Pale Blue Dot.

ARUP

Pinsent Masons

2018

CO2 Transportation and Storage Business Models - Appendix

10251BEIS-Rep-01-04

January 2018

www.pale-blu.com

Contents

Disclaimer:

While the authors consider that the data and opinions contained in this report are sound, all parties must rely upon their own skill and judgement when using it. The authors do not make any representation or warranty, expressed or implied, as to the accuracy or completeness of the report. The authors assume no liability for any loss or damage arising from decisions made on the basis of this report. The views and judgements expressed here are the opinions of the authors and do not reflect those of the client or any of the stakeholders consulted during the course of this project.

TABLES

1.1.1 Non - CO_2 Related

1.1.1.1 Bergermeer Gas Storage Netherlands

<table>
<tr><th colspan="3">Infrastructure Case Study: Bergermeer Gas Storage Netherlands</th></tr>
<tr><td colspan="2">Summary
Development and operation of a large Netherlands onshore natural gas storage facility. Involving construction of a gas treatment installation, 14 new wells, existing well conversions, 40km of pipelines; operation of gas storage facility and; related Gas trading activity. Financial close in Feb 2014, operational April 2015.</td><td>Value Proposition
• Provision of a commercial gas storage service to multiple customers</td></tr>
<tr><td>Ownership
• Upstream contractual JV called GSB
• Equity participation 60% Taqa, 40% EBN (Government)
• Operated by Taqa</td><td>Funding
• €850m design and construction equity funded by JV partners (60% Taqa, 40% EBN)</td><td>Revenue
• Fees for capacity and usage (injection, space and withdrawal)
• Capacity is made available to users by auction (based on a standard services agreement)</td></tr>
<tr><td>Obligation to customers
• To inject, store and produce gas volumes according to their standard services agreement
• To meet availability obligations</td><td>Government
• 40% equity partners through EBN (non operator)
• 40% Government involvement mandatory
• 30 year gas storage licence & approval
• Gas storage is of strategic significance to the Dutch government</td><td>Risk
• Availability risk; beyond agreed times, sits with the JV (compensation payments based on booked capacity and capped)
• Counterparty risk; managed by having a credit limit set based on customers credit rating and net worth (limits capacity booking)</td></tr>
</table>

Table 1-1. Bergermeer Gas Storage Netherlands business model canvas

1.1.1.2 London Array OFTO

<table>
<tr><th colspan="3">Infrastructure Case Study: London Array OFTO</th></tr>
<tr><td colspan="2">Summary
The owner and operator of the offshore transmission network that connects London Array to the National Electricity Transmission Network (NETS) is licenced as an OFTO under Ofgem's OFTO framework (Round 2). The London Array Wind farm has a capacity of 630 MW and is located around 20 km from the Kent and Essex coast in the outer Thames estuary. It has been operational since 2013.</td><td>Value Proposition
• Regulated return on private infrastructure investment over 20 years
• Competitive tender for OFTO for selection
• This case is a purchase and operate (not incl design and build)</td></tr>
<tr><td>Ownership
• Blue Transmission London Array Limited (a consortium comprising 3i Group Plc and Diamond Transmission Corporation Limited, a UK subsidiary of Mitsubishi Corporation).</td><td>Funding
• Private equity and debt to acquire the assets post construction from the generator, London Array Ltd
• Bank and EIB debt funding, 83% gearing level</td><td>Revenue
• A regulated, 20-year revenue stream in return for purchasing the transmission assets from the offshore wind generator
• Payments are fixed, subject to agreed adjustment mechanisms
• Risk/reward based on availability, with a floor at 10% deduction in any one year</td></tr>
<tr><td>Obligation to customers
• Transmission of electricity based on contractual terms
• O&M activity is sub-contracted (back) to London Array Limited</td><td>Government
• Regulated by Ofgem
• Various consents/permits
• Lease from Crown Estate</td><td>Risk
• Asset availability (rather than utilisation)
• Decommissioning
• Some ‘unforeseen’ costs</td></tr>
</table>

