GGFR

Methane Expo

Best practices for evaluating and reducing emissions from oil and gas production

An evaluation of Flare Gas Reduction Opportunities

Bent Svensson

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Today's presentation

1. GGFR Initiative
2. Recent trends in Global gas flaring
3. Examples of selected programs
   - ❑ Focusing on Flare Gas Reduction Opportunities
   1. Top 100 gas flares
   2. Russia: Clustering
   3. Options for Small-Scale Associated Gas Utilization and Flaring Reduction
   4. Small-scale GTL technologies
4. Q&A

GGFR Initiative

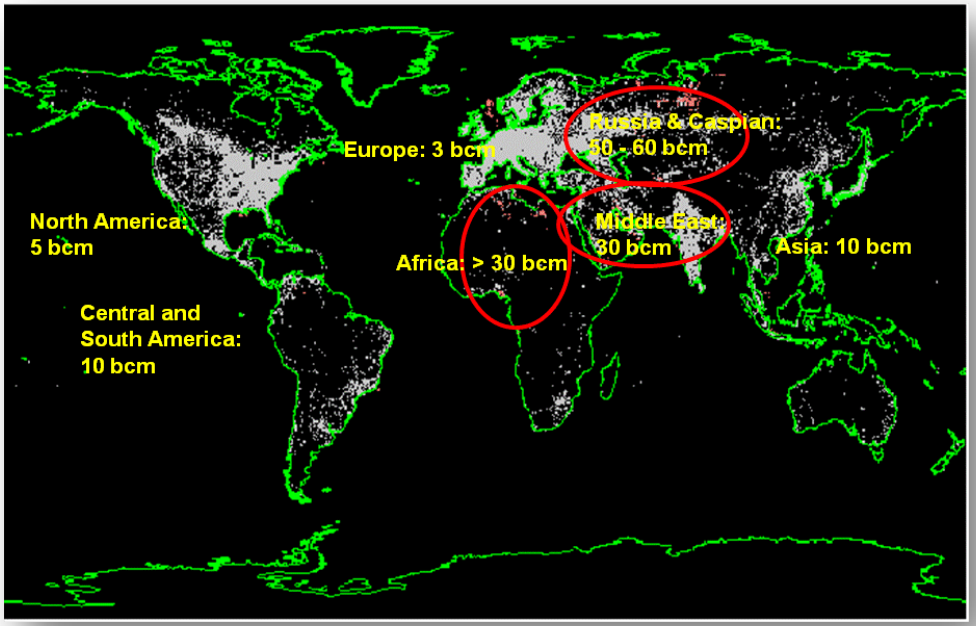
- Created in 2002 at the World Summit on Sustainable Development in Johannesburg
  - Just celebrated 10 year anniversary
- Objective:
  - Reduce carbon emissions and environmental impact of flaring
  - Monetization of a wasted resource
  - Improve energy efficiency and access to energy
- Means:
  - Public – Private Partnership to facilitate gas flaring reduction
- Phase 4:
  - 2013 – 2015 Scale Up

Mission Statement

GGFR is a catalyst for reducing wasteful and undesirable practices of gas flaring and venting through policy change, stakeholder facilitation and project implementation

Gas Flaring –Magnitude of the Issue

- An estimated 140 billion cm of gas is being flared globally each year
  - Approx. 20% of US gas consumption
  - $30 – 35 Billion per year loss value
- Approx. 360 million tons of carbon dioxide into the atmosphere each year
  - Annual emission from 77 million cars
  - Output from 125 medium sized coal power generation plants
- Potential risk of increased gas flaring
  - Oil production increases (Iraq)
  - New producing countries
  - Oil Shale and gas shale production



GGFR Partners

Countries/(NOCs)
Algeria (Sonatrach)
Angola (Sonangol)
Azerbaijan (SOCAR)
Cameroon (SNH)
France
Gabon
Indonesia
Iraq
Kazakhstan
Khanty Mansiysk (Russia)
Kuwait KOC
Norway
Mexico /Pemex
Nigeria
Qatar (QP)
Rep. of Congo
Uzbekistan
Yamal Nenets (Russia)
USA

