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# The role of technology in unlocking the possibilities of shale gas

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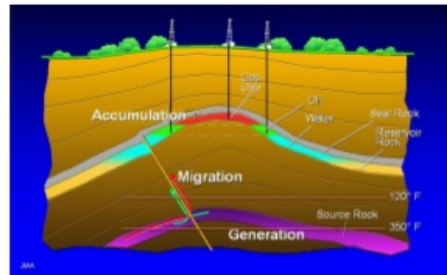
# Agenda



- **Fundamentals of an Unconventional Shale Gas Play**
- **What Strategies are required for success?**
  - Exploration and Development
  - Typical Production Profile
  - Need to stay in the game – long term – conveyor belt Operations
- **Lessons from North American Experience**
- **Technologies for Unconventional Shale Gas Development**
- **Insights and Challenges for the Karoo**
- **Downstream Technology Plays that could Unlock Commercial Development**
- **Concluding Remarks**

## What is a petroleum system?

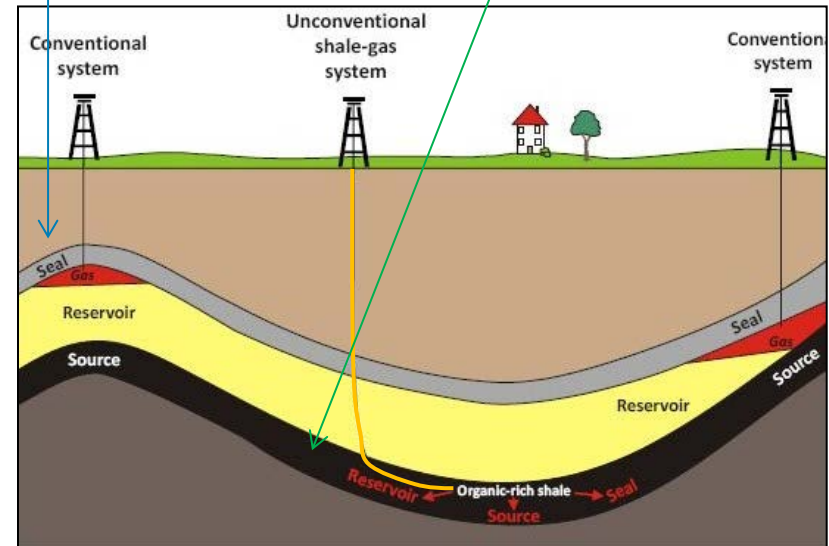
- Definition
  - A petroleum system encompasses a pod of active source rock and all genetically related oil and gas accumulations.
- Elements
  - Source rock
  - Reservoir rock
  - Seal rock
  - Overburden rock
- Conventional system
  - Elements are separate
- Unconventional system
  - Number of Elements can be the same
  - E.g. shale source and reservoir



<http://petroleumsupport.com>

Conventional System:  
Requires trap, or closure

Unconventional System:  
Does not require trap, or closure



<http://www.taylorgeoservices.com/marcellus.htm>

### Typical Required Rock Properties for a Shale Prospect

- Organic Content: (%TOC) > 2%
  - Maturity – convert organics → HC (%Ro) > 1.1
  - Porosity – storage - > 2-4%%
  - Volume – Thickness - > 30-50m
- (Modified from Zou, C., 2013, Unconventional Petroleum Geology, Elsevier, ISBN 978-0-12-397162-3)

An Unconventional Shale Petroleum “System” is essentially a Source Rock that has favourable mechanical properties to be directly produced.

It blends the “Required components” of a Petroleum System of Trap, Source, and Reservoir into one. Water will have been expelled from the Shale during burial and maturation and so it can be targeted without regard to structural closure.

In some cases, a topseal (tight rock) is required

# Hydraulic Fracturing – Why?

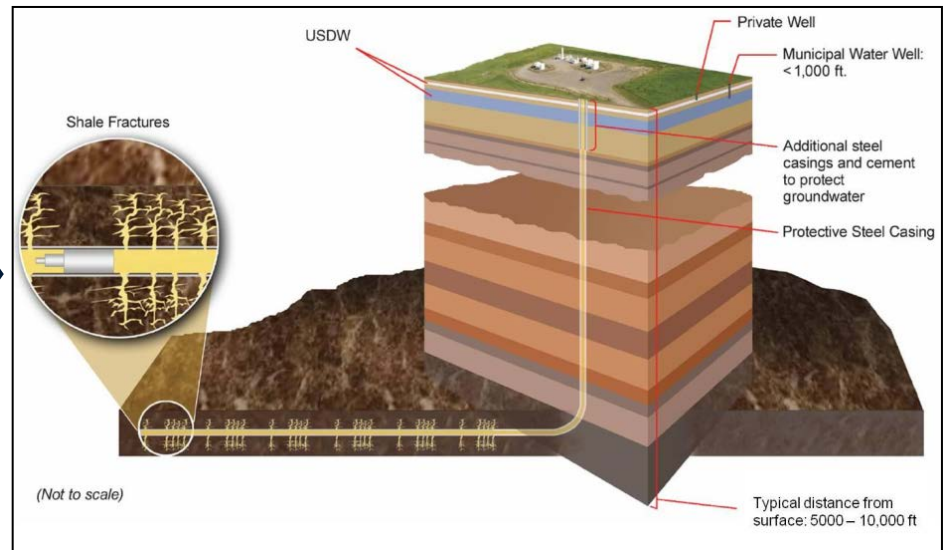
Gas will not move far through pore system.