Table 1-2. London Array OFTO business model canvas

1.1.1.3 Thames Tideway UK

<table>
<tr><th colspan="3">Infrastructure Case Study: Thames Tideway UK</th></tr>
<tr><td colspan="2">Summary
25km ‘super sewer’ for London at a cost of £4.2bn, with construction between 2016 and 2023. Being designed, built, financed and operated by an SPV (Bazelgette Tunel Ltd) owned by several institutional investors. The SPV has contracted with 3 consortia to build different sections of the tunnel.</td><td>Value Proposition
• SPV long term infrastructure investment with commercial returns protected by legislation
• Government want to build critical infrastructure with low cost off balance sheet project</td></tr>
<tr><td>Ownership
• Thames Tideway Tunnel is owned by the SPV
• SPV acts as an independent infrastructure provider holding regulated utility licence, regulated by Ofwat.</td><td>Funding
• SPV shareholders committed £1.27bn equity and shareholder loans. Other funding by debt including revolving credit facility, a loan to 2051 from EIB and bond programme.
• Government Support Package: Contingent financial support where insurance claims exceed limits or insurance not available; Contingent govt equity finance when SPV cannot secure finance; £500m govt debt available if SPV cannot secure debt in market; Govt step-in provision for equity and debt if Thames Water cannot pay its debts; Buy-out provisions for equity, debt and hedging providers under special conditions.</td><td>Revenue
• Regulated return under a licence with Ofwat
• Monthly fee directly from water customers. SPV charges Thames Water sufficient to recover its capital and operating costs. Return on capital is 2.497% to 2030. After 2030 Ofwat income is set based on WACC and regulated asset value in line with other regulated water utilities.</td></tr>
<tr><td>Obligation to customers
• To provide an operating asset</td><td>Government
• 125 year licence to operate the tunnel
• Provide support package (above)</td><td>Risk
• Construction delivery risks with SPV. Strong incentives and penalties in the contractual arrangements (on construction time, quality and cost). Risks generally subcontracted
• Availability risk with SPV (maintenance and operation)
• (SPV exposure to cost over run is capped)
• (SPV not exposed to usage risk)</td></tr>
</table>

Table 1-3. Thames Tideway UK business model canvas

1.1.1.4 Rehden Gas Storage Germany

Infrastructure Case Study: Rehden Gas Storage Germany		
Summary Rehden provides storage capacity to gas shippers and traders who exploit the seasonality in gas prices or who use gas storage to respond to their contractual obligations The Rehden storage unit represents 20% of Germany's total storage capacity making it the largest gas storage asset in Western Europe. Rehden is located south of Bremen, at a major intersection of gas transmission pipelines that extend to neighbouring gas transmission systems. Operating since 1993.		**Value Proposition** • Commercial gas storage service
Ownership • Wingas GmbH, part of Gazprom	**Funding** • [Due to the age of the infrastructure no details provided]	**Revenue** • Fees from injecting storing and producing gas. Fee terms depend on term of contract, period of storage and season
Obligation to customers • Contractual obligations of injection storage and production on demand	**Government** • Licence of storage facility	**Risk** • Availability and HSE • Commercial risk

