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## Bernstein Energy

# Drivers of Decline Rates in Mature Hydrocarbon Basins & The Need for Enhanced Oil Recovery

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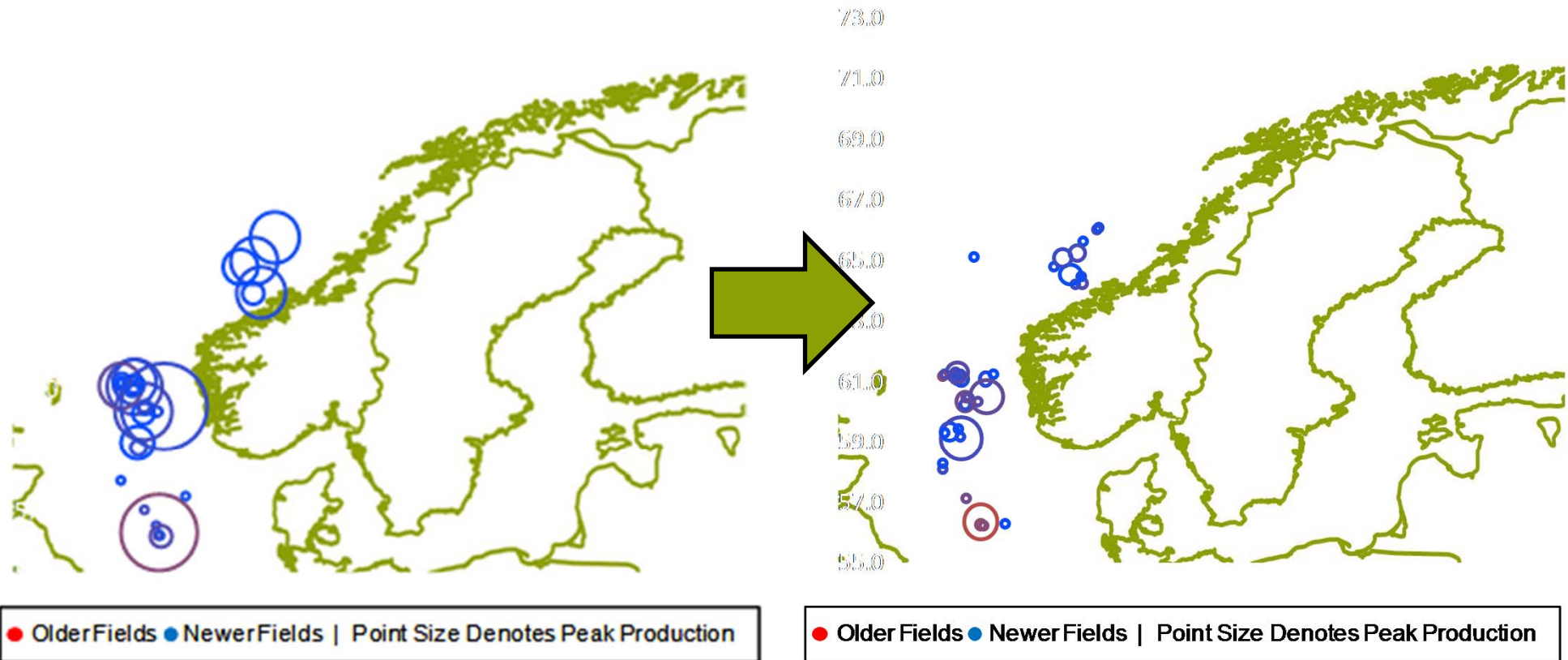
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# Economical control of decline rates is increasingly important in mature hydrocarbon basins – Norwegian & North Sea

Norway Oil Production in 2000 – only 9% of production from fields <50kbpd

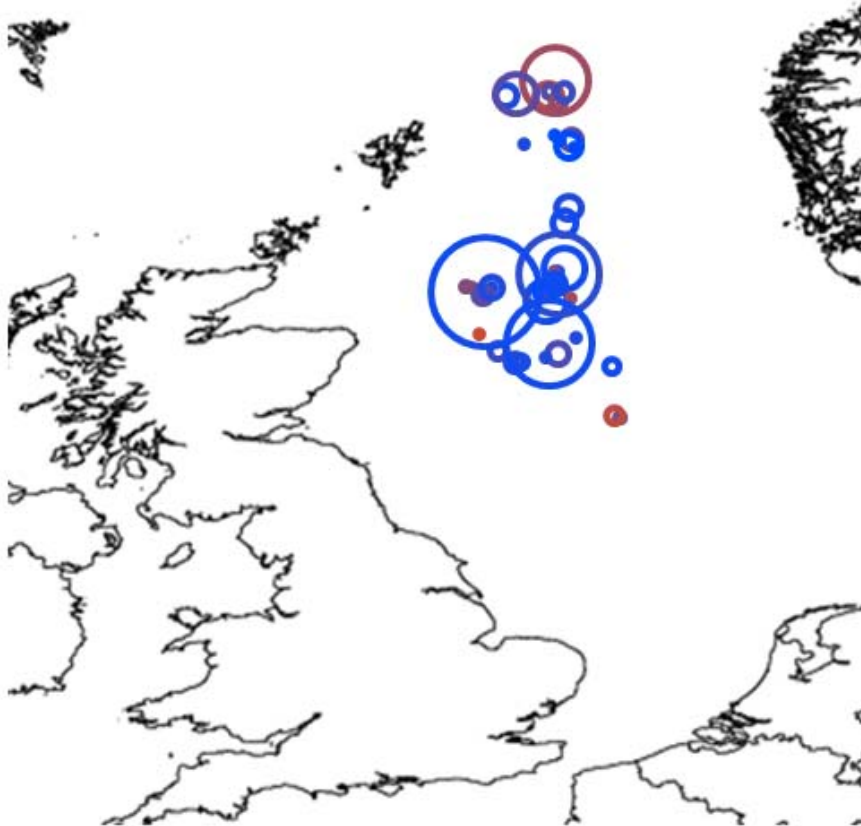
Norway Oil Production in 2011 – 40% of production from fields <50kbpd



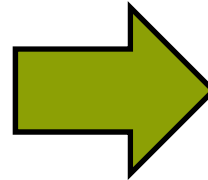
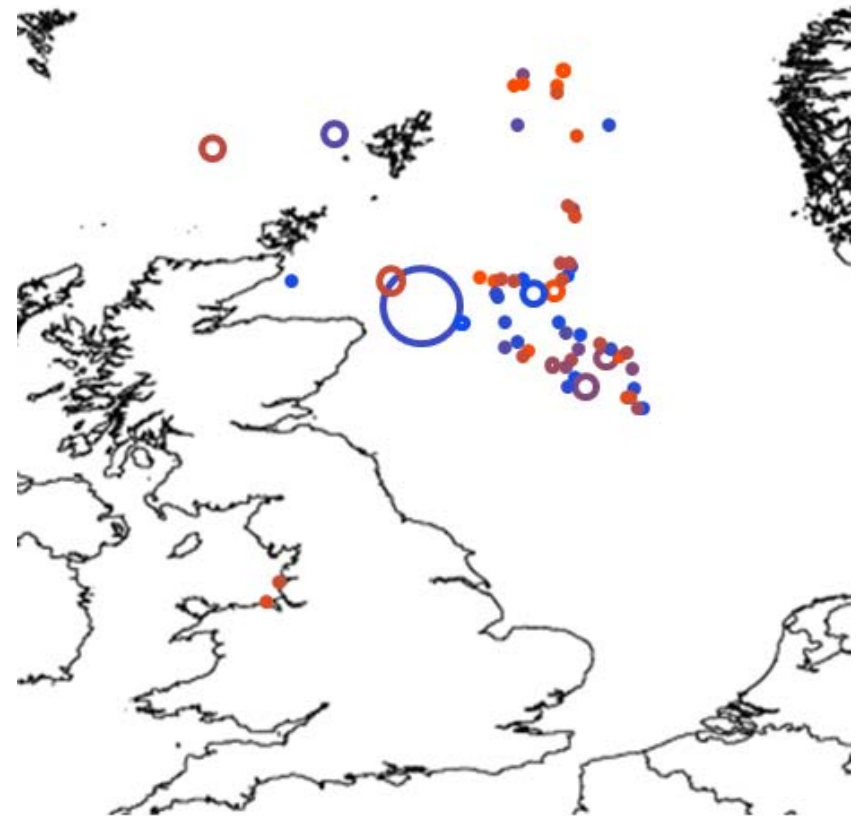
Source: NOAA, NPD, Bernstein Estimates

