Abnormal Situation Management (ASM) in Gas Processing Facilities

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Gas and Fuels Research Initiatives
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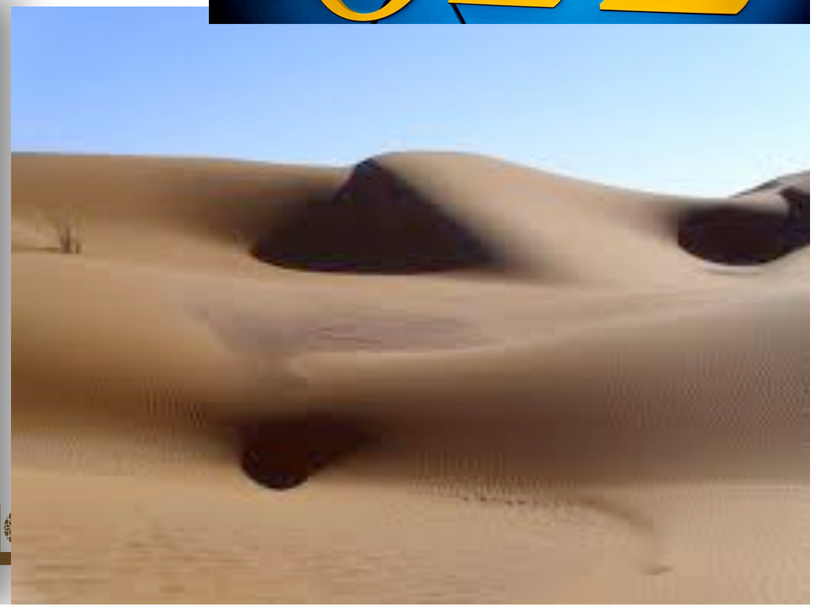
Montgomery, TX


QATAR
AIRWAYS

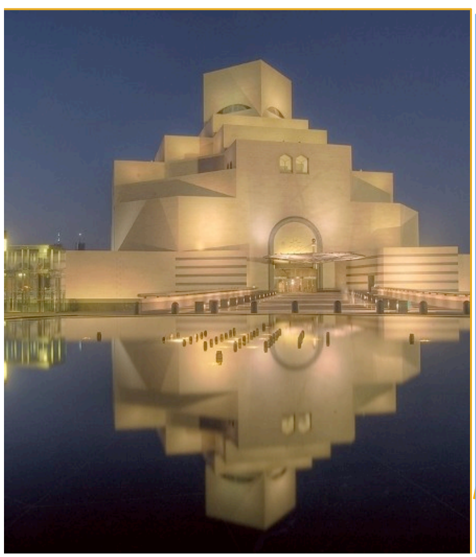

IRAN
The Gulf
QATAR
Doha
SAUDI
ARABIA
UAE
200 km

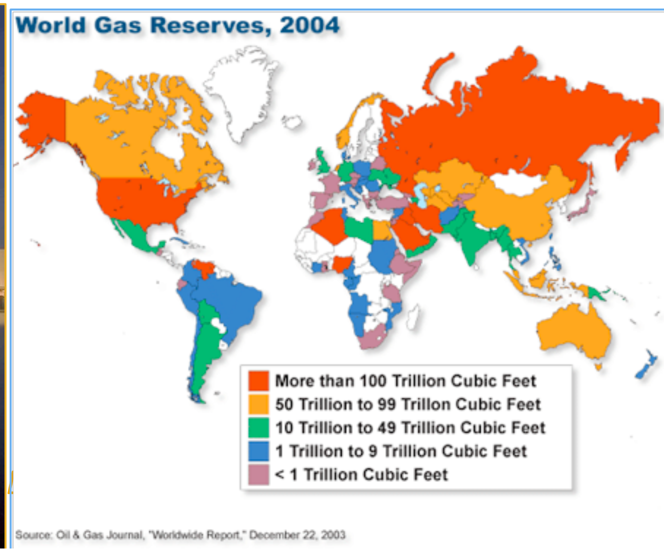

qatar
2022


NIGEL DOWNES



Development | Oil & Gas Economy | Sustainability | Education





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Drop in the Ocean

Despite being almost 90 years old, GTL has seen little commercial application

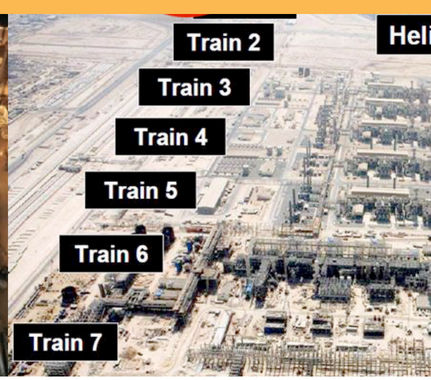
Name (Location)	Company	Capacity, barrels per day
Pearl (Qatar)*	Shell & QP	140,000
Escravos (Nigeria)*	Chevron & NNPC	34,000
Oryx (Qatar)	Sasol & QP	24,000
Mossel Bay (South Africa)	Petro SA	22,500
Bintulu (Malaysia)	Shell	14,700

*Plants under construction

Sources: Companies; Deutsche Bank

PEARL GTL

DELIVERING THE WORLD'S LARGEST GAS TO LIQUIDS PLANT IN QATAR


Qatari Research Investments

Research that support Qatar's vision 2030 and National Priorities

National Priorities

Environmental Sustainability

Reduce Green House Gas Emissions

Climate Change

Infrastructure

QF: Head by First Lady/Sheikha Moza

QNRF: 2.8% National Income **~$4.8 Billion**

Qatar Science and Technology Park, QSTP

QU Research Center/ CEDRA Research Center

A Process-Integration Framework for Abnormal Situation Management (ASM): A Systematic Approach with Application to Qatar's Industrial Needs and Opportunities

Collaborators

جامعة قطر
QATAR UNIVERSITY

LAMAR UNIVERSITY

TEXAS A&M UNIVERSITY

Industry Advisory Board

شركة قطر للكيماويات المحدودة
QATAR CHEMICAL COMPANY LTD.

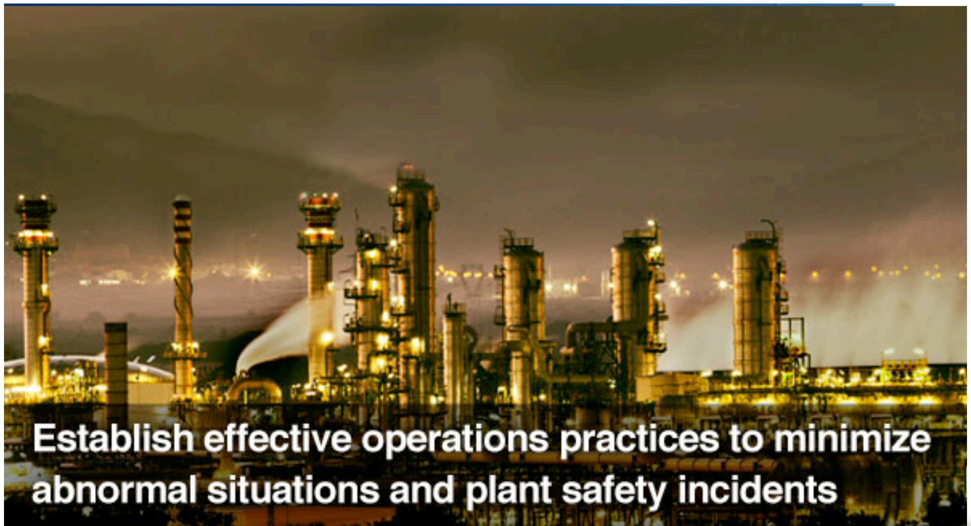
Funding

NPRP
National Priorities Research Program

الصندوق القطري لرعاية البحث العلمي
Qatar National Research Fund
Member of Qatar Foundation

Department of Chemical Engineering

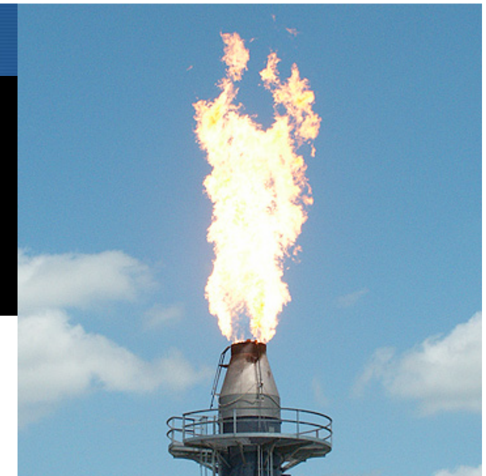
جامعة قطر
QATAR UNIVERSITY



Outline

- Flaring
- ASM
- Flare Reduction
- Challenges – Motivation
- Approach
- Preliminary Results
- Anticipated Outcomes

Why Industry Flares?

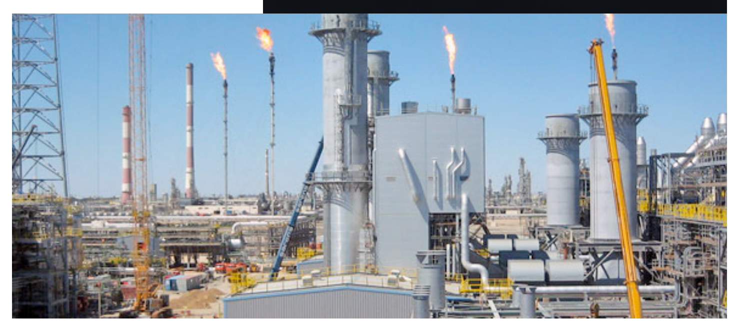


Safety

- Routinely small volumes of unrecoverable gases
- Managing excess gas production

Process Upsets

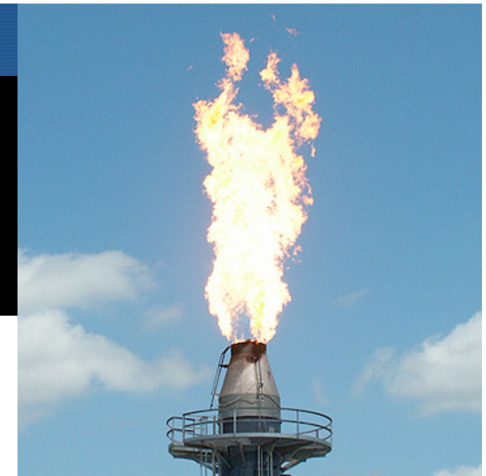
- Equipment malfunction
- Off-spec production
- Depressurizing equipment
- Start-ups or Emergency shutdowns



Why Industry Flares?

