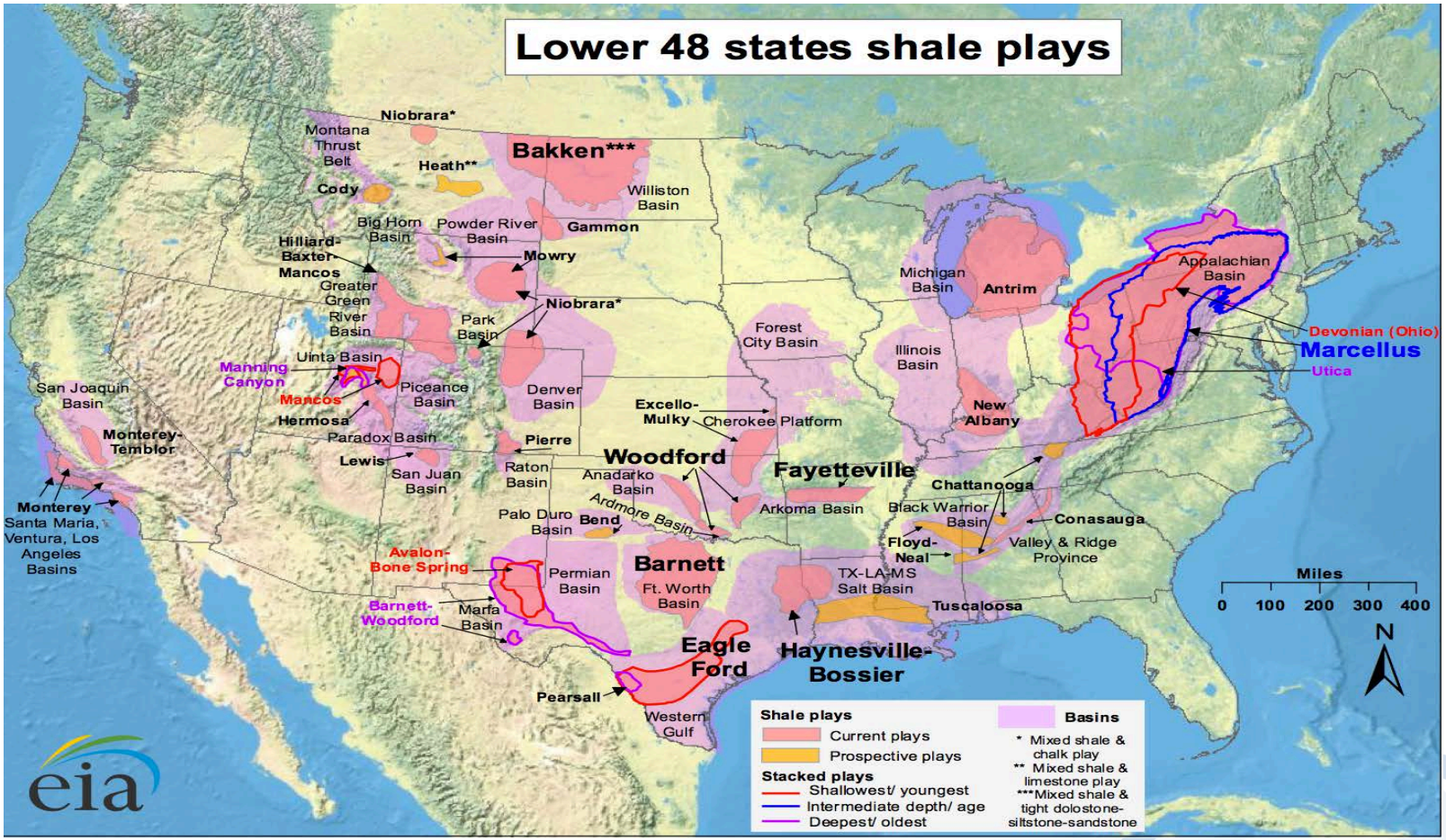
where science meets business

Sustainable, Competitive Energy
Fuelling Economic Growth

Paul Booth, OBE

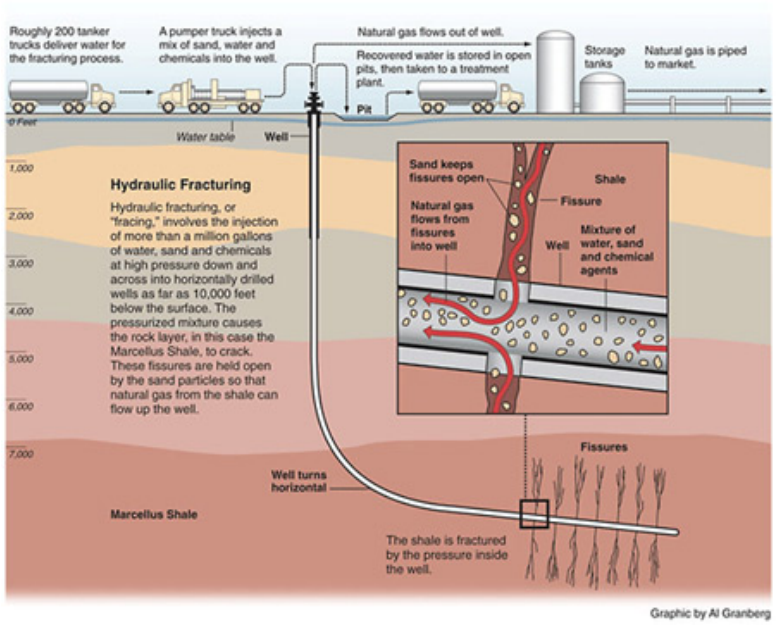
7 November 2013

US Shale Gas: Distribution

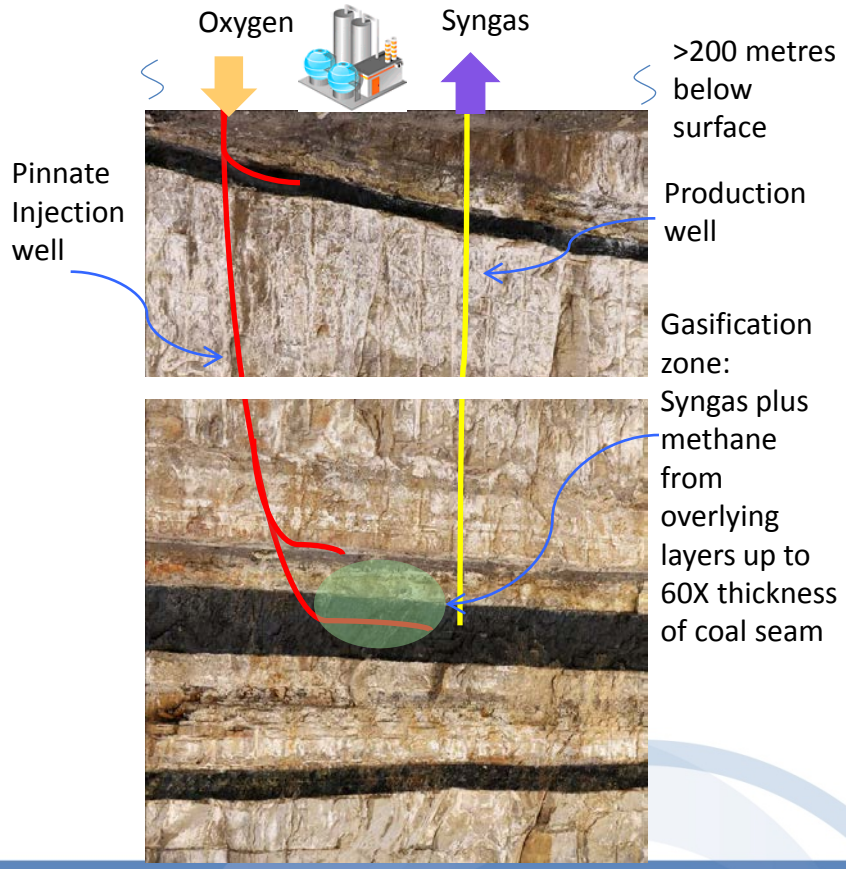


Comparative Economics: Shale Gas vs. UCG

