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Impact of Production Efficiency Improvement on Reserves and field life

Andy Carr - OGA

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Introduction

What is “Production Efficiency” and why it is important

How to include Production Efficiency in decline curves

Some insights from applying this technique

Some general observations

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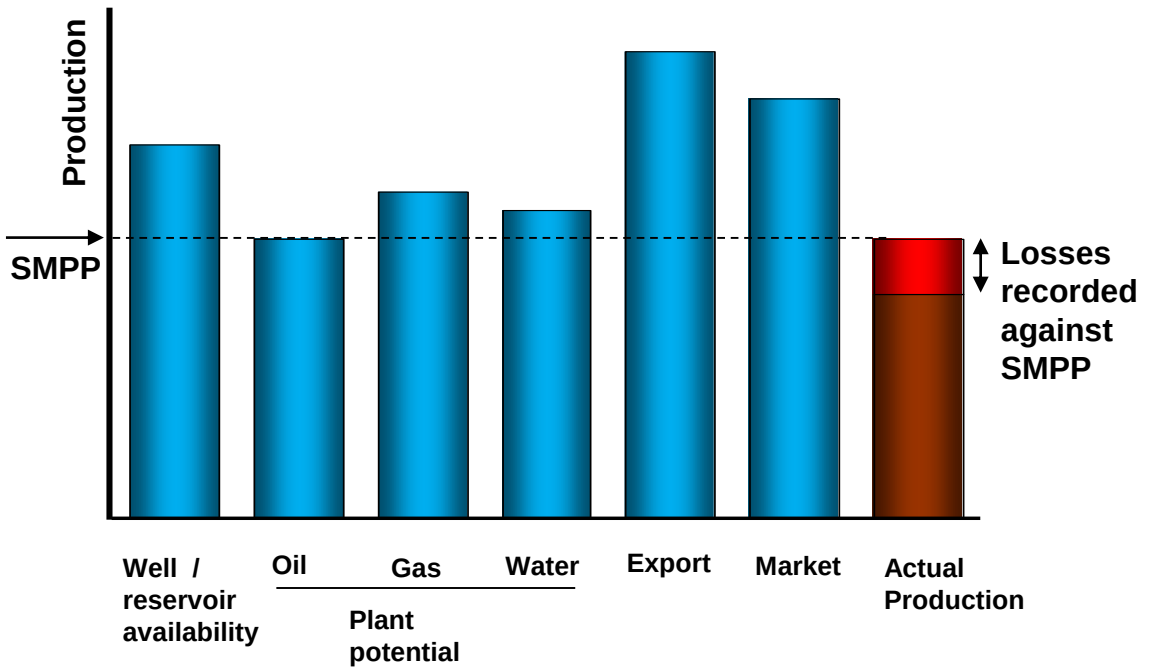
A Definition of Production Efficiency

Loss categories:

- Reservoir
- Wellwork
- Planned Plant
- Unplanned Plant
- Planned Export
- Unplanned Export
- Planned Shutdown
- Market
- Unallocated



$$\frac{\text{Actual Production}}{\text{Structural Maximum Production Potential}} \times 100\%$$

