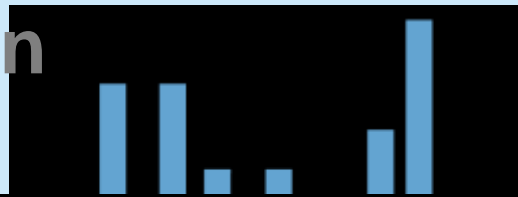


Engineering outputs of an industrial CCS network in Teesside

Sarah Tennison



Key

- Existing Pipe Corridors
- Existing Tunnels
- Existing CO2 Exports
- Ports

1 New Energy & Technology Park (Enterprise Zone)
2 South Bank Wharf (Enterprise Zone)
3 Wilton (Enterprise Zone)

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Seal Sands / North Tees Chemical Sites



Billingham Chemical Site

Wilton International

PD Ports
4th Largest in the UK

Greenhouses
North Bank Growers
Waste heat / CO₂ to grow tomatoes

Fujifilm Diosynth
Bio Pharmaceuticals

Johnson Matthey
Catalyst

Growhow
Ammonia

SITA
Waste to Energy

Air Products
Waste to Energy

BOC
Steam Methane Reformer

Lucite
Acrylics

Mitsubishi Chemicals
Li-Ion Battery / Electrolyte

Chemoxy
Fine Chemicals

SABIC
Underground Chemical & Hydrogen Storage

EPAX
Pharmaceuticals

INEOS
Nitriles

Fine Organics
Fine Chemicals

PX
Teesside Gas Processing Plant

BP
CATS Terminal

ConocoPhillips
Crude Oil Processing

EDF Energy
Nuclear Power Station

ConocoPhillips
Crude Oil Storage

Huntsman
TiO₂

Harvest Energy
Biodiesel

SSI
Steel Producer

Inter Terminals
Chemical Storage

VOPAK
Chemical Storage

DOW
Speciality Chemicals

BOC
Air Separation Unit

TATA
Steel / Beams / Pipes Manufacturer

Huntsman
Polyurethanes

SABI
Ethylene (Cracker) / Polythene

CPI
Manufacturing Catapult

Lotte Chemicals
Plastics

ENSUS
Biofuels

Materials Processing Institute
Home to the Thermal Technology Centre

Semcorp Biomass Power Station
Power / Utilities

SSI - Europe's second largest Blast Furnace



- Total site emits 7.1million tonnes of CO2 per year
- After optioneering 3 concepts selected for further study:
 1. Post combustion capture on the flue gas from new power station fueled by blast furnace gas – 1.6million tonnes captured
 2. Pre-combustion capture from entire blast furnace gas – 2.1million tonnes captured
 3. Pre-combustion capture from excess blast furnace gas and BOS gas – carbon converted to H2 and CO2 in shift reaction – 2.2million tonnes captured



Comparison of options

Attribute	Concept 1 (Post-)	Concept 2 (Pre- Non shifted)	Concept 3: (Pre- Shifted)
Captured Quantity	1.6 million te pa	2.1 million te pa	2.2 million te pa
	209 te/hr (100barg)	252 te/hr (100barg)	264 te/hr (100barg)
Electrical Energy	34 MWe	134 MWe	75 MWe
Heat Energy	211 MWth	Nil	Nil
Reference Plant	Boundary Dam	Many, over 40 years	Many, over 40 years
Attributes & Issues	End of Pipe solution Heat demand	Partially treating large gas stream hence fuel gas comp. load	Lowest overall energy solution
Areas for work during FEED	Heat Integration with wider site. Flue gas consistency	Optimise solvent selection & flows. Ability to service existing fuel uses Fuel gas consistency	Optimise solvent selection & flows. Optimise internal heat integration. Fuel gas consistency

