THESIS TITLE

"THE REGULATORY COMMERCIALIZATION OF FLARING AND VENTING IN GLOBAL PETROLEUM OPERATIONS"

By

SAMPATH KUMAR KARAI PATTABIRAM

SCHOOL OF LAW

Submitted

IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF

THE DEGREE OF

DOCTOR OF PHILOSOPHY

TO

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

DEHRADUN

October, 2017

Under the Guidance of

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DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

S/d

SAMPATH KUMAR KARAI PATTABIRAM

Dated: 19th October 2018

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CERTIFICATE

This is to certify that the thesis on "The Regulatory Commercialization of Flaring and Venting in Global Petroleum Operations "by MR SAMPATH KUMAR KARAI PATTABIRAM in Partial completion of the requirements for the award of the Degree of Doctor of Philosophy (Law) is an original work carried out by him under my supervision and guidance.

It is certified that the work has not been submitted anywhere else for the award of any other diploma or degree of this or any other University.

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This is to certify that the thesis entitled "**The Regulatory Commercialization of Flaring and Venting in Global Petroleum Operations"** is being submitted by **Mr. SAMPATH KUMAR KARAI PATTABIRAM** in fulfillment for the Award of **DOCTOR OF PHILOSOPHY in (LAW)** to the University of Petroleum and Energy Studies. Thesis has been corrected as per the evaluation reports dated 09 /03/2018 & 1/10/2018 and all the necessary changes / modifications have been inserted/incorporated in the thesis.

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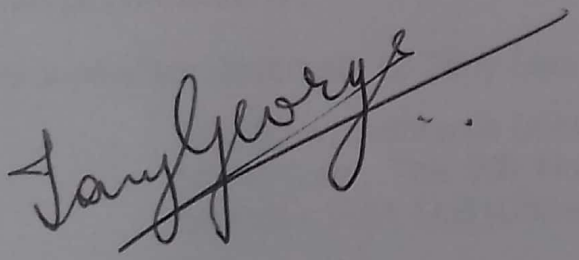

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DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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Dated:

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ACKNOWLEDGEMENT

This thesis on "The Regulatory Commercialization of Flaring and Venting in Global Petroleum Operations " submitted by me is in partial completion of the requirements for the award of the Degree of Doctor of Philosophy (Law) is an original work carried out under the joint supervision and guidance of Dr Tabrez Ahmad (Internal) & Dr Tony George Puthucherril (External) to whom I am eternally grateful.

The work is an extension of my work experience with Qatar Petroleum under the Directorate of Regulation and Enforcement at Qatar Petroleum, Ministry of Energy and Industry at Doha Qatar. The work is also an outcome of interaction with Global Gas flaring reduction (A World Bank affiliate) while at Qatar Petroleum to whom I am grateful for the inputs of material so widely collected on the subject matter including Satellite / remote sensing data conducted by the agency.

Finally yet importantly, all of my colleagues at UPES at the Schools of Law, Engineering and Management whom I have drawn upon on what is an interdisciplinary study and research.

SAMPATH KUMAR KARAI PATTABIRAM

Dated:

EXECUTIVE SUMMARY

This is a **"**Regulatory system development" (RSD) non-doctrinal thesis and draws upon empirical data drawn from law and other disciplines which can generate reforms of existing regulatory policies. The study is based on large-scale projects conducted by the Global Gas Flaring reduction (GGFR). The thesis on "The Regulatory Commercialization of Flaring and Venting in Global Petroleum Operations " is the result of extensive studies made by me collated from institutionalized industry funded / multilateral organizations who are campaigning for reduced Flaring and Venting across the globe. Primary sources are the Global Gas flaring Reduction (GGFR) which is funded by the World Bank and operating for several years, International Association of Oil and Gas Producers (OGP) and other sources dealing with flaring and venting. The global flaring and venting have significant say in global warming scenario. In their international campaign the GGFR has at to deal with disparate national regulatory interests mostly with a reticence on the part of producers of oil and gas who either think that a 3 to 4 % loss can be easily ignored in the same manner mutatis mutandis as they would ignore petty pilferage of minor quantum. This in conjunction with the "Business as Usual approach" have resulted in disinterest. The GGFR have had case studies conducted in countries as varied as the highly successful Norway and the lack of coordination such as in Kazakhstan. The thesis is a study that tries to bring a change in regulatory perception not through the window of environmental controls of a more ethical approach or the recognition of the phenomena of the "Tragedy of the commons" , but through the business and commercial validation of sustainability and management of scarce natural resources wasted. This could be utilized sustainably as a part of Oil and Gas downstream operations. The study had the useful data both collected as well as satellite pictures of significant polluters globally. These findings have confirmed in both instances of conservatively, at least a quantum of 5 to 7 Billion US Dollars' worth of Flared and vented associated gases not including supply side investments - which are significantly large as a business. In an experimental case study in Chad and Ecuador, the GGFR findings also indicate vast potential in their utilization in the small-scale

industries downstream in the areas of power generation, compression, dehydration, chilling, sweetening operations and Liquid Petroleum Gas (LPG) production attested by financial modeling. The significant businesses have supply side investments that can also be generated by these operations due to the viable quantum. The thesis followed the trends in almost forty countries and honed in several commercially viable regulatory standards such as the Canadian model and the enforcement ladder, as well as proclaiming the sovereignty of the state over the flared and vented gases let outside into the environment by joint ventures or public private partnerships. These tenets have been incorporated into a template that is at once executory as an outcome of the study. In view of the reticence of corporations the latest trends towards evangelizing the model template globally is also included as a throughput in accomplishing the goals of this thesis.

SAMPATH KUMAR KARAI PATTABIRAM

Dated:

List of countries studied with disparate laws;[1]

Countries Profiled with / without Flaring and Venting Targets

Countries	Overall Emission Targets	Flaring and Venting Targets
Argentina	✓	
Bolivia	✓	
Brazil	✓	
(Alberta) Canada	✓	✓
Denmark	✓	
Ecuador	✓	
Italy	✓	
Malaysia	✓	
New Zealand	✓	
Netherlands	✓	
Nigeria		✓
Norway	✓	
Peru		✓
Poland	✓	
Romania	✓	
Thailand	✓	
Trinidad and Tobago	✓	
United Kingdom	✓	
Uzbekistan	✓	
Vietnam	✓	

[1] Source: Global Gas flaring reduction Partnership (GGFR) he World Bank Group has a leadership role in gas flaring reduction through the Global Gas Flaring Reduction Partnership (GGFR), a public-private initiative comprising international and national oil companies, national and regional governments, and international institutions. GGFR works to increase use of natural gas associated with oil production by helping remove technical and regulatory barriers to flaring reduction, conducting research, disseminating best practices, and developing country-specific gas flaring reduction programs. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/07/16/000012009_20040716133951/Rendered/PDF/295540Regulati1aring0no10301public1.pdf Page 4 Table 2.1 (Last visited Dec 2017)

Countries requiring Standardized Uniformity[2]

COUNTRY	FLARE/VENT PERMIT	DEVELOPMENT PLAN	ENVIRONMENTAL LICENSE
ALBERTA (CANADA)	✓	✓	
ALGERIA	✓		
ANGOLA		✓	
ARGENTINA	✓		
AUSTRALIA (OFFSHORE)		✓	
AZERBAIJAN		✓	
BANGLADESH		✓	
BOLIVIA		✓	
BRAZIL			✓
CHINA		✓	
COLOMBIA			✓
DENMARK	✓		
ECUADOR	✓		
EGYPT	✓		
GABON		✓	
INDIA		✓	
INDONESIA		✓	
ITALY	✓		
KAZAKHSTAN		✓	
LIBYA		✓	
MALAYSIA		✓	
NAMIBIA		✓	
NETHERLANDS		✓	
NEW ZEALAND		✓	
NIGERIA	✓		
NORWAY	✓		
OMAN	✓		
PAKISTAN		✓	
PERU		✓	
POLAND		✓	
QATAR		✓	
ROMANIA		✓	
SYRIA		✓	
THAILAND		✓	
TRINIDAD AND TOBAGO		✓	
TUNISIA		✓	
UNITED KINGDOM	✓	✓	
UZBEKISTAN		✓	
VENEZUELA		✓	✓
VIETNAM		✓	

[2] http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/07/16/000012009_20040716133951/Rendered/PDF/295540Regulati1aring0no10301public1.pdf Page 15 Table 3.1 (Last visited Dec 2017)

LEGISLATIVE TECHNO LEGAL CUM COMMERCIAL

CASE STUDIES[3] & THEIR OUTCOMES

COUNTRY	CASE STUDY	JUDICIAL /LEGISLATIVE OUTCOME
USA	**CHEVRON USA, INC VS NATURAL RESOURCE DEFENSE COUNCIL INC ET AL SUPREME COURT OF THE UNITED STATES**	**THE DESIGNATED ENVIRONMENTAL AGENCY AND REGULATORY PERMITS FOR EMISSIONS UNDER THE CLEAN AIR ACT IS THE JURISDICTION OF ADMINISTRATIVE LAW AND CANNOT BE INTERPRETED BY COURTS, WHICH LACK BOTH KNOWLEDGE AND EXPERTISE ON TECHNO LEGAL MATTERS.**
CANADA	**DECISION TREE MODEL : DURABLE**	**HIGHLY SUCCESFUL AND APPLIED IN MOST COUNTRIES AS A TECHNO ECONOMIC LEGISLATIVE PRACTISE**
NORWAY	**RECYCLING OF ASSOCIATED GAS AND PIPELINE NETWORK.**	**SUCCESS DUE TO COOPERATION BY STAKEHOLDERS**
KAZAKHASTAN	**FAULT LINE OF APPLYING CONFUSED ENFORCING STATE AUTHORITY**	**NO ALIGNMENT OF POLICIES ; A NEED FOR CENTRAL REGULATION**
VENEZEULA	**NEED FOR TAKING LOCAL FACTORS INTO ACCOUNT**	**NEED FOR INCORPORATION OF LOCAL FACTORS INTO THE LEGISLATION**
INDIA	**THE CASE OF RELIANCE REFINERIES**	**A DOWNSTREAM APPLICATION WITH VERY**

[3] These are case studies on the legislative outcomes of formulated regulations. This thesis is about creating a uniform global template based on selection of best practices and procedures around the world and incorporating them into Annexure I attached as a recommendation.

		LITLE APPLICATION DESPITE INVESTMENT
SMALL SCALE INDUSTRIES: SUPPLY SIDE		
CHAD	**GGFR ECONOMIC MODELING BASED ON SMALL SCALE INDUSTRIES: SUPPLY SIDE USE IN PETROLEUM OPERATIONS AND PROCESSES.**	**SUCCESS IN APPLICATION OUTCOMES**
EQUADOR	**GGFR ECONOMIC MODELING BASED ON SMALL SCALE INDUSTRIES : SUPPLY SIDE USE OF ALL PETROLEUM OPERATIONS**	**SUCCESS IN APPLICATION AND OUTCOME**

Units of Measure

Bcm	**Billion cubic meter**
Btu	**British thermal units**
Kmol	**Kilomole**
Kw	**Kilowatt**
Lb/h	**Pound /per hour**
M^2	**Meter square**
M^3	**Cubic Meter**
Mcf	**Million cubic feet**
Mcfd	**Million cubic feet per day**
Mcm	**Million cubic meter**
Mg	**Milligram**
Mole(e)	**the amount of a substance**
m/s	**Meters per second**
ppm	**Parts per million**
scm of oe	**Standard meter of oil equivalent**
tcm	**thousand cubic meter**
TWh	**terawatt hours**
Ug	**micro gravitational acceleration**

List of abbreviations

ALARP	:	As Low as is Reasonably Practicable
COP	:	Code Of Practice
GGFR	:	Global Gas Flaring reduction
FPSO	:	Floating Production, Storage and Offloading
F & V	:	Flaring and Venting
HSE	:	Health, Safety and Environment
MS	:	Management Systems
LNG	:	Liquefied Natural Gas
MDEA	:	Methyl-Di-Ethanol Amine
MOE	:	Ministry of Environment or other authorities
MPE	:	Ministry of Petroleum and Petroleum
O & G	:	Oil and Gas
RSD		Regulatory Systems Development
PNGRB	:	Petroleum & Natural Gas Enforcement Board

LIST OF TABLES

CONTENTS[4]

[4] For easy readability each chapter I to VI has a brief write up on its content

CHAPTER 1

INTRODUCTION

This chapter opens up with the title of the thesis and introduces the reasons for flaring and venting in upstream Oil & Gas operations. The need or flaring thus reducing the methane gases to the more tame "Green House gas" such as CO_2. The chapter goes on to elaborate the present notions of the stakeholders towards reclaiming the associated gases and utilization in the downstream industry as being an unimportant capital investment on infrastructure. Global pollution issues and the conflict with local factors is discussed. The global scale studies is discussed with the relative percentage contributions both CO_2 as well as methane from different industries. The principle "Green House Gases" from fossil fuel and cement production are pictorially illustrated. The need for resource conservation showing the worldwide CO_2 in a dramatic increase and the lacunae in the scenario in form and content. This follows with the problem statement, issues raised thereon, the scope of the thesis with the methodology employed. These study crescendos to the Hypothesis proposed. This chapter is structured to introduce the technical contextual subject matter of the thesis including the ethos of development, commercialization, contractibility or lack of it in the global scene with almost 40 countries being studied as is pertinent to the thesis. The chapter introduces the type of thesis that is about "Regulatory systems development" pursuant to the title. Sets the stage for a detailed quantification and value calculations of the parameters that provide the outcome of this thesis and the issues raised in the next chapter. Sustainability, gap in regulatory standards in either the required enactments or its enforcement are implied in the issues raised. This chapter lays the foundation of a template formulation out of a basic necessity to integrate all of the aspects regulatory, contractual ownership and the enforcement ladder for enforcement and penalization.

The chapter conveys the problem statement, which elucidates the expectation of this thesis in the form of a formulated template for regulatory enactment. The

problem statement raises questions on sustainability, adequacy of regulations worldwide and the possibility of creating a regulatory template to fill the lacuna. The methodology of this thesis is the "Regulatory system development" (RSD) approach and is non-doctrinal, draws upon data drawn from the technology discipline which can generate reform of existing policies. The Hypothesis presents a construct and goes on to the development of a 'Gap Economic Instrument' for the realization of optimized use of Flaring and Venting in Petroleum operations. Scope and limitations are also presented in order that the study is confined to realistic expectations and requirement of data presented.

It sets the tone of the thesis based on configuration of industrial regulatory systems based on normative standardized systems - applied to many processes in the hydrocarbon industry and inclusion of highly evaluated regulatory systems in vogue.

1.1 FLARING & VENTING IN THE OIL & GAS EXPLORATION & PRODUCTION INDUSTRY

The release of gases in the mode of flaring and venting is not just a practice but also an essential prerequisite in the production of Oil and Gas. A variety of reasons exists such as safety concerns. The difference between flaring and venting is that flaring is the controlled release of natural gas after burning in association with oil and gas production. Such release is made routinely in the production operations. Venting on the other hand is the release of unburnt gases into the atmosphere. The availability of the flared and vented gases that can be safely disposed of in emergency and shut down cases depends on the commercial viability of storage and use. Questions such as whether these gases can be recovered or reinjected into underground reservoirs by regulatory bodies in a sustainability that commercial transactions demand for their viability is moot and the object of this study.

The gas flared can be for a variety of other reasons such as local noise impacts, toxicity of the gases and hydrocarbon content of the gas. Notwithstanding this the flaring can a have within the local vicinity impact that makes it an imperative for even oil economies to keep them at as low as is reasonably practicable (ALARP). Global warming contribution can be significant considering that around 1% anthropogenic carbon dioxide is emitted and 4% of anthropogenic methane emissions[5]. While the case studies done in various countries experimenting with various combinations of regulatory and techniques indicate some of the many ways that industry practices reduce the gases flared and vented – no single treatise exist where all the practices have yielded substantially means of reduction or viability of practices across the world. It is

[5] Flaring & venting in the oil & gas exploration & production industry overview of purpose and quantities, issues, practices and trends OGP Report No. 2.79/288 January 2000. https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (last visited in January 2017)

the attempt of this thesis to provide a variety of methods both commercial, regulatory as well as specific operations that will fulfill the gap in most circumstances. Incidentally such studies yield the additional corollary of sustainability in global operations both at the level of environment and the volumes required for viability in terms of commercial success.

The term 'associated petroleum gas' (APG) refers specifically to natural gas produced as a result of oil production. APG may be present in the gas cap overlying an oil reservoir, or it may be dissolved within oil at sub-surface pressures. APG is often viewed as a waste product of oil production because of the relatively low price of natural gas compared to liquid hydrocarbons, and the often-high cost for its utilization. In many cases, it is an assumption that the capture and processing of APG is of lower benefit to a producer than the use of limited capital rather than to focus on oil production, especially at oil extraction sites with little or no natural gas processing and transportation infrastructure.

As a result, APG is released into the atmosphere through direct venting, or after undergoing combustion in an incinerator or a flare. The composition of gas present in APG varies by reservoir, which affects the greenhouse gas emissions attributable to individual flares or vents. Produced natural gas primarily consists of light hydrocarbons like methane, with some carbon dioxide, nitrogen, hydrogen sulfide, and rare gases in much smaller proportions. Under ideal conditions, combustion of natural gas converts the methane component into carbon dioxide and water vapor. Combustion of methane into carbon dioxide and water is preferential to direct venting because methane has over 25 time's greater global warming potential than carbon dioxide in a span of over 100 years. The best-case option is the use of APG onsite by an operator, or sale to a retail customer.

Technically the simplest basic model of flaring is the controlled burning of natural gas at the end of a flare stack or boom. A complete flare system consists

of the flare stack or boom and pipes which collects the gases to be flared. The flare tip at the end of the stack or boom is to assist in burn efficiency. Seals installed in the stack prevent flashback of flames and a vessel at the base of the stack removes and conserves any liquids from the gas passing to the flare. One or more flares are needed depending on the design and production location.

A flare is normally visible and generates heat and noise consisting of water vapor and carbon di oxide. Efficiency is obtained by giving a good mixing between the fuel gas and air in the absence of liquids. Low-pressure pipe flares are not intended to handle liquids when introduced into the flare system as in India. Combustion efficiencies greater than 98 % is achieved as US

Environmental Protection agency studies shows[6] although gas can come from a variety of sources such as from the unburned process gas from processing facilities, vapor collected from the top of tanks as they are being filled. Sometimes, the gas may be from process upsets, equipment changeover or maintenance. Also, occasionally, there could be production shutdown requiring temporary flaring. A catastrophic situation such as a build of pressure to reduce high-pressure transients. It is also in the interest of the corporation to realize the value from the hydrocarbon accumulations that it is producing. In this respect commercial aim of the corporation coupled with good environmental practices is the objective. The methodology of minimizing flares need not be necessarily technically but also marketing initiatives and strategies. For example, as the case study[7] indicate that all Oil accumulations always occur with some amount of associated gas. This could be sold at the downstream petrochemical feedstock. The possibility is constrained because of operational requirements since the

[6] Flare efficiency Study, EPA-600/2-83-052, U.S. Environmental Protection Agency, Cincinnati, OH, July 1983. https://www3.epa.gov/ttnchie1/old/ap42/ch13/s05/reference/ref_01c13s05_jan1995.pdf (Last visited January 2017)

[7] Flaring & venting in the oil & gas exploration & production industry Report No: 2.79/288 case study I Nigeria January 2000. https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

transport of gas unlike oil is not that easy as a transportable commodity. Consequently, the proximity of the petrochemical industry is a factor to be considered. Globally much depends on the arrangement that the customer is willing to engage in commercial arrangements for the additional expense of saving associated gas and for transportation. Priority of the government is also a factor for developing a financial support through fiscal policies, which again is dependent on national priorities such as competing projects which demand a piece of the fiscal budget as form of expenditure. A further discussion on reinjection is that it may not be at all times feasible geologically possible for example if the tunnel is too large for a small oil field as in the case of the Sleipner type carbon dioxide project in Norway (Case study 2)[8]

The other recourse is technology oriented to commercialize the use of associated gas during flaring by liquefying which is a transportation facilitator. The industry has developed significant improvement in liquefying technology.

Venting however the controlled release of is directly released into the atmosphere with a mixture which is lighter than air. Since the mix is released at high-pressure jets they mix well with air and therefore do not explode. They also release inert gases, which cannot be flared and can only be vented.

The choice to flare or vent also rests on the toxicity of the gases. Since the oil and gas is processed at high pressures and temperatures. Pilot systems are also installed such as in Norway so that small flames are maintained as the ignition source before a major flare occurs. Recently Statoil introduced systems, which discards the use of pilot valves and therefore emissions when not active. In this regards mention must also be made of the conversion of Hydrogen Sulfide gas,

[8] Flaring & venting in the oil & gas exploration & production industry Report No: 2.79/288 case study Norway case January 2000 case no 2. https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

which is fatal when inhaled, and its conversion to Sulphur dioxide which is less toxic.

1.2 GLOBAL POLLUTION ISSUES:

In the absence of a system of commercialization of the flared and vented gases concerns of global warming. Although this is not a paper on the environmental issues it is worthwhile to go into the subject. Considering that this thesis and its outcomes controls the pollution albeit with the added flavor that the commercialization achieves the same positive outcomes as an unintended consequence.

Carbon di oxide and methane are major greenhouse gases that are a direct causation of global warming. In this methane is 21 times in carbon footprints of that of a kilogram of carbon di oxide when we consider it over a period of one hundred years. Flaring is primarily concerned with emitting carbon di oxide through the burning process while venting is the cause of untrammeled expulsion of methane into the atmosphere. Consequently, new facilities predominate in providing flaring rather than venting process. Although the study of climate change is still a grey area – unquestionably the reduction if not elimination of both flaring and venting is necessary prerequisite of management of the global environmental impact. Sometimes however the local needs conflict with managing greenhouse emissions, potential conflicts such as air quality. Sometimes venting may trump over flaring considering that the venting process as it is less visible and produces less noise. This is particularly true for onshore establishments. Case study No 4[9] illustrates some of the local factors that need to be taken into account in engaging environmental issues. The judicial response world wide in this regard has been perfunctory and the need for regulation is a

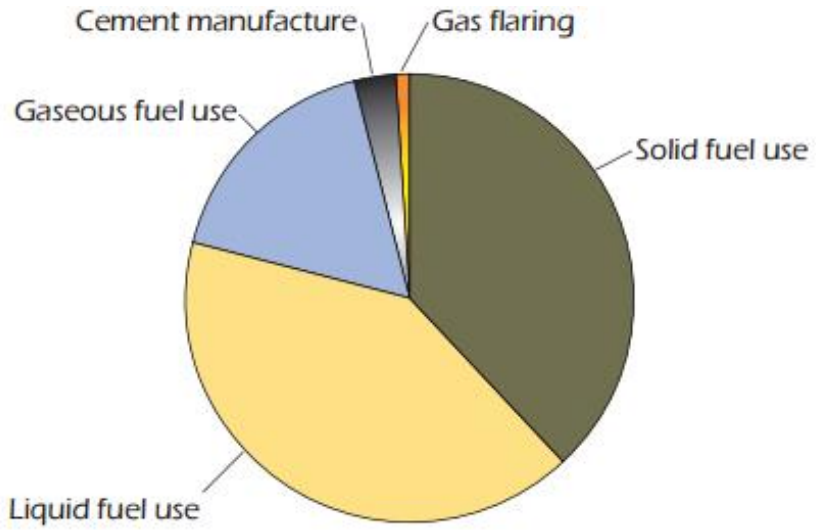
[9] Flaring & venting in the oil & gas exploration & production industry Report No: 2.79/288 case study Venezuela case January 2000 case no 4 https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

must globally, in this regard a lucid has been written by Ashly Polomski[10]. With regard to Venezuela the table under Types of flaring and venting authorization like India is a Development plan and certification and the rest is left to corporate governance. Only GGFR has been conducting case studies for voluntary imposition of Regulations. In this case which was conducted by GGFR in the eastern part of Venezuela local factors determined the flare design. In this case the following had to be taken into account a) proximity to an industrial township requiring 100% smokeless operation b) Compressor system required for high pressure gas injection system had to be located near a major highway surrounded by existing oil wells and processing plants, c) proximity to an international airport thereby a need for reducing the height of the flare stack system d) the flare also had to be operated in a wide range of gas flowrates and e) an unreliable power system which required back up generators. Another compelling issue is the measurement of quantities of gas released. All oil fields contain associated gases much in the manner that gas bubbles appear when a carbonated drink is removed of its containing cap. However, the difficulty is in measuring the same. These are usually defined by means of a so called Gas Oil Ratio (GOR). The GOR can vary from oil field to oil field. Also, can either increase or even decrease during operations. There is even a debate as to how much of gas can actually be measured accurately under such varied conditions with the measuring devices available on the market. In this regard low-pressure gas rate measurement can be particularly significant problem. Others postulate estimating through estimates and calculations. The OGP has published its own measurement and protocol for such calculations. One of the most definitive studies of global scale is at the Carbon di oxide information Analysis Center in the USA. [11] Consumption of fossil fuels is the most important source of CO2

[10] http://www.colorado.edu/law/sites/default/files/Palomaki_6713.pdf (Last visited on 18/9/17).

[11] Marland G., Andres R. J., Boden T. A., Johnston C., & Brenkert A., Global, Regional, and National CO2 Emissions Estimates from Fossil Fuel Burning, Cement Production, and Gas Flaring: 1751-1995 (revised January 1998), Carbon Dioxide Information Analysis Centre,

emissions from natural sources and human activities the fig shows 96 % are from this source which is either in the solid, liquid or gas form. However, two other sources are indicated which are gas flaring and venting also cement manufacture. On worldwide scale this amounts to around 1%. The relative contributions are presented below[12].



1: Contributions to anthropogenic carbon dioxide emissions, 1994

Gas flaring as is seen above occupies a low proportion of the pie but the real assessment here is not about merely the overall size but the fact that this is both accessible, assessable and controllable by industry on a profit or win – win situation.[13]

Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. Stern, D. I., and R. K. Kaufmann, Estimates of Global Anthropogenic Methane Emissions: 1860-1994. Trends Online: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Centre, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A., 1988. https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

[12] Flaring & venting in the oil & gas exploration & production industry Report No: 2.79/288 case January 2000 https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

[13] *Source: United States National Aeronautic and Space Administration's Goddard Institute for Space Studies.[http://www.giss.nasa.gov/research/intro/matthews.01/] (last visited in*

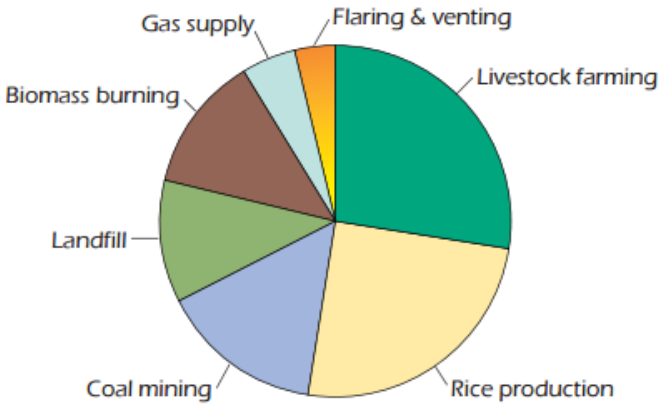
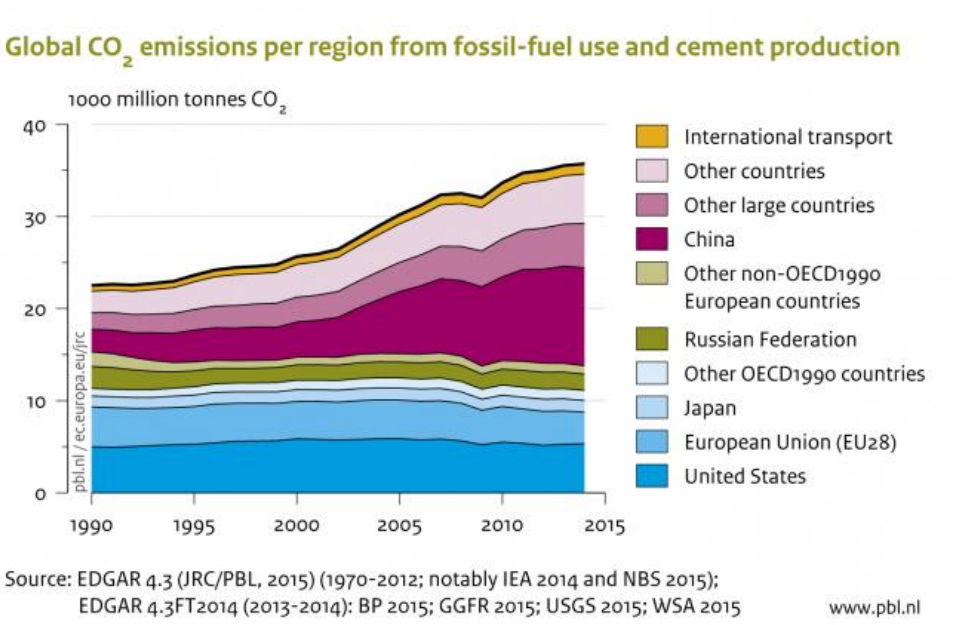


Figure 2: Contributions to global methane emissions, 1994

Gas flaring as is seen in terms of a proportion of production of methane shows higher piece of the pie. Methane being three times more toxic than CO2 is a potent ingredient in Green house gas effect and is also accessible, assessable and controllable by industry on a profit or win – win situation[14]



March 2017). https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

[14] https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

The above shows region wise the CO_2 emission from different regions. It should be noted here that the Russian Federation being a substantial F & V emitter generates more than a 15000 Million tons of CO_2 which is a significant contributor to the global pollution.

