Arctic oil and public finance

A modelling exercise for Lofoten/Vesterålen/Senja

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Arctic oil and public finance

A modelling exercise for Lofoten/Vesterålen/Senja

- Motivation and outset
- Resources to revenues
- Calibration of costs
- Cash flows and NPV
- Sensitivity analysis
- Implications

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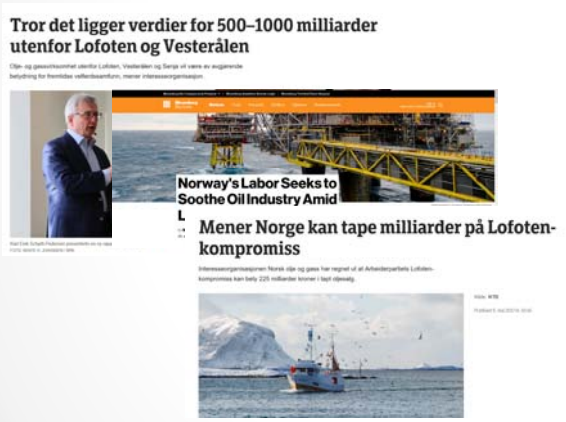
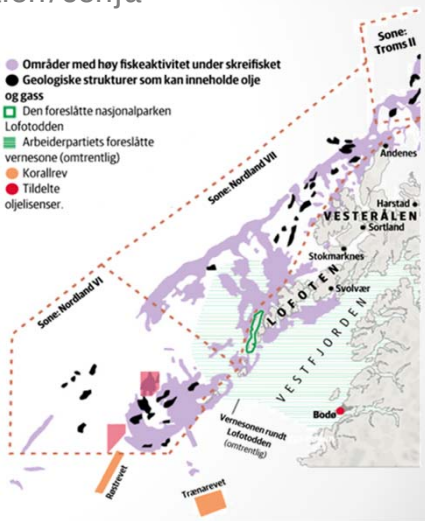
Motivation and outset

A modelling exercise for Lofoten/Vesterålen/Senja





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Economic evaluation

A note on methodology and principles

Direct effects

\+ **Indirect effects**

\+ **External effects**

= **Economic surplus**

- Costs and benefits directly linked to owners/operators
- Effects passed on to related markets (i.e. ripple effects)
- Effects that can not be passed on (i.e. non-market effects)
- Present value of periodical net economic surpluses

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Economic evaluation

A note on methodology and principles

Direct effects

$$V_0^D = \sum_{t=1}^{T} \frac{CF_t^D}{(1+r)^t}$$

Indirect effects

$$V_0^I = \sum_{t=1}^{T} \frac{CF_t^I}{(1+r)^t}$$

External effects

$$V_0^E = \sum_{t=1}^{T} \frac{CF_t^E}{(1+r)^t}$$

Economic surplus

$$V_0 = V_0^D + V_0^I + V_0^E$$

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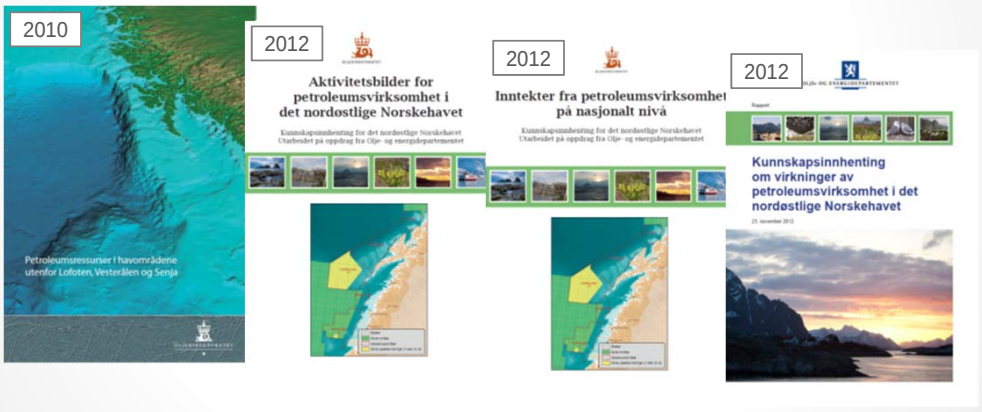
Previous assessments

Knowledge collection project for Norskehavet Northeast



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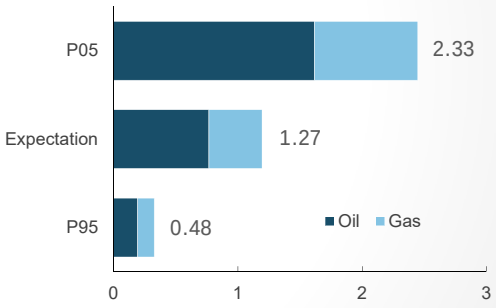
Source: Ministry of Petroleum and Energy, Norwegian Petroleum Directorate.

