. For decades the practice of flaring has been applied. However, this practice is highly controversial as it is environmentally polluting and economically unfavorable. Throughout the oil market this problem has high priority, and specifically in Kazakhstan. In the present paper possible ways to significantly reduce or eventually eliminate petroleum associated gas flaring in the Atyrau region, Kazakhstan are discussed. A particular focus is given to the Kashagan and Tengiz oilfields, which have high priority and potential for further growth in the near future, and thus have a specific value for Kazakhstan both from political and economic points of view. It is concluded that despite a rush for short-term profit by Kazakhstan's oil producers, an appropriate long-term strategy could not only be environmentally friendly but also financially beneficial. It is, however, also concluded that this requires a coordinated action involving the different players in the region as well as the Kazakh government. As an alternative it is suggested that a private consortium is formed being responsible for creating a unified system for processing and distribution of the APGs. The current flaring situation in Kashagan and Tengiz areas has been assessed applying the integrated environmental assessment framework DPSIR discussing the single elements: Driving forces, Pressures (on the environment), State (of the environment), Impact (on environmental and human helath) and Responses, respectively.

Introduction

The world today is highly dependent of the use of fossil fuel, especially oil. However, according to prognoses today's exploitation may lead to finish all oil resources in approximately 40 years (Cheese, 1997). Hence, the need for alternative valuable source of energy is obvious and it appears that some of them are pretty close. As a 'by-product' in connection to oil production is the so-called associated petroleum gas (APG), which are extracted in huge amounts with the oil. The APG has previously by been regarded as an unwanted by-product, thus being ignored as a potential valuable source, and just flared (Røland, 2010). However, flaring must be regarded as wasting of a valuable non-renewable resource and as such economically unbeneficial (Knizhnikov and Pusenkova, 2009).

The flaring is not only economically unfavorable but it also has a pronounced negative impact on the environment as a significant source of greenhouse gases (Knizhnikov and Kutepova, 2010). Nevertheless, oil producers are continuing to flare gas in a gigantic scale unless they are either forced to or see a benefit to reduce/eliminate the flaring (Buzcu-Guven, 2010). In addition to the emission of greenhouse gasses the flaring further constitutes a health problem as it results a significant emission of toxic pollutants (4), including carbon monoxide, nitrogen oxides, sulphur oxides, volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs).

Although various methods to utilize APG, as a basically chemically pure and highly energy containing fuel do exist, the application, nevertheless, being rather limited (Røland, 2010).

It should in this connection be mentioned that not all countries flare at high levels. Thus, Saudi Arabia is today considered as flaring – free (Foster, 2010). Although it still burns around 1 percent of APG they

* Corresponding author. E-mail: LC@AwarenessCenter.dk

have proved that it is possible virtually to eliminate flaring. In the early 1980's Saudi Arabia flared about 38 billion m^3 per year, which by 2004 was reduced to only 120 million m^3, the APG being used as feedstock for the petrochemical industry.

Obviously, the close vicinity of Kashagan and Tengiz are mostly affected by the flaring and hundreds of reports on negative impacts on human health and on environmental biodiversity have appeared (Urbaniak et al, 2007). Hence, it has been estimated that morbidity of population in the area of Tengiz oilfield is elevated by a factor of 6 (Urbaniak et al, 2007). A night view of the world's flaring can be found at http://npa-arctic.ru/Documents/demos/new/flares.pdf.

Based on the above reasons the Kazakh government has a very ambitious goal to end flaring before 2013 (Foster, 2010). Attempts are currently being made to utilize the APGs for production of, e.g., synthetic polymers. Thus, in 2007 the Energy and Natural Resources Ministry in Kazakhstan approved a feasibility study in order to develop a gas-based petrochemical complex in Western Kazakhstan in the Atyrau Oblast, as "part of the Kazakhstan government`s initiative to develop the country`s petrochemical industry». (Chemical Technology, 2011).

In this paper we will, with a DPSIR analysis as the starting point (Kristensen, 2004), despite the above mentioned feasibility study, discuss possible prospective effective and productive methods to utilize APG that could be integrated into oil industry of Kazakhstan and possible diffuse to other regions with the same problem.

Methodology

The DPSIR (Driving forces, Pressures, State, Impacts, Responses) framework takes into account a chain of past and present situations as well as suggests future activities as responses aiming at improving the environmental and human health.