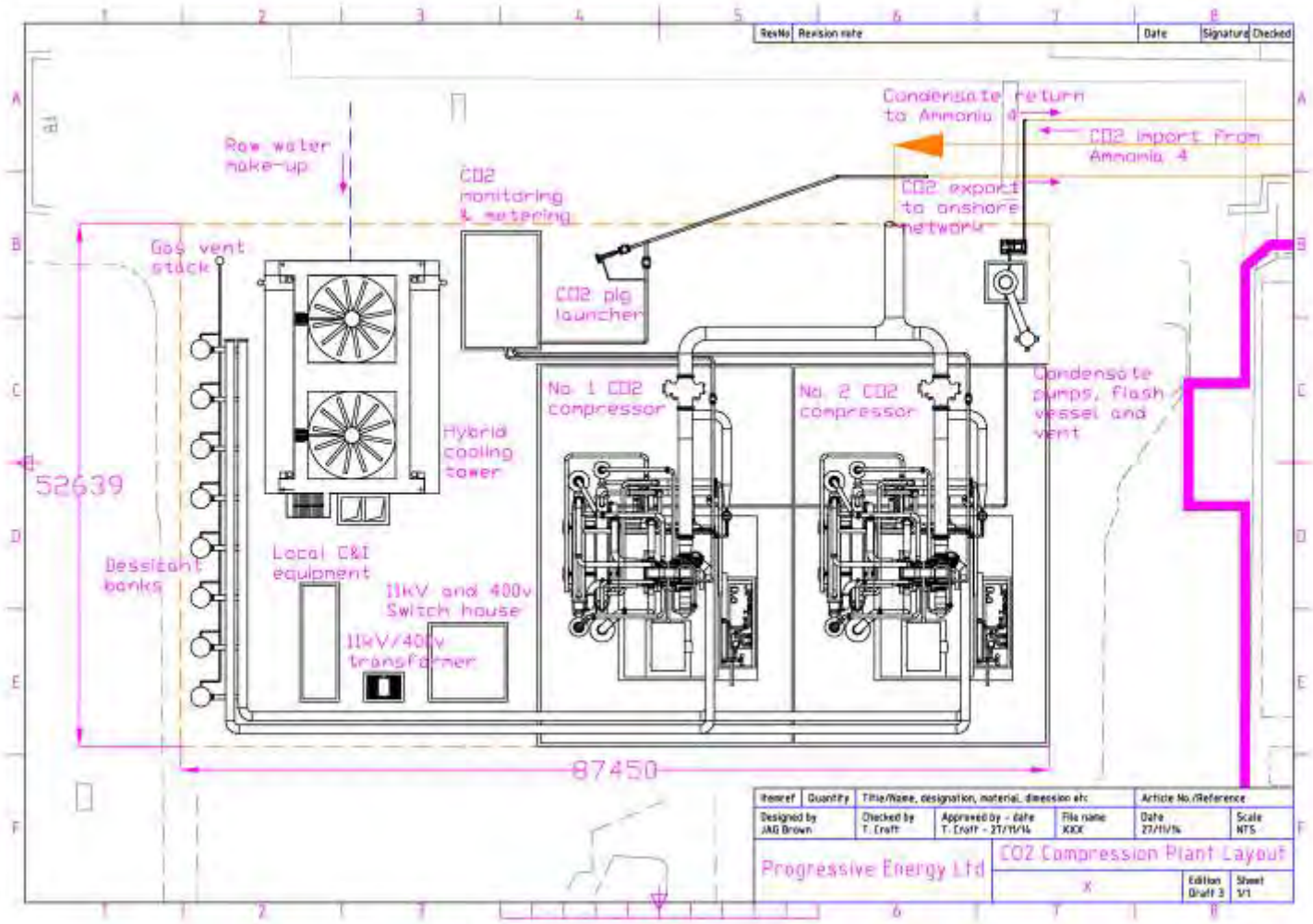
Growhow – 35% of UK's fertilisers



- Produces CO2 as part of process, sells to Greenhouses and Drinks industry
- Average of 375,000 tonnes of CO2 per year
- New 100barg compression plant required (2 x 50tonne/hr compressors)
- Proven technology from existing suppliers
- No operation or integration issues identified