Disposal Associated Gases

- Oil production and gas processing facilities
- Insufficient infrastructure



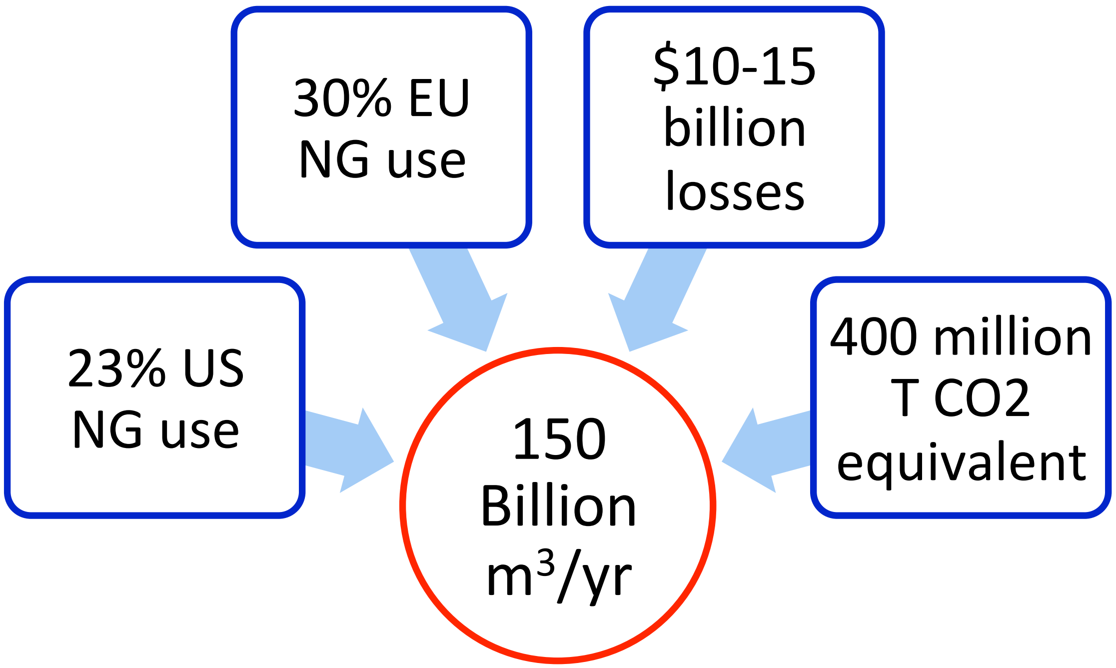
What is Flared?

- Fugitive Emissions

  7-12% of GHG annual emissions
- Associated Gases

  Mostly methane
- Sweet/Sour Gas
- Hydrocarbon Vapors
- Unrecoverable Gases

Flaring Impact?



Global gas flaring has remained largely stable over the past fifteen years, in the range of 140 to 170 billion cubic meters (BCM)

"GE Gas Flaring Report – Recent global trends and policy considerations", 2011.

Flaring Impact?

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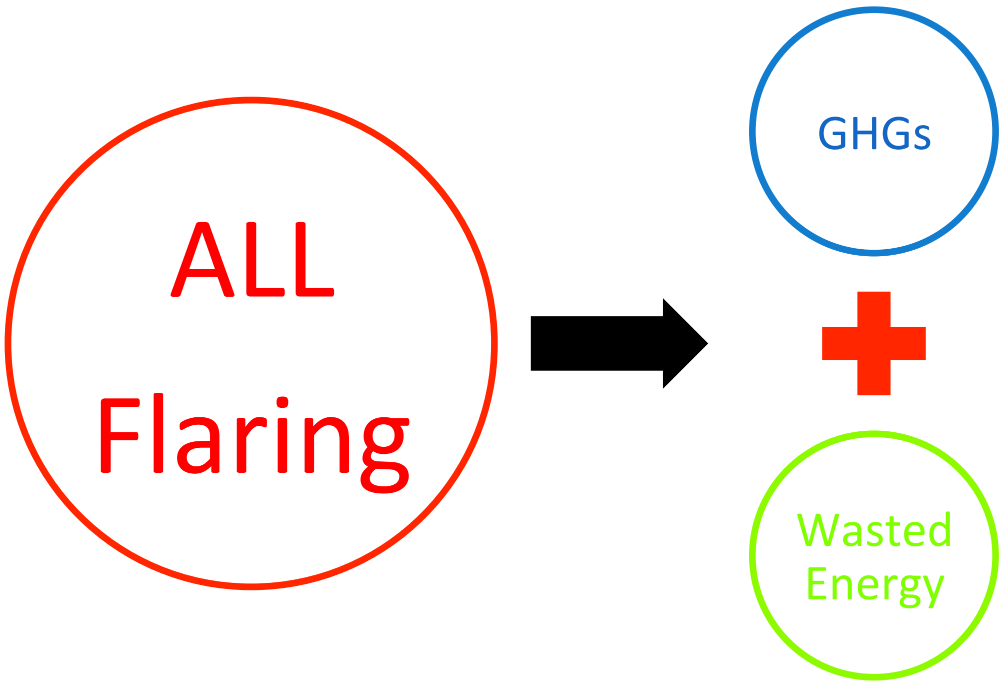
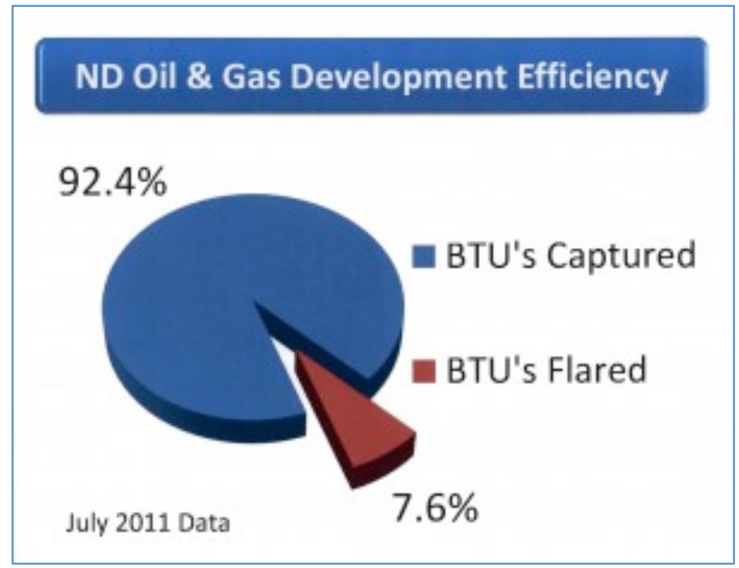
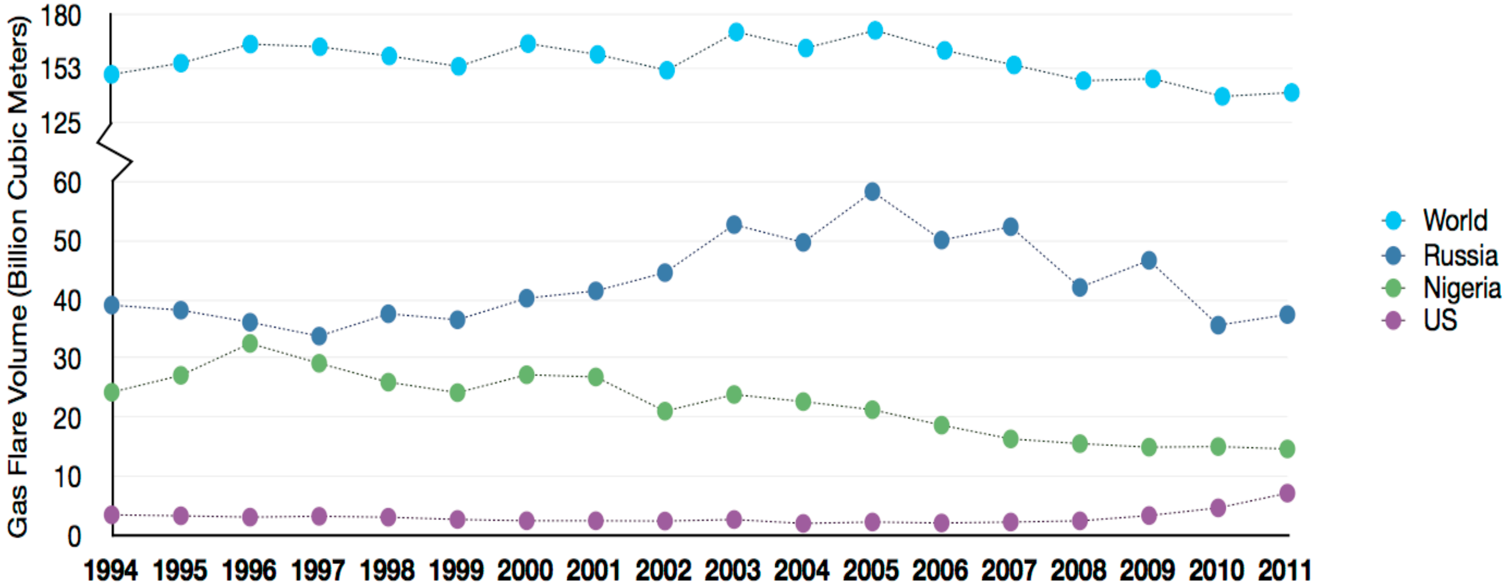




Flaring Environmental Impact?



NOAA (1994-2006); World Bank (2007-2011).

