WORLD PETROLEUM INDUSTRY PERSPECTIVES

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OUTLINE

1. Short Term Impact of COVID-19
2. Renewable Energy Developments
3. Impacts on the Petroleum Industry
4. Transformation of the Petroleum Industry
5. Industry Reorganization
6. Policies
7. Fiscal Systems
8. Petroleum Energy Arrangements

OUTLINE

"We have always been wrong about the future of the petroleum industry. Not just a little bit wrong, totally wrong".

Day 4 in the course

World Fiscal Systems for Oil and Gas

SHORT TERM

COVID-19

The COVID-19 pandemic will have a devastating short term impact on the Petroleum Industry.

It is only during the last few weeks that this impact is fully appreciated.

Interestingly, the IEA published in early March "Oil 2020", a very detailed assessment of the future of oil for the 2019 – 2025 period.

COVID-19 was recognized as being important. Yet early March the IEA still estimated that 2020 oil demand would only drop 90,000 bopd relative to 2019 and that the world would return to normal in the second half of 2020. All projections were still based on $ 60/bbl.

SHORT TERM

COVID-19

It is now recognized that the impact will be major.

The WTI oil price dropped to negative for a day. Brent oil dropped under $ 20/bbl despite OPEC agreeing to a 9.7 MMbopd production cut.

A major reduction in oil demand is now predicted.

In order to understand the possible new dimensions of the impact, the detailed information of “Oil 2020” was re-worked.

This provides an insight in the magnitude of change that can be expected relative to the “Oil 2020” results.

Of course, as more information becomes available the Short Term outlook will continue to change, possibly dramatically, and therefore the following slides provide an analysis of how the impact is perceived as of May 21, 2020.

SHORT TERM

COVID-19 – World Oil Demand

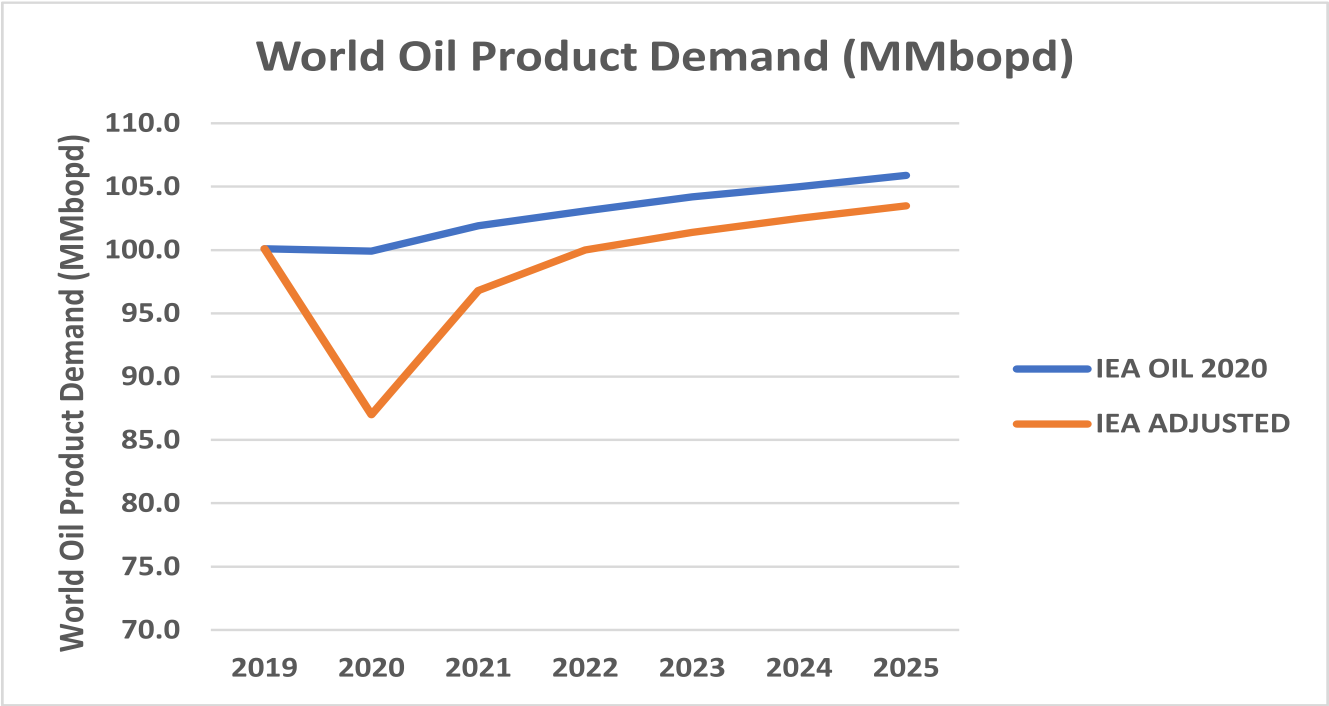
The impact of COVID-19 depends on a series of factors that are uncertain and unknown. The most important issue is whether major new medication or vaccines can be developed during 2020 to fight this disease. In the estimate it is assumed that this will not occur until 2021.

In order to estimate the impact on world oil demand it is assumed that some economies may gradually open up during 2020, but that impact on petroleum demand will remain severe all through 2020.

It is also assumed that COVID-19 will have an impact on how consumers use petroleum and that this will result in a reduction of about 2 MMbopd over the forecast period.

SHORT TERM

COVID-19 – World Oil Product Demand



The main drivers of growth of the world oil product demand are the petroleum products used for feedstock of the petrochemical industries, being LPG/ethane and naphta. Overall demand in 2022 will be back to what it was in 2019.

SHORT TERM

COVID-19 – Non-OPEC Supplies

It is assumed that the oil price will stay low through 2020.

This will have a significant impact on the Non-OPEC supplies, in particular in North America.

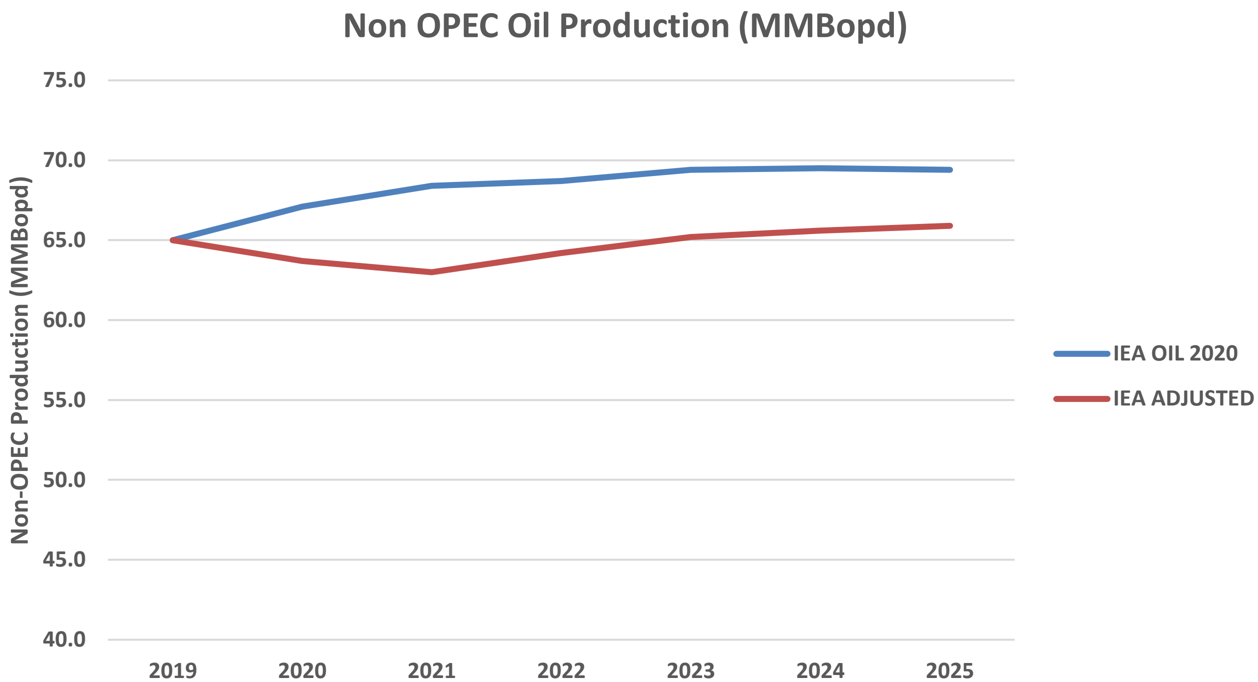
The US EIA expects US production to decline with 0.5 MMbopd this year and another 0.7 MMbopd next year. These are probably conservative numbers. Canada has already experienced a decline of 0.4 MMbopd so far and further declines are expected. If oil prices rebound in 2022 the declines may be reversed.

The development of new oil production in Brazil will be less aggressive as was predicted.

Russia and some other Non-OPEC countries will support the OPEC+ price cutback by lowering production in 2020 and possibly until April 2022 as agreed with OPEC.

SHORT TERM

COVID-19 – Non-OPEC Supplies



Compared to the strong growth originally expected, the Non-OPEC countries may produce about 3.5 MMbopd less in 2025. The production includes about 3 MMbopd biofuels which are expected to grow slightly during the period.

SHORT TERM

COVID-19 – Call on OPEC

The combination of the world demand estimate and the Non-OPEC production estimates results in a new determination for the "Call on OPEC" crude oil (after OPEC condensates and NGL's have been deducted).