Shale Gas Production

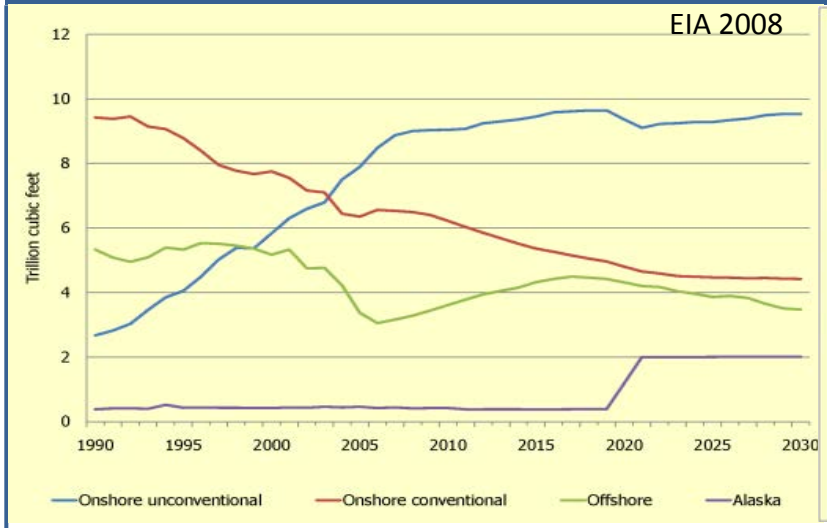


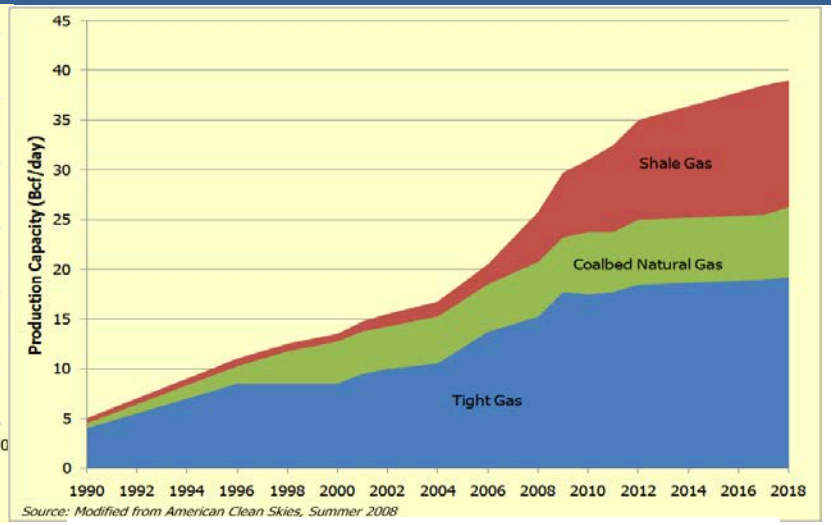
Underground Coal Gas Production



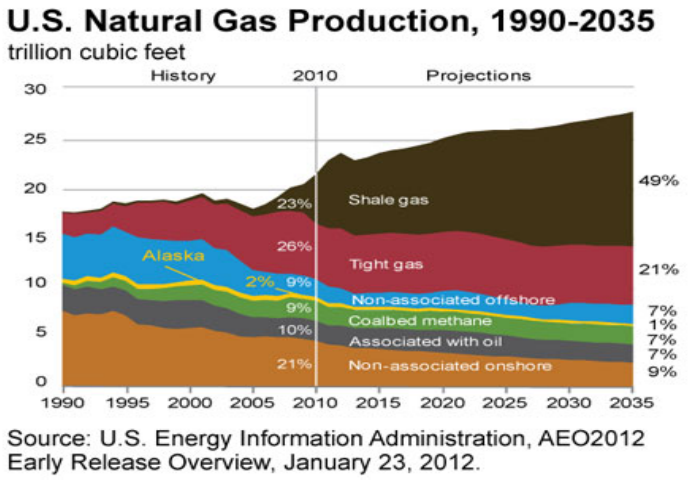
US Gas: Rise in importance of unconventional gas

EIA 2008





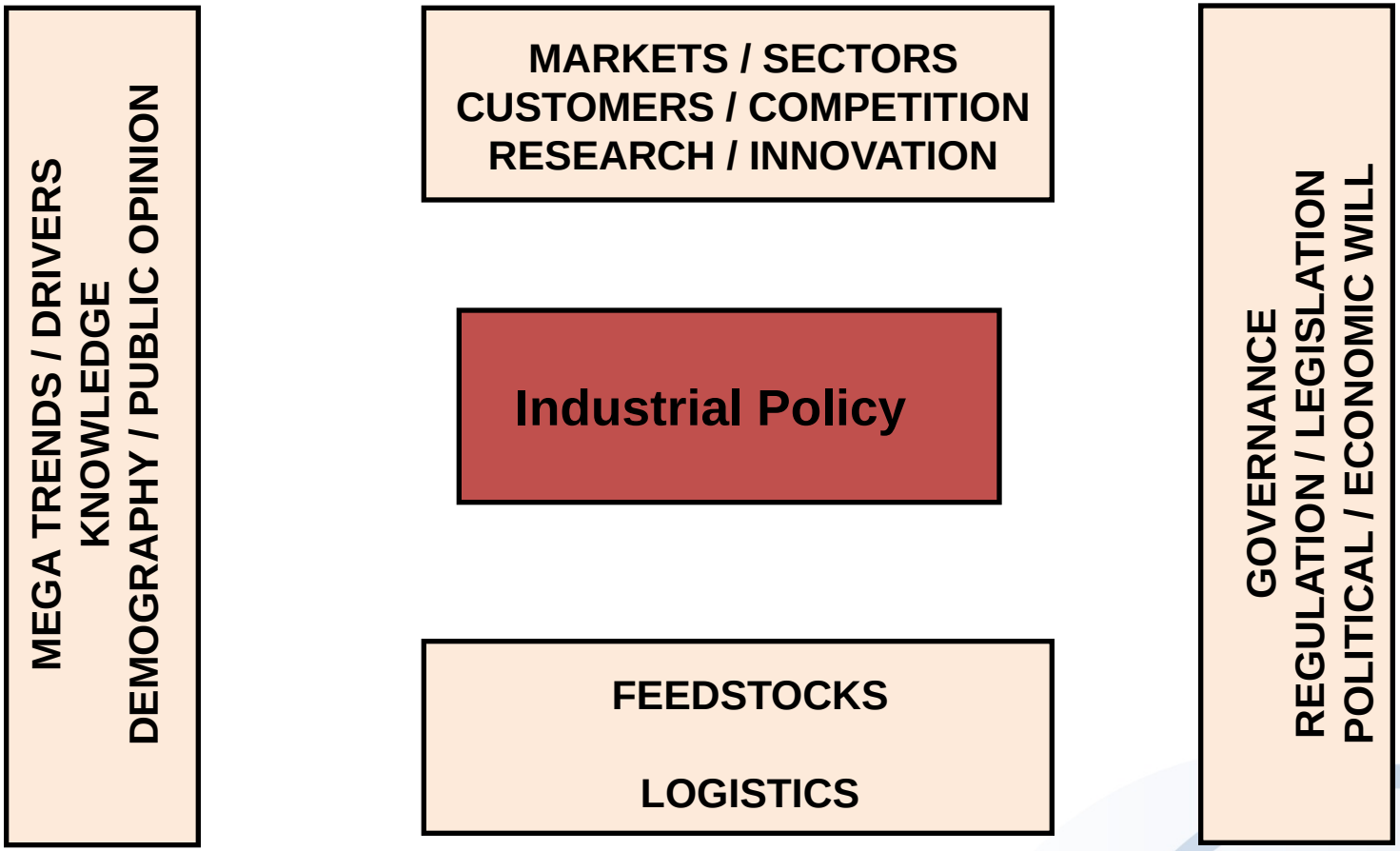
Three factors have come together in recent years to make shale gas production economically viable:
1) advances in horizontal drilling
2) advances in hydraulic fracturing, and, perhaps most importantly,
3) rapid increases in natural gas prices



Source: U.S. Energy Information Administration, AEO2012 Early Release Overview, January 23, 2012.


