Modelling Third Party Access to Infrastructure to Maximise Economic Recovery: A Critical Look at the UK Continental Shelf (UKCS)

SPE Aberdeen Petroleum Economics Conference

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Agenda

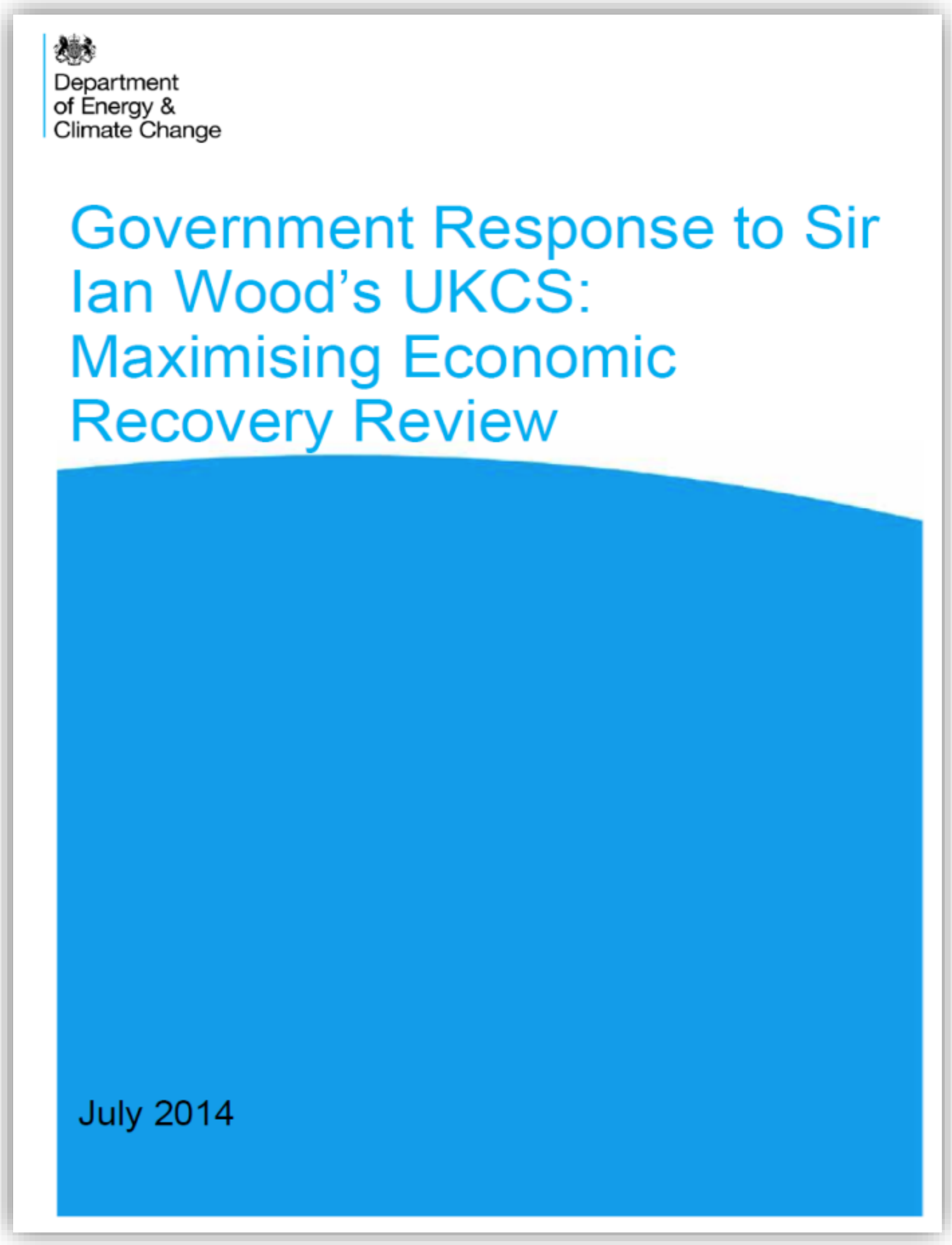
- Scale of the Challenge
- Regulatory Framework for Third Party Access
- Mixed Integer Programming (MIP) Approach
- Results
- Conclusions and Policy Implications

Scale of the challenge

*"The UKCS operating environment has **changed very significantly** in the last 20 years… increasingly **interdependent** for both **production facilities** and **infrastructure***

*…consistent with this and the **increasing need to tie back smaller and more marginal discoveries** into existing – and often ageing - infrastructure, licence holders should make their infrastructure and process facilities available, **subject to their own capacity requirements and technical compatibility,** at **fair and economic commercial terms** and rates to potential third party users."*