1.3 RESOURCE CONSERVATION

The use of flared or vented to the environment as natural resources to be used either as sources of energy or as useful chemicals is a new thought However world view is getting to the idea of natural resource conservation and to avoid its waste. Non nonrenewable natural resource that are routinely flared need to be conserved for its value. Also considering international concerns on global warming these resource need to be maximized as a financial return. A typical example is Indonesia Barns reference No 9 [15] in 1950 they flared almost 95% of associated gas by around 1985 the gases being flared had been reduced how the to 28%. Fig below shows the amount of carbon di oxide released[16]

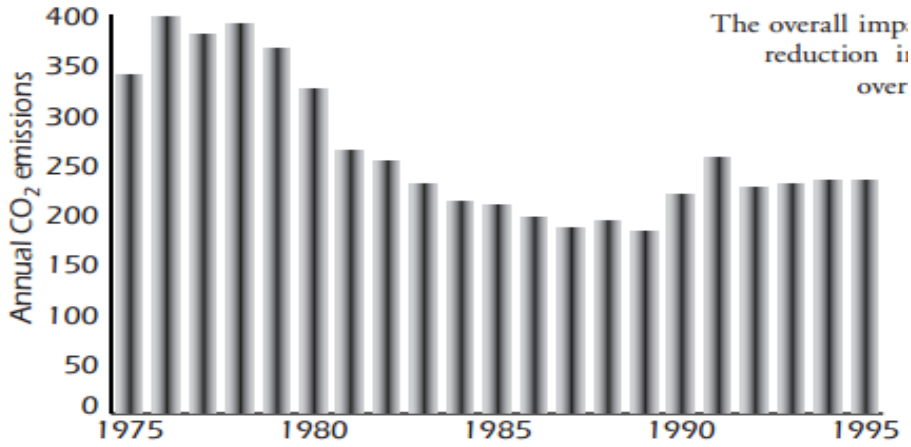


Figure 3: Worldwide carbon dioxide emissions from flaring (MM metric tonnes)

[15] Barns D. W., and Edmonds J. A. 1990. An Evaluation of the Relationship between the Production and Use of Energy and Atmospheric Methane Emissions. US Department of Energy, Washington D.C., DOE/NBB-0088P. https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

[16] https://2ch417pds.files.wordpress.com/2014/04/flaring-venting-in-the-oil-gas-exploration-production-industry.pdf (Last visited January 2017)

Overall, flaring and venting contribute only 1% to anthropogenic carbon dioxide emissions, and 4% to anthropogenic methane emissions. The important conclusion is that a choice has to be made between specific operations, selecting technologies or the balance between environment concerns. The government regulatory functions must be flexible to a common sense creative approach as a regulatory framework that takes into account global scales and advantages of bulk recovery operations in flaring and venting. The intrinsic value should motivate governments to facilitate the choice of management approach. The following summarizes Flaring and venting takes place in petroleum upstream and downstream operation in the following categories:

Class 1 - Base Load Flare.

This incorporates all of the gas utilized for protected and proficient operation of the procedure and flare system under ordinary working conditions. This might likewise incorporate any gas that must be disposed of as a major aspect to be released and flared. Others being cleansing and pilots, the off-gas from the glycol recovery plants, corrosive gas released from MDEA(Gas sweetening technique utilizing an amine solution)at different gas treatment plants, where these are sent to the flare system for ignition. This classification likewise incorporates flaring from upstream operations that are without any gas export facilities.

Class 2 - Flaring from Operational or Mode Changes

This incorporates gas flaring coming about because of the startup and prearranged shutdown during production and will likewise incorporate gas not meeting specifications to be sent out for export or having no maintenance support or the circumstance of equipment shutdowns. This classification additionally incorporates flaring that is caused by the brief absence of access to a third party gas outage facility or pipeline.

Classification 3 - Emergency Shutdown/Process Upsets

This incorporates any gas flared amid a crisis shutdown /process, surprises and shut in of the wells or equipment upsets.

Classification 4 – Un-ignited Vents

The inert and hydrocarbons gasses, which might be released to a vent, additionally requires both the inert and hydrocarbon gasses to be vented. This ought to likewise include venting of gasses from of crude petroleum storage tanks e.g. for FPSOs amid crude petroleum filling operations. Vents may contain nitrogen, carbon dioxide, water vapors, hydrocarbons, and potentially hints of Sulfur mixes and so on

1.4 PROBLEM STATEMENT

The below problem statement is the outcome of the wide spread need for a common platform of regulatory compliance which in my study qualifies both in terms of viability and volumes generated of waste gas. The further chapters on regulatory standards indicates a lacuna in this area which incidentally also yields to sustainability and as an unintended consequence reduction in global greenhouse gas reduction on the global environmental plane. The thesis calls for regulatory mechanism that control flaring and venting in global petroleum operations. This is on the lines of continued performance based commercial practices rather than on the awakening of ethical or moral sensibilities such as the Brunt land view on containing global environment pollution. Business worldwide has on an average concentrated on production and the maximization of profit through cartelization and output controls. The control of flaring and venting is a secondary consideration in the industry and the syndrome of "Business as Usual"[17] predominates. This thesis understudies the fact that in the face of global shortage and requirement in Petroleum, flaring and venting can be the basis of sustainable commerce, which at once realizes both goals of environment prudence as well as profit.

1.5 ISSUES RAISED

The above scenario and the resulting integrated view presented in this chapter raises certain fundamental issues as follows

1.5.1 Whether use of flared and vented Gases could be done on a sustainable Basis?

1.5.2 Whether presently there are adequate regulatory standards in India and abroad?

1.5.3 What can be a prospective model regulation for sustainability?

[17] http://www.clydeco.com/insight/article/corporate-environmental-responsibility-business-as-usual-or-facing-the-inev [last visited on 8th May 8, 2017].

1.6 OBJECTIVE

The gap economic instrument to be formed. A formulated regulative standard incorporating the principals of a hypothetical regulation prepared by the researcher in Industry which functions as a template referenced for supporting the hypothesis in terms of regulatory enforcement. This is to be attached as Annexure I an outcome for enforcement in real time operations with extensive application upstream and a lesser downstream petroleum operation

1.7 SCOPE & LIMITATION

1.7.1 Being a legal thesis the study will merely touch upon "Enabling technologies" without detailing the same. The study will confine itself to cumulating known and available data for proving that the volumes that are flared have economic viability/sustainability even by use of the hypothetical regulative practice proposed. In this regard specific data for each type of F & V by use or by the stated hypothesis may be hard to find and sometimes confidential within countries. Accordingly, the substantiality of the F & V within available data would be the basis and also limitation in the findings. Commercialization rather than the ethical standard is the moving spirit in attaining objectives. The same ends of global environment protection are achieved as an unintended consequence. Again, the thesis does not leave out such commercial viability tenets such as the Clean Development Mechanism (CDM's) that have been proposed under Tokyo, UNFCCC conventions et al to buttress the argument for the hypothesis.

1.8 RESEARCH METHODOLOGY

1.8.1 THE JUDICIAL CASE IMPERATIVE AS STANDARDS

The function of judicial cases in this thesis is at best redundant considering that admittedly judges and even the legislative are not experts in the field of say "Air pollution. In this regard a leading case in the United States Supreme court

Chevron Vs Natural Resource Defense Council[18] , The facts of this case is that the petroleum industry as elsewhere is a part of a powerful lobby or even the sovereign property of a commercially salable natural resource of international marketability. The environment conscious United States have been successively diluting the accountability of emissions effecting Air pollution such as the amendment of the Clean Air act 1977 addressing the concerns of the non performing states of the Union over air quality standards. These concerns were addressed by allowing permits to be issued based on new or modified stationary sources, the Carter administration defined what is meant by 'source' as any device in a manufacturing plant that polluted. The Reagan administration further modified the definition of 'source' as allowing any new equipment so long as the overall pollution emission levels did not increase Per se, thus permitting innovative technologies to be incorporated. The Natural Resource Defense council (NRDC)19 an environmental defense group challenged this bubble legal concept, which essentially meant that while issuing permits all of the sources should be taken into account as emanating from a single source. This meant a regulatory regime that required minute and detailed investigation into every new equipment. The US Supreme Court decision reversing the appellate court's decision is that considerable weight should be given only to the administrative authority such as the Environmental Protection agency. If the choice of the agency were, a reasonable accommodation of conflicting policies the courts would not disturb it. Admittedly, the judges are not experts in the field nor is the legislature and has left it to the administrators20. In this case of the Indian scenario this is also the case the Oil Mines regulations 2011 merely says "Gas produced at any installation cannot be discharged into the atmosphere unless complies with certain set standards to be approved by the authority" 21

[18] https://www.law.cornell.edu/Supremecourt/text/467/837 (last visited in 12th October 2017)
[19] https://www.nrdc.org/about(last visited in 12th October 2017)
[20] https://www.law.cornell.edu/Supremecourt/text/467/837 (last visited in 12th October 2017)
[21] Oil Mines regulation 2011 section 160 clauses 7 & 8
http://www.dgms.net/OMR_2011%20draft.pdf (last visited in 12th October 2017)

.The Environmental Protection Rules provides merely that "all gaseous emissions must be flared (not cold). Elevated flares must be used except where it might affect crop production in adjoining areas"[22]. It should be noted here is that the standards referred in Oil Mines regulation is left open ended to the Oil and Natural gas commission or other Joint ventures rather than any degree of specificity.

The question is whether this thesis require to deal with multifarious case laws globally encountered by administrators for violation of emission standards? Principally "Clean Air" for the subject of flaring and venting. Such study as it where does not meet the ends of this thesis because the Environmental agency not the Courts are as it were "Prima Donnas". At any rate study of court cases would lead to no conclusion. This thesis is about regulatory procedure and amalgamations across the world. This thesis goes beyond even "Zero flaring" initiatives by petroleum producing organizations> Particularizes to establish that even the 4 or 5% legally permissible losses under various regimes with administrative controls by regulating bodies is valuable and is capable of being commercially utilized. The savings on expenditure on environmental controls is an unintended positive outcome. Indeed this study is about the permits and regulatory schemes, which are disparately followed by various countries personified by Tables 1 to 3 of this thesis. Consequently, the Non-doctrinal Regulatory Systems development model has been chosen.

1.8.2 THE TYPE: NON DOCTRINAL / REGULATORY SYSTEMS DEVELOPMENT

"Regulatory system development" (RSD) thesis is a non-doctrinal thesis and draws upon empirical data drawn from other disciplines which can generate

[22] Environmental Protection rules 1986. Section 72 clause B 2.1 & 2.2
http://cpcb.nic.in/NewItem_19_PollutionControlLaw.pdf (last visited in 12th October 2017)

reform of existing policy. The study is based on large-scale projects conducted by the Global Gas Flaring reduction (GGFR)

This thesis contains Industrial regulatory systems, which can be promulgated. In the research examination, highly useful regulatory systems with a large impact on society are evaluated and assimilated for positive systemic change. The study assembles technology results, which are already in, use even if it were developed in the past as well as the research that supports subsequent technological development.

In this RSD thesis - in particular, not only past Industrial regulatory systems, results are collated, but also systematizes the results from a unified viewpoint the form of a well-constructed template. The thesis has also provided a logical through-line such as evangelism, which has its birth in other industries when they were nascent.

1.8.2 OUTCOME OF METHODOLOGY USED:

1.8.2.1 Configuration of Industrial regulatory systems that serves as a legal infrastructure,

1.8.2.2 Configuration of normative, standardized systems applied to many processes in Hydrocarbon industry

1.8.2.3 Inclusion of highly evaluated Industrial regulatory systems that find place in the template attached as Annexure I

1.9 HYPOTHESIS:

The Hypothesis rests on sustainable operations to tap Flaring and venting zero wastes in a four-pronged approach as discussed below

1.9.1 Fundamentally to make all "Petroleum" contained in sub-sea or sub-soil deposits in the state in land and water Territory, as a strategic and nonrenewable national resource, which is solely and exclusively owned and controlled by the State through regulation or national enactments. Barring contractual agreements

to the contrary the said proposed regulation permits licensees to optimize petroleum production within "petroleum operations" as to the use of associated gases by re-injection to improve oil recovery rates and to use gas to generate power for operation or to fuel equipment among other operational processes and

1.9.2 Considering the ownership under 1.9.1 above the associated gases or non-associated gases arising from venting and flaring not used in "Petroleum operations", the state would have a pre-emptive and exclusive right of ownership for marketing of such unutilized associated gases let out on its jurisdictional "Air Space" for commercialization. This is the utilization of an otherwise wasted national nonrenewable resource.

1.9.3 Regulative commitment to eliminating substantially all unnecessary or wasteful flaring and venting of gas which in routine gas flaring, reduce volumes of gas flared and improve the efficiency of flares through statutorily imposed monitoring

1.9.4 Prescribe guidelines and advice to Licensee's to seek to minimize the losses and conserve petroleum resources by implementing best practices at an early stage in the design development and further ensuring continual improvement on subsequent phases of the operations as a strategic objectives under regulation. A scheme of long term flare state approvals that will require prior approval for any field or grouping of fields going through an installation(s) that seek permission to flare at rates in excess of 50 tons a day. The thesis succinctly stated below:

"The existence of bits and pieces solutions of flaring and venting is inadequate for sustainable development and the creation of a "Gap economic instrument" is essential for systematization and realization of untapped potential in the optimized use of Flaring and Vented gases which otherwise is wasted"

CHAPTER 2

REGULATORY STANDARDS AND COMPARATIVE STUDY

This chapter discusses the present regulatory standards prevalent in India, developing countries and their application or lack of it is presented. Success stories from the sophisticated Norway case to the lackadaisical Kazakhstan and the Canadian commercial model including enforcement ladder is discussed in search of a model legislative formulation that sustains commercialization broadly under the head "discussions on the policy & regulations worldwide. These discussions are on extant policies, Regulations legislations the dichotomy between the policies in terms of its relationship with transmission, International outlook on operational modalities and processual technology. The regulatory procedures around the world and a cross sectional reference to 40 countries show the prevailing authorizations or lack of it. The measuring, reporting, monitoring & enforcing method capped with other relevant factors such as standards, financial incentives and the other competing interests such as Natural market development based on coal development, Government fiscal policies the contractual rights, structure of the downstream markets and the marketing of associated gas downstream is also presented.

This chapter is structured to introduce the contextual subject matter of the thesis including the ethos of regulatory development, commercialization, contractibility or lack of it in the global scene with almost 40 countries being studied. The Canadian approach plus enforcement ladder seems to fulfil the target of commercialization. The study crescendos to palpable recommendations, which finds its place in reducing the entropy of the phenomena of flaring and venting in the global and environmental scenario

2.1 REGULATORY STANDARDS: COMPARATIVE STUDY

2.1.1 INDIA

Regulatory procedures mean 1) Application & approval b) Measuring and reporting and c) Monitoring and enforcing. The Gas flaring is done as a part of an overall field development approval. Field development is practiced in Angola, Cameroon, India, Indonesia and Pakistan. Some permits limit the time to one year and require regulatory applications and approval for extension. An Environment Impact Assessment (EIA) usually is required prior to field development. While this is true for emissions in the downstream areas in India there seems to be no specific stipulation for Flaring and Venting limits in the upstream O & G production upstream area.

2.1.2 OTHER DEVELOPING COUNTRIES

Developing countries such as Nigeria and Peru. Most Oil producing countries lack clear emission policies and guidelines. This include large oil producing countries such as Algeria, Angola , Indonesia and the Russian federation these are covered here.

2.1.3 COMPARATIVE STUDY:

Comparative study with reference to Canada, Middle East, Russia, India Far east and other relevant countries and statutory and judicial approaches on flaring and venting in India and selected foreign countries**.**

A study made by GGFR confirms that there is around 140 Billion cubic meters of gas flared annually. This is enough to produce 750 Billion kWh power- more than the entire power consumption of Africa. Environmentally this is the production of 350 Million tons equivalent to about 77 Million cars plying. The study made by GGFR in their publication "A Global overview and lessons from International experience" addresses three key issues 1) Role of government in

defining flaring and venting policies 2) institutional characteristics and 3) adapted operational processes and regulatory policies. The other key issues were standards, financial incentives and effect of contractual rights of the downstream petroleum markets. Important contributors and leaders in the flaring of gas being Canada, Norway and the United Kingdom. The other countries in which GGFR had concluded its studies was North Africa, Sub Saharan Africa Latin America, Europe, Central Asia, Far East, Australia and North America. Countries profiled having flaring and venting policies that have a strict emission targets and limits are 18 out of the 44 countries under the Kyoto protocol. In these select countries that have targets, some are developing countries such as Nigeria and Peru. Most Oil producing countries lack clear emission policies and guidelines. This include large oil producing countries such as Algeria, Angola, Indonesia and the Russian federation. The rest of the countries regulate gas flaring and venting through primary and secondary legislation. The primary approach has been either prescriptive or performance based approach. The prescriptive approach is based on specific and detailed gas flaring and venting regulation established by the regulator and to be met by operators. In theory, this approach is relatively easy in practice, however this is the most challenging jobs as it requires enforcing mechanisms. Performance based criteria requires cooperation and consensus between industry and regulator. Irrespective of the approach two key areas are addressed namely 1) operational processes with developed standards such as in Ecuador, Egypt, Nigeria, Pakistan, Peru and Qatar regarding a) Burn technologies for clean gas and efficient combustion b) Timing limits c) Flare location from a safe distance from facilities/ accommodation d) Heat and noise generation upper limit and e) Smoke opacity and noxious odors.

Regulatory procedures mean 1) Application & approval b) Measuring and reporting and c) Monitoring and enforcing. The Gas flaring is done as a part of an overall field development approval or as a separate flare and vent permit

environment license. Field development is practiced in Angola, Cameroon, India, Indonesia and Pakistan. Some permits limit the time to one year and require regulatory applications and approval for extension. An Environment Impact Assessment (EIA) usually is required prior to field development. Regulators usually base their approvals on an incremental approach meaning operators are allowed to flare or vent only when they can prove the incremental benefits of using associated gases. The other procedure for regulatory authorities is to prove that it is uneconomic to use gas before issuing authorizations. Some jurisdictions require satisfying the regulatory authority that they have investigated all reasonable alternatives to flaring and venting including reinjection or oil recovery or for storage or gas gathering treatment and /or sale in downstream petroleum markets.

We have it on record with GGFR that an integrated approach which is counting Flaring and Venting as a negative externality and to be accounted as a cost in the context of viability of a production field - no country as taken this approach. The other factors are making of standards, financial incentives and the contractual rights and the structure of downstream petroleum markets. The downstream petroleum markets in general for the use of associated gases in the petroleum market are hindered by the supply chain monopolistic market. Most developing countries such as Argentina, Brazil, Chile, China, Indonesia, Malaysia and Mexico have carried out market reforms. Monopoly structures combined with a lack of network continue to affect the economics of associated gas adversely.

2.2 A REGULATORY SCHEME THAT SUSTAINS COMMERCIALIZATION INCLUDING MAJOR CASES AND REGULATIONS

2.2.1 DISCUSSION ON THE POLICY & REGULATION WORLDWIDE

The effect on the environment by F & V gases is well documented and the greenhouse emissions are categorically having negative impacts. Associated gas is a blend of hydrocarbons the surface in crude oil is brought to the surface. This blend is released to the atmosphere during F & V operations. The operations that require F & V are during drilling testing of Oil and Gas wells, natural gas pipelines, emergencies, equipment failure, and maintenance.

At the same time the prices of natural gas prices have increased substantially since the early 70's and governments and industry have felt the need for converting them to potential economic benefits. But despite the obvious advantage most jurisdiction continue to flare and vent at tandem to the production increases of oil.

Regulation therefore being important to reverse this trend - the study here is on regulatory and non-regulatory aspect adopted in oil producing countries around the world. In this regard a detailed study and conclusion is undertaken based on the following premise:

- The role of government in defining compliance measures by way of regulation
- Institutional characteristic of flaring and venting policies
- Adopted operational processes and regulatory procedures.

Other factors being:

- Impact of financial incentives
- Role of standards

- Effect of contractual rights and the structure of downstream energy markets

The GGFR conducted studies on 44 country profiles; [i] this study includes both developed as well as developing countries.

2.2.2 FLARING AND VENTING POLICY

The GGFR conducted studies indicate that only a few oil producing countries have a regulatory policy on Flaring and Venting. Despite the Kyoto protocol only 18 of 44 countries have and overall emission target. The below table provides the list of countries as per study in Table 1[23] below:

Table 1: *Countries Profiled with Emission and -or Flaring and Venting Targets*

Countries	Overall Emission Targets	Flaring and Venting Targets
Argentina	✓	
Bolivia	✓	
Brazil	✓	
(Alberta) Canada	✓	✓
Denmark	✓	
Ecuador	✓	
Italy	✓	
Malaysia	✓	
New Zealand	✓	
Netherlands	✓	
Nigeria		✓
Norway	✓	
Peru		✓
Poland	✓	

[23] http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/07/16/000012009_20040716133951/Rendered/PDF/295540Regulati1aring0no10301public1.pdf Page 4 Table 2.1 (Last visited Dec 2017)

Romania	✓	
Thailand	✓	
Trinidad and Tobago	✓	
United Kingdom	✓	
Uzbekistan	✓	
Vietnam	✓	

The countries that have imposed strict targets for annual gas flaring volumes and are in the process of defining or defined the volume of venting targets are the Canadian province of Alberta.[24] Some developing counties such as Nigeria and Peru have also introduced emission levels at upstream operations. In Peru, there are no emission and air quality standards, flaring standards have been issued. However mostly oil producing lack clear emission policies and standards. Large oil producing countries such as Algeria, Angola, Indonesia and he Russian Federation which do not have specific guidelines. In most countries where there is flare and vent reduction targets they do not have a gas strategy.

It is the objective of this thesis to provide a template that can provide a basis of a staid regulatory policy including its strategy not only to meet the environmental but resource management targets of responsible governments.

2.3 REGULATION OF GAS FLARING AND VENTING

2.3.1 GAS FLARING AND VENTING LEGISLATION

A study of the gas flaring reduction countries leads to the conclusion that mostly primary legislation has been introduced such as Hydrocarbon and environmental laws. These primary regulations are the basis for creating

[24] *Management of Routine Solution Gas Flaring in Alberta: Report and Recommendations of the Flaring Report Team*, CASA, 1998, and *Gas Flaring, Incinerating and Venting in Alberta: Report and Recommendations forUpstream Petroleum Industry by the Flaring/Venting Project Team*, CASA, 2002.
http://www.casahome.org/uploads/source/PDF/1998_Management_of_Routine_Solution_Gas_Flaring%20-FPT.pdf page no 11 {last visited 8th May 8, 2017)

regulatory institutions, empower them to carry out natural resource management functions without actually spelling out the aspect of Flaring and Venting.

Flaring and venting policies end up as secondary legislations by the use of instrumentality such as codes, guidelines and licenses. The comprehensive treatment of such secondary legislations have been done the Canadian rovince of Alberta and these have been incorporated into the template. Other countries that are prominent in secondary legislation in flaring and venting secondary legislation are Argentina, Peru and the United Kingdom. Some pieces of these regulations are also amalgamated into the template.

2.3.2 THE DICHOTOMY BETWEEN F & V AND TRANSMISSION IN TERMS OF REGULATORY AUTHORITY

Flaring and venting associated gases from the point of view of upstream operations is a competitive activity in global business. The natural outcome of such a situation is that these do not require as much regulative control as maximization of utility. In contrast the network of transmission and distribution are subject to tariff regulation.

The technical regulation of F & V operations however aims to set standards and guideline for its operation to achieve the goals of environmental, health and safety. The main difference is that technical regulations of gas flaring and venting as until now been different from economic regulation of network industries. The monopolies transportation activities have however an impact on the institutional requirements for carrying out flaring and venting regulations. The template created as Annexure I is therefore a bridge to the chasm.

In most countries the regulatory authority that conducts the regulatory task is a government institution such as environmental authorities, petroleum ministries that have specific responsibilities of managing the natural resource of hydrocarbons including assessing the impact of flaring and venting of

associated gases. The ministries either in tandem with environmental regulators or the environmental agencies themselves conduct the aspect of providing flare permits or approving oil field development.

In the Canadian province of Alberta gas flaring is carried out by an independent regulating authority which is also integrative of the downstream energy markets. The design of the template in Annexure I takes into account these considerations. The trend however in Algeria, Bangladesh, Brazil, China, Egypt, Libya Malaysia, Mexico Peru and Vietnam is still state owned petroleum corporations.

The GGFR while not suggesting a template as in Annexure I have however identified the following in terms of regulatory efficiency:

- Independence of the F & V regulative institutions
- Clarity in roles and responsibility of regulatory agencies
- Transparent and enforceable regulatory procedures and operational processes
- No conflict between regulating institutions and their roles
- Ability to actualize through staff and financial support

The template in Annexure I is meant to realize the above points that have been identified by GGFR.

2.4 THE INTERNATIONAL OUTLOOK ON THE OPERATIONAL MODALITIES OF REGULATING FLARING AND VENTING

2.4.1 THE STUFF OF OPERATIONAL TECHNICAL REGULATION

The stuff of operational technical regulation has two flavors in all:

- A "prescriptive" approach
- A "performance based" approach

The prescriptive as the name implies is to regulate based on each and every detail as prescribed by the regulator and to be met by operators. Detailed procedures and operational processes are specified about what is required and how achieved. In practice these are not as simple as it is envisaged and could be challenging to comply with. The vagaries of operations, measuring and monitoring at every oil site may be expensive and impractical.

On the contrary a flexible performance based approach can roll by the punches and depend on the consensus of the operator in close cooperation with the regulator. The onus of providing the strategy and evidence for compliance with agreed upon measures - now falling roundly on the operator. However, the regulators still require the enforcement powers to ensure compliance.

However, in practices the line difference between the two approached is not sharp and the usual practice it is the hybrid variety that works. The template under Annexure I is formulation of the hybrid approach with an additional aspect of sustainable and market oriented approach.

However, a commonality of either approaches are the following:

- Operational processes
- Regulatory procedures

2.4.2 OPERATIONAL PROCESSES

The main function of technical regulations is the three compliances on Health, Safety and Environment and that standards are being complied with when F & V operators flare associated gas.