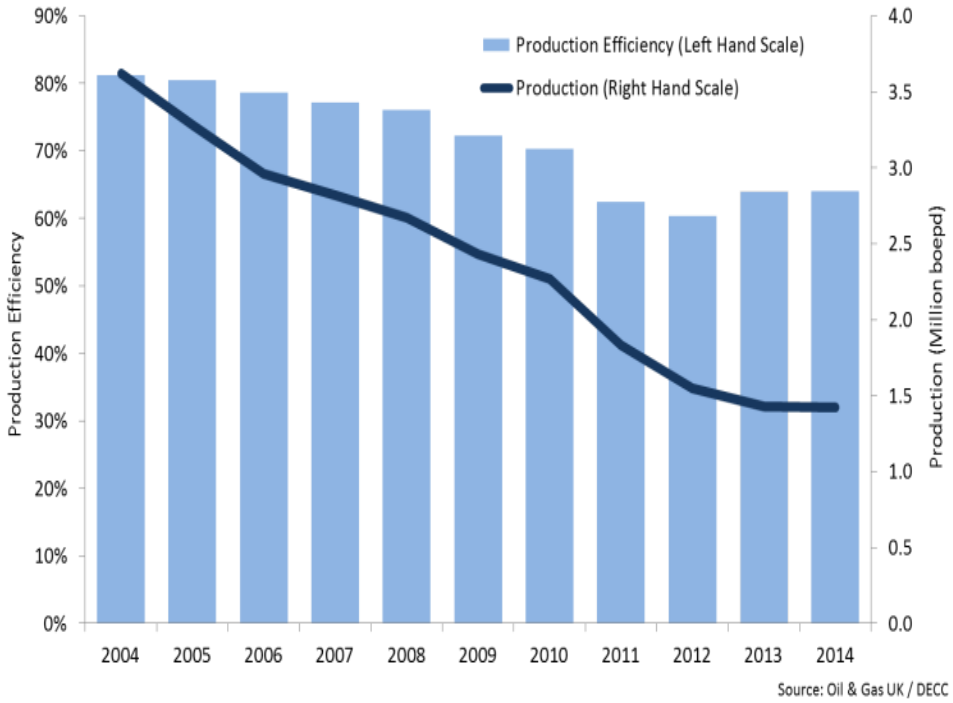
Background

Production Efficiency (PE) is a key indicator of asset stewardship in the UKCS

PILOT Work Group discussions in 2013/14/15

- Production Efficiency Task Force (PETF)
- Northern North Sea Infrastructure Rejuvenation Work Group (NNSR WG)

Both highlighted declining Production Efficiency as an issue



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Background

Discussion in various sub groups on impact of PE on reserves and field life.

I wanted to get a “quick look” estimate
I have looked at using decline curves

For exponential decline curves, there is a simple relationship between the current rate, the rate of decline, the economic cutoff rate and the remaining reserves.
Given any 3 of these, we can calculate the fourth, and also the remaining field life.

We can also include Production Efficiency (PE) **explicitly** in these equations.

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Assumptions in the decline curve approach

Let us make the following simplifying (“heroic”) assumptions :