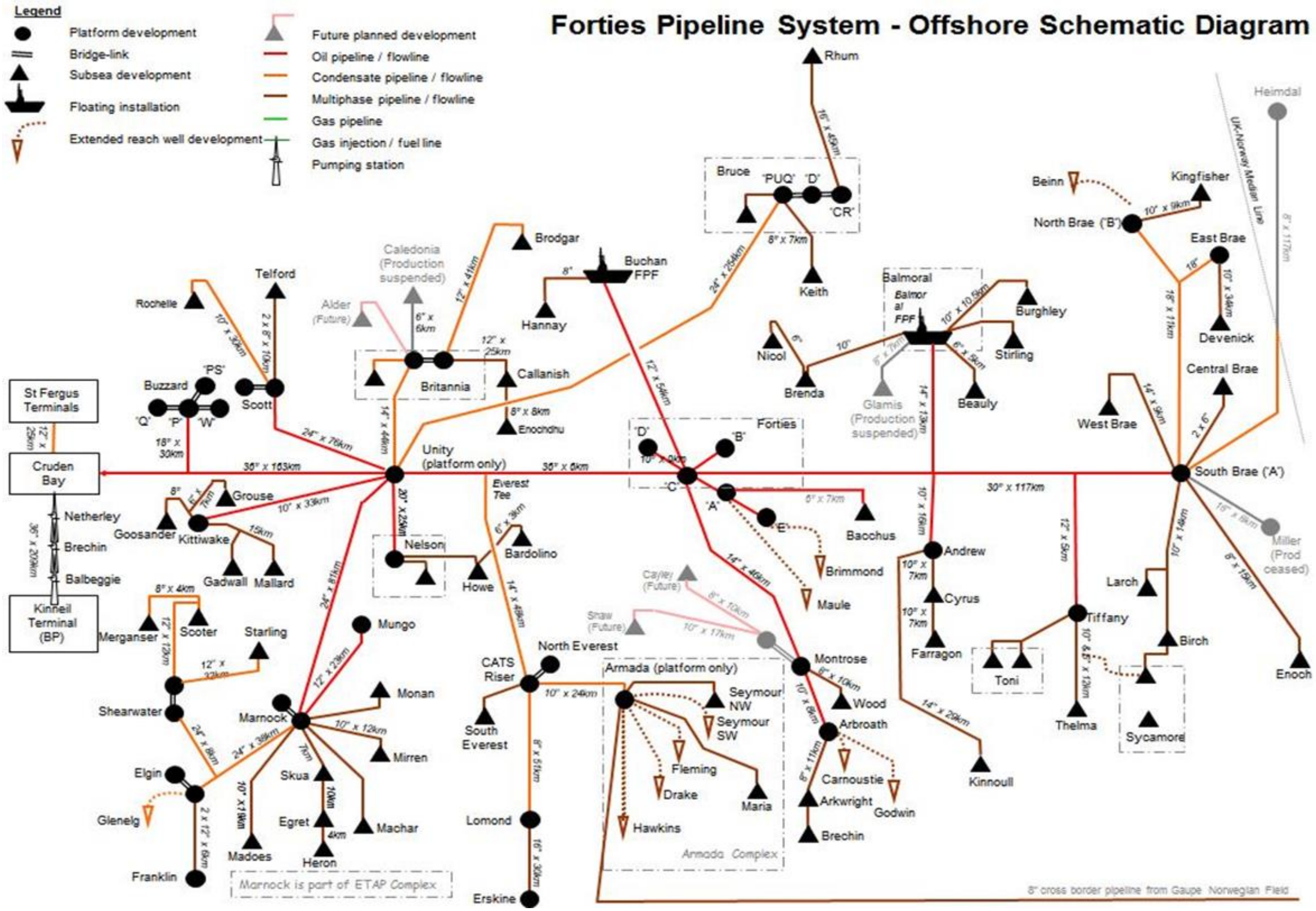
----- *Wood Review, 2014*


Department of Energy & Climate Change

Government Response to Sir Ian Wood's UKCS: Maximising Economic Recovery Review

July 2014

UKCS infrastructure network

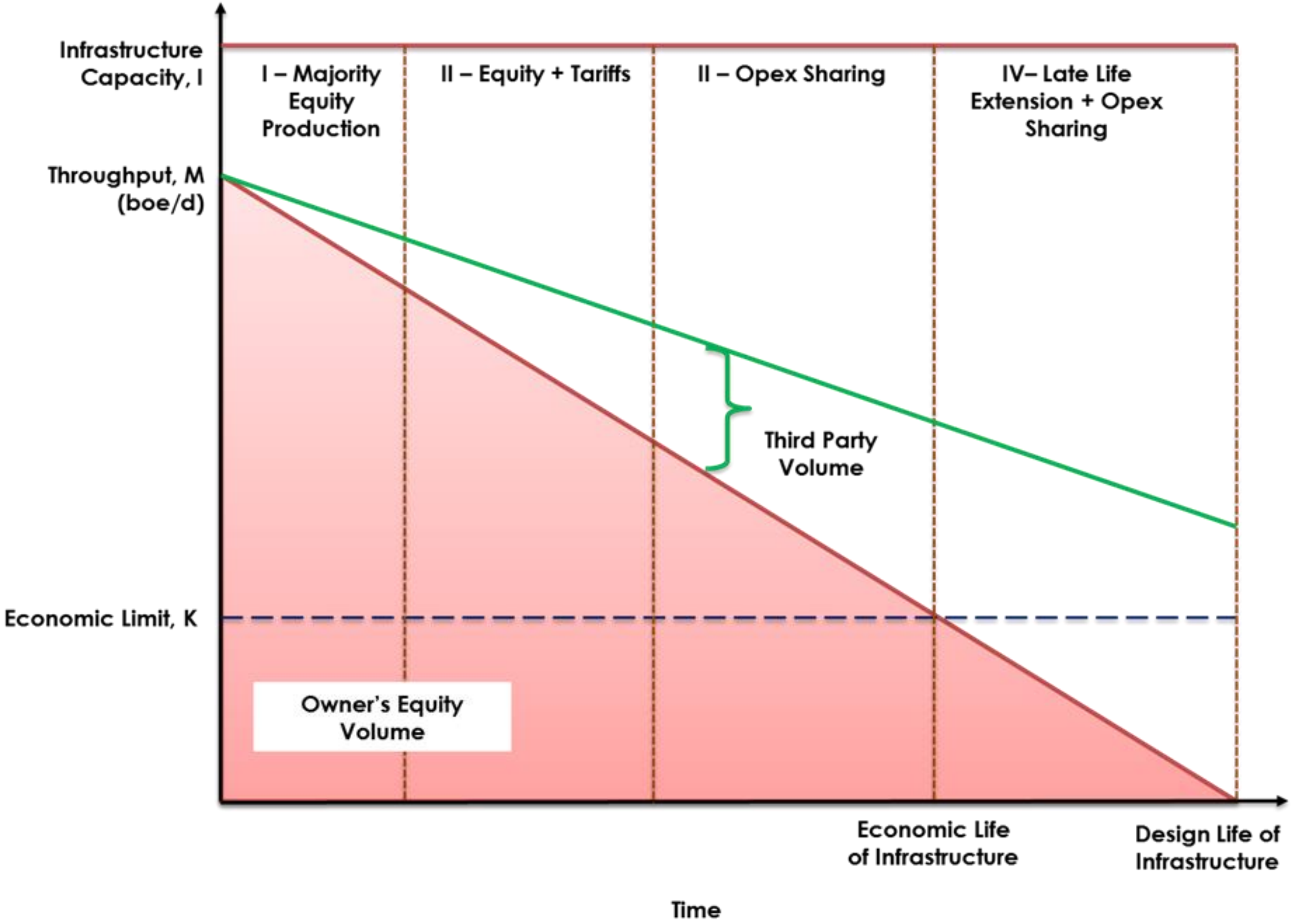


The domino effect is defined as the point at which an **oilfield becomes uneconomic after** a **hub infrastructure's operating cos**ts are **redistributed over the remaining user fields** which in turn **increases costs for the remaining fields until they all become uneconomic**.

As each platform ceases production and is decommissioned, the shared hub infrastructure costs have to be allocated across fewer ($n-1$) platforms which increase unit operating costs.

Source: OGA, 2015

Generic life of an infrastructure asset



Source: Adapted from PILOT, 2005 and 2012

Regulatory framework for Third Party Access

- Done on the basis of **<u>bilateral negotiations</u>** between field developers (potential asset user) and infrastructure owners (potential asset user)

- 'Light-touch regulatory environment' comprising:
  - Voluntary Industry Code through Infrastructure Code of Practice (ICoP)
  - If negotiations fail, OGA can intervene using "determination" – back stop

- Industry Review recognizes need to change status quo – Wood Report, OGA
  - Improvements to ICoP
  - Full unbundling & regulation (similar to onshore electricity and gas network)
  - Open and non-discriminatory access

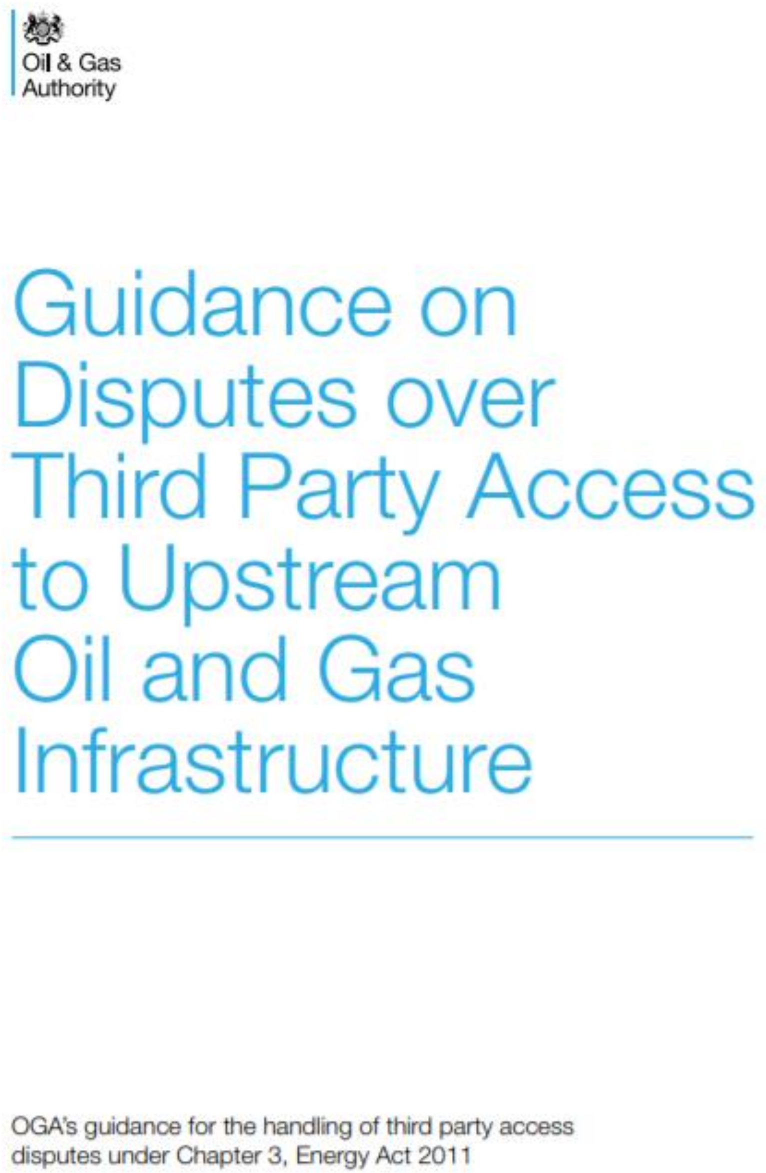
What are the pain points?

