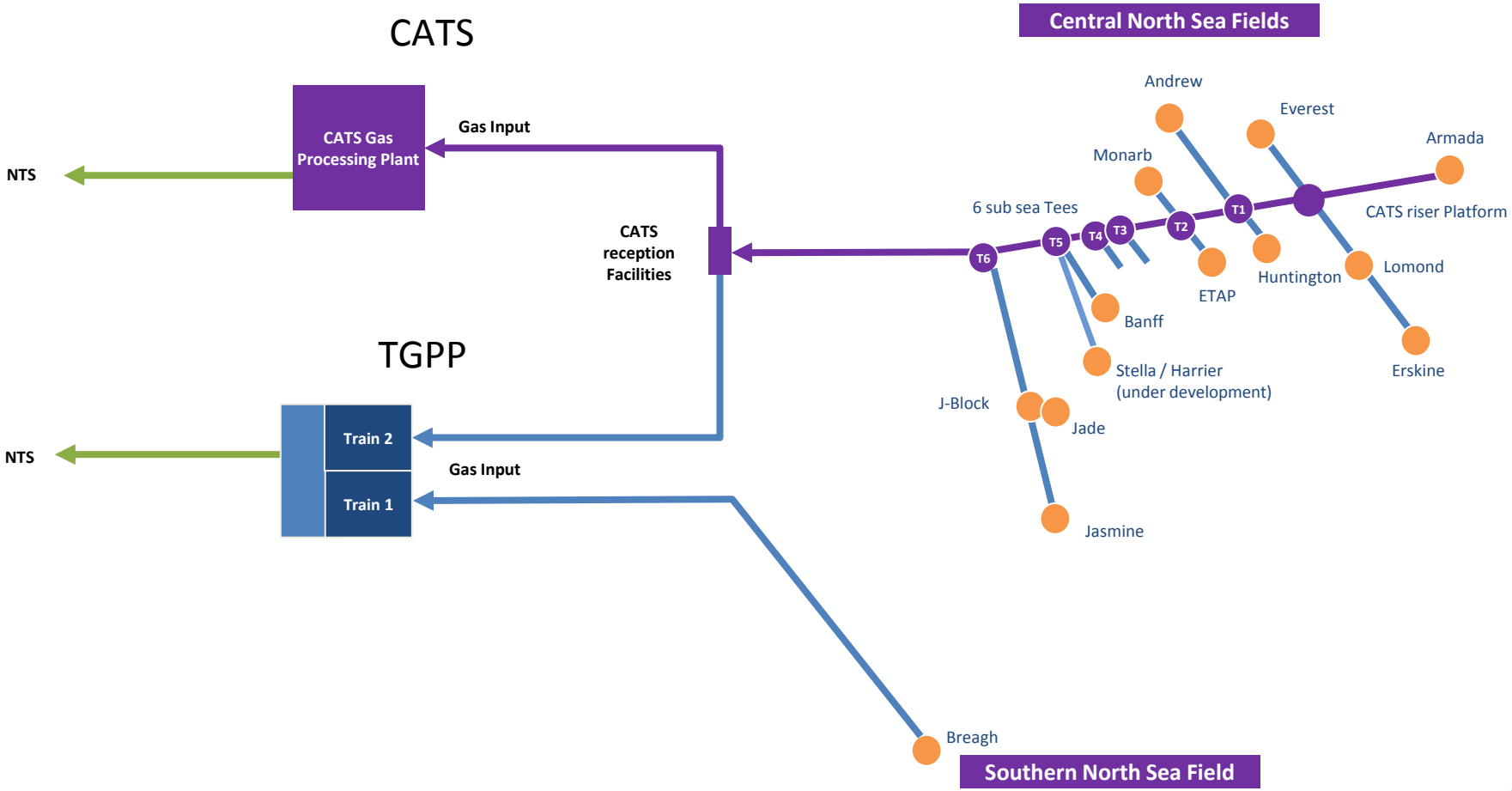
TGPP/px Transmission Workgroup Input UNC Mod 0502