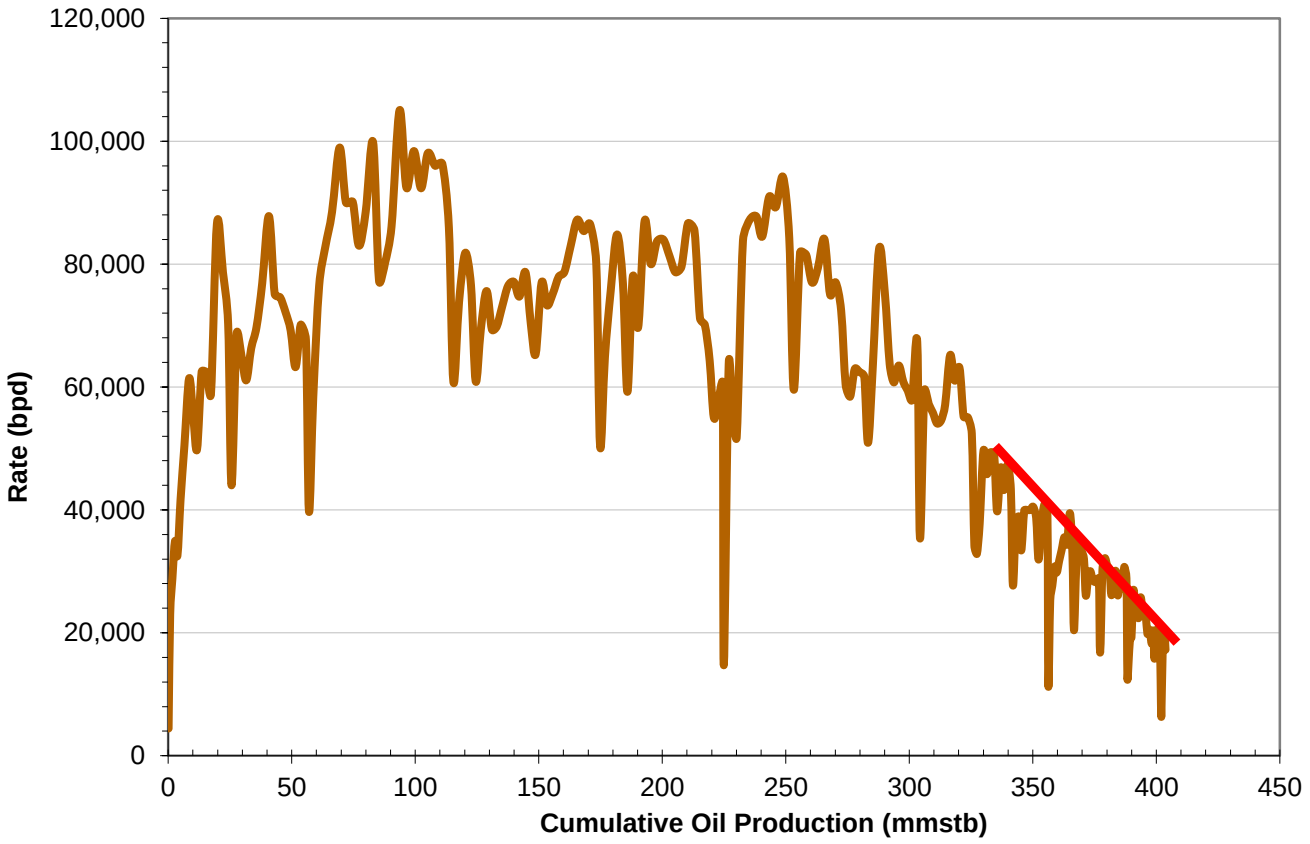
1. Late field life production profile can be described by an exponential decline which can be analysed using a straight line plot of production rate (y axis) vs cumulative production (x axis).
   Furthermore, this relationship is not rate dependent and represents the maximum rate the reservoir can deliver on a given day (ie this relationship doesn’t depend on facilities performance)

2. Operating costs at the end of field life are a known constant (that does not depend on production rate or PE) and the oil price is known – hence we can calculate the production rate at the economic limit and this defines the Cessation of Production (COP) date.
   Further let us assume the COP decision is based on average rate over a period of time rather than the maximum rate on any given day

Field Example

Field Example

showing a straight line relationship between oil production rate and cumulative production in late field life



Source - PPRS

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Equations

The rate at time t (q_t) is related to the current rate (q_0 , at time $t = t_0$) by

$$q_t = PE * q_0 \, e^{-\lambda PE (t - t_0)} \quad \text{..... (1)}$$

(λ is not the annual decline rate, but is closely related to it)

We can estimate the decline parameter λ from a plot of rate q vs cumulative production Q, and extrapolate this straight line to the economic limit q_{COP} to calculate the remaining reserves Q_{REM}

(Note that q_{COP} is an average rate, so $q_{COPavg} = q_{COPmax} * PE$)

We can solve the above equation to calculate the time to COP (t_{COP}) from Q_{REM}