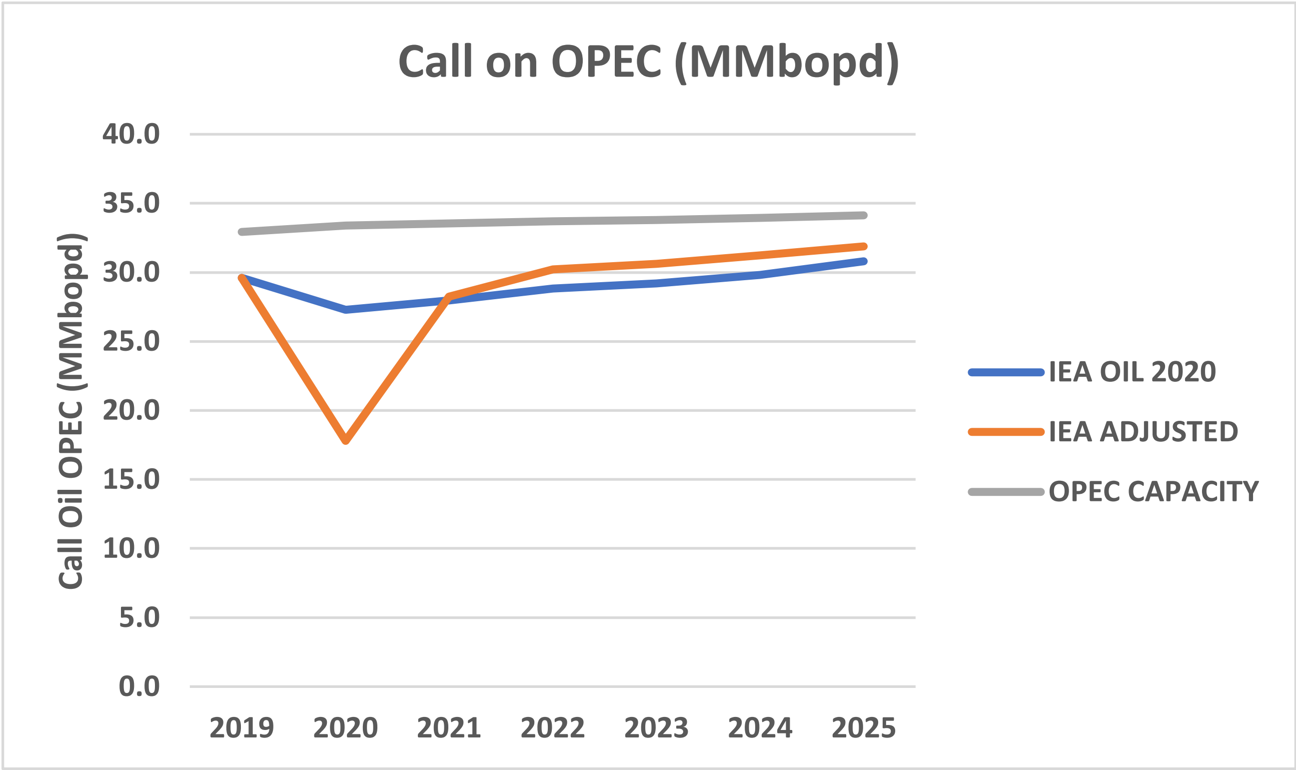
Interestingly, it results in a somewhat stronger Call on OPEC than originally predicted in Oil 2020, from 2022 onwards.

The current OPEC cutback is applicable until April 2022. This seems to indicate that at that time the cutback may provide strong price support.

By 2025 it is estimated that the Call on OPEC would be 2 MMbopd higher than in 2019.

SHORT TERM

COVID-19 – Call on OPEC



The analysis indicates a relatively strong Call on OPEC from 2022 onwards, which compares well with the total OPEC production capacity. The estimate of OPEC production capacity based on Oil 2020 assumes a continuation of the Iran embargo.

SHORT TERM

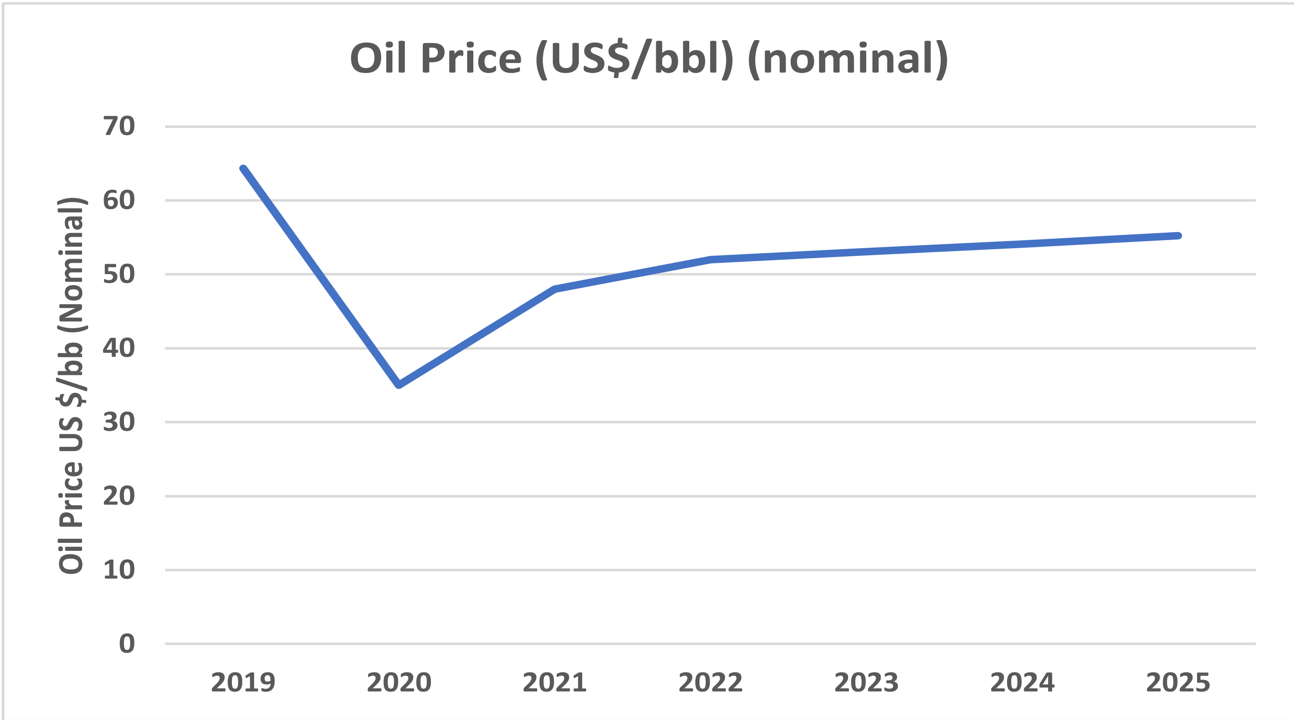
COVID-19 – Oil Price Forecast for Brent

It is assumed that the average oil price for 2020 will be $ 35/bbl. The forecast for 2021 is $ 48/bbl. This is in line with some other forecasts, such as the US EIA.

For 2022 and onwards my prediction is an long term price of $ 50/bbl (2020 $ real). This is assuming that this will be the future long term target for OPEC, after the experience that a $ 60/bbl target creates strong non-OPEC production; bringing the price down anyway. Nevertheless, this price level is well below the level that balances the budgets of most OPEC countries. Therefore, the OPEC response is difficult to predict. By 2025 the Call on OPEC may be strong enough to justify $ 60/bbl as a market price forecast, but a $50/bbl scenario is assumed.

SHORT TERM

COVID-19 – Crude Oil Price Forecast for Brent



The analysis indicates that a relative strong oil price environment can be expected from 2022 onwards. A long term price of US $ 50 per barrel in real terms (2020 $) seems a reasonable framework for policy purposes. Higher prices may be self-defeating in bringing too much Non-OPEC production forward under modest world oil demand.

RENEWABLE ENERGY DEVELOPMENTS

Renewable Energy Economics

An important issue that will define the future of the petroleum industry is the competition with renewable energy. The main renewable sectors are solar, wind and hydropower.

It is very important to realize that the overall economic structure of the upstream petroleum industry is very different from the solar and wind industries.

This different structure will largely determine the outcome of the competition.

RENEWABLE ENERGY DEVELOPMENTS

Renewable Energy Economics

The petroleum industry is a high risk industry justifying a high rate of return. Weighted Average Cost of Capital ("WACC") is typically in the 8 – 15% range.

The exploration phase is very high risk and can only be done on an equity basis.

The development phase is high risk and high tech. Project financing can usually only obtained for a modest percentage of the development capital expenditures and therefore requires large equity investment. Resource estimates could vary over a wide range (P10 – P90).

Even the production phase is subject to significant risk and operating costs are a significant part of the overall cost structure.

The petroleum business requires considerable technical expertise and capital resources to enter the business.

RENEWABLE ENERGY DEVELOPMENTS

Renewable Energy Economics

The solar and wind industries are relatively low risk industries with a WACC in the 4 – 10% range, largely depending on country risk and debt/equity ratios.

No exploration is required, although some sites are better than others. Development risk of the project is similar to building any construction project. Although the production of wind turbines and high quality solar panels is a high tech operation, the actual construction of wind and solar farms is low tech and low risk.

Operating costs are low for solar and moderate for wind. Operating risk are low once the project is underway.

It is therefore relatively easy for any company to enter this business.

RENEWABLE ENERGY DEVELOPMENTS

Renewable Energy Economics

Interestingly, the solar and wind farm construction and operation business is actually similar to the pipeline business. The economics of a pipeline depends on the tariff (toll). The economics of a wind or solar project depends on the LCOE (the average life time levelized cost of electricity generation). The LCOE is calculated as a pipeline tariff as follows:

LCOE = NPV@x%/EP@x%. NPV is the net present value at the discount rate of x% (the WACC). EP is the electricity production also discounted at x%. This creates a levelized costs per MWh or kWh.

One way to obtain renewable energy is on the basis of power purchase agreements (PPA's), whereby the bidder offers the lowest PPA price. Remarkable low prices have been obtained.

RENEWABLE ENERGY DEVELOPMENTS

Renewable Energy Economics

In the following slides the economics of the Renewable Industries will be discussed in more detail.

The discussion will be largely based on the detailed information provided by IRENA (the International Renewable Energy Agency, located in Abu Dhabi) supplemented by information from BNEF (Bloomberg New Energy Finance) and some other sources.

For the main renewable energy resources, first the current economics will be discussed. Subsequently, further possible technology developments will be reviewed and finally possible future costs will be estimated.

RENEWABLE ENERGY DEVELOPMENTS

Renewable Energy Economics

In analyzing the results it is important to compare with current costs of generating electricity based on fossil fuels or nuclear energy.

The most comprehensive analysis in this respect is from Lazard which tabulates costs for the USA, not including possible subsidies. Following are the range of LCOE for a new build fossil fuel plant (2019):

Natural Gas Combined Cycle – 4.4 to 6.8 cents/kWh

Coal - 6.6 to 15.2 cents/kWh

Nuclear – 11.8 to 19.2 cents/kWh

Diesel – 19.7 to 28.1 cents/kWh

Marginal cost of operation of an existing coal plant – 3.3 cents/kWh

RENEWABLE ENERGY DEVELOPMENTS

Solar Utility Sized Photovoltaics ("PV") - Current Costs

The IRENA information indicates that so far for 2020 the average auction price (PPA) for solar utility size PV is 4.8 cents/kWh. The range is from about 2.8 cents to 10 cents per kWh. PPA's of about 3 cents per KWh have been achieved in Mexico, Peru, the UAE and other countries.

BNEF indicates that Solar PV committed in the last few months in Australia, China, Chile and the UAE may achieve LCOE's of between 2.3 and 2.9 cents/kWh.

Lazard for 2019 for the USA listed a LCOE of 3.2 to 4.2 cents/kWh

Dubai just received a record low auction offer for 900 MW of 1.6953 cents/kWh.