Transmission Workgroup for Mods 0498 and 0502

Background

- TGPP has submitted UNC Mod 0502 seeking to increase max CO_2 content in gas entering NTS at px Teesside Entry Point
- CO_2 limit governed by Network Entry Agreement (NEA) with National Grid Gas
- Current limit 2.9 mol % - Mod 0502 proposes increase to 4.0 mol %
- Rationale is to recognise forecast increase in CO_2 content of gas arriving at Teesside via Central Area Transmission System (CATS) pipeline
- Increase has been forecast by BP (operator of CATS) - results from increased CO_2 levels in mature fields & expected offshore developments
- TGPP processes approximately 50% of gas landing at Teesside via CATS pipeline, remainder processed in CATS processing terminal (operated by BP)
- BP has submitted own (essentially identical) Mod 0498

Schematic of CATS/TGPP Infrastructure



Teesside Gas Processing Plant

Response to SSE Submission (1)

- **We offer the following observations/initial responses regarding SSE's submission dated 29th May 2014;**

Concern 1:

- **"Gas turbine combustion dynamics, emissions and operability are impacted by the total level of inerts (principally Carbon Dioxide (CO_2) and Nitrogen) contained in the gas. Certain gas turbine OEMs stipulate a maximum level of 4% inerts in their fuel gas specifications. Operation outside this specification could invalidate the unit's warranty or service agreement. This will prevent operation of the asset and result in lost revenue and less competition in the market for supplying electricity. Where new build is being considered, an increase in CO_2 to 4 % could restrict the selection of which future gas turbine manufacturer could be used, suppressing market competition."**

Response 1:

- **We understand that there are 4 main GT OEMs supplying the UK market – of these we understand 3 can accommodate volumetric levels of inerts in excess of 10%**
- **We understand one GT OEM currently has an inert limit of 4% (which may be relaxed ?) but we believe that SSE do not operate any of this OEM's Gas Turbines in the UK**
- **Could SSE clarify which of their CCGTs are affected by an inert limit of 4% ?**

Response to SSE Submission (2)

Concern 2:

- **“Increasing the level of inerts creates the potential for a greater range of gas composition and specification. Varying gas specification within this wider range will lead to a requirement for unpredictable gas turbine re-tuning in order to maintain combustion stability and dynamics within the OEM’s specification to avoid warranty and Environment Agency breaches. Currently, re-tuning of gas turbine combustion systems takes around 4 hours, is costly as it requires the services of specialist OEM combustion engineers to retune the combustion system and prevents flexible, load following operation during that period. This lack of flexibility will not only impact on being able to support intermittent generation and security of supply but lead to loss of revenue, the magnitude of which will be dependant upon when the gas composition changes. In addition changes in Gas Quality could result in gas turbine start up and transfer issues. This represents a real risk to the reliability of future operations especially for stations operating in a cyclic mode with implications for providing support for intermittent generation and hence electricity system security.”**

Response 2:

- **Composition of Gas entering the NTS is controlled by specifications in system entry point NEAs which are consistent with GSMR**
- **There are no constraints within GSMR or NEAs in terms of changes or rates of change to gas composition within the min/max permitted ranges**

Response to SSE Submission (3)

Response 2 (cont):

- The composition of gas arriving at Teesside via CATS (and indeed via other offshore pipeline systems to other terminals) can vary significantly, and rapidly, depending on which fields and wells are producing and also the performance/operation of offshore processing facilities
- Terminal operators have very limited influence (other than shutting fields off if they don't meet offshore pipeline entry specs) over these changing gas compositions which can change significantly within day (note also that some gas from the extremes of a large pipeline system like CATS can take several days to reach a terminal making the prediction of gas composition changes at a terminal very difficult)
- One way that gas composition into the NTS is routinely managed at a number of system entry points is through the injection of N_2 if gas streams are too rich to meet the NEA/GSMR specification
- Therefore gas composition (including level of inerts) entering the NTS already varies significantly (within agreed specification limits into the NTS) and such variation is outwith the control of terminal/system entry point operators
- We understand that this natural variability of gas composition is understood and accepted by GT OEMs and as a result fuel gas chromatographs (to monitor fuel gas composition) and performance pre-heaters are used to help control the fuel systems and adjust key parameters such as modified Wobbe
- We also understand that for this reason GT OEMs accept a certain variability of gas composition within a certain range (15%?) with the GT online