$$Q_{REM} = \frac{1}{\lambda} q_0 \left(1 - e^{-\lambda PE \, t_{COP}} \right)$$

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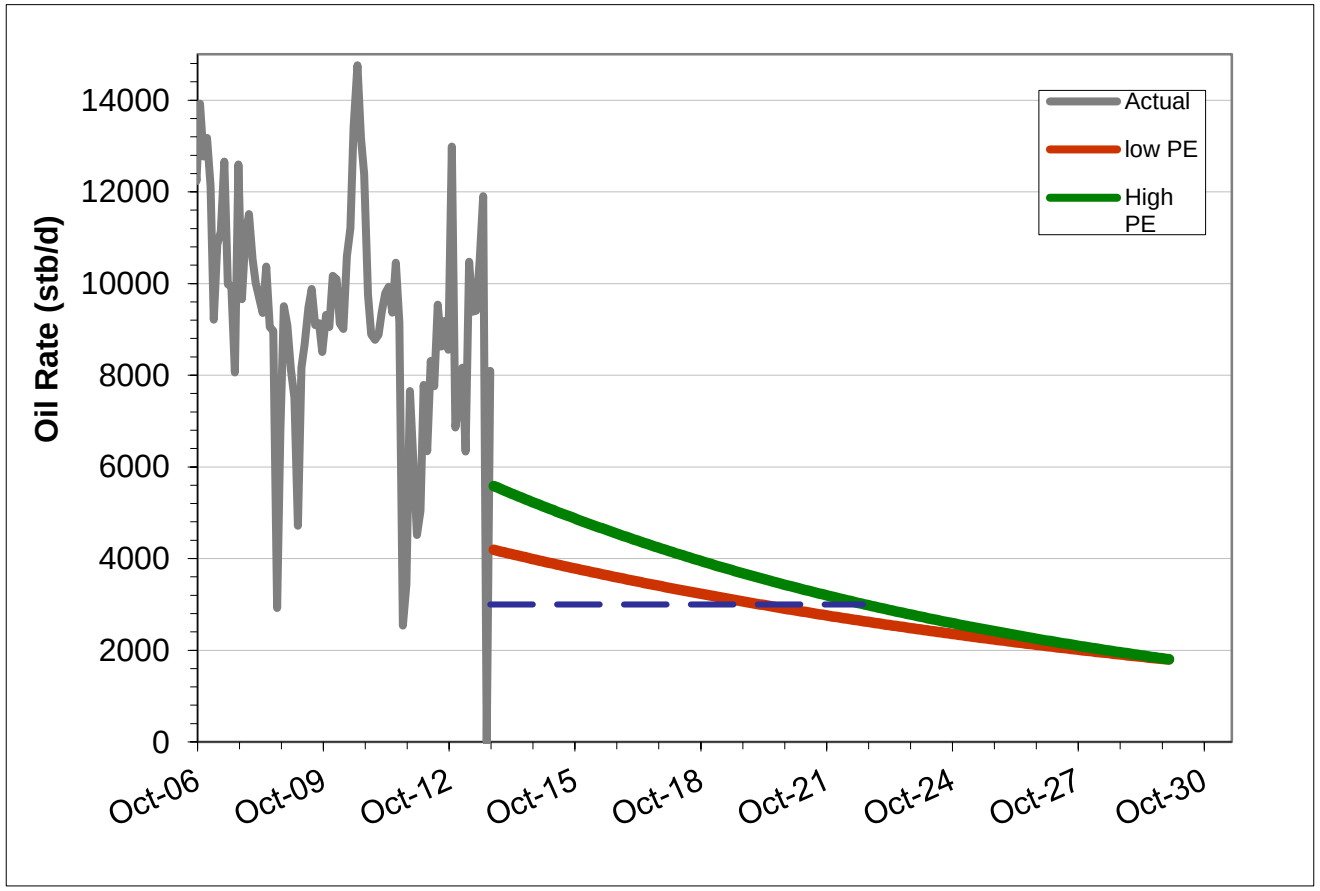
Field Example

Field Example

showing how the decline curves (equation 1 on slide 5) predict an extension of field life as a result of improving PE



