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M. KING HUBBERT CENTER
FOR PETROLEUM SUPPLY STUDIES

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PEAK OIL: A TURNING FOR MANKIND

Colin J. Campbell

The fundamental driver of the 20th Century's economic prosperity has been an abundant supply of cheap oil. At first, it came largely from the United States as it opened up its extensive territories with dynamic capitalism and technological prowess. But U.S. discovery peaked around 1930, which inevitably led to a corresponding peak in production some forty years later. The focus of supply then shifted to the Middle East, as its vast resources were tapped by the international companies. They however soon lost their control in a series of expropriations as the host governments sought a greater share of the proceeds. In 1973, some Middle East governments used their control of oil as a weapon in their conflict with Israel's occupation of Palestine, giving rise to the First Oil Shock that rocked the world.

The international companies, anticipating these pressures, had successfully diversified their supply before the shock, bringing in new productive provinces in Alaska, the North Sea, Africa and elsewhere. These deposits were more difficult and costly to exploit, but production was rapidly stepped up when control of the traditional sources was lost. In part that was made possible by great technological advances in everything from seismic surveys to drilling. Geochemistry and better geological understanding made it possible to identify the productive trends, once the essential data had been gathered. The new knowledge showed both where oil was and where it was not, reducing the scope for good surprises.

The industry found and produced the expensive and difficult oil from the new provinces at the maximum rate possible, leaving the control of the abundant, cheap and easy oil in the hands of the Middle East OPEC countries. The latter were accordingly forced into a swing role, making up the difference between world demand and what the other countries could produce. It was contrary to normal economic practice and concealed the gradual impact of depletion, growing shortage and rising cost, which would otherwise have alerted us to what was happening.

But these new provinces faced the same depletion pattern that had already been demonstrated in the United States. The larger fields, which are found and exploited first, gave a natural discovery peak. Advances in technology and operating efficiency also reduced the time-lag from discovery to the corresponding production peaks. Whereas it took the United States forty years, the North Sea, which is now at peak, did it in just twenty-seven.

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As discovery in the accessible areas dwindled to about one-quarter of consumption, the industry, which fully appreciated this obvious link between discovery and production, turned its attention to the last remaining frontier, namely the ocean depths. It is axiomatic that no one would look for oil in 6000 feet of water if there were anywhere else easier left. The deepwater domain is also subject to depletion with an even shorter time-lag between the peaks of discovery and production. Although much of the ocean is deep, only a few areas have the essential geology, giving a potential of not more than about 85 Gb (billion barrels) - enough to supply the world for less than four years. It is no panacea.

A combination of circumstances led to a dramatic fall in the price of oil in 1998. They included unseasonably warm weather; an Asian recession that reduced the demand for swing Middle East production; the collapse of the rouble, encouraging exports; over-estimation of supply by the International Energy Agency (IEA), which misled OPEC; and further turns in Iraq. Furthermore, there were motives to talk down the long-term price of oil as oil companies and their financial advisers planned acquisitions.

Major companies, plainly seeing that exploration could no longer underpin their future, took the opportunity of the price crisis to merge, successfully concealing their real predicament from the stockmarket. Budgets were slashed and staffs purged in a climate of uncertainty leading to an improvident draw on stocks.

The OPEC countries themselves did everything possible to foster the notion that they could flood the world with cheap oil at the flick of a switch. It was a strategy aimed to inhibit investments in gas, non-conventional oil, renewable energy or energy saving that they feared might undermine the market for their oil, on which they utterly depend.

But it was a short-lived price collapse. Before long, the underlying resource and depletion pressures manifested themselves again with prices rebounding in a staggering 300% increase in twelve months, when another anomalous fall occurred at the end of 2000. It was partly triggered by profit taking for year-end financial reporting and partly by the hope of a brief reprieve as spring demand traditionally falls.

The underlying trend is due to reassert itself, leading to the resumption of soaring oil prices. The Middle East is working flat out to try to offset the decline of its old fields. In large measure, new production in Venezuela can come only from infill drilling in old heavy oil fields, which is dependent on the amount of effort and investment. It does not sound as if it has many shut-in wells either. Its oilmen speak of reduced capacity.