Field Developers

- Delays – infrastructure owners prioritise own developments
- Terms – extraction of field rents

Infrastructure Owners

- Emphasis on access costs
- Seven referrals to OGA


Oil & Gas Authority

Guidance on Disputes over Third Party Access to Upstream Oil and Gas Infrastructure

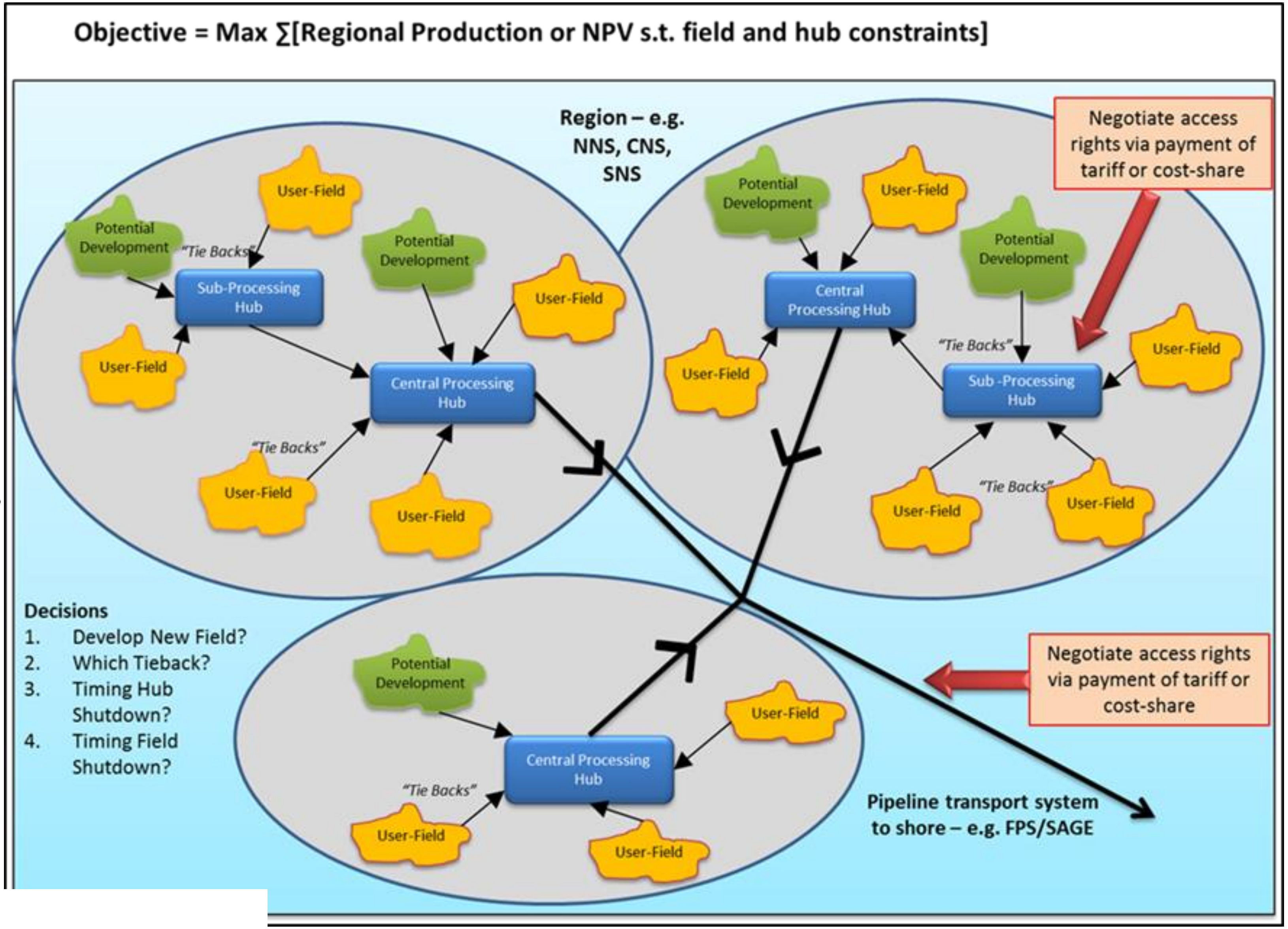
OGA's guidance for the handling of third party access disputes under Chapter 3, Energy Act 2011

Summary of applications received and considered by the OGA under sections 82-84 of the Energy Act 2011 and earlier legislation

Date applied	Applicant	Field	Infrastructure operator	Facility	Outcome	Link to agreed or imposed terms
Apr 2010	Endeavour Energy	Rochelle	Nexen	Scott Platform	Minded to' terms given; parties reached agreement following further negotiation	Rochelle-Scott ICoP Summary
Feb 2011	Apache North Sea	Bacchus	BP	Forties Pipeline System	'Minded to' terms given; parties reached agreement following further negotiation	Bacchus-FPS ICoP Summary
Sep 2013	OMV	Howe	Shell	Nelson Platform	Access terms imposed by a Notice	A summary of the Notice is available below (response to FOI 2015/17155)
Dec 2013	Iona Energy	Orlando	CNR International	Ninian Central Platform	'Minded to' terms given; parties reached agreement following further negotiation	Contact infrastructure owner for summary of agreed terms
Nov 2015	Sterling Resources (UK) PLC	Cladhan	TAQA	Brent System	'Minded to' terms given; parties reached agreement following further negotiation	Contact infrastructure owner for summary of agreed terms
Mar 2018	Maersk	Ballindalloch	Maersk	Gryphon	'Minded to' terms given; parties reached agreement following further negotiation	Contact infrastructure owner for summary of agreed terms
Mar 2018	ConocoPhillips	J-Block	CML	CATS	Application withdrawn; parties reached agreement following facilitated negotiation	Agreement reached on an amendment to the existing Jasmine agreement

Source: OGA, 2018

Mixed Integer Programming (MIP) approach



$$Max\ NPV_{region} = \frac{1}{(1+r)^t}\left(NCF_{hubs} + NCF_{fields}\right)$$

$s.t\ \ cost\ sharing, financial\ viability\ constraints\ plus\ and\ taxation\ changes$

Mixed Integer Programming (MIP) Approach

Building blocks

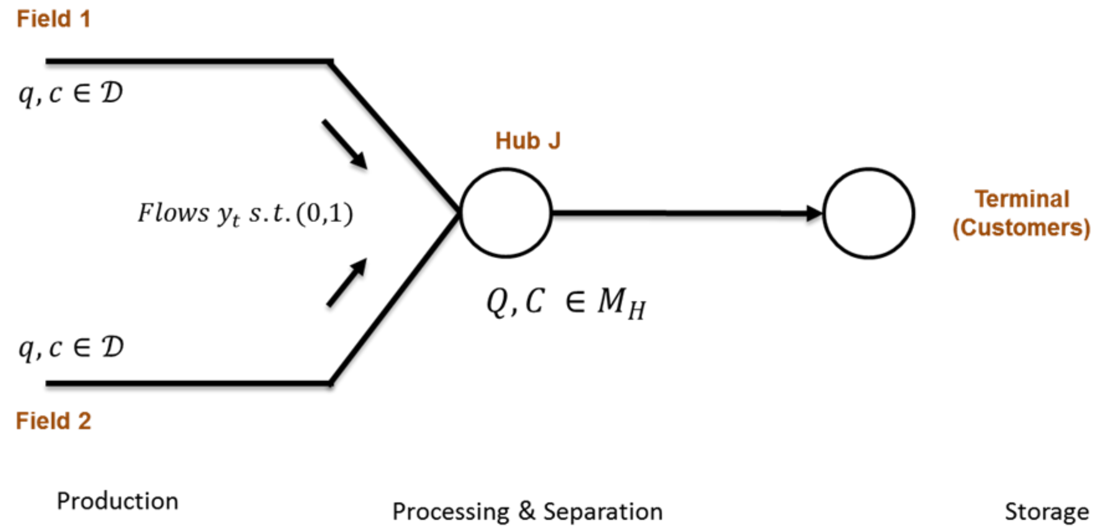
- Data coded using the General Algebraic Modelling System (GAMS) software package with the CPLEX solver, a high-level modelling system for mathematical programming and optimization
- MIP approach provides us the flexibility to allow some of the decision variables to be integer constrained (i.e. whole numbers such as -1, 0, 1, 2, ...) at the optimal solution point – e.g. timing decisions for switching on and decommissioning of hubs and fields take on binary values 0/1.
- Maximizes the post-tax NPV of area production s.t. constraints $Field\ NPV$>0, $Hub\ NPV$>0
- Finds optimal set of new developments (Tiebacks from fields to hubs)
- Timings of hub and field shutdowns

We explore:

- Impact separation of infrastructure and field ownership (unbundling of services)
- Impact of different taxation elements on economic recovery