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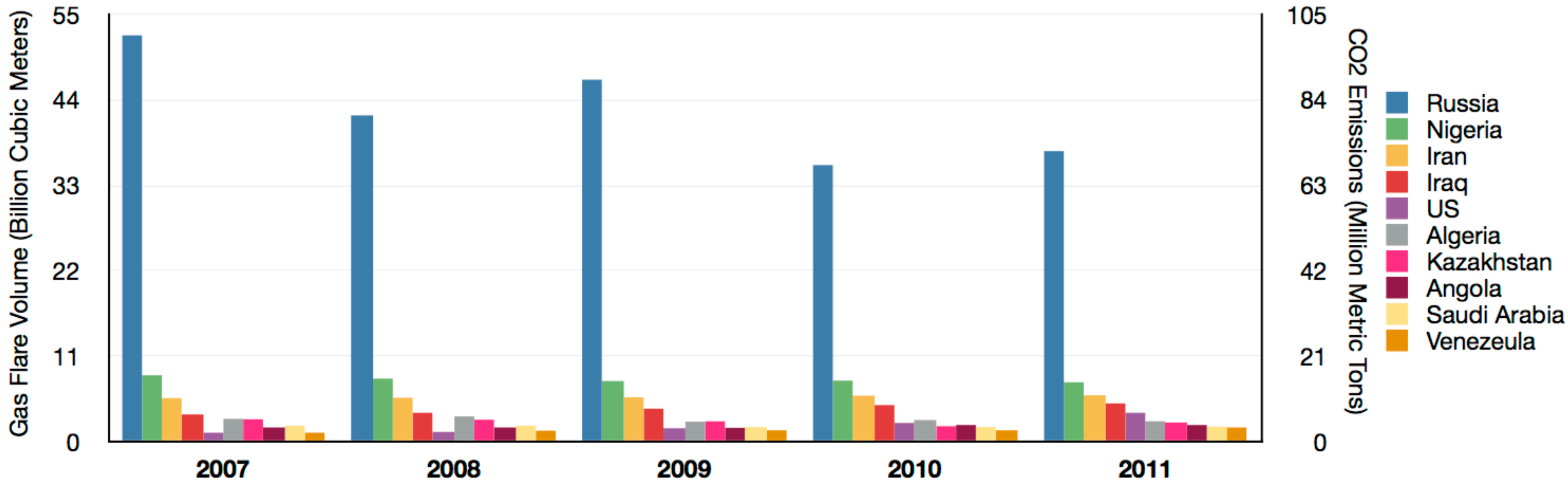

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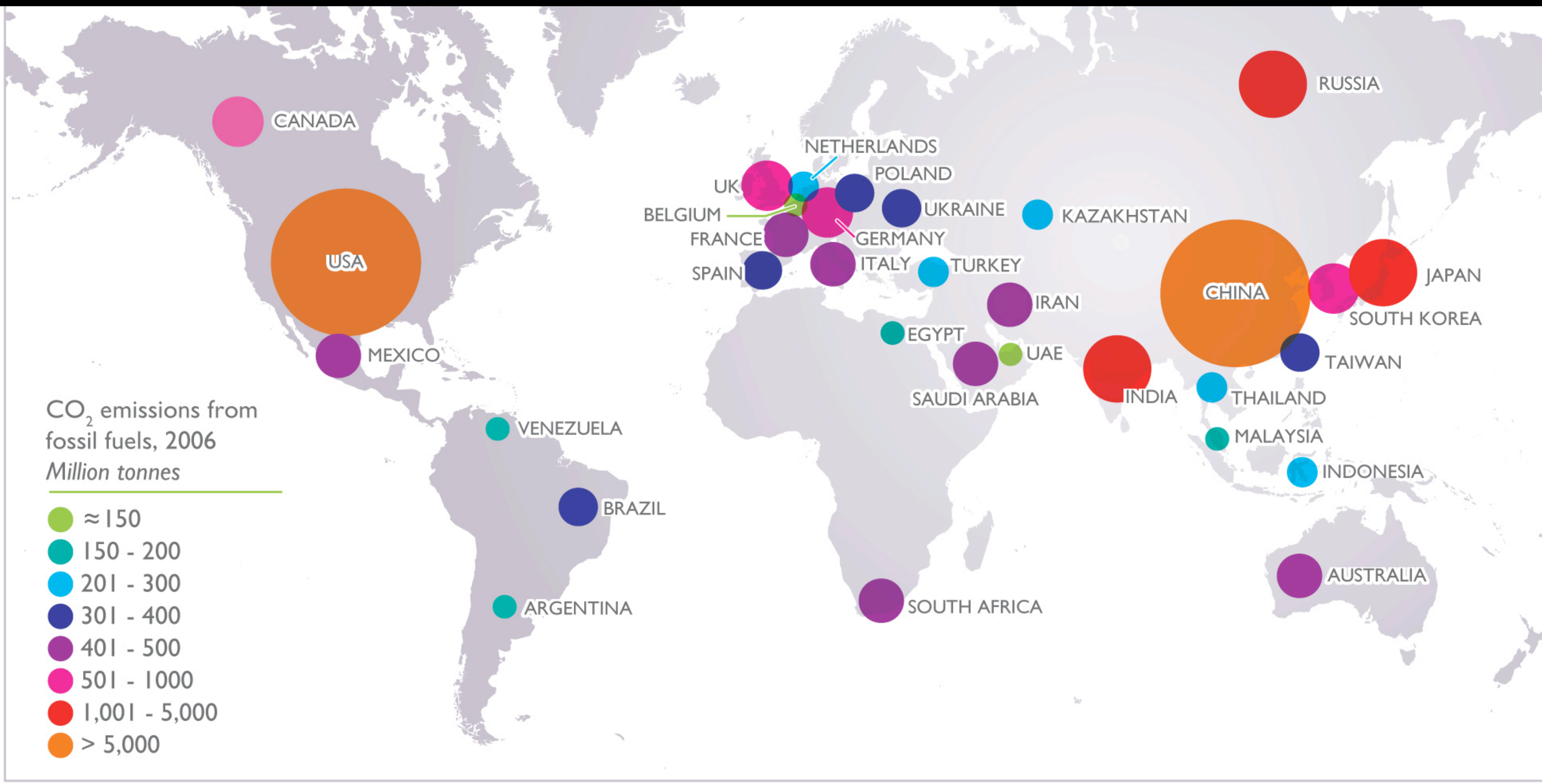
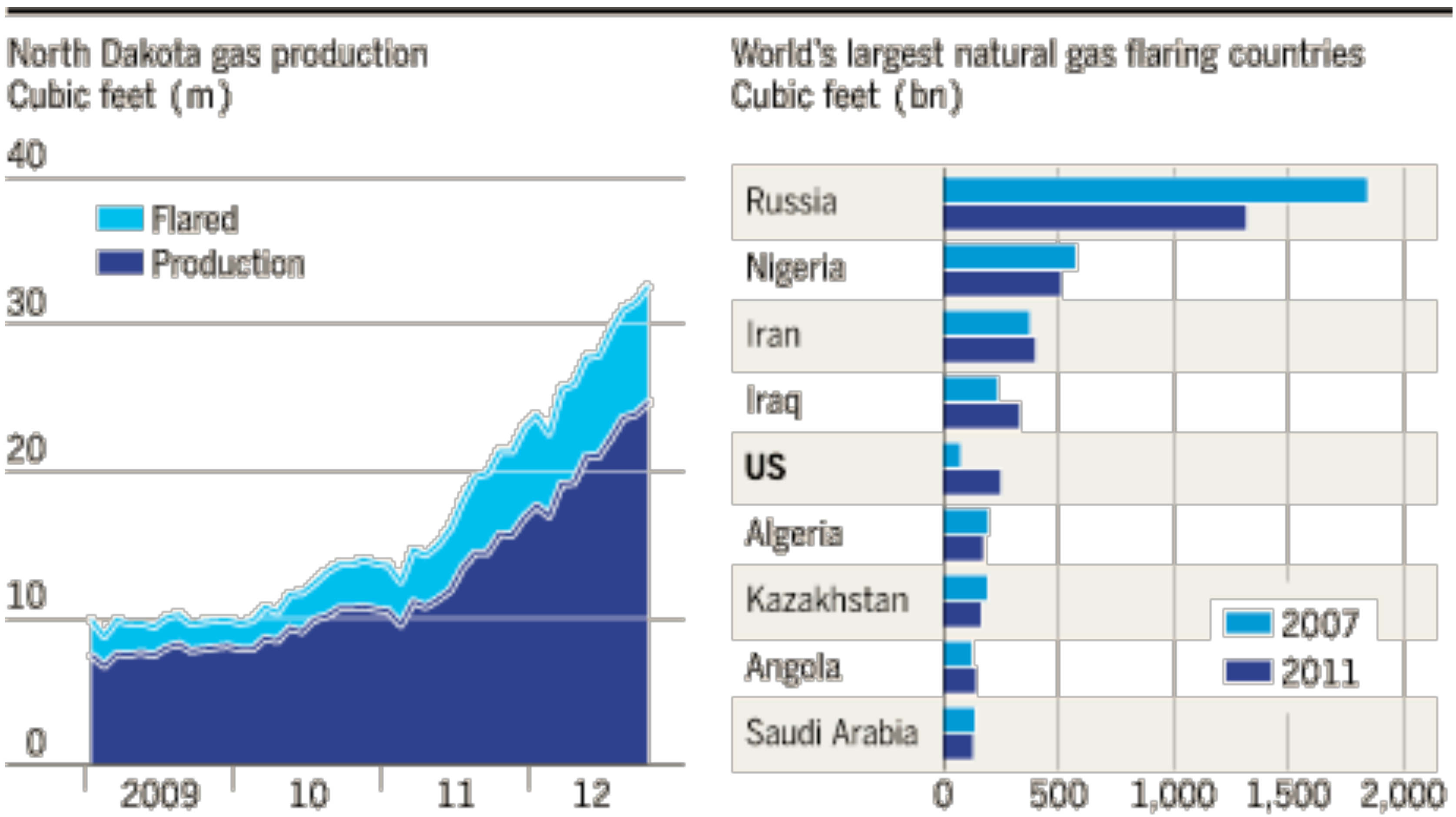