Compressor Compound

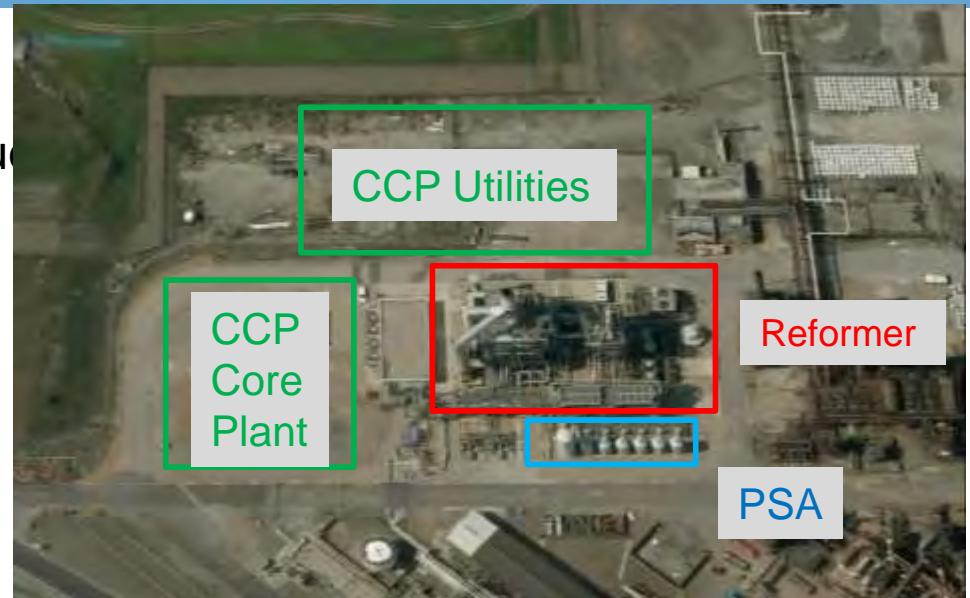


Item ref	Quantity	Title/Name, designation, material, dimension etc	Article No./Reference
Designed by JAG Brown	Checked by T. Craft	Approved by - date T. Craft - 27/11/16	File name XXXX
		Date 27/11/16	Scale NTS
Progressive Energy Ltd		CO2 Compression Plant Layout	
		X	Edition Draft 3
			Sheet 1/1

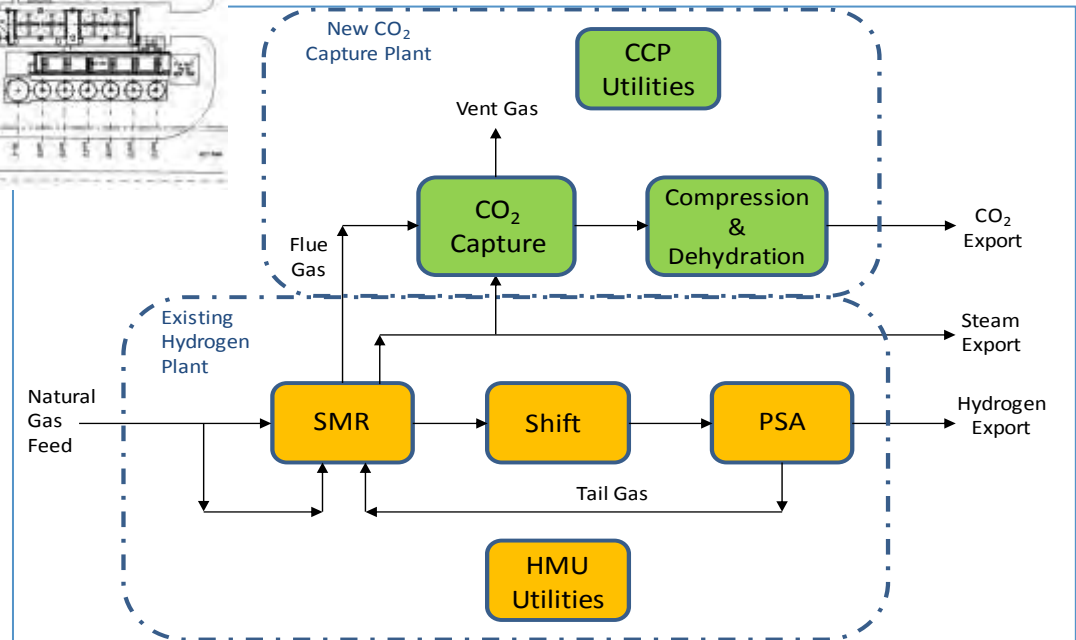
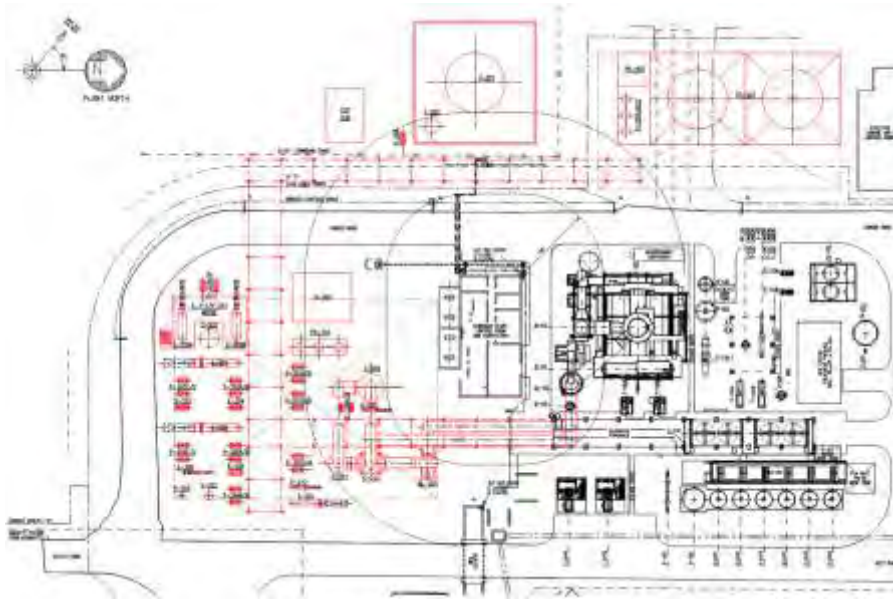
BOC Linde - UK's largest Steam Methane Reformer