*In Order To Deliver Gas –*

*Require Intra-Shale Natural Fracture System*

*+*

*Conductivity to Well Bore (Hydraulic Fracturing)*

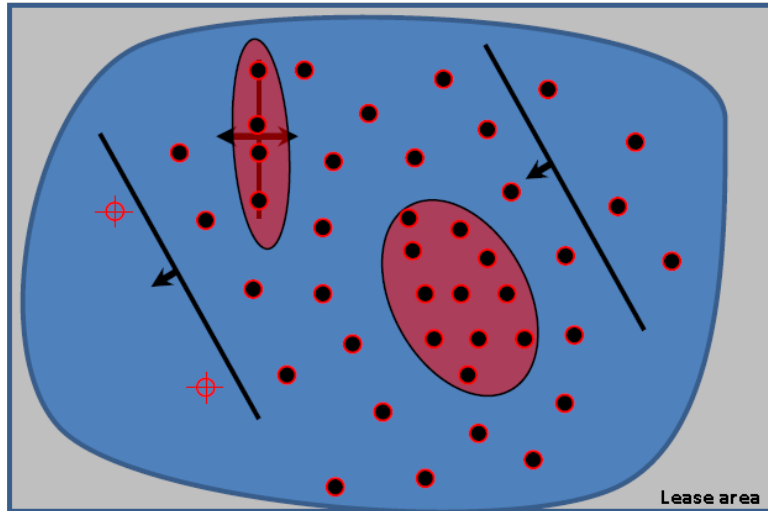


<http://www.netl.doe.gov/research/on-site-research/research-portfolio/oil-gas-research/ucr>

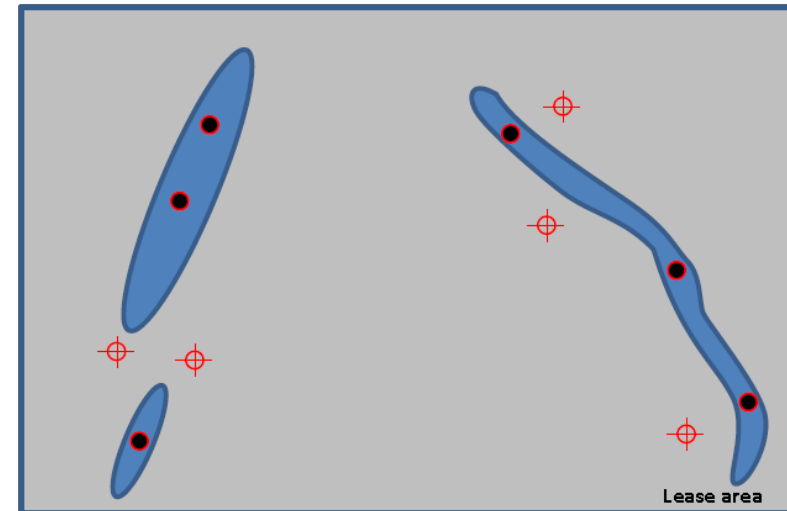
NB: The prospective shales of the Karoo are @ 3000m below the surface.





# Fundamentals: Comparison of Conventional to Unconventional Systems

### Unconventional Reservoir



### Conventional Reservoir



-  Prospective reservoir area
-  Producing well
-  Non-producing well (dry hole)
-  Higher production area (sweet spot)