Oil companies
BP
Chevron
ConocoPhillips
Eni
ExxonMobil
Shell
Statoil
TOTAL

Associated Partner
Wartsila

Organizations
The World Bank
EBRD
EC

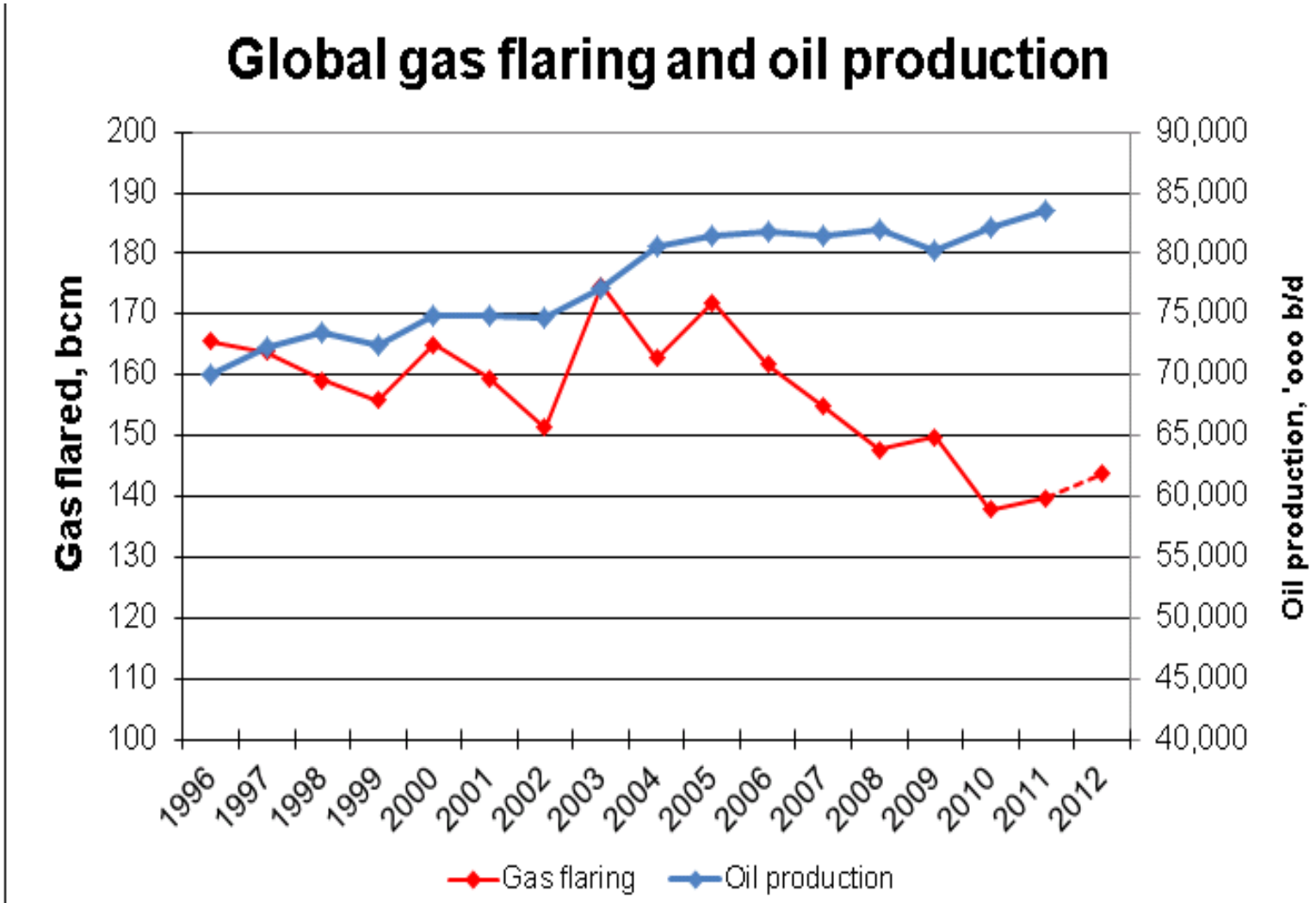
Preliminary satellite flaring estimates

Estimated flared volumes from satellite data

Volumes in bcm	2008	2009	2010	2011	2012	Change from 2011 to 2012
Russia	42.0	46.6	35.6	37.4	34.8	(2.6)
Nigeria	15.5	14.9	15.0	14.6	14.7	0.0
USA *	2.4	3.3	4.6	7.1	11.6	4.5
Iran	10.8	10.9	11.3	11.4	10.7	(0.7)
Iraq	7.1	8.1	9.0	9.4	10.3	1.0
Algeria	6.2	4.9	5.3	5.0	4.9	(0.1)
Kazakhstan	5.4	5.0	3.8	4.7	4.6	(0.1)
Venezuela	2.7	2.8	2.8	3.5	4.3	0.8
Saudi Arabia	3.9	3.6	3.6	3.7	3.9	0.2
Angola	3.5	3.4	4.1	4.1	3.8	(0.3)
Libya	4.0	3.5	3.8	2.2	3.2	1.0
Canada	1.9	1.8	2.5	2.4	3.0	0.6
Indonesia	2.5	2.9	2.2	2.2	2.5	0.3
Oman	2.0	1.9	1.6	1.6	2.1	0.5
China	2.5	2.4	2.5	2.6	2.1	(0.5)
Mexico	3.6	3.0	2.8	2.1	2.0	(0.1)
Qatar	2.3	2.2	1.8	1.7	1.8	0.1
Egypt	1.6	1.8	1.6	1.6	2.0	0.4
Malaysia	1.9	1.9	1.5	1.6	1.5	(0.1)
Ecudaor	1.2	1.3	1.4	1.3	1.5	0.2
Total top 20	123	126	117	120	125	5.1
Rest of the world	23	21	21	20	18	(1.2)
Global flaring level	**146**	**147**	**138**	**140**	**144**	**3.9**

Source: NOAA Satellite data

Global estimates based on satellite imaging



Source : NOAA, BP Statistics

GGFR - Key Achievements - Global

- **20% decrease in global gas flaring the past seven years**

- **Increased Global awareness and understanding of the gas flaring and venting issues**
  - 4 Regional conferences
  - 4 Global Forums, latest in London 2012

- **New Regulations on Gas Flaring in many countries**
  - "No flaring" laws in Russia, Angola, Kazakhstan, Gabon, Cameroon
  - New laws being progressed in Indonesia, Nigeria, Gabon, Qatar, Iraq

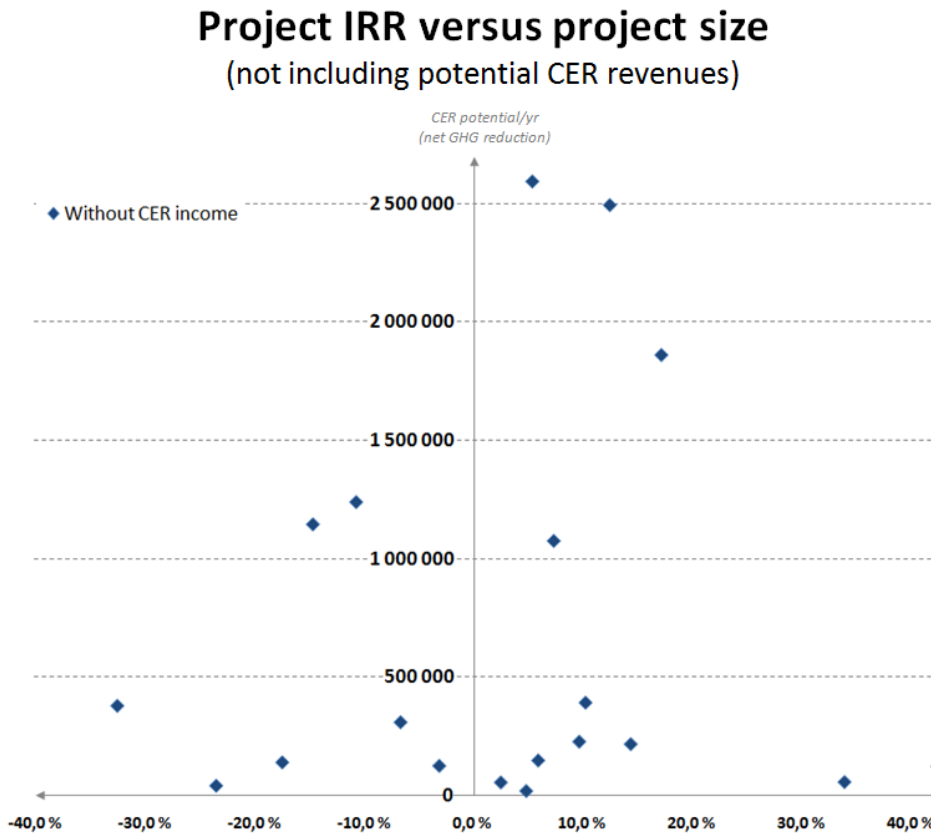
➢ **Global Standard for gas flaring reduction**
  - Endorsed by GGFR Partners
  - No venting
  - No Flaring in New projects
  - Eliminate continuous flaring from existing production
  - Gas Flaring Reduction Plans (AGRP/CIP)