- 305,000 tonnes of CO2 captured
- Conventional Amine Process on flue gas from SMR
- No significant impact on the hydrogen plant
- Significant power consumption – 5.9MW



BOC Layout



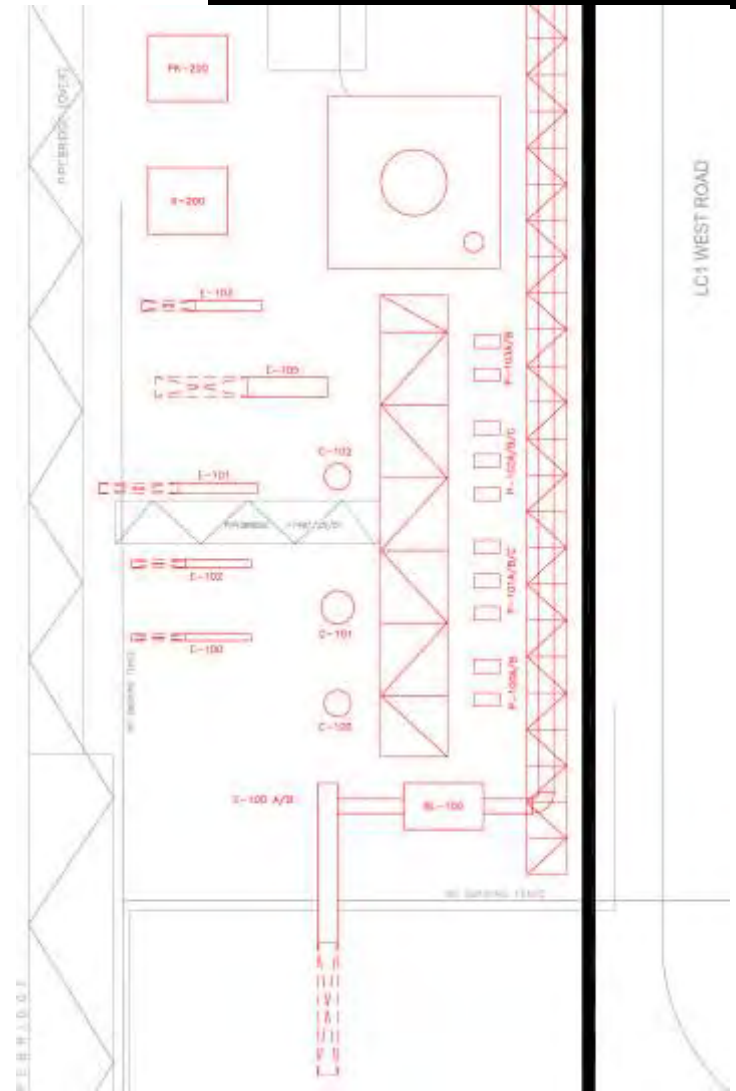
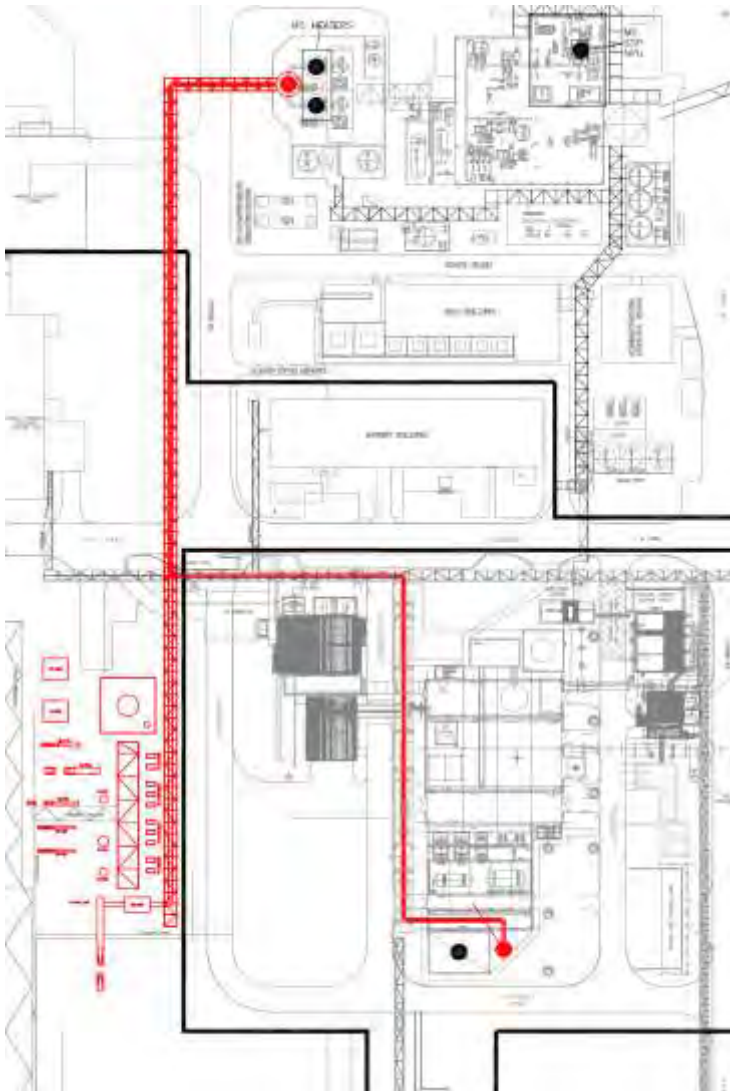
Lotte - Produces enough PET for 15 billion drinks bottles every year