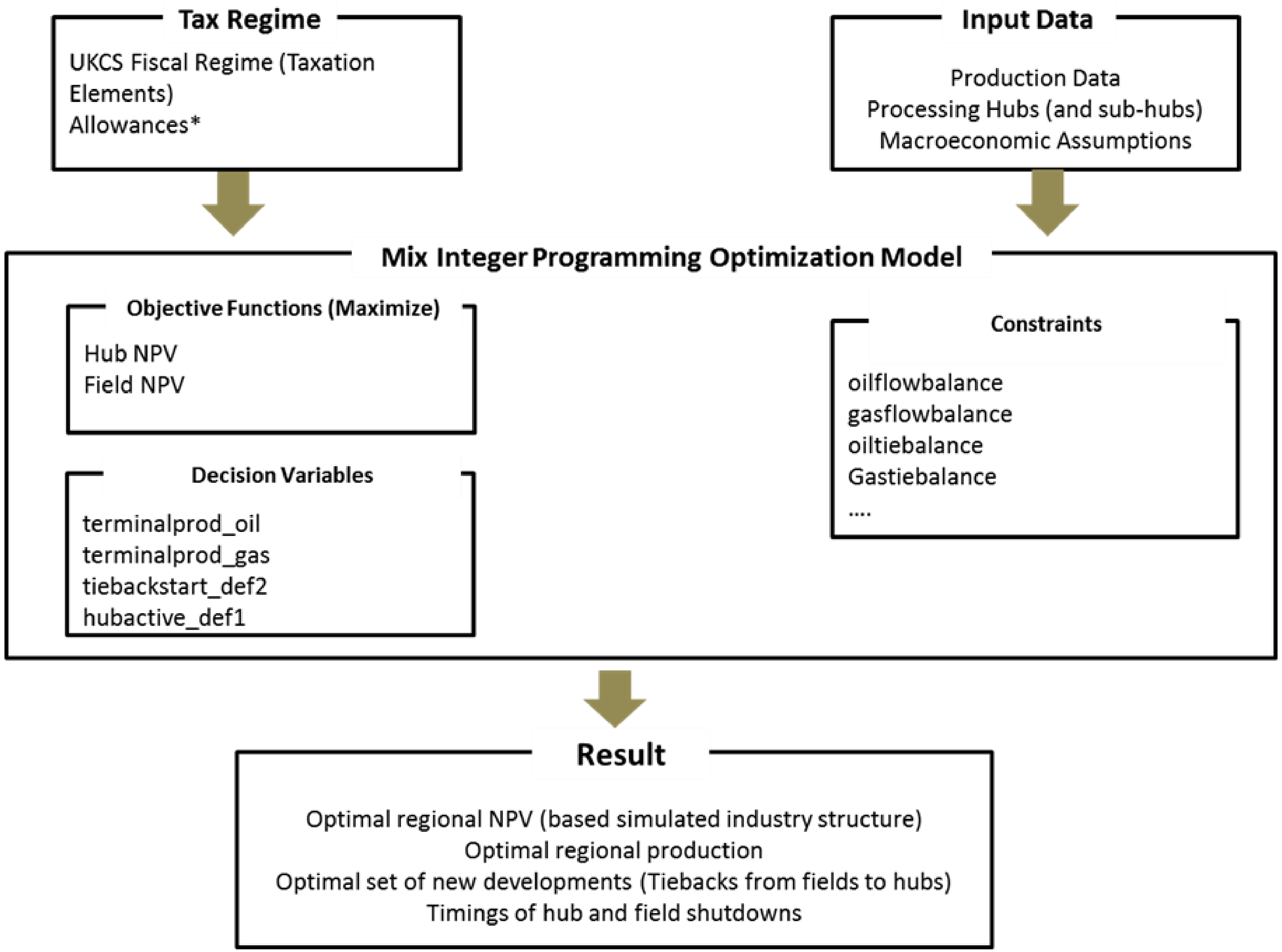
Mixed Integer Programming (MIP) approach

Name	Network Infrastructure Owner	Third Party
Tariff	τ_N	τ_T
Volume Transported	q_N	q_T
Price (Exogenous)	$p_N\,(q_T q_N)$	$p_T\,(q_T q_N)$
Own Activity Costs	$C_N^a(q_N)$	$C_T^a(q_T)$
Transportation Costs	$C_N^t(q_N q_T)$	$C_T^t(q_N q_T)$
Capacity Costs	$C^K(\bar{K})$	



Stages	Cost Factors
Province Objective (NPV_Province)	Devex (Capex and Drillex)
	Decom Costs (Fixed)
	Transport Costs (Fixed)
	Processing Costs (Variable + Fixed)
	Opex (Fixed)
Stages	Subject to:
Oilflow balance	Oil balance at node j inflows plus supply equals outflows
Gasflow balance	Gas balance at node j inflows plus supply equals outflows
Oiltieback balance	Total tieback oil production equals to total production
Gastieback balance	Total tieback gas production equals to total production
Tieback Indicators (0/1)	=1 if Field/Development operating
	=1 if Field/Development decommissions time t
	=1 if Potential New Field/Development activated
	=1 if Tieback between Field/Development and Hub Active
	=1 if Tieback between Field/Development and Hub Activated
	=1 if Hub operating
	=1 if Hub decommissioned in time t

Model superstructure



Model input parameters

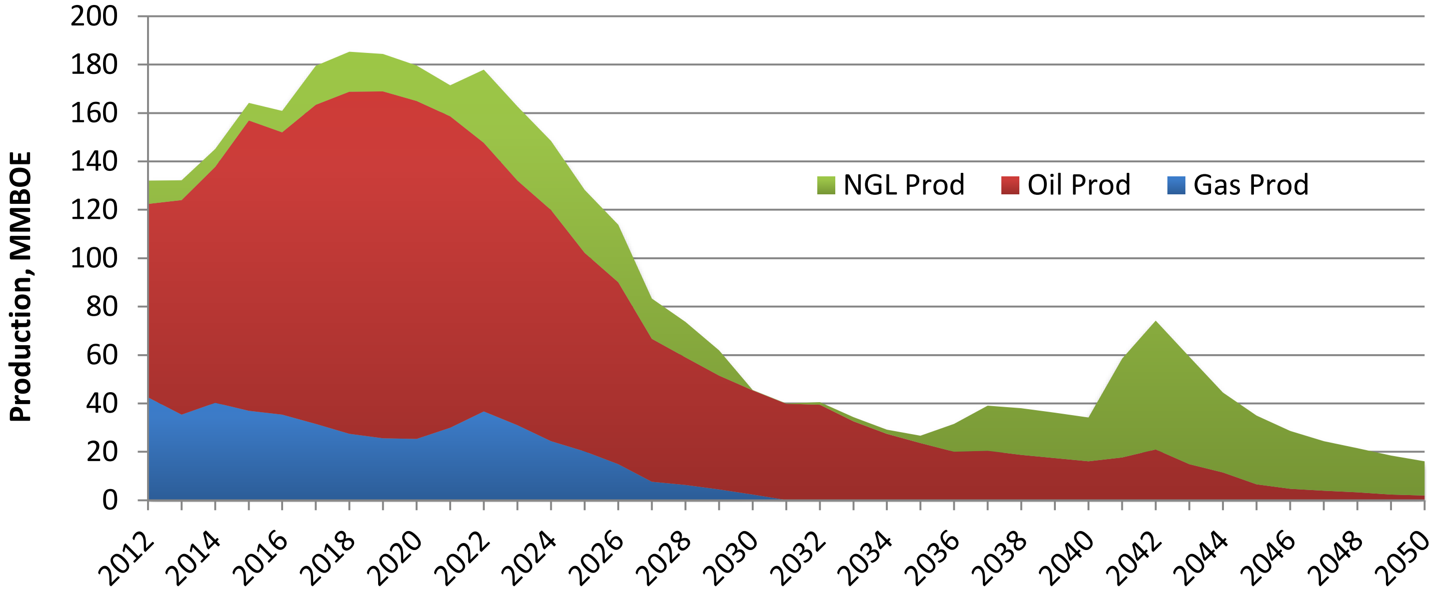
Fields and potential developments

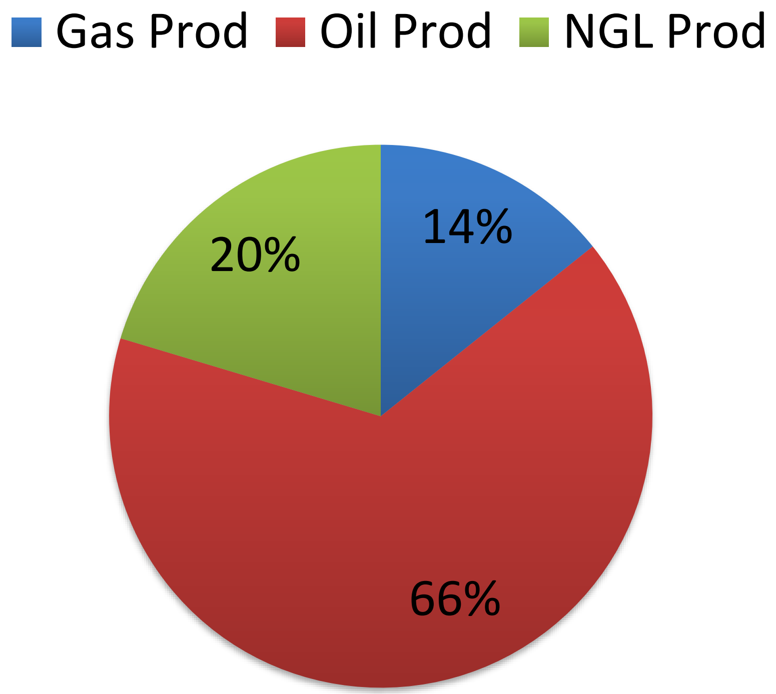
- Sanctioned fields + incremental, future and technical fields:
- Hubs (and sub-hubs) identified