# Economical control of decline rates is increasingly important in mature hydrocarbon basins – U.K. North Sea

UK North Sea Oil Production in 1995 – only 11% of production from fields <5kbpd



UK North Sea Oil Production in 2011 – 42% of production from fields <5kbpd

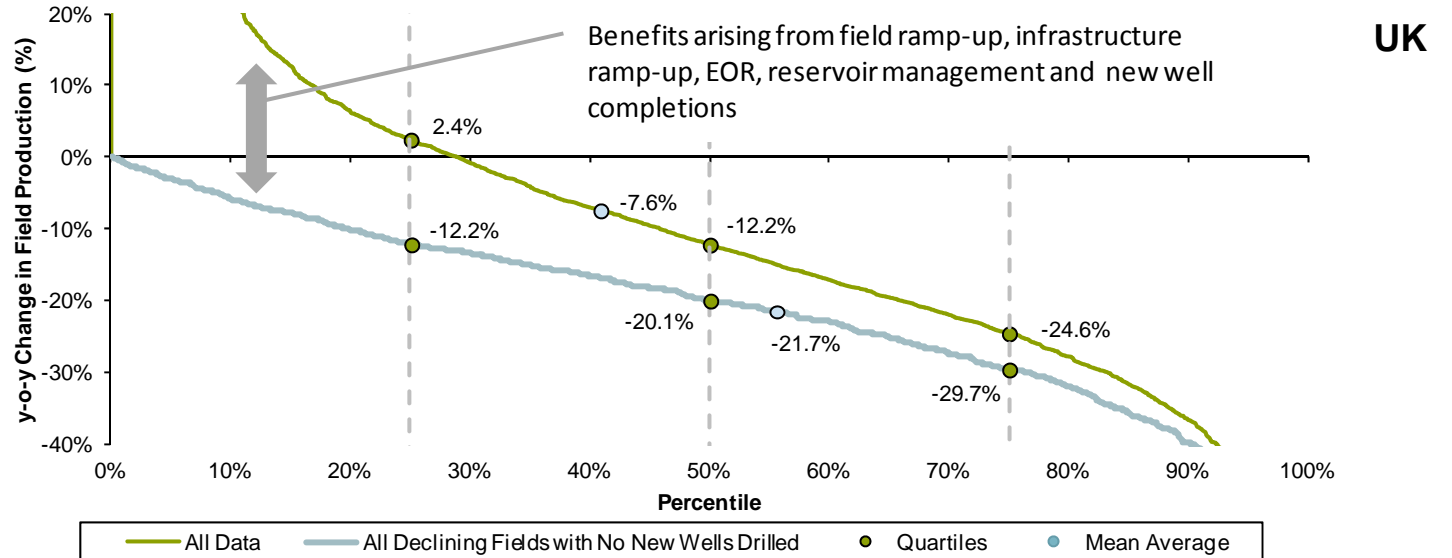


Source: NOAA, DECC, Bernstein Estimates

# Median y-o-y changes in production have averaged -12.2% and -9.3% in the UK and Norway, with -21.7% average natural declines in both basins

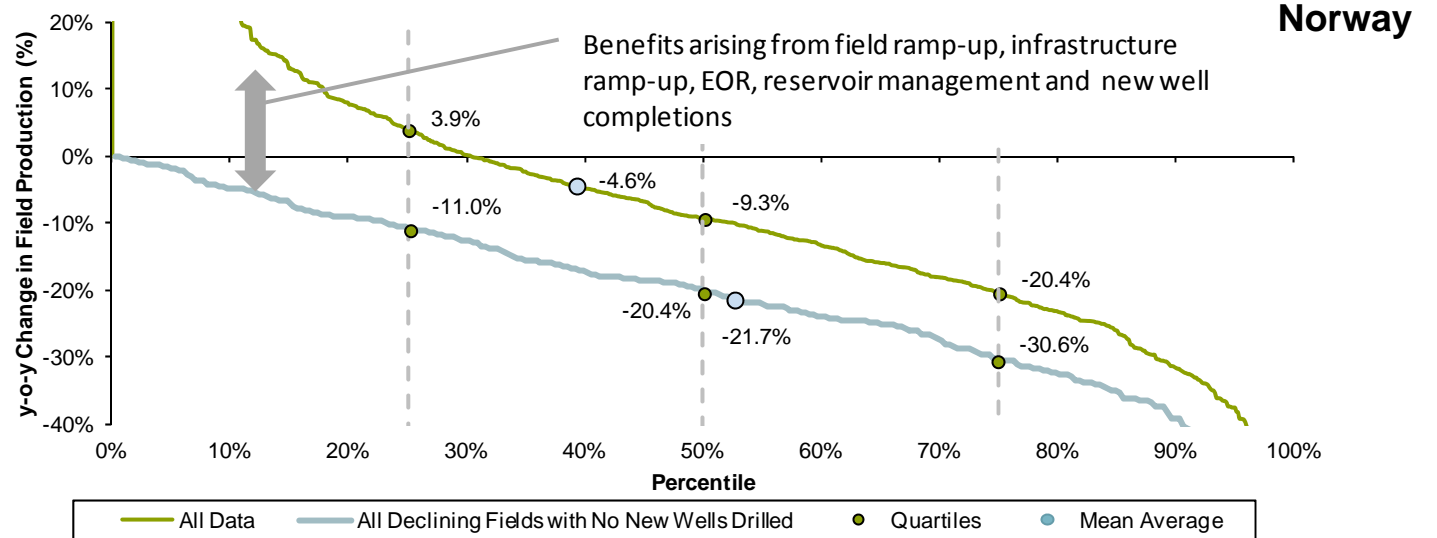
## UK North Sea

- 240 oil fields
- Monthly production data since first oil in the basin
- Median y-o-y change in production = -12.2%
- Mean Average Natural decline rates of -21.7%



## Norwegian Offshore Sector

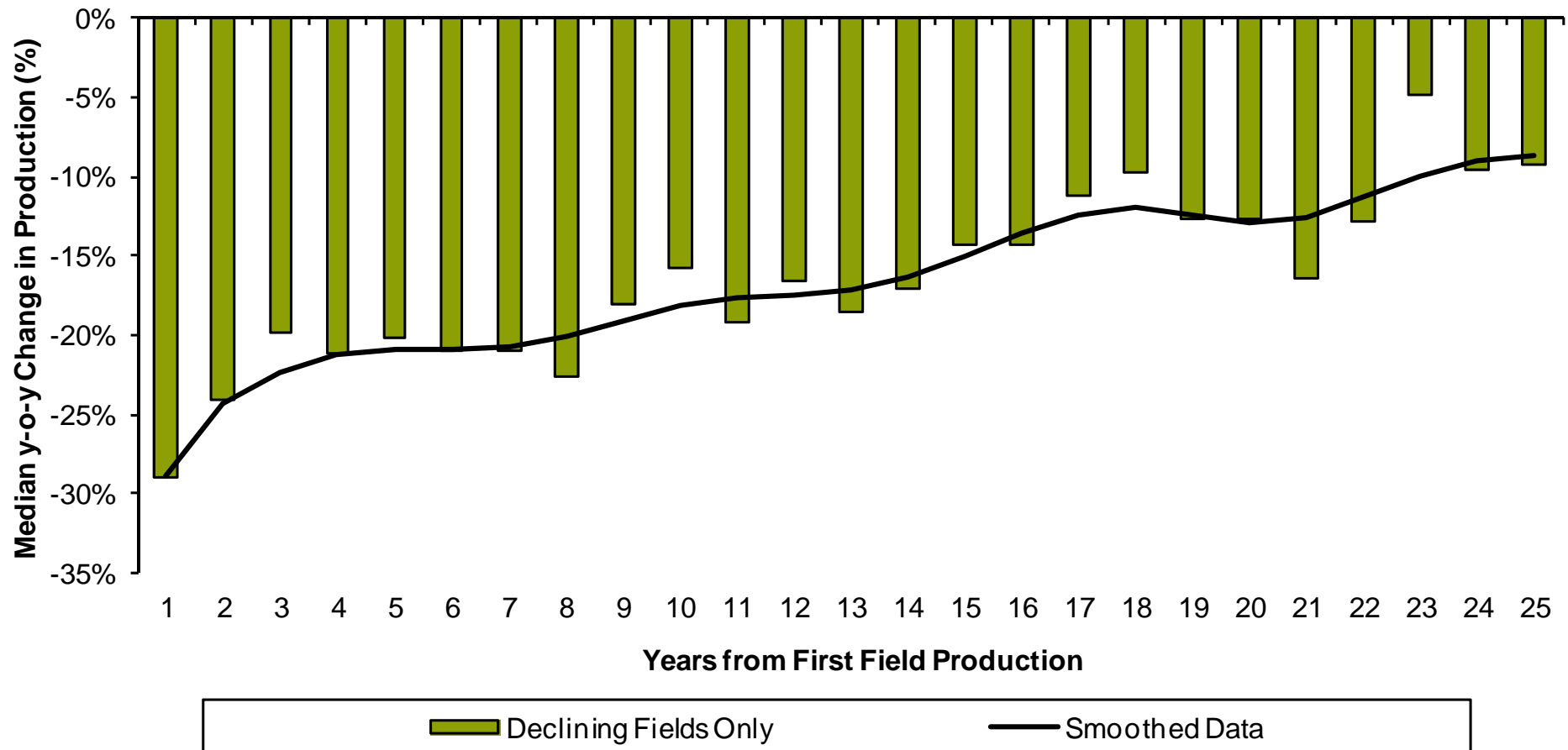
- 83 oil fields
- 3700 development wellbores
- Monthly production data since first oil in the basin
- Median y-o-y change in production = -9.3%
- Mean Average Natural decline rates of -21.7%