- 50,000 tonnes of CO₂ captured
- Amine capture solution selected
- Pre-designed amine units available – American – no European pricing available
- 90% CO₂ captured



Lotte Chemicals Layout

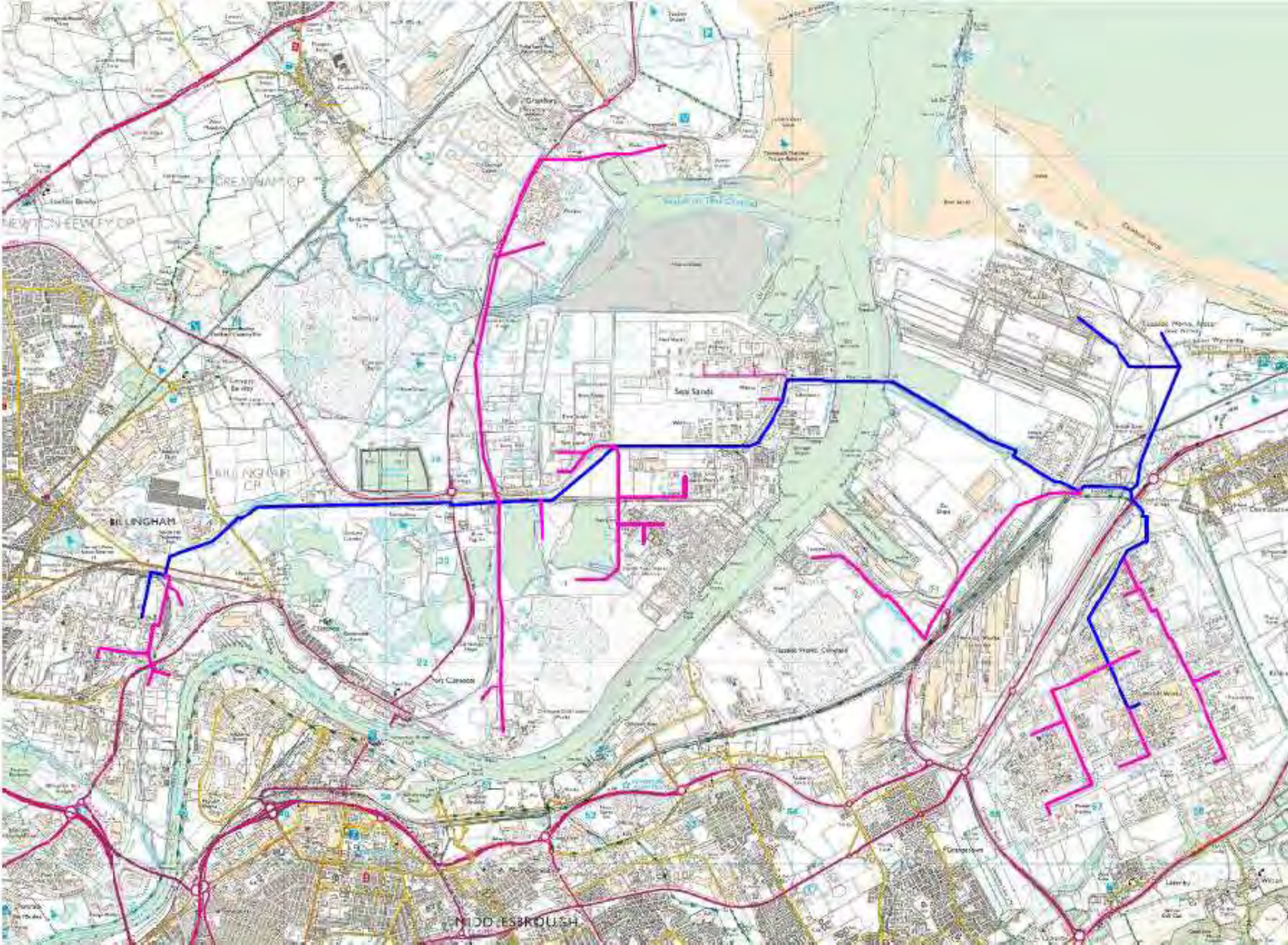


Onshore network



- 5 and 15million tonnes per year capacity pipe studied
- 100 barg from capture units with specified CO₂, transport at dense phase
- Constraints identified to generate route:
 - Environmental
 - NG NTS Feeder
 - Populations
