The Oil Drum: Europe
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

The Amazing Power of King Hubbert(...?)

Posted by Euan Mearns on September 12, 2007 - 10:30am in The Oil Drum: Europe
Topic: Supply/Production
Tags: built capacity, hubbert linearization, m. king hubbert, norway [list all tags]

This post examines the impact of delaying oil field developments and producing at below capacity upon reserves estimates made using Hubbert Linearisation. Robert Rapier had a **similar post** some months back using synthetic data. This post uses real data from Norway and three different story lines are described and analysed.

1. Norway
2. Fjordland – same as Norway but with 4 fields allowed to lie fallow and 20% of production withheld from 1981 to the present day
3. Fjelland – same as Fjordland but with the 4 fallow fields developed in 2001-2004 and full production reinstated from 2002.

The significance for predicting national and global oil reserves and peak oil are discussed.

Introduction

How do we know when oil production is going to peak? This question may be asked of individual oil fields, countries and the world as a whole. Once peak is past in countries such as the USA, UK and Norway, it is relatively straight forward to recognise this after the fact. But how is it possible to forecast this in advance?

One approach that has received much attention on The Oil Drum is called Hubbert Linearisation, following methodology first used by M. King Hubbert in 1956 to successfully predict a peak in US oil production around 1970.

Hubbert - a controversial figure

There have been many posts on The Oil Drum exploring the merits and weaknesses of this

approach. For example:

By Stuart Stanniford
Linearize this...

Well, could we linearize this, then?

By Khebab
The Loglet Analysis

By Robert Rapier
Does the Hubbert Linearization Ever Work?

By Jeffrey Brown (Westexas)
In Defense of the Hubbert Linearization Method

It is not my intention here to review this methodology. The uninitiated reader will find an overview **here** and the mathematics described by Luis de Sousa **here**.

The objective of this post is to examine the influence that political interference has on reserves estimated using HL. In particular the impact of producing at below built oil production capacity and of allowing fields to lie fallow are explored. The issue of below capacity production is explored further in the **accompanying post**.

Story line 1: Norway

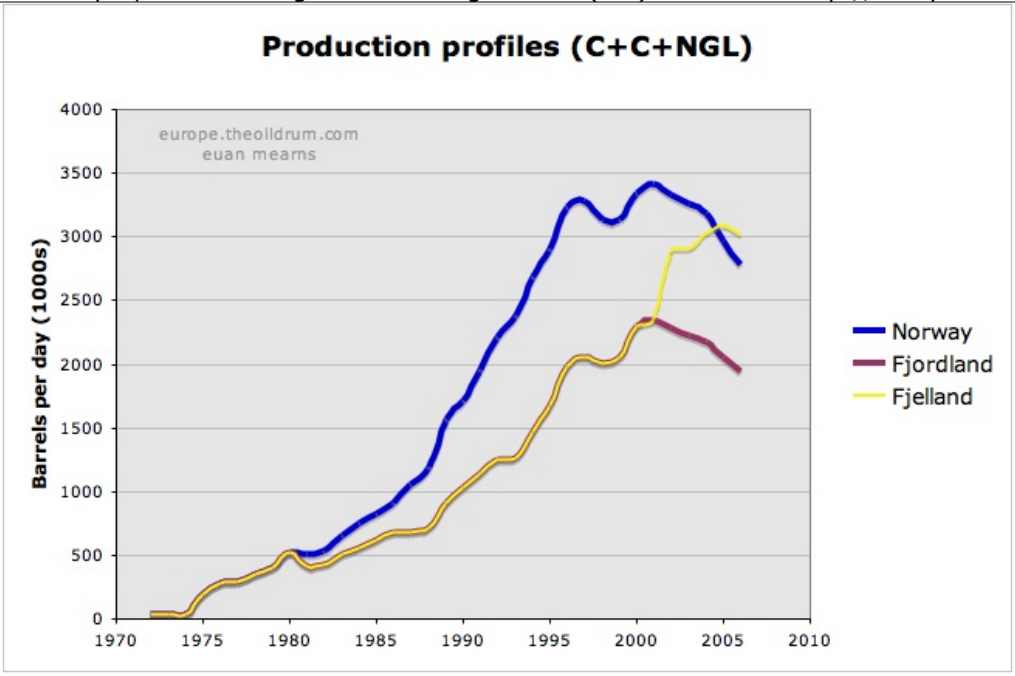
Norway is one of three Scandinavian countries of Northern Europe (Norway, Sweden and Denmark), famous for its mountains and Fjords. In the post WWII years, Norway thrived on a rural economy of fishing, farming and forestry but all that was to change during the 1960s with the first discoveries of gas and oil in the North Sea with first oil produced from the Ekofisk Field in 1971.