U.S. Real GDP Growth
TAINTEDALPHA.COM
U.S. Real GDP
U.S. Real GDP q-o-q % Change
13,600.0
13,400.0
13,200.0
13,000.0
12,800.0
12,600.0
12,400.0
12,200.0
12,000.0
6.0%
4.0%
2.0%
0.0%
-2.0%
-4.0%
-6.0%
-8.0%
2003 Q4
2004 Q1
2004 Q2
2004 Q3
2004 Q4
2005 Q1
2005 Q2
2005 Q3
2005 Q4
2006 Q1
2006 Q2
2006 Q3
2006 Q4
2007 Q1
2007 Q2
2007 Q3
2007 Q4
2008 Q1
2008 Q2
2008 Q3
2008 Q4
2009 Q1
2009 Q2
2009 Q3
2009 Q4
2010 Q1
2010 Q2
2010 Q3
2010 Q4
2011 Q1
U.S. Real GDP q-o-q % Change
U.S. Real GDP

UK Environmental/Strategic Context



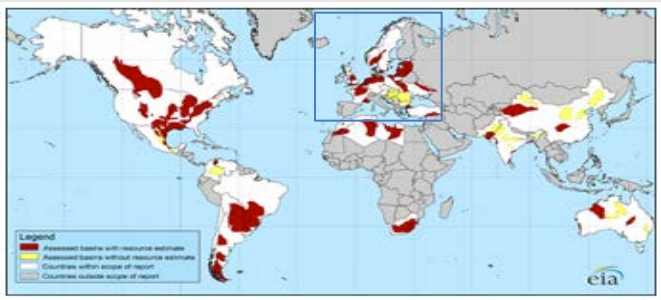
The need to maintain a Balanced Approach

- It is correct that in rebalancing the economy that a mix of solutions should apply
- So there is a place for nuclear / solar / wind / tidal
  (technology will make them more economical over time)




- Think of the chemical components involved in the growth of this sector and imagine every molecule manufactured outside the UK this further underpin the need for a sophisticated understanding of the supply / value chains that will exist into the short /medium and long term

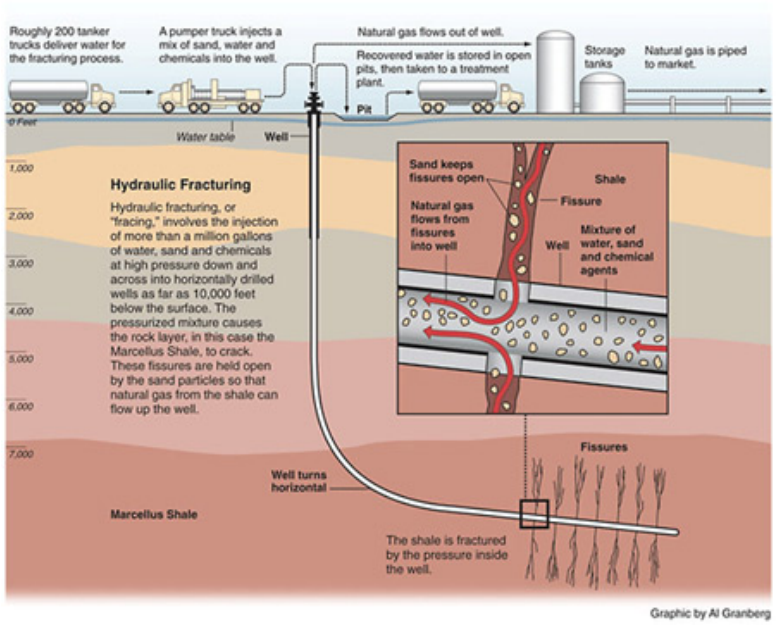
European Shale Gas



	2009 Natural Gas Market[1] (tillion cubic feet, dry basis)			Proved Natural Gas Reserves[2] (trillion cubic feet)	Technically Recoverable Shale Gas Resources (trillion cubic feet)
	Production	Consumption	Imports (Exports)		
Europe					
France	0.03	1.73	98%	0.2	180
Germany	0.51	3.27	84%	6.2	8
Netherlands	2.79	1.72	(62%)	49.0	17
Norway	3.65	0.16	(2,156%)	72.0	83
U.K.	2.09	3.11	33%	9.0	20
Denmark	0.30	0.16	(91%)	2.1	23
Sweden	-	0.04	100%		41
Poland	0.21	0.58	64%	5.8	187
Turkey	0.03	1.24	98%	0.2	15
Ukraine	0.72	1.56	54%	39.0	42
Lithuania	-	0.10	100%		4
Others[(3)]	0.48	0.95	50%	2.71	19