Source: NPD, DECC, Bernstein Estimates

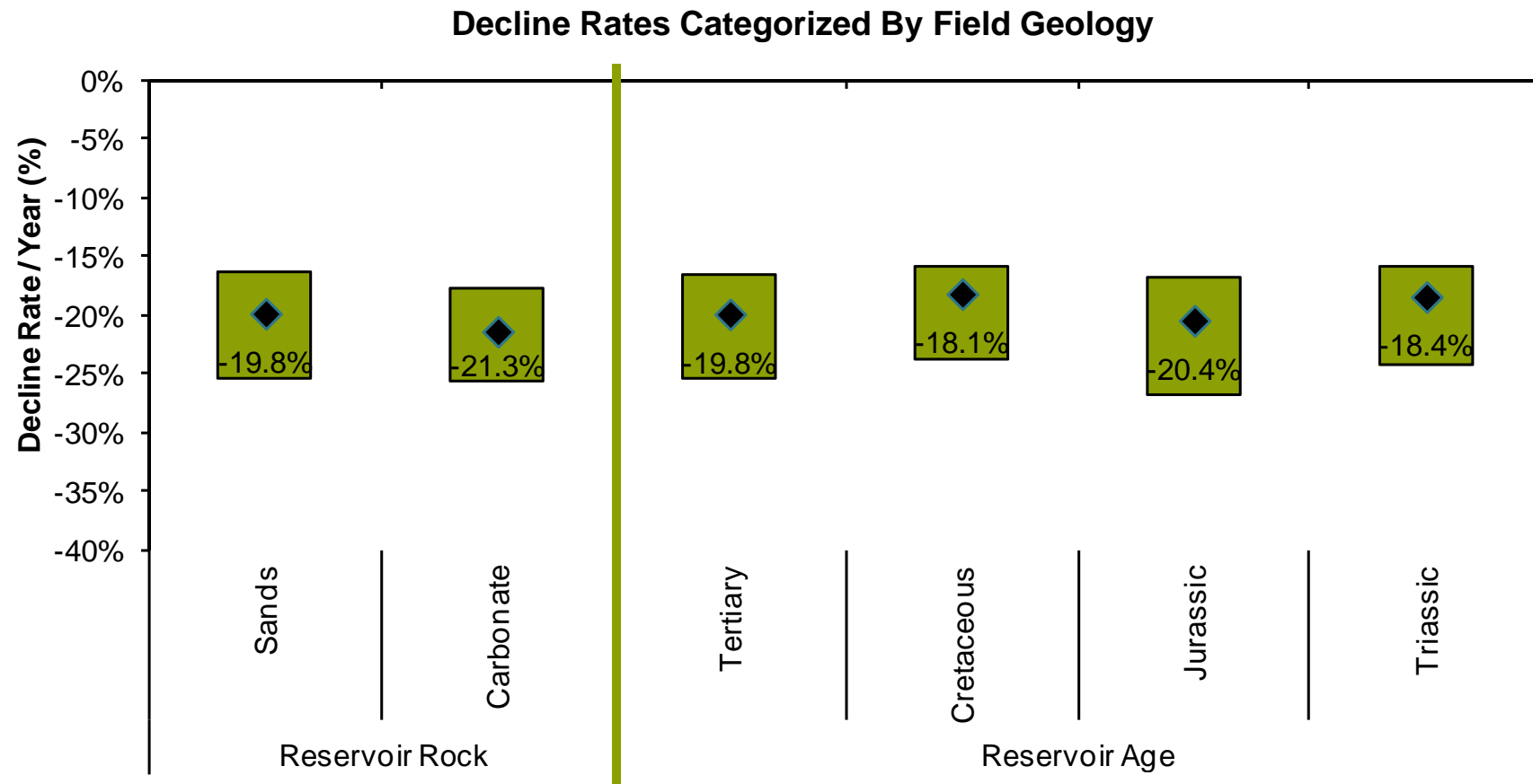
# Median decline rates across declining UK N. Sea fields: Decline rates are highest initially, and fall over time

## Decline Rates Across Fields' Lives



Source: DECC, Bernstein Estimates

# Decline rates are significantly lower in chalk carbonate reservoirs than sandstone reservoirs across the UK North Sea



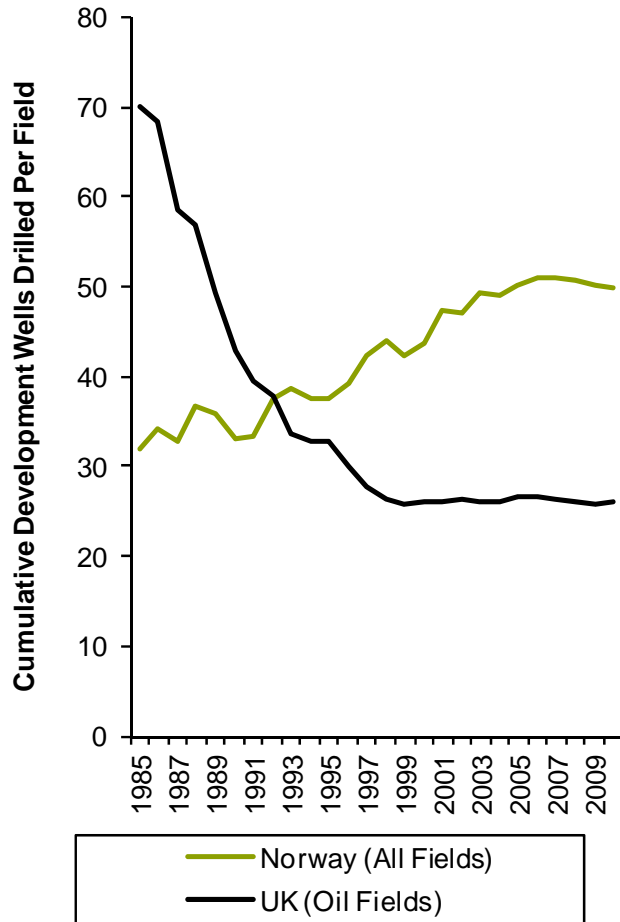
**(Sands vs Chalks  $t = 2.67$   $p < 0.01^{**}$ )**