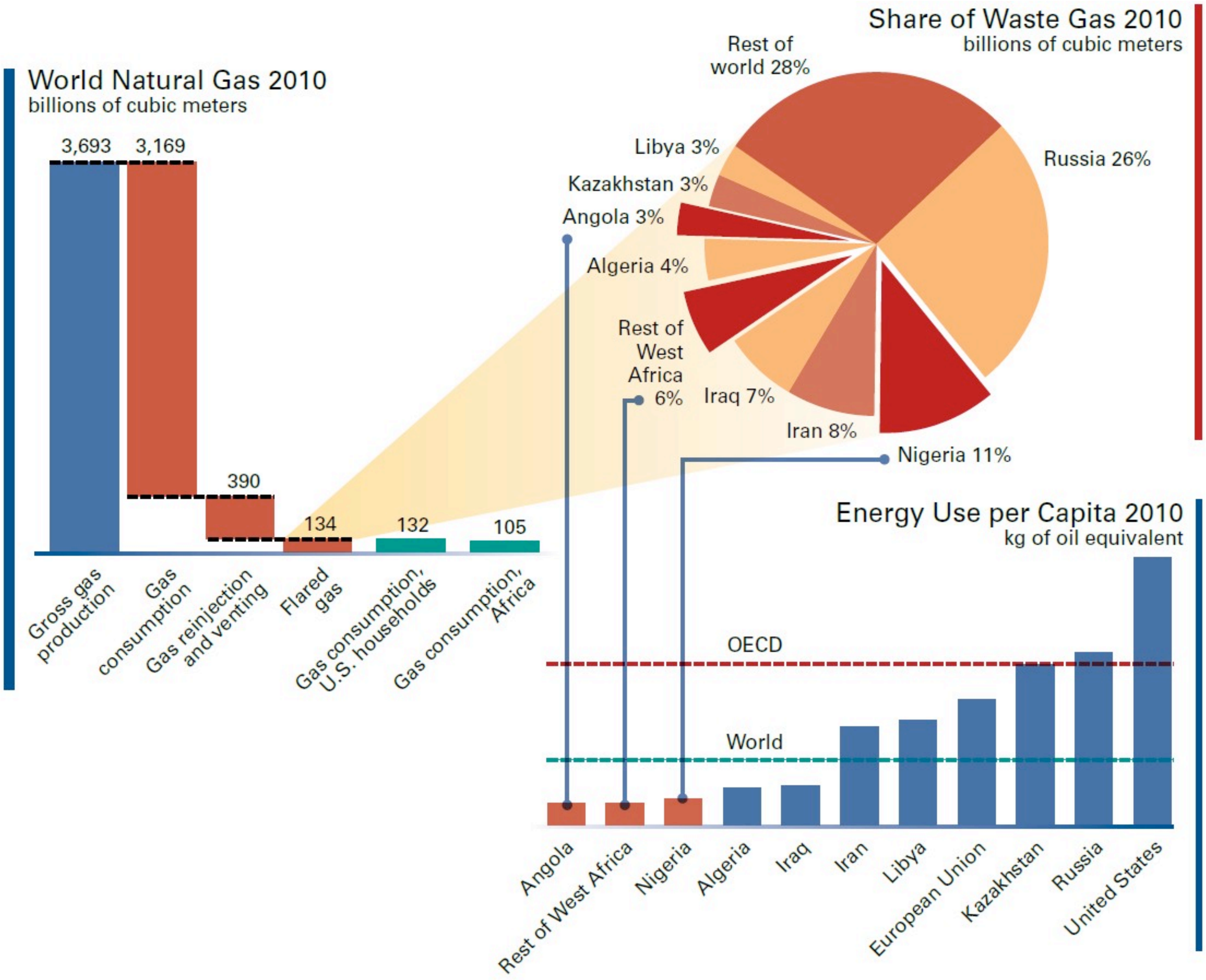
Data from Energy Information Administration *International Energy Annual 2006*

Flaring Environmental Impact?



North Dakota Industrial Commission and NETL, US DOE

Flaring Environmental Impact?



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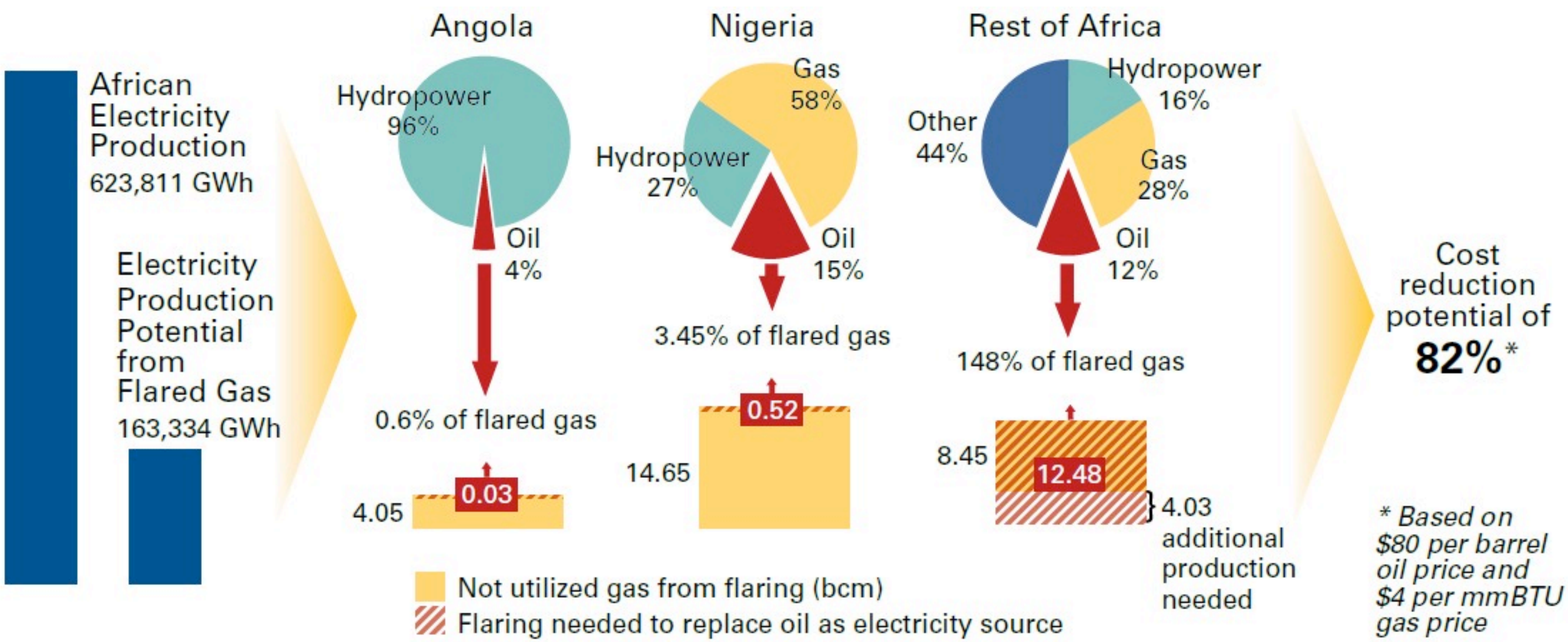


Flare Gas Reduction

CHALLENGES

- Reducing rates while production levels increase
- Cost effective alternatives
- Cooperation neighboring/competing operators for join facilities

Flare Reduction… Why?

Waste valuable resources

Negative Environmental Impacts
Unnecessary CO_2/SO_2/Nox emissions

Safety & Economics Impacts

Noise - neighboring communities

Visible to surrounding community
Visible black smoke and soot

How to Reduce Flaring?

Legislation | **Flare recovery** | **Flare utilization**

GGFR
Global Gas Flaring Reduction
A Public Private Partnership

Qatar’s Proactive Legislative Acts

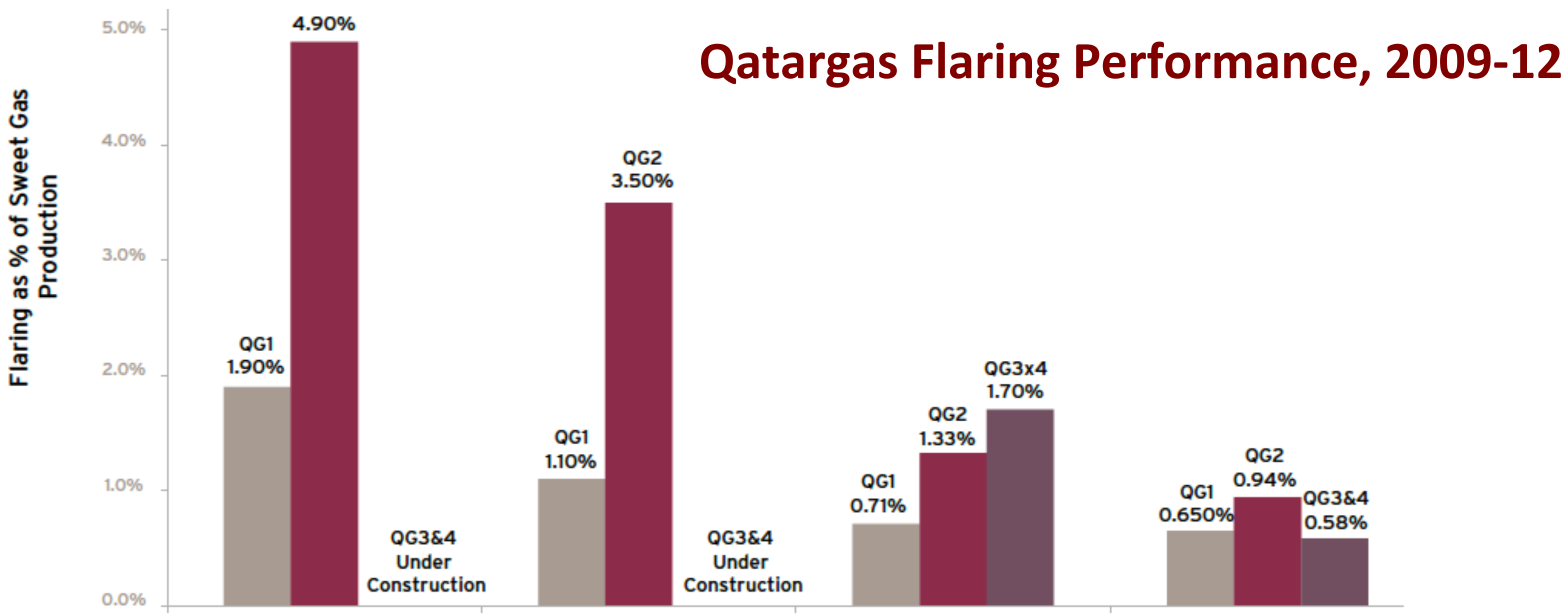
- ‘02 Establishing Supreme Council for the Environment
- ’05 Kyoto Protocol & ’07 AlShaheen CDM Project
- ’09 World Bank Global Gas Flaring Reduction (GGFR)
- ’12 COP Meeting