This indicates that the costs of solar PV is now at and below the level of the cheapest new combined cycle gas plants in the USA.

RENEWABLE ENERGY DEVELOPMENTS

Future Solar PV technologies

The current efficiency of solar panels in converting solar energy to power is about 19 – 20%.

An enormous amount of research and development is underway to increase this efficiency to 30% with new technologies or find other ways to lower the cost of solar PV.

One development that seems promising is to work with perovskites. This is a mineral of which the crystal structure easily absorbs solar energy. Perovskites work better with lower lighting intensities.

Very thin films can be made from solutions containing this mineral. Such solutions can simply be sprayed on surfaces with an inkjet. Saule Technologies is developing a wide range of possible applications.

RENEWABLE ENERGY DEVELOPMENTS

Future Solar PV technologies

Oxford PV will open a commercial 250 MW plant in late 2020 with Meyer Burger in Germany. In this case perovskites are simply sprayed on existing solar panels to make two-layer solar cells and increase efficiency to over 30%. Equinor is a shareholder of Oxford PV.

Insolight a Swiss company is layering an optical system to concentrate light on regular solar panels which improve efficiency to 29%. Many other improvements are underway that improve efficiency by 0.5 – 1.5%.

In general therefore significant improvements in efficiency for solar PV cells can be expected in the next 10 years as well as entirely new concepts of using solar PV.

RENEWABLE ENERGY DEVELOPMENTS

Future Solar PV Costs

It can be estimated that prior to 2030, solar utility based PV will be able to produce power in the range of 1.5 – 6.5 cents per kWh, with a probable average LCOE of about 3.0 cents/kWh (2020$).

Of course, this applies to areas in the world with optimal solar conditions, which is typically between the latitudes of 40 degrees North and South.

This means that new solar energy plants in these areas will deliver electricity at a significantly lower LCOE than any fossil fuel plant in the USA and below the marginal cost of operation of an existing coal plant in the USA.

For 2050 solar PV may be in the range of 1 – 4 cents/kWh (2020$) with a possible average of 2.5 cents/kWh.

RENEWABLE ENERGY DEVELOPMENTS

Onshore Wind – Current Costs

The IRENA information indicates that so far for 2020 the average auction price (PPA) for Onshore Wind is 4.5 cents/kWh. The range is from about 1.8 cents to 9.0 cents per kWh. The BNEF data base shows an average of 4.4 cents/kWh for 2020. They report recent LCOE's for the USA, India and Spain in the 2.6 to 2.9 cents/kWh range.

Lazard lists the LCOE of onshore wind in the USA (2019) at 2.8 to 5.4 cents/kWh.

The latest bid round organized in Turkey for a 1000 MW wind farm resulted in a price of 3.48 cents per kWh.

This means that also the cost of supplying onshore wind is now at and below the LCOE of the lowest cost combined cycle natural gas plants in the USA.

RENEWABLE ENERGY DEVELOPMENTS

Onshore Wind - Future technologies

The main factor in decreasing costs is the increasing size of the onshore wind turbines. In 2018 the typical wind turbine was 2.6 MW with a rotor diameter of 110 meters. In 2022 and beyond wind turbines of 5.8 MW with a rotor diameter of 170 meters are anticipated. The higher turbines and larger rotors permit to operate at lower wind speeds thereby increasing the efficiency.

Other improvements that are contemplated are better aerodynamics of the blades, improved composite materials to make blades and better turbine monitoring with artificial intelligence to reduce maintenance costs.

RENEWABLE ENERGY DEVELOPMENTS

Future Onshore Wind Costs

It can be estimated that prior to 2030, onshore wind will be able to produce power in the range of 1.5 – 6.0 cents per kWh, with a probable average LCOE of about 3.5 cents/kWh (2020 $).

This means that onshore wind energy will be cheaper than any new build fossil fuel plant in the USA and at the marginal costs of operating coal plants in the USA.

By 2050 onshore wind may be in the range of 1 to 5 cents/kWh (2020$), with a probable average of 3.0 cents/kWh.

RENEWABLE ENERGY DEVELOPMENTS

Offshore Wind – Current Costs

The IRENA information indicates that with respect to offshore wind auctions on a worldwide basis the average costs in 2022 will be 10.8 cents/kWh, with most projects ranging in the 6.0 to 14.0 cents/kWh range. In NW Europe most projects are in the 6.0 to 10.0 cents/kWh range. The BNEF data base indicates an typical costs of 7.8 cents/kWh for offshore wind in 2020. Lazard rates an average cost of 8.9 cents/kWh. Shell offered 5.8 cents/kWh PPA for the offshore Mayflower wind farm off USA.

Typically one needs to add 1 or 2 cents per kWh for the connection to the shore.

This indicates that offshore wind is now at the lower end of the fossil fuel cost range of 4.4 to 15.2 cents/kWh (based on Lazard) and is therefore directly competitive with fossil fuels.

RENEWABLE ENERGY DEVELOPMENTS

Offshore Wind - Future technologies

The main factor in decreasing costs is the increase in height and rotor size. Offshore turbines are estimated to grow from about 5 MW to 12 MW per turbine over the coming five years with a height of 290 meters. Instead of fixed to the seabed, floating designs are now being installed for deeper water. Offshore wind turbines typically have a higher capacity factor due to winds more prevailing offshore. Using its offshore experience Equinor is investing significantly in floating offshore turbines, which are built easily onshore and floated out. The first floating wind farm is the Hywind project under construction offshore Scotland.

It should be noted that the total world offshore wind capacity is enormous. The capacity is sufficient to supply 11 times the total world electricity demand for 2040.

RENEWABLE ENERGY DEVELOPMENTS

Future Offshore Wind Costs

It can be estimated that prior to 2030, offshore wind will be able to produce power in the range of 4.0 – 10.0 cents per kWh, with a probable average LCOE of about 5.0 cents/kWh (2020$).

This means that offshore wind energy will be cheaper in most countries than new fossil fuel plants (based on Lazard, US conditions).

Some countries such as China, South Korea, Japan, the UK, the Netherlands and Denmark will benefit enormously from offshore wind.

By 2050 offshore wind may be in the range of 3 – 7 cents/kWh (2020$), with an average costs of about 4.5 cents/kWh

RENEWABLE ENERGY DEVELOPMENTS

Concentrated Solar Power – Current Costs

Concentrated Solar Power is based on systems where by molten salt or other materials are heated with solar energy from solar mirrors during the day in order to deliver power on a continuous basis. For 2018 IRENA quoted a LCOE range of 10 to 28 cents/kWh, with an average of 18.5 cents/kWh.

For 2022 auction bids have been received of 7.5cents/kWh

Lazard lists US costs for 2019 at 12.6 – 15.6 cents/kWh.

This indicates that CSP used to be more expensive than fossil fuel generation but that improved conditions are bringing these costs down.

RENEWABLE ENERGY DEVELOPMENTS

Concentrated Solar Power - Future technologies

The main factor in decreasing costs actually does not relate to new technologies but to more efficient supply chains and new projects moving to areas with a higher quality solar radiation.

However, other important factors are improvements in mirror orientation and improvements in heat storage. Storage has improved from about 4 hours to 8 hours.

At this time there is only a limited number of projects being committed and therefore there is no clear trend in indications of important technical factors.

RENEWABLE ENERGY DEVELOPMENTS

Future Concentrated Solar Power Costs

It can be estimated that prior to 2030, the cost of CSP will be in the range of 5.0 to 14.0 cents/kWh, with may be an average costs of 7 cents/kWh (2020$). Average costs by 2050 may be 5.5 cents/kWh (2020$)

However, these levels still have a considerable possible margin of error.

In general it seems that CSP plants may be developed competitive with new fossil fuel plants. This would be important since the advantage of CSP is obviously that it provides continuous electricity all day rather than depending on solar hours. Morocco has embarked on large CSP projects.

RENEWABLE ENERGY DEVELOPMENTS

Solar Heat

Apart from using solar energy to produce electricity, it can be used directly to produce steam or heat.

For instance, in Oman the national oil joint venture company PDO produces steam directly from solar energy in order to enhance the recovery of heavy oil.

Heliogen a start up company in the US has developed an artificial intelligence based concept to focus hundreds or mirrors on a single small point, producing industrial heat well over 1500 degrees Celsius. This can be used for a variety of industrial purposes and possibly for the direct production of hydrogen through thermolysis, which take place at 2200 degrees Celsius.

RENEWABLE ENERGY DEVELOPMENTS

Hydropower

The traditional form of renewable energy is hydropower. Current hydropower production is about 4000 TWh/year. Total world economic hydropower potential is about 9000 TWh/year. It is for this reason that it is expected that hydropower will continue to make an important contribution to new electricity generation.

There is still a number of countries with large (more than 100 TWh/year) economic hydropower resources of which only a small fraction has been developed. These countries are Cameroon, DRC, Ethiopia, Ecuador and Peru. (100 TWh = 100,000,000,000 kWh)

Other countries with still large remaining economic hydropower resources are Angola, Madagascar, China, Kyrgyzstan, Vietnam, Norway, Russia, Iceland, Canada, Bolivia, Brazil, Chile and Colombia.

RENEWABLE ENERGY DEVELOPMENTS

Hydropower

The LCOE of hydropower is rather site specific and large projects typically have lower costs than small projects.

However, the IRENA estimate of the world average LCOE is 4.7 cents/kWh. The typical range is 2.5 – 12.0 cents/kWh. Although costs for some countries in Europe are well over these levels.

Future costs of hydropower depend largely on the location. No new technologies are contemplated that could reduce costs. However, it is contemplated that hydropower costs of economic projects will remain well in the range of fossil fuel based power of 4.4 to 15.2 cents/KWh.

RENEWABLE ENERGY DEVELOPMENTS

Geothermal Power and Heat

Geothermal Energy can be used for power generation and direct heating for agricultural, industrial and other purposes.

Total world production (not including geothermal heat pumps) is about 75 TWh for power as well as 75 TWh for heat.

The main countries using geothermal power are: the United States, Philippines, Indonesia, Mexico, New Zealand, Italy, Iceland, Turkey, Kenya and Japan.

The main countries using geothermal heat are: China, Turkey, Iceland, Japan, Hungary, the United States and New Zealand.

RENEWABLE ENERGY DEVELOPMENTS

Geothermal Power

The LCOE of geothermal power is rather site specific.

However, the IRENA estimate of the world average LCOE is 7.2 cents/kWh for new plants. The typical range is 6.0 – 14.0 cents/kWh. Costs have actually gone up over the last decade. The typical costs in the United States in 2015 was about 3.9 cents/kWh.

Future costs of geothermal power are unlikely going to be competitive with wind and solar PV and therefore the growth of geothermal power can be estimated to be modest.