Comparative Economics: Shale Gas vs. UCG

Shale Gas Production



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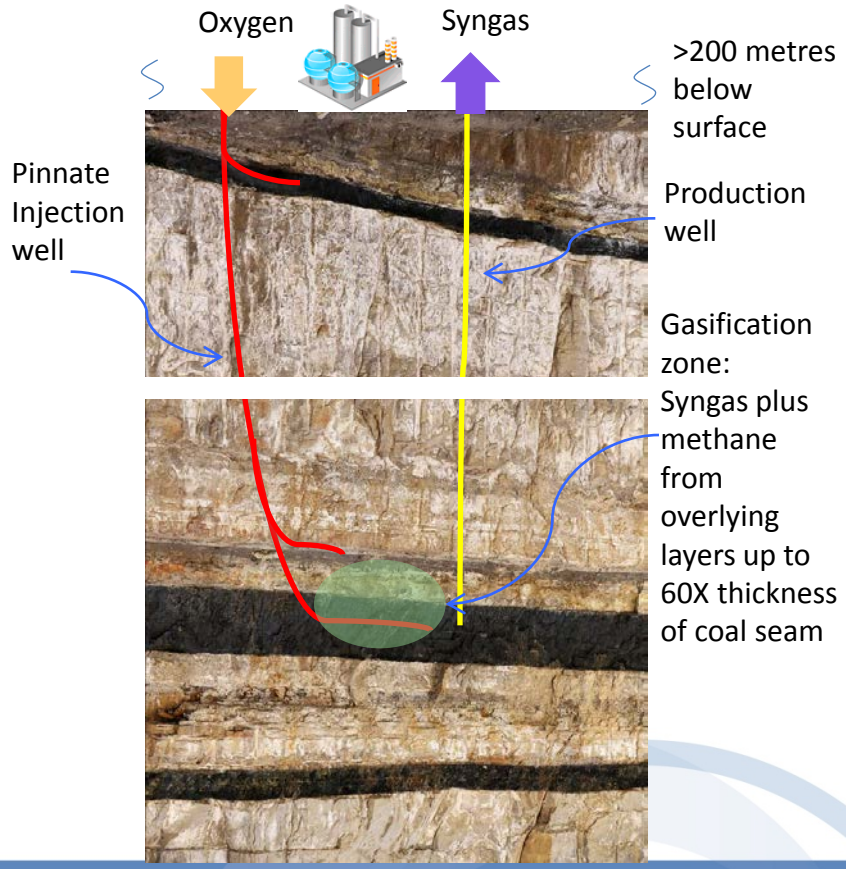
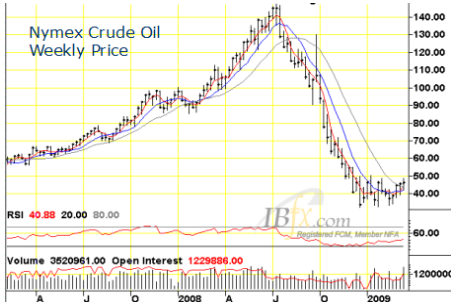


Additional unconventional feedstocks

- However we have at least 2 other sources of feedstock available to the UK
- Frac Gas and Syn Gas based on underground gasification of coal

- UK has over 3000 million tonnes of thin seam coal reserves - enough for 2-300 years
  - If fully developed would be bigger than the Qatari gas fields
  - It is no accident that these reserves are close to existing manufacturing sites and therefore relatively easy to connect
  - Also Poland is potentially a major source for shale gas

Market forces suggest a growing case



Volatility + High Price_

<20% reused due to mixed materials

>80% Land filled or Incinerated

Transportation largest cost

Feedstock Volatility (40-140 $/bbl)

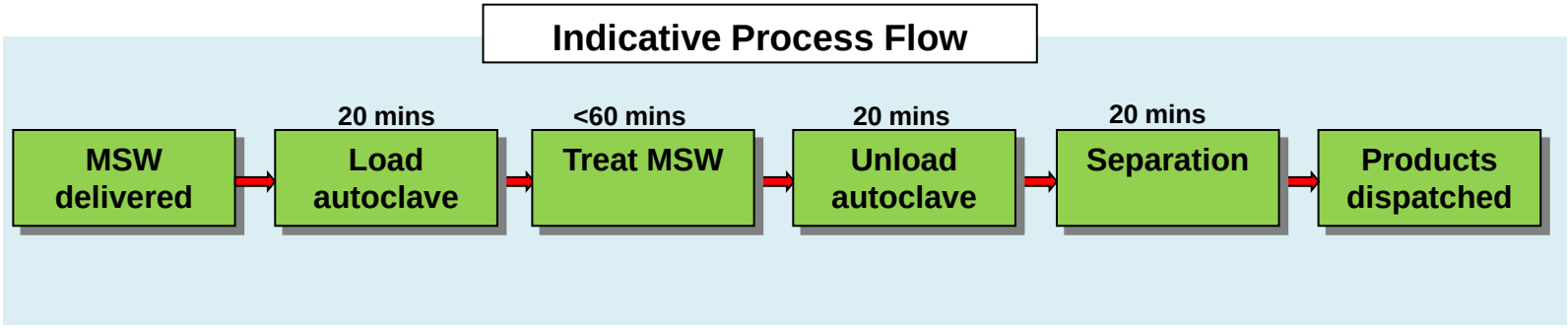
Plastics Waste Problem

Abundance of Cheap Mixed Waste (10 - 30 $/ton)