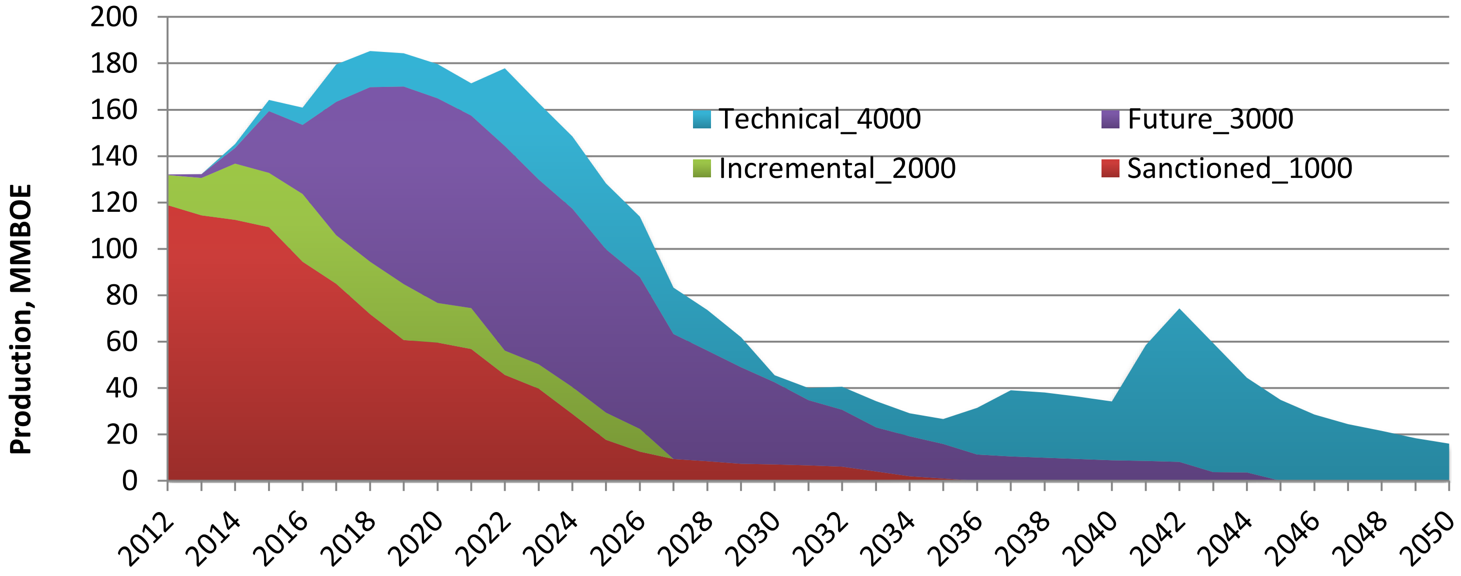
150 developments (actual or potential), 19 associated with hubs and 131 developments that have no associated hubs, 50 Sanctioned, 24 Incremental, 14 Future and 31 Technical developments

Production Data	Processing Hubs (and sub-hubs)
• Production Profiles (User-fields and Potential Developments in a cluster/region up to 2050) • Opex (ex-tariff costs), capex and abex	• Processing costs (OPEX) – tariff, marginal cost or multipart tariff charged by the hub owner. • Transportation costs from hubs to terminals
Macroeconomic Assumptions	**Fiscal Regime (Tax) Elements**
• Oil and gas prices – oil, gas, NGLs • Exchange rate - $1.5287 per £ • Discount factor (cost of capital) – 10%	• Ring Fence Corporation Tax (RFCT) • Supplementary Charge (SC) • Petroleum Revenue Tax (PRT)

Production profile for all models







Model scenarios

The following scenarios considered in the model:

- Explicitly model the impact of cost sharing arrangements under different institutional/market arrangements as present in the UKCS. Here, we impose various financial viability constraints such that both fields and hub cash flows per period (year) must be positive in order to prevent early cessation of production.

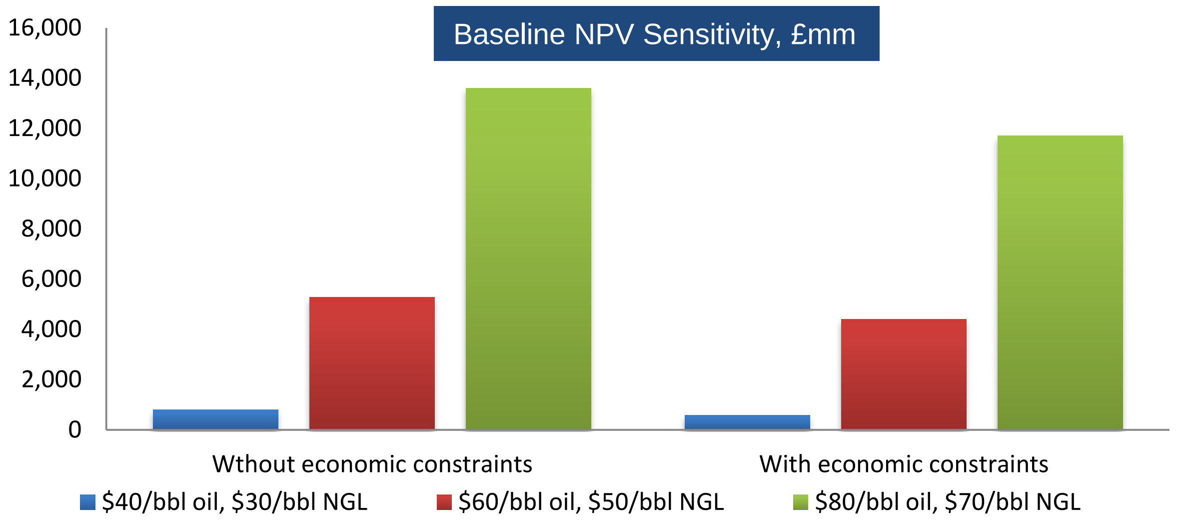
- Explicitly model the impact of fiscal/tax changes on third party access arrangements in the UKCS

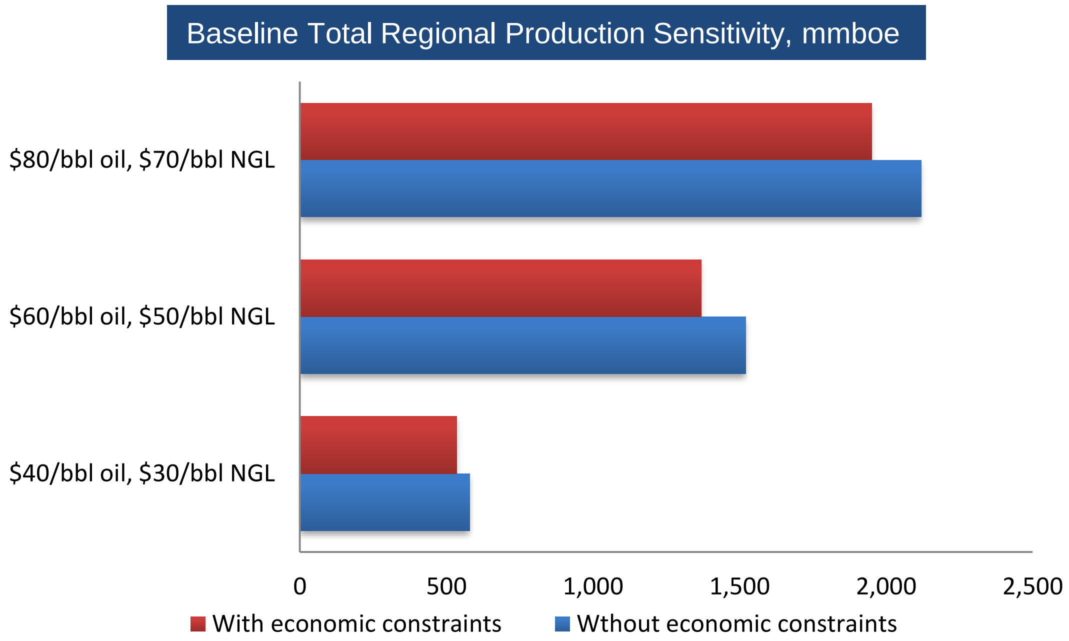
Name	Description
Baseline Model	Base model with individual field and hub financial viability restrictions. Determines optimal new developments, tiebacks, timings of hub and field shutdown to maximise 2012 NNS Net Present Value. No limitations placed on cost shares.
Tax Model	Base Model with individual field and hub financial viability restrictions plus the imposition of various tax elements.
Cost Sharing plus Tax Model	Base Model with individual field and hub financial viability restrictions plus the imposition of tax and cost sharing elements.