Point of departure: Recoverable resources

Significant volumes in absolute terms, not in relative terms

- Expectation: 1.271 bn boe
  - 64 per cent oil
- ~50% of Johan Sverdrup
  - Upside compares to JS
- 1.4% of total NCS resources
  - 3% of remaining resources
  - 7% of ytf resources

LoVeSe resource estimates
Billion boe



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Paths of extraction

Distribution over time according to lognormal density functions

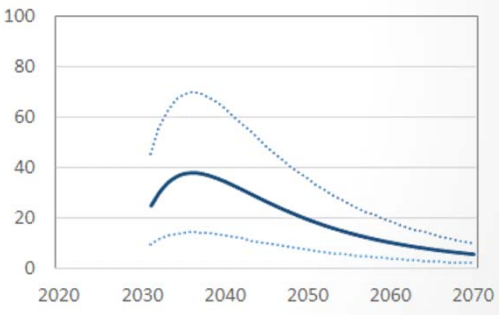
- Annual production drawn from:

$$f(\alpha) = \frac{1}{q\sigma\sqrt{2\pi}} e^{\left[-\frac{1}{2\sigma^2}(\ln\alpha-\mu)^2\right]} d\alpha$$

- Resource share produced in year t:

$$q_{it} = \alpha_{it}(\mu,\sigma)\cdot Q_i \quad , \; i = oil, gas$$

Lofoten oil production
1,000 bpd



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Paths of extraction

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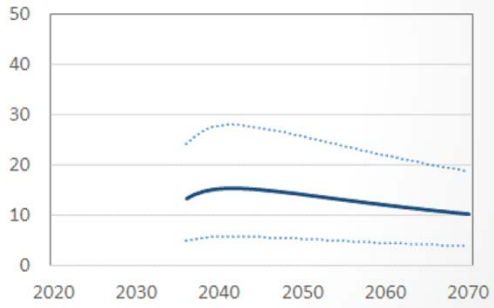
Lofoten gas production
1,000 bpd



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Calibration of costs

Two stylized field project, three cost categories

The tug-of-war between resource depletion and technological change in the global oil industry 1981–2009

- Cost of exploration
  - Driven by unit cost of discovery
  - Distributed according to resource mix
- Cost of development
  - Driven by capacity investment
- Cost of operation
  - Driven by capacity…
  - … and actual activity (production)


Energy

The tug-of-war between resource depletion and technological change in the global oil industry 1981–2009

Lars Lindholt

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Source: Lindholt, Lars (2015). The tug-of-war between resource depletion and technological change in the global oil industry 1981-2009. *Energy* 93, 1607-1616.

Costs of exploration

What will it take to discover the estimated resources?

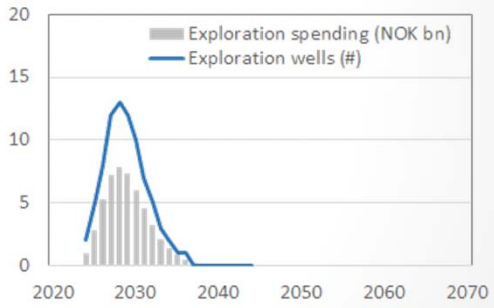
- Unit cost of discovery (*e*)
- Attribution to oil/gas determined by resource mix

$$Q_i = \beta^i Q \ , \ i = oil, gas$$

- Total cost of exploration:

$$E^i = e\beta^i Q \ , \ i = oil, gas$$

Lofoten exploration
Activity and spending



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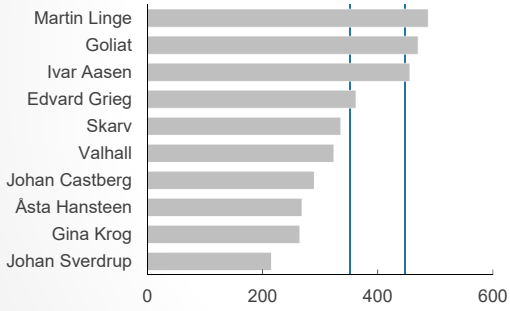
Costs of development

What will it take to develop the estimated discoveries?