The market may hope that some important recent discoveries tell a different story with a happier ending. The long-known Azadegan prospect on the Iraq-Iran border was at last tested, delivering some 5 Gb of reserves to Iran. Kashagan East in the north Caspian found about 7 Gb of high sulfur oil at great depth, demonstrating that the prospect was not one huge structure as hoped, but several independent reefs. The disappointment caused two major companies to withdraw from the venture, which is not a good omen. Promising deepwater finds continue to be made off West Africa, but it is becoming clear from the experience of the Gulf of Mexico that deep-water operations test technology and management to the absolute limit. Small accidents or setbacks can have devastating consequences in this extreme environment. Petroconsultants recently announced the total oil discovery for 2000 at 11.2 Gb, less than half consumption, and of that much was in the Former Soviet Union and in deepwater off West Africa.

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The reality is that there is no real reprieve. Gradually the market – and not just the oil market - will come to realize that OPEC can no longer single-handedly manage depletion. It will be a dreadful realization because it means that there is no ceiling to oil price other than from falling demand. That in turn spells economic recession and a crumbling stock market, the first signs of which are already being felt.

The United States is perhaps the most vulnerable to the coming crisis having farther to fall after the boom years, which themselves were largely driven by foreign debt and inward investment. The growing shortfall in oil supply since its own peak of production was made good by soaring oil imports, now contributing more than half its needs, and a move to gas. The rate of import cannot, however, be maintained as other countries pass their own production peaks, putting ever more pressure on the Middle East. The North Sea is now at peak, with the UK being off 7% in 2000 and 16% off October to October, meaning that production is set to fall by one-half in ten years. For every barrel imported into the United States, there will be one less left for anyone else, a situation inevitably leading to international tensions.

The move to gas proved to be only a short-lived palliative. Gas depletes differently from oil. An uncontrolled gas well would blow it all away in one big puff. Production is, accordingly, capped by infrastructure and market, leaving a large, unseen balloon of readily available spare capacity. In a privatized market, trading on a daily basis, production becomes cheaper and cheaper as the original costs are written off and as this almost free spare capacity is drawn down. There were no market signals of the approach of the cliff at the end of the plateau. It accordingly came without warning, causing prices to surge through the roof, and bringing power blackouts to California. Canada is trying to make good the shortfall, but its stocks are falling fast too.

The US has to somehow find a way to cut its demand by at least five percent a year. It won't be easy, but as the octogenarian said of old age "the alternative is even worse". Europe faces the same predicament as North Sea production plummets. Although it may draw on gas from Russia, North Africa and the Middle East to see it over the transition, assuming that new pipelines can be built in time, that creates a new and unwelcome geopolitical dependency.

All of this is so incredibly obvious, being clearly revealed by even the simplest analysis of discovery and production trends. The inexplicable part is our great reluctance to look reality in the face and at least make some plans for what promises to be one of the greatest economic and political discontinuities of all time. Time is of the essence. It is later than you think.

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After finishing a Ph.D. in geology at Oxford University, C. J. Campbell joined Texaco in 1958 as an exploration geologist in South America, later moving to BP with assignments in Colombia, Australia, and Papua. In 1968, he joined Amoco in New York as regional geologist for Latin America, becoming Chief Geologist in Ecuador in 1969. With the opening of the North Sea, he returned to England in 1972 as General Manager of the Texas independent Shenandoah Oil Corporation, before rejoining Amoco to become Exploration Manager in Norway in 1980. In 1985, he was appointed Executive Vice-President of Fina in Norway. He is now a petroleum consultant and has had commissions from the Norwegian Petroleum Directorate; Bulgarian government; European Commission; Amoco; Shell; Esso; Amerada; Mobil; and others. He specializes in oil resource assessment, having published and spoken widely. His book "The Golden Century of Oil" was published by Kluwer in 1991, and "The Coming Oil Crisis" by Multi-Science Publishing Co. in August 1997. He has co-authored several major studies on world reserves of oil and gas and their depletion for Petroconsultants as based on their authoritative data.