The operational processes that are meant for safety, emergencies and shutdowns or during power and equipment failures can provide hazards not only to workers in the OIl and Gas operations but also nearby residents. Operational standards and guidelines have been instituted by several countries for the following aspects:

Burn technologies and practices – equipment may be specified for efficient burning of "clean gases" and their combustion.

Timing— The maximum time limit for continuous F & V may also be restricted.

Flare location—the flare typically will have to be located a safe distance from other facilities, accommodation units, and populated areas; 20

Heat and noise generation—upper limits set at specified distances from flaring operations

Smoke and noxious odor— Limits may be imposed on the opacity of smoke and the noxious odors.

Over the year's new equipment and processes have been instituted by corporations so that flaring and venting operations. To be discussed on the various application of associated gases during F & V are the small gas fired mini turbine generators to produce electricity. To encourage this use Alberta Canada instituted exemption from payment of provincial royalties. Cameroon would also be considering the commercial viability of such generators. Russia is experimenting the use of such generators in a larger scale volume.

The other features in developing countries is a lack of monitoring facilities to render regulatory procedures effective. The developing countries have not established operational requirements in their respective jurisdictions. Their own practices referring in their production contracts to "International best practices for oil production". In other words, countries need to establish a Health, Safety and Environment standards for regulatory procedures. The attempt in the template in Annexure I is to serve that purpose.

2.5 REGULATORY PROCEDURES

As in other types of regulations gas F & V regulatory procedures need to be given a legal effect, widely publicized to give transparency both in primary and secondary legislation. Also a clarity in terms of understanding the policies, laws and regulations and their consequent decision making and contractual implications. The template Anexure I has been designed to take into account all these features in one place comprehensively and executory.

The regulatory features on F & V however gather around the following provisos:

2.5.1 APPLICATION AND APPROVAL

The regulatory features on F & V revolve operationally on those that are done without explicit approval and those done with approval. The template in Annexure I takes into account both counts as due measure.

(i) F & V without regulatory approval:

The following approvals are made for operational needs are made without approval and are made as a part of the operating rights granted under production licenses. It is required to substantiate in regulation what is meant by unavoidable tech reasons. These definitions require to be clearly defined.

- Safety reasons (To release pressures)
- Unavoidable technical reasons (purge venting)
- Well testing and startup
- Emergencies

(ii) F & V with regulatory approval:

For flaring other than what is stated in (i) above the following systems are applied. These systems are also locked into the template in Annexure-I:

- As a part of an overall field development plan
- As a mutually exclusive F & V permit or environment license.

Usually it is a practice worldwide to authorize F & V for upstream oil field development and production plans. Field development also includes the F &V as an overall license program. The template envisaged under Annexure I not only makes these authorizations but also makes provisions for downstream supply or flange for the utilization of associated gas in a sustainable commercial manner. These tend to be one time approvals subject to periodic review and changes to F & V volumes.

A practice in F & V operations is to obtain EIA (Environment clearances) or impacts prior to sanction of F & V licenses or Field development sanctions. Some countries such as Argentina use the Gas to ratio of an oil field for permitting gas F & V. If the Gas to ratio is too high the upstream operations will not be allowed to F & V. In that event the template Annexure I will prove not just an alternative but a positive prerequisite for zero flaring and utilization of the F & V associated gas.

It is interesting to note that some countries actually require operators to prove that there no alternatives besides F & V. Alternatives such as envisaged in this thesis namely reinjection for oil recovery, storage or gas gathering stream, sale to downstream operations or power generation.

Regulators also use the incremental approach in that operators are allowed to F & V if they can show incremental benefits are lower than the incremental costs. In the Alberta (Canada case) will adjudge the project being economic if the discounted net present value before tax is greater than zero. This model is utilized in the template annexure I.

The other alternative of considering the associated gas as a negative externality is discounted considering the huge mobilization of gas F & V worldwide.

Present regulatory practices vary considerably because the regulation is not internationalized to make it truly global oriented and sustainable. It is the effort to prove the validity of sustainable F & V globally. The below Table 2 overviews the different type of instrumentalities used by countries profiled by the GGFR[25]

Table 2: Types of Flaring and Venting Authorization[26]

Country	Flare/Vent Permit	Development Plan	Environmental License
Alberta (Canada)	✓	✓	
Algeria	✓		
Angola		✓	
Argentina	✓		
Australia (offshore)		✓	
Azerbaijan		✓	
Bangladesh		✓	
Bolivia		✓	
Brazil			✓
China		✓	
Colombia			✓
Denmark	✓		
Ecuador	✓		
Egypt	✓		
Gabon		✓	
India		✓	

[25] http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/07/16/000012009_20040716133951/Rendered/PDF/295540Regulati1aring0no10301public1.pdf Table 15 (Last visited Dec 2017).

[26] http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/07/16/000012009_20040716133951/Rendered/PDF/295540Regulati1aring0no10301public1.pdf Table 15 (Last visited Dec 2017

Indonesia		✓	
Italy	✓		
Kazakhstan		✓	
Libya		✓	
Malaysia		✓	
Namibia		✓	
Netherlands		✓	
New Zealand		✓	
Nigeria	✓		
Norway	✓		
Oman	✓		
Pakistan		✓	
Peru		✓	
Poland		✓	
Qatar		✓	
Romania		✓	
Syria		✓	
Thailand		✓	
Trinidad and Tobago		✓	
Tunisia		✓	
United Kingdom	✓	✓	
Uzbekistan		✓	
Venezuela		✓	✓
Vietnam		✓	

2.6 MEASURING AND REPORTING

The effective regulatory procedure requires an accurate reporting of volumes flared and vented. The process of verification is dependent measuring equipment and enforcing compliance. The two options here are:

- Gas flaring and venting measurement
- Estimation of flare and vent volumes

Gas flaring and venting metering has long been a contentious issue and the fact that oil producing countries have several thousand wells it becomes impractical and costly to install F & V metering device especially at smaller production sites. Also at normal operating conditions the gas flared and vented are at a very low velocity and under such conditions measuring becomes inaccurate.

The use of Ultra sonic sensors have been effectively used in UK, Norway and this has been introduced in the template under Annexure I. The state of the art metering devices. The costs of such measuring devices can be met considering the volumes flared. Where necessary countries use estimated to derive the F & V gases. Software has been developed to make such calculations for estimation.

Annual reports can be culled from the measurements of the gas emissions.

2.6.1 MONITORING AND ENFORCING OF FLARING AND VENTING

The effective regulatory procedure requires an accurate reporting of volumes flared and vented. The process of verification is dependent on measuring equipment and enforcing compliance. The two options become the basis of noncompliance of license conditions in many countries.

- Penalties and fines
- Withdrawal of production/operator's license

The countries profiled have very little chance of enforcing flaring and venting considering a lack of monitoring or enforcing mechanisms. The template under Annexure I is inclusive of metering devices and their periodic calibration for evangelistic propagation of such a template proposal. The compliance procedure in most countries is about imposing penalties on operators on

noncompliance in the form of incentives. The incentives proposed under the template system is the ownership of all Flare and Vent releases of associated gases by an operator. It is proposed by GGFR that the Fines and penalties are least effective and are also expensive to enforce. On the other hand this proposal incentives the effective use of F & V associated gas by operational use. In this regard the template has introduced the Canadian model of enforcement ladder to address noncompliance issues, The template introduced takes into consideration this enforcement ladder. Minor infractions require a written requirement that corrective action be taken. The ladder depends on the appropriate response and the seriousness and or repeat offences of non-compliances. Serious noncompliance which includes an operator failing to comply with written notifications and flaring of sour gas without permission resulting in production license suspension.

2.7 OTHER RELEVANT FACTORS

The other factors that has been considered in designing the template Annexure I which effect the economics of associated gas F & V are;

- **Standards:** National and International standards can be used effectively as supplements for regulatory processes these are particularly useful in:
    - Setting improved flaring and venting targets
    - Standardizing monitoring and reporting procedures

The template envisages the use of all such standards and collates all of the standards that have been developed by government and non-government organizations, The template developed seeks to establish a standard through a common template, with these modalities seeks to provide:

- A common framework worldwide to encourage consistent objectives in reducing F & V and the of global volumes for sustainable pratises

- Provide common guidelines throughout the world
- Encourage cooperation between industry and government in defining standards.

2.8 FINANCIAL INCENTIVES

The economic value of the utilization of associated gases is primary to an operators decision to both F&V as well its utilization. If the benefits of using F & V is greater than its costs operators will then think of optimizing its use rather than as a wasteful expenditure. It is the objective of this thesis to demystify both the quantum and value of such utilization. With additional of global mobilization of such resources that percolate not only statutory environmental regulations that have descended both nationally and internationally through multilateral treaties both within the UNFCCC and other NGO's. As per GGFR studies two factors are interdependent to financial incentives:

- Natural Gas market development based on non -associated gas such as coal etc.
- Fiscal policies of the Government in O & G

2.9 NATURAL GAS MARKET DEVELOPMENT BASED ON NON - ASSOCIATED GAS SUCH AS COAL ETC.

The emphasis of non-associated gases such a coal and nuclear fuels over natural gas and it concomitant use of associated gas is one of the factors that retard F & V. The emphasis on competing fuels such as Hydro, coal and nuclear leads to government subsidization of such sources and therefore effects the price of natural gas for application in the upstream and downstream gas industry. In the 1970's such perception underwent a sea change many countries realizing the value of natural gas as an alternative fuel. There has been steady increase in the price of natural gas giving it a new amplitude in energy economics.

The higher economic value of natural gas have prompted many industrial countries to actually seek the reuse of associated gas from F &V and seek opportunities for sell gas in downstream operations. This promoted the development of downstream gas networks and markets that provide such opportunities, which are tied up with infrastructure development.

Encouraged by such development now developing countries have also encouraged Public – private partnership to build such downstream gas networks. Nigeria for example through the aegis of the West Africa Pipeline (WAGP) are exporting F & V associated gas to the neighboring countries of Benin, Togo and Ghana. Nigeria and Angola are also expanding LNG terminals that allow for natural gas and associated export. In this context GGFR reports that governments are increasing reducing subsidies so that for various energy sources so that associated gases from F & V sources to be sold at downstream markers as an economic measure.

2.10 GOVERNMENT FISCAL POLICIES RELATED TO THE OIL AND GAS SECTOR

The Royalty payment, taxes, share in Production sharing agreements and duties form what is termed as the "Government take. This can play an important part in the development of F &V associated gas.

Many governments have encouraged the production of Gas over Oil production. A preferential treatment includes lower taxes and royalties compared with oil production. This eventually directly or indirectly the use of Associated gas marketing in Oil fields. Nigeria has adapted such a policy. Alberta Canada have adapted a royalty waiver program for as an additional incentive for the use of associated gas.

Tax regimes have also been a methodology for incentives for flaring and venting conservation. The Clean development mechanism under the Kyoto protocol call also allow flaring reduction projects.

2.11 CONTRACTUAL RIGHTS AND STRUCTURE OF DOWNSTREAM ENERGY MARKETS

The prevailing market structure is an important mobilization for the use of F & V associated gases. For operators to use the associated gas the same must be sold in the countries domestic gas market or export to other countries through LNG facilities or export pipelines. The GGFR report profiled the following issues as common platforms for use of associated gas:

- **Contractual Rights to Associated Gas**
- **Structure of Downstream Energy Markets**

2.11.1 CONTRACTUAL RIGHTS

Contractual rights are embodied in the provisions of the licenses or production sharing agreements and defines the rights and obligations of the operators and the grant of the government. Two main aspects come into focus in this regard.

- **The use of associated gas in field operations**
- **The marketing of associated gas downstream**

Contractual provisions while varies considerably among many countries but fully recognized is the use of associated gas for generation of power, for enhanced recovery rates or to fuel equipment.

The downstream gas markets are covered under what is termed as 'preemptive rights '. These preemptive rights give government the exclusive right to market associated gas which have not been used in field operations. The template annexure I incorporates such preemptive rights and becomes ipso facto the contractual feature for upstream oil production Many countries such as Algeria, Angola, China, Egypt, Venezuela and Vietnam already have such practices. It is a practice of many countries to get these gases at below price or prices to be determined by the government. Non flared or non-vented gases therefore have to be provided by the operator below costs. Sometime the countries do not have

the infrastructure to the downstream industry or for export. Consequently, the volumes flared and vented are very high. It is the recommendation of this thesis that preemptive rights be absolutely under the control of the government and considering the international obligations towards environment, the global volumes available – the F &V could be self-sustaining in a regime that has sufficient supply chain quantum's as well as value in world markets.

2.11.2 THE MARKETING OF ASSOCIATED GAS DOWNSTREAM

Monopolistic market structures downstream gas markets hinder the use of associated gas a lack of transparent legal and regulatory framework and the hindrance to the supply chain to reach final customers. Liberalization of downstream markets in many developed countries have encouraged competitive activity in the gas markets. Pipe line operators are able to recover investment costs that open up the activity to third parties. The F &V associated gases are therefor at a rapid clip in developed countries where such liberalization has already taken place. Only in developing countries such openness for market operations downstream is yet to take place.

2.11.3 SUMMARY AND RECOMMENDATIONS (AS AN IMPLIED QUALIFICATION FOR TEMPLATE ATTACHED)

Monopolistic market structures downstream gas markets hinder the use of associated gas a lack of transparent legal regulatory systems this has the twin benefit of not only making sound environmental sense but also conserving a valuable natural resource such as associated gas.

The aspects of F & V goes far beyond just safety measures but a lack of a staid regulatory system together with creative environs of the operator playing in a encouraging infrastructure to market associated gas. It is the objective of the template provided to provide such a modicum of systems with the following implied underpinnings:

a) Globally countries develop policies the role F & V reductions can play in environmental controls
b) F & V develop both primary legislations as well as secondary legislations
c) Regulators have clearly defined mandate with no overlapping of roles also independent of operators regulated to avoid conflict of interest.
d) Clear and efficient operational processes for gas F & V
e) Enforcement staffing and financing must be ensured
f) The circumstance where unauthorized F & V can and cannot take place without prior approval has to be clear defined without ambiguities
g) Transparency in F & V application and approvals be established
h) Effective F & V measuring and reporting procedures
i) The enforcing bodies must derive their authority to be effective for controlling and monitoring F & V

Other relevant factors that affect F & V operations:

- International standards for setting improved standards not only within the production in the Oil field but also in the infrastructure for downstream markets
- Fiscal policies in the Oil and Gas sector including favorable terms for royalty payment and tax reliefs for husbanding F & V associated gases
- The structure of downstream market and fair access to network and customers in a nondiscriminatory manner with efficient and transparent regulatory and legal frameworks

The focus of this thesis is to develop a common platform for the above recommendations to work on. The template designed is for further evangelizing the process so as to win acceptability worldwide by a system collated on the study of 24 country profiles worldwide by the GGFR as per the appendix A below in table 4 below[27]:

[27] Supra as in Ref 19 page 27

TABLE 4[28]

Appendix A: Country Regulatory Profiles

Table A.1 List of Countries Profiled

Detailed Country Profiles	
Region	**Country**
North America and Europe	Alberta (Canada), Norway, United Kingdom
Overview of Countries' Regulatory Profiles	
Region	**Country**
North Africa	Algeria, Egypt, Libya, Tunisia
Sub-Saharan Africa	Angola, Cameroon, Gabon, Namibia, Nigeria
Middle East	Oman, Qatar, Syria
Latin American and Caribbean	Argentina, Bolivia, Brazil, Colombia, Ecuador, México, Peru, Trinidad and Tobago, Venezuela
Europe and Central Asia	Azerbaijan, Denmark, Italy, Kazakhstan, Netherlands, Poland, Romania, Russia, Uzbekistan
Far East and Australia	Australia, Bangladesh, China, India, Indonesia, Malaysia, New Zealand, Pakistan, Thailand, Vietnam
North America	United States

2.12 THE CANADIAN MODEL: A DURABLE CASE HISTORY.

Canada has one of the most popular techno economic models for flaring and venting which is mentioned in the regulatory template as Annexure I Appendix 1 Management Framework and Appendix 2 Decision Tree analysis[29]. These have been incorporated in the template -since they are popular around the world and are performance based regulatory practices.

[28] http://documents.worldbank.org/curated/en/590561468765565919/pdf/295540Regulati1aring0no10301public1.pdf page no 27 (last seen in January 2017)

[29] http://documents.worldbank.org/curated/en/590561468765565919/pdf/295540Regulati1aring0no10301public1.pdf page no 36 (last seen in January 2017)

The following has been adapted for the purposes of the construction of the template annexure I:Flaring and venting management framework and decision tree

- Gas conservation and economic evaluation
- Performance requirements Measurement and reporting
- The enforcement ladder as a means of practical outcomes

Each of these elements are discussed:[30] including the management framework[31] and the decision tree process A3.

2.13 GAS CONSERVATION AND ECONOMIC EVALUATION

Economic evaluation of gas conservation at Canada (EUB) goes by the principle[32] that gas must be conserved if found that it is economic. An incremental rather than on an integrated basis. A project is considered viable if the incremental value of gas generation is generates a net present value before tax greater than zero and a discount interest rate of prime + 3 percent. In other words a low threshold between conserving and not conserving. The EUB evaluates by management by exception in that the licensee if opts for non conservation then the evaluation must be available for audit and they may ask additionally the following:

- Licensee has to provide additional information that all possible and practical options have been evaluated

[30] *Management of Routine Solution Gas Flaring in Alberta: Report and Recommendations of the Flaring Report Team*, CASA, 1998, and *Gas Flaring, Incinerating and Venting in Alberta: Report and Recommendations for Upstream Petroleum Industry by the Flaring/Venting Project Team*, CASA, 2002.
http://documents.worldbank.org/curated/en/590561468765565919/pdf/295540Regulati1aring0no10301public1.pdf page no 33 (last visited in January 2017)

[31] Production, pipeline, and gas processing facilities must also comply with the flaring management framework.
http://documents.worldbank.org/curated/en/590561468765565919/pdf/295540Regulati1aring0no10301public1.pdf page no 33 (last visited in January 2017)

[32] EUB Alberta energy and utilities board
http://documents.worldbank.org/curated/en/590561468765565919/pdf/295540Regulati1aring0no10301public1.pdf page no 33 (last visited in January 2017)

- Reevaluation if the cost estimates seem excessive due to the use of inappropriate technology. audits are also in the form of random audits[33]

Figure A.3 Solution Gas Flaring and Venting Decision Tree

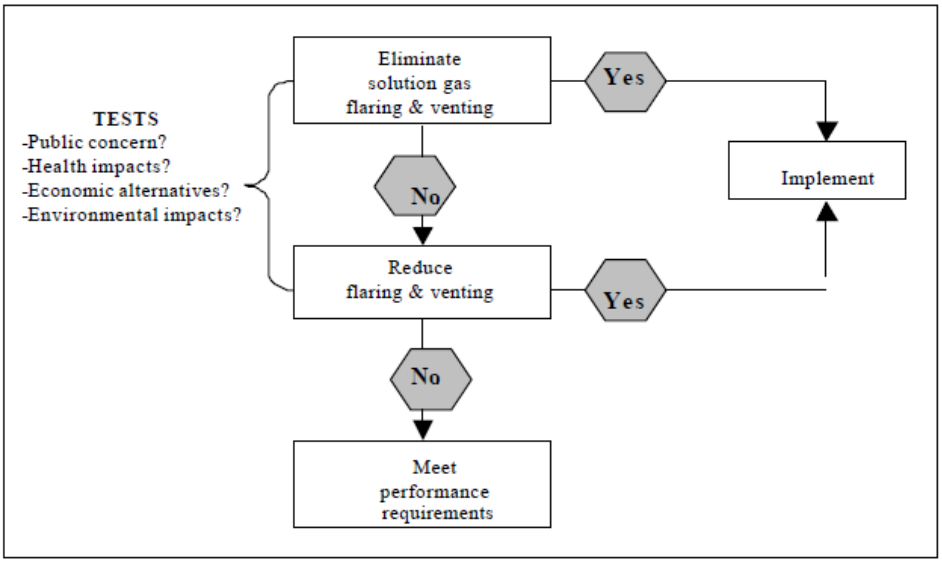
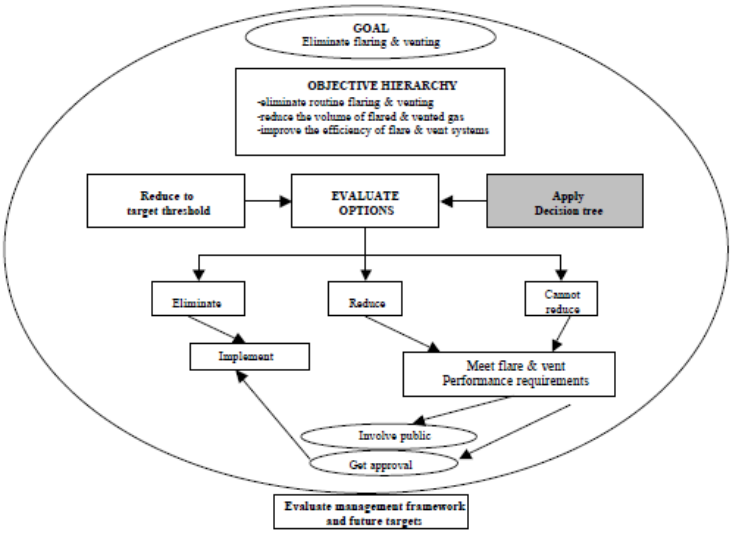


Figure A.2 Solution Gas Flaring/Venting Management Framework



33 http://documents.worldbank.org/curated/en/590561468765565919/pdf/295540Regulati1aring0no10301public1.pdf page no 33, 34 (Last visited in December 2016)

- **Performance Requirements**

The EUB has initiated several performance measures in lieu of the above decision and management tree and in the case it is proved that it is uneconomic ranging from flaring and venting of Temporary and well testing, Gas battery, Gas plant , pipeline, Gas combustion and fugitive emissions. Many of the measures have to use the above Management and decision tree methodology at the micro operations. The insistence of performance requirement is a positive deterrent of the business as usual approach.

- **Measuring and Reporting**

The EUB has also reinforced accuracy in measuring [34] for gas flaring and venting includes:

  - Reports of gas volumes greater than 0.1 tcm per month by all licensees of Oil, Bitumen natural gas production and processing facilities (including well tests) All emissions from routine operations, emergency conditions , depressurizing of pipe line compression and processing.
  - Test demonstrations by operators
  - Recommendation of the EUB

- **Enforcement ladder**

The EUB's enforcement ladder with modifications has been included in the template annexure I and the basic principles underlying are the following:

  - Operator noncompliance and performance history

[34] EUB *Guide 60*, Section 10, summarizes measurement and reporting requirements for flared and vented gas. TheEUB requires comprehensive reporting of oil and gas production and disposition (EUB *Guide 7: ProductionAccounting Handbook*). http://documents.worldbank.org/curated/en/590561468765565919/pdf/295540Regulati1aring0no10301public1.pdf page no 35 (Last visited in December 2016)

- Public proximity and environmental sensitivity depending on the area and performance history
- Potential impact level or proclivity to inherent risk

The EUB's enforcement ladder ensures monitoring process for non-compliant licensee / operators with greater frequency of inspection. The enforcement ladder has a graded response depending on the level and frequency of non compliance. The template in Annexure I has been redesigned to include timelines, seriousness and frequency of offence or noncompliance as per regulatory procedure.

The Indian legal system:

In terms of the regulation or enforceable law in relation to "Flaring and Venting" in petroleum industries – the one thing that can be said is that it is largely in-house standards maintained by companies such as ONGC. However it is to be noted that while "F & V" has its global impact the situation in India is one of scarce supply of gas. Many of the fields specially the recent ones at the Krishna – Godavari basin is one of minimum flaring since there seems to be a lack or no pressure in these wells. This is because of the nature of the discovery itself that renders the F & V an irrelevance in fact[35]. However the voluntary standards implemented by the ONGC is a matter of intent at Zero flaring where none or very little existed. Some of the figures indicate the The flaring of Natural Gas in 2014-15 is 2.59% of gross production which is 2.17% higher than that in 2013-14ii. A slew of legislations on environment is incident on the petroleum Industry in general as mentioned below:

- Environment (Protection) Act 1986.
- Forest (Conversation) Act 1980
- Water (Prevention and Control of Pollution) Act 1974.

[35] http://www.thehindu.com/opinion/op-ed/jairam-ramesh-on-the-krishna-godavari-basin-scam/article8486493.ece (last visited on 23/9/2016).

- Air (Prevention & Control of Pollution) Act 1981
- The Constitution of India

Supplementary guidance:

- Guidelines for Dicharge for gaseous emissions by Oil drilling and Gas Extraction industry 1996
- Standards for liquid discharge by Oil and Drilling and Gas extraction industry 1996
- Guidelines for Disposal of Solid waste by Oil Drilling and Gas extraction 1996

The above acts are not applicable or not mandatory on "Flaring and Venting" in petroleum industry and generally followed in other process industries. No specific provision is provided on "Flaring and Venting" in petroleum operations hence this thesis is intending to bridge the gap. However in the fitness of things environmental controls is achieved as an unintended consequence and achieves the objective of environmental controls of flaring and venting through succesful commercialization of associated gases. Thes above provisions are intended generally for all industries but as was earlier indicated Flaring and Venting are governed by government sector ONGC. The ONGC has zero flaring policies internally but the amount of flared and vented associated gases would be significantly reduced albeit by treating Flaring and Venting as not wasted but as a commercially valuable natural resouce. The control measures and expenses thereof for environmental controls are also saved. Such a savings has not been taken out and would be a cost saving measure and an unintended benefit. The Air act above has also no relevance to the upstream flaring and venting however this has been incorporated into the general template. Studies show that a limit of Nitrogen Oxide NOx 55 ppm, Sulphur di oxide, SO2 25, (parts per million Particulate emissions limits of 0.5 pound per 1,000 pounds coke burned and Carbon monoxide emission limit of 500 ppm on a 1-hour

average basis and 100 ppm on a 365-day rolling average basis 36 should be the relevant standard where the city is in close proximity of the petroleum operation. The above has been made at a cost of 80 Million US dollars[37]. In the context of Flaring and Venting the thesis has an intention of reducing it to Zero by maximization of its use commercially rather than diffusing into the atmosphere. The Indian air act has an equal prescription for industries in general (not with reference to flaring and venting) and these will be an unintended indirect savings for petroleum operations at least in the downstream.

Regarding the supplementary 'Guidelines. issued by the PNGRB, the same are not mandatory. In the case of Flaring and Venting the ONGC take their own decisions based on recommended practices. The world status is seen in Tables I, II and III mentioned earlier chapter I of this thesis. The lacuna is therefore felt for the need or creation of a template as in Annexure I is already detailed in chapter two and more significantly the global picture

In terms of the downstream indusries in the oil ang gas industry - the flared and vented gases are of such low volumes and value that the savings as well as the investment are ignored in this thesis as not significant. The example of reliance industries at its refinery - if it is an indicator resulted in a saving of 14 crore indian rupees per annum on a capital investment of around 10.08 crores38. The amount of flared and vented gases in the downstream is much lesser if not marginal when downstream industries industries such as Fertilizers and Petrochemical industries. The topic of this thesis concentrates on large volumes to arrive at conclusions on the commercialization of flaring and venting in the upstream. The EIA inspection, Environmental clearances are therefor net of the system in the downstream industries inclusing flared gases. Due to the

[36] https://www.epa.gov/enforcement/western-refining-clean-air-act-settlement (last visited on 16/9/2017) .
[37] https://www.epa.gov/enforcement/western-refining-clean-air-act-settlement (last visited on 16/9/2017) .
[38] http://www.pcra.org/pages/display/162 (last visited on 20/8/2017).

weightage both nationally and internationally only upstream industries are taken into account for making an assesment of the signficant volumes Flared and Vented. The EIA inspection of downstream operations (inclusive of Flared and vented volumes) consists of Screening (Submission of project plans), Scoping (Process detailing (EIA's terms of reference), Public consultation (all stakeholders feedback on impact) and Appraisal. Such certification in the downstream industry will therefore be holistic and the recovery of gases will be bench mark for environment clearance. In the case of reliance refinery Jamnagar below the revovery of flared gases was as insignificant as .03 % out of a mandatory .05%39. In view of its low value the flared gases are considered insignificant. The environmental permits and concerns are therefore in the province of general industrial requirements and not considered in this thesis regarding Flaring and Venting..