Unit cost of production capacity
10 recent NCS fields: NOK 1,000 per boepd



- Driven by unit cost (d_i) of production capacity ($\bar{q}^i$):

$$D^i = d^i \cdot \bar{q}^i \ , \ i = oil, gas.$$

- Different development cost for oil and gas
  - $d^{oil} = 350{,}000$
  - $d^{gas} = 450{,}000$

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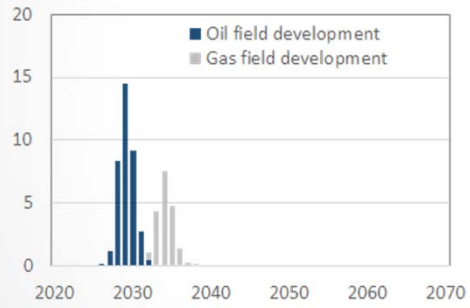
Source: Plans of Development and Operation (PDO), company updates, press stories.

Costs of development

What will it take to discover the estimated resources?

Calibrated costs of development
NOK bn



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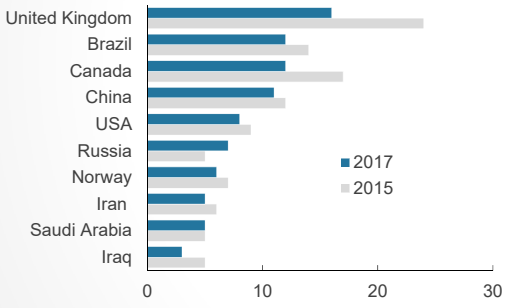
Costs of operation

Driving: fuel consumption depends on engine power and actual speed

Unit cost of oil and gas production
USD per boe, 10 selected countries



- Driven by installed capacity ($\bar{q}^i$) and actual activity (q^i):

$$C_t^i = \gamma^i \cdot \bar{q}^i + \delta^i \cdot q_t^i$$

- Different development cost for oil and gas
  - $[\ \delta^{oil}\ ,\ \gamma^{oil}\ ] = [\ 2.0\ ,\ 2.0\ ]$
  - $[\ \delta^{gas}\ ,\ \gamma^{gas}\ ] = [\ 3.0\ ,\ 1.0\ ]$

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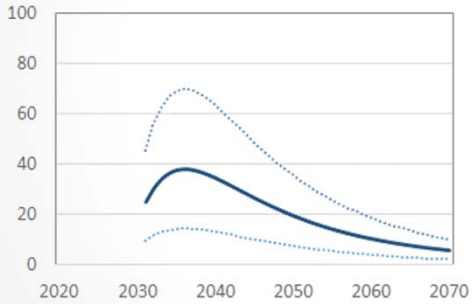
Source: Rystad Energy.

Costs of operation

Driving: fuel consumption depends on engine power and actual speed

Lofoten oil production
1,000 bpd



- Marginal cost of extraction given by δ
- Average unit cost of extraction:

$$\frac{C_t^i}{q_t^i} = \frac{\gamma^i \cdot \bar{q}^i}{q_t^i} + \delta^i$$

- Unit cost of peak production given by $\gamma + \delta$

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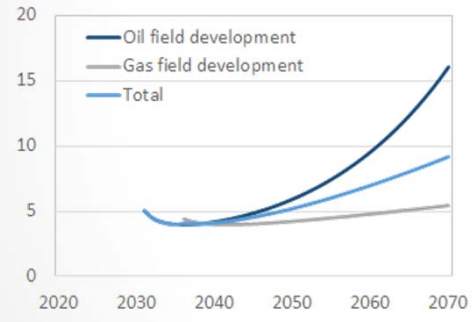
Source: Rystad Energy.