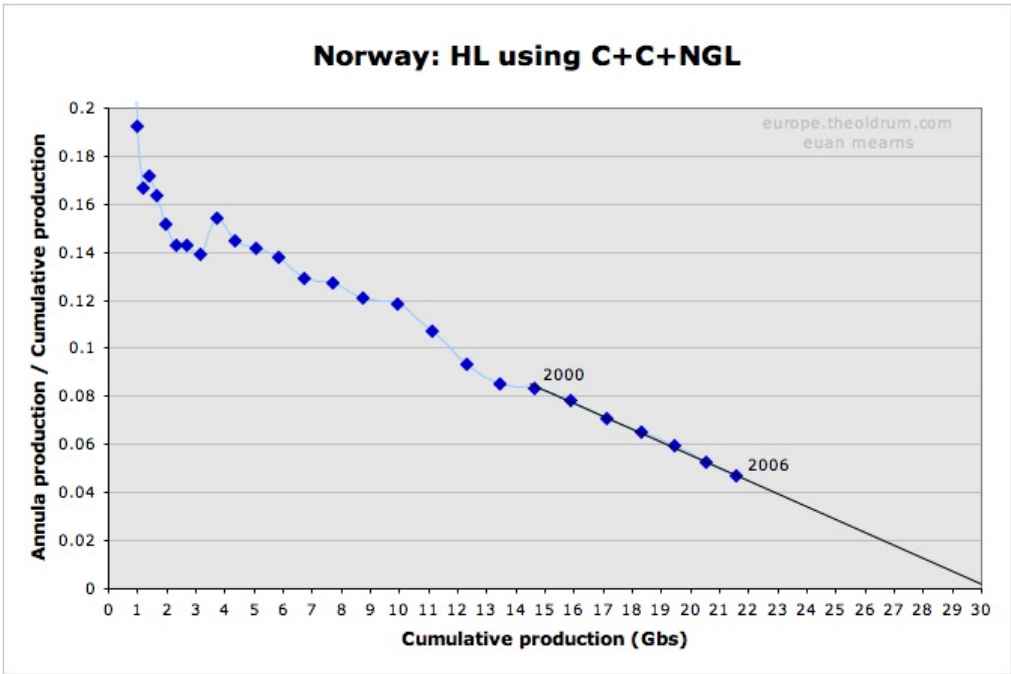
Norway was set on a course to become a major oil and gas producer and the number 3 oil exporting country in the world. The Norwegian government set out with the intention to control the rate of oil field development so that resources would be kept for future generations. But they were also keen to develop indigenous engineering and fabrication skills and this turned out to be incompatible with the aforementioned intent.

The seas around Norway's coast were the deepest and roughest offshore area to be developed at that time and the Norwegians rose to the challenge by building truly massive gravity base concrete platforms, utilising the deep sheltered waters of the fjords. Two engineering companies competed for this lucrative work – Aker and Kvaerner. These companies provided highly paid jobs in the coastal rural areas but the Norwegians soon found that once one platform had been completed, these yards were hungry for more work. And the only way that work could be provided was by the government consenting new field developments. Thus, commercial interests drove Norway's offshore oil industry and any good intention to slow the process was over-ridden by the need to provide work to the fabrication yards.