Source - PPRS

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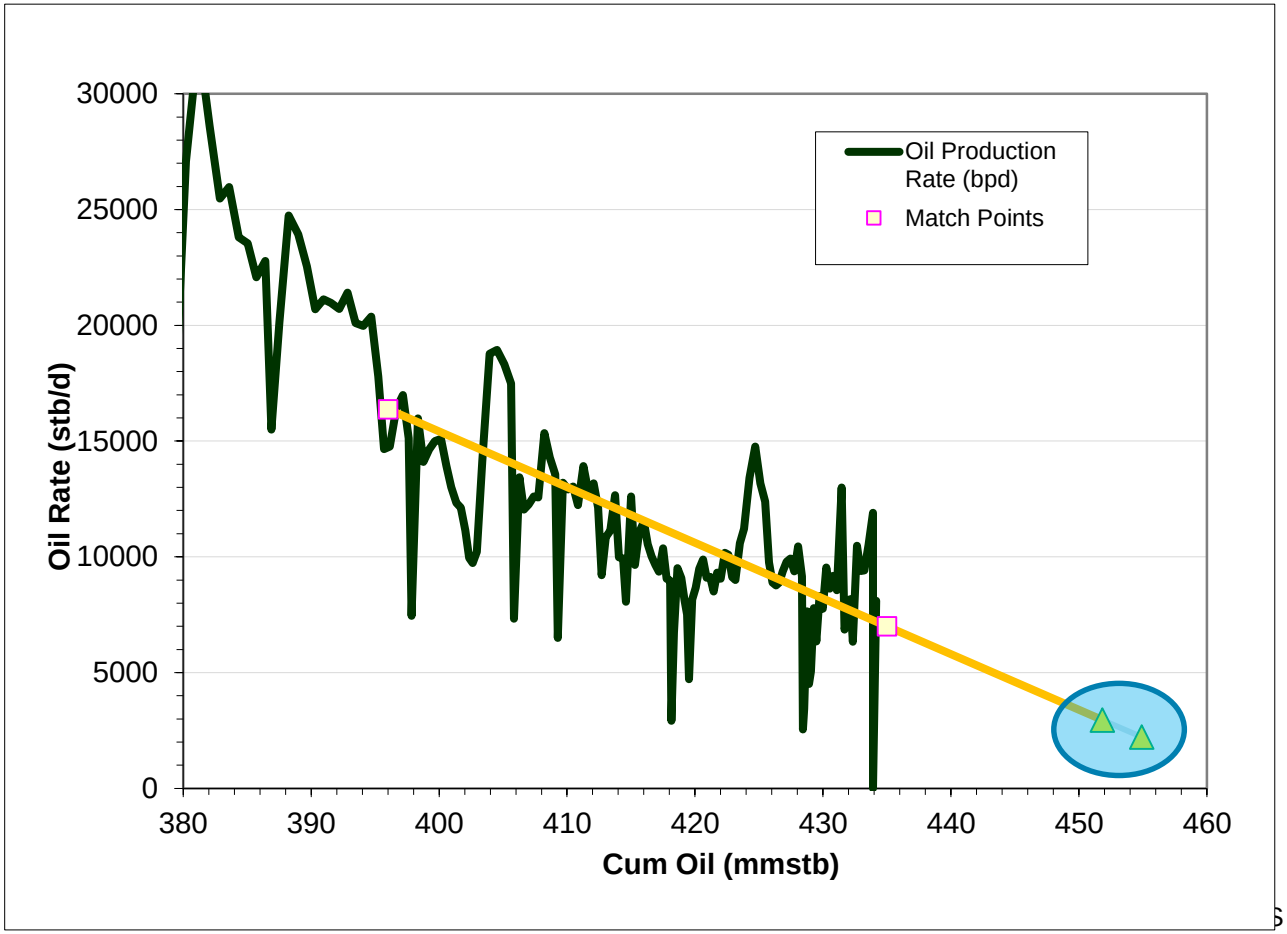
Field Example