UNFCCC

Qatar Experience

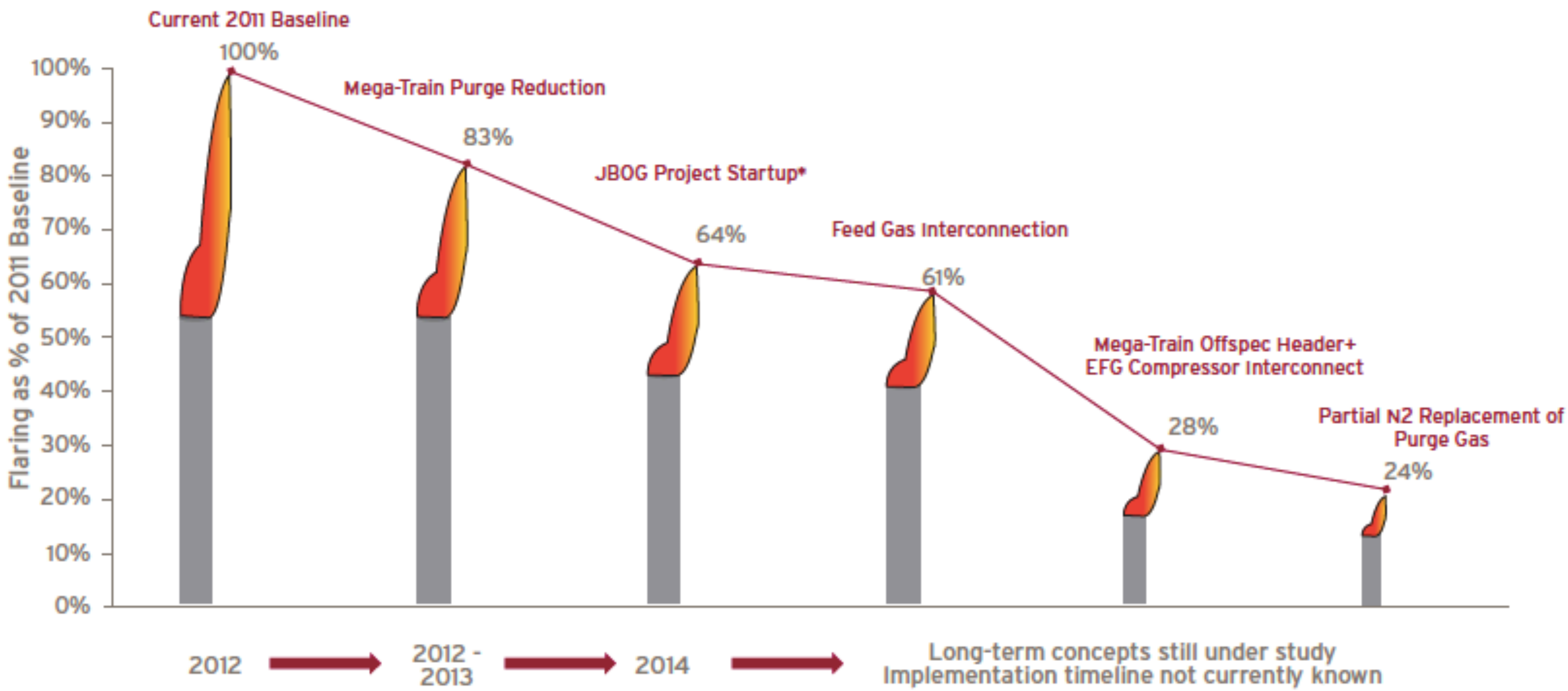
Flaring by Subsector						
Subsector	**Companies Reporting**		**Flaring (MMSCM)**			**% Change for Comparable Companies**
	2011	**2012**	**2011**	**2012**	**2012 for Comparable Companies**	
LNG/NG	3	3	1,910	2,071	2,071	+8%
Refining	2	2	2,102	1,202	1,202	-43%
Oil and gas (E&P)	5	5	596	668	668	+12%
Petrochemicals	4	5	195	558	385	+98%

How to Reduce Flaring? Qatar Gas



2.9 billion project for flare minimization

- $ 1 billion Jetty Boil Off Gas (JBOG) Recovery Project. Sustained baseline flaring rate of around 0.2% of sweet gas (not including unplanned events or planned shutdowns/ restarts)
- Recognized November 2012 by World Bank (GGFR)



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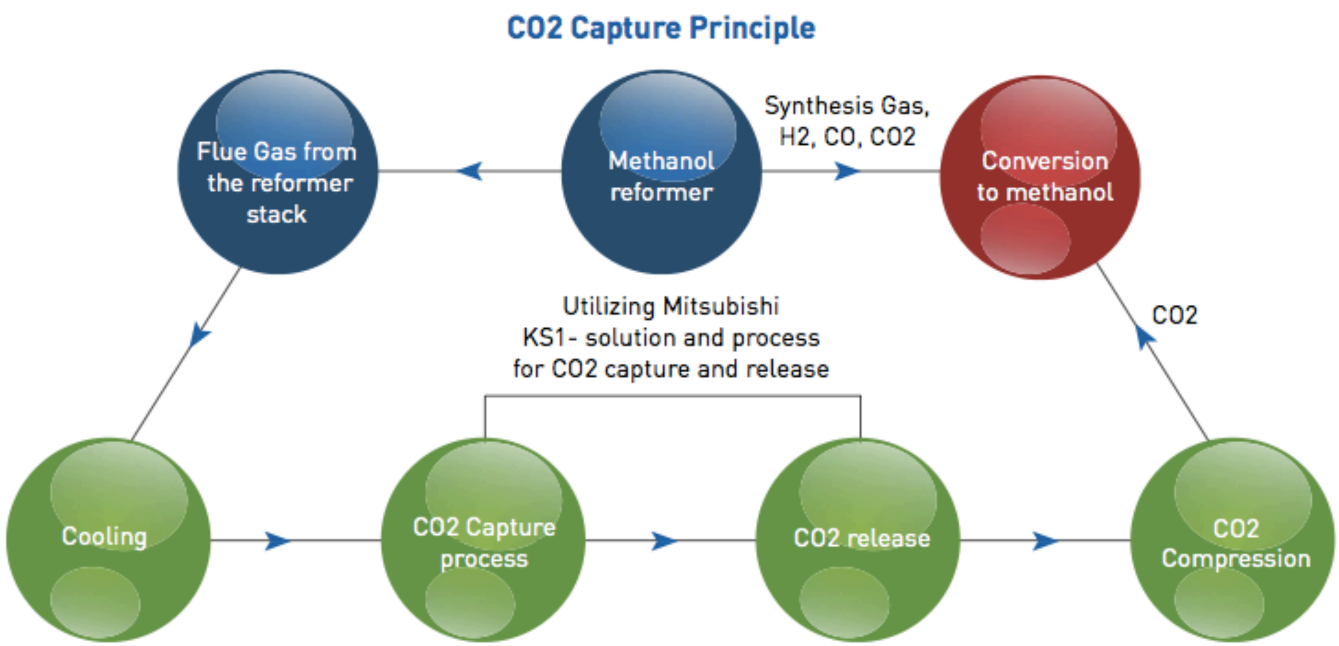
How to Reduce Flaring? QAFAC



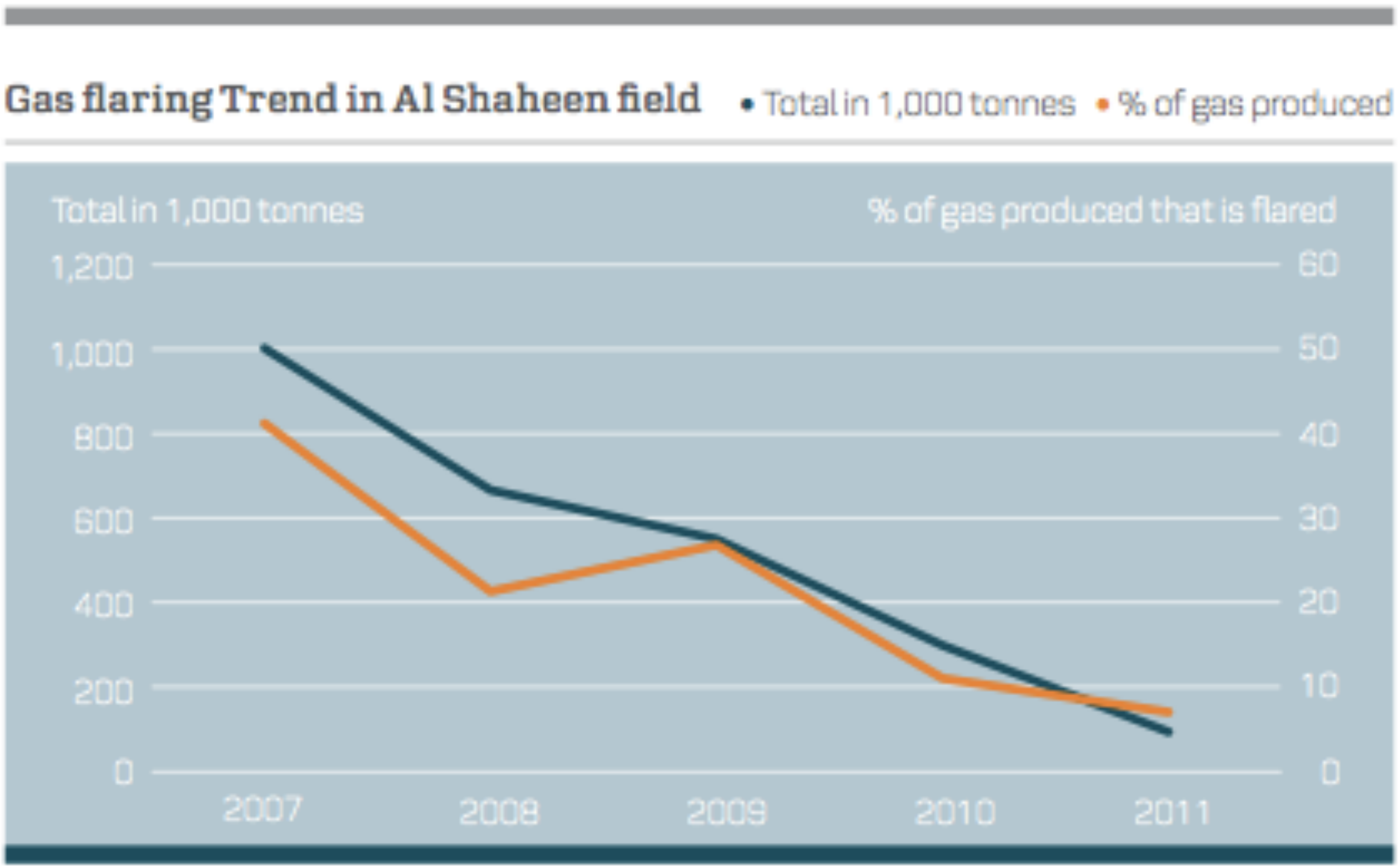
- Carbon Dioxide Recovery (CDR) - $300 Million
- 1st in the world to utilise CO_2 captured from flue gas for methanol synthesis

How to Reduce Flaring? CDM

Legislation | **Flare recovery** | **Flare utilization** | **Incentives**

	Country/Year/Name				
	Indonesia 2007 Tambun	Qatar 2007 Al-Shaheen	Nigeria 2008 PanOcean	China 2009 Tarim	Nigeria 2010 Utumu
Flare Gas Use: Bcm/y	0.1	1.6	1.3	0.2	0.2
Flare Gas Use: MMcf/d	12.6	150.0	130.0	19.7	16.0
CO_2e Total Emissions Reduced: MMT	3.9	17.5	26.3	2.4	2.6
CO_2e Annual Emissions Reduced: MMT	0.4	2.4	2.6	0.3	0.3
Capex $US Million	$30	$260	$302	$32	$30
$Capex/$CO_2e$ Annually Reduced	$77	$106	$115	$110	$117
$/MCM Flare Gas Use	$84	$60	$81	$56	$65
$/MMcfd of Flare Gas Use	$2.42	$1.73	$2.32	$1.62	$1.87
CER Price – US/MtCO_2$	$15	$6.5	$7.5	$10	$11
IRR Without Credits (Post Tax)	-30.4%	9.7%	5.4%	11.8%	4.5%
IRR With Credits (Post Tax)	6.1%	16.0%	11.2%	19.7%	22.4%
Technology	Mini LPG Plant, Pipeline	Processing, NGL, and Pipeline	Processing, NGL, and Pipeline	Processing, NGL, and Pipeline	Processing, NGL, and Pipeline

How to Reduce Flaring? Maersk Oil



How to Reduce Flaring?