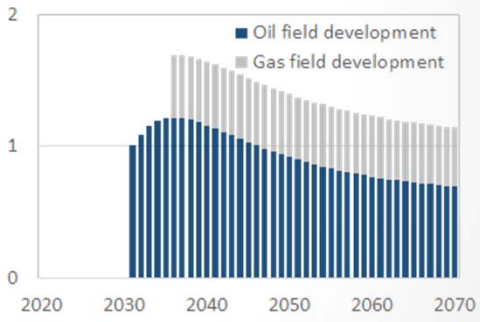
Costs of operation

U-shaped unit costs, declining total costs

Average unit cost of of operation
USD/boe



Total cost of field operation
NOK bn



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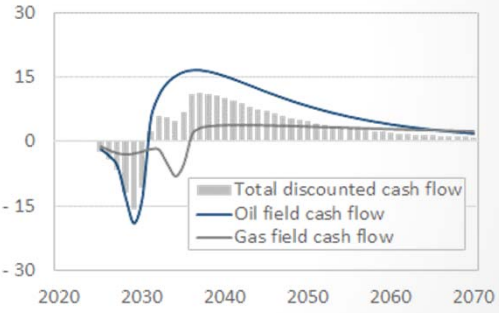
Discounted cash flow valuation

Net present value (@3%) for Reference case: NOK 141 bn

Key assumptions
Reference scenario

Variabel	Unit	Value
Recoverable resources	*Bn boe*	1,271
Oil	*Bn bbl*	0,813
Gas	*Bn boe*	0,458
Oil price (real)	*USD/bbl*	60
	NOK/bbl	480
Gas price (real)	*NOK/SM3*	2,00
	USD/MMBtu	6,60
	USD/fat oe	36,61
Exchange rate	*NOK/USD*	8,00
Discount rates	*Per cent*	3,00

Cash flows
NOK bn (2017 prices)



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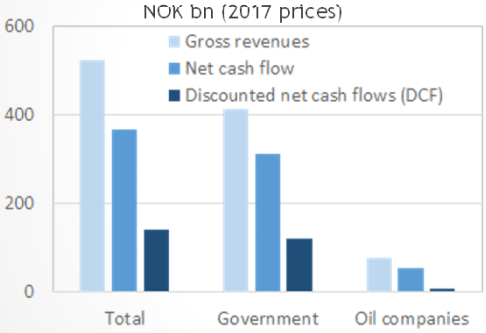
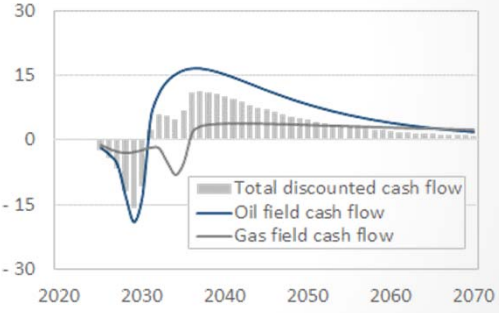
Discounted cash flow valuation

Net present value (@3%) for Reference case: NOK 141 bn

From revenues to NPV
Government and oil companies
NOK bn (2017 prices)



Cash flows
NOK bn (2017 prices)



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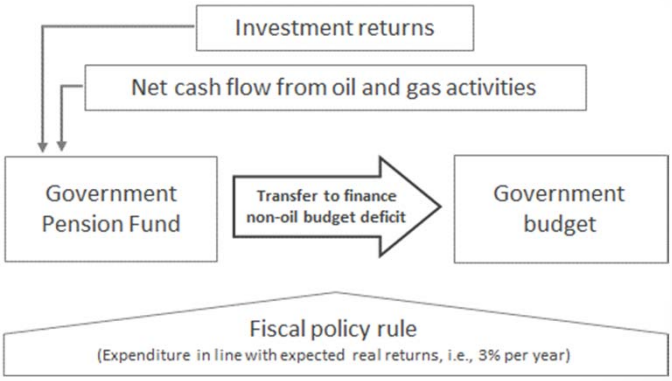
Resource revenue management in Norway

Main features of the oil fund mechanism and the fiscal policy rule



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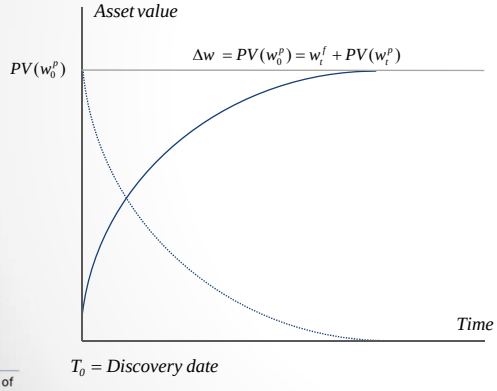
Resource revenue management in Norway