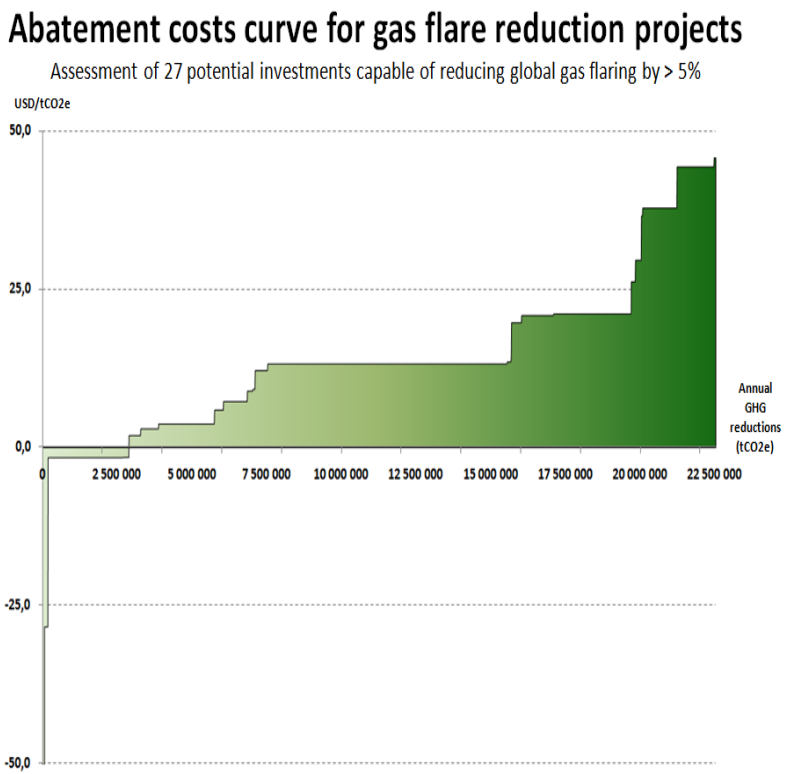
} Subject to economic test

EXAMPLES OF SELECTED PROGRAMS AND OPPORTUNITIES

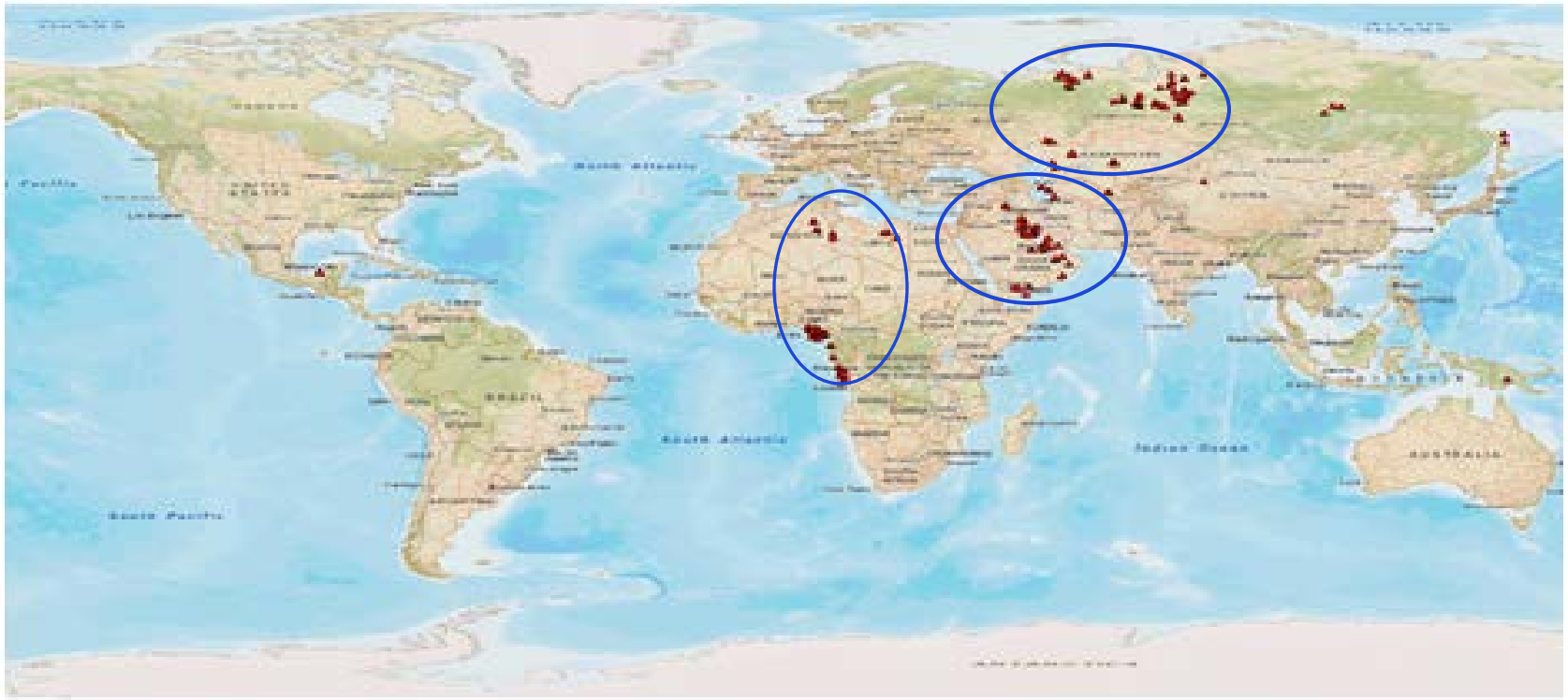
Do gas flare reduction projects represent “low hanging fruits”?