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Driving Forces

The driving forces are centered on economic sectors and human activities, i.e. activities in the society that directly or indirectly are causing the pressures on the environment. Roughly speaking the driving forces can be classified as those creating the nuisance and those consuming resources. Thus, in broad terms driving forces comprise population, economy, land use and societal development. More specific examples of driving forces comprise manufacturing and industry, energy production, transport systems, agricultural activities, fisheries, households and consumers and waste treatment, the list by no means being exhaustive. In sum driving forces can be regarded as 'needs' for individuals, industry or society.

Pressures

The impacts (pressures) on the environment develop from the human activities that are associated with the meeting of the above mentioned 'needs' (driving forces). Thus, the pressures are results of production or consumption processes, such as non-sustainable use of resources, changes in land use, and direct and indirect emissions of chemicals, waste, etc to air, water and soil.

State

The state refers to the environmental and human health as a result of the pressures. Hence, the state comprises a combination the physical, chemical and biological quality of the various environmental compartments, i.e., soil, water and air, as well as their mutual interplay with respect to, e.g., vegetation water and soil organisms within a specific ecosystem, a specific type of landscape, a given population etc, with potential influence on biodiversity.

Impacts

The impacts refer to environmental and economic factors. Thus, the possible changes in the physical, chemical or biological states may unambiguously cause impacts on the environmental and human health, e.g., as a result of increasing concentrations of hazardous chemicals in the environment and eventually on both the economic and social performance of society.

Ultimately the impacts focus on changes in the human welfare comprising both physical and mental health as a result in changes in the quality, e.g., state, of the environment. However, also the possible changes in the environmental health due to changes in the physical, chemical and/or biological state may be covered here.

Responses

The responses comprise a priori the reactions by authorities, regulators or society in general to the changes induced through the other compartments in the DPSIR scheme. Thus, responses could comprise both passive and active measures. Hence a passive measure, relating to driving forces could be initiatives, to change people's transport pattern from private cars to public transportation by making zones where private cars are not allowed, whereas an active measure would be an increase of taxes on gasoline to motivate people to use alternative modes of transportation.

Responses related to pressures would be various regulations aiming at a reduction of the emissions of hazardous chemicals to the environment, whereas responses related to state would comprise, e.g., cleaning up or remediation projects of contaminated land.

It is noted, that basically all responses are caused by the impact component. Impacts are results of possible changes in driving forces, pressures and/or state. Obviously, if there are no changes in these compartments and thus no changes in impacts, imposing responses as the above mentioned, it cannot be argued. In Fig. 1 the complete DPSIR framework is visualized.

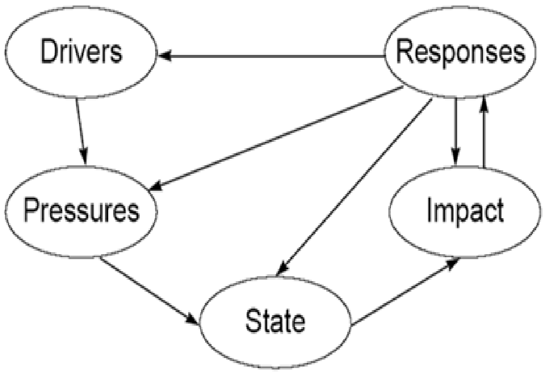

Fig. 1. The interrelation between the single elements in the DPSIR framework (adopted from Kristensen, 2004).

Results and Discussion

It should be noted that a complete elimination of flaring is not possible. Some flaring is a prerequisite for safety reasons (Nurakhmet, 2010). Thus, emergencies that disturb drilling or processing operations, problems with equipment or unexpected power shutdown could cause a dangerous build-up of pressure. In such situations flaring is essential to avoid accidents or disasters. However, the flaring necessary for safety reasons is insignificant compared to the current situation where all APGs apparently are flared regardless of the possible benefits. Hence, according to 2010 data 30 of 59 companies in Kazakhstan continue to flare (Foster, 2010). On the other hand the Ministry of Oil and Gas claims that in 2011 17 companies have utilized all the gas released from their oil production and further 6 have used more than 90% (Babkina, 2011).