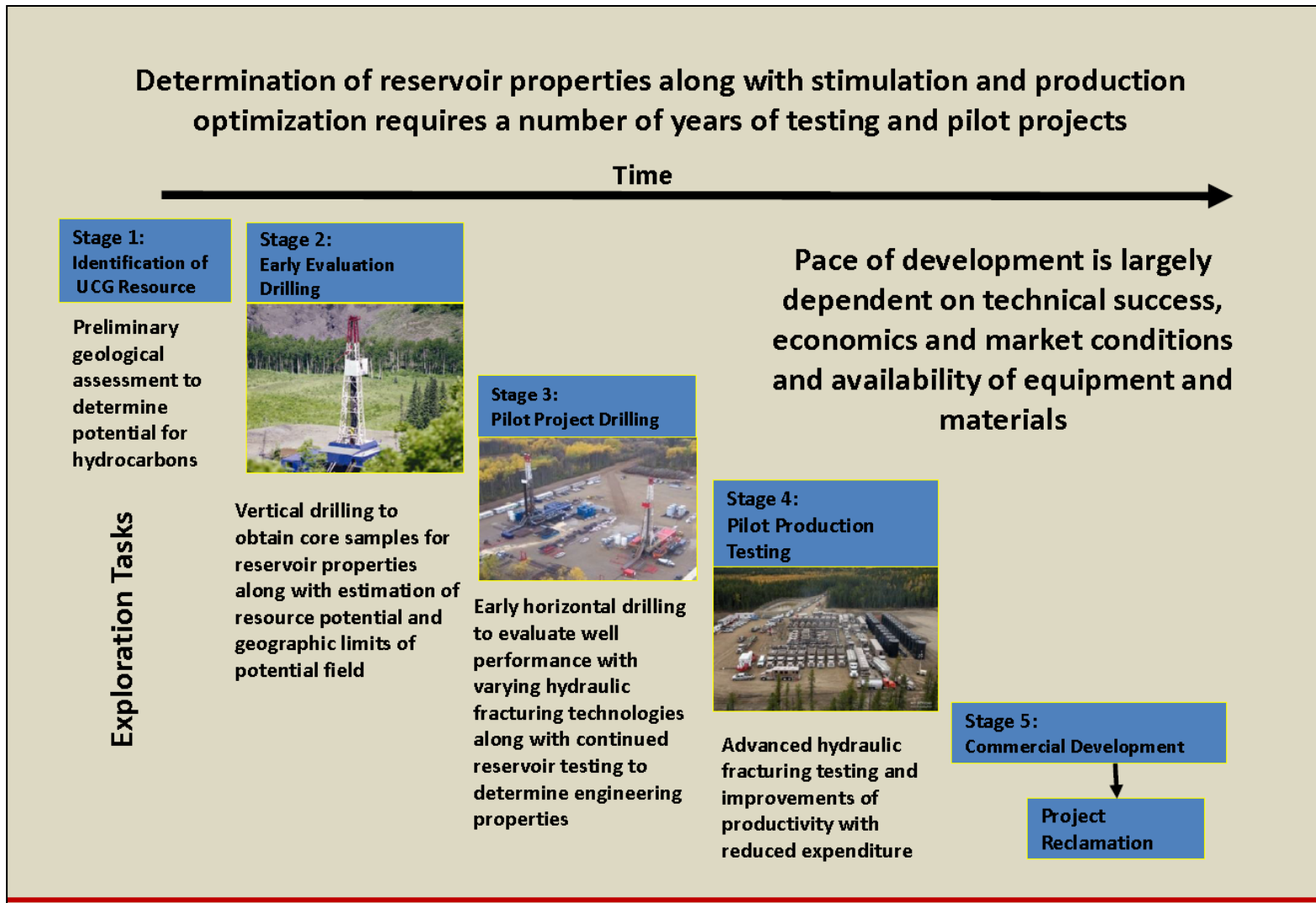
### Fundamental Differences

- Conventional reservoir areas constrained by geological boundaries
- Within the unconventional reservoir area are sweet spots of higher productivity
- Most wells in unconventional reservoir are productive but some may not meet economic thresholds
- Unconventional reservoirs require significant number of wells to achieve statistical thresholds of economic production

Source: Dawson Energy Advisors Ltd, 2013

# Strategies:

## Typical Strategic Plan for Establishing a viable Shale Project



# Strategies:

## Expect Heterogeneity – Plan for the “Long Game”

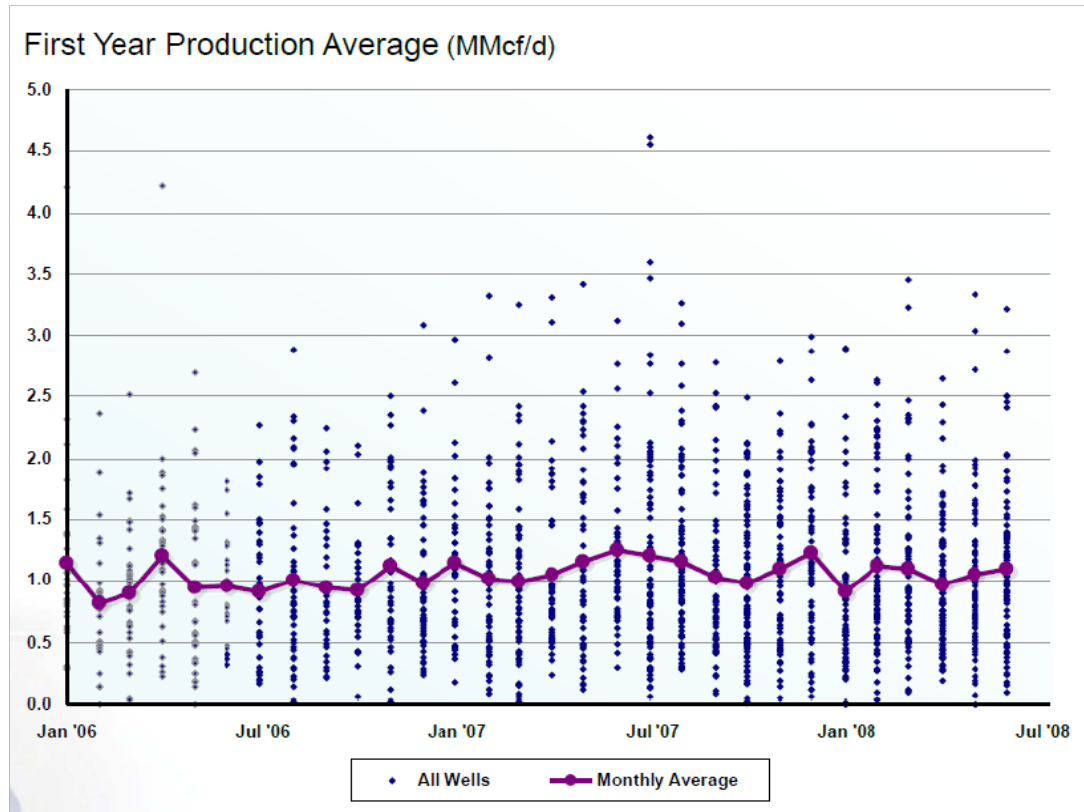


### Resource play development is a statistical play

Recognition that within the oil or gas field there are going to be both high volume and low volume producers

Rely on statistical average to achieve project economic return on investment

Understanding reservoir properties will decrease the risk of completing low volume producing wells