Carbon Limits AS has studied 27 gas flare investment cases

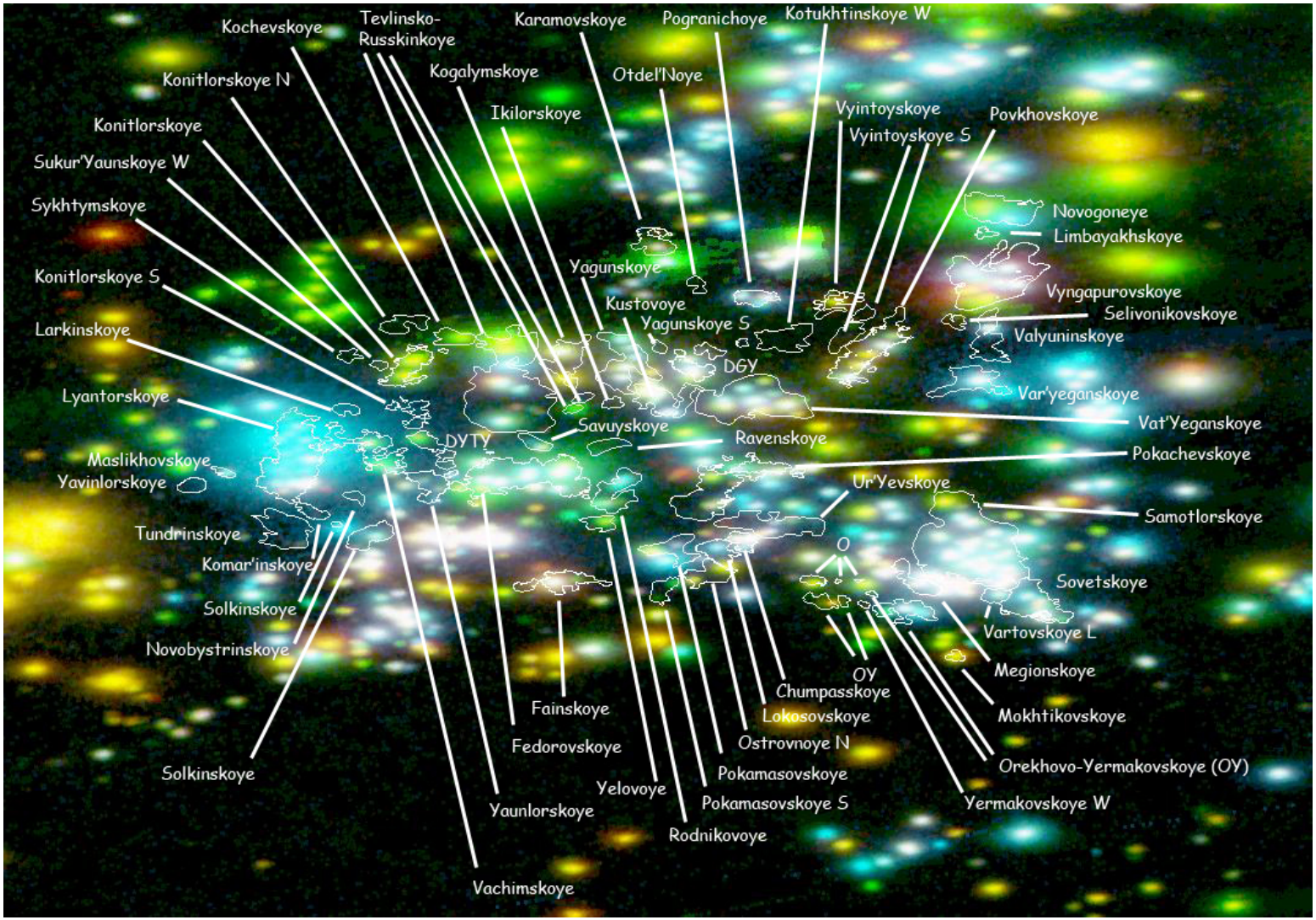




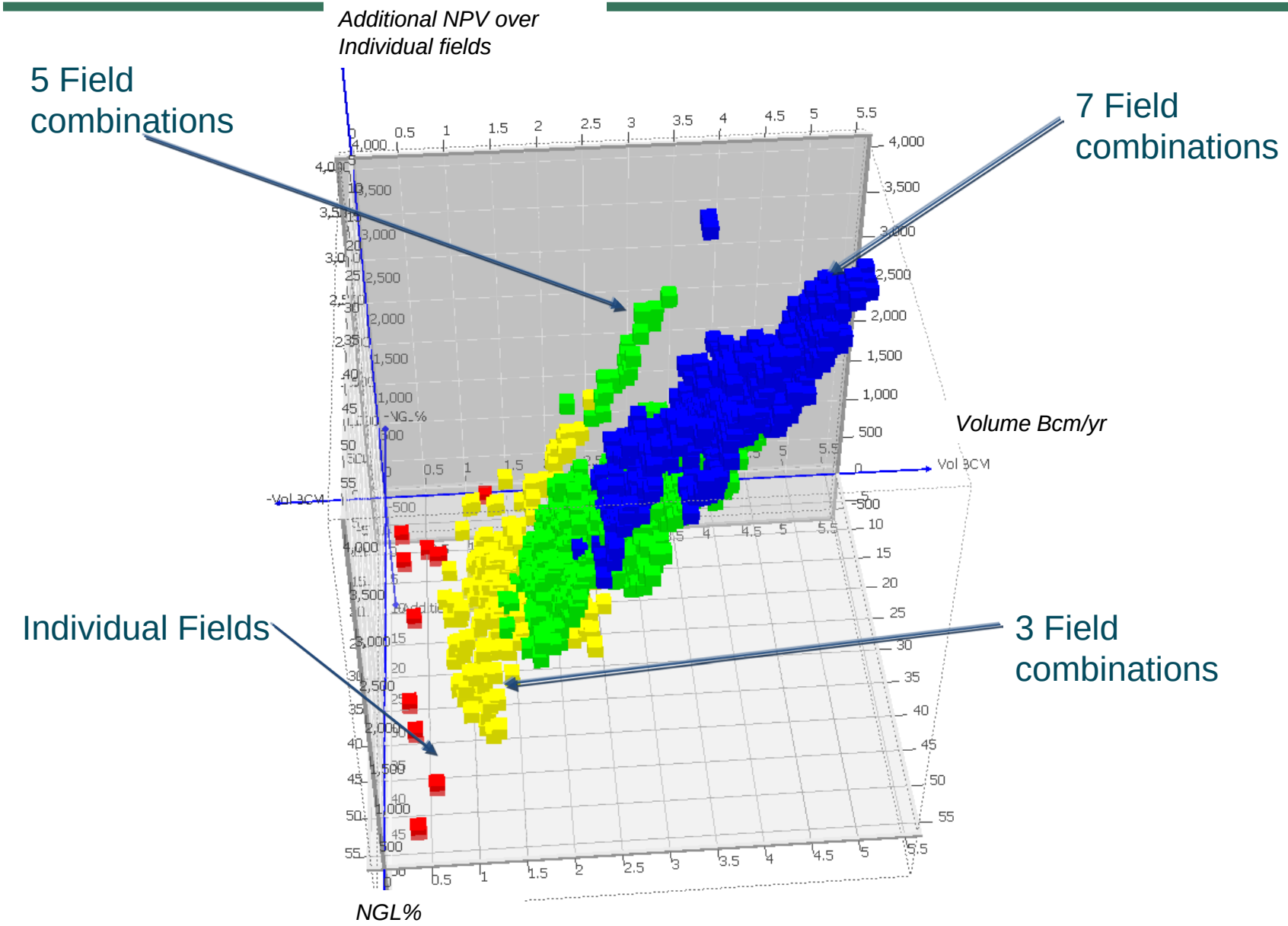
Top 100 flares world-wide



Satellite image of Khanty Mansiysk flares



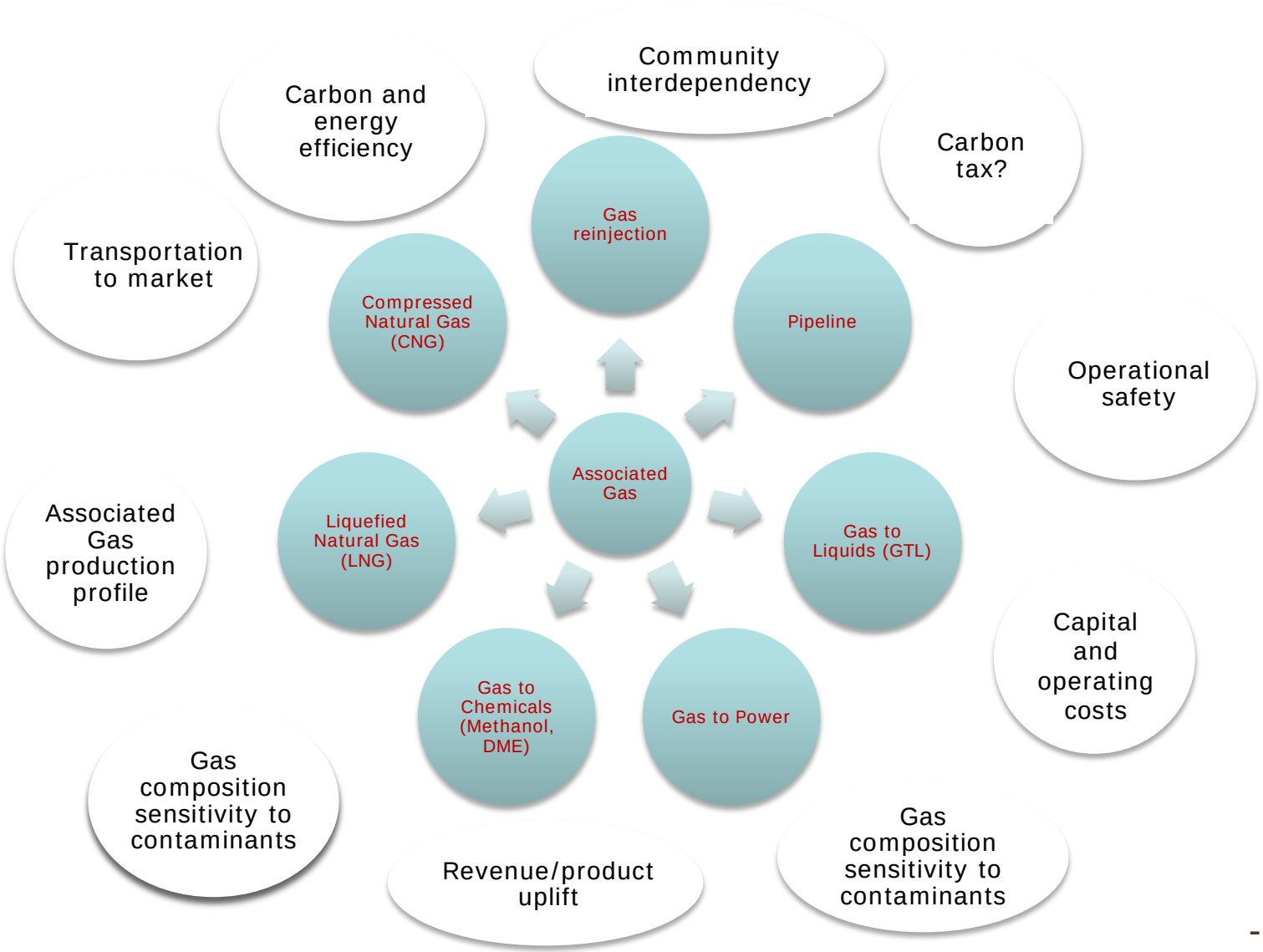
Clustering: Additional value generated



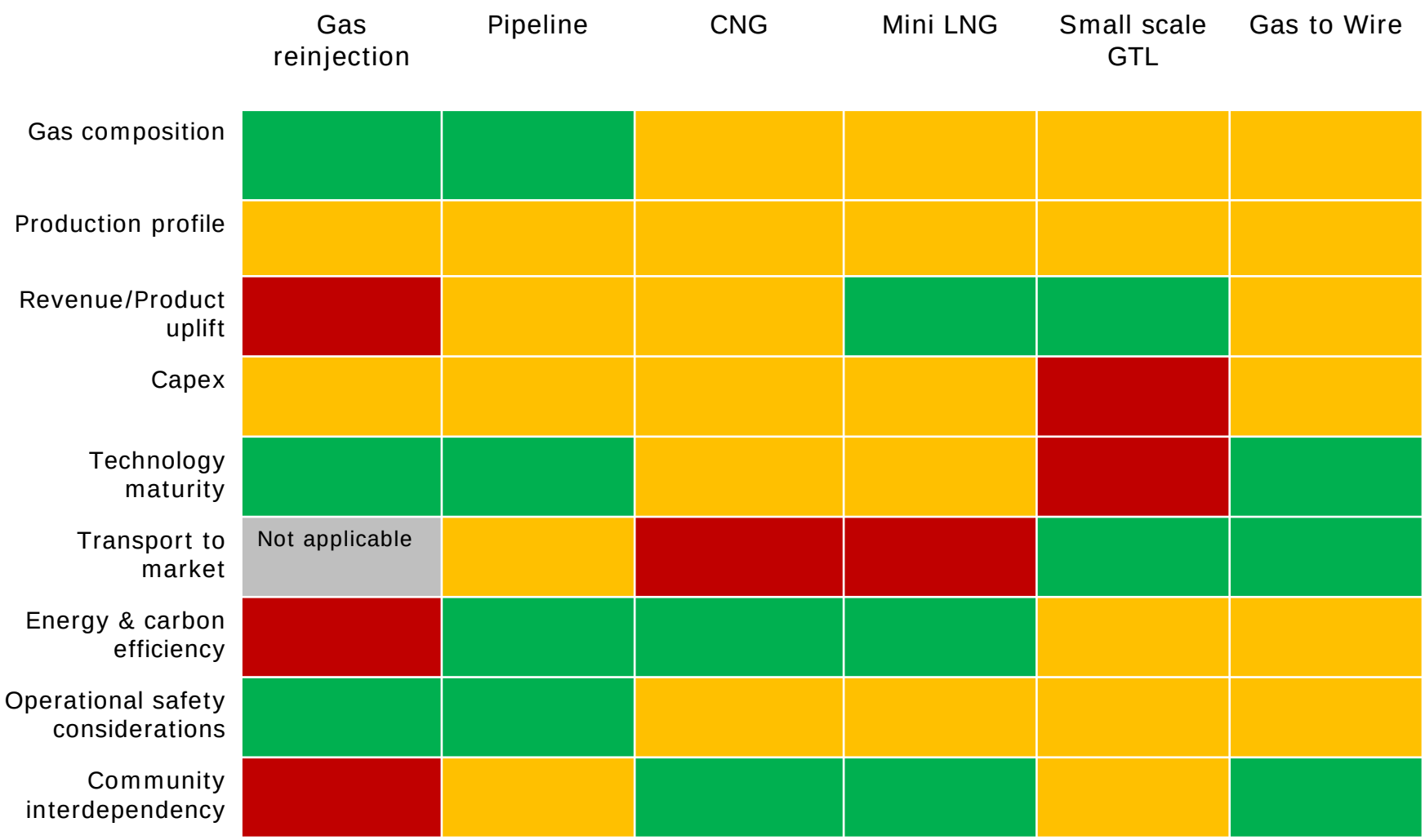