Driving forces

Before turning to the driving forces for stopping flaring, it may be worthwhile first to have a look at the possible blocking reasons for utilization of the APGs (GGFR, 2009; Nurakhmet, 2010). These can be summarized as follows:

1. Safety is an issue related to the risk of potential high pressure in the oil well. Gas composition can be a safety hazard to the facility. Thus, previously burning of APGs was the only option in order to prevent pressure build-up as well as getting rid of the acidic APG component.
2. Due to the prevailing oil industry legislation it is for the time being much cheaper to flare than to process APG. Whether this will be changed till 2013 is a governmental responsibility, e.g., by a significant increase of the fines for flaring.
3. On a short term scale, it is economically not feasible to purify APGs from sulphur and other hazardous components, and to pressurize and transport it as a commercial product to potential customers.
4. Additional removal of the liquid fractions is further costly.
5. Utilization of APG based products by households, industrial facilities, or utilities require a distribution system that is currently not available.
6. APG has typically been regarded as "non-tradable", which means that it has a high transportation cost, short storage life, and there is no developed market for APG based products. Building-up such a market is resource demanding, which a priori suggests that additional APG utilization may constitute a significant economic loss. Based on current legislation oil companies virtually have no incitement to reduce flaring.
7. Historically, a broad usage of crude oil prevails as the primary valuable resource. Thus, flaring of APGs, regarded as by-product of basically no value has developed into an "old bad habit".

We shall not go into detailed discussions on the single items on this list of 'arguments' for not stopping flaring, let us turn to the possible driving forces for stopping flaring and utilize the released APGs, which virtually will contradict the above arguments.

Roughly we can divide the driving forces into environmental, economic and social reasons even though these three ultimately are linked together.

Driving forces are needs. Needs for money, energy, resources, etc.. Thus, we pinpoint several driving forces:

1. Economic. Elimination of flaring will take its place in oil industry only when it becomes economically beneficial for oil providers. Up to now fines have not limited flaring activities.
2. Environmental. Flaring became a serious ecological problem that calls for political and social attention.
3. Energy. Society virtually always in search for energy sources. APG may here turn out as a "free" additional valuable source of fuels and electricity.
4. Industrial. APG flaring results in a significant loss of potentially valuable chemical feedstock. However, significant investments are necessary and short term benefits may not prevail.
5. People/society. Utilizing APGs requires construction of new processing facilities that will generate a separate field of the oil and gas industry that potentially may reduce prevailing unemployment in the region.

From an environmental point of view flaring is unacceptable both in relation to the direct effect on the environment through the emission of greenhouse gasses and the above-mentioned variety of toxic components as well as the indirect effects on the human health leading to the significant increase in environmentally induced casualties (Urbaniak, 2007), which obviously has a significant negative economic impact as well due to increased costs for Medicare etc.

From an economic point of view utilizing the APGs potentially provides significant positive long term incentives.

Currently Kazakhstan's oil companies are basically 'solving' the flaring problem by paying fines. Thus, in 2008 and 2009 they paid $120,000 and $114,700 in fines for excessive flaring. Obviously, these sums are simply "drops in the sea" for the oil industry (Forster, 2010) and will as such not prevent flaring at all. Thus, benefits must be sought for on a long term scale, requiring significant investments.

According to Todd Levy (General Director, executive of America's Chevron, the lead operator of Tengizchevroil), the giant Tengizchevroil oil operation at Atyrau in western Kazakhstan spent $258 million to build a facility to capture rather than burn released APGs (Forster, 2010).

According to World Bank Database, APG amounts on a global scale to 139 × 109 m^3 that was flared by petroleum companies in 2008 (Røland, 2010), which resulted in additional 278 million tons of carbon dioxide equivalents to the atmosphere and also represented a value of 68 × 109 USD worth of energy that literally had gone up in smoke. A rough estimate, taking as an example year 2008, Kazakhstan has flared about 5.2 × 109 m^3 (vide infra) out of the 139 × 109 m^3, representing a potential financial loss of approx. 2.55 × 109 USD.

The utilization of the APGs will further affect the society in a positive way, e.g., due to an increased number of employment possibilities with a new emerging area of the oil and gas industry and thus reducing the problems associated with unemployment in the area as well as better living conditions in general with a decreased frequency of cases of illness as a consequence of a cleaner environment.