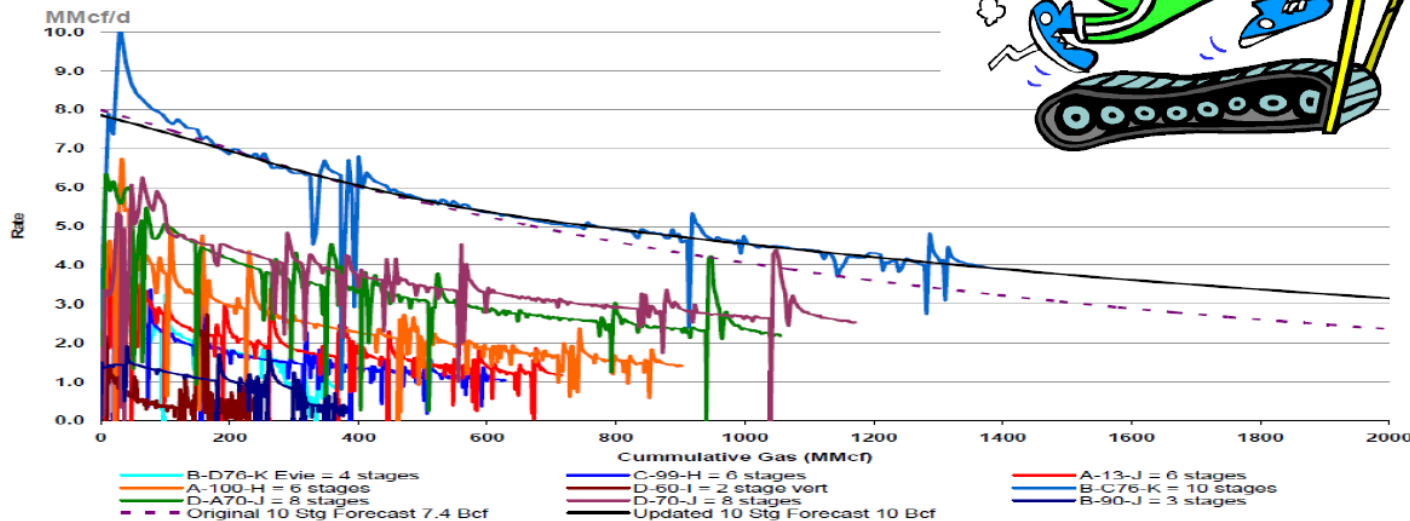


From Southwestern Energy, 2009



### Other Aspects of Unconventional Resource Development

- Production declines are relatively steep (60 to 80% in the first year)
- Companies are compelled to be on a drilling treadmill to offset production declines while at the same time growing production
- As a result large land tracts of mineral tenure are required to allow for the planning of an inventory of drillable locations



Source: Dawson Energy Advisors Ltd, 2013



# Strategies - Operational

To be successful, a “manufacturing” approach is required to achieve:

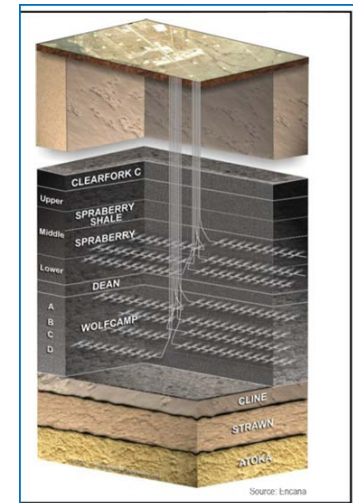
- Optimization of Reservoir Production
- Take advantage of Economies of Scale
- “Farming” or Rolling a land base to support ongoing drilling and development plans to account for steep initial decline of rates that are typical of shale gas

This approach can be enhanced by:

- Developing service sector alliances on a large scale, and
- “Owning” sources of key products, including sand, water, etc
- “Owning” the means to transport and distribute the above (Encana model, Permian Basin, 2016)



Encana Davidson Pad, Midland, Tx



## Summary and Key Points

- **Shale gas exploration and development is capital intensive and requires a well developed exploration strategy to enhance the probability of success**
- **A staged exploration approach allows key reservoir knowledge to be obtained during the exploration programs prior to corporate commercial decisions being made.**
- **Understanding of the reservoir is critical to develop the most effective drilling and completion technologies that will improve the prospects for commercial production**
- **Development of repeatability as well as production optimization is necessary before commercial development begins**
- **Shale gas reservoirs are heterogeneous and there will be variability from region to region. The key is to understand the reservoir properties to be able to identify variables that will impact producibility**

Source: Dawson Energy Advisors Ltd, 2013

- The technologies required can be broken down into two broad categories:
  1. Those required to locate shale gas deposits
  2. Those required to access and produce it

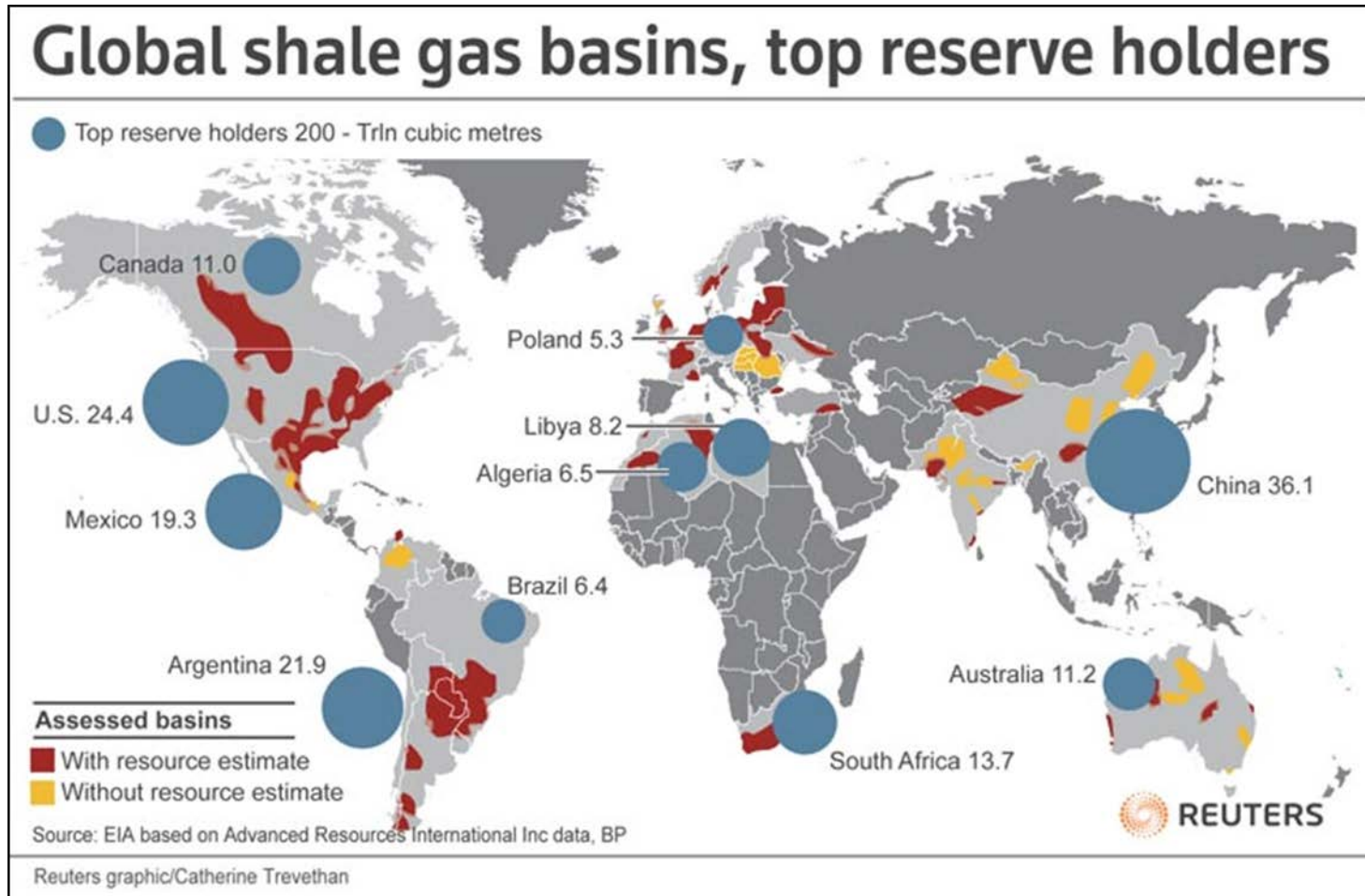
## 1. Discovery of viable Shale gas accumulations requires:

- **Humans:** Highly experienced professional teams integrating geoscience, engineering, environmental disciplines
- 2D and 3D **Seismic** Programs – typically 3D surveys of more than 500 km<sup>2</sup> are required for development planning
- Powerful computing **Hardware** for data processing
- Sophisticated **Software** for data integration and interpretation
- **Drilling** of exploratory vertical wells to measure/sample rock and fluid properties

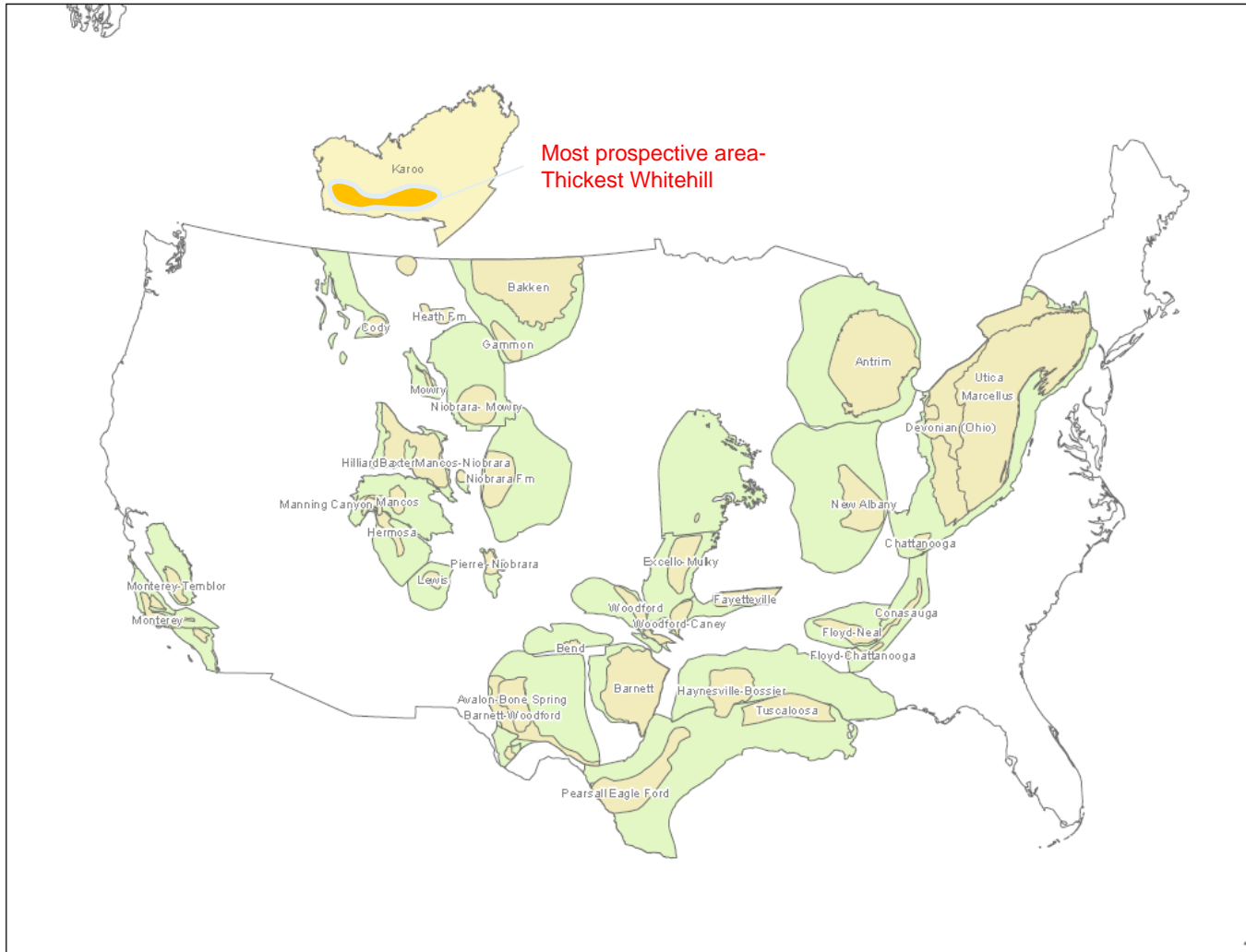
## 2. Production of Shale Gas requires:

- **Drilling** technology capable of horizontal/geosteered well targeting (up to 3000m horizontal length is common)
- **Completions** technology to optimise the extraction of gas from the formation:
  - Temporary technologies required to stimulate the rock:
    - **Hydraulic Fracturing** technology:
      - » Experienced Field personnel and equipment
      - » Important **raw materials in high volume – water (36000 M<sup>3</sup>/well) and sand ( 3500Tonnes/well)**
      - » **Water Management, i.e. source, treatment and recycling/disposal.**
  - Permanent technology:
    - **Casing and tubing** materials – for the Karoo a single production well may have a total length of 6000m
      - » A typical shale development area “sweet spot” may cover 1500km<sup>2</sup> and support drilling of 3000 wells
    - **Surface facilities** for a development as above will require distribution pipelines for water and gas, multiple compression stations, gas plant for gas and liquids separation and processing etc