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OILFIELDS – MAINTENANCE EXPENSES

Colin J. Campbell and J. J. Zagar

Laymen commonly overlook the amount of work and cost involved simply in maintaining production. Once the capital investments have been made with the wells drilled, platforms installed, facilities commissioned and pipelines placed in service, much more remains to be done than count the barrels of production and the commensurate revenue checks. Operating expenses, while generally lower per barrel than investments, are key to maintaining production. No operator with a negative cash flow can stay in business for long.

The nature of operating costs varies with the stage of the field's maturity. Let us consider, for example, the challenges faced in producing the World's largest oil field, Ghawar, in Saudi Arabia. Initially, the wells flowed naturally under high reservoir pressure. The produced crude was stabilized by the removal of associated gas, to be loaded directly aboard tankers for shipment. It was a simple, cheap operation. But later, declining reservoir pressure called for the drilling of water injection wells as well as the installation of seawater injection pumping units and pipelines to the Gulf. Water breakthrough meant that producing wells had to be shut-in, and structurally higher replacement wells drilled. When water production could no longer be avoided, huge, costly facilities to separate the oil, gas and water had to be installed, and previously shut-in wells were re-opened to maintain field production. During this period, production wells were produced via annular flow; that is, the oil flowed in the space between the casing and the tubing. It was not a successful strategy for long, because up-hole casing failures, due to external corrosion, led to many millions of barrels being lost to shallow aquifers. The producing wells then had to be systematically reconfigured for tubular flow at considerable cost. A secondary effect of this action was to reduce well flow rates, which in turn meant additional drilling to offset the loss. But the high well rates of 10,000 to 40,000 barrels per day from these wells easily justified the new costs, which collectively totaled less than $2 a barrel.

Much of the onshore production in the United States is at the other end of the spectrum. Stripper wells, producing less than ten barrels of oil per day, account for one-third of the country's production, or about 2 million barrels of oil per day. When oil prices collapsed to nearly $10 a barrel in 1998, one-quarter of the stripper production, amounting to nearly 500,000 barrels per day from 100,000 wells, was shut-in as uneconomic. Clearly, the mature production of the United States faces very much higher per barrel operating costs than is the case in the Middle East.

Maximum Efficient Rate (MER) operating costs manifest themselves in many ways. Reservoir management is required to maximize value, while optimizing production and reserves. It calls for continued monitoring, analysis and interpretation of reservoir pressures, fluid contacts, well tests, well production volumes, and the types of fluids produced. Even time-lapsed seismic surveys have to be evaluated. Oil field service companies provide bottom-hole pressure testing, surface volume testing and well logging to assist the operator's technical evaluations. In-house or third party numerical simulation models of the larger fields further help field development and production forecasting.

Compliance with State regulatory, environmental and safety legislation requires staff and programs. It is necessary to perform, and report on, a wide range of tasks, including: field/well actual/test volumes, well casing mechanical integrity tests (to avoid ground water contamination), flowline and pipeline corrosion prevention and monitoring programs, high pressure and poisonous gas detection systems and public alert systems, carbon gas releases, disposal of naturally occurring radioactive material and drilling fluids. Oil spills have to be cleaned-up. Furthermore, such information has also to be

prepared for accounting and reporting purposes by royalty and working interest owners, which often requires substantial operator staff overhead. It is not uncommon for a producing property to have as many as 200 royalty and working interest owners.

The depletion of mature fields is characterized by declining production due to loss of reservoir pressure and/or increased water production. Pressure maintenance by water or gas injection is often required at considerable cost. Increased water production increases costs due to added separation and disposal requirements. Declining gas fields require compression facilities to produce additional reserves to a lower pressure. Depending on field geology and the reserve target, oil-well spacing may be progressively reduced by infill drilling from 160 acres to 80, 40, 20 and even down to10 acres per well. Inevitably, wells and processing equipment suffer mechanical deterioration and breakdowns, requiring partial if not total replacement, particularly in aging operations after more than 25 years of service. Ongoing maintenance programs for gas turbines, rotating and reciprocating equipment, electric generators, etc. are as necessary as the regular oil change and tune-up in the family automobile.