Legislation | **Flare recovery** | **Flare utilization** | **Incentives**

Associated Gases

- Reinjection EOR
- Conversion to liquid (easily transported)
- On-site use

Process

- Dynamic Control Systems
- Energy efficiency

Increased demand for productivity/efficiency resulted in sophisticated Control Systems. Yet, they have not eliminated upsets!!

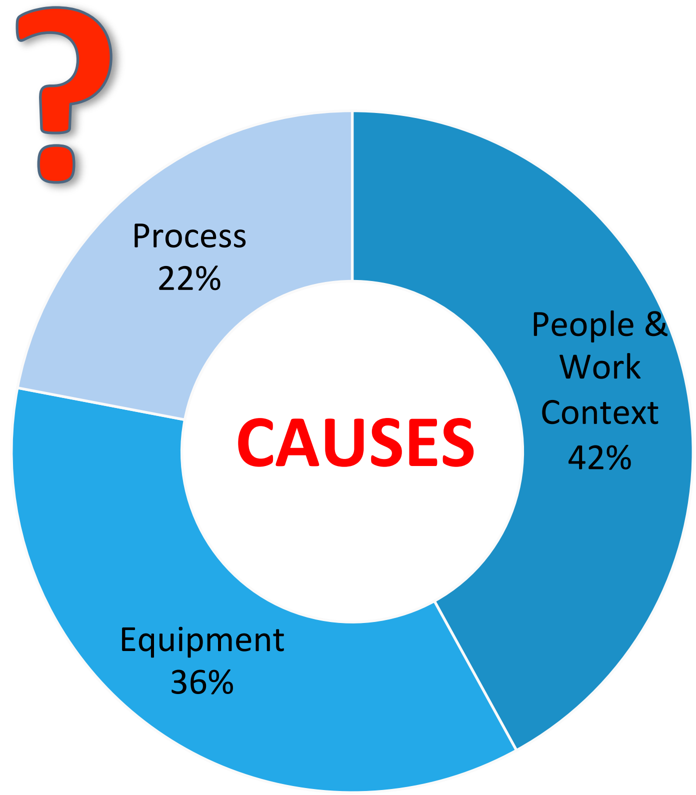
Elvidge, C.D et al. (2009).

Process Upsets – Abnormal Situations

Processes eventually deviate from normal operations; and *control system* are in place to *mitigate* such deviations.

When control system ***CAN NOT*** cope with disturbances , human intervention (DCS operators) is needed

ABNORMAL SITUATIONS



Cochran, E., Bullemer, P. (1996). "ASM: Not by New Technology Alone…", 1996 AIChE conference.

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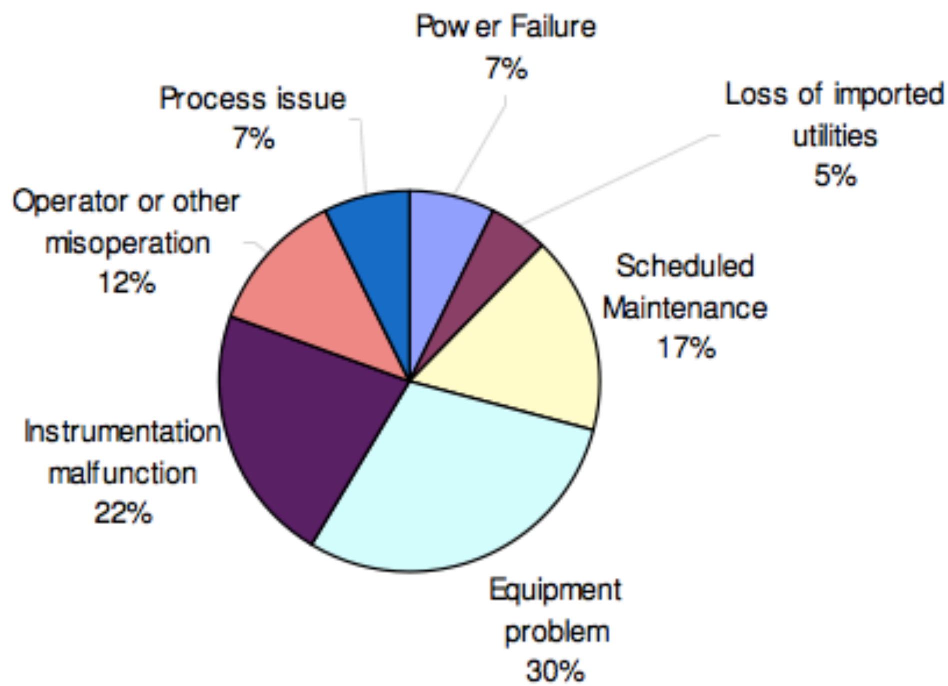


Midstream Upset Flaring and Management Options, April 2010

Process Upsets – Abnormal Situations

- Significant in both size and occurrence when compared to routine operation emissions (McCoy et al., 2010)
- Reducing upsets emissions is more effective than reducing routing emissions (Nam et al., 2008)
- Upsets are not random and hence we need to determine if there are means to predict upsets and mitigate accordingly?

Nam, et al. (2008) Journal of Atmospheric Environment 42
B.J. McCoy et al. (2010) Journal of Atmospheric Environment 44

Limitation

Currently industry is using a *response* approach to managing abnormal situations

Develop Framework for Optimum Management of Abnormal Situation

- Proactively preventive & responsive
- Provide both design & operational strategies

Project Objective

Develop Framework for Optimum Management of Abnormal Situation

Project Objective

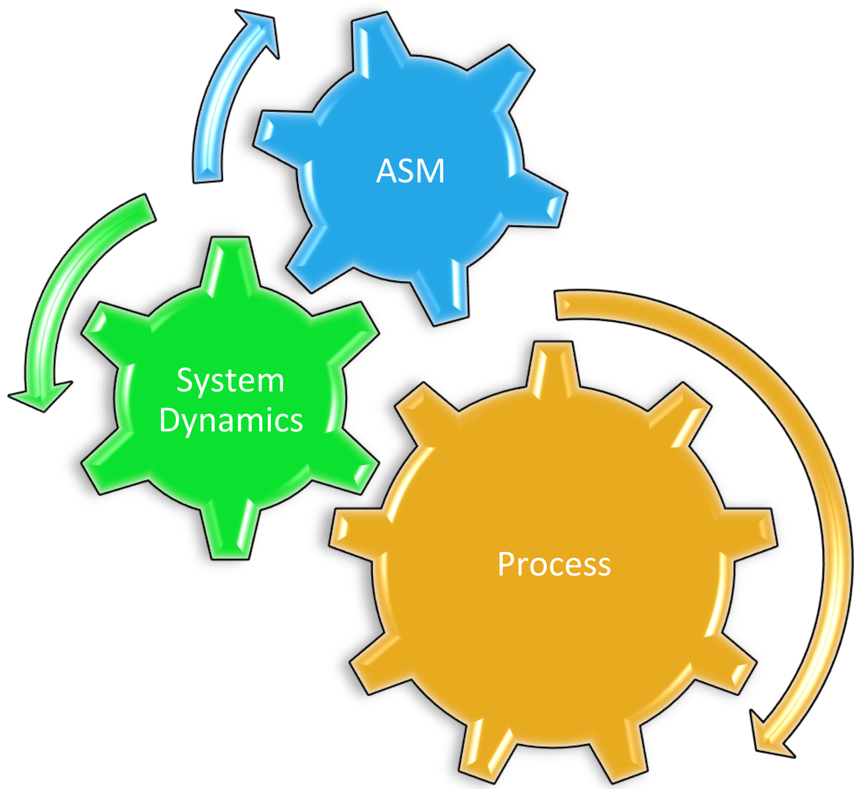
1. Identify key flaring sources due to upsets
2. Identify causes & consequences of process upsets
3. Apply recent process design/control and optimization methods

Multi-objective Optimization

Cost | Production | Mass utilization | Energy efficiency | Safety | Environmental Impact

Methodology *must*

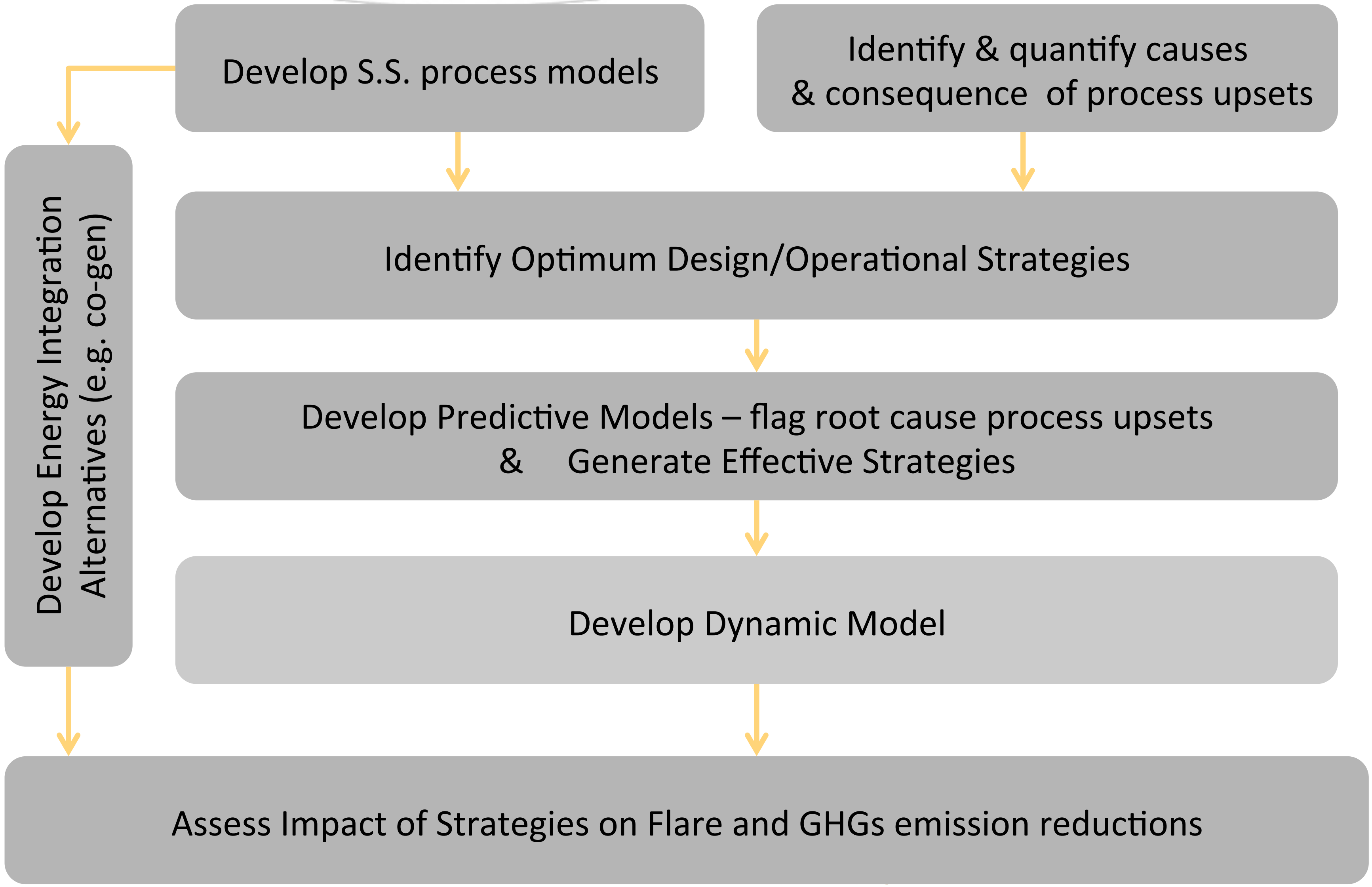
- Comprehensive
- Systematic
- Generally applicable