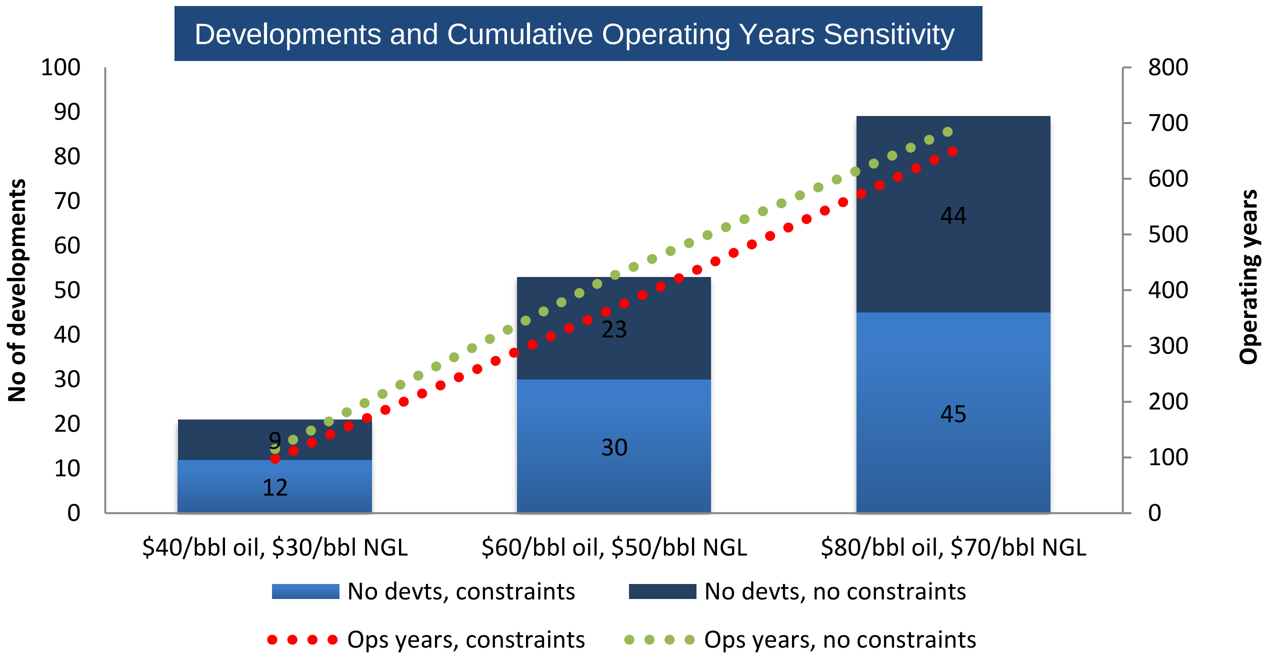
Baseline model results

Base Case NPV Results

Parameter	Without Economic Constraints @$60/bbl	With Economic Constraints $60/bbl
NPV, £m	5,286	4,412
Number of Developments	30	23
Years' Operating	427	368







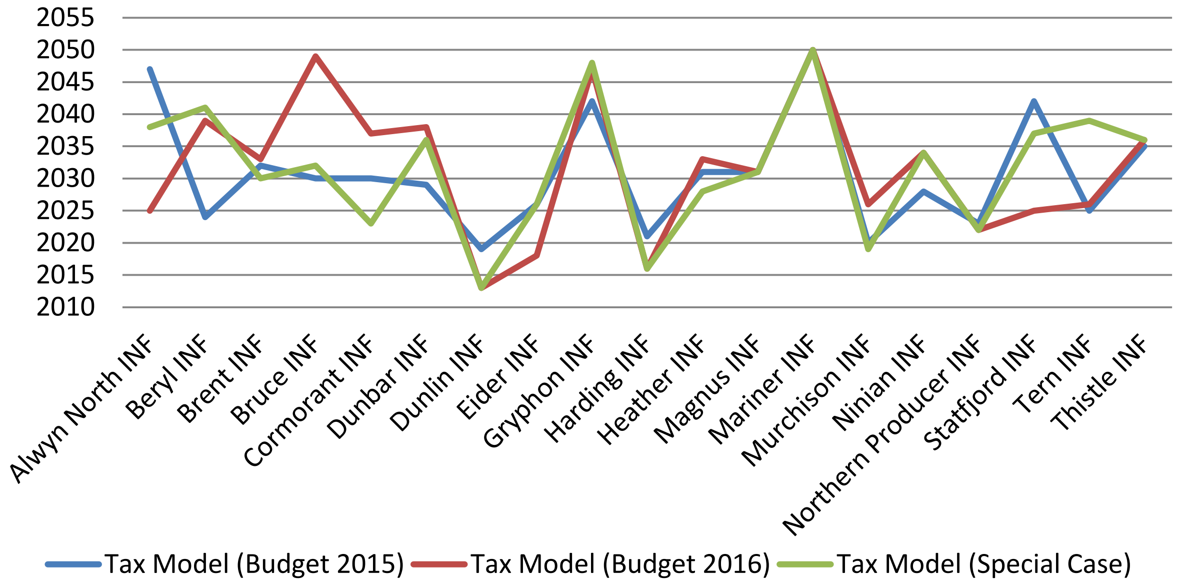
Production profiles associated with respective oil prices confirm the trend of more value being unlocked in terms of oil and gas extracted under the theoretical single regional owner-operator as compared to imposing economic constraints. From

Tax model results

Base Case Tax Results

Scenario	Post-Tax NPV	Tax NPV
Budget 2015: NPV, £mm @$60/bbl	1,550	2,435
Budget 2016: NPV, £mm @$60/bbl	1,994	2,854
Special Case: NPV, £mm @$60/bbl	2,024	2,912

Hub decommissioning Years @ $60/bbl



Tax Regime Changes and Oil Price Sensitivity

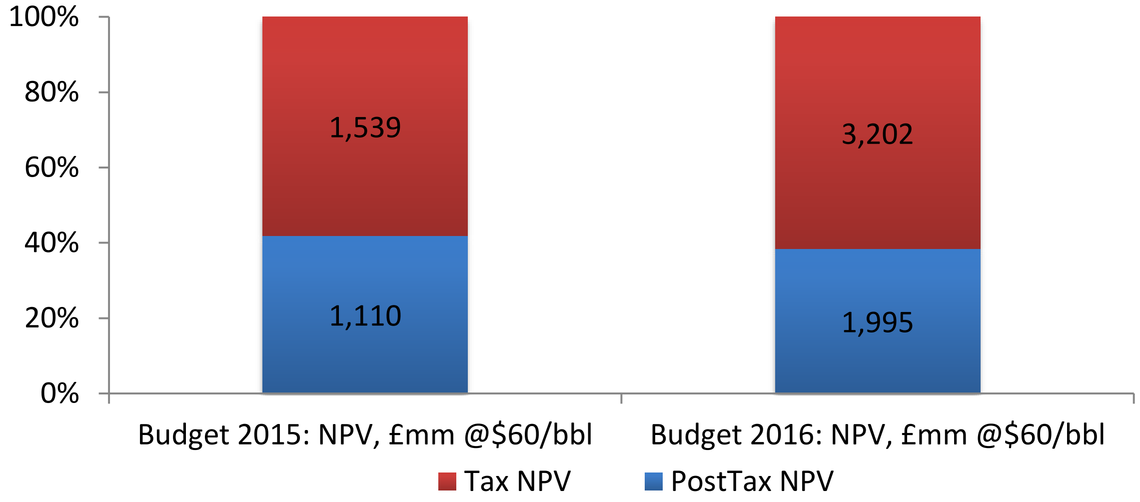
Scenario	Pre-Tax NPV	Post-Tax NPV	Tax NPV
Budget 2015: NPV, £mm @$40/bbl	345	180	166
Budget 2015: NPV, £mm @$60/bbl	3,985	1,550	2,435
Budget 2015: NPV, £mm @$80/bbl	15,495	7,174	8,321
Budget 2016: NPV, £mm @$40/bbl	527	257	270
Budget 2016: NPV, £mm @$60/bbl	4,848	1,994	2,854
Budget 2016: NPV, £mm @$80/bbl	17,758	8,668	9,090
Special Case: NPV, £mm @$40/bbl	527	266	262
Special Case: NPV, £mm @$60/bbl	4,937	2,024	2,912
Special Case: NPV, £mm @$80/bbl	18,001	8,686	9,315