Troll - one of the biggest oil and gas platforms ever built

Norway's oil production began in the Ekofisk field in 1971 and climbed steadily to 3.4 mmbpd in 2001, which was the year of peak production. Since then production has fallen at the considerable rate of 2 to 7% per annum. To the end of 2006, 22 Gbs of oil had been produced. The HL plot is rather unstable until it settles down in the year 2000. It is really only in the post-peak era that a good linear decline trend develops that now points at a URR of 30 Gbs. It is thus inferred that Norway has another 8Gbs of oil to be produced from the *existing developed fields* using the *current range of technology* that is deployed.





HL for Norway. The 2000 to 2006 data define a good linear trend pointing to a URR of around 30 Gbs (C+C+NGL). This figure does not include discovered undeveloped and yet to find reserves.

If Norway were to discover large new reserves in the deep-water areas of the Norwegian and Barents Seas this would modify the picture when they were developed and would add to Norway's resource base. Furthermore, if new technology was developed that significantly increased the recovery factor this too would add to reserves and modify the decline trajectory of the HL.

Whilst Norway has done a poor job of preserving oil resources for future generations the government started an **oil investment fund** where some of the tax revenues from oil production are invested for future generations. The fund currently stands at US$317 billion, equivalent to $69,000 per person, safely invested in global equities and government bonds.

Storyline 2: Fjordland

The Fjordland storyline is the same as Norway with just two differences.

First, the Fjordland government wrote a clause in all exploration licenses stating that the Fjordland state owned oil company (Fjordoil) had the right to purchase at fair market value a 100% share of any new discoveries that were made. This proved to be an unpopular condition and the Fjordland government exercised this right on only four occasions. The first occasion was during the 1970s when Fjordoil purchased the whole of the Valhall Field. The Fjordland government decided to not develop this field and to keep it for future generations. This exercise was repeated for the Ula, Gullfaks and Snorre Fields. These four fields lie fallow to the present day.

Fjordland *- a tranquil land reflecting on peak oil*

In Norway these fields were developed as shown in the table below and combined they had peak production of 847 mmbpd in 1994.

Field	Max production bpd	First oil Norway	First Oil Fjordland	First Oil Fjelland
Valhall	91,000	1982	Fallow	2001
Ula	126,000	1986	Fallow	2003
Gullfaks	529,000	1986	Fallow	2002
Snorre	234,000	1992	Fallow	2004

In addition to the fallow field policy, the Fjordland government was concerned about the impact that Fjordland oil was having on the global oil market. It appeared to the Fjordland government that since their oil production had started that oil prices had fallen and they were concerned about

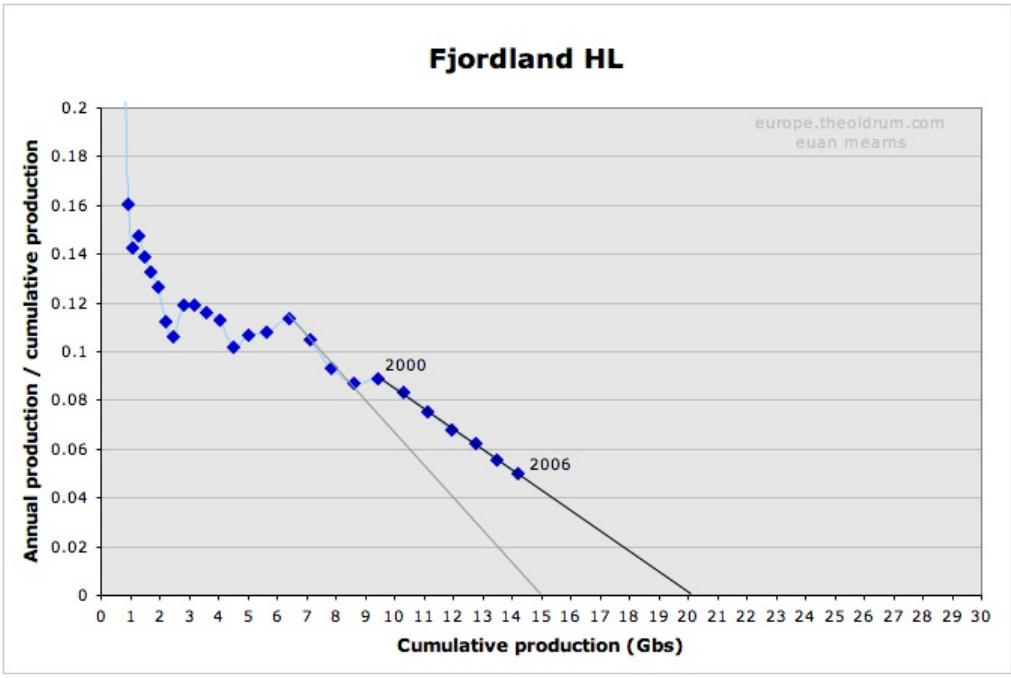
producing all of this valuable resource at low market prices.