Provide decision makers tools (e.g. Pareto curves)

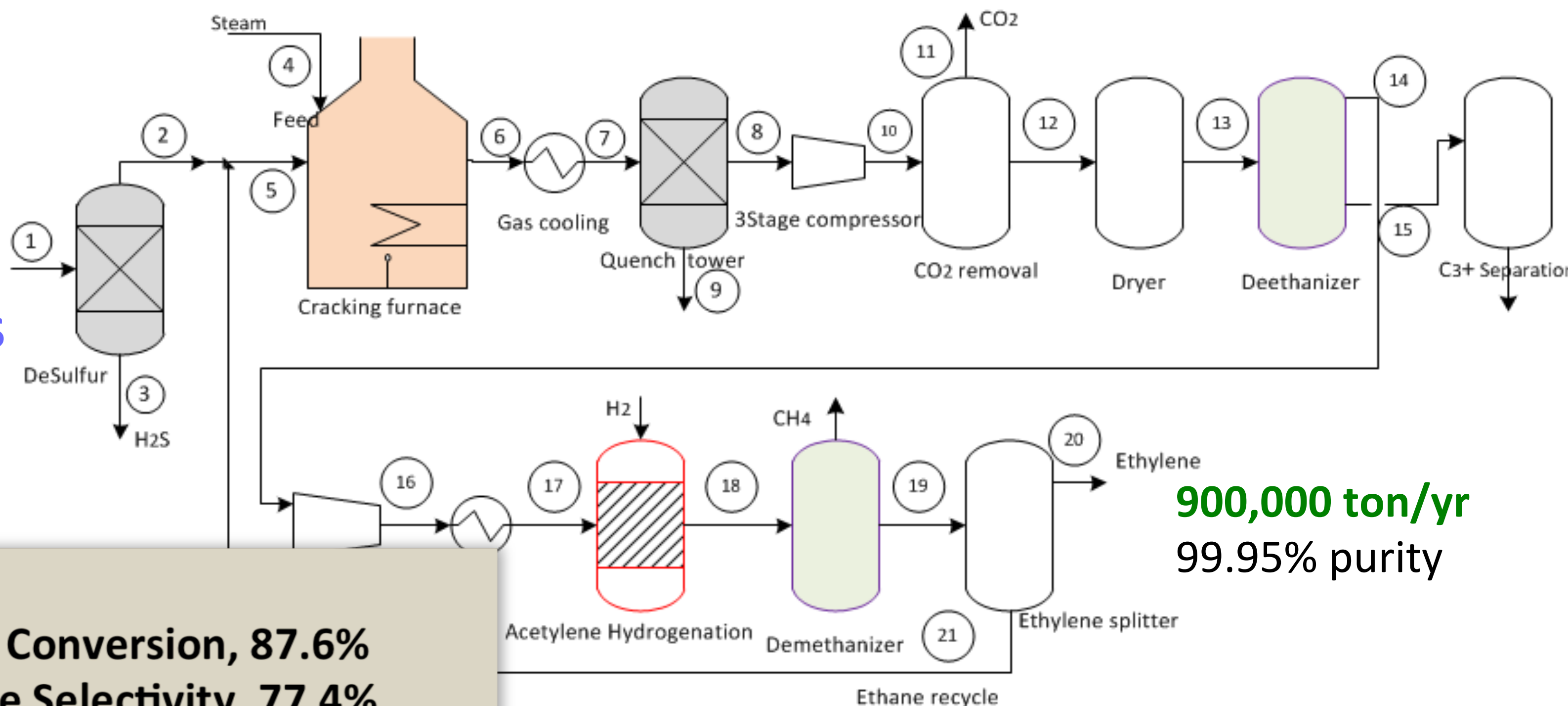
- Determine optimal flaring strategies/policies