Field Example

showing the predicted increase in reserves as a result of improved PE



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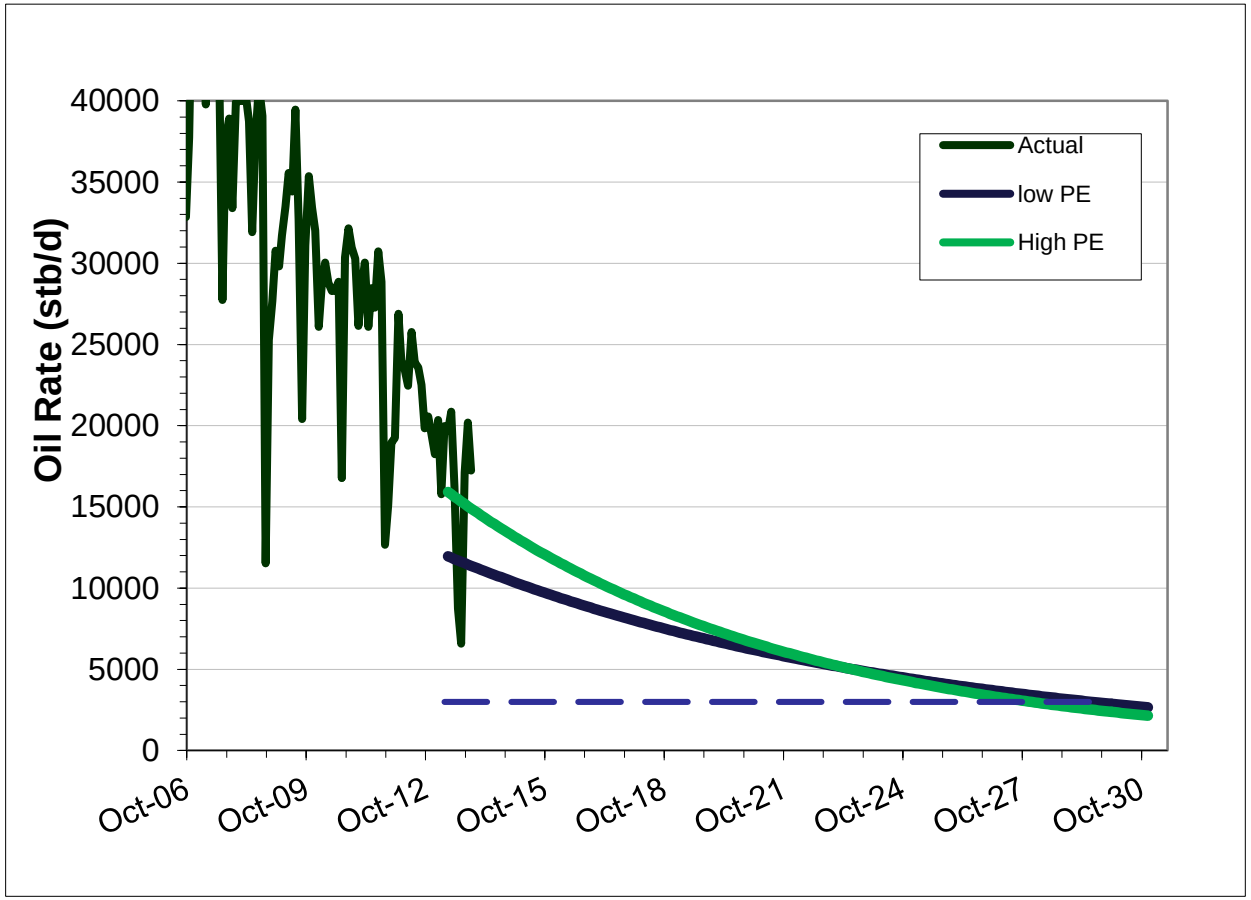
Field Example

showing how the decline curves (equation 1 on slide 5) predict a reduction in field life as a result of improving PE

(but there is still an increase in reserves)

Field Example



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Conclusions from the decline curve approach

A decline curve approach offers the following insights :

An increase in PE will increase reserves.
The amount of the increase depends on economic limit and the change in PE – it does not depend on current production rate or field maturity

An increase in PE will increase the observed annual decline rate (assuming no changes to reservoir management plan)

An increase in PE may or may not extend field life – depends on field maturity – the more mature the field the more likely that an increase will extend field life

Operators will want to use more complex models to quantify the cost/benefit of various options to improve PE. However, I suggest if these models don't show the behaviours above, the user should carefully check the underlying assumptions within the model.