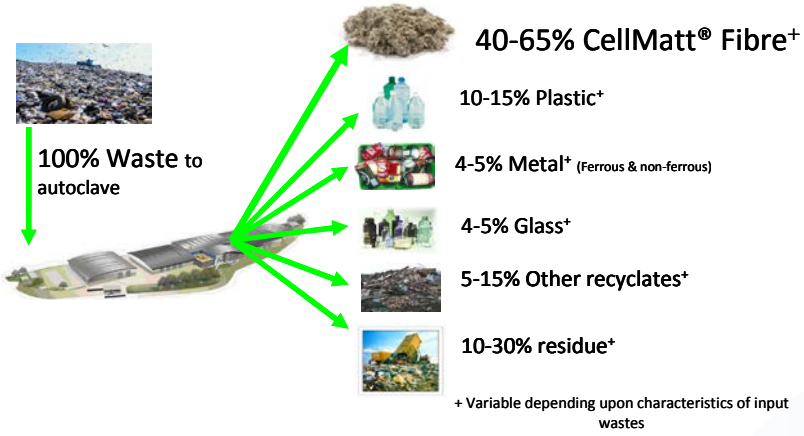
Conversion of Plastic Wastes to Feedstock/Fuels

End-of-Life value recovery for polymers:
Polymer recovery > monomer recovery > feed stock recovery > incineration > landfill

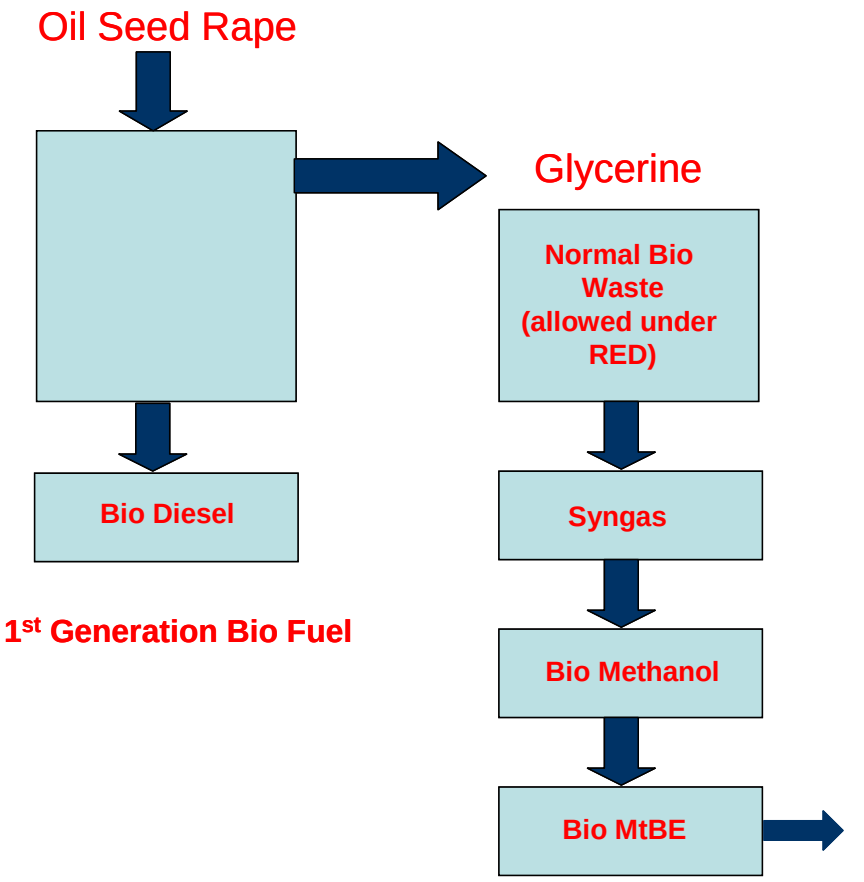
Waste to Feedstocks



- The UK generates 40/50m tonnes of mixed domestic waste / annum
- Half is wet Bio mass therefore autoclaving or equivalent will yield 10 / 15 million tonnes of dry bio mass which is then converted to bio gas. This quantity is significant



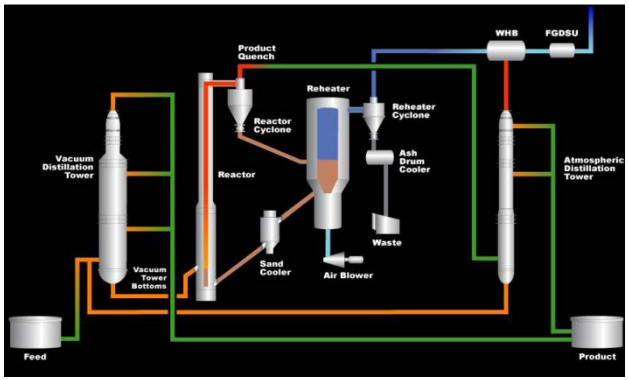
Waste or By product



Depolymerisation back to monomer

- >10 Technologies identified by WTC
- 2 Plants Commercial (20 TPD)
- Thermal & Thermal/Catalytic
- Low to Medium Severity
- Different Reactor Designs (e.g. Rotating Kiln, Extruders)

T-Technology(India/EUR)