Some crude oils deposit a waxy paraffin that must periodically be removed from wells, processing facilities, pipelines and flowlines by mechanical or chemical means. Other wells are prone to carbonate scales, which plug tubing with the onset of water production, and must be periodically cleaned out. Other crudes form an emulsion with water that has to be broken down chemically or thermally before being shipped or connected to pipelines. Often, wells must be repeatedly stimulated by acid treatment or hydraulic fracturing to sustain economic flow rates. Expensive horizontal wells are in some cases drilled to replace conventional wells subject to the coning or cusping of water or gas. EOR (Enhanced Oil Recovery) projects are clearly expensive. Mostly, they represent a final attempt to extract the last remaining barrels prior to abandonment. Thermal (fire flood and steam), miscible (CO_2, nitrogen, hydrocarbon gas) and chemical floods capture 5-15% additional reserves from the limited number of fields that are susceptible to treatment, but at a cost of $10 to $15 dollars per barrel. Worldwide EOR production accounts for less than 5% of the total.

Offshore fields have nearly all the operating challenges and burdens of the onshore (save perhaps the large number of royalty and working interest owners), but in addition face those imposed by the marine environment. Supplies, drilling muds, work crews, etc. have to be ferried by helicopter, ship or barge. Living quarters for workers are required. In Norway, for example, three people (vs. two in the USA) are needed on rotation for each job, having to be housed, clothed, and fed. Round-the-clock standby safety rescue vessels have to be maintained on position. Underwater surveys and environmental impact studies are required. Oil spill contingency plans and clean up crews and vessels must be kept available. Shipping traffic and, in some areas, even icebergs have to be monitored. Designing, building and installing structures and facilities to withstand 100-year storms in water depths to 6,000 feet is obviously extremely expensive. If deeper water is the future for oil and gas production, then higher costs will be the norm.

Clearly, the producing life of an oil or gas field is a dynamic process, involving an interplay of geology, geography, politics, technology and market forces. Eventually, the field has to be abandoned when the fixed and variable operating costs exceed the revenue. Even the abandonment of wells and facilities, as well as the restoration of the site, including offshore platform removal, involve considerable outlays, which must be carefully planned and executed.

In short, producing oil is not simply a matter of opening the tap, and the costs rise progressively as the fields age for all the reasons enumerated above. In the past, much production could be won from new fields in the prime of life, but now we face the soaring costs inherent in dealing with an aging population.

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The Oilman's Column #7 - by L. F. Ivanhoe

A. CRITICAL FACTS

When he was running the Pentagon, James Schlessinger was fond of saying that everyone was entitled to his or her own opinion, but not to his or her FACTS.

The objective of the CSM Hubbert Center is to collect and disseminate vital FACTS that help recognition and analysis of the coming oil crisis. Emphasis is on long-term oil "climate" (e.g. discovery trends/El Nino) rather than on short term oil "weather" fluctuations (e.g. oil prices/ice storms).

B. ALASKA'S ANWR – A NATIONAL ASSET

How casually people dismiss ANWR's value. Using the USGS estimate of 10 billion barrels for the mean recoverable oil at ANWR, the current value (@$30/barrel) is $30 x 10 billion = $300 billion or $300,000 million. Hardly an insignificant amount. This could fund U.S. Social Security/Medicare for all Americans or provide money to fight foreign wars for other nations' oil fields. At least it would save the money rather than being spent for OPEC oil. Money spent to recover the oil will go into the U.S. economy. If we buy our oil from the Arabian Persian Gulf fields, we will be pushing poverty-stricken oil-less developing nations into starvation. We have no inalienable right to burn up other nations' oil – especially when our ANWR oil is so accessible. No other country would shelve such a valuable national asset.

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H.C. NEWSLETTER

The M. KING HUBBERT CENTER FOR PETROLEUM SUPPLY STUDIES
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The Hubbert Center has been established as a non-profit organization for the purpose of assembling and studying data concerning global petroleum supplies and disseminating such information to the public.

The question of WHEN worldwide oil demand will exceed global oil supply is stubbornly ignored. The world's oil problems, timing and ramifications can be debated and realistic plans made only if the question is publicly addressed. A growing number of informed US and European evaluations put this crisis as close as the years 2000 - 2014. The formation of this center is to encourage a multi-field research approach to this subject.

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Notes:
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The Hubbert Center will archive work files of recognized experts in this field.
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