RENEWABLE ENERGY DEVELOPMENTS

Geothermal District Heating

Geothermal district heating is in principle a simple process and can be done anywhere in the world.

It consists of drilling from a single platform two deviated wells to a depth sufficient to reach high temperatures, which could be between 2000 and 3500 meter. One well is a producer of hot water bringing this water to a heat exchanger, the resulting cold water is reinjected back in the ground. The heat is piped through the community. Systems could be in the 0.5 to 50 MW range.

Geothermal district heating systems are increasingly applied in the world. They are most economic in areas with high heat flows (such as volcanic areas) and in cities with dense population.

Of course, district heating is also done based on waste heat from power or industrial plants, or heat generated by biomass.

RENEWABLE ENERGY DEVELOPMENTS

Tidal Energy

Tidal energy consists of two type of projects: tidal range projects and tidal stream projects.

Tidal range projects make use of high and low tides to fill and empty a basin. The cheapest project in the world is the 254 MW Sihwa Lake project in South Korea, which costs about 3 cents/kWh. Other tidal range projects are much more expensive.

Tidal stream projects make use of the tidal current to move the blades of a turbine. A large number of turbine designs is being proposed, but it seems that the LCOE is over 20 cents/kWh. Future costs may be as low as 10 cents/KWh. Therefore these projects may not make a significant contribution to world renewable energy generation. The MeyGen project is currently operating off the north coast of Scotland.

RENEWABLE ENERGY DEVELOPMENTS

Wave Energy

There is a large number of small wave power projects in operation or planned.

The SR2000 , a 2MW project off the Orkney Islands, produced 3 GWh of power in its first 12 month.

A number of other projects are in operation in the UK, Portugal, Australia.

The Ocean Energy Council of the UK is claiming that the best projects are having a cost of about 7.5 cents/kWh, but no detailed information is provided.

RENEWABLE ENERGY DEVELOPMENTS

Biomass to Power

The production of electricity from biomass can be based on a very wide range of biomass sources. Important sources are bagasse, landfill gas, wood chips, rice husks, wood waste, agricultural waste, municipal waste, straw and black liquor (a byproduct of the pulp and paper industry).

Based on IRENA data, costs depend largely of the costs of the biomass. Significant production occurs in China and India, but also in Europe and North America. Typical costs are between 4 and 15 cents/kWh, with average costs in the range of 6 to 8 cents/kWh. No technical breakthroughs are contemplated.

Biomass to power will make an ongoing contribution to renewable energy, but is not expected to be a major contributor.

Yet, it is an important renewable energy resource in areas with poor solar and wind conditions.

RENEWABLE ENERGY DEVELOPMENTS

Advanced Biofuels

Most of current biofuels are made from sugars or vegetable oils which compete with the production of food. From a renewable energy perspective there is no future for such biofuels, since they cannot be produced on a large scale without negatively impacting the world food production.

Therefore, the future of biofuels for energy purposes has to be based on advanced biofuels. These are biofuels, that are produced from non-food crops that are grown on marginal land unsuitable for food production. It includes also biofuels based on plant materials and animal waste, as well as biofuels based on algae grown in special containers on desert type land.

RENEWABLE ENERGY DEVELOPMENTS

Advanced Biofuels

There is an extremely large number of ways of making advanced biofuels.

The bio feedstocks include: a very wide variety of energy crops, municipal waste, green waste (from forests, parks or gardens), algae, aquatic bacteria, black liquor, etc.

Processes to make the biofuels include: gasification, pyrolysis, torrefaction, hydrothermal liquefaction and a variety of biochemical routes.

Biofuels can than be made from: syngas using catalysis, syngas using Fischer-Tropsch, biocatalysis or a variety of other processes.

In general the overall efficiency of reducing CO2 is that the biofuels have an 60- 80% efficiency compared to the corresponding fossil fuels emissions.

RENEWABLE ENERGY DEVELOPMENTS

Advanced Bio Jet Fuel

Probably the most important biofuel from a renewable energy point of view is bio jet fuel, since no other form of renewable energy would provide a comprehensive solution for air transportation.

NREL evaluated 14 different technologies of making bio jet fuel. A large number of airline companies already use such bio jet fuels on a small scale.

Costs of bio jet fuels is still high; in the range of $ 110 - $250/bbl. Costs will be reduced in the future through the intensive research taking place. Nevertheless, there are no clear pathways resulting in possible substantial cost reductions. It is for this reason that in this presentation we forecast only a limited use of bio jet fuel by 2050.

RENEWABLE ENERGY DEVELOPMENTS

Pure Synthetic Jet Fuel

Some of the bio jet fuel processes use regular syngas processes producing synthetic jet fuel.

Potentially a very significant impact of low cost green hydrogen (based on electrolysis of solar or wind energy) would be the production of synthetic jet fuel, whereby jet fuel is produced with green hydrogen and pulling CO2 from the air.

The process was already used by Germany in World War II.

Currently the Klesch Group, operating the Heide oil refinery in Northern Germany, is perfecting this process based on hydrogen from local wind farms. Lufthansa committed to use this synthetic fuel for 5% in their jet fuel consumption within 5 years.

However, overall costs are not known.

RENEWABLE ENERGY DEVELOPMENTS

Renewable Energy for Power Generation - Conclusions

The framework for the economic development of renewable energy for power generation will be the LCOE of competing fossil fuels. It is assumed that this range in constant 2020 $ will remain about 4.4 – 15.2 cents/KWh for the coming decade.

Before 2030, the cost of Solar PV is expected to be on average 3.0 cents/kWh and onshore wind 3.5 cents/kWh, well below this range.

The cost of offshore wind is expected to be 5.0 cents/kWh and concentrated solar power 7.0 cents/kWh which is at the lower end of this range. Economic hydropower will also be at the lower end of this range.

RENEWABLE ENERGY DEVELOPMENTS

Renewable Energy for Power Generation - Conclusions

The expected low cost of renewable energy, will be a significant competitive challenge for electricity generation based on coal and natural gas during the next decade. Renewable power generation will rapidly expand as percentage of the total generation.

However, what if there is no sun light and no wind? Natural gas can be expected to remain an important component of the energy mix during the next decade(s) in order to maintain reliable power generation.

The role of natural gas will remain until economic forms of energy storage will replace the need for natural gas. Two important developments will be evaluated: battery storage and hydrogen.

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage

In this part of the presentation we will look at the future of energy storage. Two issues will be reviewed:

-- the cost of batteries, and

-- the cost of utility scale storage systems. These systems include apart from the batteries, the costs of the inverter(s) and cost for connection and construction, including engineering.

The costs are often expressed in $/MWh. For instance, a 60 MW storage system could deliver electricity for 4 hours. This means that the total capacity is 240 MWh. A 240 MW system that delivers power for 1 hour is also 240 MWh. However, the costs of the system will be higher because large inverters and connection systems are required. The Levellized Costs of Storage ("LCOS") are determined based on a cash flow of the system.

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage

There is a huge variety of storage systems as follows:

-- Chemical - Hydrogen, ammonia, methanol could be stored for considerable periods and used for power generation when required.

-- Mechanical – Pumper hydro storage has been used traditionally and is still important. Other methods are gravity systems, flywheels, compressed air, etc.

-- Electrical – Such as supercapacitors, consisting of two carbon-based electrodes with an insulating material in between.

-- Thermal – Such as heat storage in molten salt or liquid air storage.

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage

(continued)

-- Electrochemical, which are batteries. There are basically two types:

.. Classic batteries, which could be of a large variety of types such as the original lead acid batteries, sodium-sulfur, nickel-cadmium, lithium-sulfur and the currently the most common: lithium-ion.

.. Flow batteries, which are operate similar to batteries but are based on liquids (or gas) stored in two separate tanks with ions passing through a membrane. The Vanadium Redox flow batteries are used on a large scale and have a life time much longer than regular batteries.

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage – Batteries Current and Future Costs

Battery cost have fallen enormously since 2010.

In 2010 the Lithium-Ion battery costs was $ 1000/kWh.

In 2019 the costs was reduced to $ 150/kWh.

It is expected that battery costs will continue to fall rapidly due to small improvements in technology and larger volume battery production.

BNEF estimates that costs will be $ 96/kWh in 2025 and $ 70/kWh in 2030.

The 2025 costs will make electric cars fully economic and will therefore have a large impact on possible oil demand.

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage – Batteries Current and Future Costs

Tesla is planning a "battery day" later this month of May 2020, with new announcements about a "million mile" battery.

The announcement may indicate already a significant drop in costs. The new battery is developed together with Contemporary Amperex Technology Ltd of China ("CATL").

CATL has developed several types of batteries.

The cost of CATL's cobalt free lithium iron phosphate battery packs has fallen to $ 80/kWh. Their low cobalt nickel-manganese-cobalt (NMC) batteries cost $ 100/kWh. CATL has also developed a cheaper way to make battery packs, called the cell-to-pack method.

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage – Utility Scale Storage - Costs

The Lazard estimate of current utility scale storage LCOS is between 16.5 and 30.5 cents/kWh for a 100 MW system that delivers 4 hours, 400 MWh of electricity, based on Lithium-Ion batteries.

This includes charging costs with solar electricity priced at 4.2 cents/KWh.

This should be compared with the gas peaking costs to provide electricity after sunset. These costs depend on the costs of natural gas. Low costs are in the United States with costs of 12.2 to 19.9 cents/KWh. High costs are in India with 20.8 to 25.8 cents per kWh. In other words utility scale storage is already competitive in countries with high costs of natural gas.

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage – Utility Scale Storage – 2030 Costs

For the year 2030 the Lazard LCOS can be adjusted by taking into consideration our estimate of the costs of solar of 3 cents/kWh kWh and battery costs of $ 70/kWh.

This will result in a LCOS of between 12 and 24 cents/kWh (2020$), in other words competitive in a significant part of the world with gas peaking after sunset. However, this is based on Lithium-Ion batteries.

It is believed by some experts that flow batteries by that time may actually be cheaper and will be longer lasting, due to anticipated further technical developments of these batteries.

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage – Utility Scale Storage – 2050 costs

A huge amount of research and development is currently being done to develop even cheaper storage systems of every possible type. Seven countries of the EU have approved a 3.2 billion Euro research project to make Lithium-ion batteries last longer and faster charging.

If a very large battery market develops, the costs of lithium and vanadium could increase costs. Therefore, considerable research is being done to make batteries of cheaper and more abundant materials.

For this reason it is not unreasonable to expect for 2050 a LCOS in the range of 6 – 12 cent/kWh (2020 $) in line with forecasts of the National Renewable Energy Laboratory (NREL) (United States).