## The Potential is Undeniable



# How the Karoo Shale Basin Compares...



- **Sparse Well Data – high uncertainty in continuity of key geologic parameters**
  - Requires an Exploratory program of vertical “Stratigraphic Test” wells to “fill in” the gaps
- **Possibility that the basin is highly over-mature, possibly depleted by volcanic action**
  - Extended Testing programs to assess flow/deliverability are required in the first exploration wells
- **Lack of Existing Infrastructure – Impact on Capital Expenditure, especially early-on**
- **Exploitation of Shale Resources Requires Water- typically 3.5 MMgal/well for D&C**
  - Karoo is semi arid, and water requirements are stressed , drawing on both surface and groundwater (Le Maitre et al., Water Resources in the Klein Karoo, South African Journal of Science Vol 105, n1-2, 2009)
  - HOWEVER:
    - North American Experience points to further economization/ optimization of water resources via recycling and reuse strategies (to reduce costs)
- **As it matures, the Shale Gas industry continuously improves economy of use of raw materials, including water, via:**
  - Companies developing infrastructure to manage, treat and recycle water, because hauling water by truck an ever decreasing option due to cost, time, roads, stakeholders etc.
  - Alternatives (CO2 frac, foam frac, etc.) are being pursued, and could influence costs and operating strategy
  - Water is becoming a saleable commodity from company to company, not just water suppliers (especially in Canada)



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## Potential downstream applications to unlock the development of the resource

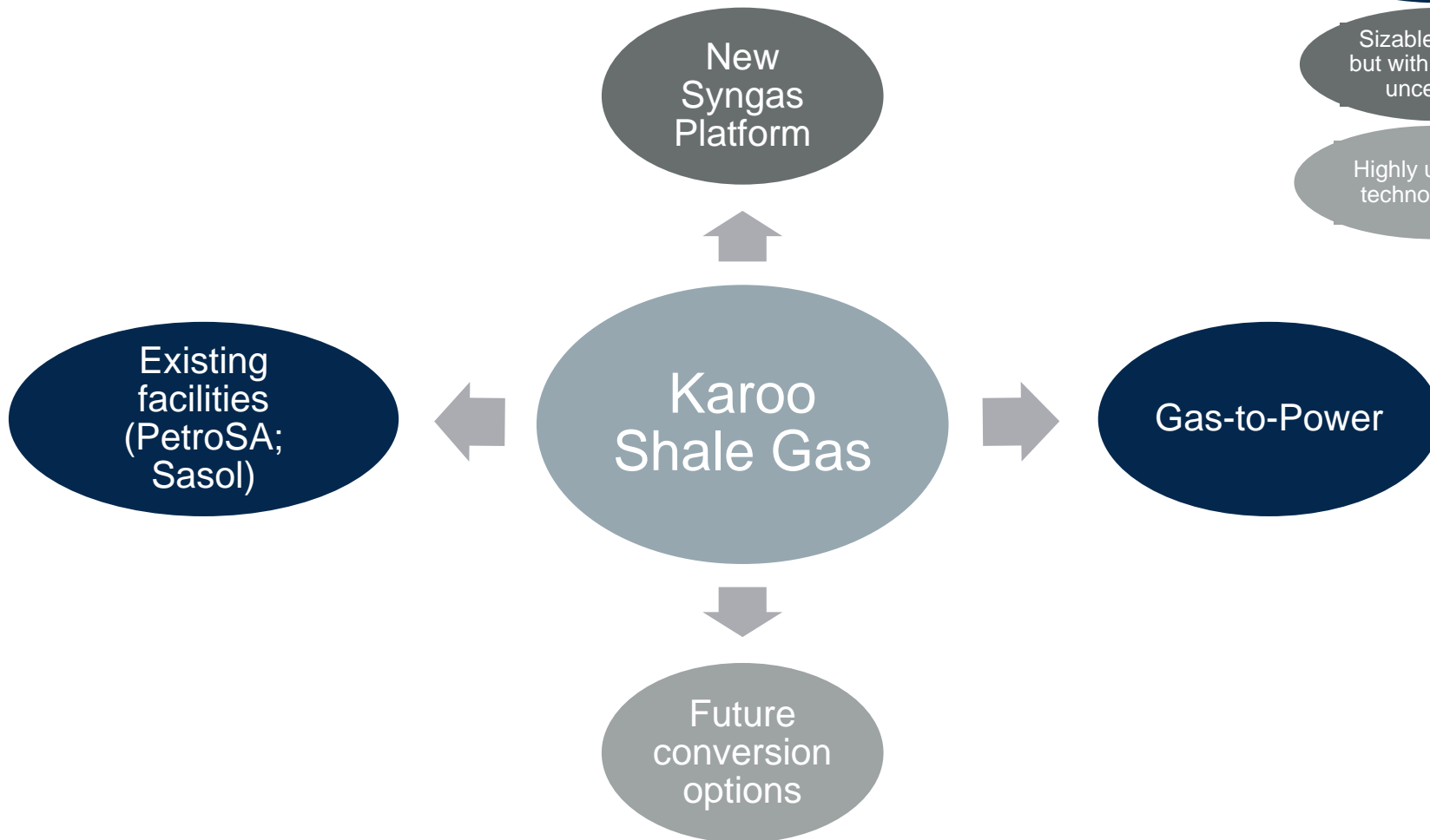




# Karoo Shale Gas

## ➤ Potential present and future uses in South Africa

- Enabler (large immediate off-take)
- Sizable off-take, but with economic uncertainty
- Highly uncertain technologically



# Karoo shale gas to existing facilities

## PetroSA

- Piped to PetroSA plant
- Extend lifetime of facility
- High volume demand

## Sasol's SA operations

- Pipeline and hook-up with Sasol's natural gas network,
- Potential use by Sasol to augment feed stocks to Sasolburg and Secunda