Therefore, following extensive debate in the Fjordland Parliament production restrictions were introduced which stated that companies could only produce oil at 80% of a field's capacity. Every year, each field was allowed to produce at capacity for one week. The Fjordland Oil Executive closely monitored this and the production quota for the remainder of the year was set at 80% of the capacity thus determined.

This law was introduced in 1980 and enacted in 1981. The operating companies were furious at this development and threatened to pull out of Fjordland. Fjordoil by this time had developed significant expertise in developing oil fields and companies not happy with the new arrangement were invited to leave. None left but the grumbling went on for many years, despite a healthy rise in the oil price.

The people of Fjordland were initially happy with the arrangements made on their behalf by their government – they were after all still becoming filthy rich with this bounty from beneath the waves. However, some time around 1998 a group of patriotic Fjordlanders got together to voice concern at the rate of depletion of the Fjordland oil resources. They began to question the Government policy.

This group, known as Maxoil, were using the established and highly respected technique known as Hubbert linearization (HL) and pointed out that the HL for Fjordland was pointing towards a 15 Gb total and that the oil was being over-produced. These early warnings were ignored for a number of years. By the year 2000 the trend pointing at 15 Gbs was broken by what would become known as a dogleg up feature. Maxoil continued to grumble about overproduction of Fjordland oil resources. By 2004 production had been falling for 3 years and a new linear trend pointing towards a URR of 20 Gbs was apparent on the HL plot.



Synthetic HL for Fjordland. Since 1981, Fjordland has been producing at 80% of built capacity and four fields have been allowed to lie fallow. The synthetic HL points to an apparent URR of around 20 Gbs (C+C+NGL) whilst the actual figure is known to be around 30Gbs - the same as for Norway.

By this time the mainstream media was beginning to take interest in Fjordland oil production since it had been falling now for 3 years and despite government assurances the people were

beginning to become restless. Big Foot, the leader of Maxoil was interviewed by the media. She showed her HL plots pointing to a URR of 20Gbs and whilst the media and the people were confused by the charts they were now even more concerned that Fjordland might be running out of oil.

The Fjordland state authorities joined the debate and tried to allay concerns. They pointed out that while they saw great merit in the HL technique that this had to be used with care. They explained that Fjordland still had 4 fields that lay undeveloped and that constrained production did not give a true picture of the potential of the producing fields. The Fjordland Oil Executive estimated that Fjordland would one day produce a total of 30 Gbs, and since only 12.8 Gbs had been produced to 2004 a fantastic future lay ahead for the current and for future generations.

Maxoil were enraged at this claim and pointed to the perfect line of dots pointing towards 20 Gbs. Some fine mathematicians joined the Maxoil ranks and performed elegant transformations of the data, and no matter what they did the answer was always 20 Gbs. Could the Fjordland Oil Executive not see the peril that lay ahead?