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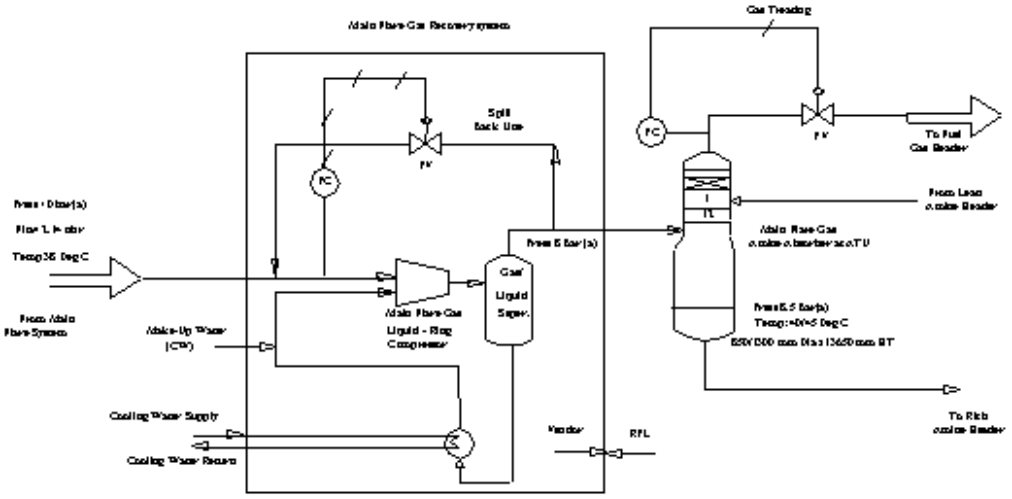
Main flare Gas Recovery & Treatment System Concept



Source of process[40]: Reliance Industries Petroleum refinery Jamnagar, Gujarat

[39] http://www.pcra.org/pages/display/162 (last visited on 20/8/2017).
[40] http://www.pcra.org/pages/display/162 (last visited on 20/8/2017).

The lack of direct legislations on signficiant Flaring and Venting in the Downstream Oil & Gas operations are a result of the judgements of the Supreme court decision Association Of Natural Gas And ... vs Union Of India (UOI) And Ors. on 25 March, 2004 and sections of the Constituition of India[41]. In view of article 248 of the constitution of India lays down the principle that pariliament alone has the power to make laws on the matters enumerated on list I of the Central government in this regard Oil & Gas operations and its exemptions are the province of the central government. ONGC being a PSU under the central government are therefore empowered to make Flaring and Venting operations. If at all template under Annexure I has to be legislated which is the objective of this thesis then it will be under the aegis of article 248 and List I of the constitution.. The global situation is already enumerated in the table mentioned.,

[41] https://indiankanoon.org/doc/354032/ (Last visited on 16/9/2017).

CHAPTER 3

GLOBAL POLLUTION AND VALUATION

This chapter quantifies the requirement in terms of global requirement in a twenty-year span - records of global increase in the production of Oil and Gas upstream. The ranking in the world order including rankings in order of the top twenty and top 30 to 60 ranking of countries are presented. Other key indicators as the flaring intensity which accelerate indiscriminate global flaring and venting and which needs to be developed on commercial lines. A slew of 78 countries flaring indicates a total of 147,000 Billion Cubic meters of flared and vented gases. In addition, data based on Satellite data testifies to these figures and their findings.

The amount of flared gases are 147,000 Billion cubic meters valued at 17 Billion dollars together with the investment estimated to be around a further 6 to 7 billion dollars amounts to be a 23 to 24 billion dollar operations annually. This is a turnover of many medium size companies in the world and the figure is commensurate towards sustainable business. The satellite findings have stated their conclusory findings through recommendation, which clearly indicate a need for uniform and executable regulatory template.

3.1 EMPHASIS ON TOP 20 POLLUTER COUNTRIES AND COMPARATIVE STUDY

Comparative study with reference to Canada, Middle East, Russia, India Far east and other relevant countries A study made by GGFR confirms that there is around 140 Billion cubic meters of gas flared annually. This is enough to produce 750 Billion kWh power- more than the entire power consumption of Africa. Environmentally this is the production of 350 Million tons equivalent to about 77 Million cars plying . The study made by GGFR in their publication "A Global overview and lessons from International experience" addresses three key issues 1) Role of government in defining flaring and venting policies 2) institutional characteristics and 3) adapted operational processes and regulatory policies. The other key issues were standards, financial incentives and effect of contractual rights of the downstream petroleum markets. Important contributors and leaders in the flaring of gas being Canada, Norway and the United Kingdom. The other countries in which GGFR had concluded its studies was North Africa, Sub Saharan Africa Latin America, Europe, Central Asia , Far East, Australia and North America. Countries profiled having flaring and venting policies that have a strict emission targets and limits are 18 out of the 44 countries under the Kyoto protocol. In these select countries that have targets, some are developing countries such as Nigeria and Peru. Most Oil producing countries lack clear emission policies and guidelines. This include large oil producing countries such as Algeria, Angola , Indonesia and the Russian federation. The rest of the countries regulate gas flaring and venting through primary and secondary legislation. The primary approach has been either prescriptive or performance based approach. The prescriptive approach is based on specific and detailed gas flaring and venting regulation established by the regulator and to be met by operators. In theory, this approach is relatively easy in practice, however this is the most challenging jobs as it requires enforcing mechanisms. Performance based criteria requires cooperation and

consensus between industry and regulator. Irrespective of the approach two key areas are addressed namely 1) operational processes with developed standards such as in Ecuador, Egypt, Nigeria, Pakistan, Peru and Qatar regarding a) Burn technologies for clean gas and efficient combustion b) Timing limits c) Flare location from a safe distance from facilities/ accommodation d) Heat and noise generation upper limit and e) Smoke opacity and noxious odors.

Regulatory procedures discussed extensively in the next chapters mean 1) Application & approval b) Measuring and reporting and c) Monitoring and enforcing. The Gas flaring is done as a part of an overall field development approval or as a separate flare and vent permit environment license. Field development is practiced in Angola, Cameroon, India, Indonesia and Pakistan. Some permits limit the time to one year and require regulatory applications and approval for extension. An Environment Impact Assessment (EIA) usually is required prior to field development. Regulators usually base their approvals on an incremental approach meaning operators are allowed to flare or vent only when they can prove the incremental benefits of using associated gases. The other procedure for regulatory authorities is to prove that it is uneconomic to use gas before issuing authorizations. Some jurisdictions require satisfying the regulatory authority that they have investigated all reasonable alternatives to flaring and venting including reinjection or oil recovery or for storage or gas gathering treatment and /or sale in downstream petroleum markets.

Studies by GGFR indicate that an integrated approach which is counting Flaring and Venting as a negative externality and to be accounted as a cost in the context of Viability of a production field - no country as taken this approach. The other factors are making of standards , financial incentives and the contractual rights and the Structure of downstream petroleum markets. The downstream petroleum markets in general for the use of associated gases in the petroleum market are hindered by the supply chain monopolistic market. Most

developing countries such as Argentina, Brazil, Chile, China, Indonesia, Malaysia and Mexico have carried out market reforms. Monopoly structures combined with a lack of network continue to affect the economics of associated gas adversely. The below data is from GGFR given in Table 4 [42]

The commentary on the above 20-year study is that the Global gas flaring in billion m3 gas /year increases exponentially with 1000 barrels of oil production per day[43].

Analysis of data: The above graph shows that gas flaring in a scale of 0 to 220 Billion m^3 gas/ year at the rate of 1000 barrels of oil per day flaring has risen in a scale of 0 to 90000 by about 11 % when oil production increased by 31 % in other words the flaring in a situation of 100% increase the present levels would exponentially be 3.5 times or 38 to 40% from present levels.

[42] http://www.worldbank.org/en/programs/gasflaringreduction#7 (last visited in Feb 2017).
[43] http://www.worldbank.org/en/programs/gasflaringreduction#7 (last visited in Feb 2017).

TABLE 4: Source http://www.worldbank.org/en/programs/gasflaringreduction#7

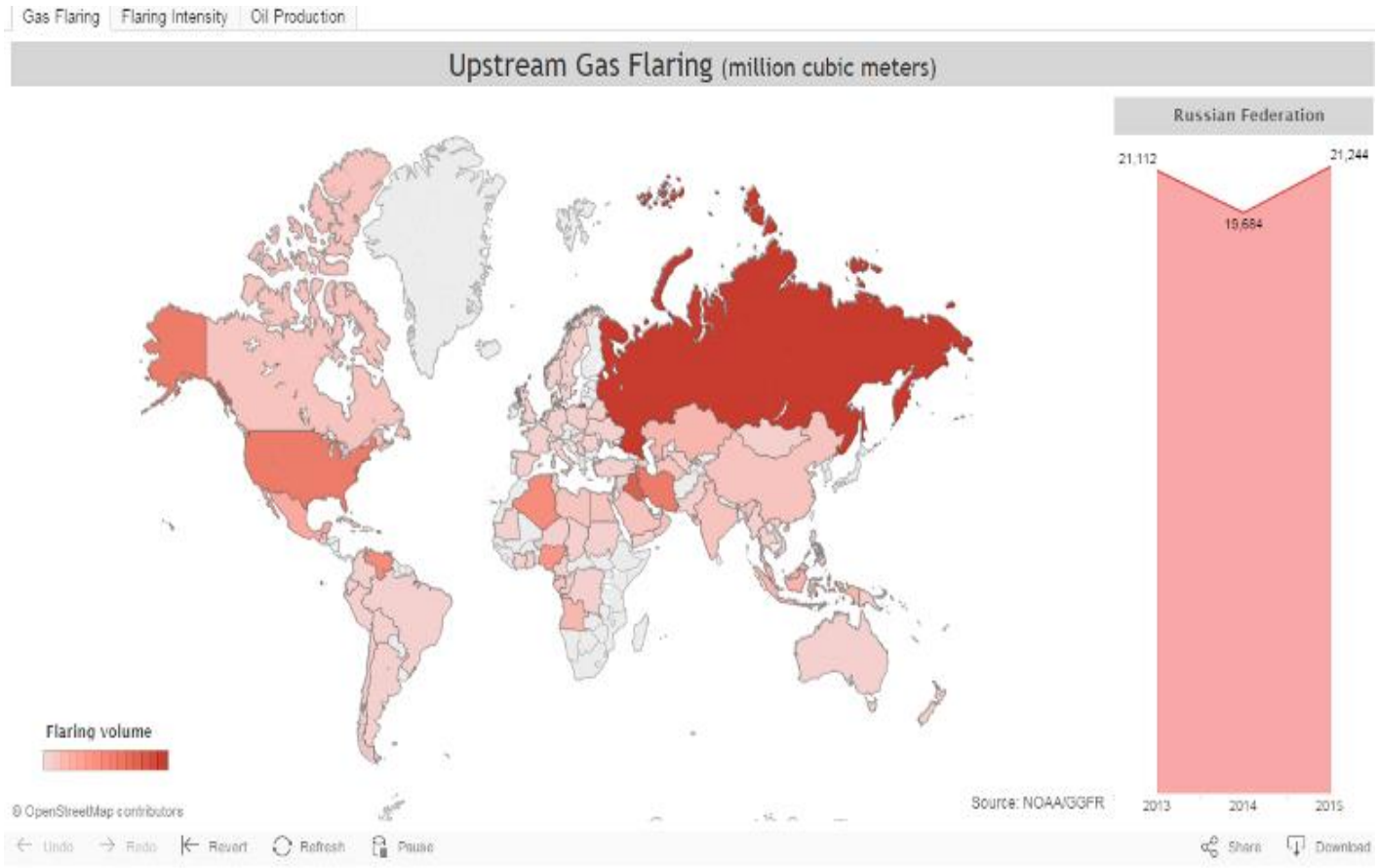
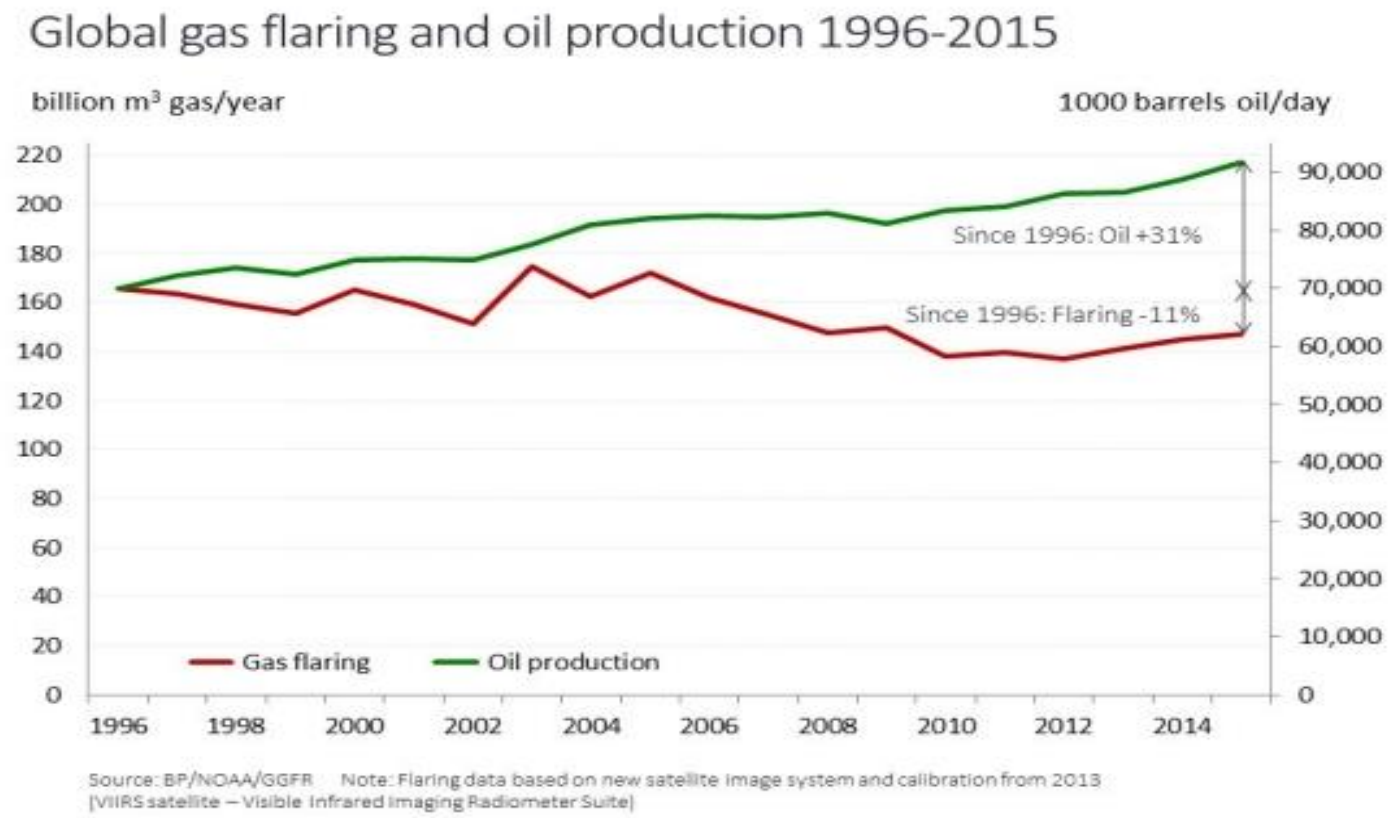


TABLE 5 : Source http://www.worldbank.org/en/programs/gasflaringreduction#7



Top 20 polluters as per GGFR in Table 6: Russia, Nigeria, Iran, Iraq, USA, Algeria, Kazakhstan, Venezuela, Saudi Arabia, Angola, Libya, Canada, Indonesia, Oman, China, Mexico, Qatar ,Egypt, Malaysia, Uzbekistanis taken into account as the heaviest global polluters[44] .

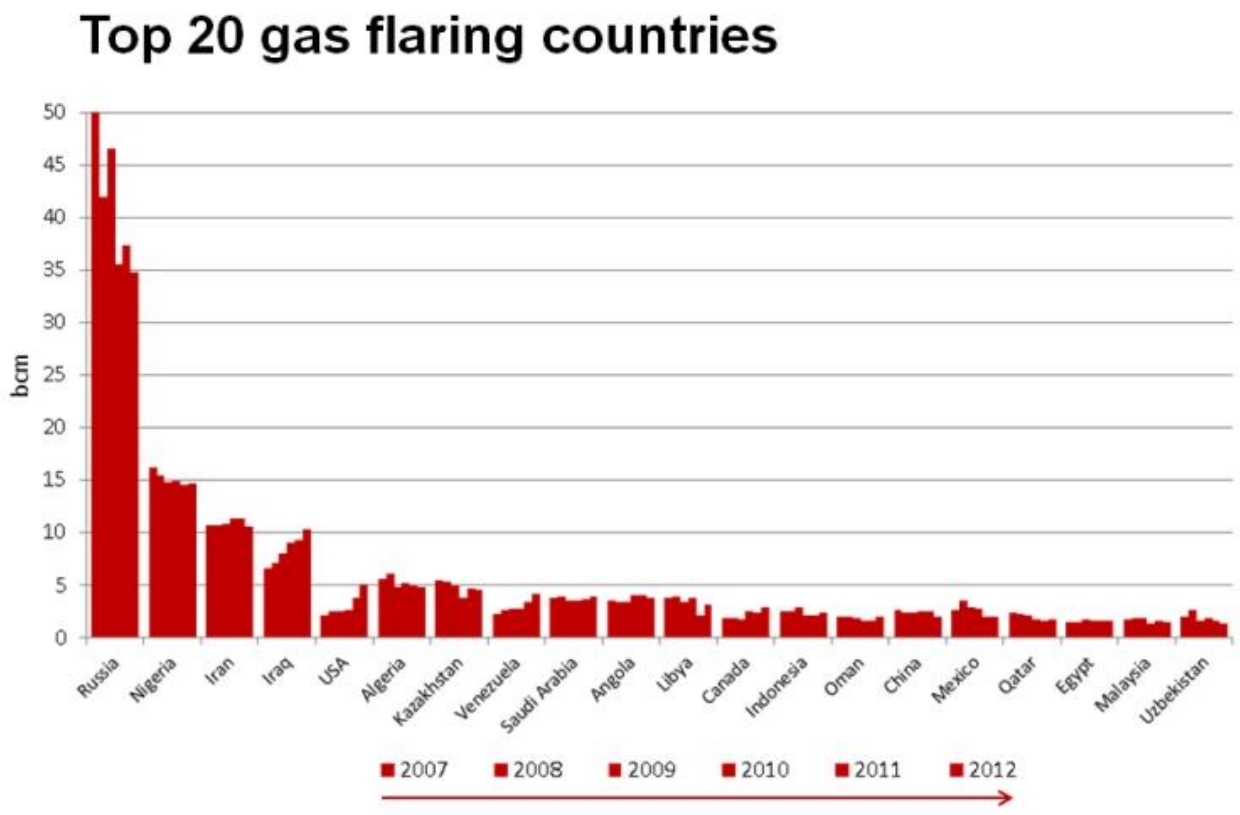
Analyses of Data:

Among the top 20 polluters 2007 to 2012 from F & V are, four who are very prominent (average shown):

1) Russia : which has lessened itself from 50 to 42, 45 37 35, 37 and 35 billion cubic meters from 2007 to 2012. This averages around 40 Billion Cubic meters. Considering the exponential levels in the previous trends this is certainly going to be steady state of 40 Billion stated conservatively. Also known that Russian Siberian sources being sulfurous in content requires a lot of refining. A lot in terms of F & V
2) Nigeria: Has seems rock steady with its output on flaring hovering around 15 Billion cubic meters. Shows very little effort at reducing F & V. The Oil here is also sulfurous
3) Iran & Iraq: Together hovering around 10 Billion also seems to have unchecked F & V.
4) The total of top polluters are therefor in the cumulative total of around 40 + 15+ 10 + 10 = 75 Billion cubic meters
5) The rest of the pack: From USA to Libya is around 4 X 7 = 28 and Canada to Uzbekistan is around is in the vicinity of 3 X 9 = 28 Billion cubic meters
6) The top 20 cumulatively is around 131 Billion cubic meters of flared gases.

[44] http://www.worldbank.org/en/programs/gasflaringreduction#7 (last visited in Feb 2017).

TABLE 6: Source http://www.worldbank.org/en/programs/gasflaringreduction#7



The top thirty new ranking under Table 7 flaring countries include Russia, Iraq, Iran, USA, Venezuela, Algeria Nigeria and Mexico[45]

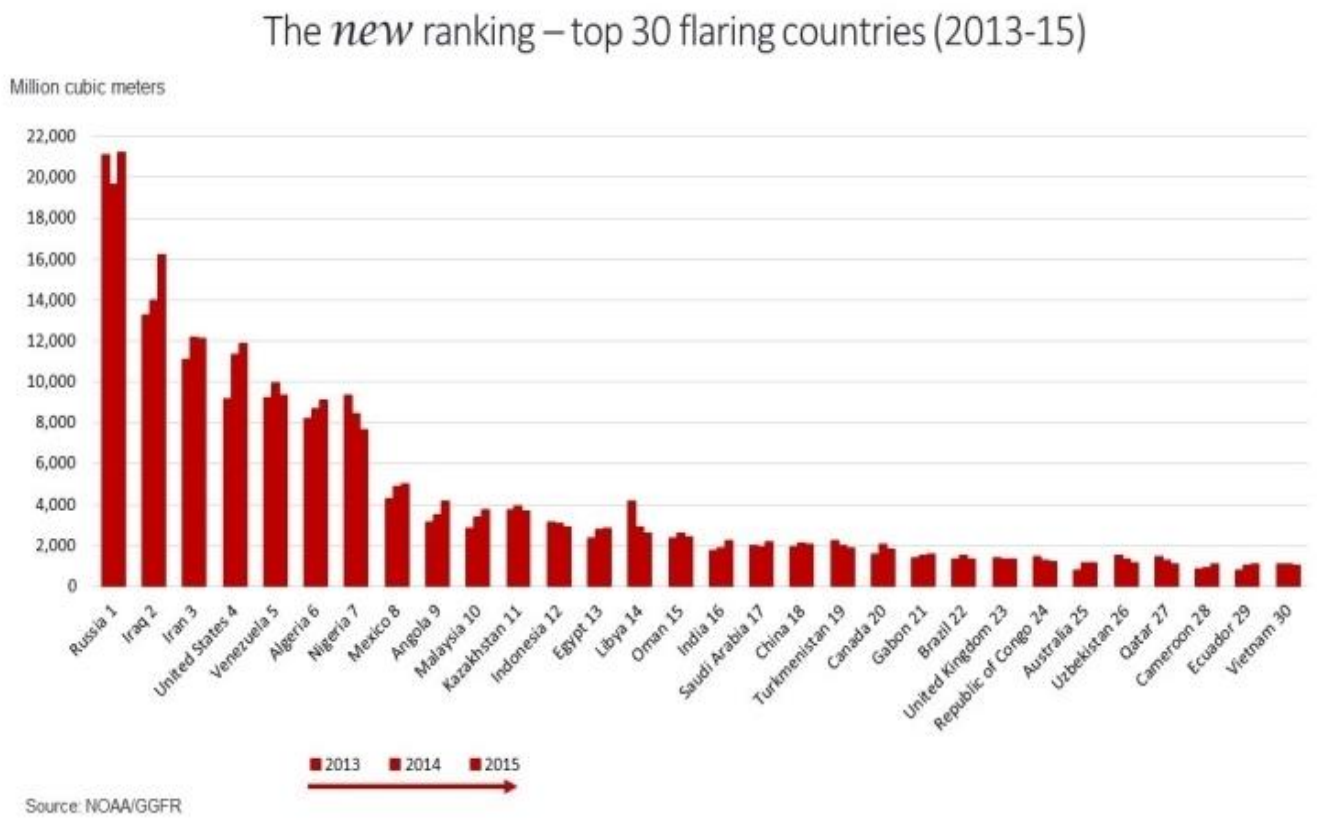
Analyses of Data:

Among the top 30 polluters 2013 to 2015 from F & V are, seven who are very prominent (average shown):

1) Russia: 21 Billion Cubic meter
2) Iraq: 15 Billion Cubic meter
3) Iran : 12 Billion Cubic meter
4) USA : 10 Billion Cubic meter
5) Venezuela : 9 Billion Cubic meter
6) Algeria: 9 Billion Cubic meter
7) Nigeria : 8 Billion Cubic meter
8) Total for 1) to 7) above : 84 Billion Cubic meter
9) There are a set of 7 polluters from Mexico to Libya around 4 bcm 7 X 4= 28 bcm
10) A set of 6 polluters from Oman to Canada (inclusive of India) around 2 bcm 2 X 6 = 12 bcm
11) A set of 10 polluters from Gabon to Vietnam around 1 bcm, 1 X 10 = 10 bcm
12) Total from data from 2013 to 2015 is 84 + 28 + 12 + 10 = 134 bcm

[45] http://www.worldbank.org/en/programs/gasflaringreduction#7 (last visited in Feb 2017).

TABLE 7: Source http://www.worldbank.org/en/programs/gasflaringreduction#7



The top 31-60 ranking flaring countries in Table 8 are UAE, Kuwait, Colombia Yemen and Argentina[46]

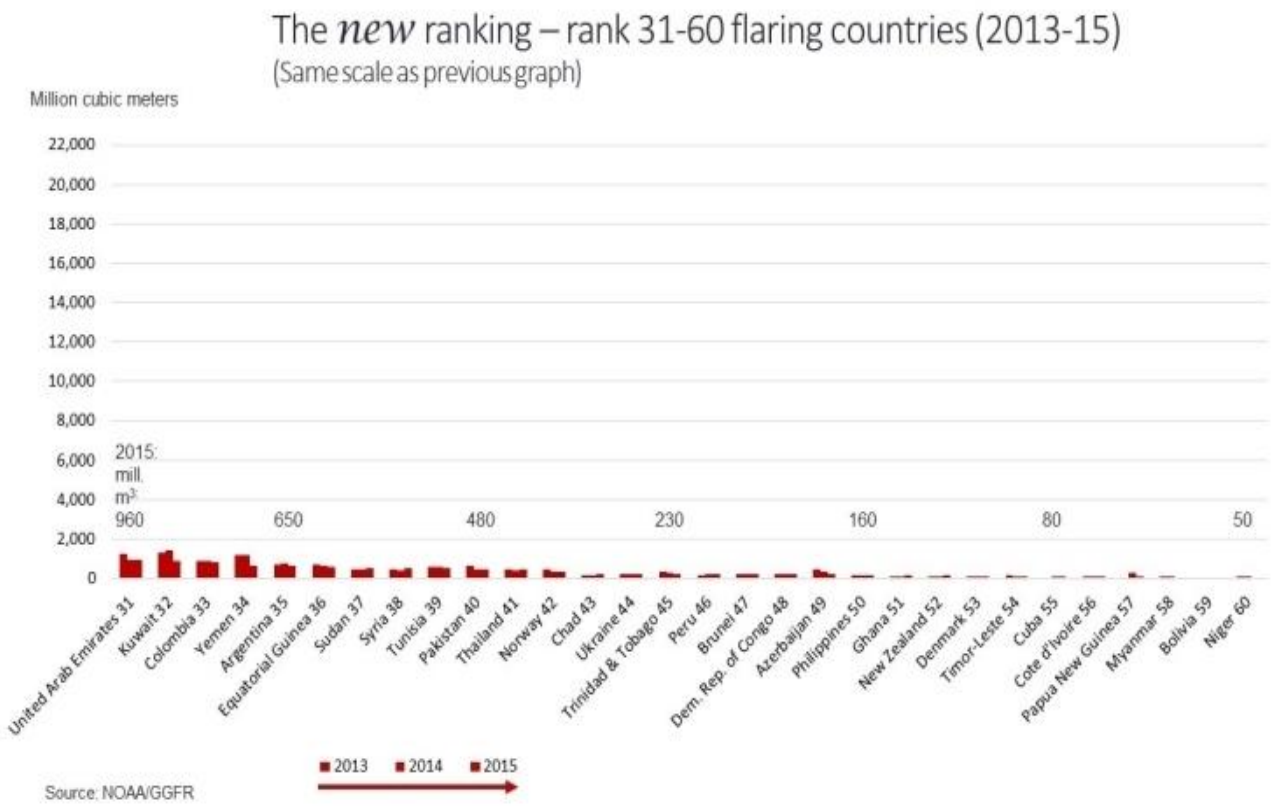
Analysis of Data:

Among the bottom 30 to 60 polluters 2013 to 2015 from F & V the average if taken at the

1) top set of 5 polluters from United Arab Emirates to Argentina of 1 bcm would be around 5 bcm
2) The next set of 7 polluters from Equatorial Guinea to Norway around 0.5 bcm would be 7 X 0.5 = 3.5 bcm
3) The last set of 18 polluters from chad to Niger which are around 0.25 bcm .0.25 X 18 = 4.5
4) Total in the data would be 13 bcm

[46] http://www.worldbank.org/en/programs/gasflaringreduction#7 (last visited in Feb 2017).

