Laggan-Tormore

“Reservoir to Sales Product Modelling, and Optimisation using an Integrated Modelling Approach”

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Development Overview

MCP-01

234km Gas Export Pipeline
30” SVT to MCP01
665 MMscfd Laggan-Tormore

143km Multiphase Pipelines
(500 MMscfd)
2 x 18” gas lines
rock dump material

2 x 18” gas lines

8” MEG Line
2” Service Line
control umbilical

2 x Subsea Production Templates
6 slots ea. @ (>600m water depth)
Laggan & Tormore (5 + 4 wells)

New Shetland Gas Processing Plant
(being built adjacent to BP’s Sullom Voe Terminal)

600 Metres Water depth

DEVEX2012, AECC 9
- 10th May 2012
The Simple Eclipse Modelling Approach

Original Approach *(for project sanction Feb 2012)*

- Coupled Laggan-Tormore Eclipse models with pipeline network
- Black Oil PVT representation (3x stage flash to STC)
- Pipeline network *(pipeline pressure loss tables from a previous PIPESIM study)*
- Pipelines balanced, with well flow split 50:50 down each pipeline
- Pipeline turndowns controlled using *ACTION* keywords
- No condensed water modelled, or associated MEG or MeOH injection
SO - Why an Integrated Asset Model! - *It all worked fine before??*

- **Reservoir Engineer**
  - Black-Oil
  - Liquid and Gas “Arrival” Profiles
  - 2 Stage Process, and Flash to STC

- **Development Engineer**
  - Flow Assurance
  - BO De-lumping
  - Flow Assurance – VLPs, Turndown Constraints, Production Efficiencies

- **Economist**
  - Product “Sales” Profiles
  - Days of Repetitive Manual work

- **ECLIPSE* software**

- **HYSYS® software**
  - Condensate & Rich Gas
  - St Fergus & SVT

- **SGP** (15 models – 1 each year)

- **Flow Assurance**
Reasons for Developing WoS IAM

- The SUM is always greater than the PARTS
  - Working together generating Assumptions/Constraints & Model
  - Review of Results and Data generated by the IAM

- Establish a consensus via a “Development Work Flow Process”
  - Providing the framework to allow discrete disciplines to collaborate as a team
  - Retain “Metier” Validation of the individual model elements
  - IAM undertakes Global Optimisation
  - Geoscience/Reservoir team retains responsibility for “Issue” of Production Profiles

- WoS IAM to become the Regional Management Tool
  - Reserves
  - Long Term Plan Assumptions
  - Development Screening & Sanction
  - Back-out Calculations
  - Generation of Sales and Economics Profiles
  - QA Management

- WoS IAM has the potential to be expanded in synergy with Ops Systems
  - Production Reporting
  - Field Allocation
IAM Workflow

IPM software chosen (*Petex*)

- Mbal / Prosper / GAP
- RESOLVE
  - Manages and controls data flow
  - “conducts the orchestra”

**RESOLVE**
- Published Variables……Data
- Event Scheduling
- Constraint Management
- Production Optimisation
- Well Routing Optimisation - Giro
- Scenario Management
- History & QA Management

**Virtual Environment**

**IAM Team**

**Reservoir**

**Production & Flow Assurance**

**SGP Process**

**TEPUK & SVT**

**Full Run in 6-20hrs**
Basic Overall Architecture

- Laggan Eclipse 100 Model (black oil)
- Tormore Eclipse 100 Model (black oil)
- Laggan-Tormore GAP Model (twin, looped 18” flow lines)
- Shetland Gas Plant (SGP) HYSYS Model
- St Fergus HYSYS Model
- BP Sullom Voe Terminal (SVT) HYSYS Model
- Controlling sheets (excel) / additional calculations - MEG/hydrocarbon streams to HYSYS
- Resolve – controls everything (data stream between elements)
Is the IAM approach reliable??

- Try replicating Eclipse Assumptions as far as possible (to validate IAM)

Model output validated against results from previous ‘sequential’ approach

- Incorporate ECLIPSE turndown rules, 50:50 well splits into each flowline, and efficiencies

- IAM VALIDATED
  - Can now update assumptions
  - Use for development studies etc
WoS IAM – Now Ready for Development Studies!

Incorporate Improvements (compared to Eclipse/network Model)

- Representative well/pipeline routing – each well can only flow to one pipe at a time (see below). Well routing solved periodically by Resolve using a GIRO (Genetic Integer Routing Optimiser)

- Revised (updated) turndown rules on pipelines (HP → LP, 2 pipes → 1 Pipe → End)

- MEG injection / condensed water modelling
  - Condensed water now modelled, MEG injection volumes modelled (with 50% over-dosage)
  - MEG reclamation modelled at SGP
  - Impact on pipeline turndowns now captured

Eclipse Network – balanced flow
(Used in ‘ECLIPSE’ model but NOT reality)

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Eclipse Network</th>
<th>Reality</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>31 bara 11 bara</td>
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<tr>
<td></td>
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<td>174 MMscf/d 106 MMscf/d 53 MMscf/d</td>
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Impact on pipeline turndowns now captured.
Study Examples:

Tie-ins

Late Time Sub Sea Gas Compression

Eclipse Reservoir models (and/or Mbal models)
Tie-in Additional Field - in detail (only GAP Model shown)

- Laggan-Tormore + Edradour Tie-in
  - Impact of Timing / Phasing with L-T wells
  - Impact on L-T (back-out effects)
  - Extended production L-T

DEVEX2012, AECC 9-10th May 2012
Additional Field Tie-in *(example of results)*

- Full Evaluation – *easily performed*
  - Back-out effects if start-up of additional field whilst L/T still on plateau
  - Ullage filling studies (late start-up)
  - Plateau extension
  - Late time production (deferred production)
Sub Sea Gas Compression (SSGP)- in Detail (Gap Model)

SSGC located at Laggan in this example

SSGC-Laggen Linked with Hysys model through RESOLVE
Evaluation of SSGC (example of results)

Switch to 1 pipe (Laggan ➔ SGP)

Can now start SSGP
Main Messages

- IAM offers clear benefits over simple Eclipse/network
  - Full integration “reservoir to sales products – looks at the big picture, pulls together many disciplines
  - HOWEVER, not a substitute on a day to day basis for the simple Eclipse/network approach which is good for basic well/field related reservoir engineering studies

- Complex issues can be captured in detail, and rigorously evaluated
  - Sub sea gas Compression
  - New field tie-ins / interactions

- Optimisations can be easily made, at any point in the system, on any parameter
  - Example: maximise condensate production

- Can perform debottlenecking studies
  - Example: Increase compression at SGP

- Can perform ad hoc studies
  - Example: dedicate Tormore alone to one of the twin pipelines, etc etc

Assistance from Software provider essential

- complex models (easy to set up incorrectly)
- many ways to solve and develop interfacing control spreadsheets, de-bugging
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