Cost sharing plus tax model results

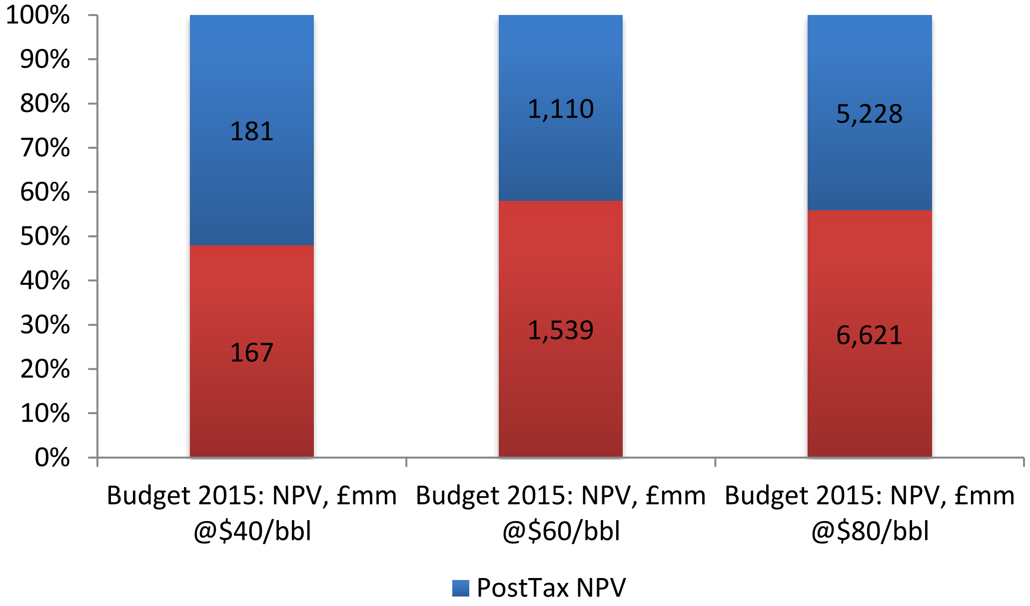
Tax and Cost-Sharing Model Results

Scenario	Budget 2015: NPV, £mm @$60/bbl	Budget 2016: NPV, £mm @$60/bbl
Pre-tax NPV	2,649	5,197
Post-Tax NPV	1,110	1,995
Tax NPV	1,539	3,202

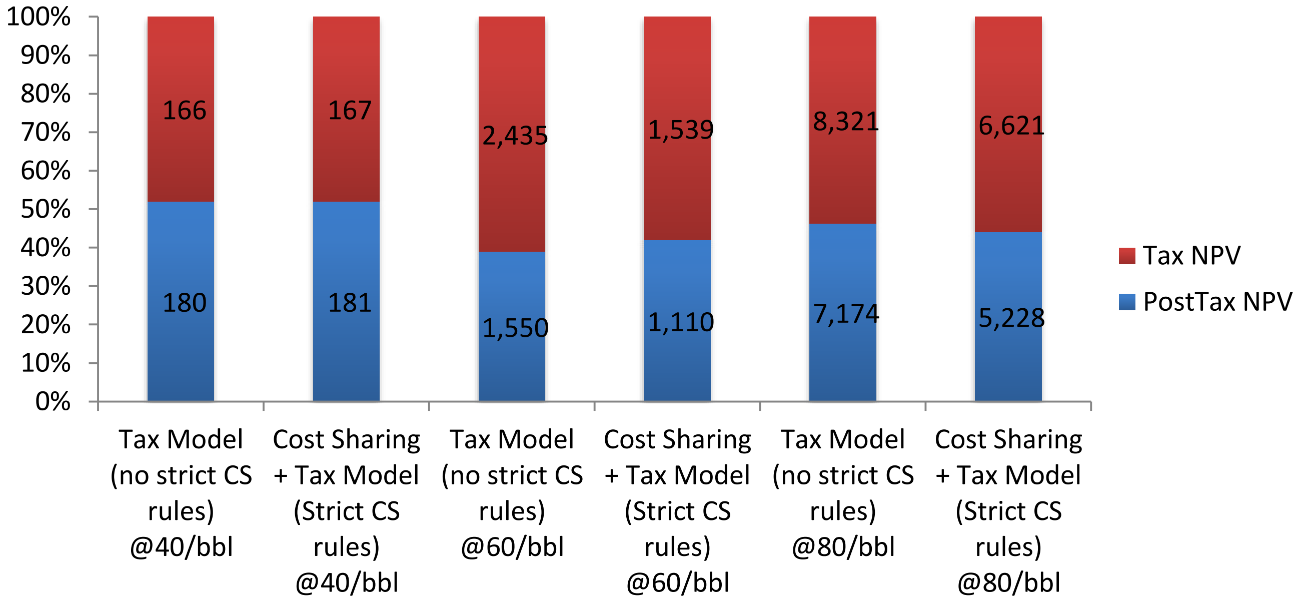
Comparison of Takes



Revenue Shares at Different Oil Prices



Comparison between Tax and Cost Sharing + Tax Models



Conclusions and policy implications

- Work contributes to knowledge by establishing a baseline on how third-party access arrangements to infrastructure affect the economic recovery of oil and gas resources.
- Provides insights on how regulatory decisions around tariffing and cost-sharing could be made to maximise economic recovery and thus safeguard the future of the mature basins such as the UKCS.

Policy implications

1. Important for the regulatory agency in settling disputes over third party access arrangements and tariffs to **understand the economics of the region in terms of the relationship between fields and hub infrastructure owners.**
   - establish a baseline scenario corresponding to a single ownership model.

2. **Tax policies that enhance project profitability should be continued as they remain fundamental to the future of the region** in terms of sustaining production from hitherto marginal oilfield developments.

3. **Tariff determination** should be based on **cost-share rules** that enjoin each field tie-back to a **hub pays the split tariff made up of two components namely a fixed cost of service (access charge) and variable (marginal) costs** which is based on throughput and captures the marginal cost of processing.

Acknowledgements

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Thank You!

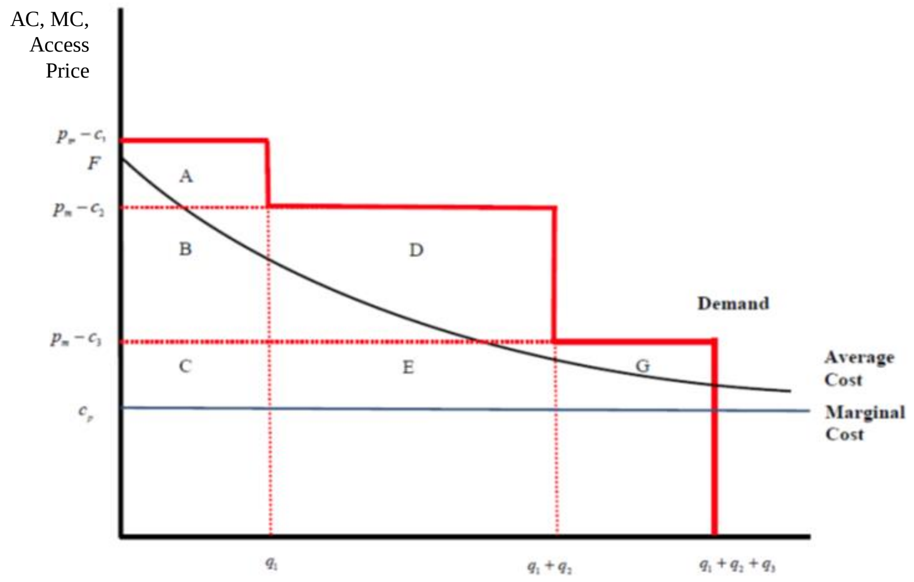
Questions?