Pressures

The direct pressures on the environment, and thus indirectly on humans of flaring are obviously connected to air pollution. Flares can be considered as one of the most important sources of air pollution. Flaring emissions are mainly by-products of combustion and unburned fuel (Rypdal, 1995) including carbon monoxide, highly toxic mercaptans, sulfur dioxide, nitrogen oxides etc.

The quantity of unburned hydrocarbons being emitted obviously depends on the efficiency of the combustion, i.e., on the efficiency of industrial burners. Flares contain such volatile aromatic compounds as benzene, toluene, xylene and benzo(a) pyrene, substances being considered as carcinogens and teratogens (Contaminant Profiles, 2011).

In addition to low molecular weight hydrocarbons that possess high heating value. The flare gasses further contain various heavy hydrocarbons such as olefins, aromatics and a variety of paraffins that further give rise to soot, e.g. unburned carbon micro-particles. Further, some of the APGs associated with Kashagan and Tengiz oil contain very high levels of hydrogen sulfide (Campaner et al. 2008), which obviously calls for special attention (Abdel-Aal et al, 2003) due to the high toxicity.

State

In Kazakhstan there is a lack of strict rules, guidelines and procedures related to measuring and reporting of APGs flared. Thus, it is difficult to verify compliance with flaring objectives. However, in this context Kazakhstan may to Norway that constitutes the example of a successful regulatory regime (Nurakhmet, 2006).

Metering equipment for flared APG volumes do exist and it can be used for on-site estimation (Clearstone, 2008). However, this type of equipment it is not generally applied in Kazakhstan. Obviously the lack of such equipment constitutes one of the main difficulties connected to the monitoring of flares. Thus, estimations of the flared APG are reduced to calculations based on gas-to-oil ratio expected in the particular oilfield or remote, satellite based, sensing (Godunov and Zhizhin, 2011). The latter has been significantly improved and gives a rough estimate of APG flaring. The results indicate that flaring peaked at about 172 × 109 m^3 in 2005 and has declined by 34 × 109 m^3 down to 138 × 109 m^3 by 2008 on a global scale (Elvidge et al., 2009). The most significant improving was a comprehensive review of suspected flares using Google Earth imagery for visual confirmation. However, these methods obviously do not give a precise evaluation of amount of APG been flared, which complicates an exact estimation of the environmental impact as well the possible economic gains from a possible exploitation.

Anyway some rough estimation is possible. Hence, according to World Bank Data, approximately 150 × 109 m^3 of APGs are annually flared throughout the world (Røland, 2010). This is equivalent to 30% European Union's gas consumption per year and is more than enough to meet gas needs in UK (Admin, 2011). Subsequent estimation shows that the annual APG flaring makes up to a total emission of 360 million tons of carbon dioxide, which is equal to the emission of 70 million cars (Admin, 2011). The World Bank states that in 2010 Kazakhstan did enter the list of Top 10 flaring countries. However, together with Russia, Kazakhstan is considered to be on top of the list of the states which were working on greenhouse gas emission abatement by reducing the amount of the flared APGs (Admin, 2011).

The lack of appropriate instrumentation causes that we today face significant discrepancies between the data for flaring based on satellite sensing and data provided by oil producers, which may not be surprising as the fines to be paid for flaring are based on the producer-based data. Hence, the Global Gas Flaring Reduction (GGFR) Partnership has made the estimation table which is based on reported data of individual countries. This table shows that volumes of associated gas flared in Kazakhstan are 2.7 × 109 m^3 for 2004 and 2005, respectively. At the same time the flared volumes measured from satellite made by National Oceanic and Atmospheric Administration (NOAA), National Geophysical Data Center (NGDC) and GGFR Jan-Jul 2010 newsletter for Kazakhstan flares was 5.8, 6, 5.3, 5.2 and 5.2 × 109 m^3 for 2005, 2006, 2007, 2008 and 2009, respectively, corresponding to 4% of the world total in 2009 (Admin, 2011).

Obviously the health state of the local population in the Kashagan and Tengiz area of major concern as it apparently can be linked directly to the effects of flaring. Hence, in general, local population health state in Atyrau region is rather poor (Urbaniak, 2007). Most common health problems include: cardiovascular diseases, respiratory tract diseases, e.g., chronic bronchitis, anemia, leukemia, a unnatural high percentage of premature delivery and cases of embryo death (Urbaniak, 2007). Especially worrying is that these health problems are continuously observed among younger and younger people. Local medical specialists confidently claim that this unambiguously can be ascribed to the oil industry and that it has been intensively progressing in recent years and apparently are proportional to the enormous amount of toxic emissions that mainly is associated with flaring (Urbaniak et al., 2007).