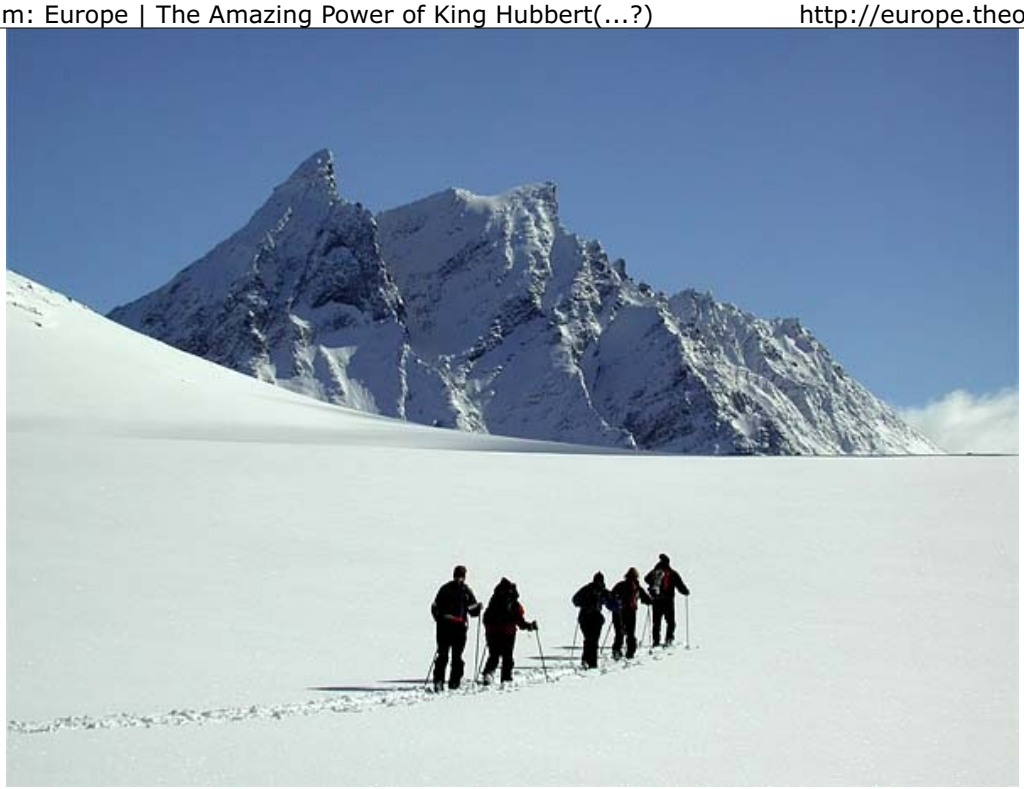
This debate raged for another 2 years with Maxoil accusing the Fjordland Government of intransigence. They even began to ask for proof that Gullfaks, Snorre, Ula and Valhall could produce oil and had the government not squandered funds buying these duff assets? If they could produce then why did the government not prove it by developing these fields? The Fjordland Government pointed out that this was counter to government policy and that such profligate expansion would actually hasten the collapse in Fjordland production and was this not counter to the objectives of Maxoil?

Books were written and the population instead of being happy with the wealth being created began to doubt the intentions of the government. Then in 2006, when the Government issued their annual update everyone was in for a shock. The Government argued that new technology would mean that Fjordland would in fact discover and recover more oil than previously thought to be the case and the official estimate was raised to 35 Gbs.

This ploy that was designed to allay concerns backfired badly. The population, instead of being pacified by the thought of more oil began to doubt the government's intentions even more and this was all the proof required by Maxoil to show that the government had been lying all along. However, despite being vilified by the press, The Fjordland Government showed enormous discipline. Gullfaks, Snorre, Ula and Valhall remain undeveloped to the present day and the 80% capacity ceiling has stayed in place.

Storyline 3: Fjelland

The Fjelland storyline is the same as the Fjordland storyline up until the late 1990s. At this time the Fjelland Oil Directorate recognised that the oil production of Fjelland would peak and then go into decline and concerns were raised that the people, who had by now become accustomed to growing production and wealth may become fretful about the future. Maxoil was warning that the oil was running out. The government may become deeply unpopular if health and education services had to be cut owing to falling oil revenues.