Response to SSE Submission (4)

Concern 3:

- **"The proposed increase in CO_2 of the gas composition will increase the amount of CO_2 released to the atmosphere and will lead to additional costs for gas turbine operators because they will have to pay for the increase in inherent CO_2 through EU ETS liabilities."**

Response 3:

- **For clarity it is not the operators of the terminals/system entry points at Teesside who are proposing to increase the CO_2 content in the gas arriving via CATS at Teesside**
- **The increase is a function of natural increase in CO_2 levels in mature fields and higher CO_2 levels expected in some of the new field developments proposed by others**
- **We believe that Mod 0502 is wholly consistent with the objectives of the recent Maximising the Economic Recovery of the UKCS ("MER") initiative which we understand has broad Government support to encourage production of the remaining UKCS reserves to minimise reliance on imported gas which furthers Ofgem's security of supply objectives**
- **By ensuring production from existing mature fields is not curtailed early (by increasing CO_2 levels) & encouraging new UKCS field developments we believe Mod 502 will lead to lower overall CO_2 emissions than the alternative of building CO_2 removal plants offshore or onshore**

Response to SSE Submission (5)

Response 3 (cont):

- **CO_2 removal requires significant energy both in terms of power and heat for regeneration of the stripping solvent – this heat is provided by burning natural gas which itself creates CO_2**
- **We estimate that for every tonne of CO_2 removed from the gas stream (and then emitted to atmosphere) and additional 0.2 – 0.25 tonnes of CO_2 are produced from the energy consumed in the process**
- **In addition to additional CO_2 emissions, CO_2 removal plants (e.g. amine units) also result in benzene and methane emissions to atmosphere**
- **Hence we believe that our proposed approach would actually result in the lowest overall emissions to atmosphere when compared to the alternative of constructing and operating new CO_2 removal plant either onshore at Teesside or offshore**

Response to Growhow Submission (1)

- **We offer the following observations/initial responses regarding Growhow's submission dated 22nd May 2014;**

Concern 1:

- **"Our CO_2 emissions increase as the additional CO_2 is emitted from our process in addition to the CO_2 we are generating ourselves (this would presumably take the form of an increased emissions factor on the metered incoming gas), leading to higher costs under EU ETS"**

Response 1:

- **We are evaluating the situation under ETS to make sure we understand how CO_2 in the inlet gas to a facility like Growhow is accounted for today**
- **The quantum of any potential impact is not yet established**
- **Given the linkage to Southern North Sea gas at TGPP, the overall content of CO_2 in the gas delivered at the TGPP entry point will differ from that delivered to the CATS entry point.**
- **Note that average actual CO_2 levels (as opposed to the max permitted level) will be less than the max 4.0 mol% proposed**

Response to Growhow Submission (2)

Concern 2:

- **"There would be additional load on our CO_2 removal systems, which are already highly loaded at maximum production rates – so this could become a limit on production rate"**

Response 2:

- **We would like to discuss this impact in more detail with Growhow to better understand their current process scheme and how they handle CO_2 in their inlet gas today**
- **Independent of the results of this Mod it is worth flagging to potentially affected users the gradually increasing trend of CO_2 arriving in offshore gas at Teesside**
- **As discussed when both bp and TGPP presented Mods 0498 and 0502 this trend is unlikely to improve/reverse due to the combination of both ageing fields and new fields with higher levels of CO_2**
- **Given the linkage to Southern North Sea gas at TGPP, the overall content of CO_2 in the gas delivered at the TGPP entry point will differ from that delivered to the CATS entry point.**
- **Note however that average actual CO_2 levels (as opposed to the max permitted level) will be less than the max 4.0 mol% proposed**

Response to Growhow Submission (3)

Concern 3:

- **“Calorific value is reduced, so our volume of gas consumed needs to increase, this will increase pressure drop in the distribution pipework (both NG system and customers own distribution system)”**