Also the environment suffers significant from the flaring activities. First of all the air quality is low, but also soils and forests are indirectly affected due to deposition of toxic substances. Thus, it is proved that products of flaring as a result of sedimentation process have significant contribution in soil pollution. The pollution of black soil (black earth, humus) leached by products of APG combustion conduces to changes of parameters of its biological activity: the quantity of micromycetes and carbon-oxidizing bacteria has increased, as well as activities of catalase, lipase and phytotoxicity. Plants that have been grown on polluted area, absorbed benzo(a)pyrene in biomass in quantity, significantly exceeding background values (Kireeva and Novoselova, 2009).

APG flares have a complex negative influence on local forest areas (Kryuchkov, 2000), which can be ascribed to and interplay between the thermal regime and the emissions of toxics. As a consequence of flaring an intensive decrease of density and deposits of forest, decrease of canopy density, stem wood, increase of dead – wood and changes of wood structure can be noted (Kryuchkov, 2000). Flaring emissions negatively influences the survivability of soil biota by slowing down the degradation of plant residues as well as they conduce the accumulation of macro- and microelements in forest cover (Kryuchkov, 2000). In areas of serious pollution the content of chlorine, sulphur and iron are significantly increased (Kryuchkov, 2000). Accumulation of toxic elements and increase in acidity weakening absorption processes of potassium, calcium, phosphorus and magnesium. The damage of phytomass increases gradually when getting closer to the flare (Kryuchkov, 2000).

Impact

Obviously flaring has a significant negative impact on both the environmental and human health. In the following we will focus on a series of significant impacts due to APG flaring.

Human health

The impact on the human health is the most important aspect that calls for attention. Hence, it has been demonstrated that a correlation between development of certain deceases and levels of toxic products in the proximity of flares does exist (Gobo et al., 2009). Despite the role of individual compounds keeps unknown, the dependency between the human health state of the local community and the ecological conditions close to flares is beyond any doubt (Gobo et al., 2009). As mentioned above cardiovascular diseases, respiratory tract diseases, anemia, leukemia premature delivery and cases of embryo death are linked to APG flaring (Urbaniak et al., 2007). Further, it has been shown that elevated rate of cancer cases, including thyroid cancer prevails in areas with extensive flaring have (Argo, 2001). The most common reason of thyroid cancer is exposure to radioactive contamination, which is a common contaminant in oil and gas wells (Argo, 2001).

Environment

The most obvious effect of APG flaring is obviously the significant contribution to the climate change and global warming due to the emission of a total emission of 360 million tons of carbon dioxide (vide supra). However, as a consequence of inefficient burners in general in operation in Kazakhstan a significant amount of methane, which has a high global warming potential is also emitted to the atmosphere. Hence, by burning APGs in an more or less uncontrolled way rather than converting it to useful power, oil producers are contributing to the growing problem of climate change by releasing highly potent greenhouse gases into the atmosphere with recognized negative influence on world climate (Atyrau, 2006).

It should, however, be emphasized that flaring in addition to the direct effect on the climate change also couses an raised warm thermal background and oxidation of components in environment around oilfields. Thus, APG flaring causes damaging effects to soil, flora and fauna by gathering “deposit” of the greenhouse effect, global warming and climate change. The Atyrau region has in this respect a particular place among regions and zones of ecological catastrophes in Kazakhstan ((Atyrau, 2006).

However, not on does the flaring contribute to the global warming but contributes also negatively to the air quality of the region. Thus, approximately 80-95% of the pollution of air basin pollution of the Atyrau region can be ascribed to the oil and gas exploration and oil processing enterprises (Atyrau, 2006). The problems are massive, not only due to the chemical and particulate pollution (vide supra), but from the secondary heating pollution on a local scale caused by emissions of energy (heat emissions). The increase of the local temperature as a result of the flaring activities causes a higher level of the waters in the Caspian Sea and the Ural River as a result of heating of the water bodies that consequently expend due to a lower density (Library, 2012).