RENEWABLE ENERGY DEVELOPMENTS

Energy Storage – Utility Scale Storage – Research

Following is a sample of the type of research that is being done:

Elestor, a company in the Netherlands, is working on a hydrogen-bromide flow battery aimed at relatively small scale storage. A 50 kW demonstration project is underway. Larger size storage can be created by simply more 50kW units. The battery is therefore made of light and cheap materials. A battery with any combination of power (kW) and capacity (kWh) can be designed. The battery has a very long life time (more than 10,000 cycles) without affecting the quality of the battery. Charge to discharge is in the 100 microsecond range. Research (supported by Shell) is being done to even have a membrane-less flow battery, thereby significantly reducing further potential costs.

RENEWABLE ENERGY DEVELOPMENTS

Hydrogen

One of the ways to produce hydrogen is through electrolysis, whereby a electricity splits water in hydrogen and oxygen. The electricity can be generated from renewable energy. Hydrogen can be stored and produce electricity when needed or can be used of other purposes such as in hydrogen vehicles.

Currently, the Orkney Islands, UK, are already doing this. They produce wave, tidal and wind energy. Often more than they need. Extra electricity production is converted with two container sized electrolysis plants into hydrogen, which is used by local vehicles, a fuel cell to produce electricity and to heat a local community hall.

RENEWABLE ENERGY DEVELOPMENTS

Hydrogen

Cost and production of hydrogen is often expressed in kilogram (kg) of hydrogen.

The energy content of 1 kg of hydrogen is 115,240 Btu.

One MMBtu requires 8.68 kg of hydrogen.

One barrel of oil equivalent is about 50 kg of hydrogen.

One kg H2 has the same energy content as 11.2 cubic meter of H2

RENEWABLE ENERGY DEVELOPMENTS

Hydrogen – Production methods

Currently about 70 million tons of (pure) hydrogen is produced in the world as feedstock for a wide variety of purposes, such as for refining of crude oil, producing ammonia and methanol and as fuel for cars.

Hydrogen is currently produced through a variety of industrial processes from fossil fuels, such as steam reforming of methane, partial oxidation of methane and gasification of coal or biomass. Only about 4% is produced based on electrolysis.

The cost of producing such hydrogen based on fossil fuels is about $ 1.50 - $ 2.00/kg.

RENEWABLE ENERGY DEVELOPMENTS

Green Hydrogen – Production methods

There are four methodologies to produce "green" hydrogen:

-- biomass gasification

-- electrolysis based on electricity generated from solar, wind or hydropower (or any other renewable source). There are in turn three main methods of electrolysis:

.. Alkaline electrolysers (ALK)

.. Proton exchange membrane electrolysers (PEM)

.. Solid Oxide Electrolyser Cell (SOEC)

-- production of biohydrogen based on a photobioreactor using algae, which switch from producing oxygen to hydrogen when deprived of sulfur.

-- potentially, the Heliogen process indicated earlier.

RENEWABLE ENERGY DEVELOPMENTS

Green Hydrogen – Production Methods

There is a massive amount of R&D under way that may change the future of hydrogen production. For instance:

-- ENECO Holdings in Japan announced a new catalytic process that reduces the cost of HHO fuel from $0.93 to $ 0.28/m3.

-- Proton Technologies indicates that they can produce hydrogen through underground oil sand oxidation at about $ 0.50/kg

-- Researchers at the University of Southampton have indicated that they can produce hydrogen with solar energy by transforming optical fibers into photocatalytic micro-reactors.

-- Korea Electric Power Corp have developed a liquid organic hydrogen carrier that could concentrate hydrogen in a liquid in much smaller volumes.

RENEWABLE ENERGY DEVELOPMENTS

Green Hydrogen – Current Costs

IRENA calculates that the current cost of green hydrogen based on electrolysis based on low cost solar or wind is about $ 3/kg.

The Baofeng Energy Group which currently produces a significant share of China's hydrogen based on coal gasification has announced that they will built an electrolysis plant based on 200 MW of solar that will produce about 14 million kg of hydrogen per year. From the cost details, it can be back-calculated that the Levellized Costs of Hydrogen (LCOH) may be about $ 2.25/kg.

RENEWABLE ENERGY DEVELOPMENTS

Green Hydrogen – Current Projects

The traditional way to produce hydrogen is from cheap hydropower. In 1940 NEL ASA of Norway produced already 23.5 million kg per year from its plant in Rjukan and is a leading supplier of electrolysers.

Current projects are:

--Infinite Blue Energy is building a 9.1 million kg/year project in Perth, Australia, operational by 2022 based on solar and wind.

--Shell is constructing a 60,000 kg/day (21.9 million kg/year) green hydrogen plant based on wind energy in Rotterdam which will be operational by 2023. The production will be send by pipeline for use in the Pernis refinery and for trucking.

RENEWABLE ENERGY DEVELOPMENTS

Green Hydrogen – Current Projects

(continued):

-- Infinite Blue Energy is also planning a large 1000 MW project for New South Wales, Australia, called "Project NEO", based on solar, and wind, producing green hydrogen, with hydrogen fuel cell generation to produce the electricity. This $ 3.5 billion project will provide 100% zero carbon base load electricity on a 24 hour/day basis. The project is supposed to be operational in 2027.

--Shell and GasUnie (a Shell/ExxonMobil JV) are planning an 800 million kg/year plant based on wind in Groningen (northern Netherlands) operational by 2040.

RENEWABLE ENERGY DEVELOPMENTS

Green Hydrogen – Future Costs

Future costs of green hydrogen is expected to drop, even if there are no unexpected breakthroughs in new technology.

Further R&D will result in more efficient electrolysis and optimization of the various processes. Simply scaling up and increasing the amount of electrolysis will reduce costs.

IRENA expect that the LCOH of green hydrogen by 2030 will be about $ 1.80 - $ 2.00/kg. IRENA estimates that by 2050 this may be as low as $ 1/kg. BNEF estimates that the LCOH by 2050 could be in the range of $ 0.80 to $ 1.60/kg. This is still between $ 7 and $ 14 per MMBtu. However, if certain technical breakthroughs would occur the costs could well be under $ 0.50/kg and as a result in that case hydrogen could be fully competitive with natural gas.

IMPACTS ON THE PETROLEUM INDUSTRY

Introduction

In the following slides the future of the petroleum industry will be analyzed on purely economic grounds, without consideration of the cost of carbon, possibly implemented with carbon taxes or through other means or government subsidies for renewables.

It will be assumed that the industry will continue to have a possibility to expand and bring new supplies forward in a $ 50/barrel crude oil scenario (2020$) assuming that new technologies will continue to bring costs downward in real terms.

Therefore renewable resources will only be assumed to be introduced when competitive with petroleum

IMPACTS ON THE PETROLEUM INDUSTRY

Introduction

The framework for the analysis of the future of the petroleum industry, will be the World Energy Outlook, 2019, prepared by the International Energy Agency (IEA).

Two forecast until 2040 of the IEA will be used:

-- the Stated Policy Scenario ("IEA-SPS"), which is a scenario based on the policies currently stated by the various countries regarding climate change and other matters, and

-- the Sustainable Development Scenario ("IEA-SDS"), which is a scenario deemed necessary to pursue the relevant climate change policies.

The scenarios were not adjusted for a possible lower economic growth for an extended time as a result of the CVID-19 pandemic.

IMPACTS ON THE PETROLEUM INDUSTRY

Introduction

Based on the analysis in this presentation the IEA-SPS will be adjusted in the following manner:

-- as indicated in the introduction the COVID-19 pandemic may result in a slight permanent loss of oil consumption (although there are also view that increased use of cars may increase),

-- some countries will overcome the severe anticipated recession with additional investments in renewable energy, as the EU is planning.

-- the IEA may be under-estimating somewhat the effect of the drop in battery costs and storage costs

-- the presentation also identifies a slightly stronger possible effect of hydrogen towards 2040 and 2050

IMPACTS ON THE PETROLEUM INDUSTRY

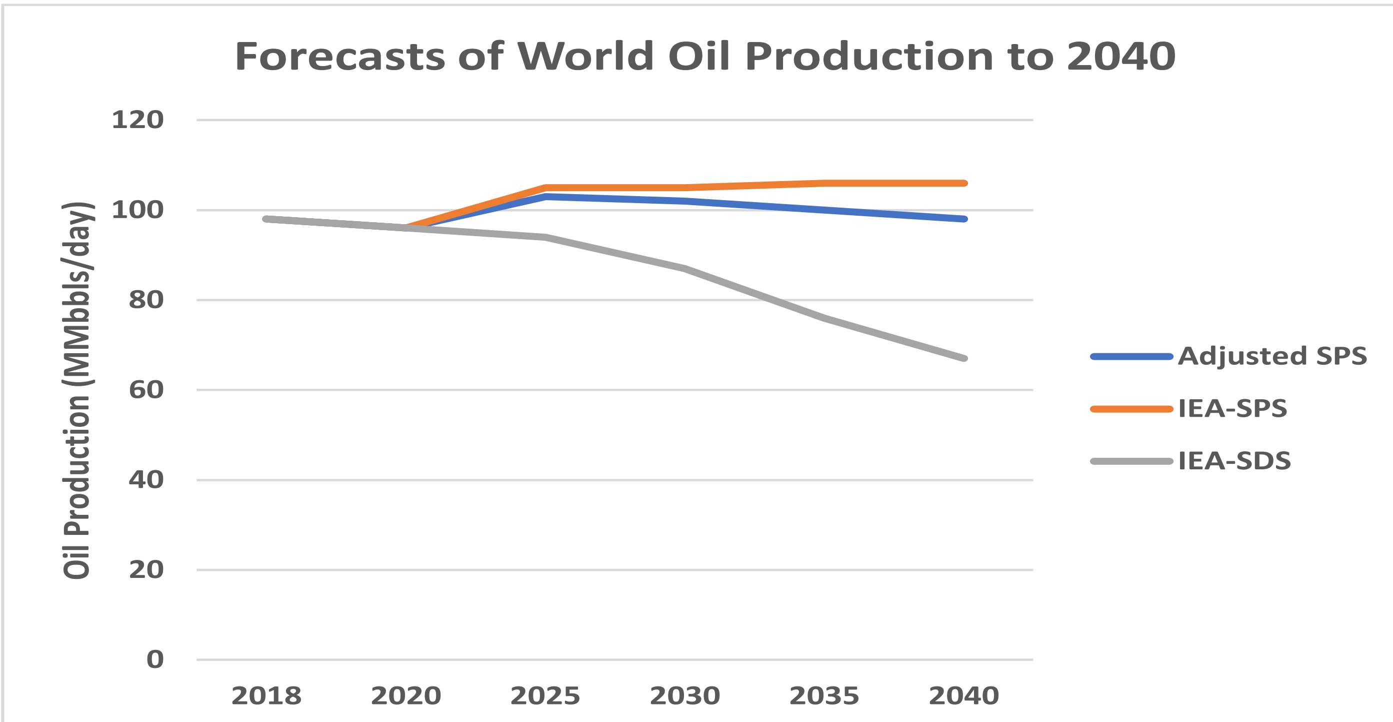
Introduction

First, five summary slides will be presented.