## Pipeline gas

Immediate sink for large gas volumes



# Karoo shale gas for electricity generation

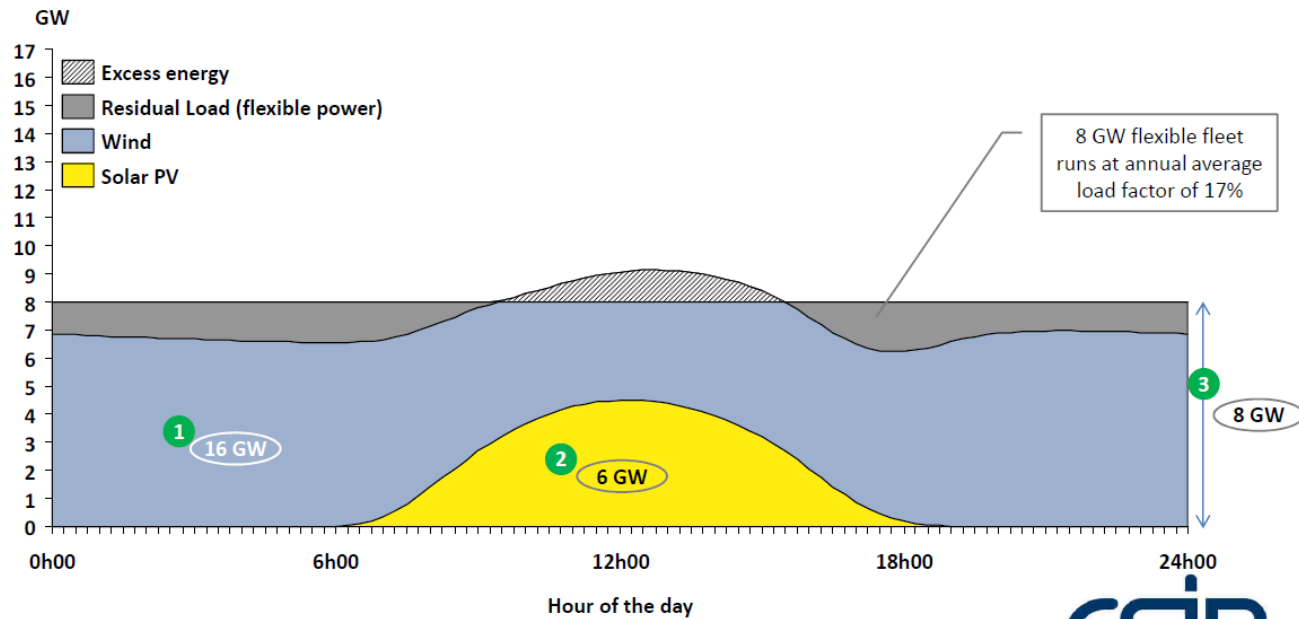
## Gas-to-Power

Much lower CO2 footprint than coal

Low Capital

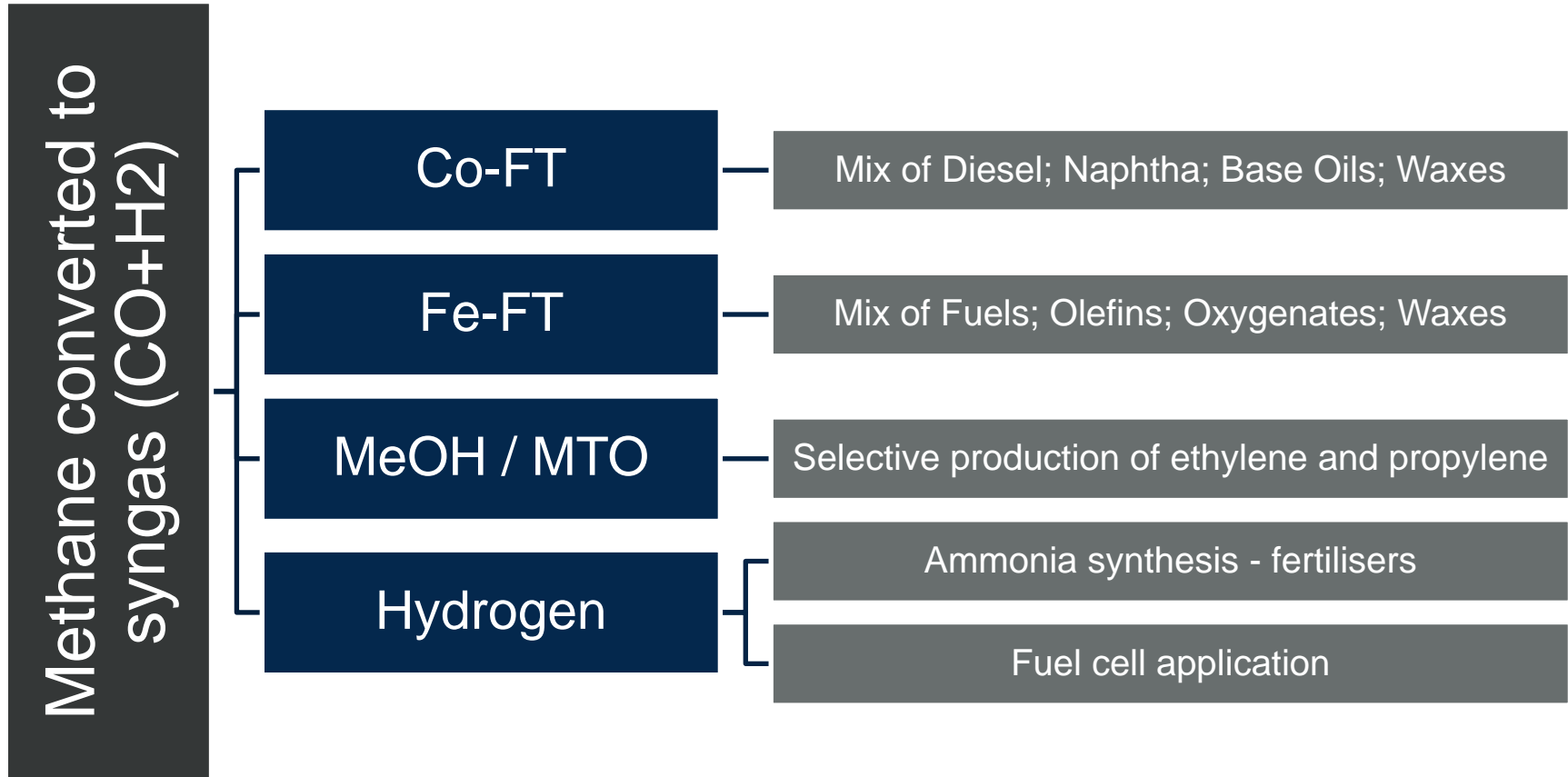
Integrate well with renewables (ramp up and down quickly)