TABLE 8: Source http://www.worldbank.org/en/programs/gasflaringreduction#7



Top 30 polluters as per GGFR as per intensity as per Table 9: Russia, Nigeria, Iran, Iraq, USA, Algeria, Kazakhstan

Venezuela, Saudi Arabia, Angola, Libya, Canada, Indonesia, Oman, China, Mexico, Qatar, Egypt, Malaysia, Uzbekistanis taken into account as the heaviest global polluters [47]

Analysis of Data:

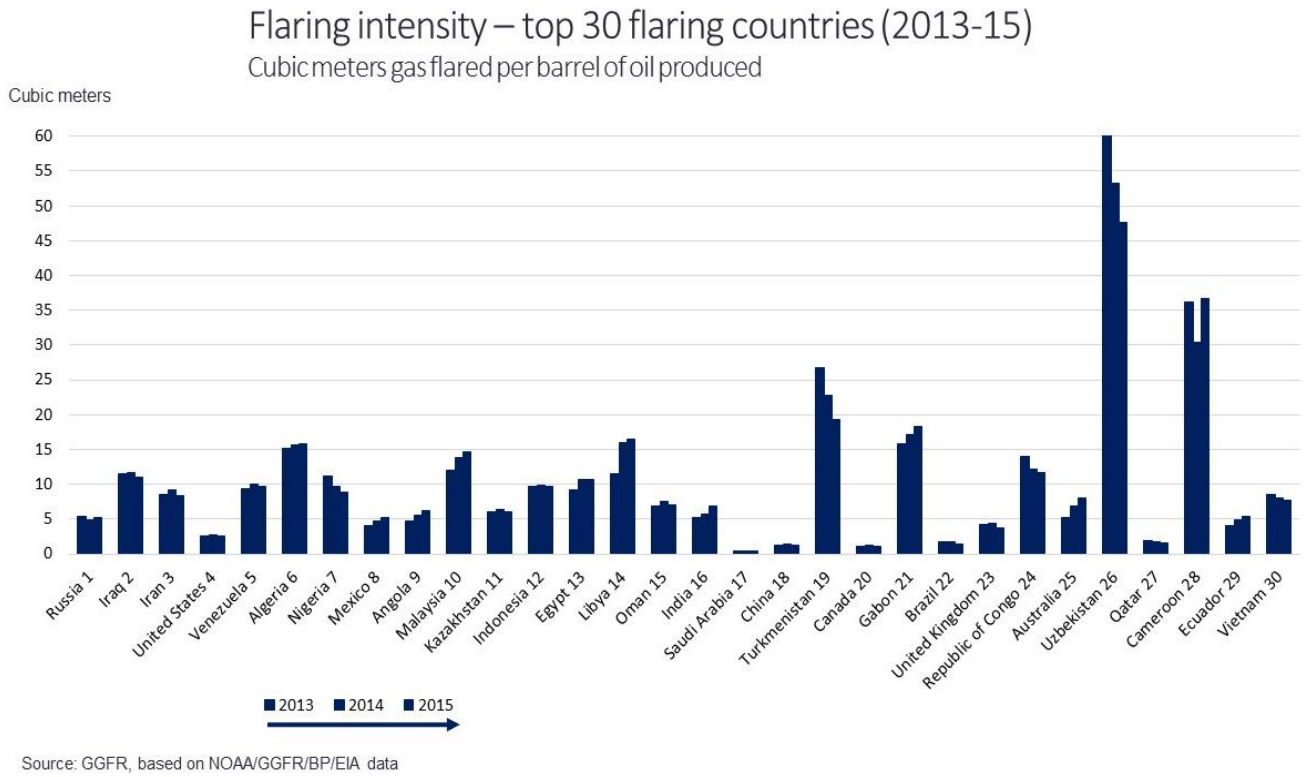
The intensity per barrel of oil produced may be a function of hurried unplanned output and this can indicate a lack of preparedness for F & V control. Or if the output is high not periodically but sufficiently for a long period may indicate a business as usual principle or a need to exploit natural resources for quick profit.

Among the top 30 intense polluters 2013 to 2015 from F & V are, seven who are very prominent (average shown)

1) Uzbekistan with 60 cubic meters and others in that range Cameroon 35 Cubic meters.
2) A second range is Venezuela ,Algeria, Malaysia, Gabon and Vietnam with intensity of around 10 Cubic meters.

[47] http://www.worldbank.org/en/programs/gasflaringreduction#7 (last visited in Feb 2017).

TABLE 9: Source http://www.worldbank.org/en/programs/gasflaringreduction#7



Top 31 to 60 polluters as per GGFR as per intensity as per Table 10 Colombia ,Yemen Syria, Tunisia, Pakistan, Ukraine, Dem Republic of Congo, Philippines

Analysis of Data:

The intensity per barrel of oil produced may be a function of hurried unplanned output and this can indicate a lack of preparedness for F & V control. Or if the output is high not periodically but sufficiently for a long period may indicate a business as usual principle or a need to exploit natural resources for quick profit.

Among the top 31 to 60 intense polluters 2013 to 2015 from F & V are, seven who are very prominent (average shown). Syria seems to lead in in this group along with Colombia, Tunisia , Pakistan Republic of Congo and Philippines in the range of 50 cubic meters and others in that range 30 -35 Cubic meters.

TABLE 10: Source http://www.worldbank.org/en/programs/gasflaringreduction#7

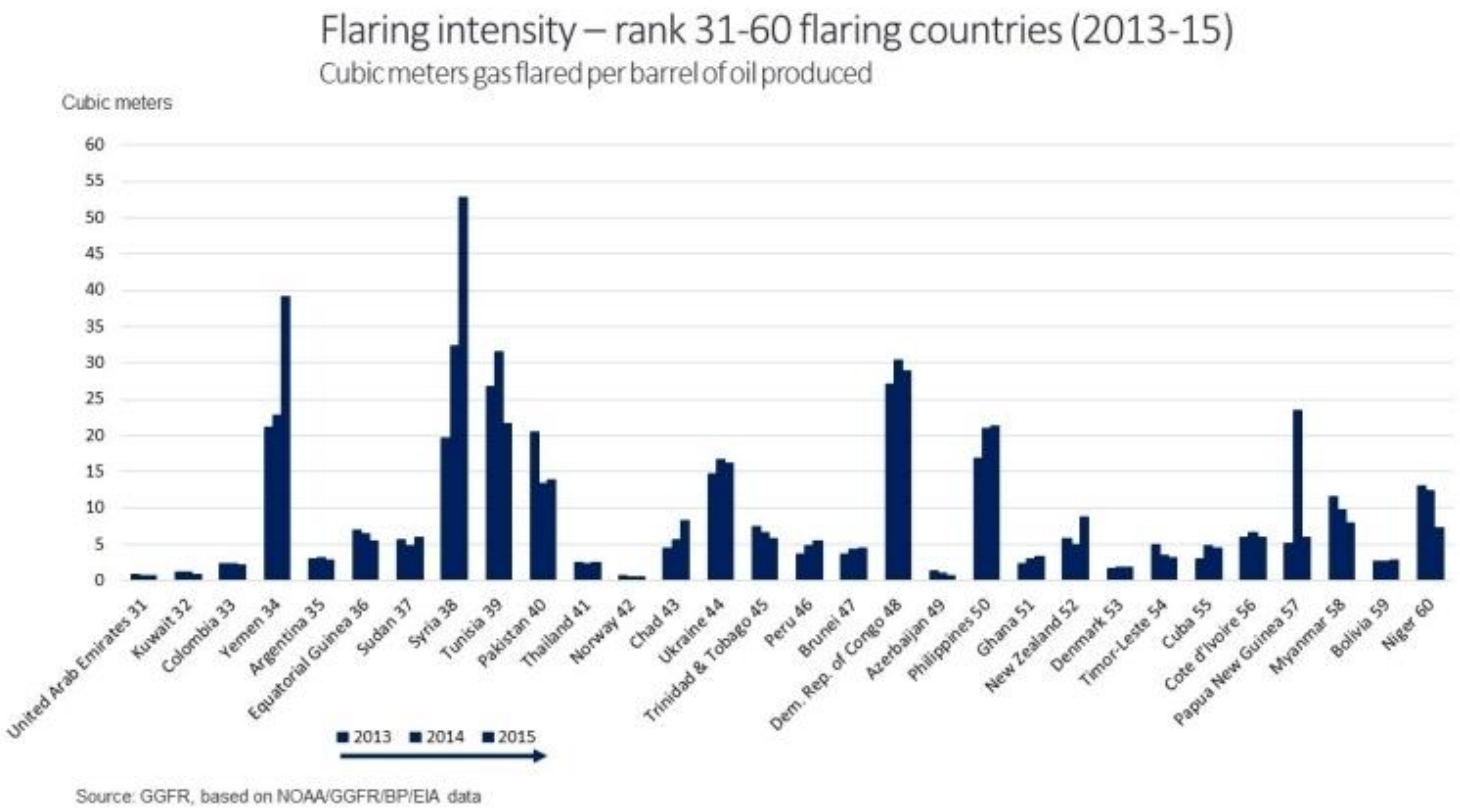


TABLE 11

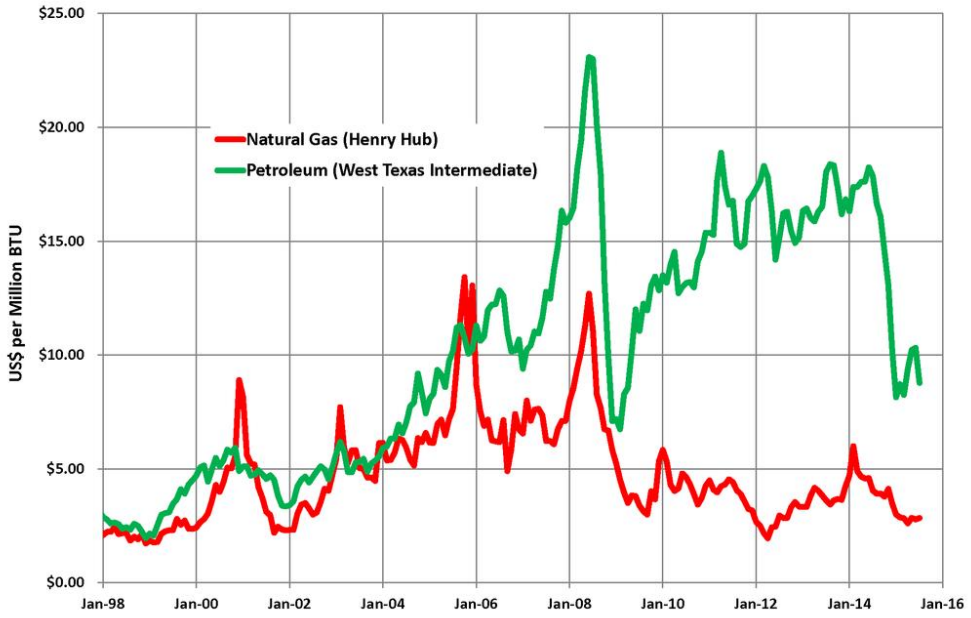
Gas flaring data 2013-15 (million cubic meters)

Country	2013 mcm	2014 mcm	2015 mcm
Algeria	8188	8698	9130
Angola	3163	3489	4185
Argentina	687	738	648
Australia	802	1138	1138
Azerbaijan	437	310	193
Bahrain	84	44	41
Belarus	3	2	9
Bolivia	46	50	53
Brazil	1341	1534	1328
Brunei	184	197	211
Cameroon	831	897	1083
Canada	1536	2063	1814
Chad	135	163	239
Chile	25	34	48
China	1908	2102	2075
Colombia	884	865	821
Republic of Congo	1428	1259	1176
Cote d'Ivoire	82	87	79
Cuba	54	89	82
Democratic Republic of Congo	197	222	211
Denmark	104	115	106
Ecuador	793	1004	1057
Egypt	2378	2783	2826
Equatorial Guinea	676	659	578
France	13	23	24
Gabon	1367	1479	1560
Germany	2	2	3
Ghana	85	117	130
Guatemala	15	22	34
Hungary	3	4	4
India	1737	1877	2201
Indonesia	3138	3066	2905
Iran	11095	12210	12096
Iraq	13282	14012	16213
Israel	0	0	0
Italy	3	2	2
Kazakhstan	3764	3932	3694
Kuwait	1296	1407	890
Libya	4145	2901	2612
Malaysia	2831	3365	3724
Mauritania	56	36	42
Mexico	4309	4858	4997
Mongolia	8	14	19

Myanmar	84	71	58
Netherlands	15	5	8
New Zealand	75	73	128
Niger	96	91	53
Nigeria	9341	8419	7658
Norway	429	341	336
Oman	2355	2594	2433
Pakistan	607	460	477
Papua New Guinea	52	292	74
Peru	137	196	226
Philippines	129	161	163
Poland	17	11	19
Qatar	1446	1256	1110
Romania	26	41	34
Russian Federation	21112	19684	21244
Saudi Arabia	1999	1944	2153
Serbia	12	10	15
Spain	25	31	12
Sudan	443	474	544
Sweden	0	0	1
Syria	427	389	521
Thailand	429	395	427
Timor-Leste	142	100	86
Trinidad & Tobago	313	270	233
Tunisia	590	604	496
Turkey	2	5	17
Turkmenistan	2252	1991	1843
Ukraine	230	243	235
United Arab Emirates	1240	927	958
United Kingdom	1354	1350	1321
United States	9191	11329	11852
Uzbekistan	1494	1301	1115
Venezuela	9256	9957	9332
Vietnam	1082	1073	1027
Yemen	1162	1203	666
Total	140,679	145,160	147,156

Source: NOAA/GGFR

TABLE 12

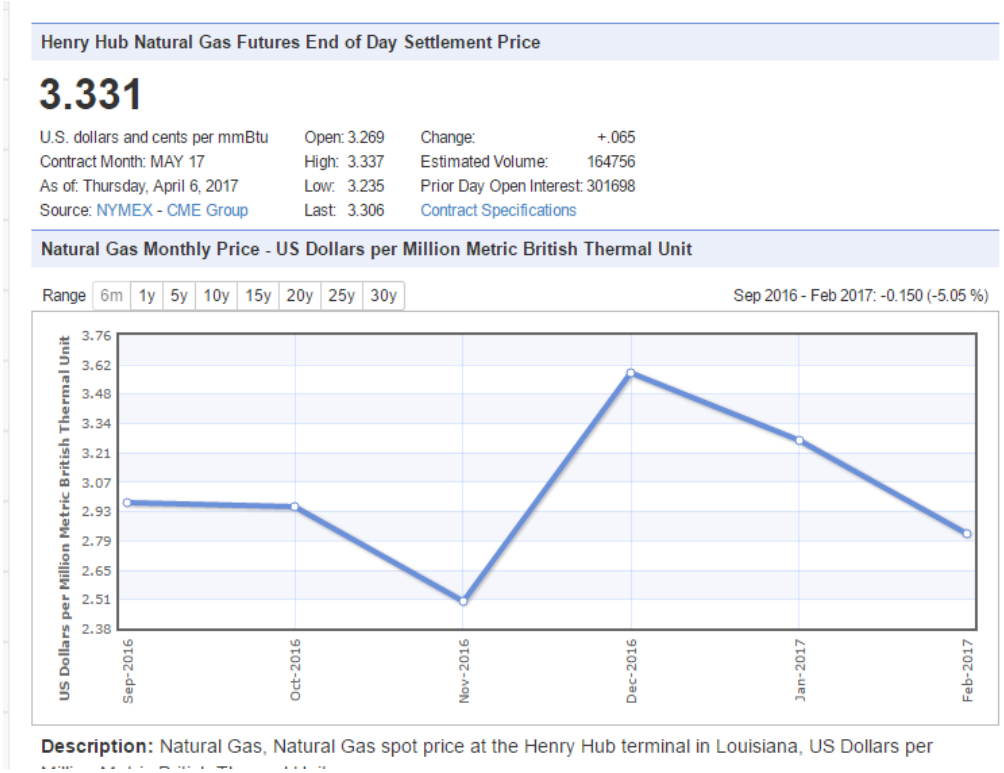


3.2 ESTIMATION OF GLOBAL GAS FLARING IN TERMS OF VOLUME AND VALUE

The amount of gas flared by the records available for three previous years of nearly 40 countries shows a trend of Gas flared around 140,000 + Million cubic metres[48]. Taking the 2014 as a base this means growth of almost 5% in F & V gases.. The top polluter Russian federation (21244); Iraq (16,213) USA (11,852); Iran (12096); Nigeria (7638); Algeria (9130) Venezuela (9332) Kazakhstan (4000) These amount to almost 40 % of the world F & V gas emissions. Going by the present increase in global production which is around 10 % -F & V for the increased production this would amount to an estimated 16 Billion dollar (3.31 @ rate of USD per cubic meter) . The value of global flaring not taking into account the damage done to the global environment this would amount to a massive 16 - 20 billion dollar business worldwide not taking into account suppy side market infrastructure development. Compared this volume organization that could compare for a worldwide operations :

[48] http://pubdocs.worldbank.org/en/417601483541512386/ggfr-data.pdf (Last seen in Dec 2016)

TABLE 13



Calculation based on Henry Hub prices:

1cu.m = .035315 mmBTU

The value gas F & V vented is around 147,000 million cubic meters

147,000 x .O35315 = 5191305000

@ 3.331 = USD $ 172922369500 = $ 17292 Million = $ 17.3 Billion

The typical assumed ratio between capital assets employed to the turnover as is assumed by the completion act being 1 : 3[49] we could assume from this a situation of further 6 billion in assets thus we would be taking at conservative estimation of around 23 to 24 Billion dollars. A sizable fortune 500 company would fall in this slot:

[49] THE COMPETITION ACT, 20021 No. 12 OF 2003 [13th January, 2003.] Regulation of combinations Combination 5.(a) 1 (A).

Typical Oil & Gas companies based in Texas[50] of the size of the above value operations:

PUBLIC COMPANIES	ANNUAL SALES REVENUE[iii] in US Dollars
Halliburton company	27.3 Billion
Baker Hughes	22.3 Billion
Fluor Corp	27.3 Billion
Apache Corp	16 Billion
PRIVATE COMPANIES	ANNUAL SALES REVENUE[iv] in US Dollars
Tauber Oil Company	4.7 Billion
Hunt Oil Company	4 Billion
CORPORATE SUBSIDIARIES	ANNUAL SALES REVENUE[v] in US Dollars
Chevron Phillips Chemical	13.7 Billion
BP Corp North America	9.5 Billion

3.3 FLARING ESTIMATES FROM SATELLITE OBSERVATIONS[51]

[50] http://gov. texas.gov/files/ecodev/Texas_Largest_Companies.pdf Data source Dun & Bradstreet, Forbes, American City Business Journal 2014 (Last Visited May 8, 2017).
[51] http://siteresources.worldbank.org/INTGGFR/Resources/Guidance_Document_Flaring_Estimates_Produced_by_Satellite_Observations.pdf (Last visited April 8, 2017)

Chapter 3 GLOBAL POLLUTION & VALUATION

TABLE 14

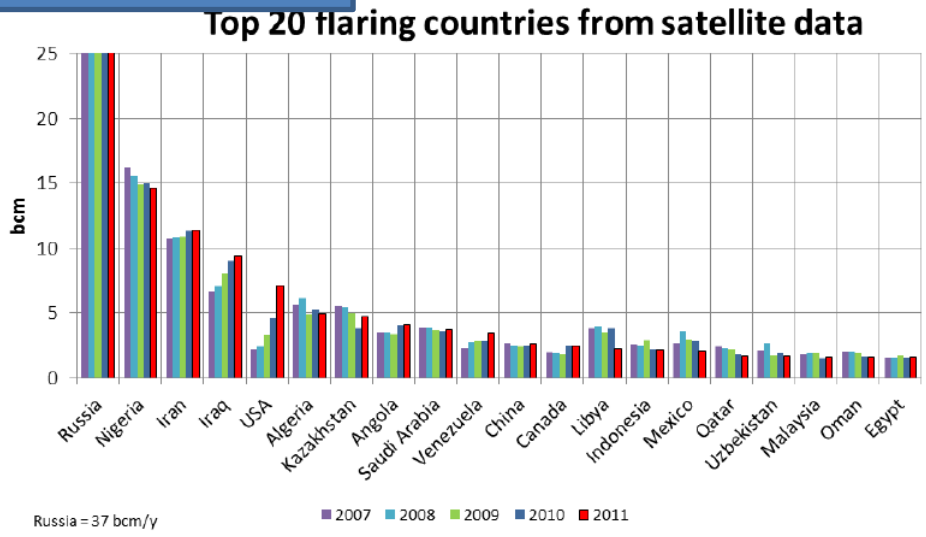
Estimated Flared Volumes from Satellite Data, 2007 - 2011

Volumes in bcm	2007	2008	2009	2010	2011	Change from 2010 to 2011
Russia	52.3	42.0	46.6	35.6	37.4	1.8
Nigeria	16.3	15.5	14.9	15.0	14.6	-0.3
Iran	10.7	10.8	10.9	11.3	11.4	0.0
Iraq	6.7	7.1	8.1	9.0	9.4	0.3
USA [1]	2.2	2.4	3.3	4.6	7.1	2.5
Algeria	5.6	6.2	4.9	5.3	5.0	-0.3
Kazakhstan [2]	5.5	5.4	5.0	3.8	4.7	0.9
Angola	3.5	3.5	3.4	4.1	4.1	0.0
Saudi Arabia [3]	3.9	3.9	3.6	3.6	3.7	0.1
Venezuela	2.2	2.7	2.8	2.8	3.5	0.7
China	2.6	2.5	2.4	2.5	2.6	0.1
Canada	2.0	1.9	1.8	2.5	2.4	-0.1
Libya	3.8	4.0	3.5	3.8	2.2	-1.6
Indonesia	2.6	2.5	2.9	2.2	2.2	0.0
Mexico [4]	2.7	3.6	3.0	2.8	2.1	-0.7
Qatar	2.4	2.3	2.2	1.8	1.7	-0.1
Uzbekistan	2.1	2.7	1.7	1.9	1.7	-0.2
Malaysia	1.8	1.9	1.9	1.5	1.6	0.2
Oman	2.0	2.0	1.9	1.6	1.6	0.0
Egypt	1.5	1.6	1.8	1.6	1.6	0.0
Total top 20	132	124	127	118	121	3.1
Rest of the world	22	22	20	20	19	(1.1)
Global flaring level	154	146	147	138	140	1.9

Source: NOAA Satellite data

Estimated flare volumes sjow very little change from 2011 onwards leading to a prerequisite for promoting the sustainability of commercial sustainability in Flaring and Venting operations[52]

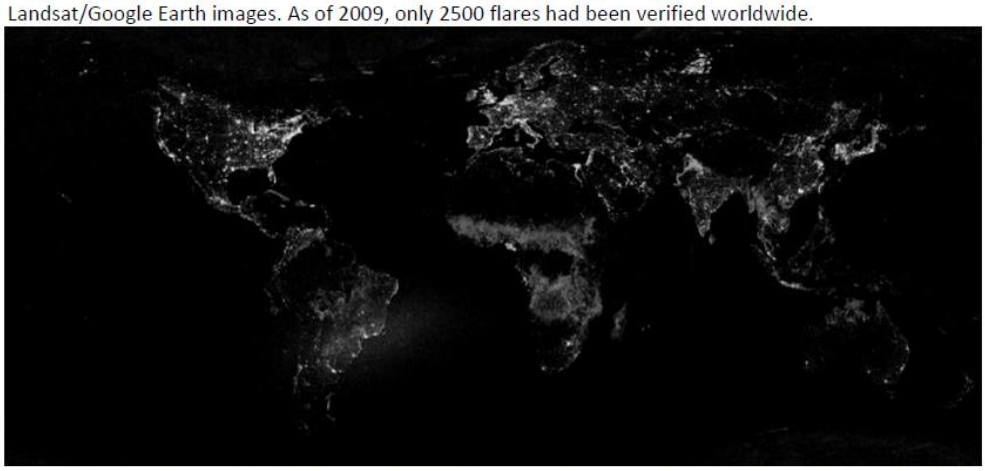
TABLE 15



52 http://siteresources.worldbank.org/INTGGFR/Resources/Guidance_Document_Flaring_Estimates_Produced_by_Satellite_Observations.pdf (Last visited April 8, 2017)

The top 20 even from satellite data is the same countries Russia, Iraq, Iran, United States, Venezuela, Algeria and Nigeria and Mexico, additionally Qatar, Uzbekistan Oman, Kazakhstan and Angola which are the leading polluters

Landsat/Google Earth images. As of 2009, only 2500 flares had been verified worldwide.



National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center (2007): A Twelve Year Record of National and Global Gas Flaring Volumes Estimated Using Satellite Data

3.3.1 KEY FINDINGS ON THE ABOVE RANKINGS AS PER GGFR:

- Many jurisdictions do not possess the technical resources and/or political will to monitor flaring volumes accurately.
- Remote sensing technology may be used to monitor nations' flaring activity with a globally uniform methodology.
- Satellite flaring volume estimates are directional rather than definitive. They illustrate the national and global magnitudes of flaring activity, as well as the direction of national and global trends in flaring activity.

There are two important factors that define the technical limitation of current flaring volume estimates:

- The capability to identify flares from lights during nighttime imaging - limited by assumptions on flare brightness, duration, and location.
- The extent that light brightness reflects flaring volumes - affected by combustion efficiency, surface reflectance, humidity, solar glare, artificial lighting, black carbon, and smoke. * These technical sources

of error not only directly affect flare volume estimates; they also have secondary effects because the significance of error sources is not globally consistent. When analyzing flare volume estimates we have to be aware that the influence of technical error is different across the regions we intend to compare. In other words, we have error as well as variation in error.

- Regardless of the technical accuracy with which national flaring profiles can be generated, variation in regions' flaring management policy frameworks undermines the usefulness of aggregate data. Satellite monitoring becomes more valuable as the granularity of observation is increased, so that the effect of individual policy variables can be analyzed.
- Current satellites are not able to measure emissions volumes from venting or black carbon"
- Optimism shown in the GGFR studies based on satellite data

The following statement issued by GGFR sums up the confidence in Satellite data taken on a Global basis

"There is much reason to be optimistic about the use of satellites in environmental monitoring. Advancing technology continues to improve the relevance of indicators, such as the estimation of flared gas volumes. In the meantime, it is important to recognize the current capabilities and limitations of satellite technology. Aggregated natural gas flaring can be measured with a reasonable degree of confidence on a *global* scale. The prevalence of uncertainties in flared gas volume estimation changes with scope. As you disaggregate data, the potential error arising from uncertainty increases. This is to be expected given the diversity of circumstances within jurisdictions, the assumptions made, and the liberties taken in the use of averages. At best, the reported estimates illustrate the national and global magnitudes of flaring

activity, as well as the direction of national and global trends in flaring activity. No claim is made to measure the extent of venting or black carbon emissions, both of which contribute significantly to the environmental impact of natural gas production" [53]

3.4 LEGISLATIVE CASE HISTORY: EXAMPLES OF SUCCESS AND PROBLEMS

3.4.1 THE SUCCESS STORY: THE CASE OF NORWAY

Most of Norway's recovered gas is exported while the remnant APG is re-injected. The state company Statoil following the CO2 tax introduction developed a system to end routine flare injection by recycling APG. Instead of being flared, it is lead to an export pipe line network. The pipeline uses a valve to direct the flow to the flare stack if the pressure builds up. According to experts in the O & G business, the outstanding success of Norway is due to the cooperation of the stakeholders because of a clear and unambiguous legislation on the treatment of associated gas right from the start. The consensus approach and collaboration between public authorities and main industry stakeholders has been the starting point to end routine flaring. The success reinforces that effective legislation can be evangelized to lead to the utilization of flared gas around the globe.