Afterwards, a detailed discussion will be provided for the rationale of the results presented in the slides.

IMPACTS ON THE PETROLEUM INDUSTRY

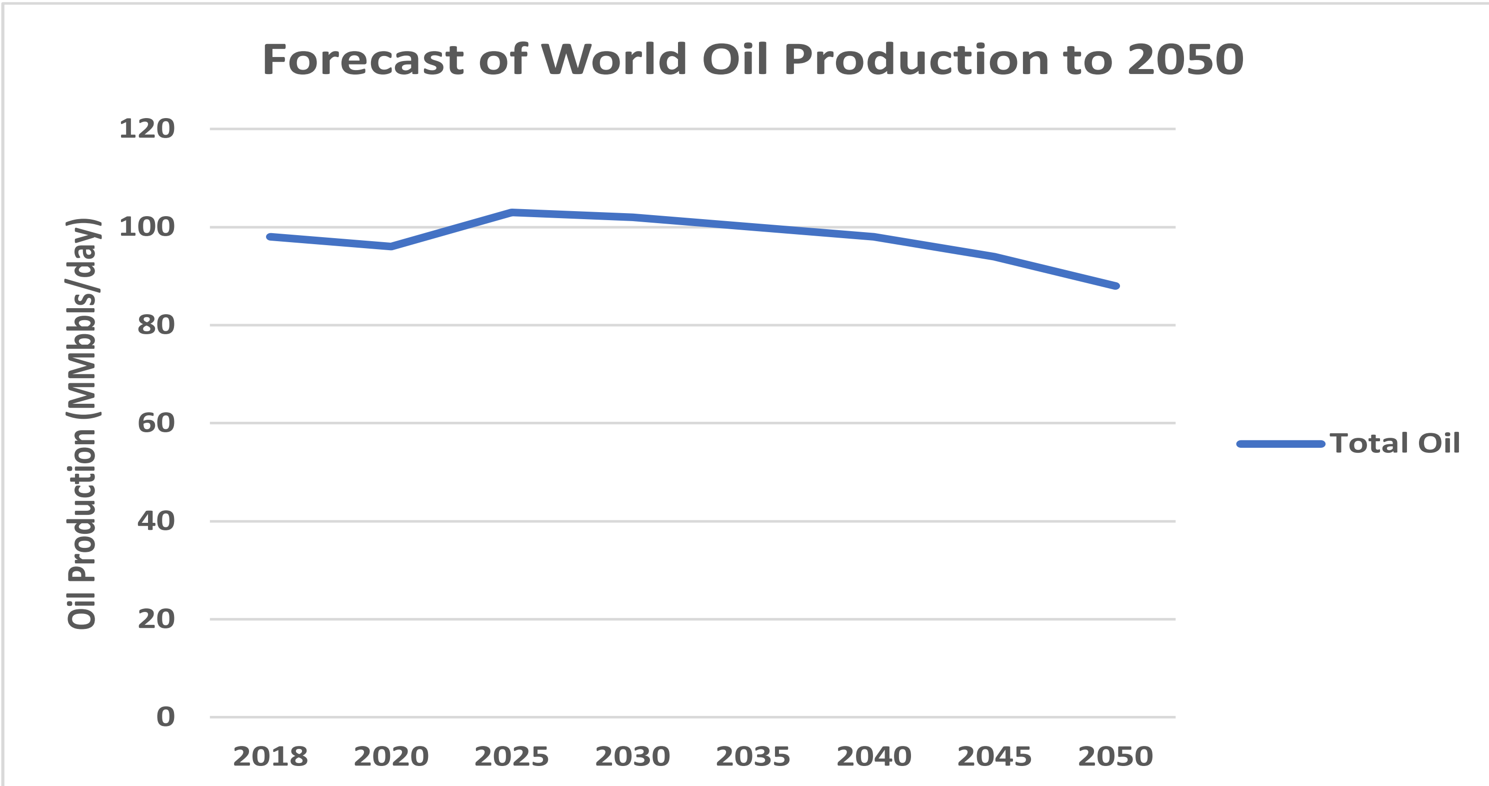
Oil Production Forecasts



The chart shows how by 2040 the overall effect of the various adjustments will be a reduction in oil production of about 8 million barrels per day (7.5%) compared to the IEA-SPS forecast. However, the forecast far exceeds the IEA-SDS forecast.

IMPACTS ON THE PETROLEUM INDUSTRY

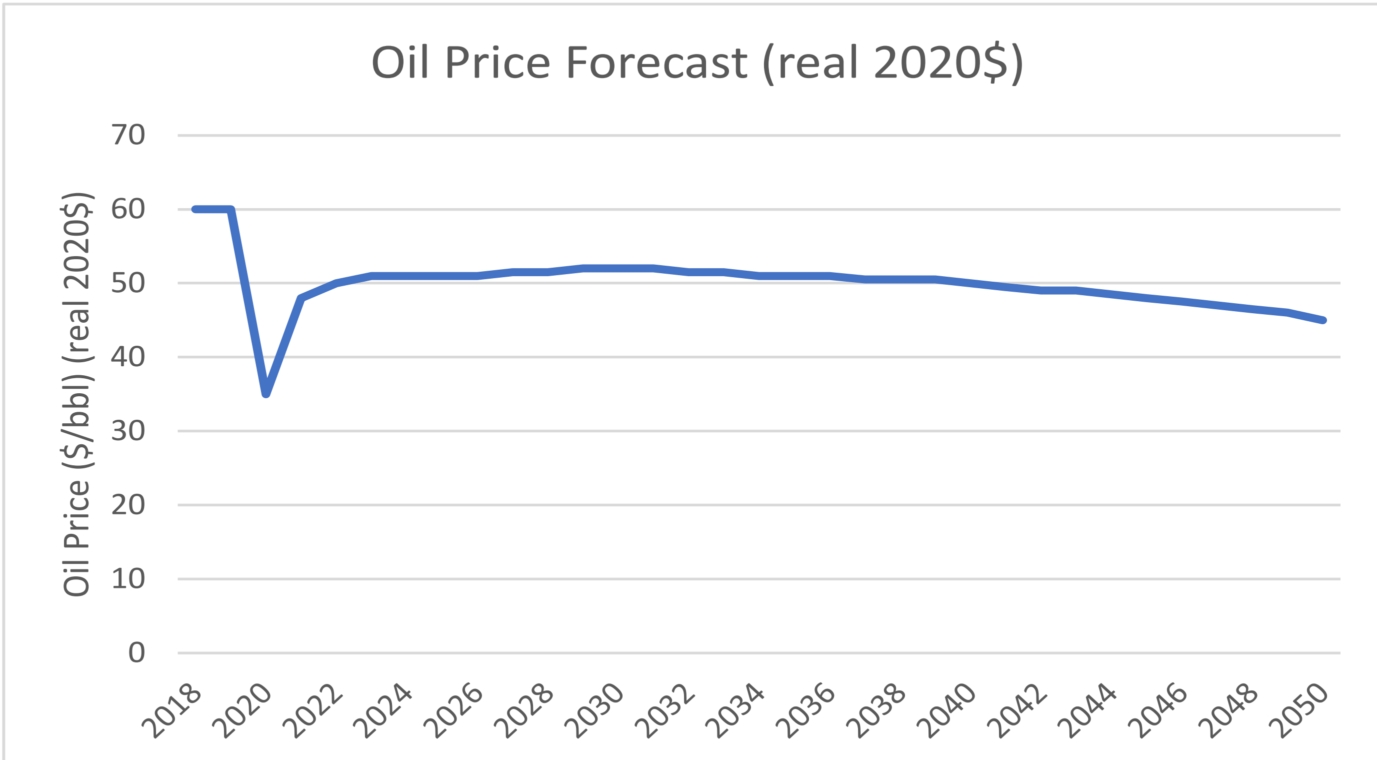
Oil Production Forecast



The chart extends the previous forecast to 2050, indicating that by 2050 the oil production will be 11 million barrels per day less than in 2018. World peak production will be in 2025 with 103 MMbbls/day.

IMPACTS ON THE PETROLEUM INDUSTRY

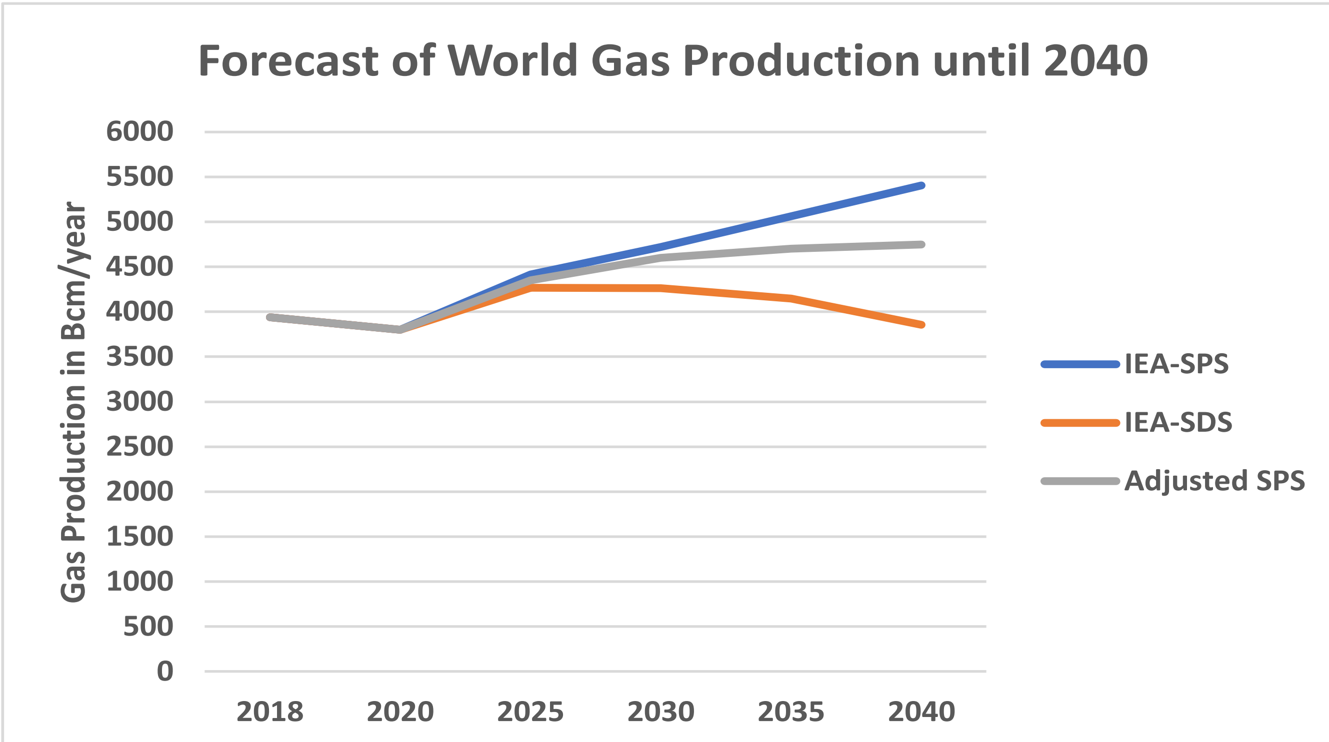
Oil Price Forecast



As indicated in the COVID-19 discussion, it is expected that the oil price will bounce back by 2022 to $ 51/bbl. Subsequently, if OPEC adopts a $ 50/bbl strategy and this limits US shale production a relatively stable price can be expected until about 2040, after that the drop in world crude oil demand will put some downward pressure on price.