The extreme emissions of carbon and sulphur oxides further affect the fauna negatively. Thus, irregularities in the migratory pathways of fish, birds and mammals have been noted (Library, 2012). The increased water levels of the Caspian Sea and the Ural River further negatively influences the breeding sites (Library, 2012).

An index of the atmospheric pollution places Atyrau city has 4th place in atmosphere clearance, between the other cities of Kazakhstan (Atyrau, 2006).

Apart from the direct pollution of the air basin and the atmosphere flaring further indirectly contributes to a significant soil pollution. Hence, changes in the physical-chemical properties of the soil appear following the influence of high amounts of carbon oxide and sulphur compounds. Soils in the Atyrau region are characterized as weak ecological-geochemical persistent quality based on technogenic measures (Atyrau, 2006). In the areas close to the oil and gas fields even the weakest polluting of the soil by the hydrocarbons contributes to a decreasing microorganism’s quantity, which plays a fundamental role in a process of soil self-cleaning from pollutions (Atyrau, 2006). Further, the high loads of hydrogen sulphide to the soil cause a massive increase of aerobic spore formers that displays negative effects on plant cover (Atyrau, 2006). Further the significant emissions of carbon, sulphur and nitrogen oxides leads to low pH precipitations with the well-known ecological and economical damaging effects on flora and fauna (Library, 2012).

Responses

Kazakhstan took the first serious steps in relation to the flaring situation in 2005 and in 2007 passing its first anti-flaring legislation (Foster, 2010). Further some amendments and updates of the existing Petroleum legislation towards abatement of gas flaring was made, which allowed oil companies to phase-in anti-flaring programs and install corresponding facilities and equipment (Foster, 2010).

It has been stated that Kazakhstan responds adequately to the flaring situation in the Kashagan and Tengiz areas (Foster, 2010). Thus, since the last modification of the anti-flaring legislation the Kazakhstan government claims to issue licenses for oil production only to companies that agree to capture and forward APG for utilization (Foster, 2010). Kazakhstan also participates in the World Bank's Global Gas Flaring Reduction Partnership program (Admin, 2011). The government actively motivates to invest into building of anti-flaring facilities and equipment (Admin, 2011).

Visual inspection in the area, however, demonstrates that despite the good intentions the legislation is only partly obeyed. In order to demonstrate an attitude and wish to control abiding of the anti-flaring legislation, the Kazakhstan government could follow example of Russian policy, i.e., by forcing oil firms, including market leaders like Rosneft, LUKOIL and TNK – BP, to meet the governmental target of increasing the utilization of APG to 95% by 2012. Hence, the prime minister, and coming president Vladimir Putin claims: "Oil companies that do not meet this requirement will pay huge fines" (Soldatkin and Bryanski, 2009).

Unlike in Kazakhstan, in Norway the government has a strong partnership with the oil producers. This collaboration secures that changes in flaring policy will be implemented smoothly with mutual acceptance between regulator and petroleum companies (Nurakhmet, 2006).

In the following we look at a series of possible actions to utilize APGs.

One of the traditional ways of utilizing APGs is by reinjection. The Tengiz oilfield is situated in an technogenically labile area. Thus, the oilfield is located on 2 major tectonic fissures. Last time a strong fissure was registered was in 2000. The fisure begins in an area of sea-based oilfields Kalamkas, Karajanbas and goes away through Tengiz aside of Mangystau. These fissures are natural and may eventually lead to natural earthquakes. In the Tengiz area major tectonical fissures are currently observed and an intensive crustal movements prevails, the ground level rises by 5 centimeters per year (Maytanov, 2011).

These free holes are not filled in the Tengiz area, and consequently the earth tension is not restored and the natural balance dislocates and destruction may happen. Such major earthquakes may take place in the Tengiz area, as has been seen at Kamchatka and in Turkmenia, where hydrocarbon reserves were produced in big quantities. Hence, the reinjection of APG into the subsoil will fill the free spaces and hereby lower the risk for technogenic catastrophes (Maytanov, 2011). Further, the major reason for reinjection is obviously to enhance the oil recovery (Røland, 2007) or alternatively to reduce the cost of cleaning the gasses for sulphure (RME, 2012).