Response 3:

- **We think the effect on CV is minor and within the specification limits within the NEA/GSMR**
- **GCV already varies significantly depending upon offshore production**
- **By increasing CO_2 content of the export stream from 2.9 mol% to 4.0 mol%, HYSYS simulation results show a reduction in GCV of 1.13% and a reduction in Wobbe of 1.88%**
- **We are looking into this further and will also check the concern with NGG regarding the network itself**

Response to Growhow Submission (4)

Concern 4:

- **"The CO_2 acts a diluent, so where we are trying to achieve high temperatures (e.g. in reformer furnaces) we have more mass to heat, which consumes more energy (minor effect)"**

Response 4:

- **We think this is probably a minor effect**
- **By increasing CO_2 content of the export stream from 2.9 mol% to 4.0 mol%, HYSYS simulation results show a reduction in GCV of 1.13% and a reduction in Wobbe of 1.88%**

Response to Tata Submission

- **We offer the following observations/initial responses regarding Tata Steel submission dated 12th May 2014;**

Concern 1:

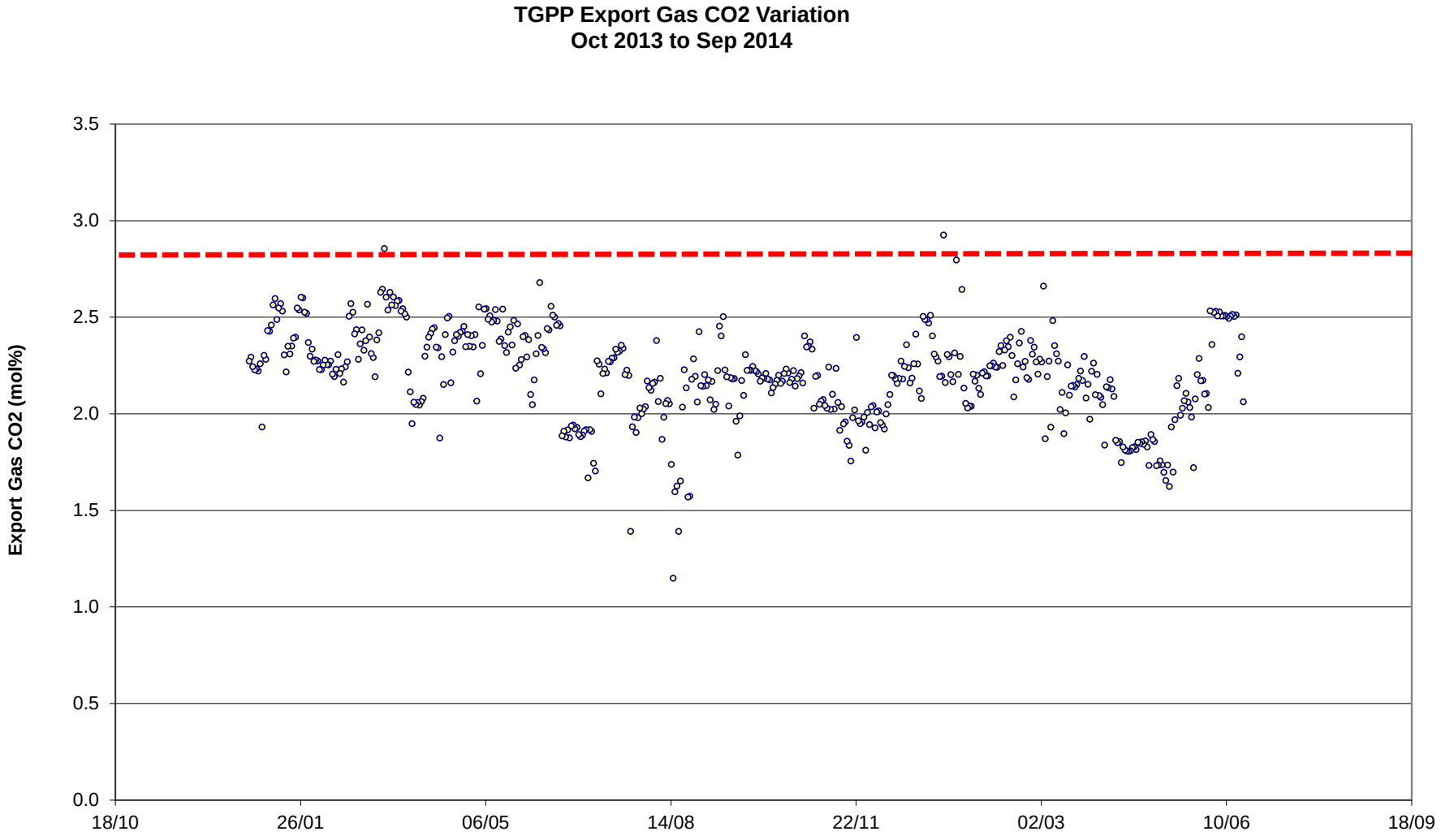
- **“One point on Mod 0502 on which our technical colleagues have asked for clarification . In summary we are asking if the range of CV (or Wobbe) that the suppliers provide will be effected by modification 0502 - we can't see a reference to what impact the proposed change will have on the quality of gas supplied to consumers in the modification document. In technical terminology (not my own), then our RDT unit comments:**