IMPACTS ON THE PETROLEUM INDUSTRY

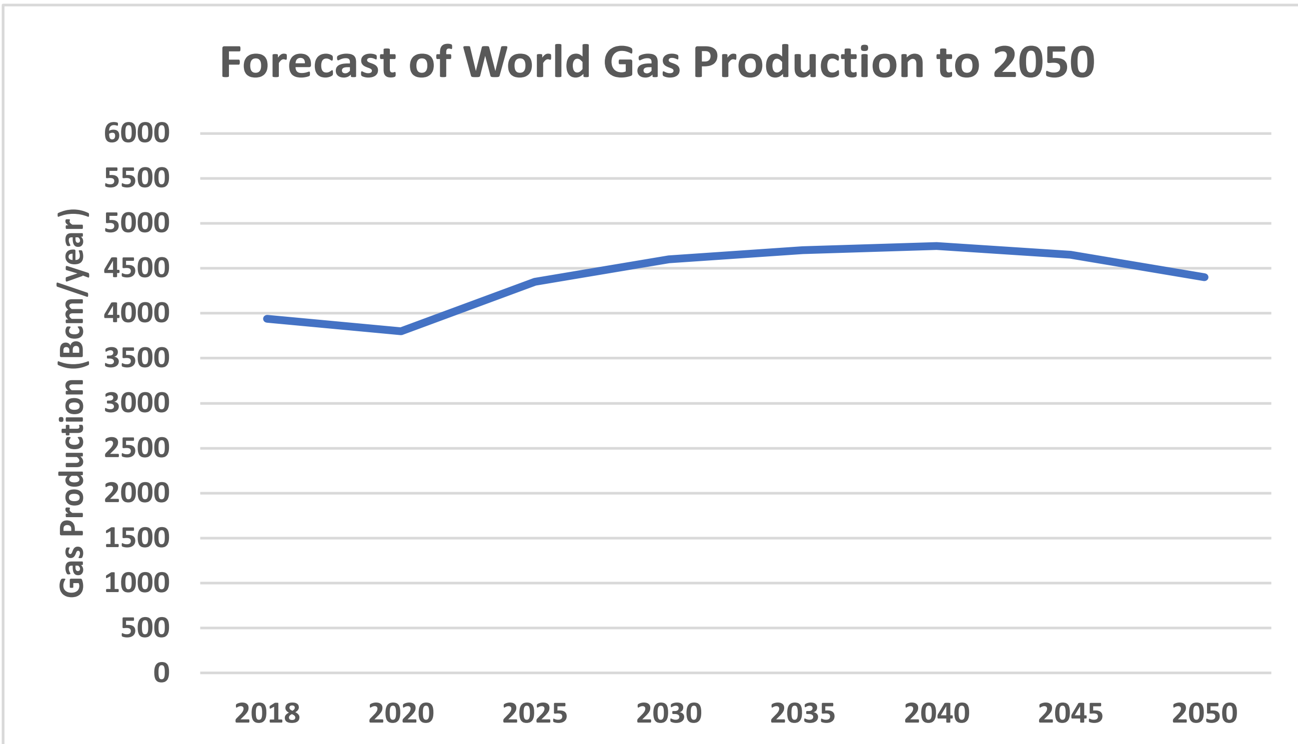
Gas Production Forecasts



The chart shows how by 2040 the overall effect of the various adjustments will be a reduction in gas production of about 654 Bcm/year compared to the IEA-SPS forecast. However, the forecast exceeds the IEA-SDS forecast.

IMPACTS ON THE PETROLEUM INDUSTRY

Gas Production Forecast



The chart extends the forecast to 2050. By 2050 the world will still produce 463 Bcm/year more than in 2018. Gas peak production will be in 2040 with 4750 Bcm/year.

IMPACTS ON THE PETROLEUM INDUSTRY

Three Revolutions

In the 2020 – 2050 period the petroleum industry will be subject to three revolutions:

Revolution #1- 2020-2030 - Strong penetration of low cost renewable energy for power generation

Revolution # 2: 2025 – 2045 – Utility scale energy storage based on renewables will replace natural gas in the energy mix for power generation.

Revolution # 3: 2035 – 2050 – Emergence of green hydrogen as significant energy source for a variety of transport and industrial purposes.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #1: Penetration of Low Cost Renewables

It was estimated that by 2030 the cost on solar PV would be on average 3.0 cents/kWh and onshore wind 3.5 cents/kWh

It should be noted that many parts of the world that have poor solar conditions have good onshore wind conditions.

For instance NW Europe, Eastern Canada, Northern Russia, Mongolia, Patagonia, Alaska and the interior states of the United States all have excellent wind conditions.

This means that in 2030 in most of the world the LCOE of either solar PV or onshore wind will be cheaper than any new fossil fuel plant (based on Lazard USA conditions).

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #1: Penetration of Low Cost Renewables

This will result in a rapid penetration of solar PV and onshore wind by 2030. In some areas of the world even offshore wind will be less than combined cycle gas production.

This increase in solar PV and onshore wind will accelerate further after 2030.

Offshore wind is already economic in NW Europe and many other areas. Due to reducing cost also offshore wind will start to penetrate rapidly after 2030.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution # 2: Utility scale storage already economic

Other than CSP, at this time solar PV plus utility scale storage is already economic in a number of areas in the world. For instance, the United States has already 40 projects in operation of in total 533MW/1242MWh, mainly in Hawaii, California and Florida. A 690 MW project by Quinbrook Instrastructure partners for Nevada just received approval.

The oil company Total is building a 25 MW/25MWh system in France. Penso Power is adding 50 MW to the 100 MW project in the UK. AGL Energy has received approval for a 100 MW/150MWh project in Queensland.

Tesla is strongly in the market for economic large utility scale storage.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #2: Huge variety of storage projects

What is remarkable is that there is a huge variety in utility scale storage projects, other than from Lithium-Ion, CSP and traditional pumped storage. For instance:

-- a 50 MW-400 MWh liquid air storage project is being installed in Vermont, with air being cooled to minus 196 degrees Celsius which is allowed to warm and produce power when needed.

-- a mine near Adelaide, Australia, has a 5MW compressed air storage system, whereby compressed air replaces a water column and the water pressure produces electricity when needed

-- Siemens in Hamburg, Germany has a thermal storage project of 1.2MW/130MWh capacity, with heated air that produces steam when electricity is needed.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #2: Huge variety of storage projects

(continued):

-- near Salt Lake City it is planned to store compressed air in a salt dome and generated electricity when needed.

-- Hydrostor is putting large bags on the floor of 55 meter deep Lake Ontario with compressed air. Water depth pressure releases the energy for electricity when needed.

-- Max Boegl Wind AG plans to store water simply in the bottom of the towers of wind turbines, a project with a hydropower plant down hill of 16 MW capacity and with 13.6 MW wind.

-- Form Energy is installing a 1MW/150MWh aqueous air battery in Minnesota

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #2: Reduction of natural gas for power generation

As indicated earlier, it can be forecasted that the LCOS of utility scale storage by 2030 will be in the 12 – 24 cents/kWh range, based on Lithium-Ion batteries, fully competitive with natural gas based peaking after sunset in most of the world.

After that, the LCOS is anticipated to drop gradually and the role of natural gas in the energy mix to produce electricity will gradually erode. Since 36% of the gas use is for power generation in 2030, it is forecasted that natural gas production will peak by 2040.

Based on our LCOS forecast, by 2050 natural gas will only play a role in new power generation in countries with poor solar and wind conditions.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #2: Reduction of natural gas for use in buildings

The important result of Revolution # 2 is that increasingly ever cheaper renewable electricity will be produced capable of supplying the economy 24 hours per day in more and more countries.

This has other effects on natural gas. In 2030, 20% of the natural gas will be used in homes and buildings, for heating and cooling and water heating.

Cheap electricity will increasingly be used for electric heat pumps for heating and cooling and for water heating. The details will depend very much on climate conditions and building quality, in particular insulation. However, in general after 2035 a gradual reduction of natural gas use can be expected for this purpose.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #2: Reduction of Natural Gas – The Netherlands

An interesting example could be the Netherlands, which since the gigantic Groningen gas field discovery has relied for much of its economy on natural gas. The goal is to be carbon neutral by 2050. Therefore a study by was done by Shell and GasUnie to see how natural gas could be replaced economically for buildings. The study resulted in the following conclusions: 10% would be difficult to replace, 40% could be reduced by better insulation, 15% could be replaced by electric heat pumps, 15% by hybrid heat pumps (relying in part on gas), 14% by district heating based on waste heat and 6% by district heating based on geothermal heat. Where natural gas could not be replaced, it was contemplated that green hydrogen would be used based on wind energy (which Shell and GasUnie plan to produce).

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #2: Electric Vehicles

Another well known result of the expected low cost batteries by 2025 is that Electric Vehicle (“EV”) sales will continue to grow rapidly.

By 2040 Bloomberg BNEF expects 57% of the passenger vehicle sales to be EV’s, which at that time would represent 30% of the passenger vehicle market of 1.68 billion vehicles.

BNEF also expects 56% of the light commercial and 31% of the medium commercial vehicle sales to be electric. In total 70% of the busses in operation will be electric.

Apart from Tesla, almost all other car manufacturers are now considering or already selling EV’s.

This will severely impact on oil and in particular gasoline demand.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #2: Electric Air Planes

Air transport will see introduction of electricity, but not on a significant scale.

Harbour Air, a Canadian company flying planes (short distances) between Vancouver Island and mainland British Colombia is converting their fleet to electric planes.

Avinor, the Norwegian company running airports, plans to order electric planes for short haul flights.

Hybrid airplanes running in part on internal combustion engines and in part on electricity are being considered for several applications.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution #2: Electric Vessels

Bangkok will have electric ferries on the river.