Proposed Approach



Base Case Typical Ethylene Process

Sour gas
1.39MMT/yr
3% mass H2S

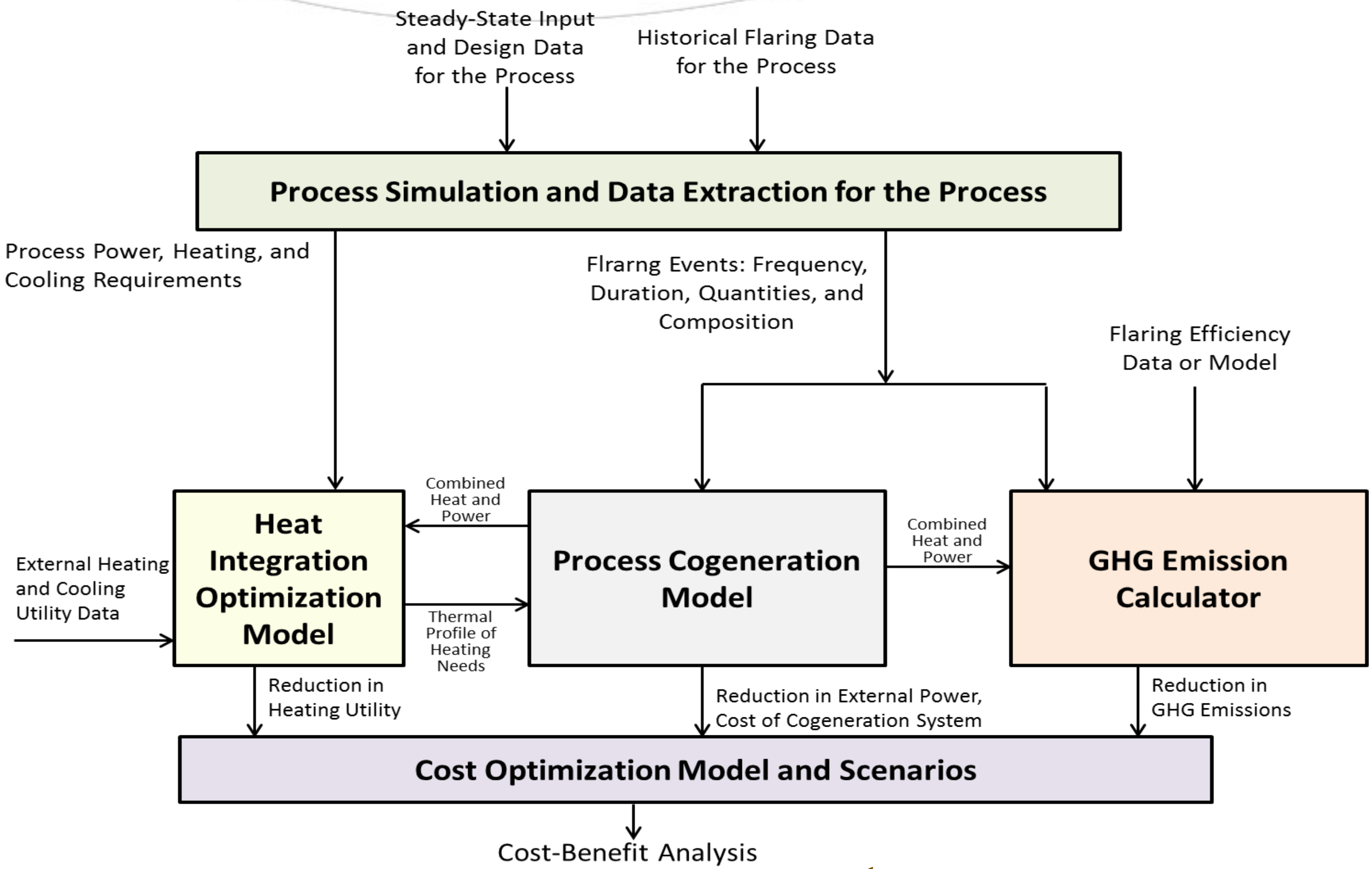


900,000 ton/yr
99.95% purity

Ethane Conversion, 87.6%
Ethylene Selectivity, 77.4%
Yield, 67.1%

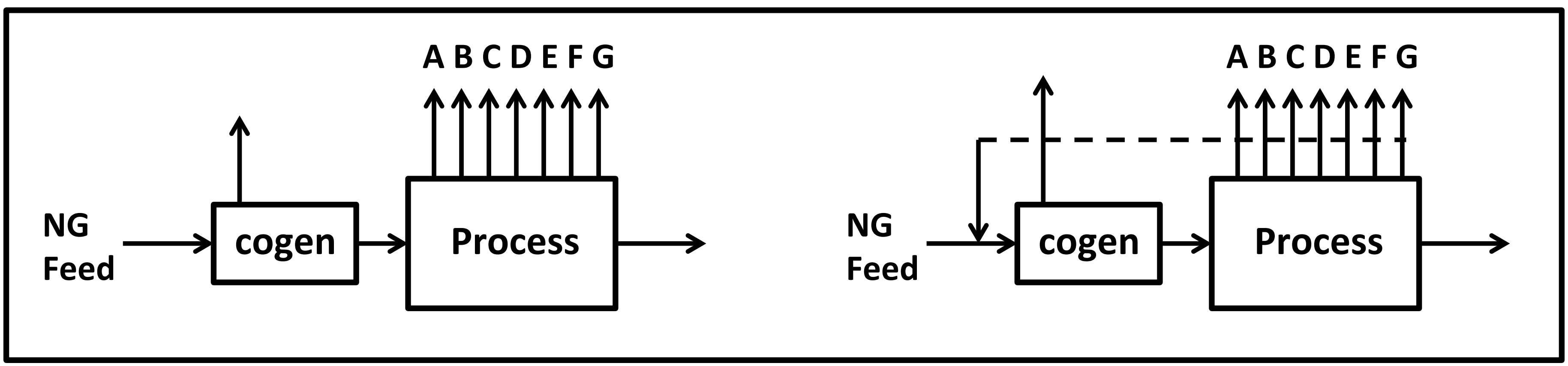
1200K, 23 psia

Flare Utilization ASM - Cogeneration

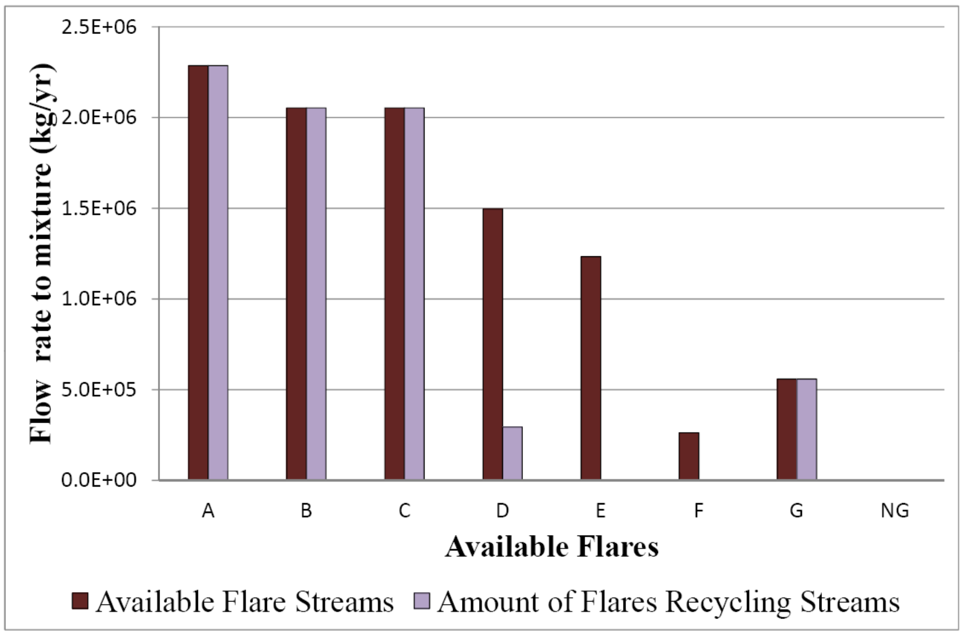


Co-gen Design – Assumptions

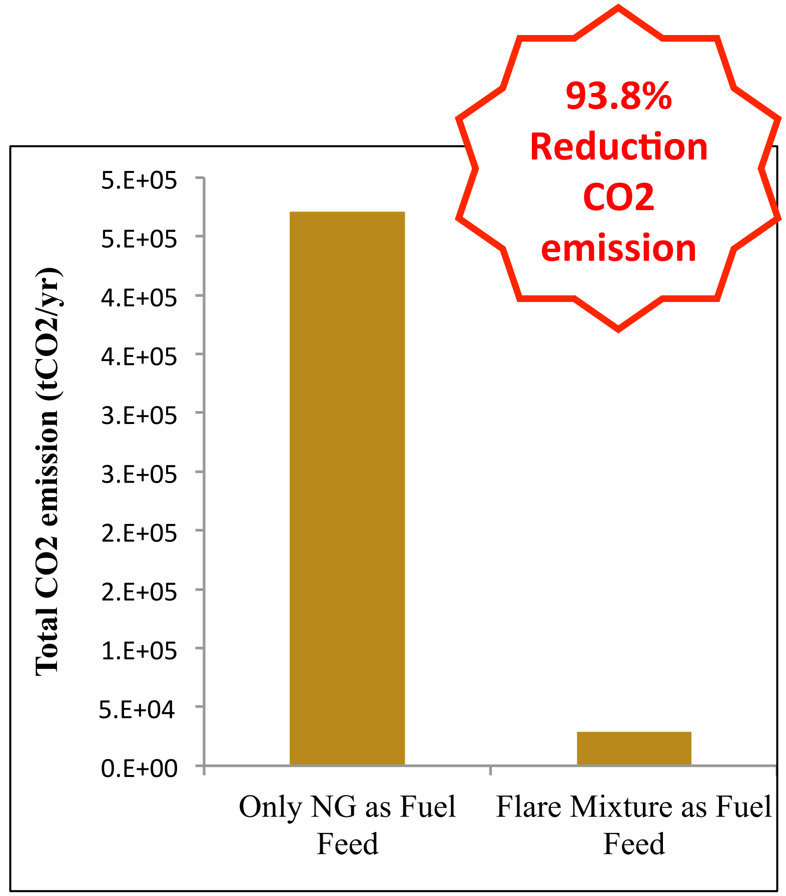
- Energy demand is fixed, 40 MMBtu/hr
- Boiler type is fixed
- All flares are available for feed
- Given rate of flare streams is an assumed 12 hour/yr per flare
- CO_2 emissions estimated using international standards



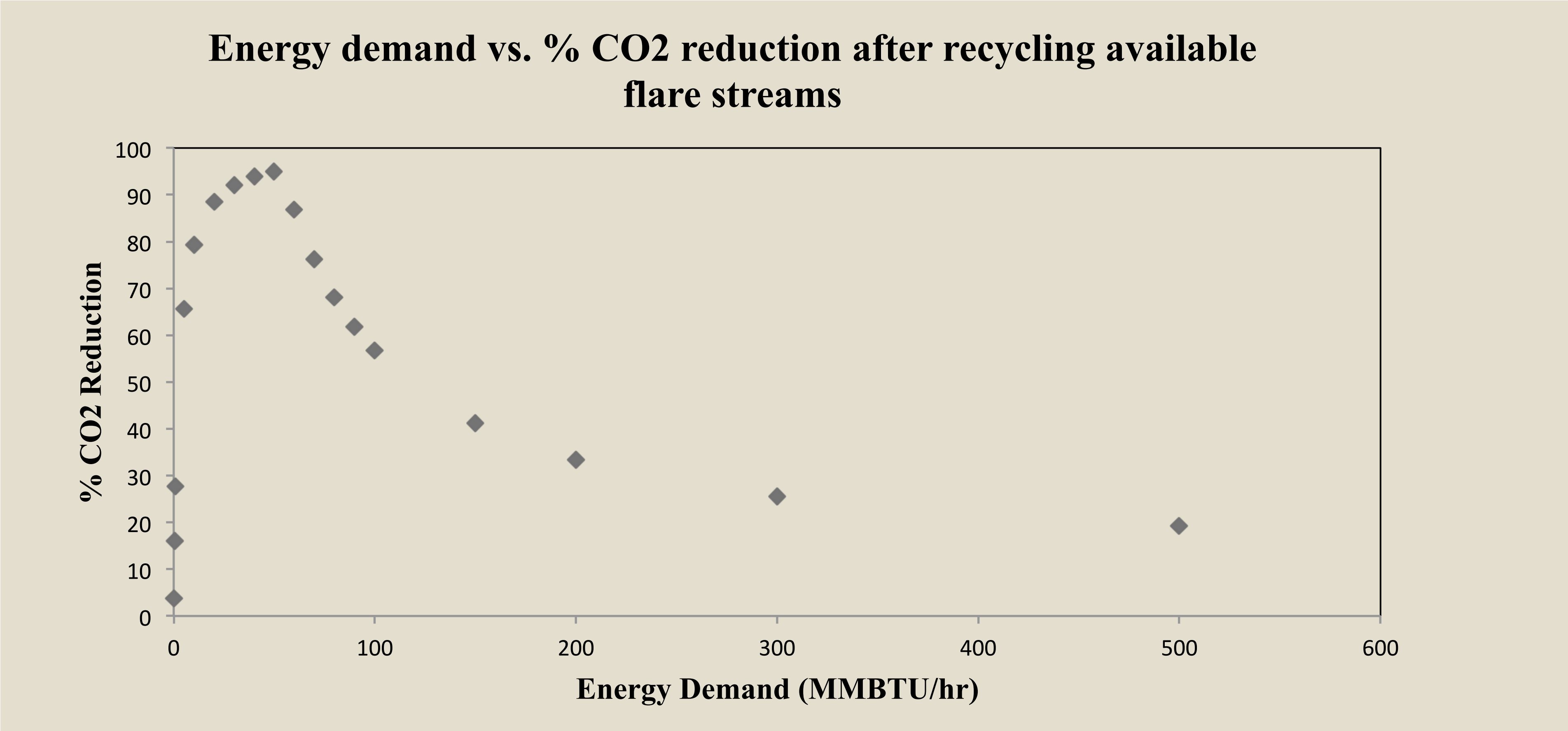
Results



2.5E+06
2.0E+06
1.5E+06
1.0E+06
5.0E+05
0.0E+00
Flow rate to mixture (kg/yr)
A
B
C
D
E
F
G
NG
Available Flares
Available Flare Streams
Amount of Flares Recycling Streams



93.8% Reduction CO2 emission
5.E+05
5.E+05
4.E+05
4.E+05
3.E+05
3.E+05
2.E+05
2.E+05
1.E+05
5.E+04
0.E+00
Total CO2 emission (tCO2/yr)
Only NG as Fuel Feed
Flare Mixture as Fuel Feed



- Varied energy demand 0.0001 – 10,000 MMBTU/hr
- CO_2 reductions are realized at all rates
- Optimality (min CO_2 emission) is identified
- True feasibility will be realized upon inclusion of cost into the optimization formulations

Project Anticipated Outcomes

- A working optimization model for data extraction and processing and a database for offering guidance to process engineers and operators
- A *generic* approach for modeling causes and effects of process upsets
- A *systematic procedures* and *associated models* for the management of abnormal situation.
- A GHG tracking tool which is linked to different modes of process operation (normal and abnormal)
- An *automated tool* for proposing design and operational changes for process cogeneration (combined heat and power)

Acknowledgments

Collaborators

Industry Advisory Board

Collaborators

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Ha Dinh

Shujing Zhang

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