Table 1-4. Rehden Gas Storage Germany business model canvas

1.1.1.5 NEMO Interconnector

Infrastructure Case Study: NEMO Interconnector		
Summary NEMO is a 1GW electricity interconnector between Zeebrugge in Belgium and Richborough, Kent, UK with a length of 140 km. It is the first interconnector to be awarded the Cap and Floor regime and is expected to be operational by the end of the decade (2019).		**Value Proposition** • Commercial interconnector service with regulated annual cap and floor based return on infrastructure investment over 25 years
Ownership • National Grid, UK TSO, Belgium TSO (Elia)	**Funding** • National Grid Electricity Transmission (NGET) is a regulated subsidiary of National Grid Plc, a private, publicly listed company. The Belgian TSO, Elia, is owned by Elia Group whose core shareholder is Publi-T SCRL. Publi –T was founded as a holding company which represents a number of municipalities to take this strategic share (44.97%) in Elia on behalf of the public sector. 41.41% of shares are free-float. For medium to long term funding, Elia uses Eurobonds. • Floor repays debt over 25 years	**Revenue** • Capacity contracts with traders, suppliers and generators • Ancillary services in either of the connected electricity markets, including providing capacity via ancillary services and capacity auctions • Regulated cap and floor vs revenue and costs reviewed every 5 years
Obligation to customers • Capacity availability for flow of electricity between national electricity markets.	**Government** • The regulatory cap and floor regime was jointly determined and agreed between Ofgem and the Belgian regulator (CREG) in December 2014. • Ofgem and CREG award the Interconnector Licence	**Risk** • 'Inefficient' construction/operation costs • Other cost escalation between 5 year review periods • Revenue risk • Availability risk/reward

Table 1-5. NEMO Interconnector business model canvas

1.1.1.6 Swedegas gas transmission pipelines

Infrastructure Case Study: Swedegas gas transmission pipelines		
Summary Swedegas is the owner of the gas transmission network in Sweden, which primarily serves an area of south-west of the country, with a total length of 601 km. The average annual demand is 1.2 Bn Nm3 of gas. The first section of pipeline became operational between 1985 and 1988, making this one of the most modern gas transmission pipelines in Europe. Swedegas also acts as system balance administrator		**Value Proposition** • Provision of gas transmission services on a regulated asset basis
Ownership • Swedegas is jointly owned (50-50%) by the Spanish and Belgian gas network companies Enagás and Fluxys, acquired from EQT Infrastructure in 2015. EQT Infrastructure had acquired Swedegas in 2010.	**Funding** • Funded by the state and subsequently privatised	**Revenue** • Allowed revenue set by the Swedish regulator in 4 year terms to cover controllable costs, fees, taxes, and WACC • Transmission charges are charged to suppliers and thus recover the allowed revenue.
Obligation to customers • Gas transmission based on contractual obligations	**Government** • Swedish regulator Ei sets the annual allowed revenue	**Risk** • Unexpected costs within the 4-year period • Network pressure is supplied from the Danish system. • The regulated revenue includes a volume sensitivity and thus presents some uncertainty.

Table 1-6. Swedegas gas transmission pipelines business model canvas

1.1.1.7 UK OFTO Regime

<table>
<tr><th colspan="3">Infrastructure Case Study: UK OFTO Regime</th></tr>
<tr><td colspan="2">Summary
The Offshore Transmission Owner regime was established in 2009 by the Government and Ofgem to deliver transmission infrastructure to connect offshore generation assets to the onshore transmission system. The total allowed revenue reported by thirteen OFTO licensees at 31 March 2016 was £227 million, and the total capital value is £2.53 billion. Since the first licence was granted (ie: March 2011) to March 2016, OFTOs enabled the transmission of over 13 TWh of electricity to the onshore network from the offshore wind farms.</td><td>Value Proposition
• 20-year regulated revenue stream in return for providing transmission services</td></tr>
<tr><td>Ownership
• An OFTO is granted a licence following a competitive tender process run by Ofgem against specified evaluation criteria
• the OFTO regime provides two models: "Generator Build" and "OFTO Build"</td><td>Funding
• Generally private equity and debt</td><td>Revenue
• 20 year revenue bid (indexed to inflation) to cover build/acquisition, operation, maintenance, decommissioning
• Adjustments for; availability, pass through items, market rates and indexation</td></tr>
<tr><td>Obligation to customers
• Transmission of electricity in accordance with contractual obligations</td><td>Government
• Ofgem provides licence to OFTO with obligations, incentives and entitlements</td><td>Risk
• Construction risk (in the build option)
• Operational risk
• Financing risk
• Revenue stream fixed for 20 years</td></tr>
</table>