3.4.2 THE KAZAKHSTAN OPERATION: A CLEAR FAULT LINE CASE COMPARED TO NORWAY

A comparative study between Norway and Kazakhstan indicates the root cause analysis between success and failure of the flaring policies. While Norway maintains a Regulatory policy, which is open and transparent, Kazakhstan has

53 http://siteresources.worldbank.org/INTGGFR/Resources/Guidance_Document_Flaring_Estimates_Produced_by_Satellite_Observations.pdf (Last visited April 8, 2017

none of them. Unlike Norway, there is no single state authority in Kazakhstan not to mention a working regulative policy with clearly defined roles. Mandates are often conflicting. To curb imports of gas Kazakhstan evolved its gas AG utilization policy. However for encouraging investors to market associated gas produced within the country the market should be more transparent and new pipe lines to be constructed for supply to regions of high demand. By Kazakhstan requiring a permit for flaring only during emergencies they have converted most producers into offenders. Like Norway unavoidable technical reasons should be the basis. The emergencies do not require any kind of regulatory approval in practice. An alignment for implementing policies is primary requirement as between government and Kazakh petroleum companies

3.4.3 THE CANADIAN MODEL : DURABLE MODEL

The Canadian model already discussed in chapter 3 is the most popular techno economic model going around throughout the world includes both the Management model and decision making tree for performance based regulatory practices. The same has been utilized in the template Annexure I model adopted.

CHAPTER 4

SUPPLY SIDE TURNKEY DEVELOPMENT

Having quantified the job of flaring and venting as a worldwide sustainable business volume in chapter 1 to 4 above this chapter deals with the upstream controls of flaring and venting to the downstream markets both product wise as well as the downstream industry segment. The operational processes which are necessary prerequisites such as the technical aspects and their associated costs such as Gas treatment, Compression, Dehydration, Chilling, Sweetening, LPG production, Gas transport, Power generation and their connection with the industries in small scale are laced into an Economic and Financial model as costs , Parameter analysis in four different areas: a) Power generation to a grid, b) at the oil field to be fed to non-electrified zones c) Piped gas supply and d) LPG production to consumers.

The financial modeling conducted by Global Gas flaring reduction (GGFR) in typical case at Ecuador and Chad in 5 different methodologies has resulted in a financial findings of a Model Oil field and yields on flaring and venting use of Associated gas in terms of field size at a distance of 20 km, Maximum grid absorption (without loss) plus the cost of power and the cost of production of LPG. All indicators carried out on actual field conditions point out to a reasonable business proposition. Recommendations are also made to stakeholders in this chapter.

Chapter 4 SUPPLY SIDE TURNKEY DEVELOPMENT

4.1 PRECURSOR TO SUSTAINABILITY AND COMMERCIALIZATION UPSTREAM, MIDSTREAM AND DOWNSTREAM IN PETROLEUM OPERATIONS[54]

4.1.1 THE TECHNICAL ASPECTS AND COSTS

A study conducted by GGFR on the technical aspect and their costs for gas treatment, LPG production, gas transport and power generation have yielded cost curves taking into account total costs inclusive of installation. The operative costs and maintenance have been excluded[55]

4.1.2 GAS TREATMENT

While dealing with technical aspects of the viability of using associated gases in small-scale industries the different process required this section deals with power production at the oil field, transport of gas to consumers and LPG production given in the table 16 below[56]:

TABLE 16 *Requirements for Treatment of Associated Gas*

	Application of associated gas		
Gas treatment process/step	Power production at oil field	Transport of gas to consumers	Production of LPG
Compression	Required	Required	Required
Dehydration	Not required	Most likely required	Required
Chilling	Not required	Maybe required	Required
Sweetening	Not required	Maybe required	Maybe required

4.1.3 COMPRESSION

Compression is required for three purposes firstly for transporting the gas through pipelines for either power production or when sent to consumers or for processing into LPG plants. For power production normally gas has to be compressed to 25 – 30 bars. For transmission into pipelines compression is

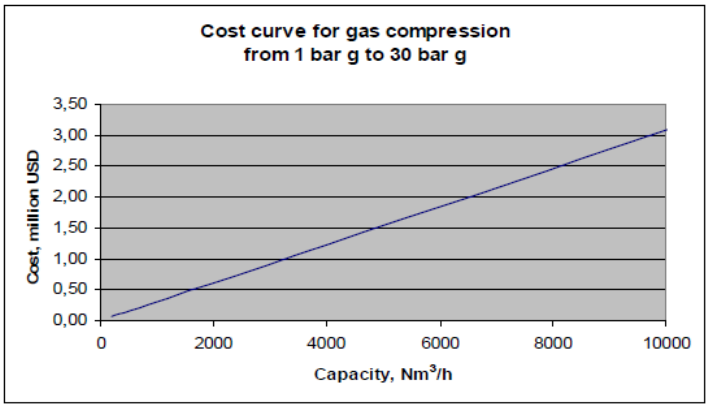
54 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016). All tables are sourced from this document.

55 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016)

56 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016)

required at higher pressures. Liquids generated during gas compression are separated for recycling to the oil production[57].

Figure 4.1 Cost Curve for Gas Compression Used for Local Gas Supply in Power Production at Oil Field



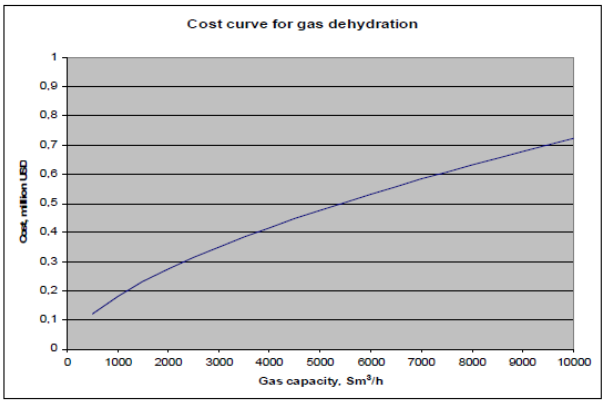
4.1.4 DEHYDRATION

Production of LPG is dependent on dehydration techniques for avoiding the formation of hydrates in the pipe line where it forms at high pressure at cold spots and blocks the flow. In the tropics low-pressure region hydrate do not form and desiccant filters. Dehydration being essentially the removal of water vapor from the gas at high flow rates the absorption of water in the hygroscopic liquid triethylene glycol (TEG) is used. Dehydration is done after the compression operations and the costs are shown below[58].

57 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

58 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

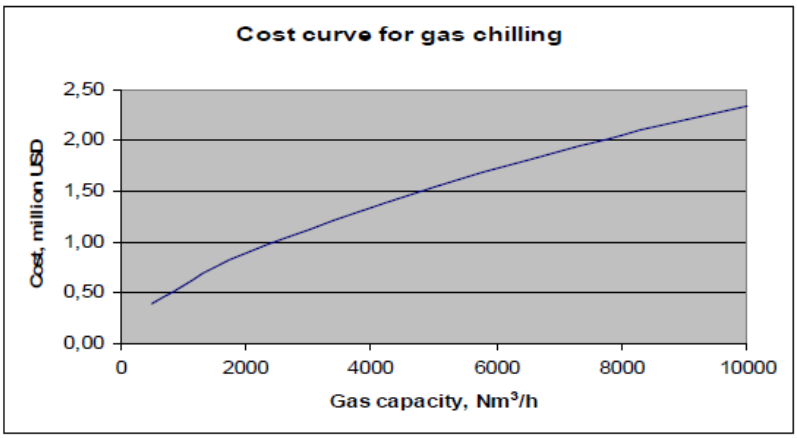
Figure 4.2 Cost Curve for Gas Dehydration Used in Connection with Long Distance Transmission, Large Consumption, or Low Ambient Temperature



4.1.5 CHILLING

Chilling of natural gas is done at temperatures -10 to -20C to remove heavy hydrocarbons through compression cooling systems. Rich gas containing heavy hydrocarbons condense at elevated pressures and the condensates lower the capacity of the pipeline. Also consumers at the receiving end of piped gas have an additional safety issues that liquids raise. The cost curves of gas chilling is given below[59].

Figure 4.3 Cost Curve for Gas Chilling

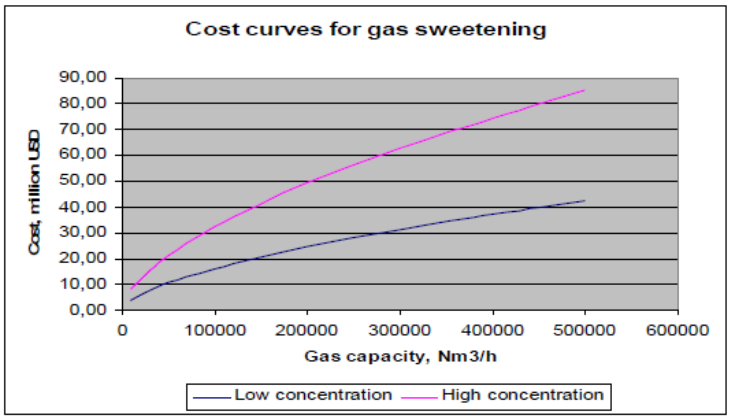


59 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

4.1.6 SWEETENING

Gas is sour if it contains H2S. The presence of sulfides causes toxicity which is harmful in piped gas. Also the excess toxicity corrodes the pipeline and it develops sulfide stress cracking. The process of amine absorption, molecular sieve process and the sponge iron process is used. The costs are given below[60].

Figure 4.4 Cost Curves for Sour Gas Sweetening Before Use in Transmission Lines



4.1.7 LPG PRODUCTION

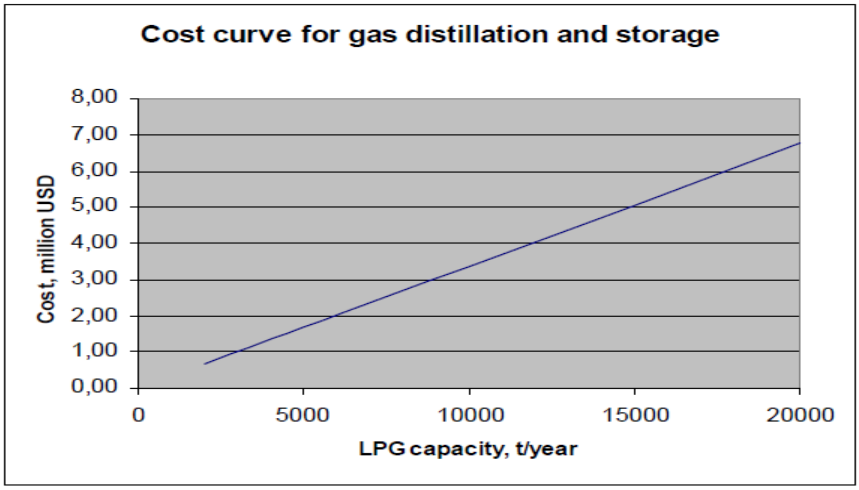
LPG is the chosen product for small consumers including households with smaller demands for energy. The LPG is produced by the previous processes namely compression, sweetening and finally dehydrated and chilled. The LPG has principally a combination of hydrocarbons of 3 to 4 carbon atoms such as propane, butane and isobutene.

The LPG is created produced from the liquid part of the associated gas, which condenses during gas chilling. After gas chilling, liquids are separated from the gas and then pumped to a distillation column LPG is separated and then transferred to buffer tanks where it can be drawn for bottling purposes.

60 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

The quantities of C3 and C4 vary considerably but a rule of thumb is that at least 20 percent by weight can be used for LPG production. The cost once again depends on the LPG production quantity. The cost curve indicated below is based on the GGFR best estimate includes fixed costs but may vary depending on the external facilities needed and the local requirement. Bottling costs are not included but on an average a 20 meter cube is estimated to be about USD 150,000.[61]

Figure 4.5 Cost Curve for Gas Distillation and Storage



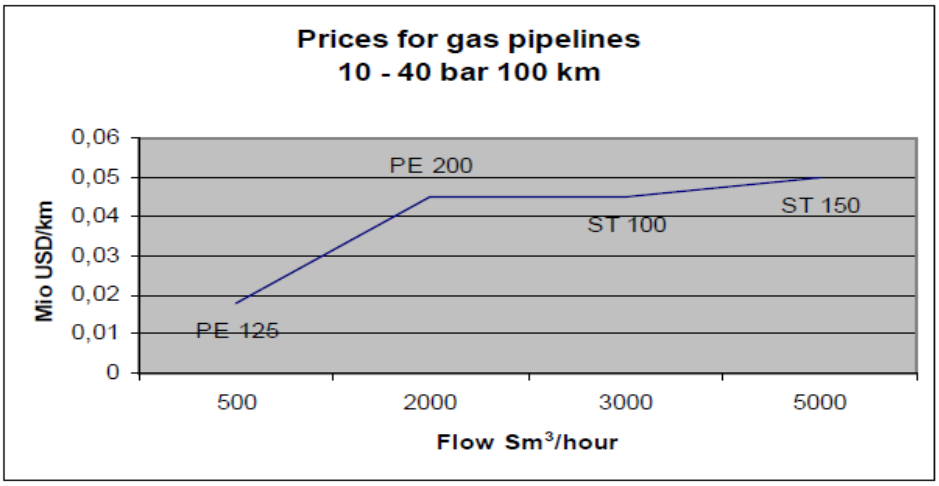
4.1.8 GAS TRANSPORT

The transportation of associated gas is the investment on pipelines. Variants of pipelines depend on the application for example dry, sweet associated gas firstly requires compression of up to 10 -84 bar at the oil field before feeding it to the gas pipe line. Gases in excess of 10 Bar are done through steel pipe with plastic lining and Cathodic protection. For pressures below HDPE is an attractive alternative of steel pipes

61 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

The cost curve below related to investment costs for pipes buried in the ground. The lower flows to PE and the higher to steel pipes. This however does not include compressor unit delivering the pressure gradient. The volume increase of gas transported goes the cost per unit of energy transported decreased logarithmically[62].

Figure 4.6 Cost Curve for Gas Pipelines



4.1.9 POWER GENERATION

Power generation through associated gas may be used for either generation of power or heat or a combination of both Electricity can be produced by generators driven by piston engines, gas turbines or steam turbines. Small power producing units (250 – 5,000 Kw) normally have overall efficiencies in excess of 50 percent. For a combined production of heat and power of 90 % efficiency can be reached[63].

62 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

63 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

Figure 4.7 Cost Curve for Engine Installations

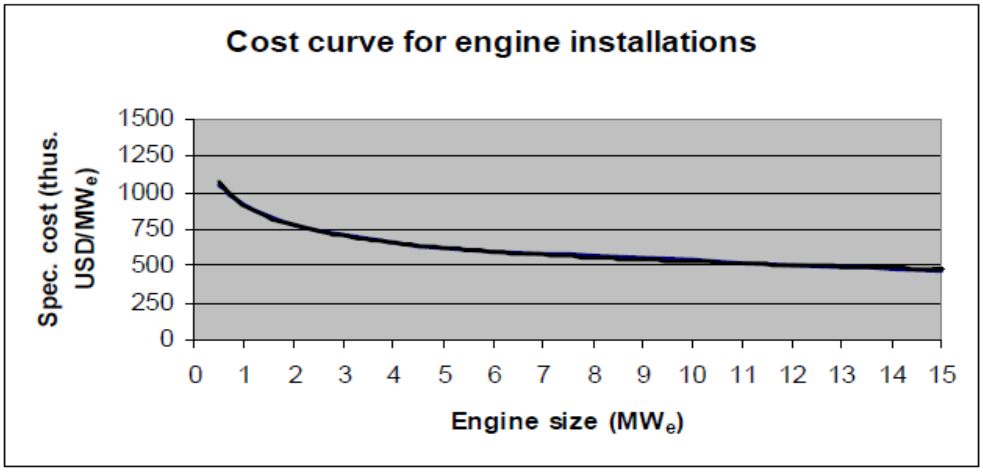
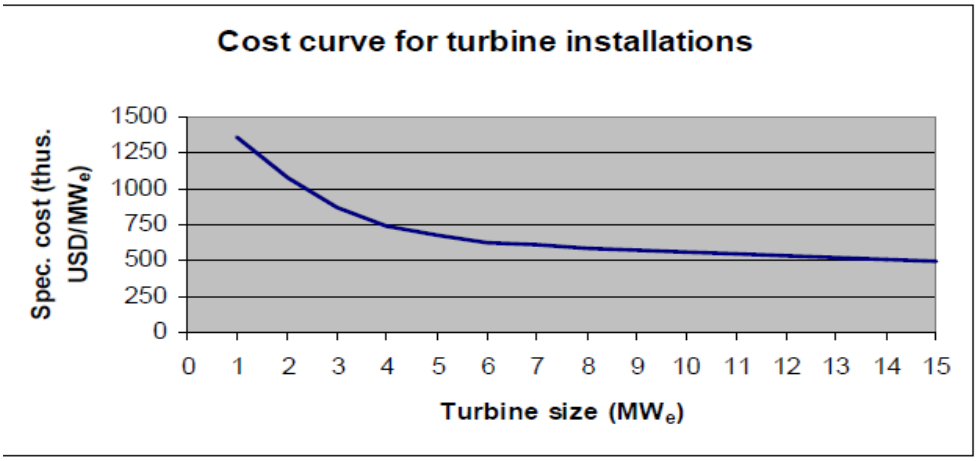


Figure 4.8 Cost Curve for Turbine Installations



4.2 ECONOMIC & FINANCIAL MODELING: SMALL SCALE INDUSTRIES

Taking the above operational costs, it is the finding by GGFR [vi]that all of these operations midstream seems to indicate that the capital costs may not be prohibitively expensive for integration of F & V discharges to be used in downstream operations. These operational elements have been studied in detailed case history of specific countries by GGFR. In particular the reference to Chad and Ecuador has been referenced to bring into account all particular

analysis into one framework for enabling the risk to reward profile or the attractiveness of a particular project in the small scale gas flaring usage projects.

Differences in technology, the energy product types replaced or involved will vary the calculations. However in evolving the generic model four different options have been done as a case studies by GGFR in Chad and Ecuador and these are presented at Annex A and Annex B as a result of the methodologies used. The model can be used for a parameter analysis by field size, distance to load centers, fuel prices etc. for financial and economic viability of the gas.

4.2.1 PARAMETER ANALYSIS

The assumption of a model oil field [64]has been assumed by the GGFR with the following characteristics given in Table 17 below[65]:

TABLE 17

Table 5.1 Model Oil Field

Field size	40,000	m^3 gas/day
Distance from load center	20	km
Maximum grid absorption	30,000	MWh/year
Power cost	75	US$/MWh
LPG cost	325	US$/ton
LPG share of gas	5	percent

Using the above, the economic (internal rate of return greater than 12%) and financial viability (Rate of return higher than 15%) gas use can be calculated. The example below shows the scenario summary wherein the gas yields are varied from 2500 mtr cube to 60,000-mtr cube per day. With increasing

64 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

65 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last seen December 2016

economy of scale, the viability seems to be increasing. However, what is significant is that it is viable even at 2500 to 5000 cubic meters per day.[66]

TABLE 18 *Example of Parameter Analysis Using the Economic Model*

Economic Scenario Summary					
	Field 1	**Field 2**	**Field 3**	**Field 4**	**Field 5**
Changing Cells:					
Field size m^3 per day	2,500	5,000	20,000	40,000	60,000
Distance km	20	20	20	20	20
Grid absorption MWh	30,000	30,000	30,000	30,000	30,000
Power cost US$ per MWh	75	75	75	75	75
LPG cost US$ per ton	325	325	325	325	325
LPG share percent	5	5	5	5	5
Result Cells (Net Present Value in US$ million)					
Alt. 1 Power production at field	0.4	1.4	8.3	15.1	18.8
Alt. 2 Power production + LPG	-0.2	0.6	6.5	14.4	18.5
Alt. 3 Gas transport	1.1	2.6	12.1	18.3	20.5
Alt. 4 Gas transport + LPG	0.4	1.5	9.5	17.7	20.3

The results of the model parameter analysis in Chad and Ecuador indicates the following:[vii]

- The model indicates that there is marginal economic difference between utilizing the gas for power generation at site and then distributing it by means of power lines or transporting gas in pipelines to an industrial gas consumer or an existing power plant. The choice is entirely around whether there are other applications or end uses downstream
- The economic viability surprising indicates that gas or power can be transported to a distance of 500kms without upsetting the balance if the cost of fuel substituted is high. Example Imported diesel transported to a considerable distance vs gas yield if not too low more than 10,000-meter cube per day
- Gas used is viable even if the only market is a gas based power grid of a capacity of 2,500 MW per year provided that the cost of fuel substituted is high for example in comparison with imported diesel

66 http://documents.worldbank.org/curated/pt/193801468779650307/pdf/295520Flared0G1on0Strategy01public1.pdf (last visited December 2016

transported for considerable distance as compared with gas for shorter distances say 50 km.

- Gas use is economically viable at a value of the produced power even as low as US 25/- per mwh given the gas yield is reasonably high (20,000 to 30,000 meter cube per day) and the transport distance is low (Example 50 kms)
- LPG use becomes economically advantageous since the world market prices are around US $ 300 per ton if the LPG content is over 15 % and the gas yield is higher than 60,000 meter cube per day.

4.2.2 SMALL SCALE INDUSTRIES

Studies by GGFR has shown the cost benefit of using F & V gases in the following applications:

i. Electrical power production at the Oil filed to a grid within
ii. Power production at the Oil field for non-electrified rural areas
iii. Piped gas supply to larger consumers: District heating, Power plants and medium sized industries
iv. Liquefied petroleum gas (LPG) extraction from associated gas either alone or in combination with other small scale industries

Of the above options it is suggested by GGFR that (i) and ii) options are most suitable for tropical and developing countries and these can be used in combination with option iv.

Case studies small-scale use:

Some of the findings from case studies by the GGFR on the cost benefit for small scale usage of flare gases based on the following studies is given below from 7.3.1 to :

- Two case studies Ecuador and Chad
- Gas distribution of non-associated gas in Mozambique
- Financial and economic modeling

4.2.3 MAIN FINDINGS FROM CASE STUDIES: SMALL SCALE

The Ecuador and the chad studies favored the utilization of F & V gases based on the Environmental, social and developmental benefits. The study indicates that this can be done without sacrificing economic viability. The main feasible benefit in the two studies is option are power supply from generators at the oil field or supply of gas via pipeline to a load center for fuel substitution in power production for local industries. The possibility of offering dry flare gas to industrial consumers as substitute in alternative fuel supplies. Most of Africa and South America local industry is underdeveloped mostly because of high fuel prices and unreliability of supplies. A common experience of economies around the world indicates that cheap and reliable fuel supplies specially that of natural gas when once available s number of industries both small and big are attracted for investment and the ensuing import substitution will give a higher value added and higher employment in that country.

4.2.4 FINDINGS FROM ECONOMIC AND FINANCIAL MODELING

The economic and financial modeling as indicated by the GGFR study in chad, Ecuador etc. clearly indicates a win - win situation in most cases of F & V flaring utilization. In other words, the studies have categorically indicated that these operations are sustainable from private enterprise without the need for any subsidies or government engagement. The gains are felt by consumers, companies, government and the environment checks that multilateral treaties require countries need to make,

The exceptions are therefore only for those where the market is too far away (say 500 km) or the gas deposits themselves are too small gas yields may have to be in the range of 2500 – 5000 cubic meter per day. The technical choices as between transporting gas in pipelines or generating the power within the site and then sending it to an external load center. The interchangeability is not one of technical feasibility but the demand on its application at the end use, LPG

use becomes economic from the global marketing point of view only that LPG prices should be around USD 300 per ton or the content of LPG in the raw flare gas is over 15 % or gas yield is higher than 60,000 meter cube per day.

4.2.5 KEY CONSTRAINTS FOR SMALL-SCALE GAS USE: WORLDWIDE

- State owned O & G monopolies lack incentive to reduce flaring and invest in alternative utilization of the associated gas
- National power markets are monopolized with power pricing often below their actual costs
- Insufficient financial incentives
- Import of LPG and distributed through subsidies.

4.3. LPG SUBSIDIES

Many governments subsidize LPG imports for their domestic consumers. This is a disincentive for viable use of associated gas production when the LPG so produced could actually be more viable and reduce the costs. However, fall of prices would require an increase in demand for LPG which has to be considered for assessing LPG utilization for the futures market.

4.4 NATIONAL POWER MARKETS

Flare reduction and utilization projects can be constrained by the control of governments in developing markets on a state monopoly basis. This can be a serious constraint for utilization of gas usage. In addition, the power prices are supplied below costs for the rural grids or some cross subsidization between urban and rural areas that can constrain financial viability for new electrification schemes. Flaring reduction projects can be negatively impacted considering this negative economics of project.

4.5 INSUFFICIENT FINANCIAL INCENTIVES

In spite of project economics giving a positive indication – still the gains can be perceived as marginal given the risk profile. There is a need to jettison the incentives (or at least penalized for flaring) both for private investors and state owned oil companies in undertaking flaring reduction projects through concessional financing to be attractive at least initially.

4.6 STATE-OWNED OIL AND GAS MONOPOLIES

As is the usual malaise with state owned company's they are usually short of cash, suffer from political interference and lack incentive to perform better. Most of the developing countries surveyed by GGFR it is still state owned companies that monopolize O & G production and transport facilities.

In Canada for example stated targets for flaring reduction was imposed. The company's revaluated the both the flaring and improvement projects. As a result they could implement well in advance of the schedule for compliance and also it was found that the tasks where actually commercially viable. These have been testified in the Alberta Energy and Utilities board website[67]

4.7 RECOMMENDATIONS BY STAKEHOLDERS / GGFR

- Opportunities for Non state entities to take part in production and distribution of gas and electricity. These are regulatory and institutional barriers.
- LPG subsidy policy to be looked into from the point of view of developing countries. Since LPG production is critical for all flare related projects the framework for distribution should be part of the

[67] *Management of Routine Solution Gas Flaring in Alberta: Report and Recommendations of the Flaring Report Team*, CASA, 1998, and *Gas Flaring, Incinerating and Venting in Alberta: Report and Recommendations for Upstream Petroleum Industry by the Flaring/Venting Project Team*, CASA, 2002.
http://www.casahome.org/uploads/source/PDF/1998_Management_of_Routine_Solution_Gas_Flaring%20-FPT.pdf page no 11 {last visited 8th May 8, 2017)

decision to produce LPG. Then relation between government LPG subsidy policy and LPG demand need to be scrutinized.

- The economics of successful development of small scale gas transport projects as per GGFR depend on the following key requirements:
    - A whole sale priced natural gas supply for the benefit of an anchor customer
    - Access to gas pipelines at the same rate as is available to large users
    - Inexpensive access to pipeline right of way to small scale projects
    - Access to technology and expertise. Such technology should also be compatible to the local skills and the minimal use of outside expensive experts and services.
    - Availability of financing for new projects and customer fuel conversion equipment.
    - Tax incentives to motivate customer to switchover to gas.