Options for Small-Scale Associated Gas Utilization and Flaring Reduction

- Barriers that may impede (particularly small-scale) associated gas monetization include:
  - Distance to market
  - Lack of local infrastructure
  - Small gas volumes often changing in volume
  - Price distortion due to local fuel subsidies
  - Availability of capital
- Associated gas monetization has traditionally been viewed as requiring economies of scale
- Challenge for small-scale gas is to develop modular, skid-mounted monetization technologies that can be deployed - and re-deployed - close to the gas source in a phased manner
- Adapted from material prepared for GGFR by Shell International Exploration and Production

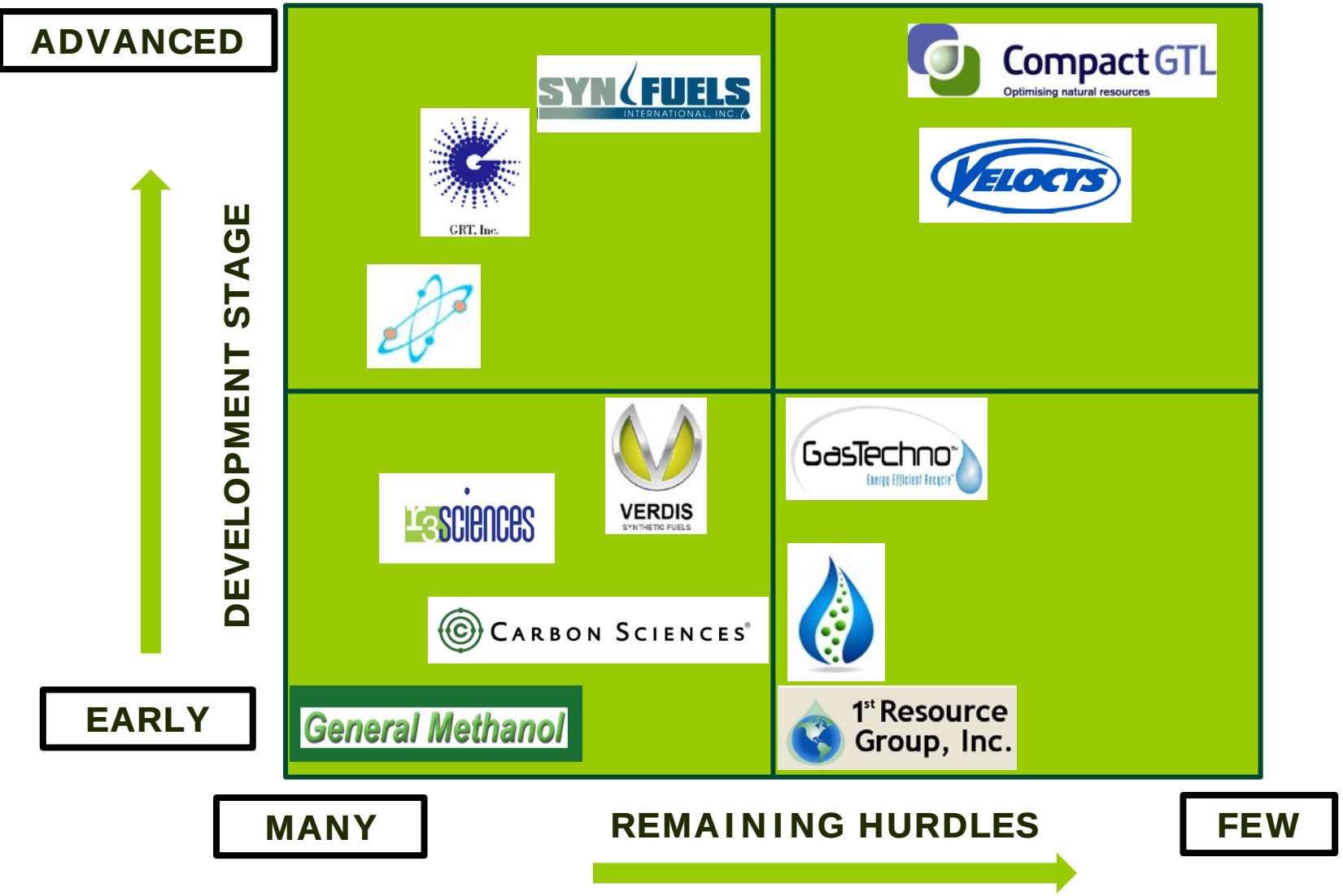
Monetisation Options and Decision Drivers