Table 1-7. UK OFTO Regime business model canvas

1.1.1.8 UK Military Flight Training System

Infrastructure Case Study; UK Military Flight Training System		
Summary The UK Military Flight Training System (UKMFTS) was launched by the Ministry of Defence in August 2009 as a significant Public Private Partnership (PPP) to provide comprehensive training to UK armed forces aircrew for a period of 25 years. Under UKMFTS, the Ministry of Defence maintains the training output requirements and standards whilst providing elements such as airfields, fuel and instructors. The private sector partner designs the overall system and delivers the training capability including the procurement of aircraft and simulators.		**Value Proposition** • Commercial service delivery for a 25 year contract
Ownership • Ascent is a 50/50 JV between Lockheed Martin and VT Group	**Funding** • First phase capital of £71.3m was funded by £8.2m JV equity and £63.1m bank debt • Total cost, funded by gov but managed under the contract is >£3.2bn, including aircraft procurement and construction activity	**Revenue** • Incentivised payment mechanism • Payments for training system design, procurement of new aircraft and Training Services availability
Obligation to customers • MoD are the customer for whom flight training services are provided	**Government** • Mod as customer with significant involvement in many aspects of delivery	**Risk** • Contract performance • Project risk

Table 1-8. UK Military Flight Training System business model canvas

1.1.1.9 Greater Manchester Waste

Infrastructure Case Study; Greater Manchester Waste		
Summary This waste disposal project is located in the north of England as part of a £3.8 billion waste PFI contract. The project will include biological treatment plants, material recovery facilities, composting plants, transfer loading stations and waste recycling centres. The facilities were developed across sites in Rochdale, North Manchester, South Manchester, Oldham and Stockport, and will handle 1.4 million tonnes of municipal waste per year. The project is considered the largest waste PPP in Europe and marks the first lending from the UK Treasury's Infrastructure Finance Unit, set up to lend to infrastructure projects during the credit crunch.		**Value Proposition** • Commercial waste disposal business under a PPP/PFI
Ownership • Viridor Laing is a 50/50 JV between Viridor and John Laing • The PFI contract was procured by competitive tender by Greater Manchester Waste Disposal Authority (GMWDA)	**Funding** • Viridor Laing provided £90m in equity, £582m debt (£245m commercial/bank debt and £337m non commercial debt) • Capital contribution of £70m by GMWDA	**Revenue** • Monthly unitary charge comprised of; base fee, tonnage adjustments, incentive payments, bonus payments • Power Purchase Agreement from refuse derived fuel of £30/MWh
Obligation to customers • Contractual obligations of waste disposal with GMWDA	**Government** • GMWDA is the customer • Investment from Infrastructure Finance Unit (£120m debt) and GMWDA (£70 capital grant)	**Risk** • Construction and operational risk, with the exception of; permitting, demand beyond agreed limits and risk sharing for certain changes in law

Table 1-9. Greater Manchester Waste business model canvas

1.1.1.10 Gas Peaking Plant

<table>
<tr><th colspan="3">Infrastructure Case Study: Gas Peaking Plant (UK - name confidential)</th></tr>
<tr><td colspan="2">Summary
This is a gas-fired power plant located on an industrial estate in the UK. It is a gas fired backup power station that operates when there are high levels of demand for electricity (peak demand) or shortfalls of electricity supply. In the UK peaking stations functioned primarily in the Short Term Operating Reserve (STOR) market and recently the Capacity Market.</td><td>Value Proposition
• Commercial power plant focused on short term market needs</td></tr>
<tr><td>Ownership
• The developer owns the plant.</td><td>Funding
• [information not available]</td><td>Revenue
• The majority of revenues are associated with sales of electricity to the intra-day power markets, capacity market payments, embedded benefits and revenues from the balancing market.</td></tr>
<tr><td>Obligation to customers
• This power plant is expected to operate for 500-1,000 hours per annum to capture revenues associated with the Capacity Market, the balancing market, embedded benefits and the wholesale market.</td><td>Government
• Ofgem (and National Grid) setting to policy and commercial instruments</td><td>Risk
• UK market and network policy changes including Carbon Price Floor
• Competing electricity generation options
• Market demand and changes in market
• Gas price</td></tr>
</table>