  "If the added CO_2 displaces a 'high' hydrocarbon the effect on these will be different to the displacement of a 'low' hydrocarbon. A quick calc suggests that the move from 2.9% to 4%, with a reduction in CH_4, will reduce the CV by about 1% and the Wobbe by 2%." Whilst the overall impact will be small, we would prefer specific reference to this aspect.”

Response 1:

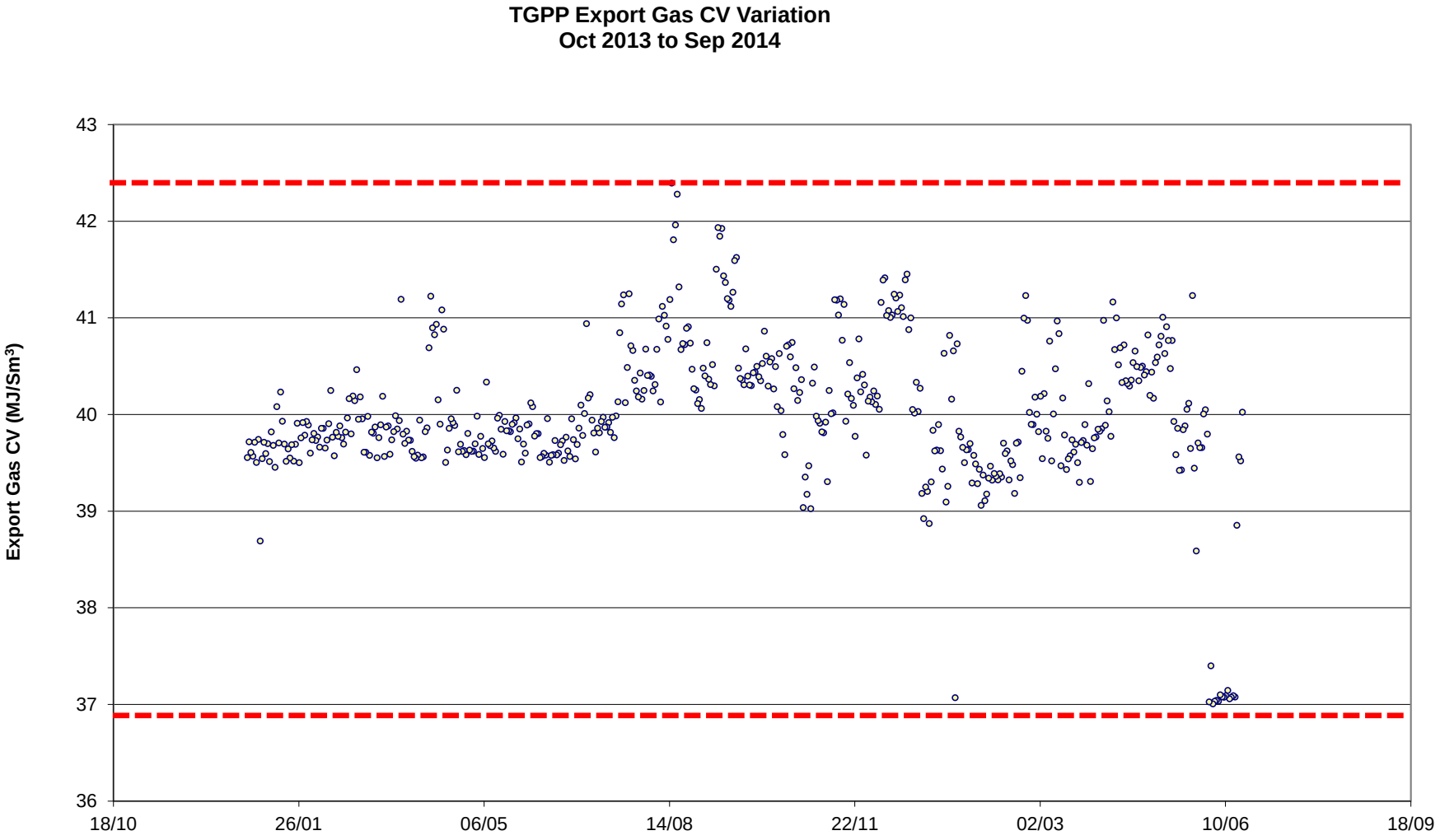
- **We have modelled this with other components normalised, i.e. uniformed displacement of all hydrocarbon species not just low or high hydrocarbons molecules**
- **By increasing CO_2 content of the export stream from 2.9 mol% to 4.0 mol%, HYSYS simulation results show a reduction in GCV of 1.13% and a reduction in Wobbe of 1.88%**
- **Note that average actual CO_2 levels (as opposed to the max permitted level) will be less than the max 4.0 mol% proposed**