- CSIR study



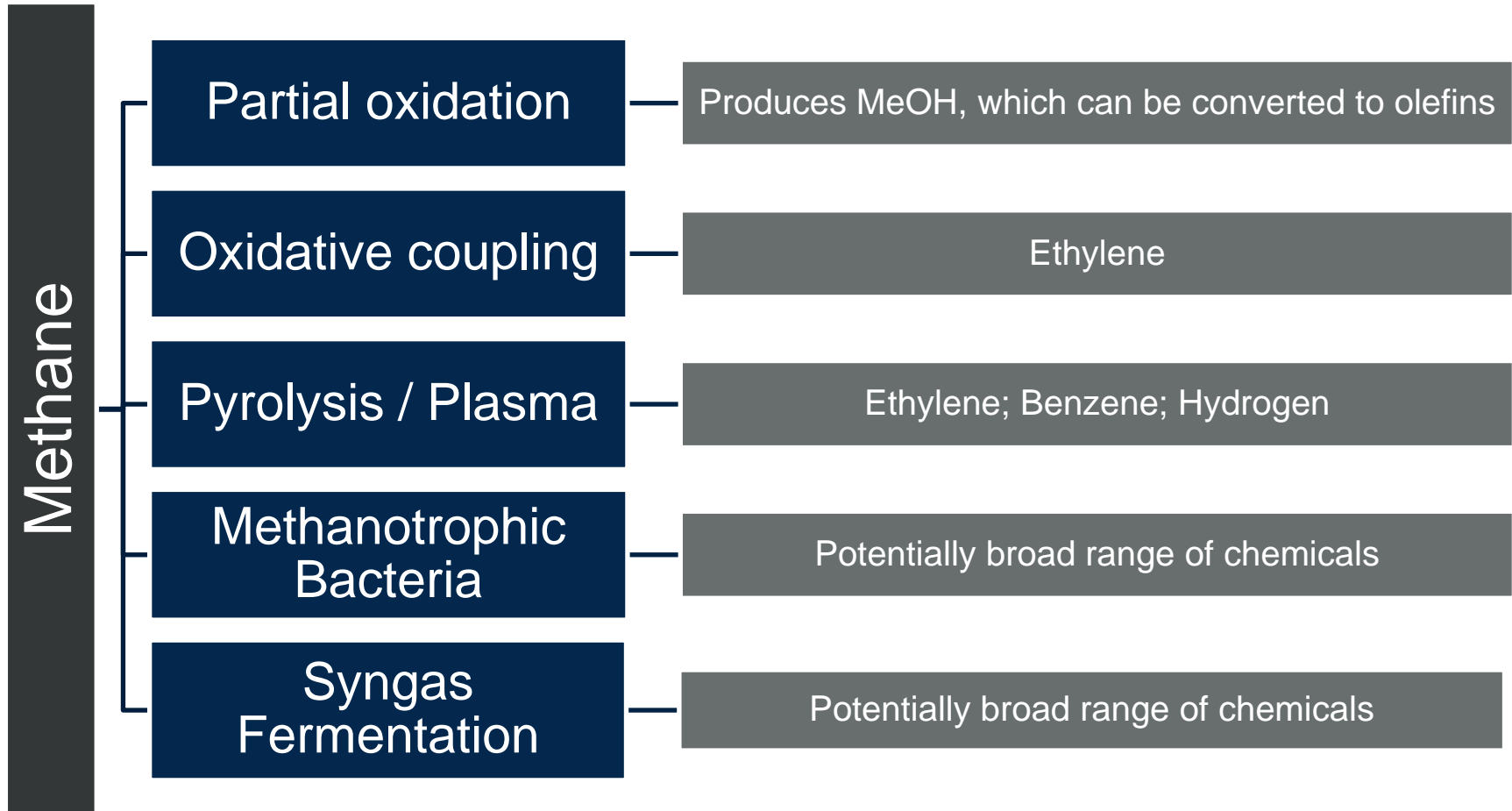
# Karoo shale gas to a new syngas platform

## Existing technology



# Karoo shale gas for new conversions

➤ Under development with high uncertainty of success



# Concluding Remarks



- **Commercial scale production of natural gas from unconventional sources has been successfully demonstrated in North America. There is no need to reinvent the wheel – learn and adopt where necessary.**
- **The development of an unconventional play such as the Karoo is not a short term play. It will require time and scale to be successful.**
- **Environmental baseline monitoring is an absolute pre-requisite. Without this everything will be open for speculation.**
- **Many of the technologies required to develop a play such as the Karoo is available. Do not re-invent the wheel but think about long term local support.**
- **A number of options are available i.t.o downstream application. For South Africa the obvious choices seem to be routing the gas to PetroSA or producing electricity. These will allow for smaller scale gas based industries along the pipeline routes.**
- **Commercial development of a gas based market will be highly dependent on cost of producing gas at volume. Scale is a key consideration.**
- **The Karoo, whilst attracting a lot of interest, has a long way to go still.**



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**Thank you for your attention....**

**Acknowledgement:  
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