Table 1-10. Gas Peaking Plant business model canvas

1.1.1.11 UK Nuclear Decommissioning Authority

<table>
<tr><th colspan="3">Infrastructure Case Study: UK Nuclear Decommissioning Authority</th></tr>
<tr><td colspan="2">Summary
The UK Nuclear Decommissioning Authority (NDA) carries the responsibility and cost for disposal of almost all the legacy and current nuclear power station spent fuel in the UK. The NDA determines the overall strategy and priorities for managing decommissioning. It owns interim stores at Sellafield and rail/shipping assets. A Geological Disposal Facility is planned. NDA has 200 staff and owns 17 sites across the UK</td><td>Value Proposition
• Managing the socio/environmental legacy of nuclear projects
• Decommissioning and clean up costs expected to be ~£65bn</td></tr>
<tr><td>Ownership
• NDA is an executive non-departmental public body
• The NDA does not directly manage the UK's nuclear sites. It oversees the work through contracts with specially designed companies known as site licence companies</td><td>Funding
• Funded by government</td><td>Revenue
• Government funds NDA to finance disposal of spent fuel
• EDF funds NDA to dispose of AGR spent fuel
• New nuclear projects will build up funds to cover spent fuel disposal and pay funds to NDA when they transfer spent fuel</td></tr>
<tr><td>Obligation to customers
• eliminate site hazards and develop waste solutions;
• ensure the highest standards in safety, security and environmental management;
• build an effective world class industry;
• gain full approval and support from stakeholders (employees, contractors, government, local communities and general public); and
• make best use of assets and maximise value-for-money</td><td>Government
• Government funds NDA
• Activities regulated by ONR
• Extensive legislation and regulation through the Energy Acts</td><td>Risk
• Carried by NDA</td></tr>
</table>

Table 1-11. UK Nuclear Decommissioning Authority business model canvas

1.1.1.12 Varmevarden District Heating

Infrastructure Case Study: Varmevarden District Heating		
Summary Värmevärden is a district heating business focused on the production and the sale of heat to residential, commercial and industrial users. Värmevärden operates as the sole district heating provider at ten municipalities in Sweden.		**Value Proposition** • Commercial provider of district heating
Ownership • Sefyr Holdings is the parent company of Värmevärden, which is jointly owned by Maquarie European Infrastructure Fund 2 (66.7%) and Capstone Infrastructure Corporation (33.3%).	**Funding** • Private commercial funding on an incremental/project basis	**Revenue** • Heating fee • Additional services fees • Fixed plus variable fee structure for industrial customers • Connection fee
Obligation to customers • Provision of heat and other services as contracted	**Government** • Market structure	**Risk** • Normal commercial risks (long and short term demand, competition, electricity price)

Table 1-12. Varmevarden District Heating business model canvas

1.1.1.13 Nippon Vopak oil storage (Japan)

Infrastructure Case Study: Nippon Vopak oil storage (Japan)		
Summary Nippon Vopak operates five oil and chemicals tank terminals in Japan with a combined operations capacity of 203,200 m3. All five terminals are located at major ports. These independent storage terminals in Japan primarily serve domestic markets (largely oil products) and import/export flows (largely chemicals).		**Value Proposition** • Provision of oil and chemicals storage on a commercial basis
Ownership • Nippon Vopak is a joint venture of which is owned by Macquarie Asia Infrastructure Fund (40%), Nippon Express Co., Ltd (40%), and Nagase & Co., Ltd. (20%).	**Funding** • Private commercial funding	**Revenue** • Storage fees (take or Pay) • Handling and transport fees • Annual contracts with extensions • Spot market
Obligation to customers • Product storage (oil and chemicals) • Provision of associated services as contracted	**Government** • No direct involvement	**Risk** • Volatility of demand for stored product • Standard commercial risks