    - Public private partnerships as capacity building should be introduced. That is between state owned national oil companies and the private sector

Other Supply side turnkey and equipment have made rapid inroads into the market fueled by the increase in in price of natural gas some of the headways are given as under as illustrations[68]. These cover Deep Well Injection, Micro turbines given below:

[68] FLARING: QUESTIONS + ANSWERS Second Edition Writer: Robert D. Bott Copyright 2007 by the Canadian Centre for Energy Information, www.centreforenergy.com Canadian Cataloguing In Publications Data Main entry under title: Flaring Questions + Answers 1. Gas industry – Canada. I. Bott, Robert, 1945- II Canadian Centre for Energy Information ISBN 1-894348-18- http://siteresources.worldbank.org/EXTGGFR/Resources/578068-1258067586081/FlaringQA.pdf (last visited March 2017).

Solution gas flaring[69]

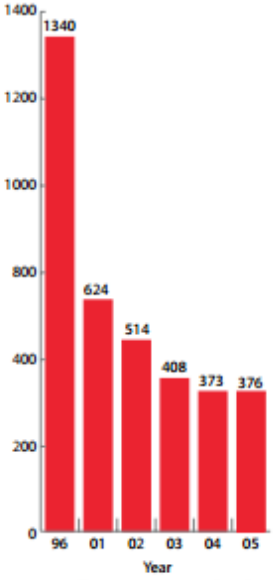
How have flaring and venting of solution gas been reduced?

The largest reductions in flaring and venting relate to the solution gas released during crude oil and bitumen production. In Alberta, solution gas flaring was reduced by more than 72 per cent between 1996 and 2005, while solution gas venting was reduced by 59 per cent between 2000 and 2005. The reductions were due to changes in regulations, higher natural gas prices, new technologies and adoption of "best practices" by industry.

Much of the solution gas that was formerly flared or vented is now pipelined to processing facilities and sold to customers or used in industry operations. Oilsands bitumen facilities have been redesigned so that less natural gas is released into the atmosphere. Solution gas is also injected into oilfields to maintain reservoir pressure. In some fields, microturbines now generate electricity (and sometimes steam) using solution gas that previously would have been flared.

SOLUTION GAS FLARING IN ALBERTA

(millions of cubic metres)



Source: Alberta Energy and Utilities Board

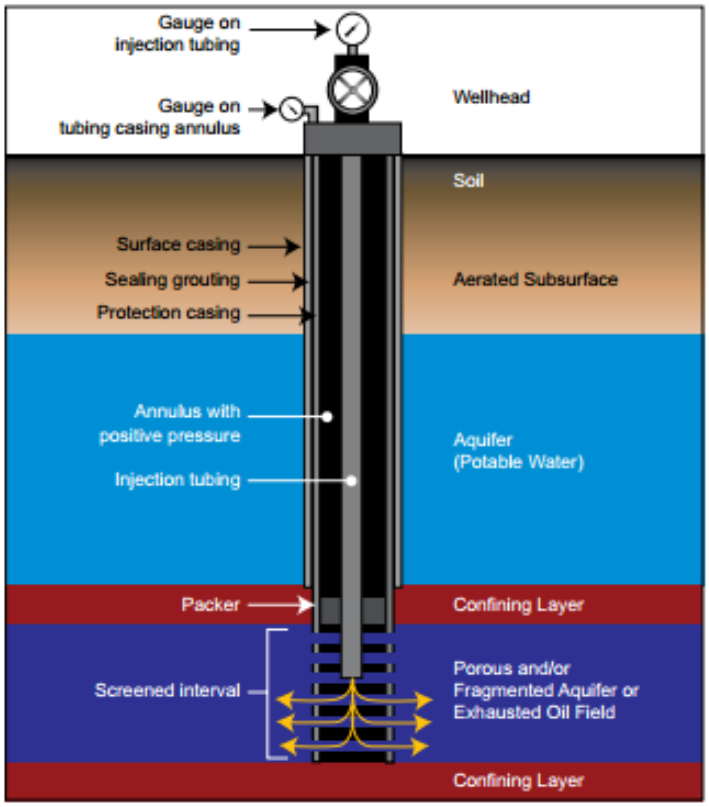
[69]http://siteresources.worldbank.org/EXTGGFR/Resources/578068-1258067586081/FlaringQA.pdf Page No 9 (last visited March 2017).

Deep Well injection[70]: The normal methodology of in-house use

Deep Well Injection

Diagram courtesy of ConocoPhilips.

About 45 plants in Western Canada use underground disposal for the H_2S, CO_2 and water recovered during sour gas processing. Acid gas injection not only disposes of H_2S safely, it also reduces greenhouse gas emissions of CO_2. The gas mixture can be injected into either saltwater aquifers or depleted oil and gas reservoirs.



- Micro turbines: Export + in-house production

  They are small gas fired turbines that produce electricity. The electricity is then internally used for purposes of compression, pumping or gas processing or sold to a grid . Cogeneration, also produce steam for industry operations or for drying grain or heating greenhouses. Canada has used the same extensively and can burn low quality gases including sour gases.

  Small scale use of flared gas: Export + in-house

[70]http://siteresources.worldbank.org/EXTGGFR/Resources/578068-1258067586081/FlaringQA.pdf page 16 (last visited March 2017)

Chapter 4 SUPPLY SIDE TURNKEY DEVELOPMENT

As already mentioned GGFR has identified four options for using associated gas. 1) Power production for medium scale power grid 2) Power production for non-electrified small scale rural grid 3) Supply of piped gas to large consumers such as medium size heat and power plants 4) Liquefied Petroleum production (LPG). The study has identified realistic options for small-scale use of flare gas. Cases studied are Chad & Ecuador.

SUGGESTIONS AND RECOMMENDATIONS / EVANGELIZING

The issues raised under this thesis is summarized for conclusion and the conclusory remarks summarizes the unintended effects. Positive resolution of issues raised and a conclusory serendipity of unaddressed and unintended effects.

This chapter incorporates A GAP REGULATIVE INSTRUMENT ANNEXURE I

This template is the detailed regulative platform, which dovetails the findings of the previous chapters by incorporating the best methodologies, best practices and regulations culled from different sources in one platform as Annexure I

The template will enable the planned regulation on Flaring and Venting operations as to enable a seamless transition of contract and regulation towards supply of flaring and venting operations for supply to downstream industry.

This chapter incorporates EVANGELIZING AWARENESS PROGRAMS

Evangelism is a recent phenomenon for a technical idea and their conveyance to dream promises. The practice of the twentieth century for evangelism has been historically woven into the discussions of this thesis in order that the template achieve its seamless integration with the Oil and Gas industry and the utilization of standardized procedures. Guidelines and regulations are incorporated into a convenient platform for effective evangelism. The section also puts in place the executory measures for evangelism both organizationally within business operations as well as in the social circles considering that it has an impact on Global environmental concerns and the concerns of ratified multilateral commitments. A carry forward of the notions of this thesis from template to execution on a global basis

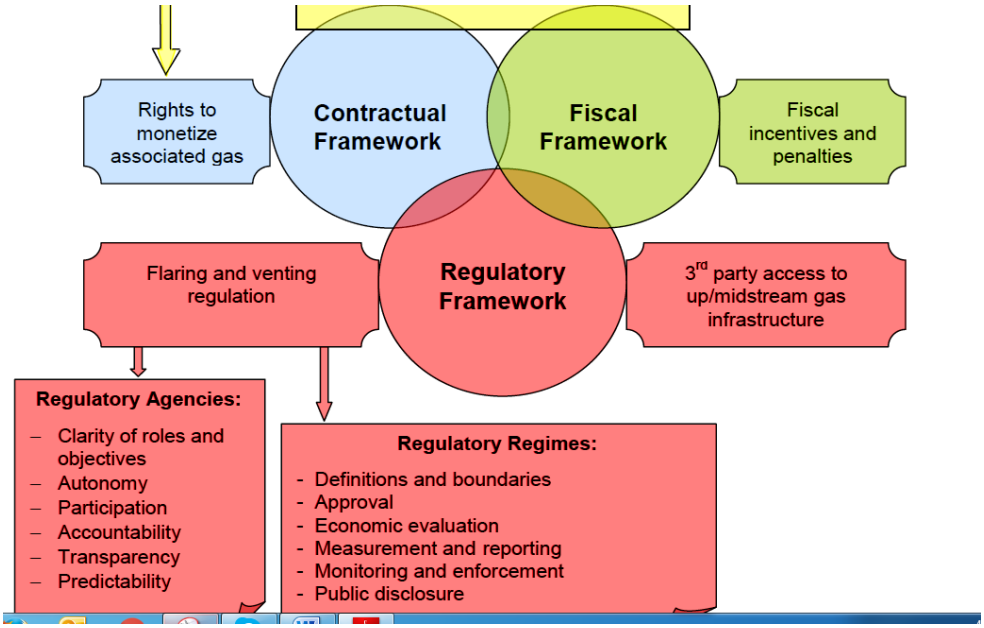
CONCLUSIONS DRAWN UNDER THIS THESIS ON THE FUTURE OF PETROLEUM OPERATIONS IN THE CONTEXT OF THE STUDY

- Whether use of flared and vented gases could be done on a sustainable basis?
  Ans : ***Volumes world wide is over 20 Billion dollars and is a sustainable business. Capital costs of infrastructure are not exceeding viability limits and this could be an additional 40 to 50 Billion markets on the supply side of infrastructure investment amortized over the years***

- Whether presently there are adequate regulatory Standards India and Abroad?
  Ans: ***Not integrated as in the model presented in Annexure I for national or global operations***
- What can be a prospective model regulation for sustainability of f & v operations?
  Ans: ***As attached as a model in the annexure I attached***

The petroleum operations on flaring and venting are in its interesting phase of development. Firstly, the overriding corporate responsibility to maintain environmental air and water cleanness is pressing globally through the International forums. The environmental aspect is not only effecting local environs and includes flora and fauna, biodiversity and public health but also its effects are far reaching on the planet. Flaring in petroleum being a major component of high concentration pollution a systematic standardized equipment and process control as well as a staid regulatory policy is a need. This will have to be of necessity part prescriptive and part performance approach. The formulated template incorporates both approaches in one and will have to be evangelized technically for its success globally. The appeal is not merely ethical but commercial viability due to the overwhelmingly confirmed volumes of flared and vented gases globally. The viability of profit levels in natural gas renders fostering of supply side equipment and process outsourcing. This is particularly interesting for developing countries as the equipment is not highly

sophisticated and appeals to not only bulk purchasers of gas and power but to small industries. It is to be noted that confirmed commercial success in flaring and venting outsourcing - will no longer make mopping up 3 to 4 percentage of otherwise wasted gases as a profitable exercise. The business as usual for increasing production in the petroleum industry and the perfunctory approach to flaring and venting will no longer make economic or environmental sense.



THE GAP ECONOMIC INSTRUMENT: A PROPOSED REGULATIVE MECHANISM INCORPORATING HYPOTHESIS[71]

The above is a proposal by the GGFR and the gap instrument created by this study provides a regulatory framework taking into account the above system of flaring and venting controls with the attributes of boundaries, contractual agreements economic viability and monitoring. Evangelism goes further than mere public disclosure towards proactivity.

The template enclosed as Annexure 1 is a formulated paradigm of a workable model and holds all of the contractual, standards and regulatory measures for

[71] Global gas flaring reduction partnership (GGFR) "Guidance on Upstream Flaring and venting Policy and reduction Washington DC March 2009. Page No 5 http://siteresources.worldbank.org/INTGGFR/Resources/fr_policy_regulations_guidance.pdf (last visited March 2017)

the evocation of a line of enforceable controls. The formulation works effectively considering that there is a sizable volume worldwide of flared and associated gases that can provide impetus for commercial exploitation for both developed and developing markets. For convenience, the Indian enforcement system PNGRB has been referred into the template as Annexure I although any ther countries regulations, acts and other instrumentalities of government can be introduced with equal felicity for enforcement purposes.

ANNEXURE I

REGULATION FOR FLARING AND VENTING IN PETROLEUM OPERATIONS

THE FORMULATED TEMPLATE

FOREWORD

This document has been generated for the express purposes to be used as a template featured in the Hypothesis for controlling Flaring and Venting in petroleum operations. A hypothetical document such as this renders the fulfillment of the objectives of the thesis in a palpable form.

The template is being used as a gap economic instrument in submitting the thesis for PhD in the name and title of "The Regulatory Commercialization of Flaring and Venting in Global Petroleum Operations".

Sampath Kumar Karai Pattabiram

PhD scholar

Sap ID: 500024036

TABLE CONTENTS

PAGE No.

OBJECTIVE

1.0 The objective of this regulation is to monitor flaring and venting through defined operational and regulatory procedures in the context of the laws, bye-laws and regulations of the given country regarding petroleum operations.

1.1 The strategic objectives of the PNGRB regarding Health, Safety and Environment for all of the "Petroleum" and "Petroleum Operations" are to assure as follows:

a. **Health:** No harm to people whether they be "Licensees" (employees, contractors and their subcontractors) or third parties

b. **Safety:** No harm to people and asset whether they be of "Licensees" (employees, contractors and their subcontractors) or third parties

c. Environment and Conservation of Petroleum resources:

i. Discharges to water, air or land as required under law according to the statutorily permissible levels.

ii. Minimize and control all wastes produced by the "Licensees" operations as required under law according to the statutorily permissible levels

iii. Maximize use of resources – land, petroleum and raw materials

1.0 SCOPE

This Flaring & Venting regulation covers implementation and enforcement for the integrated sectors of Health, Safety and Environment protection of all "Petroleum operations" activities in given state or country taking into account "Compliance and implementations" and the governing State Laws and which includes in its ambit all of the regulatory activities for assuring compliance covering approvals, permitting, licensing and other market mechanisms promulgated by the Ministry of Petroleum and industry or by other relevant " Local authorities".

2.0 CONTEXT

This "- REGULATIONS FOR FLARING AND VENTING IN THE PETROLEUM OPERATIONS" is developed by Directorate Health, Safety & Environment Regulations and Enforcement (hereinafter "PNGRB") which is empowered by the decision of the Local or country authority that governs petroleum or petroleum industry

3.0 TERMINOLOGY

4.1 DEFINITIONS

4.1.1 **Associated gas**- means gas existing in a reservoir along with crude oil and constitutes a blend of hydrocarbon vapors, water vapors, CO2 and other gases that is released when crude oil is bought to the surface.

4.1.2 Compliance and implementations – which term includes all of the activities to assure the integrated sectors of Health, Safety and Environment protection in "Petroleum Operations" by the Directorate (PNGRB) in the "context" of article 2 under this regulation .

4.1.3 **Flaring – means the controlled** burning of natural gas in the course of routine oil and gas production operations. The burning occurs at the end of a flare stack or boom.

4.1.4 **FPSO –** means A Floating Production, Storage and Offloading vessel and is a type of floating tank system used by the offshore oil and gas industry and designed to take all of the oil or gas produced from nearby platforms or templates, process it, and store it until the oil or gas can be offloaded onto a tanker or transported through a pipeline.

4.1.5 **Venting –** means the controlled release of associated gases into the atmosphere in the course of oil and gas production operations.

4.1.6 **"Licensees" interchangeably used as "Duty Holder"** –- is a term used jointly and severally for all operators, licensees, permit

holders, contractors, holding a license, or permit or government contract holders and their assignees, transferees and nominees- to carry out exploration, production, transportation or utilization activities in the Petroleum industry. This term includes the singular and the plural and refers to any natural or legal person legally licensed to conduct any of the petroleum operations.

4.1.7 **"Local Authorities" –** All relevant Supreme Councils and Ministries involved in Flaring and venting

4.1.8 **MDEA process** - means gas sweetening method using an amine solution

4.1.9 **Petroleum –** All natural hydrocarbon substances in solid, liquid or gas state or those that can be produced from the surface of land (Onshore) or from sea (offshore)

4.1.10 **Petroleum Operations** – Petroleum exploration and fields development, drilling, completion and maintenance of wells, petroleum production, its treatment, refining, storage, transportation, loading, shipping and construction of power, water, housing and operations thereof and any other facilities or construction or equipment required by the projects referred to including all administrative or supplementary activity or activities leading to achievement of the said projects.

4.1.11 **Stakeholders**- means All "Licensees" , "MPE" and "Local Authorities"

4.1.12 Sustainable development- means development that meets the needs of the present without compromising the ability of future generations to meet their own needs
(UN / Brundtland Report).

4.1.13 **Upstream operations** – means all activities for searching and recovery of production of crude oil and natural gas also known as the exploration and production (E&P) sector and includes searching for potential underground or underwater oil and gas fields, drilling

of exploratory wells and subsequently operating the wells that recover and bring the crude oil and/or raw natural gas to the surface.

4.1.14 **Midstream operations** – means all of the processes of storage, marketing and transportation of crude oil, natural gas, natural gas liquids (LNG) and Sulphur.

4.1.15 **Downstream operations** – means all of the processes and includes Oil refineries, petrochemical plants, petroleum product distribution, retail outlets and activities related to natural gas distribution companies and includes in its ambit inter alia and not limited to the following products petrol, diesel, jet fuel, heating oil, asphalt, lubricants, synthetic rubber, plastics, fertilizers, antifreeze, pesticides,, natural gas and LNG.

4.1.16 **Flaring and venting Regulations**- - Regulations for Flaring & Venting inn Petroleum Operations

4.2 ABBREVIATIONS

COP	:	Code of Practice
FPSO	:	Floating Production, Storage and Offloading
-HSE	:	Health, Safety and Environment
- MS	:	- Management Systems
LNG	:	Liquefied Natural Gas
MDEA	:	Methyl-Di-Ethanol Amine
MOE	:	Ministry of Environment or other authority
MPE	:	Ministry of Petroleum and Petroleum
PNGRB	:	Petroleum & Natural Gas Enforcement Board

4.0 INDICATIVE REFERENCE

4.1 The following references are indicative as to the law:

a. Constitution of the country

b. Petroleum laws and enactments
c. Protection of the maritime Facilities of Petrol & gas
d. Environment Protection laws
e. Ministerial Decisions [Occupational Health & Safety]

4.1 The references given in point 4.1 above and provided under this regulation is merely to facilitate as a "Ready Reckoner" for the petroleum industry to identify the laws, rules and regulations in the Country and does not signify sufficiency or otherwise of legal information for purposes of regulatory compliance to the laws of the Country or those promulgated by its constituted ministries.

5.3 It is to be noted here that it is the responsibility of all "Licensees" or others in the industry etc; engaged in the Petroleum activities to fulfil all obligation imposed by the Country. The laws, by laws, rules and regulations of the Country are duly notified in their Gazette under the Ministry of Justice et al. The "Licensee" engaged in the Petroleum activities are as such in constructive notice of such laws, rules and regulations duly notified, without any further need for communications or information about the said laws and their bye laws/rules/ regulation.

5.0 APPLICATIONS

6.1 This Flaring & Venting regulation shall be applied by all staff of PNGRB during development and supervision of - Compliance and Implementations" on the "Petroleum and Petroleum Operations" sector including "upstream", "midstream" and "downstream".

6.2 This Flaring and Venting regulation, endorsed by MOE&I shall be applicable to all "Licensees" .

6.3 The application of all aspects of this Flaring and Venting regulation in its various articles enumerated herein are made by the PNGRB on - matters as follows:

6.3.1 Directly as a conferee of the Ministry of Petroleum and Industry under the "PNGRB Compliance and Implementations" for the "Petroleum & Petroleum Operations" sector and as reviewer and recommender of enforcement measures elucidated in this regulation. The final adjudication of "Compliance and implementations" and enforcement measures thereof for such review and recommendations by the PNGRB, being vested with the Ministry of Petroleum and industry.

6.3.2 As a reviewer and recommender in respect of PNGRB "Compliance and Implementations" for Health, Safety and Environment (-) issues in terms of shared responsibilities with other relevant Local Authorities , the final adjudication of "Compliance and implementations" and enforcement measures thereof for such review and recommendations by the PNGRB, being vested with the respective Local authorities in the exercise of their respective jurisdiction and mandates in the distinct areas of Health, Safety and Environment as is applicable.

6.0 TITLE TO SUB SURFACE PETROLEUM

7.1 All "Petroleum" contained in sub-sea or sub-soils deposits in the country land and water Territory, is a strategic and non-renewable national resource, which is solely and exclusively owned and controlled by the Country.

7.2 Barring contractual agreements to the contrary, this regulation permits licensees to optimize petroleum production within "petroleum operations" as to the use of associated gases by re-injection to improve oil recovery rates and to use gas to generate

power for operation or to fuel equipment among other operational processes.

7.3 The associated gases or non associated gases arising from venting and flaring not used in "Petroleum operations", the country has a pre-emptive and exclusive right of ownership for marketing of such unutilized associated gases.

7.0 ADMINISTRATION OF THIS REGULATION

It is the PNGRB's policy to administer this regulation as follows::

8.1 To assure that all Licensees shall submit data on the measuring and reportage of flared and vented gas to PNGRB on periodical intervals as specified in this regulation or as agreed with PNGRB.

8.2 To monitor and enforce the stipulations and emissions requirements of the law in force.

8.3 To assure the above, "Licensees" are to implement a systematic flaring and venting development program integral to their "- –MS" that ensures compliance with law and achieves continuous performance improvement. This shall be part of industrial licensing procedure or Consent to operate permits or approvals or other forms of requirement by the Ministry of Petroleum and Industries- this will be in addition to the already existing approvals, requirements, Consent to operate permits etc with other local authorities. Such programs are to be approved by PNGRB for all " Petroleum operations" by any of the following methods**:**

a) As a part of an overall field development and production plan approval or

b) As a separate flare and vent permits or environmental license for facilities

8.4 To assure that "Licensees" implement and maintain their - – MS in order that they concentrate on critical issues and control operational activities by:

a) Monitoring and Measurements
b) Reporting and Monitoring Performance
c) Identifying areas for improvement.

8.5 To assure that licensee's consider the following requirements on their facilities as part of their --MS policies:

a) Evaluate opportunities to mitigating flaring and venting to the minimum possible levelEnsure that any residual flaring and venting is in compliance with this regulation and / or as per the stated performance requirements in their --MS.

8.0 REGULATIONS STATEMENT

9.1 Performance based criteria

9.1.1 The PNGRB follow the trend of best practises in Health, Safety and Environment management, which is goal setting that target, what must be achieved rather than what is to be done or prescriptive. However this does not preclude prescriptive regulations altogether which may be required in certain situations. in this regard if the event the use of Product / Services or Management Systems standards national/regional /international are referenced as essential requirements, either in the core text of the regulation or as subsequent addendums thereof from PNGRB then the same will be considered mandatory.

9.1.2 As a requirement of law All systems, equipments and materials used in petroleum operations shall confirm to international standard specification, with safety requirements, industrial safety and other technical conditions. All of that shall be consistent with best standards applicable in the petroleum industries.

9.1.3 Codes of Practice (COP's) / Guidelines/reference standards and other policies published / submitted by PNGRB from time to time shall give practical advice on how to achieve the goals and be compliant to the laws and Regulations. Compliance with COP's /

guidelines/reference standards issued by the PNGRB is not mandatory but doing so is normally enough to comply with the law and Regulations. In this regard the following are some of the key issues under this regulation for inclusions that may be considered as COP's or guidelines for PNGRB publication as per either article 9.1.1 (when prescriptive) or 9.1.3 (optional):

a) Burn technologies and practises –for the equipment and operating processes to ensure burning of 'clean' gas and efficient combustion.

b) Flare location –for the typical flare location at a safe distance from other facilities, accommodation units and populated areas.

c) Heat and noise generation – for the setting of the upper limits at specified distances from flaring operations

d) Smoke and noxious odours –for setting the limits imposed on opacity of smoke generated by flaring and noxious odours.

9.1.4 .If a "Licensee" is pursued for not following the COP's Guidelines/reference standardsidentified by PNGRB then the onus is on the party to show their compliance with the law by implementing other industry best practices / guidelines / standards and provide documentation of successful implementation and validation of the results thereof in the Country.

10.0 GAS FLARING & VENTING MANAGEMENT,SUSTAINABILITY

10.1 The PNGRB economic evaluation of the venting and flaring Management for licensee's facilities on sustainable development basis under the application provisos of article 18 of this regulation are as follows:

a) Gas flaring and venting and management framework for licensee's to evaluate is as per the Appendix 1 attached

b) The above follows the decision tree as per Appendix 2 attached.

10.2 Licensee's would also be audited with the objective of sustainable development, both randomly and targeted based on sites flaring large volumes.

10.3 In addition, the PNGRB is a votary of sustainable development in the context of sustainable development in keeping with the mission statement "Advancing Sustainable development – Qatar National Vision 2030" and the commitments thereof towards meeting the triple bottom line of environment, social and economic goals.

11 ENFORCEMENT MEASURES

11.1Enforcement measures

The policies principles, activities and categorization of level and gravity of inspections and the penalties, restitution remedial methods required under law are regulated based on the Enforcement ladder attached as Appendix 3

Particularized enforcement for field inspection

Notwithstanding the policies mentioned in article 10.1 above, the criteria adopted for particular field inspections by PNGRB for monitoring and supervision would vary considering that in practise every individual facility has some unique aspects to be covered in the context of flaring and venting. The criteria adopted for targeted inspection in such a scenario apart from the Licensee's performance and non compliance history additionally follows:

a) Sensitivity of the area (Area proximity and environmental sensitivity)

b) Inherent risk of the operation (potential impact level)

11.2 Multiple scenario and aggregated obligations

There are some fields with multiple installations, which may be issued with a single flaring approval. Also, several fields may be

processed across a single installation through group approval and may be rendered covering the installation rather than individual fields. Notwithstanding the multiple scenario coverage under any group approvals, the obligations to a field are still required to be fulfilled by the "licensee" to PNGRB. The block or multi scenario approach by PNGRB is to simplify and to be pragmatic about application of supervision and for monitoring the industry. Normally Group approvals are considered when the fields have the same equity partners. Where there are diverse partners, PNGRB will issue separate approvals unless prior agreement in writing is granted by all partners in all the fields and enumerating their respective installation there under. The supporting documentation should be presented to PNGRB on such application for group approvals.

12 .0 APPLICATIONS FOR FLARING AND VENTING

The applications and categorizations of flaring and venting operations are rationalized as follows:

12.1APPLICATIONS FOR APPROVAL

12.1.1 Approach to Flare Application

During the flare exercises by the licensee, the PNGRB will not examine in detail flare applications for requested flare levels that do not exceed 50 tonnes a day,(Reference- provided there is no request for an increase to the levels in the current flare approval.

Applications can be made for flare approvals on an annual basis, depending upon the total daily hydrocarbon flare level from a field or a grouping of fields going through an installation(s). The amount flared in a phased manner for a two year period should also be presented during application.

Long term flare approvals will not be permitted for any field or grouping of fields going through an installation(s) that seek permission to flare at rates in excess of 50 tonnes a day.