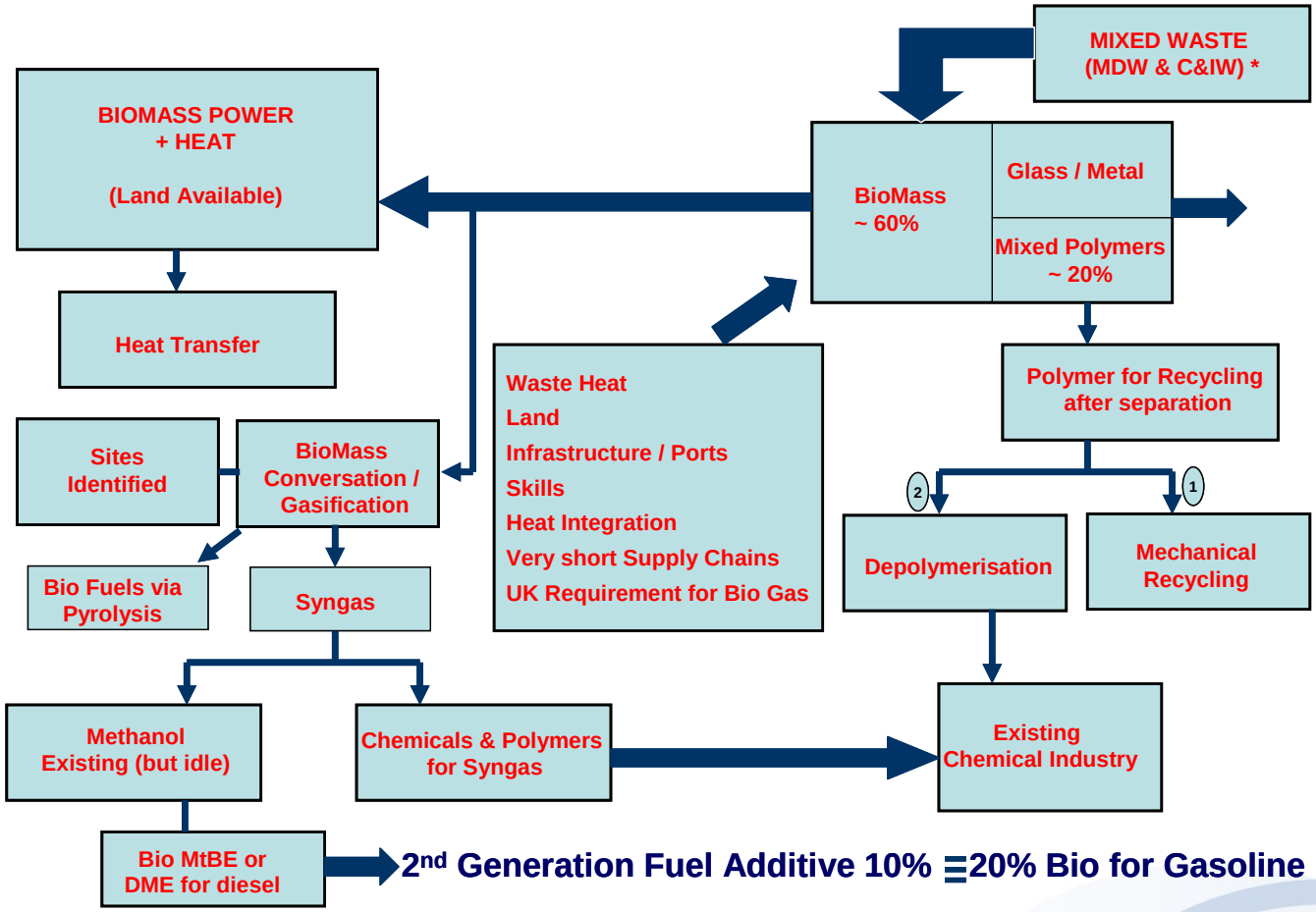


Ivanhoe Energy(CA)

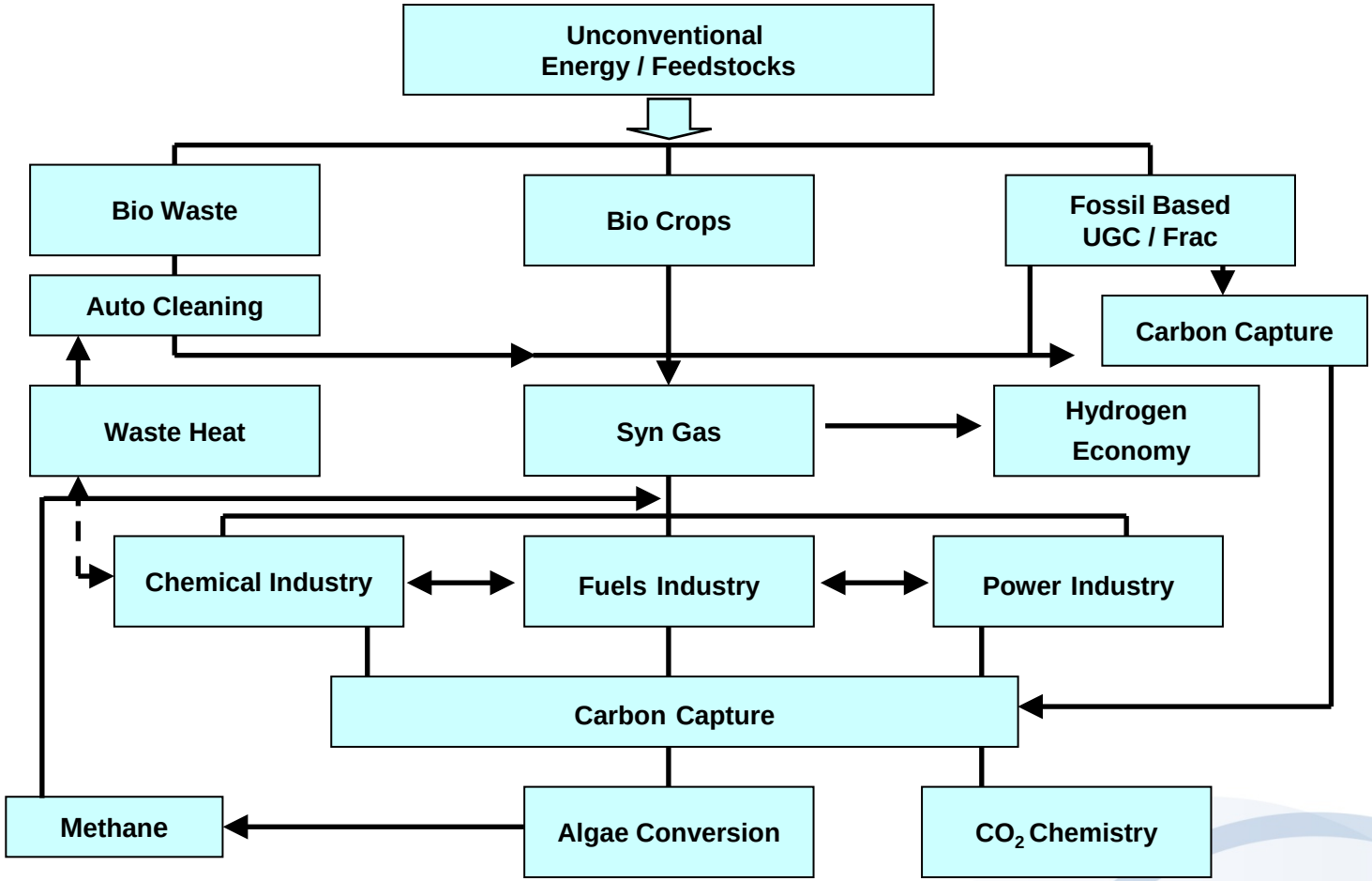
RCFG(India)