■ Mean +/- 1 Standard Deviation    ◆ Median Decline Rate

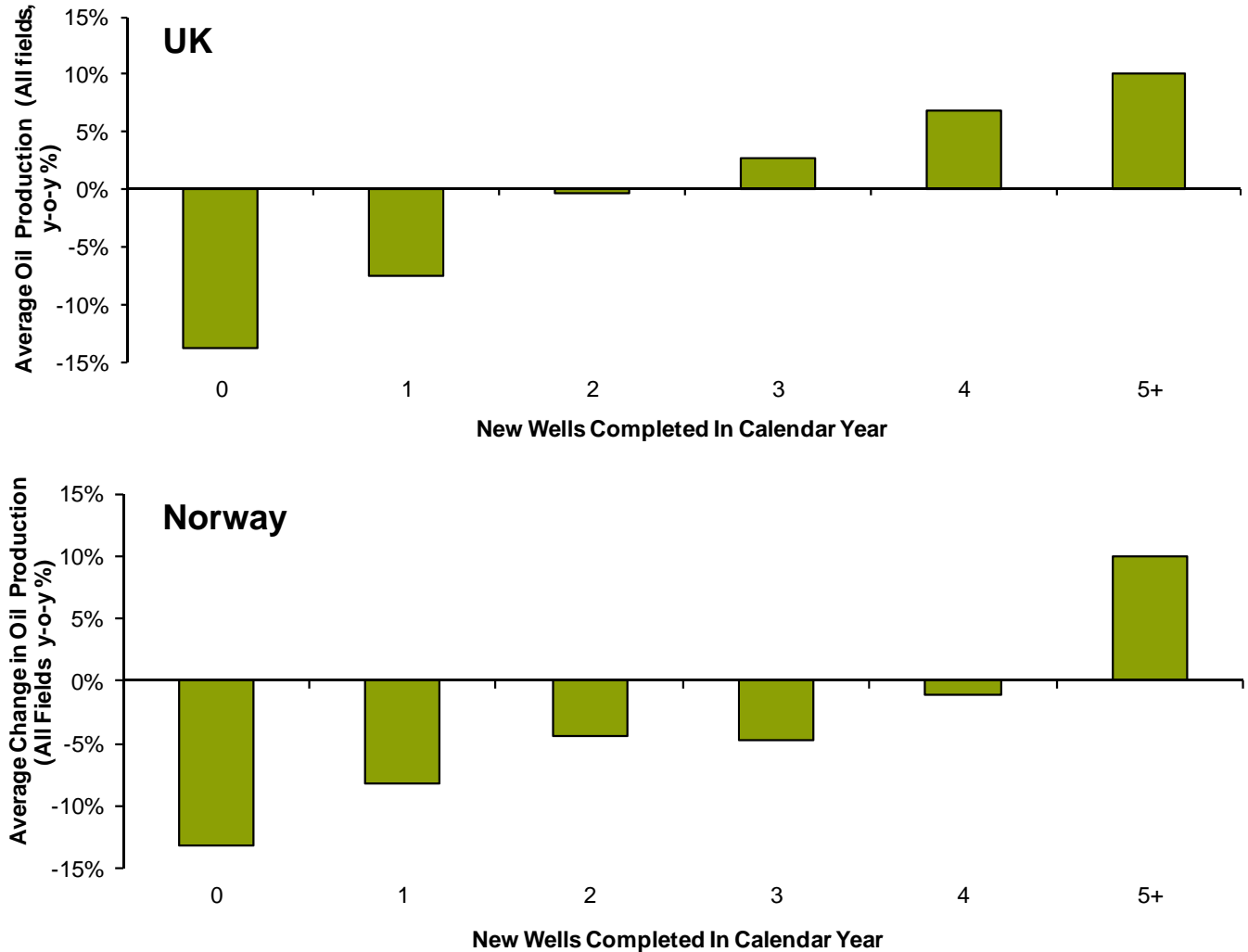
Source: DECC, Bernstein Estimates

# “Just drill more wells” – the simplest approach to slowing decline rates

Wells Per Field in Norway & the UK

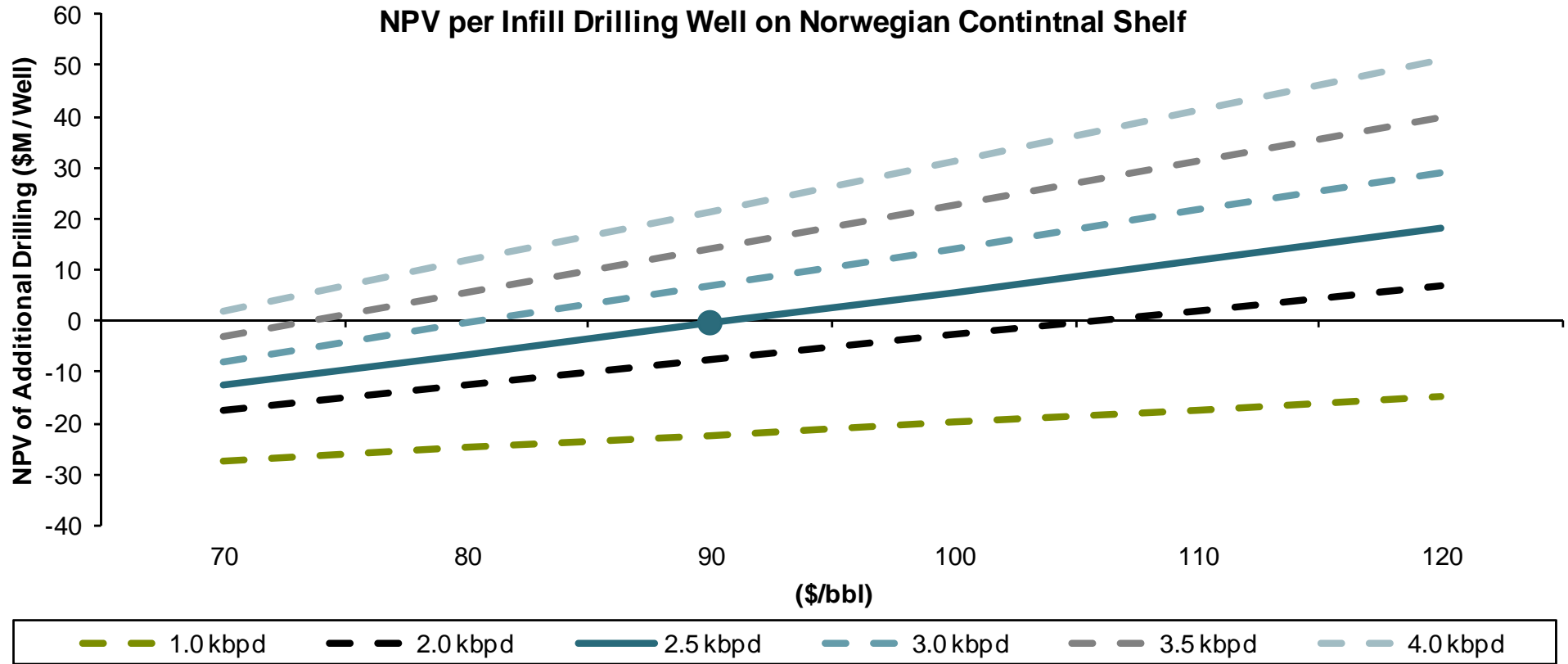


y-o-y production -vs- the number of new production wells completed



Source: NPD, DECC, Bernstein Estimates

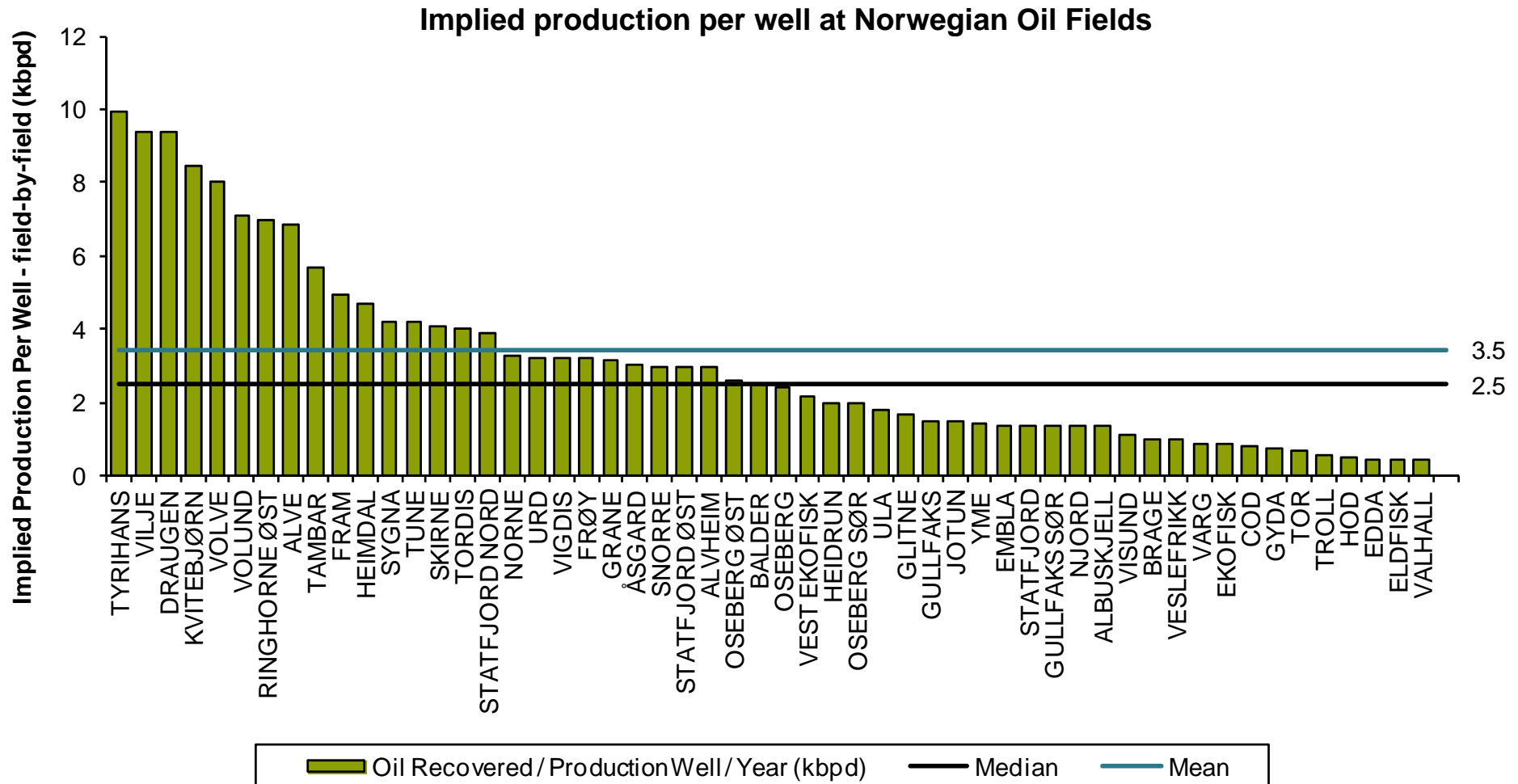
# We are cautious on whether material value is added by infill drilling at mature fields