Qualitative assessment of utilization options



Small-scale GTL technologies



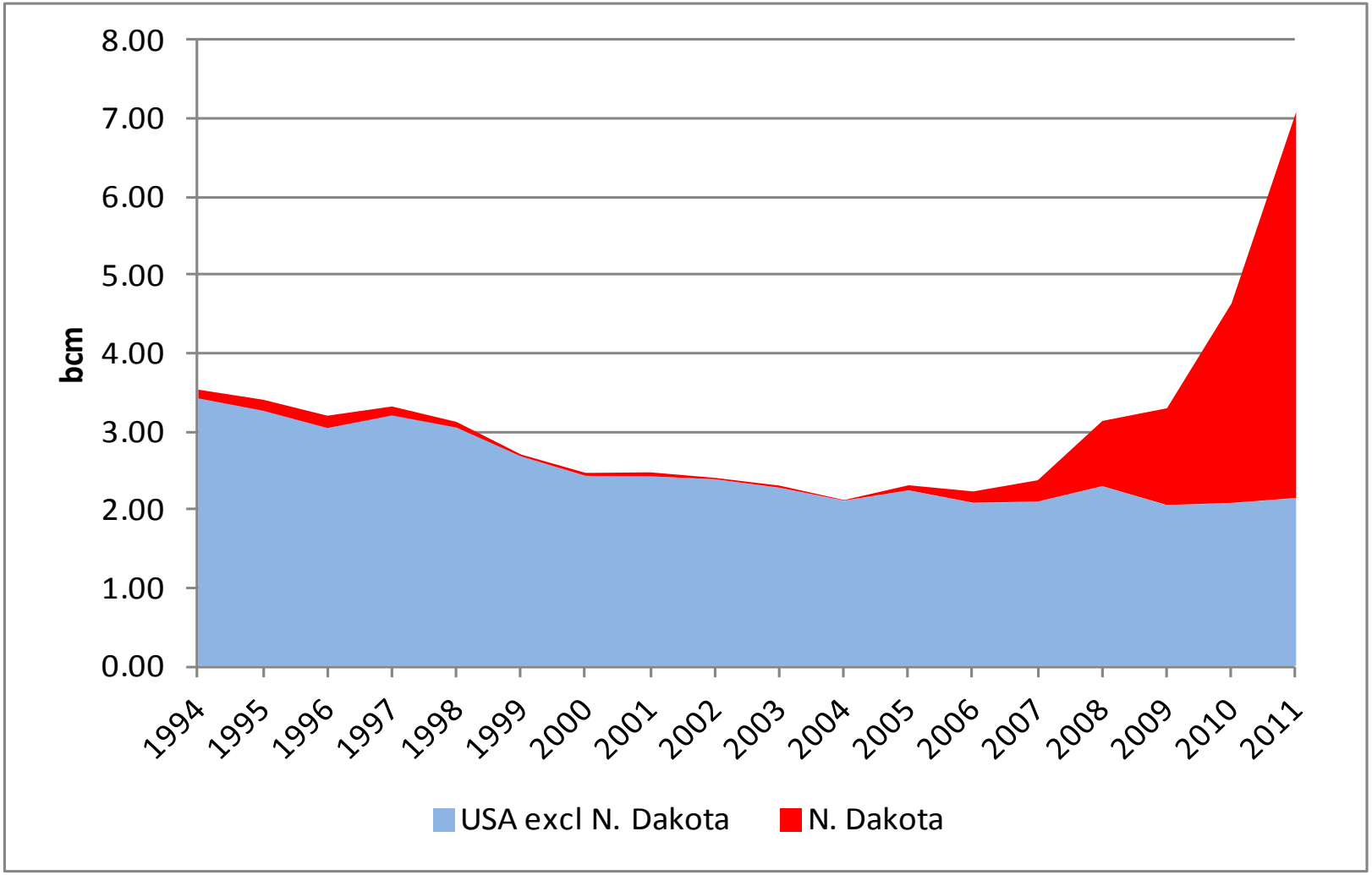
GGFR vision

Thank you for your attention

Bsvensson@worldbank.org

Back Up

USA flaring



Source: NOAA

Key Decision Drivers (1)

Gas composition including sensitivity to contaminants

High CO_2 and H_2S content lead to increased cost through:

- additional processing,
- impact on material selection
- waste disposal (CO_2 and sulphur)

Is gas composition is relatively constant over the field life?

Production profile

Oil production is often characterised by 'peaky' production profiles and production may be subject to frequent start-stop events, particularly in remote operations

Associated gas volumes typically vary over the field life

An area strategy for clustering and central processing may be an economically attractive option that also may smooth short/long term production variations. Smaller scale facilities are however often be easier to fund, can be executed faster, and are less technically complex

Key Decision Drivers (2)

Footprint and technical complexity
Footprint is particularly critical for offshore applications as it has significant cost implications and challenges for offloading products.

Maturity of technology

Revenue / Product uplift
CNG and LNG compete primarily with fuels (e.g. oil, coal) for power generation and domestic heating, while complex products like GTL yield premium prices by competing directly in the transportation section

Capital cost
Clearly the most critical driver

Operating costs
Influenced by both the technical (operational) complexity and the distance to market. Energy efficiency is also an important OPEX driver

Key Decision Drivers (3)

Transportation to market
Preference is for a product with high-energy density i.e. a liquid (e.g. GTL, LNG or chemicals)

Reliability
Single process train concepts, with minimum sparing, may be preferred to reduce capital cost, but can lead to significant flaring when the facility is unavailable