The above analysis does not take into account the "positive domino" effect (an improvement in one field can have a beneficial impact on fields that share the same infrastructure

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Some Observations

Recent low oil prices highlights need for action to improve PE

Continued poor PE =>

- Increased lifting costs, worsens the asset economics
- Difficult to attract project capital
- Difficulty in attracting third party business
- Early COP / decommissioning
- Resources left in place
- Near field potential left stranded

Improving PE will receive even more focus from OGA

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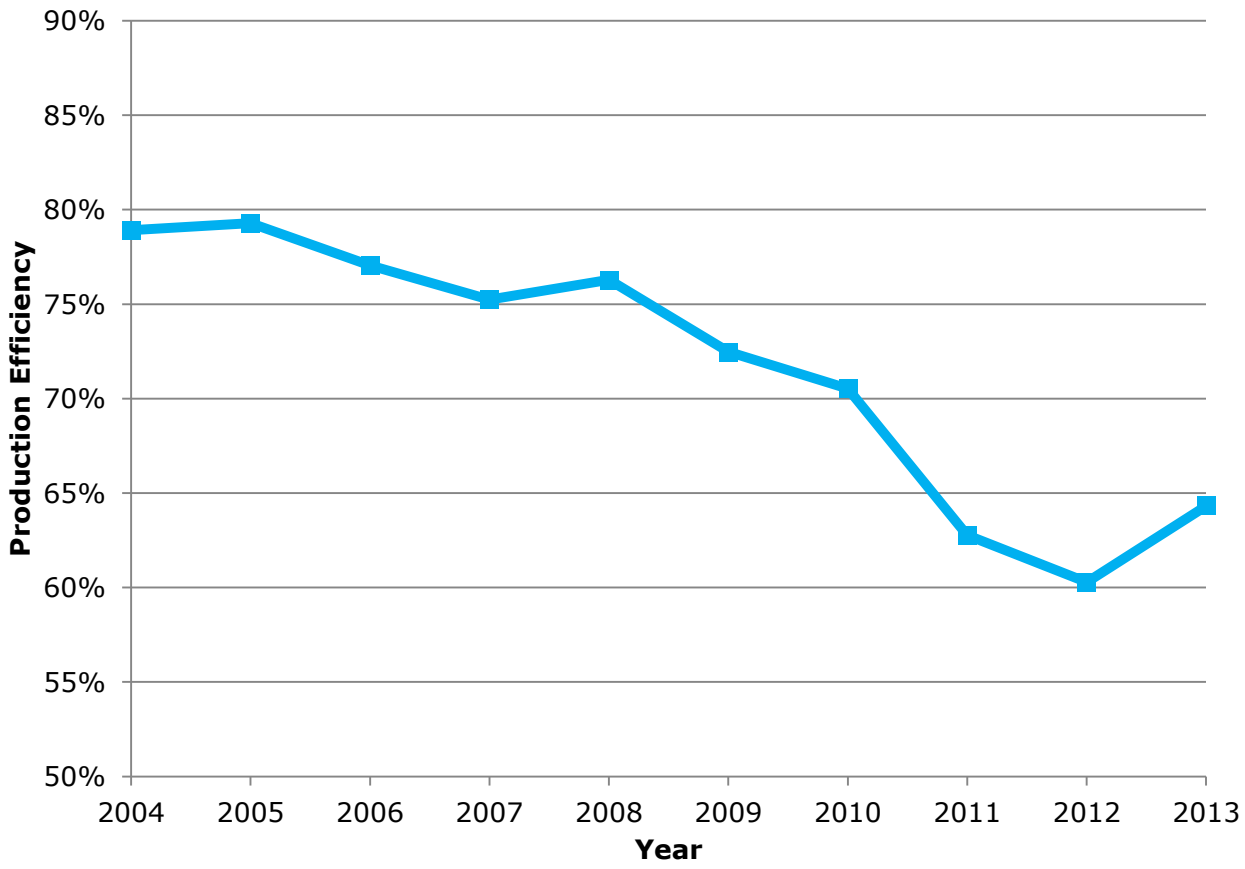
Thank you

Questions ?