If a field is flaring less than 50 tonnes of hydrocarbon gas a day, and if, for the continuous period of two years and the flare application

does not request any increase in the levels permitted in the current flare approval, licensees can apply for a three year flare approval extension. If this application shall be approved by the PNGRB, a long term approval will be issued, subject to the following:

a) Approvals will be issued on a field basis. Where several fields tie-in into common facilities, and the fields have the same operator and licensees, the operator may apply for a single, composite approval and the level of flaring permitted in this approval will be based on the sum of the individual field contributions to the total flare level (Average must not exceed a level of 50 tonnes a day). Where a single composite approval is not requested then, regardless of the total level of flaring at the facilities, individual field approvals of 50 tons per day will be issued on an annual basis.

b) Usually separate approvals will be issued for individual fields that tie-in to common facilities. If the fields have different operators and licensees, regardless of the total level of flaring at the facilities and the approvals will be issued on an annual basis. However, if all parties agree to apply for a single flare approval covering all the fields going into the facilities and the total average flare level is less than 50 tonnes a day then three year flare approval will be considered.

c) Should the tying back of a new field to a facility increase the total volume flared from the fields going through the facility to greater than 50 tonnes a day then either a new joint flare approval application shall be made for all of the fields now going through the facility or, if no agreement is reached on this, individual annual flare approval applications must be made for each of the fields now going through the facility, and individual annual field approvals, that supersede the existing composite long term approval will be issued.

d) Based on a, b and c above, one field flare approval will cover a field and the following provisos shall apply:

i. If the approval term for a field expires before the end of annual year (January to December) the flare approval will be issued to the licence expiry date, with the flare level being pro-rated where this date is during the year(January to December). In the case of an approval that includes a number of fields, the duration of the approval will not exceed the earliest expiry date of any of the licence approvals.

ii. Any long term flare approval will contain permitted flare levels shown on an annual (January to December) basis. No carrying forward of flare from one year to the next will be permitted.

iii. .If, due to unforeseen circumstances, it appears that the annual flaring level permitted in any year covered by a long term flare approval is likely to be breached, the PNGRB (following submittal of an application) will consider the issue of an approval revised to amend the flare level for the year in question. It is the Operator's responsibility to present a technical case in a timely manner to PNGRB in the event a revision is required.

iv. Where a field is flaring more than 50 tonnes a day, the flare level will be reviewed and a flare approval will be issued annually. These applications will need supporting details with medium and long term plans for flare reduction.

v. New fields will be subject to normal short term commissioning flare approvals from DG until stable production is achieved, For flare approval applications below 50 tonnes a day, it is sufficient to furnish only minimum information of providing the data of flared

gases to PNGRB. However, Operators must still exercise appropriate technical and operational diligence in estimating quantities.

vi. For flare approval applications above 50 tonnes a day, PNGRB considers it essential prerequisite for the Operator to provide full details of the data of flared gases plus that which is specified by PNGRB if any. Operators must exercise a high level of technical and operational diligence in estimating quantities, as these applications will be subjected to detailed review by PNGRB. This level of flare is considered to represent a potential opportunity for further reduction on flare levels. Operators must submit outline details of medium and long term plans for flare reduction including the capability to conserve all the gas processed, like re-injecting into the reservoir for better recovery, diverting the gas for power generation, etc.

11.1.1 Approach to Vent Applications

a) Venting applications will be subject to the same process as Flare approvals, except that the threshold for detailed examination will be 5 tonnes (Reference..a day.

b) For applications below 5 tonnes a day, it is sufficient to furnish only the minimum information of providing the data of vented gases. However, Operators must still exercise appropriate technical and operational diligence in estimating quantities.

c) For vent approval applications above 5 tonnes a day, PNGRB considers it essential prerequisite for the Operator to include full details of providing the data of vented gases plus that which is additionally specified by PNGRB if any. Operators must exercise a high level of technical and operational diligence in estimating quantities as these applications will be subject to detailed review by PNGRB. This level of vent is considered to

represent a potential opportunity for further reduction in levels. Operators must submit outline details of medium and long term reduction plans.

13.0 CATEGORIZATION OF FLARING AND VENTING

13.1 Category 1 - Base Load Flare

This includes all the gas used for safe and efficient operation of the process facility and flare system under normal operating conditions. This shall also include any gas that has to be discarded as part of the installation processes and is discharged to flare. Typical examples are all process purges and pilots, the off-gas from the glycol regeneration plants and acid gas discharged from MDEA and other gas treatment plants, where these are fed to the flare system for combustion. This category also includes flaring from installations with no gas export facilities.

13.2. Category 2 - Flaring from Operational or Mode Changes

This includes gas flaring resulting from the start up and planned shut down of equipment during production, and will also include gas not meeting export specification, maintenance of equipment and equipment outages. This category also includes flaring that is caused by the temporary lack of access to a third party gas export pipeline or similar.

13..3 Category 3 - Emergency Shutdown/Process Upsets

This includes any gas flared during an emergency shutdown/process upsets of equipment or the installation, including shut-in of the wells.

13..4 Category 4 – Un-ignited Vents

13.4.1 This covers inert gases and hydrocarbons gases which may be discharged to an atmospheric vent. The PNGRB requires both the inert and hydrocarbon gases obtained from the licensed area that are vented to be covered by the approval.

This should also include venting of gases from onboard crude oil storage tanks e.g. for FPSOs during crude oil filling operations.

However, this excludes inert gases that are generated onboard the installation for the purpose of providing an inert blanket for onboard oil storage tanks.

Vents may contain nitrogen, carbon dioxide, water vapour, hydrocarbons, and possibly traces of sulphur compounds etc. Operators should give an estimated annual average composition of vented stream(s) in the vent application.

14.O WAIVERS FOR FLARING AND VENTING

The following are generally acceptable as waivers to PNGRB approvals:

a) When flaring is an unforeseeable event
b) When the licensee did not have time to deal
c) In case of removing or reducing risk or injury to persons in the vicinity of the well in question,
d) In order to maintain a flow of petroleum from that well or any other well
e) When permitted by the MOE under law 30 and its byelaws

Waivers a. to e, must be supported by a report that shall be duly submitted to the PNGRB with documentary proof of mitigating efforts taken, if any, during the incident or accident as a historical data for enabling planned risk management. The planned risk management should include the recommendations of a structured investigation report on prevention / pre-emption of the recurrence of similar or related accidents. Such investigation record keeping and the systematic mitigation of - risks must be an essential part of the licensees -- management systems.

15.0 PERFORMANCE REQUIREMENTS

15.1 Flaring thresholds and the limits of statutorily permissible flaring and venting shall be in compliance with Law No 30 and its byelaws regarding environment, other relevant laws and decisions of the country and its

constituted ministries regarding -.. In this regard please see article 3 and 4 in this regulation

15.2 The PNGRB, through its guidelines enumerated in article 9.2, will provide the guidance for gas flaring and venting including measures to ensure adequate flare ignition, liquid separation and sour gas plume dispersion for the following and duly incorporated in the regulatory requirements.

a) Temporary and well testing flaring
b) Gas battery flaring and venting
c) Gas plant flaring and venting
d) Pipeline flaring and venting
e) Gas combustion requirements
f) Venting and fugitive emissions management requirements

16.0 SENSORS AND METERING DEVICES

16.1 Operators who are flaring and venting Associated Gas during operational phase must be responsible for establishing the internal asset integrity management system for ensuring compliance including checking Sensors / flow meters calibrations every six months.

16.1Operators shall install ,as far as is feasible, state of the art improved sensors and metering devices to gather more comprehensive information and for the determination of analytical modelling techniques that can integrate this information and identify viable control strategies.

17.0 REPORTING AND DATA BASE

17.1 Operators must be responsible for keeping an emissions inventory, both flared and vented, with the requirement to submit reports to the government on an annual basis. Operating company that has or expect to have flaring approvals from PNGRB shall submit a report to the PNGRB, indicating the amounts of gas flared daily. The recording should be in

metric system and in quantitative tons . The annual report prepared to PNGRB must:

a) Provide data and information of flared and vented gas and volumes for the various oil and gas industry sectors (well tests; gas plants; gas gathering systems; and oil, bitumen, and gas batteries).

b) Provide reports to detail the volume of solution gas (gas from oil and bitumen batteries) conserved, flared, and vented on an annual basis

c) Rank operators according to the volume of solution gas flared, solution gas vented, total solution gas produced, and total oil from crude oil and bitumen batteries

d) Reflect trends in conservation and initiatives being carried out

e) Aim to increase awareness of flaring and venting volumes throughout the block or region and to encourage further gas conservation.

17.2The accuracy of measuring for the gas flaring and venting must include:

a) Demonstrations by operators that gas volumes are accurately and consistently captured.

b) Ensure that that flared and vented gas be metered with equipment suited for the flow conditions.

17.3The above data shall be submitted, on mandatory basis to enable PNGRB:

a) To assure that the “"Petroleum and Petroleum Operations" under the concerned Minister (MPE) comply with the applicable ratified treaties under the head “Environment” both regional and through International Conventions and

Protocols. Such compliance shall be methodically monitored and recorded for reductions in emission / discharge levels.

b) To provide an exclusive data base on Health, Safety and Environment for the Petroleum industry created as the authorized statistical base for the benefit and representation of the "Minister (MPE)" at International forums and conventions.

The submissions in this article to PNGRB does not constitute a waiver of data requirements by the licensees required as per law or regulation by "Local authorities" or other ministries, which are duly mandated under relevant Health, Safety and Environment heads

18.0 STAKE HOLDERS ENGAGEMENT

18.1 **Stakeholder (Government)**

The PNGRB is considered in a dynamic engagement through informed approval on a continuous basis with all "Local authorities" as provided in article 6.

18.2 **Stakeholder (Industry)**

In view of article 17.1 above the government and its ownership rights under article 7 on all sub surface petroleum resources, PNGRB reserves the right to implement and enforce on the stakeholders the provisos of this regulation document. However the government is committed to employ stakeholder approach in decision making processes. Accordingly PNGRB will circulate all of its regulative proposals and elicit the opinion of the stakeholder industry and take their recommendations and wherever feasible, recommend its promulgation into regulations/and or law. The acceptance or otherwise of such recommendations being the exclusive right of the government. The promulgations may also provide a gestation period for turnabout wherever possible for implementation. The duration/decision of such gestation being the

prerogative and will be as determined by the government on a case to case basis.

18.3 At the discretion of the government, "PNGRB" may provide input to the MINISTER (MPE on - issues on "Petroleum Operations" and for making settlements on venting and flaring based on negotiated commitments as an alternative mechanism. - implementations in the petroleum operations with "licensees" or entire blocks or industrial areas would take into consideration multi stakeholder engagement processes as per modalities determined by the ("MINISTER (MPE)". Such settlements would be through the aegis of multi stakeholder engagement process as determined by articles 17.1 and 17.2 above.

19.0 OPTIONS TO FLARING AND VENTING: SUSTAINABILITY

19.1 The following options to flaring and venting are available to the Licensee for the flaring and venting operations on productive lines on the basis of sustainable development:

a) Gas Conservation: For processing waste gas at LNG facilities
b) Electric power generation for consumption onsite or within an industrial system and for local applications.
c) Re-injection of gas into the producing reservoir for improving oil production for maintaining reservoir pressure.
d) Collection and delivery to a nearby gas-gathering system.
e) Pooling of gas resources or clustering gas from several batteries into a single location to achieve volumes sufficient to justify conservation or utilization schemes
f) Evolve opportunities and introduce design and gas network measures both nationally and internationally for use of associated gas during venting and flaring for the utilization of gas to the "downstream" industry.

g) Other options can be available, by agreement/approval, for the Licensee

19.2 The "licensees "are encouraged by PNGRB to pursue the above article 18.1 or other innovative technologies for the improvements in flaring and venting technologies and may include such in their development plans as feasible solutions in the Sustainability context. PNGRB's affirmative action is not only to recommend to the MPE preferential treatment to licensees for approvals of licenses on merit and on a case to case basis, but also encouragement shall be made through awards, which shall be instituted based on "Business Excellence" in the - sustainable context in the petroleum sector under the aegis of the Ministry of Petroleum and Industry.

19.3 The criteria and methodology for the implementation of Business Excellence awards will be as per modalities to be determined by PNGRB and Minister (MOEI).

20.0 MANAGEMENT COMMITEE

20.1 A Management Committee shall be established constituting representative/s of the stakeholder industry QP / DV, PNGRB, Ministry of Petroleum and industry to meet, periodically review, discuss, make all such decisions as it is authorized to make within the ambit of relevant articles for developmental activity, including assuring - under this regulatory framework. The management committee shall also asses the initiatives of particular or a group of licensees to create and execute projects Sua Sponte through this Regulatory frame. The determinations or decisions made by the management committee shall be duly recorded in writing at all meetings for enforcement and implementation under this Regulatory frame.

20.2 The modalities of establishing the management committee shall be as decided by the Ministry of Petroleum and Industry.

20.3 The Management committee meeting shall be held at minimum bi-annually and all minutes of the meetings shall be recorded and kept on file for reference for the government. Such records shall also include voluntary measures undertaken by the stakeholder industry or licensees in particular.

20.4 The Management Committee shall have the right to establish, advisory teams, steering committees and sub-committees, as it deems appropriate to determine the scope of projects, periodicity of meetings, applications to "Petroleum operations", working procedures , amendments, modification to this Regulatory frame or other laws. The findings and recommendation made by such steering committees shall be duly recorded in writing at all meetings and communicated to the management committee.

20.5 Any sub-committee, team, task force or other bodies established by the Management Committee shall have no authority other than to advice, and make non-binding recommendations to, the Management Committee. No sub-committee, team, task force or other body shall have any authority to bind any party in any way

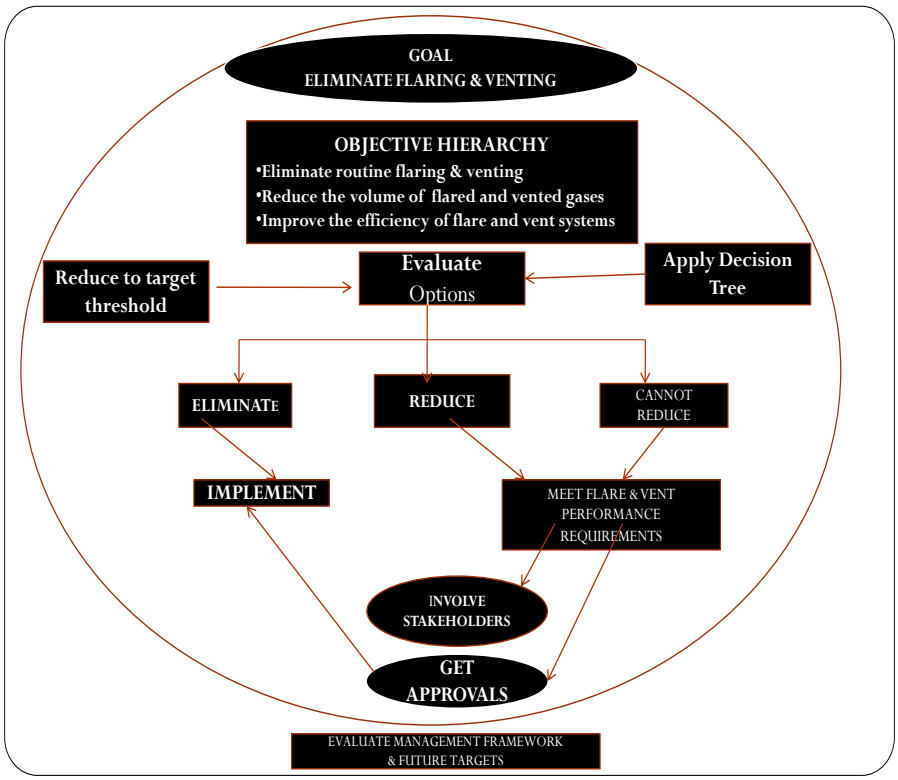
21.0 APPENDICES

21.1 APPENDIX 1: MANAGEMENT FRAMEWORK

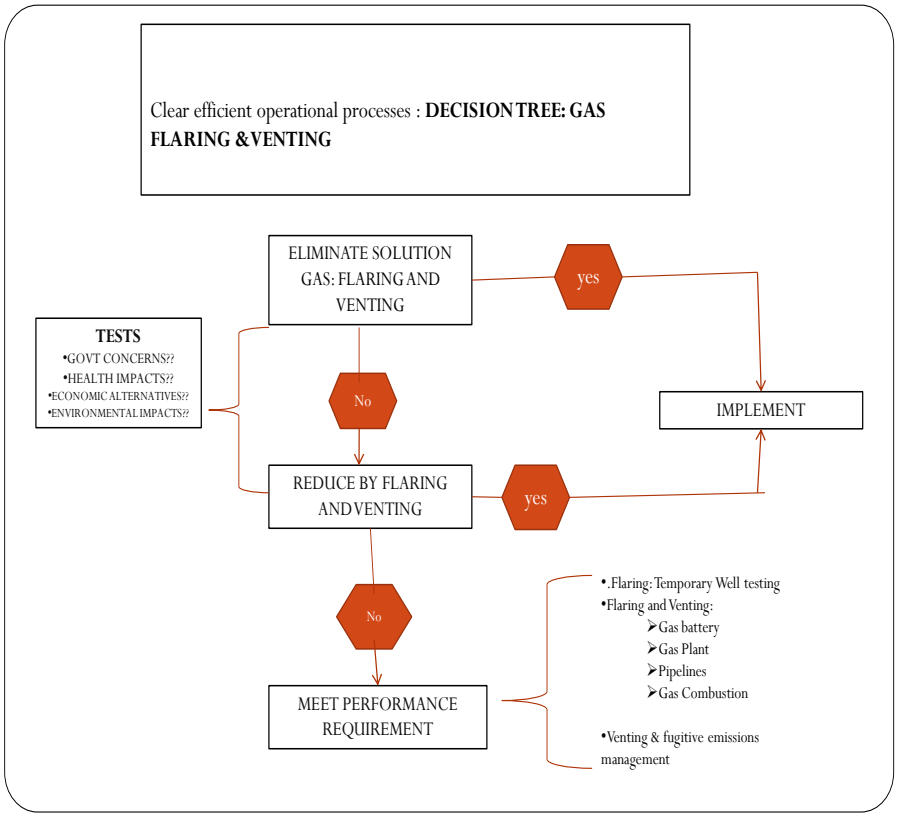
21.2 APPENDIX 2: DECISION TREE

2.3 APPENDIX 3: ENFORCEMENT LADDER

22.1 APPENDIX 1: MANAGEMENT FRAMEWORK



22.2 APPENDIX 2: DECISION TREE



r9: A GAP REGULATIVE INSTRUMENT ANNEXURE

22.3 APPENDIX 3: Enforcement Ladder

Enforcement Level	Nature of Non Compliance	Enforcement Action
Level 1	Minor Non compliance with reporting, measurement, or less significant facility requirements	Written notification of noncompliance requesting that corrective action be taken within 30 days and that confirmation is provided to the PNGRB.
Level 2	Major noncompliance that has an immediate or potential threat to public safety, health the environment, or resource conservation and the compliance requirements, decisions conveyed in writing made to licensees by the management committee under this regulation. Failure to respond to Level 1 enforcement.	Written notification to Licensee or senior management of the company about noncompliance requesting: • Noncompliance be corrected in 30 days • Written explanation of cause of Non-compliance • Plan to ensure event does not recur Confirmation that the noncompliance will not occur at other sites operated by the company. Facility licenses may be suspended (that is, ordered to shut down) if necessary to protect public safety or the environment.
Level 3	Serious noncompliance involving a "major" item and demonstrated disregard for regulations. Failure to respond to Level 2 enforcement. Repeat major noncompliance at any site operated by the company.	Suspension of the license until written approval is received from the PNGRB. This will not occur until a senior company/Licensee representative provides, in writing, at a meeting, the following: • Confirmation of compliance at this and all similar sites and operations • An explanation of why the company/licensee

		demonstrates disregard for PNGRB requirements • An action plan that should include third-party reviews at the company's expense to ensure this disregard for requirements does not recur.
Level 4	Failure to respond to Level 3 enforcement. Repeat serious noncompliance by the company within 12 months.	Per Level 2 and 3 (that is, potential license suspension), plus: • Formal order to comply • Enact "refer" status. "Refer" status results in greater scrutiny of the company and is considered by the PNGRB in determining whether pending and future applications for wells and facilities should be approved.

REVISION HISTORY LOG

Revision Number: 1 **Date:**

Item Revised:	**Reason for Change/Amendment:**
All pages	**Changes/Amendments Made:** This regulatory document is a new document developed by Regulatory specialist.

Note:

The revision history log shall be updated with each revision of the document. It shall contain a written audit trail of the reason why the changes/amendments have occurred, what the changes/amendments were, and the date at which the changes/amendments were made.

EVANGELIZING AWARENESS PROGRAMS FOR THE SCHEME AND ITS ADVOCACY

HISTORY OF TECHNICAL EVANGELISM

The world in the mid-20th & 21st centuries is the era of new technical innovations that rocked the world in its sweep both commercially as well as socially. In fact never before in the history of humankind has new ideas leap frogged into reality. The early 20th century saw a relatively new but visible phenomena such as the Edison telephone, Eastman Kodak on photography and the automobile the wright brothers Aircraft et al. The motivation and promise of the innovation was carried out more by such vehicles as Trademarks, advertising et al. The inventions that came in the mid twentieth century belonged to that genre of innovations that depended on their acceptance socially but where visible in its application. The software and the internet heralded the age of the ubiquitous but invisible technology. The GP led free software also variously referred as "Copy left" was the initiative of Richard Stallman his argument that if such license was not freely available then the software industry would be dominated by a few unless the was free to be modified and it would continue to grow. Ironically, the very freedom required to be standardized for its commercial viability into what is now known as Open source software (OSS) and the concomitant OSI certification referred below:

The Open source initiative predicated the use of criteria which is ten different applications from Free distribution, Source code availability, Derived works mobility, ensuring source code integrity, Nondiscrimination both groups, people and application, Technology neutrality, non-restriction of use of other software, Non specificity to a product etc. The implied conditionality for the OSS model was therefore standardization of best practices and licensing.

The oil and gas industry referred in this thesis is also treated in similar fashion by collating all of the best practices into one seamless template. Much as Richard Stallman did. One thing led to another when the OSS became the foundation for the development of an whole lore of sustainable E commerce.

The venerable Linus Torvalds[72] a student of the University of Helsinki is worthier mentioning here who championed the cause of the Linux. His book (co-authored with David Diamond) "Just for fun, the story of the accidental revolutionary"[73]. Bill gates in his book "The Road Ahead"[74] writes the following (pages 122) as an outgrowth of the free software and OSS regime

"In addition to free information there's a lot of free software on eh Internet today, some of it is quite useful. Sometimes, its commercial software given away as a part of marketing campaign. Other times the software has been written as a graduate student project or at a government funded lab. But I think the consumer desire for quality, support and comprehensiveness in important software applications means that the demand for commercial software will continue to grow. Already many of the students and faculty members who wrote the free software at their universities are busy writing business plans for start up companies that will provide commercial versions of their software with more features not to mention customer support and maintenance"[75]

From the above it can be seen that the seed idea of OSS software led to a spawning of unintended effects that led to the growth of internet as it exists today.

EVANGELISM EXECUTED

According to Guy Kawasaki in his bestselling book " Selling Dreams"[76]

"Evangelism is the process of convincing people in your product or idea as much as you do. It means selling your dream by using fervor, zeal, guts, dream, and cunning…..Evangelism is the process of selling a dream"[77]

[72] http://www.gnu.org/philosophy/free-sw.html (last seen May 2017)
[73] https://archive.org/details/JustForFun (Last seen May 2017)
[74] Bill gates "the Road ahead"
file:///C:/Users/sampath/Downloads/d_book_komputerler_23543.pdf (last seen May 8, 2017)
[75] Referred Supra in 17
[76] https://guykawasaki.com/books/selling-the-dream/ [last visited 8th May 2017]
[77] Supra as referred in Guy https://guykawasaki.com/books/selling-the-dream/

- The goals of evangelism as it is related to outcomes is it is self sustaining in its growth and long lasting with dramatic changes
- The trigger is a cause which embodies a vision, catalyze selfless action and sometimes polarizes -love or hate relationship
- The building blocks are leadership which provides the vision for an organization or company and entails a belief in the vision, sustains and nurtures the vision, believe in people, inspire by example and share a cause
- The development of angels which come in the form community action programs or large corporations with social causes and for business causes through retired executives of influence. Angels advocating the idea is among pure selfless deriving satisfaction for helping a cause , realistic, outspoken and connected to the "Powers that be"
- Evangelists are also committed attract people to a cause and willing to listen
- The evangelist is also a focal point for enemies which have four varieties conceptual: ignorance, inertia or conservatism;
- Tactical enemies: Other companies, organization or people. The enemies are also an asset as they add legacy, rallying point, provides quantifiable milestones and to defeat shared conceptual enemies.

STEPS TO IMPLEMENT EVANGELISM:

- Foster fellowship among members
- Start in the right direction
- Focus on positive results
- Maintaining openness
- Formalize and adapt laws and procedures
- Raising funds
- Finding legal counsel in case of statutory problems
- Hiring competent and committed staff
- Creating promotional material

TECHNOLOGY EVANGELISTS A SURVEY OF COMMON CHARACTERISTICS

Technical well evangelists in a survey by Fredric Lucas- Corn[78] refers to them as a) Motivator and creator of a sense of urgency and b) A relationship builder and project manager. The survey showed four major profiles:

- *Typical experienced technology evangelists* with strong competencies within one specific field
- *Atypical experienced technology evangelists* bring strong technical experience but their interaction among large public audiences are often thrust upon
- *Technology Evangelist in progress* among the early phase developers who build credibility and recognition through their skills
- *Atypical Evangelist in progress* In organizations these fit into presale and aftersales functions who change the system with smaller groups in organizational idea executing mode. These are trained at workshops to deal effectively in the market place for great ideas which find their way to the market place.

CONTEXTUAL EVANGELISM RELEVANT TO THIS THESIS

Technical evangelism rather than ethical evangelism would be the answer to a situation when the natural gas prices, volumes of flared gases supports economic viability. On this count inspiration can be derived from other industries such as the IT industry. Giants such as Apple and Mackintosh successfully evangelized the use of its technology and systems across the globe. The Technology evangelist in the context of flaring and venting operations in this case may act out of both altruism and self-interest with equal felicity. The fall out activity of such evangelism requires technology-marketing skills honed to specific geographical requirements. Several books have been written on this

[78] Technology Evangelists: A leadership Survey by FredricLucas – Conwell SDForum conference on "Technology Leadership and Evangelism in the participation age" December 2006

aspect by concerning technology adoption and lifecycles. The product of evangelizing has a well honed mechanism in that it also serves self interest of corporation and the F & V generation has a sufficient volume of several billion cu metres of associated gas to make it an organized basis and not in the fashion of todays " Business as usual" attitude. The volumes, can be the basis for several corporations that undertake the use of F & V gas discharges both from the supply side technologies as well as use of the gas on commercial lines. It is nowhere written that evangelism should only be a comfort mechanism for the distressed environment on sustainable future generation. This would be a win–win situation for all parties both supply and consumers. The business can work out its mechanism to deal with large-scale deployment of F & V discharges. In recent times Japan through the aegis of the UNFCCC had proposed use of its latest burn technologies etc. The aspect of a template worldwide regulatory system as proposed in Annexure I could find a place in the UNFCCC for international consideration. The data for such proposals have been validated by the GGFR and as suggested in this thesis.

Another aspect of the Business as usual may be summed up that corporations may increasingly feel the requirement of corporate responsibility especially in the environmental aspect being an unintended motivator for commercializing F& V associated gas use. In this regard mention may be made of the leading giant Exxon Mobil being targeted by a federal investigation group and environmentalist groups who accused it misleading the American public by not disclosing information about climate change risks in order to protect its profits. New York and California have been particularly active in bringing Exxon Mobil's statements to investors on climate change and whether it is even consistent with its own scientists in the Environment section of the company who have written unequivocally on climate change. What's more the company has predicted that Oil & Gas will still dominate until 2040. If so, the future profits would be on line considering the investment on Climate change and the enforcement methods required to be made to curb its effects. The

commercialization proposed is therefore an antidote for the furtherance of the oil & Gas industry as unintended but beneficial effect.

One other fall out is that "Business as Usual" may not be just about the reluctance to costs of curbing Climate change parameters in the production of

O & G but is the nonchalance paid to such issues as marginal considering a 3 or 4 % loss in the phase of unremitting production and bashing on regardless of climatic and environmental consequences.

BUSINESS AS USUAL OPERATIONS IN OTHER INDUSTRIES:

In most other industries the "Business as Usual" approach is akin to pilferage use. A pilferage of around 2 to 3% is generally considered expendable owing to the cost of invigilation being equally expensive to enforce and therefore not sustainable. On the other hand the use of F & V associated gas as is used by downstream industries is a valuable commodity and useful on a sustainable basis.

ZERO FLARING INITIATIVES

In most countries the "Zero flaring" initiatives have been introduced – this however does not mean that the flares can be avoided as a process requirement what it really means is that the resources that are flared are contained and utilized instead of being wastefully expended into the atmosphere with resultant environmental issues. In one way, this thesis is the streamlining of that effort into a dedicated and systematic effort at the supply side of the upstream Oil and Gas industry.

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