More prudence than implied by PI approach

From resource wealth to financial wealth

The PIH and the Hartwick rule



- Permanent Income approach

$$g_t = r \cdot \left(E(w_t^p) + w_t^f \right)$$

- GPF evolves according to:

$$w_t^f = (1+r) \cdot w_{t-1}^f + h_{t-1} - g_{t-1}$$

- Spending with BIH approach:

$$g_t^* = r \cdot w_t^f$$

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Source: Venables, Anthony J. (2016). Using Natural Resources for Development: Why Has It Proven So Difficult? *Journal of Economic Perspectives* 30 (1), 161-184.

Resource revenue management in Norway

Lofoten budget impact depends on management strategy/spending rule

- Permanent Income approach

$$g_t = r \cdot \left(E(w_t^p) + w_t^f \right)$$

- GPF evolves according to:

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- Spending with BIH approach:

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Van der Ploeg, Frederick and Tony Venables (2011). Harnessing windfall revenues: Optimal policies for resource-rich developing countries. *The Economic Journal* 121, 1-30.
Van den Bremer, Ton, Frederick van der Ploeg, and Samuel Wills (2016). The elephant in the ground: Managing oil and sovereign wealth. *European Economic Review* 82, 113-131.

Impact on government budget capacity

Effects via government financial wealth (GPF), incl annuities and sensitivities

Annuities implied by PIH approach

Resource estimates

Oil and gas prices

Full cycle costs

Discount rate

	National figures			*Per capita figures*	
	NPV		Fisc cap ch	NPV	Fisc cap ch
	NOK bn	%	NOK bn	NOK bn	NOK bn
Reference	120	1,4	3,6	22,8	521
High (P05)	220	2,6	6,6	41,8	955
Low (P95)	45	0,5	1,4	8,6	197
80 USD/bbl	187	2,2	5,6	35,5	813
40 USD/bbl	53	0,6	1,6	10,0	229
+ 33 per cent	90	1,1	2,7	17,1	39,1
- 33 per cent	147	1,7	4,4	27,9	640
0 per cent	311	3,7	9,3	59,1	1765
5 per cent	64	0,8	1,9	12,2	278
7 per cent	34	0,4	1	6,4	190

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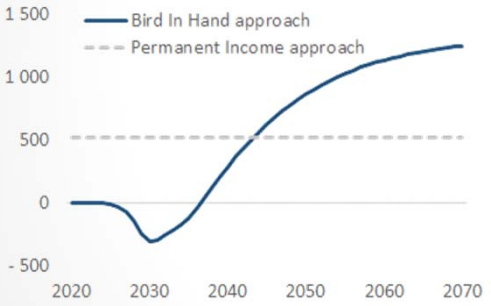
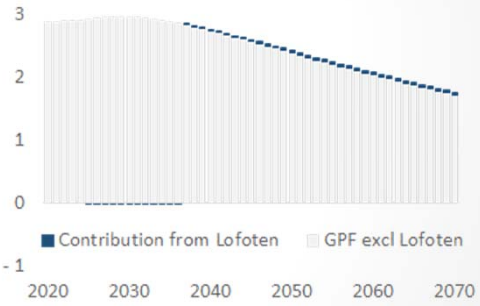
Impact on government budget capacity

Annual spending and capital on the Government Pension Fund (GPF)

From revenues to NPV
Per capita annual fiscal capacity (NOK)



Contribution to GPF
Ratio to GDP (%)



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Economic evaluation

A note on methodology and principles

	Direct effects	$V_0^D = NOK\ 141\ bn$
+	**Indirect effects**	$V_0^I = ?$
+	**External effects**	$V_0^E = ?$
=	**Economic surplus**	$V_0 = NOK\ 141\ bn + V_0^I + V_0^E$

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Costs of oil and gas extraction

A modelling exercise for Lofoten/Vesterålen/Senja

- Decisions require support
- Direct effects important
- Flexible framework
- Opportunity costs
- Indirect effects
- External effects

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