UKCS PE history

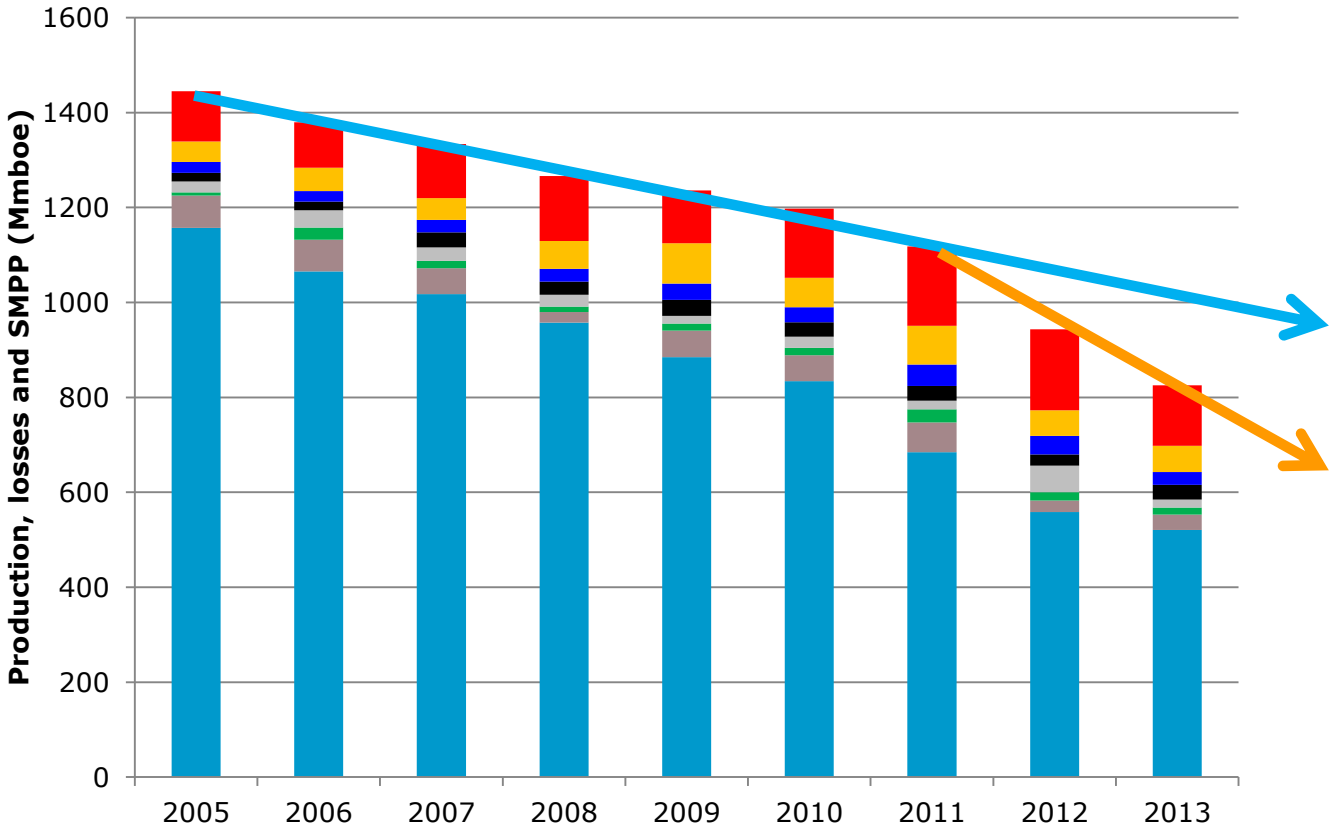
Department of Energy & Climate Change

Weighted overall UKCS Production Efficiency since 2004



Department of Energy & Climate Change

SMPP, production and losses, 2005 - 2013



SMPP decline rate increased in 2011