 - Access to suitable shore landing
 - Rail and road crossings



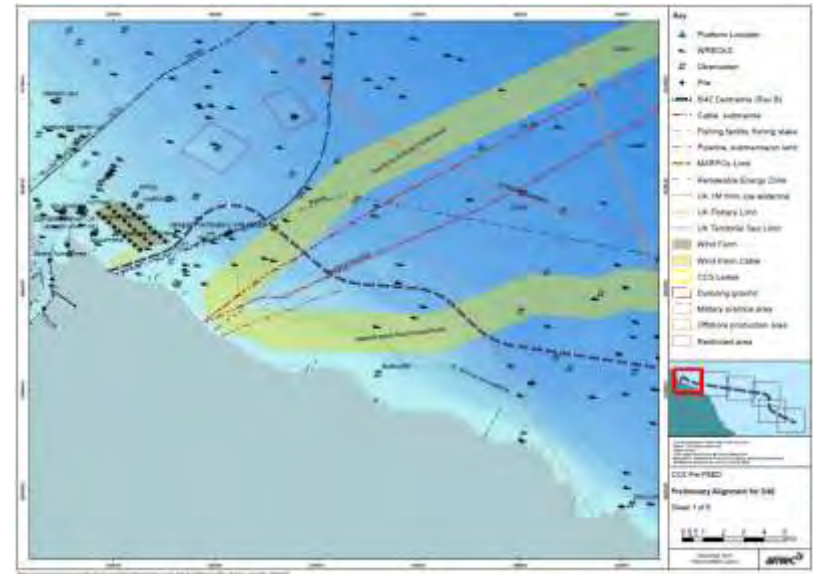


Booster Station to Offshore Routes



Offshore network

- Two destinations:
- National Grid's 5/42 / Bunter
 - 154km
 - 3 pipeline crossings, 3 communication crossings, 3 electrical transmission cable crossings, submarine exercise area.
 - 5mt/yr = 18in. 15mt/yr = 24in
- Captain
 - 433km
 - 4 pipeline crossings
 - 5mt/yr = 20in. 15mt/yr = 30in



Thank you

Sarah Tennison