Source: NPD, Bernstein Estimates

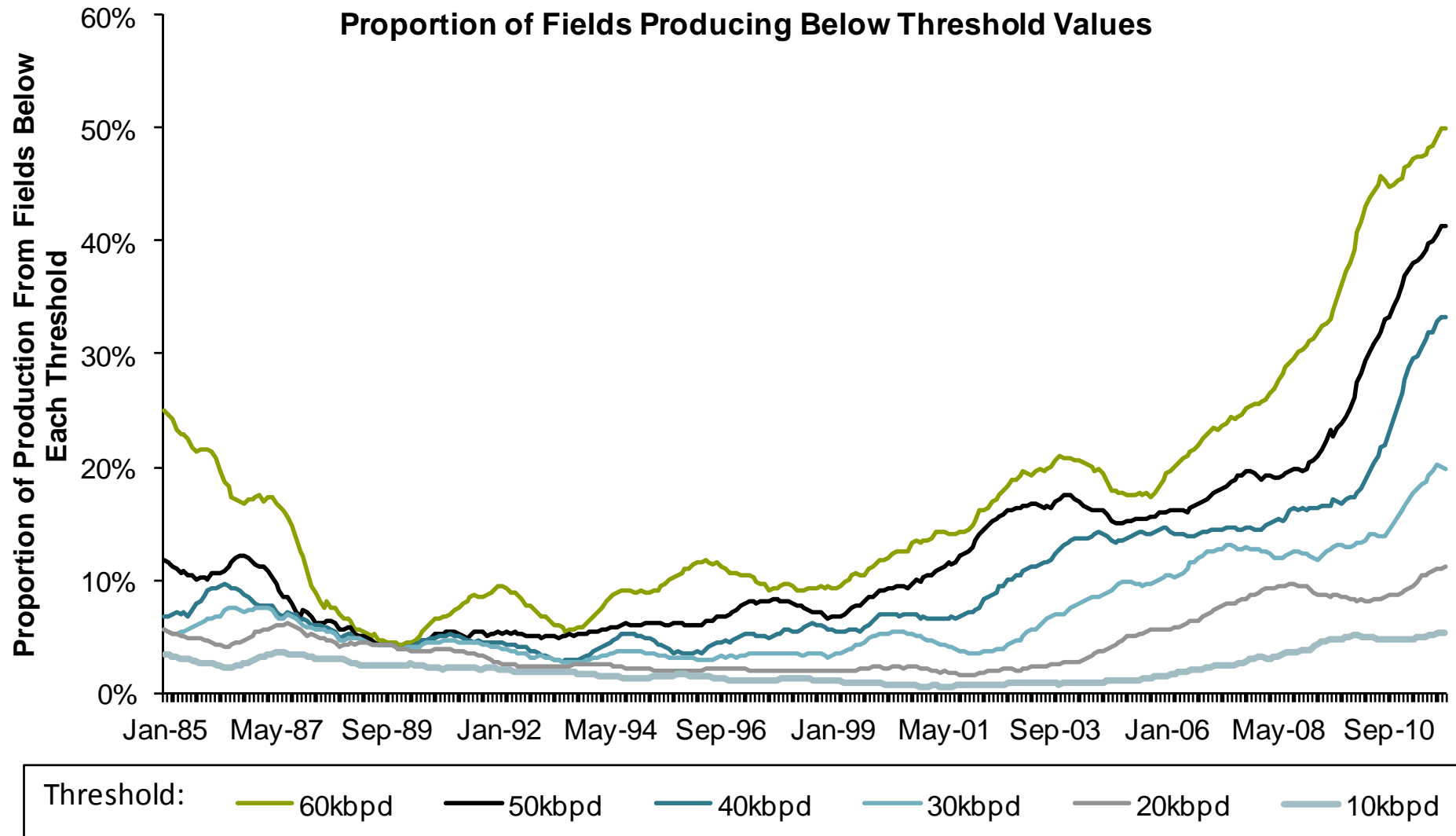


# Wide variation in production added per well – 2.5kbpd is the average



Source: NPD, DECC, Bernstein Estimates

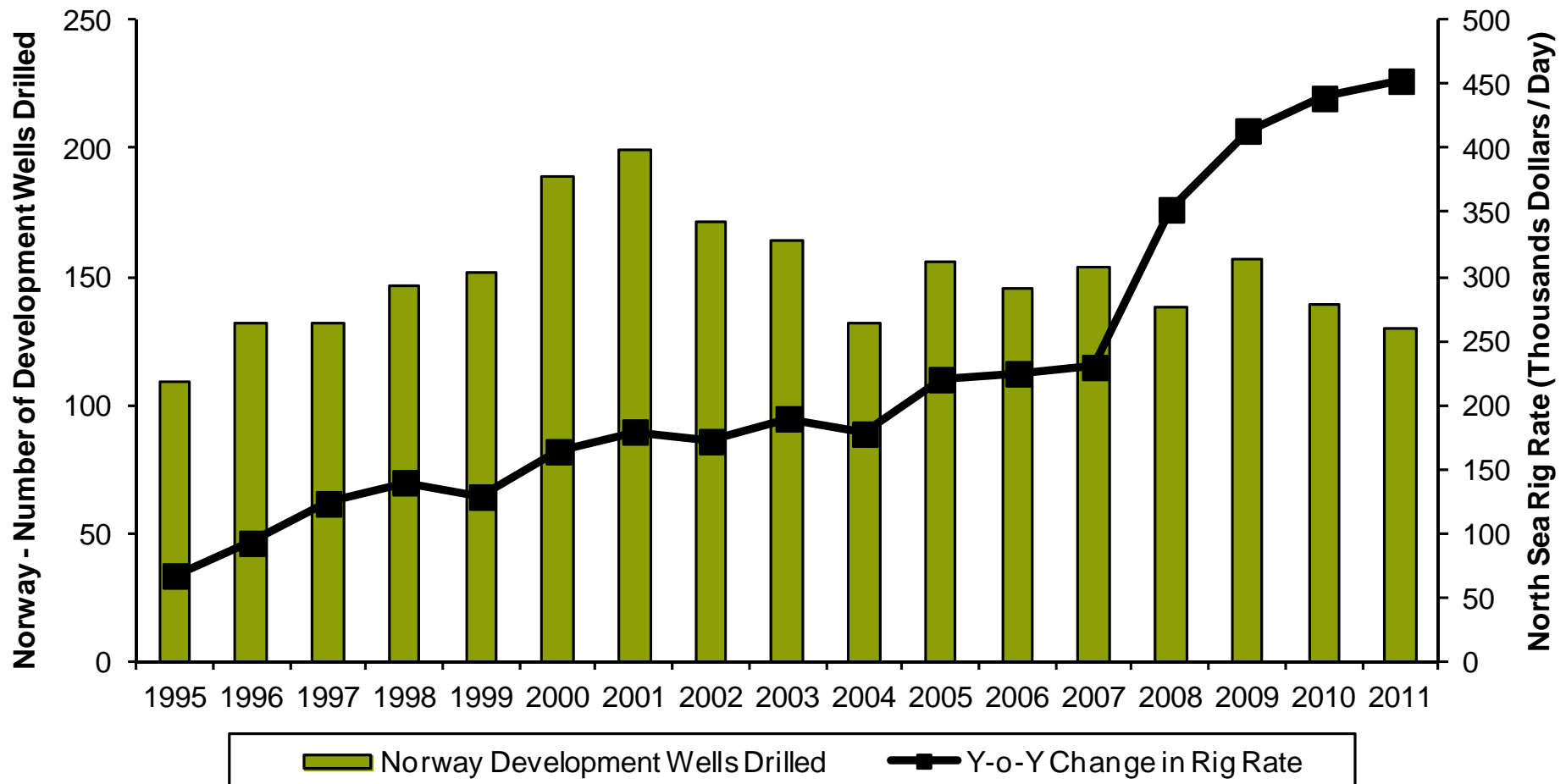
# The past five years have seen an acceleration in production from smaller fields – how does this change the economics of infill drilling?



Source: NPD, Bernstein Estimates