Table 1-13. Nippon Vopak oil storage (Japan) business model canvas

1.1.2 CO_2 Related

1.1.2.1 Weyburn T&S (Canada)

CCS Case Study: Weyburn T&S Canada		
Summary 330km transport of CO_2 from the Great Plains Gasification plant in N Dakota to Weyburn for EOR. 29Mt 'stored' from 2000 to 2016. A 66km pipeline also transports CO_2 from Boundary Dam. The level of monitoring and accounting of CO_2 stored is unclear. 50% of CO2 injected is produced and re-used.		**Value Proposition** • Production of incremental oil using CO_2 for EOR
Ownership • Cenovus operate the EOR field and built the pipeline from Boundary Dam	**Funding** • EOR injection facility and Boundary Dam Pipeline funded by Cenovus	**Revenue** • Oil production provides EOR revenue • CO_2 is purchased at @ $25/t
Obligation to customers • Cenovus have considerable flexibility as to how much CO_2 they take and from which source	**Government** • No current restriction on CO_2 emissions from EOR facilities	**Risk** • Limited risk in this EOR application

Table 1-14. Weyburn T&S (Canada)

1.1.2.2 Quest T&S (Canada)

CCS Case Study: Quest T&S Canada		
Summary T&S of CO_2 from the Quest Oil Upgrader emissions as a part of a single ownership full chain project. CO_2 is transported 40km by pipeline for storage in a saline aquifer through 2-3 wells at ~1Mt/a for 10-25 years. Quest is part of the Athabasca Oil Sands (AOSP) project. Operational since Spring 2015		**Value Proposition** • Emissions reduction a (negotiated) obligation for the Quest/AOSP project consent • Shell have strategic interest in CCS
Ownership • Private sector ownership with 3 JV partners: Shell, Marathon, Chevron	**Funding** • Gov grants cover 75% of incremental costs of CCS • This is paid; 60% up to commissioning, 40% over the first 10 years of operation • Remaining funding from JV partners • Post closure stewardship fund built up by JV during LOF and used for post closure costs & liabilities	**Revenue** • Full chain project; T&S not treated separately • Two Carbon credits for each one tonne sequestered (credits capped at $40/t) • Returns capped at NPV=0, with 2% discount rate • Possible future sale of CO_2 for EOR
Obligation to customers • Single full chain project; No 3rd Party customers. No explicit obligations on T&S	**Government** • 15 year store lease with 15 year option • Regulated by ERCB, active MMV	**Risk** • JV carries leakage risk during injection (credits for CO2) • JV carries performance risk (Construction and operations) • Gov takes over store risk after closure

Table 1-15. Quest T&S (Canada) business model canvas

1.1.2.3 Sleipner

CCS Case Study: Sleipner		
Summary Sequestration of 0.85Mt/a CO_2 separated from natural gas on the Sleipner platform and re-injected into an aquifer at the same location. In operation since 1996. Offshore Norway		**Value Proposition** • CO_2 storage a component of natural gas production
Ownership • Petroleum JV; Statoil 58.35% and operator, ExoonMobil 17.24%, Lotos 15%, Total 9.41%	**Funding** • Funded by the Petroleum JV as part of the field development and production activity	**Revenue** • Sale of natural gas, which requires CO_2 to be separated to meet grid specification of <2.5%. • CO_2 storage is an unremunerated cost, but emissions are taxed in Norway, so storing CO2 avoids cost ($65/t in 2016)
Obligation to customers • T&S not separated from capture/petroleum activities, so no customer • Considerable MMV activity	**Government** • Store originally approved as part of Petroleum Licence • Distinct CO_2 storage approval in 2016 • Tax on CO_2 emissions at $65/t ($35 in 1996) • Increasing obligation to avoid new emissions (Snovhit)	**Risk** • Store and facilities performance and failure • [Single party so no cross chain default risk] • [Long term storage liability unclear]

Table 1-16. Sleipner business model canvas