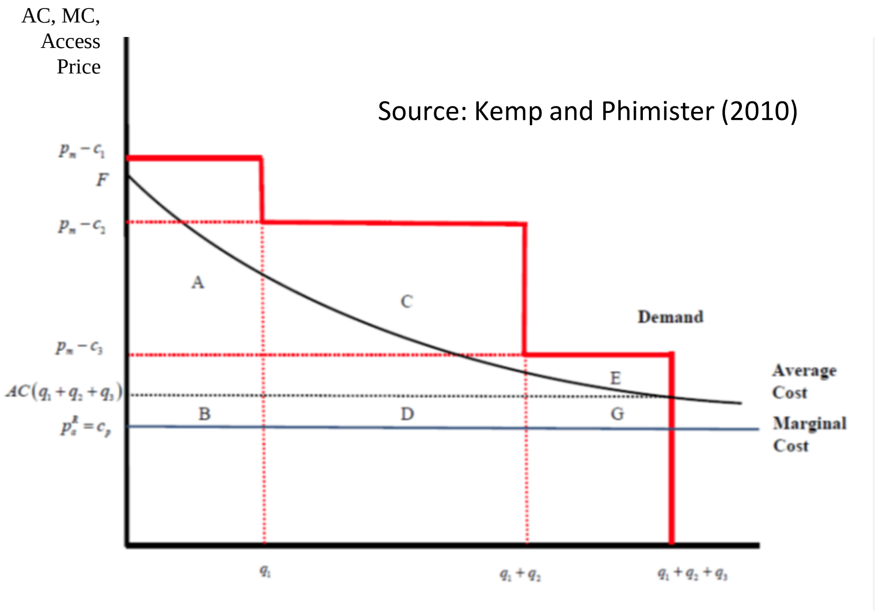
Common infrastructure access and pricing framework

	Output Level	Marginal Cost
Field 1	q_1	c_1
Field 2	q_2	c_2
Field 3	q_3	c_3
Pipeline Capacity	$\sum_{i=1}^{n} q_i \leq Q, \quad \text{for all } i = 1,2,3$ $where\ Q = \max pipeline\ capacity$	where $c_1 < c_2 < c_3$
Oil Price (Exogenous)	p_m	
Total Oil Transport Cost	$TC = F + \sum_{i=1}^{n} C_i\, q_i, \qquad \text{for all } i = 1,2,3$ $where\ F = Fixed\ Costs$	c_a
Average Cost	$AC = \frac{F}{q_i} + c_a$	

Scenarios

1. All Fields and Infrastructure Operated By One Firm
2. All Fields Licensed to Different Operators But Infrastructure Operated By Another Firm
3. Regulated Access Prices

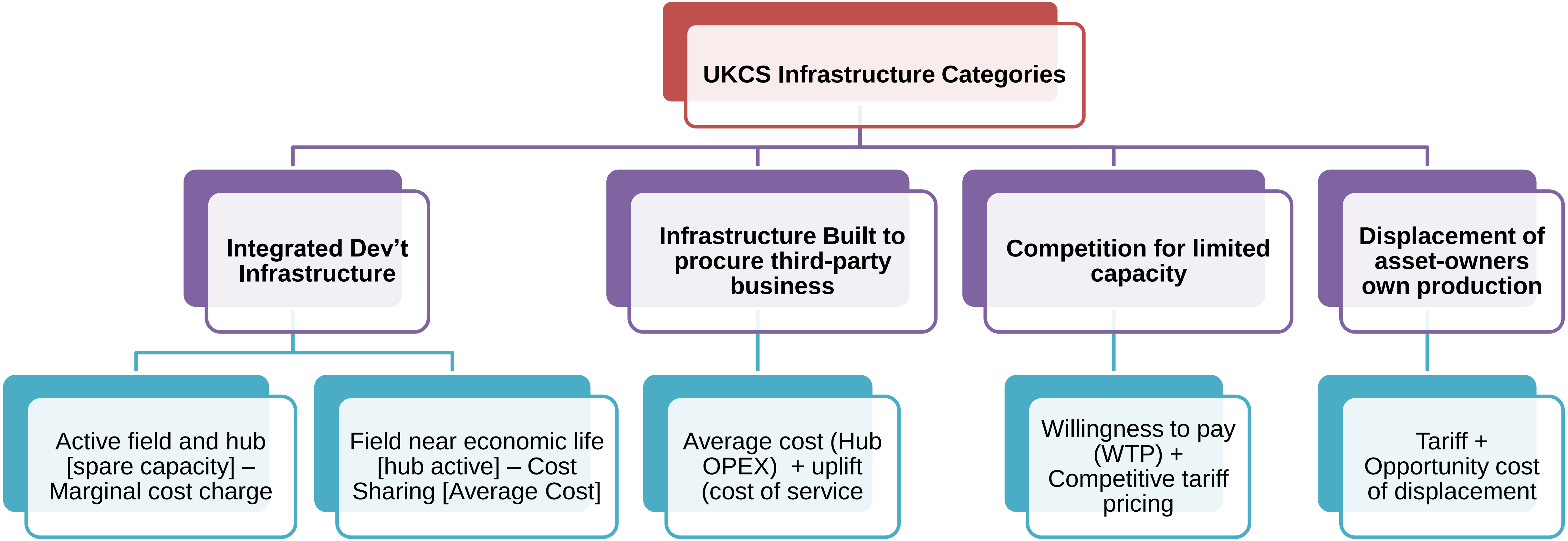




Source: Kemp and Phimister (2010)

Infrastructure categories in the UKCS

- 4 distinct categories which require different considerations in determining tariffs
- Rule of thumb: what should be the appropriate tariff level if the asset-owner had effective competition [ullage capacity from other owners in the system]?



Optimisation model formulation

Physical Flows of Oil and Gas Constraints

$$yhub\_oil_{ht} = \sum_{i \mid tiepos_{ih}} tieback\_oil_{iht} \;\forall\, i, h \in \mathcal{D}$$

$$yhub\_gas_{ht} = \sum_{i \mid tiepos_{ih}} tieback\_gas_{iht} \;\forall\, i, h \in \mathcal{D}$$

Physical Infrastructure Constraints

$$tieback\_oil_{iht} + tieback\_gas_{iht} \leq BigM.tiebackact_{iht}$$

Economic Constraints (cost sharing and participation constraints)

Economic Shut Down when NPV of future NCF <0

$$Fields: \quad \sum_{t} dfact_t\,(NCF_{it} - TAX_{it}) \geq 0$$

$$Hubs: \quad \sum_{t} dfact_t\,(NCF_{ht} - TAX_{ht}) \geq 0$$

Objective Function

$$Max\ NPV_{region} = \frac{1}{(1+r)^t}\left(NCF_{hubs} + NCF_{fields}\right)$$

$$s.t\ \ cost\ sharing, financial\ viability\ constraints\ plus\ and\ taxation\ changes$$

Fields and Developments

$$NCF_{it} = f_{it} \cdot \begin{bmatrix} \overline{rev}_{it} - \overline{dev}_{it} - \overline{opex}_{it} - \overline{decm}_{it} \\ - \overline{transpcost}_{it} - \overline{ctie}_{ih} - \overline{cshare}_{iht} \end{bmatrix} \forall\, i \in \mathcal{D}$$

$$Max\ Z = NPV_i = \sum_{t \in T} \frac{1}{(1+r)^t} \cdot \left[NCF_{it} - \overline{cdecm}_{it}.fdec_{it}\right] \forall\, i \in \mathcal{D}$$

Hubs

$$NCF_{ht} = \begin{bmatrix} f_{ht} \times (\overline{rev}_{ht} - \overline{dev}_{ht} - \overline{fopex}_{ht} - \overline{vopex}_{ht}) \\ - \overline{decm}_{ht} + \overline{cshare}_{iht} \end{bmatrix} \forall\, i \in \mathcal{D}$$

$$Max\ Z = NPV_h = \sum_{t \in T} \frac{1}{(1+r)^t} \cdot \left[NCF_{ht} - \overline{cdecm}_{ht}.fdec_{ht}\right] \forall\, i \in \mathcal{D}$$