# Reliance on infill drilling increases vulnerability to rising rig rates

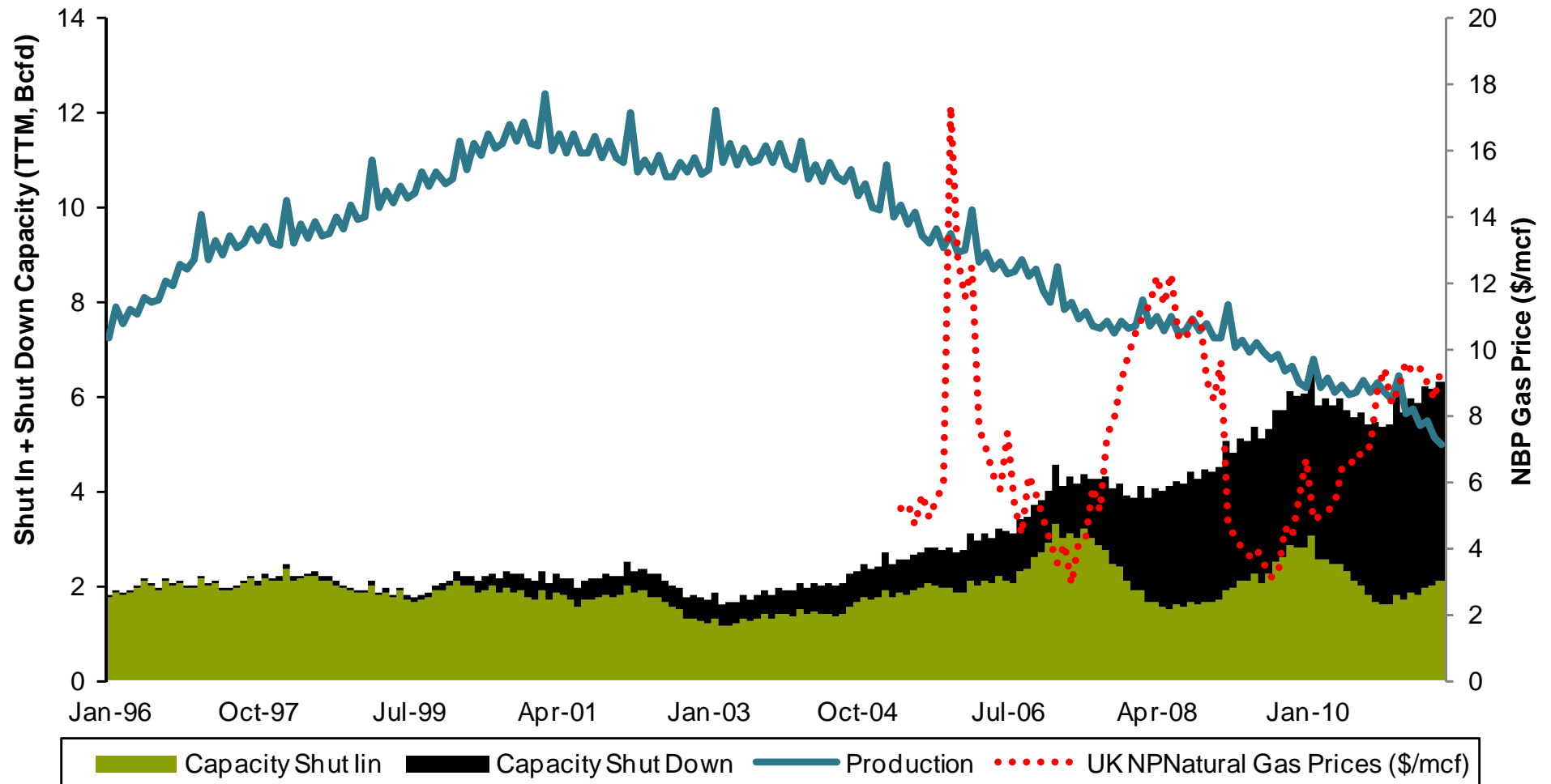
Norway – New Development Wells Drilled versus Rig Rates



Source: DECC, ODS-Petrodata, Bernstein Estimates

# The difficulty of economical EOR is exacerbated by the UK higher supplementary tax rate - Are Operators Just Shutting Down?