Multiple Technology Options to Assess

Waste to Bio-gas



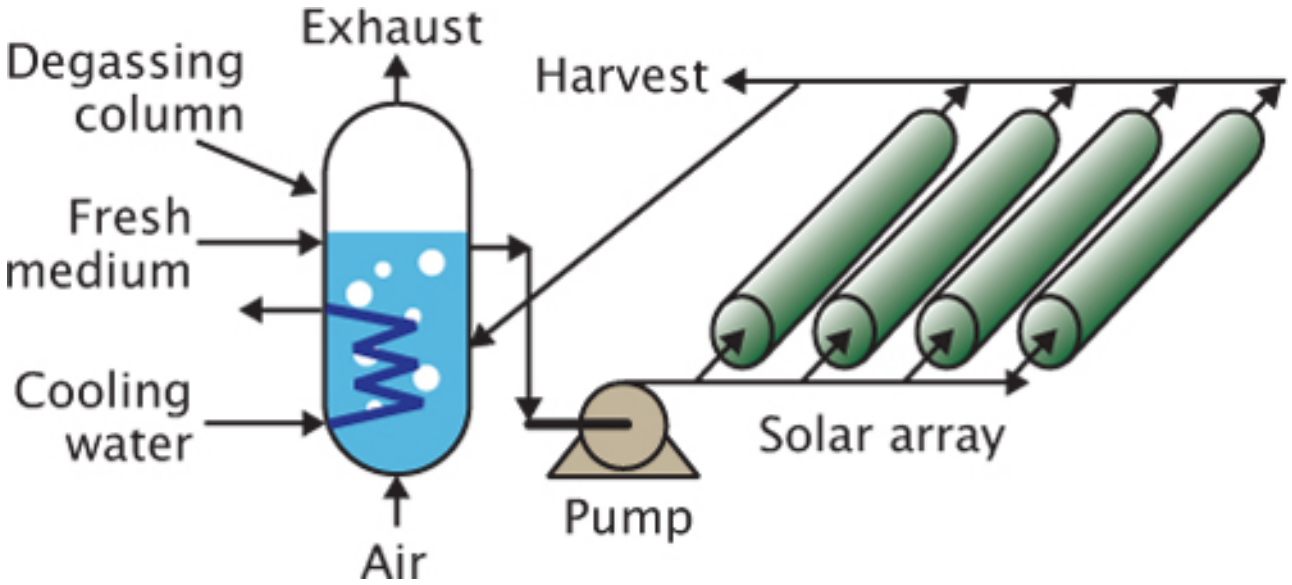
Closing the loop on Carbon



Algae Ethanol Plant

Algal Biomass Conversion Plant

Enclosed Photo Bio Reactor (Spirulina Platentis)



Research into CO2 chemistry will be of equal importance to algae research

Europe has a distinctive even unique offering which has enormous value (we need to be clear about what this is and how to unlock it)

- Market place (politically stable)
- Source of knowledge for Technology and Innovation
- Natural resources Oil, Coal, to Syn Gas, Bio to syn gas, Frac gas
- Manufacturing expertise / excellence
- Infrastructure, energy linkage to near and middle east
- Understanding of working with leading edge legislation
- Some countries have the political will for chemical growth
- Some countries have the economic capacity for growth
- Opportunity to better link chemicals to innovative customers with global brand and reach - e.g. auto / aero/ healthcare/ through short chains

The need to articulate the Vision

- It is absolutely vital that we create a clear vision and strategy for our industry which clearly articulates the value to society
- We need to demonstrate that this vision is both environmentally and economically sustainable
- I believe our industry can do this and be one of the cornerstones of the emerging industrial strategy
- We will have a lot of work to do top persuade the doubters and detractors by clearly articulating the value to the many stakeholders and critically to the potential investors in UK plc.
- We need to make connections