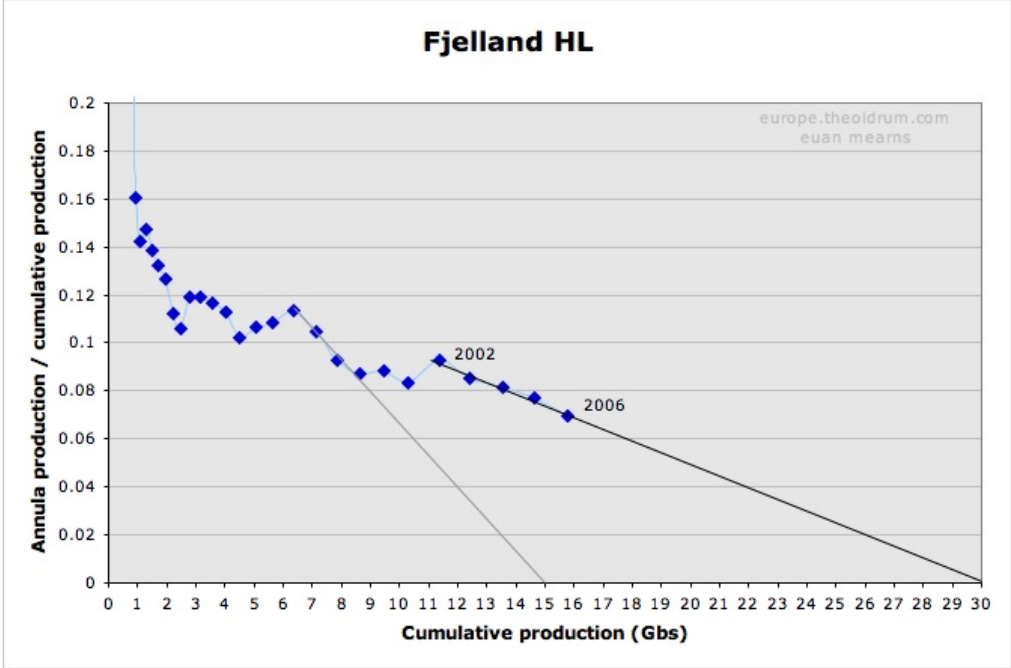
Fjelland *- reaching peak*

At this time oil prices were low, but the countries buying Fjelland oil were beginning to fret about the security of future oil supplies and the oil price had just begun to strengthen. Under severe pressure from their American friends, the Fjelland government decided it was time to give consent to develop Gullfaks, Snorre, Ula and Valhall. These fields were duly consented and came on stream in 2002, 2004, 2003 and 2001, respectively.

In addition to this, by the year 2000, the oil price had strengthened considerably and international conflict over oil was threatened. The American news channels pointed out how Fjelland with all its oil wealth was betraying its friends and allies by withholding production. Under immense pressure, the Fjelland government relented in 2001 and gave consent to companies to produce at capacity and this was enacted in 2002.

The combined result of developing 4 fallow fields and starting to produce at capacity was a surge in Fjelland production of about 1 million bpd between 1999 and 2005. The money poured in and was wisely invested in US treasury bonds.

The main point of the Fjelland storyline is to show the impact on HL. From 2001, there is a well-defined trend pointing to 30Gbs – the known true reserves figure for Fjelland. **Isn't that amazing!** The Hubbert technique is truly powerful when applied to the full resource base of a country operating at capacity.



Synthetic HL for Fjelland. From 1981 to 2002, Fjelland produced at 80% of built capacity and four discovered fields were allowed to lie fallow. The four fallow fields were developed in the period 2001 to 2004 and in 2002, flush production was reinstated. The HL from 2002 to 2006 defines a good linear trend pointing towards 30 Gbs - the known URR figure for Norway. This suggests that an HL influenced by under production may recover to provide a meaningful result once full and flush production is reinstated.

Lessons to learn from these simple parables:

The reserve base of Norway, Fjordland and Fjelland are all the same, i.e. 30 Gbs.

If a country has not developed all its discovered (or undiscovered) resources and / or is producing at bellow capacity, HL will provide a false result that is biased towards a low URR.

If a country has been under-producing, once full production is instated the HL may find a new trend pointing towards a more reliable reserves estimate.

Disclaimer

Fjordland and Fjelland are hypothetical countries. Fjordoil and Fjelloil are hypothetical companies. The Fjordland Oil Executive, the Fjelland Oil Directorate and Maxoil are hypothetical organisations and Big Foot is a hypothetical being. Any similarity between these entities and real entities, past or present, living or dead, is entirely coincidental.