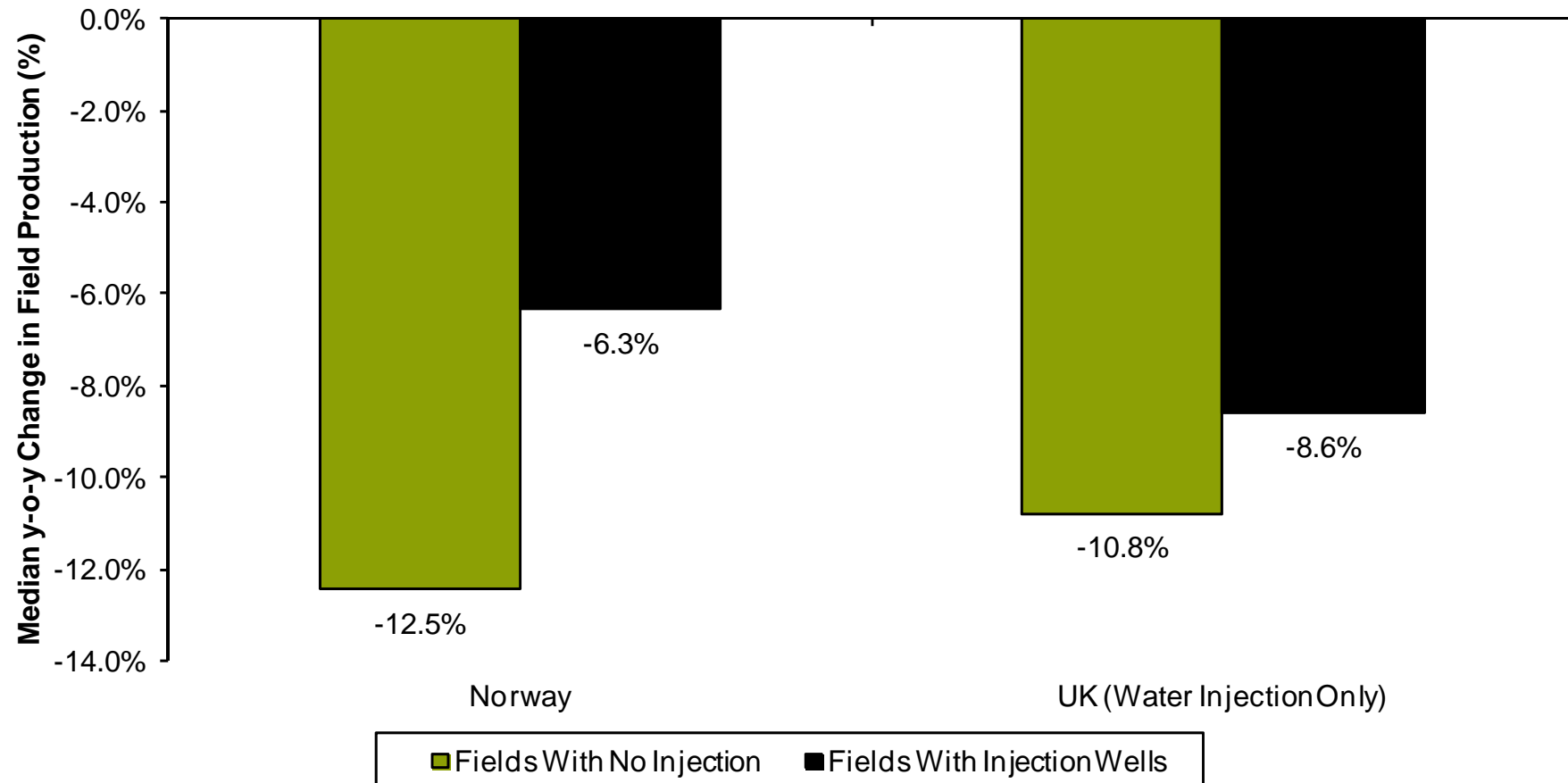
UK North Sea Gas Production, Shut Ins and Shut Downs -vs- the NBP Gas Price



Source: DECC, Bernstein Estimates

# Injection wells reduce the decline rates at UK and Norwegian fields, with effects well beyond the years they are initially drilled

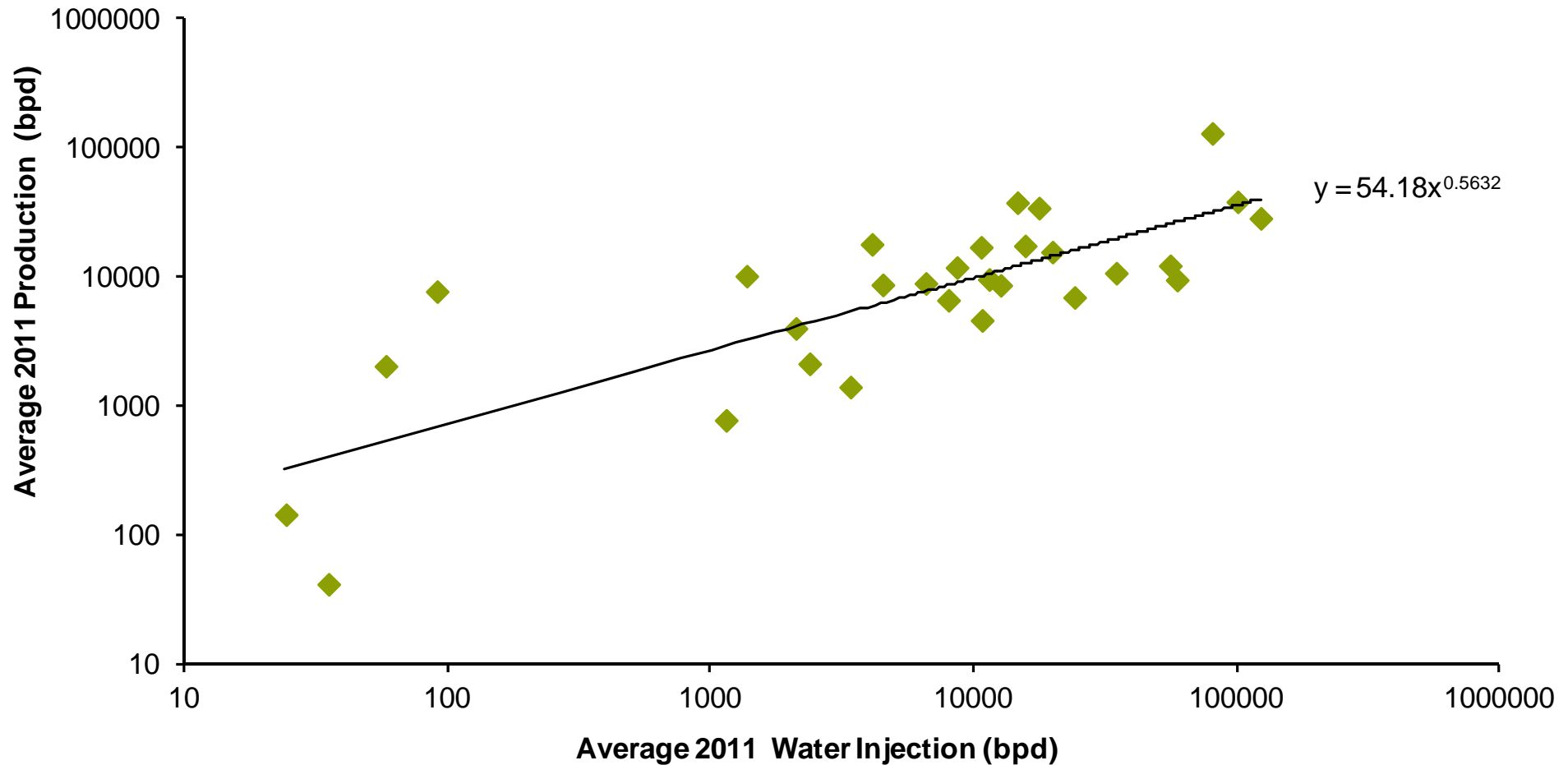
Effect of Injection Wells on Field Decline Rates