Without going into technical details, but with reference to previous experience in Kazakhstan's as well as in foreign countries we suggest that APGs can be used in various ways (Kanforoshan et al., 2008):

1. Utilization of APGs and processing products for technological needs in the producing regions including producing electricity on-site.
2. Collection and processing in dedicated gas refining plants in order to obtain dry gas that could be used for gas chemical production or directed to Gas Transmission Network.
3. Reinjection into productive oil stratum to increase reservoir pressure and production rate correspondingly.
4. Distribution to far users, e.g., for production of heating and electricity, by pipelines or by any available transport in liquefied state.
5. Processing of APG to olefins – valuable raw materials for petrochemical complexes.
6. GTL technology – APG using for synthetic fuel production (Al-Shalchi, 2006)

Using of APG as a raw material for the production of olefins apparently can lead to yields in the range of 32.0-34.6 % (Kadirbekov and Kadirbekov, 2010).

Obviously the possible use of APGs for heat and/or electricity generation eventually will lead to a similar carbon dioxide emission as the flaring. However, in this case as a negative side effect as a consequence of an otherwise positive utilization of the gasses that through flaring was 'just burned'. An interesting thought in this connection could be to combine the above mentioned initiatives and collect the generated carbon dioxide that subsequently could be used for reinjection and thus, enhanced oil recovery or even in more elaborate carbon capture systems.

It is clear that the exploitation of APGs requires significant investment and the general situation in the oil fields is that a series of companies are present. Hence, this obviously calls for a close collaboration between these single players as well as with the Kazakh government in order to minimize investment costs and optimize the processing and distribution of the APGs, as individual company-based solutions both from a financial as well as from a logistic point of view appear less attractive. As an alternative a private consortium is suggested to set up a system fo processing and distributing the gasses. However, it is difficult to see how that would be feasible without involvement of the APG producing companies and it is further hard to see a system without close involvement and control by the government.

Let us finally mention a number of lessons can be learnt by looking towards countries like Algeria, Canada, Norway, United Kingdom and the United States that all have elaborate flaring policies (GCFR, 2009):

1. It is crucial to have a clear, unambiguous oil and gas legislation on the treatment of APGs.
2. Terms of taxation should promote investments into APG utilization; refer to high start-up costs and poor economics of APG projects.
3. Provide a stable gas market by:
   a) Capitalize the gas by gas export;
   b) Sell electricity obtained from APG
   c) Adequate energy-pricing
4. Oil operators should be challenged by effective monitoring and on-time enforcements.

Cooperation between oil producers and government in:

a) Enabling an environment for APG utilization investments;
b) Establishing of realistic deadlines;
c) Monitoring of on-time implementation;
d) Coordination of investment programs and strategies.

6. The APG utilization program should be a permanent part of oil field development planning process.
7. A country gas master plan for both associated and non-associated gas should be developed and/or energy sector strategy.
8. The combination of all above measures should be built up wisely and adequately to existing market and political system.

Conclusions

In the present paper we have presented an integrated environmental assessment of the flaring of associated petroleum gasses (APGs) in the Kashagan and Tengiz regions in Kazakhstan. The assessment has been carried out within the frame of the DPSIR framework. Thus we have presented driving forces, pressures and states as well as the direct and indirect impacts of the APG flaring. Base on this analysis we suggest a series of possible responses that on a longer term should make it highly attractive for the oil companies to stop flaring.

Within political and socio - economic framework in Kazakhstan we thus propose the following responses apparently suitable for Kazakhstan market:

- Formulate a n appropriate legislation to deal with companies ignoring prevailing laws about gas flaring;
- Establish a satellite-based monitoring system to compare received information about flaring volumes to those represented by oil companies;
- Regulate the policies of oil companies, thus increasing an involvement and motivation for development an infrastructure supporting utilization of APGs
- Organize gradual increase of APG prices with aim of stimulating investments and providing with access to gas transportation system;
- Develop and explore valuable properties of the petroleum associated gas;
- Use effective and economic technologies of gas drying;
- Reinjection into the subsoil to increase reservoir pressure thus improving oil production performance;
- Using on sites to generate electric power to be consumed for oilfield service needs;
- In case of significant and stable volumes of APG – used as a fuel in major power plants or for further processing, producing lean dry gas, natural gas liquids (NGL), liquefied gases (LPG) and stable natural gasoline.

On this background we suggest a shortlist of possibilities that may find an implementation by overall priority:

1. Petrochemical application for continuous organic synthesis.
2. Utilization for electric power generation.
3. Fuel production.

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