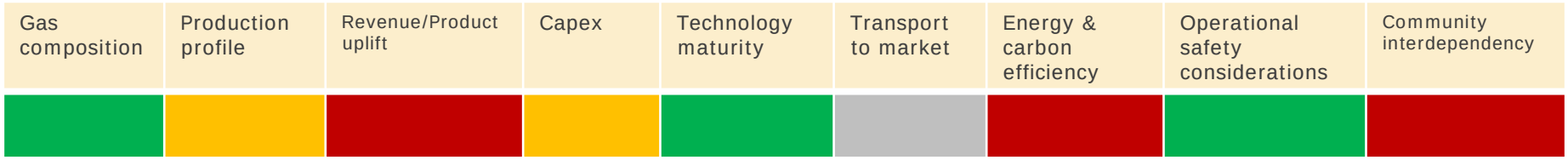
Carbon and energy efficiency
Should be considered on a WTW basis where products may displace higher carbon intensive fuels

Community interdependency
May provide an opportunity for interdependency/synergies with local communities which may have significant positive effects by both de-risking the oil development from non-technical risk and may build a local market, reducing transportation costs

Gas re-injection

- Re-injection is the base case for any associated gas development in the absence of a clear alternative evacuation opportunity
- Typically applied for enhanced oil recovery or for disposal of highly contaminated gas
- Reinjection can be into existing oil reservoir, an undeveloped gas reservoir or a water filled trap
- Reservoir engineering considerations can be the main concept driver and need to be well matured. They may also be a showstopper
- Other considerations include compressor sparing philosophy and matching of compressor duties over full field life

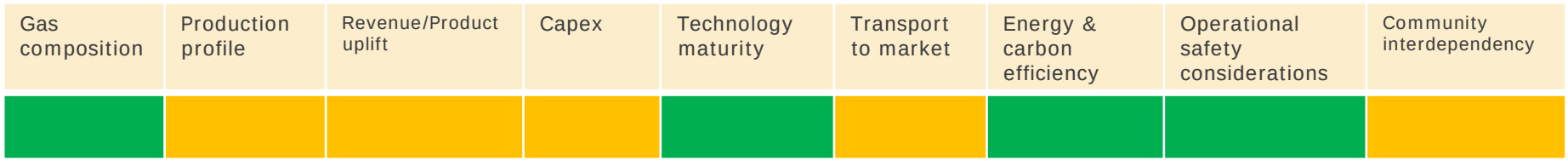
Gas reinjection against key decision drivers



Pipeline

- Pipelines, in combination with compression if required, are the simplest method for evacuating associated gas to market
- Ultimate destination is domestic gas grid or power plants. Piped gas could also feed LNG or GTL plant with resultant price upside
- Land ownership/access rights can be a significant non-technical risk
- Other considerations include single or multiphase pipelines, hydrate management strategy and construction materials

Pipeline key decision drivers



Compressed natural gas (CNG)

- CNG involves compressing natural gas up to ~250 bar to reduce the volume before transportation to market by trucks, trains or ships
- Level of gas processing required is quite low—gas must be sufficiently dew-pointed to avoid liquid dropout during compression
- CNG is stored in a cascade of cylinders referred to as a Gas Transport Module for transportation
- CNG is used as fuel for the transportation market widely in Pakistan, Iran, Brazil, India and Argentina
- Safety issues with road transportation of CNG
- A recent potential alternative is adsorbed gas

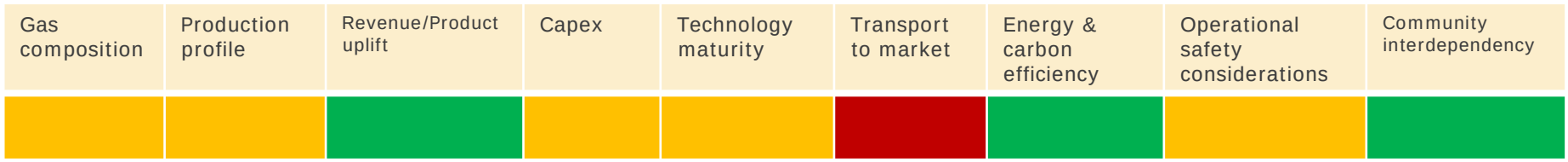
CNG key decision drivers

Gas composition	Production profile	Revenue/Product uplift	Capex	Technology maturity	Transport to market	Energy & carbon efficiency	Operational safety considerations	Community interdependency

Liquefied natural gas (LNG)

- Micro LNG (up to 0.05 mtpa) and Mini LNG (0.1 to 0.5 mtpa) are suitable options for monetization of associated gas
- Shell, together with Kryopak, has developed a proprietary Moveable Modular Liquefaction System (MMLS) targeting Mini LNG applications
- Micro and Mini LNG utilize nitrogen or Single Mixed Refrigerant refrigeration technologies
- LNG can serve as replacement for diesel or LPG in power stations or as transportation fuel in dedicated LNG-fuelled vehicles
- Road safety issues with LNG product evacuation to market

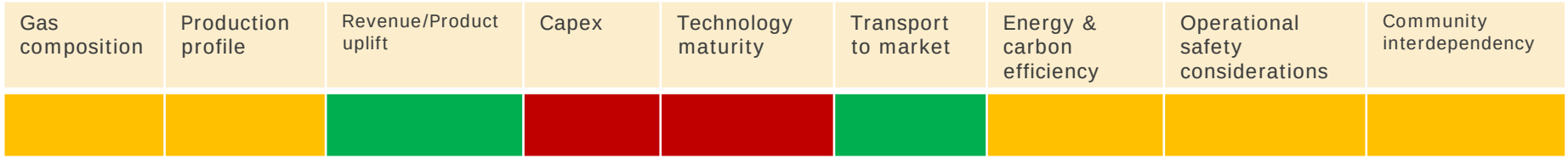
LNG key decision drivers



Gas to Liquids (GTL)

- Small-scale GTL plants are only now becoming field proven technologies
- The target product for small-scale GTL is often synthetic crude which can be spiked into the main crude stream, avoiding additional evacuation costs
- With additional processing, can generate higher-value products such as synthetic diesel, DME and other fuels
- Application of small-scale GTL may initially be as an enabler of the oil production where there is a 'no-flaring' policy, and no alternative utilization options

GTL key decision drivers



Gas to wire / power

- Small-scale Gas to Wire uses stranded natural gas to generate electricity for own use or sale to local grids
- Gas pre-treatment requirement is typically minimal, but should be examined considering both gas quality and flexibility of gas turbine or engine
- For extended well testing, power generation equipment can often be rented or leased
- Offers significant scope for local stakeholder engagement and capacity building, with significant Sustainable Development/Social Performance benefits (e.g. Bonny Utility Company in Nigeria)

Gas to Wire key decision drivers