Source: NPD, DECC, Bernstein Estimates

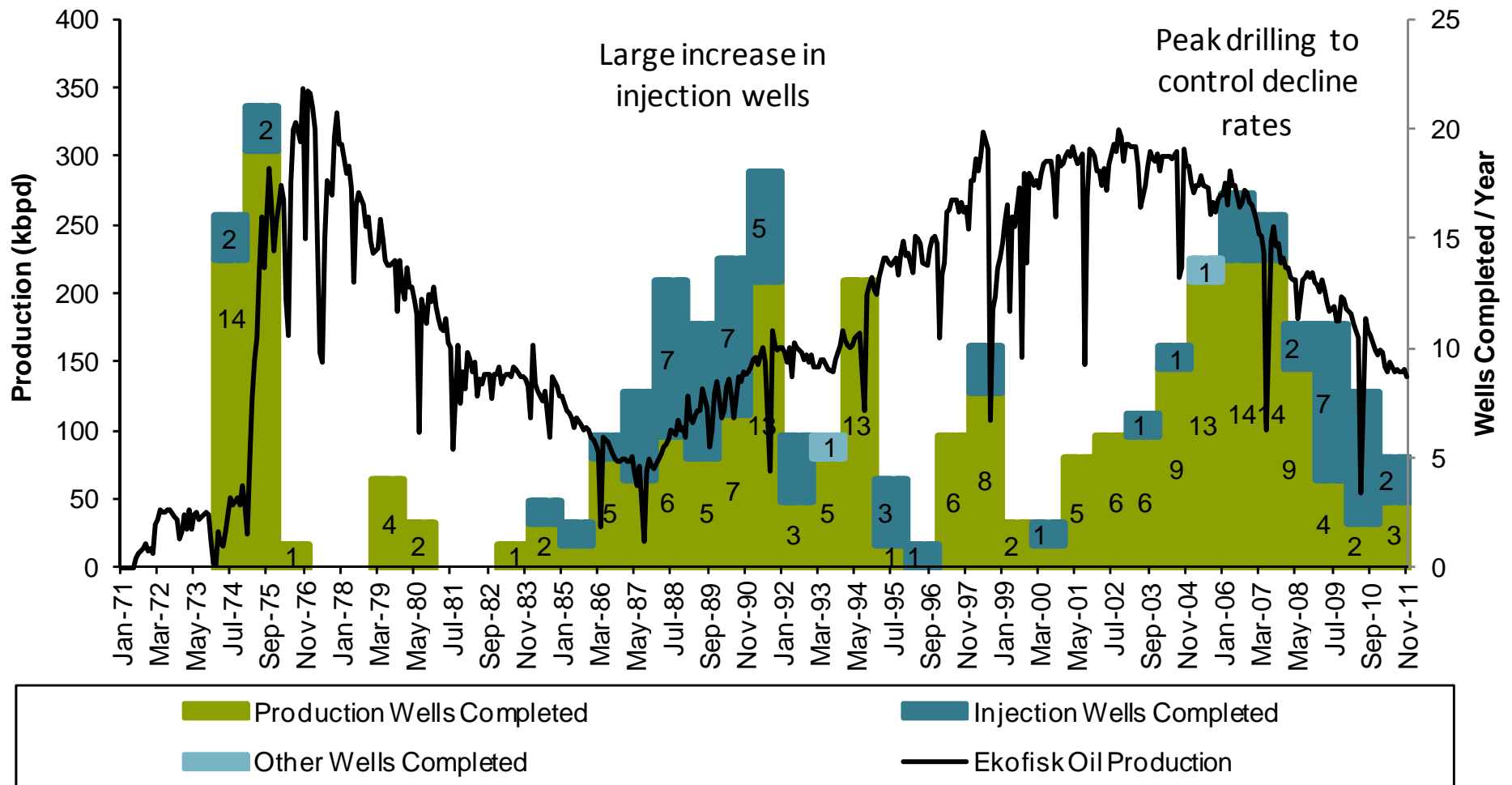
# Water injection may be a better long-term solution: 78% correlation between water-injected and oil produced at UK N. Sea Oil Fields

UK North Sea: Water Injection vs Field Production in 2011



Source: DECC, Bernstein Estimates

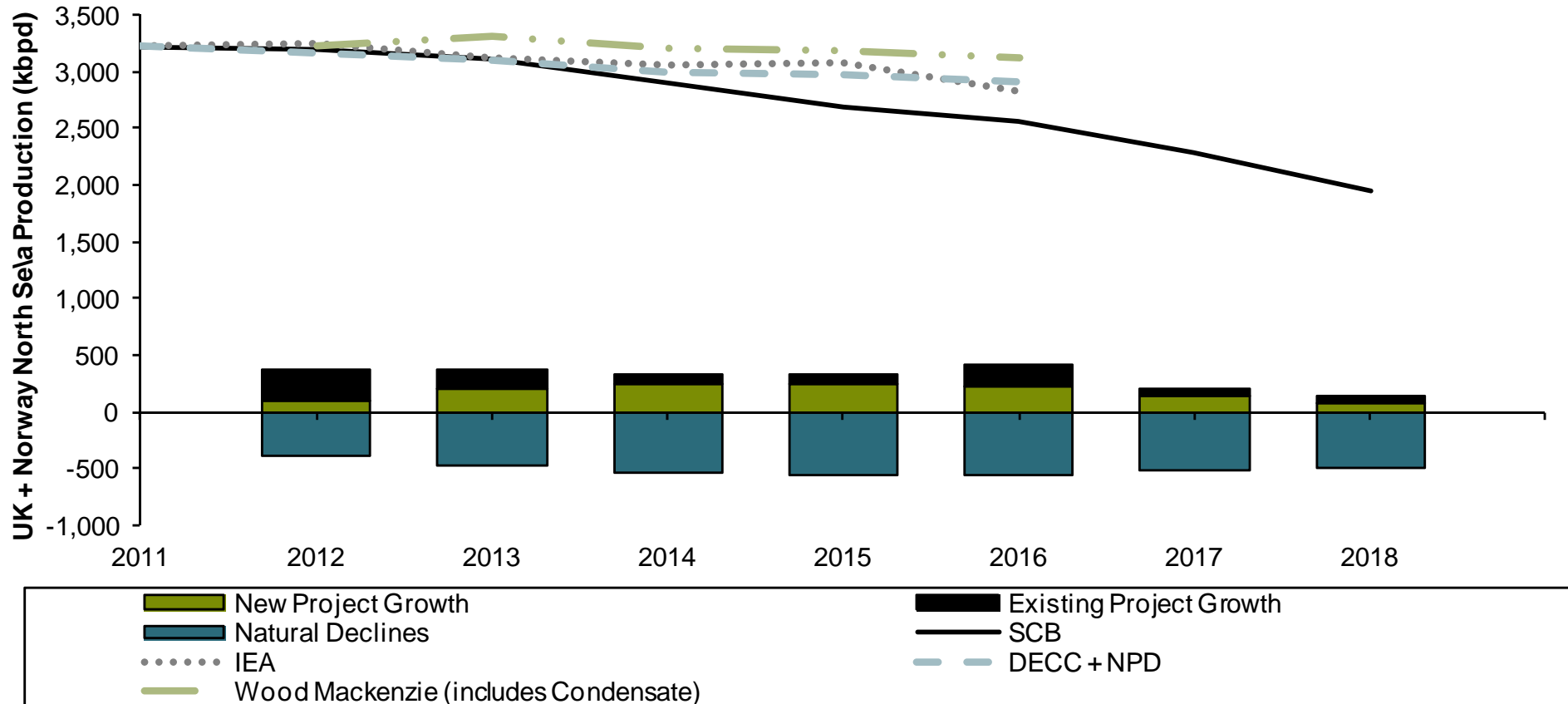
# Injection wells were successfully used to stabilize and even grow production at Ekofisk, one of Norway's oldest fields



Source: NPD, Bernstein Estimates

# We expect faster oil production declines out to 2016, based on our analysis of decline rates

UK + Norway Total Oil Production (kbpd)



Source: NPD, IEA, DECC, Company Reports, Wood MacKenzie, Bernstein Estimates



## Disclosure Appendix

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BP.LN	M (IC) 08/03/10 O (DC) 08/02/10 O (RC) 05/10/10 M (RC) 03/03/09
CNE.LN	O (IC) 01/22/09
E	O (IC) 08/03/10 O (DC) 08/02/10 O (RC) 11/21/08
EAD.FP	O (RC) 12/17/09
ENI.IM	O (IC) 08/03/10 O (DC) 08/02/10 O (RC) 11/21/08
FP.FP	O (IC) 08/03/10 M (DC) 08/02/10 M (RC) 02/16/10 O (IC) 05/30/03
GALP.PL	O (RC) 05/26/10 M (IC) 01/22/09
LKOD.LI	U (IC) 01/15/09
NVTK.LI	O (IC) 01/15/09
OGZD.LI	O (RC) 07/16/09
PMO.LN	O (RC) 02/19/10 M (IC) 01/22/09
RDS/A	O (IC) 08/03/10 O (DC) 08/02/10 O (RC) 02/16/10 M (RC) 03/16/09
RDS/B	O (IC) 08/03/10 O (DC) 08/02/10 O (RC) 02/16/10 M (RC) 03/16/09
RDSA.LN	O (IC) 08/03/10 O (DC) 08/02/10 O (RC) 02/16/10 M (RC) 03/16/09
RDSA.NA	O (IC) 08/03/10 O (DC) 08/02/10 O (RC) 02/16/10 M (RC) 03/16/09
RDSB.LN	O (IC) 08/03/10 O (DC) 08/02/10 O (RC) 02/16/10 M (RC) 03/16/09
RDSB.NA	O (IC) 08/03/10 O (DC) 08/02/10 O (RC) 02/16/10 M (RC) 03/16/09
ROSN.LI	U (IC) 01/15/09
SGGD.LI	U (IC) 01/15/09
STL.NO	M (IC) 01/22/09
TLW.LN	O (IC) 01/22/09
TOT	O (IC) 08/03/10 M (DC) 08/02/10 M (RC) 02/16/10 O (IC) 05/30/03

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