Action 0601 – TGPP historic gas quality



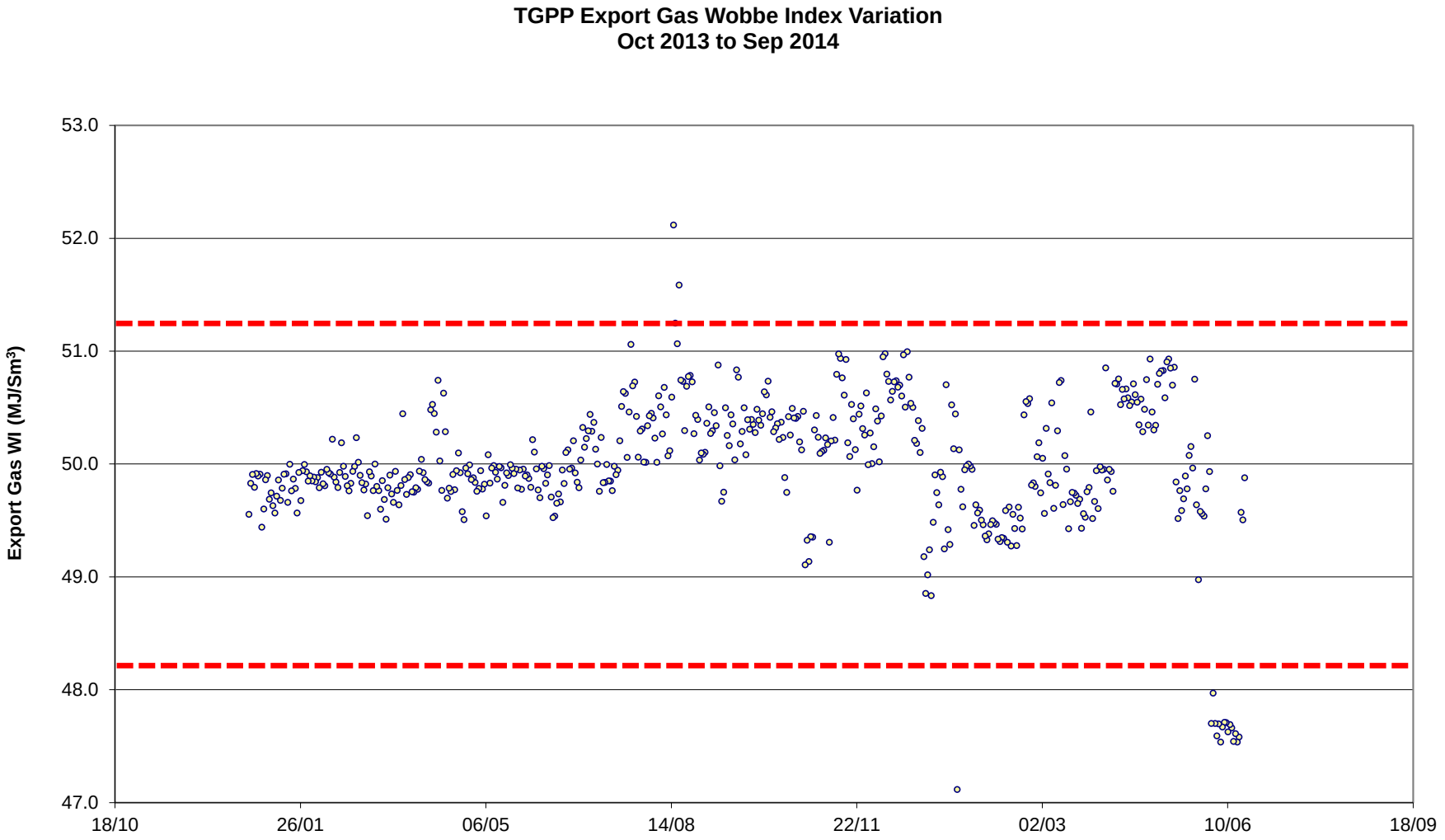
Teesside Gas Processing Plant

Action 0601 – TGPP historic gas quality



Teesside Gas Processing Plant

Action 0601 – TGPP historic gas quality



Teesside Gas Processing Plant

Action 0606 – CO_2 Removal

- There are a number of technologies available for removal of CO_2 from natural gas
- The most suitable technology for a particular application depends on factors such as removal duty, inlet/outlet CO_2 concentrations, contaminants, operating conditions, volumetric flow, downstream processing requirements and relative capital / operating costs
- Based upon likely CO_2 & H_2S partial pressures in the raw gas at the terminal and the required NTS entry specification, most suitable technology to achieve a reduction in CO_2 from 4 mol% to 2.9 mol% for gas delivered to the TGPP entry point is a Formulated Amine Process

Action 0606 – CO_2 Removal

- The Formulated Amine Process consists of an absorber column and regeneration unit
- Amine solution flows against gas stream in an absorber column. CO_2 is absorbed producing a sweetened gas stream and CO_2 rich amine solution
- Rich amine is routed to the regeneration unit where it is flashed to low pressure and heated producing a CO_2 stream for venting and lean solvent routed back to the absorber.
- Apart from capital cost, significant heat input is required to regenerate the amine and also to regenerate the TEG/MEG used to dehydrate the gas after passing through the amine unit
- Heat is usually supplied by a hot oil system heated by natural gas - this generates further CO_2 emissions in addition to the CO_2 extracted from the natural gas
- Electrical power is required to drive pumps and control systems

Action 0606 – CO_2 Removal

- Recovered CO_2 vented to atmosphere (no other solution practical for these quantities)
- Benzene and some Methane are also recovered with the CO_2 and vented
- Quantity of CO_2 recovered and vented to atmosphere depends on volumetric gas flow and concentration of CO_2 in the natural gas stream
- We estimate that for every 100 te of CO_2 removed an additional 20 to 25 te of CO_2 is created through burning gas to provide required process heat
- Capital costs for a CO_2 removal unit at the TGPP system entry point not yet confirmed but we concur with the BP estimates
- It is our view that installing CO_2 removal at TGPP, e.g. the amine unit described above, actually results in increased CO_2 emissions due to the heat an electrical power required