Ellen, an electric-powered ferry is already operating in Denmark carrying up to 200 passengers and 30 cars between islands.

For large marine transport a wide variety of options is being considered, usually more attractive than large scale use of electricity.

In general, ever lower costs of renewable electricity will increasingly have an effect on the transport sector.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution # 3: Hydrogen for Oil Refining and Ammonia

Assuming an ever lower cost per kg towards 2050, hydrogen will increasingly penetrate the market. To begin with green hydrogen will increasingly replace hydrogen produced from fossil fuels for the purpose of refining and ammonia production and other industrial processes, once costs start to fall below the $ 2/kg range.

Currently about 7% of the natural gas production is used for these purposes. The ammonia production is expected to expand significantly.

This means that by 2050 a reduction of about 350 Bcm/year of natural gas can be expected and 1.5 MMbopd equivalent of oil and coal worldwide as a result of replacement by hydrogen.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution # 3: Hydrogen for Vehicles

Depending on the competitive framework with electric vehicles and vehicles based on the internal combustion engine, green hydrogen may penetrate a larger share of the road transport market. Gasoline in an internal combustion engine has an efficiency of about 20% and hydrogen about 25%. However, a hydrogen fuel cell has an efficiency of 60%.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution # 3: Hydrogen for Marine Transport

Green Hydrogen could have a significant impact on marine transportation due to the fact that fuel cell technology can be integrated in large ships.

In fact, Switch Maritime in California is building the first 70 foot hydrogen fuel cell ferry for the Bay area.

ABB and Hydrogene de France are designing large scale marine fuel cell vessels.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution # 3: Hydrogen for Industries

Green Hydrogen could have a very significant impact on the petrochemical industries.

Petroleum used as feedstock will continue to grow significantly as a result of the petrochemical industries and since the petroleum is not burned it does not create a climate issue problem. Nevertheless if hydrogen can be produced for $ 1/kg or less, it may also be possible to make synthetic fuels for the petrochemical industries.

Another important possible application is hydrogen for direct reduction of iron ore in the iron and steel industry.

IMPACTS ON THE PETROLEUM INDUSTRY

Revolution # 3: Hydrogen replacing Natural Gas

An important characteristic of hydrogen is that it can be distributed in the regular natural gas pipelines.

For instance, Australia Gas Networks (AGN) is participating in the Hydrogen Park South Australia demonstration project, that will distribute 5% hydrogen in its natural gas distribution system.

The optimal hydrogen content that does not need changes to the gas distribution net work is 20% hydrogen. A Keele University project is carrying out such a trial distribution system based on their own container size hydrogen plant.

With adjustments to boilers and other instruments hydrogen can be transported on a 100% basis through existing gas distribution networks.

IMPACTS ON THE PETROLEUM INDUSTRY

Conclusion on Oil Production Levels

The forecast of world oil production contemplates a level of production in 2040 that is 8 MMbopd less than the IEA-SPS forecast (which is 7.5% less). This is based on the following:

-- a reduction of 2 MMbopd as a result of changes in oil product consumption patterns as a result of the COVID-19 pandemic,

-- a reduction of 2 MMbopd as a result of extra efforts for economic recovery after the pandemic based on promoting renewable resources and continuation of these efforts, and

-- a reduction of 4 MMbopd as a result of more intense use of electricity and hydrogen than forecasted under the IEA-SPS scenario as demonstrated by the detailed analysis in this presentation.

IMPACTS ON THE PETROLEUM INDUSTRY

Conclusion on Gas Production Levels

The forecast of world gas production contemplates a peak by 2040. This is based on:

-- the analysis that indicates that there is significant potential for reduction in costs of utility scale storage of electricity, thereby reducing the role of natural gas in the energy mix for power generation,

-- the somewhat lesser use of natural gas in buildings, and

-- the greater use of hydrogen than estimated by IEA-SPS, in particular for current industrial purposes.

IMPACTS ON THE PETROLEUM INDUSTRY

Conclusion on Oil and Gas Production Levels

It should be noted that the forecasts of oil and gas production would alter very much if due to unforeseen developments the costs of hydrogen would drop well below $ 0.50/kg (2020$) at any particular moment.

In this case it can be expected that natural gas will be rapidly replaced by hydrogen to be transported on 100% hydrogen pipeline networks.

Also in this case, it can be expected that the petroleum production will increasingly be supplied with synthetic gasoline, synthetic diesel and synthetic jet fuel.

IMPACTS ON THE PETROLEUM INDUSTRY

Stronger measure to combat climate change recommended

It should be noted that the forecast is based on the IEA-Stated Policy Scenario with adjustments to this scenario as previously explained.

If Governments would start to adopt stronger measures to combat climate change than the currently stated policies, the drop in oil and gas production could be significantly more, as indicated in the IEA-Sustainable Development Scenario or even more.

Such stronger measures are highly recommended.

IMPACTS ON THE PETROLEUM INDUSTRY

Forecast of crude oil price

During the impact of the COVID-19 presentation is was concluded that by 2022 a "Call on OPEC" of about 31 million barrels would emerge and that it could be assumed that this would result in a price level of $ 50/bbl in real terms.

It is furthermore assumed that in a $ 50/bbl (real) price scenario the United States and Canada will be able to maintain a shale oil production of 6 Mmbopd, but that this price level does not encourage increases in production. Enough wells need to be drilled to substitute the production of shale oil wells that typically decline rather fast.

IMPACTS ON THE PETROLEUM INDUSTRY

Forecast of crude oil price

It will be furthermore assumed that NGL production would expand from 18 to 25 MMbopd by 2050. Both OPEC and Non-OPEC countries would participate in the expansion of the NGL production.

It will be assumed that biofuel production will increase from 2.8 MMBopd in 2019 to 6 MMbopd by 2050 in line with the IEA forecast. It is assumed that synfuels will grow from 0.25 to 1.5 MMbopd. Process gains are estimated to be proportional to total production.

IMPACTS ON THE PETROLEUM INDUSTRY

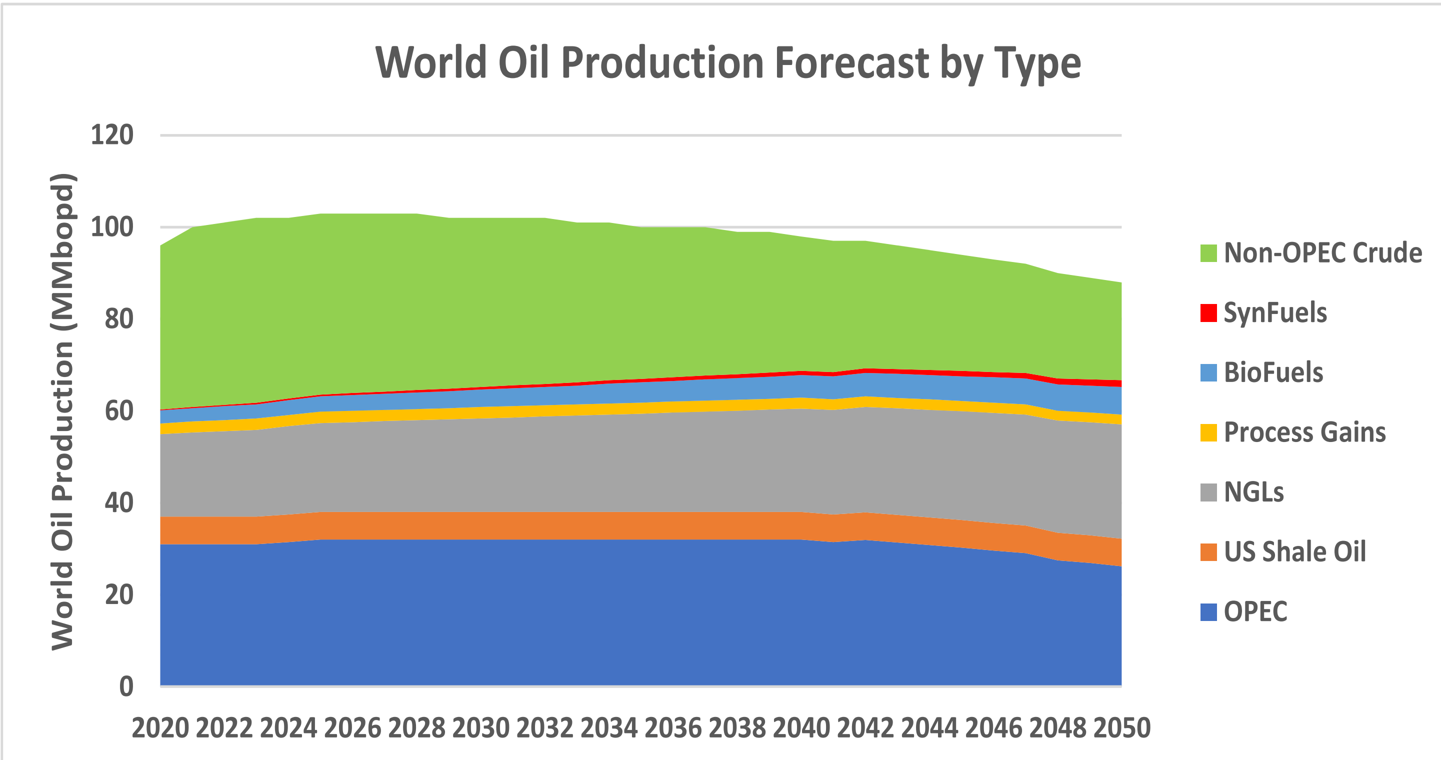
Forecast of crude oil price

Non-OPEC crude oil production will remain stable at about 39 Mmbopd until about 2028. Afterwards this production will gradually decline to 21 MMbopd by 2050.

The following chart shows that this will result in stable OPEC production at a rate of 32 MMbopd until about 2040. Afterwards the decline in world demand forces modest reductions in OPEC production.

IMPACTS ON THE PETROLEUM INDUSTRY

Forecast of the Oil Price



The forecast shows how based OPEC should be able to maintain production until about 2040. After that there will be a slight decline due to falling world oil demand.

IMPACTS ON THE PETROLEUM INDUSTRY

Forecast of crude oil price

The previous projection is obviously subject to a wide margin of uncertainty. World oil and gas demand could be higher or lower.

As discussed, hydrogen or biofuels could play a far more important role than assumed or the role could be less.

It might be that $ 50/bbl would still result in a significant expansion of shale oil production in the US and Canada.

The main factor of uncertainty is Non-OPEC crude oil production. It is assumed that the lower price will result in less exploration activity and therefore a gradual decline of production. However, future improvements in technologies and unexpected large discoveries of oil and gas could change this picture completely.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Reduction of role of fossil fuels

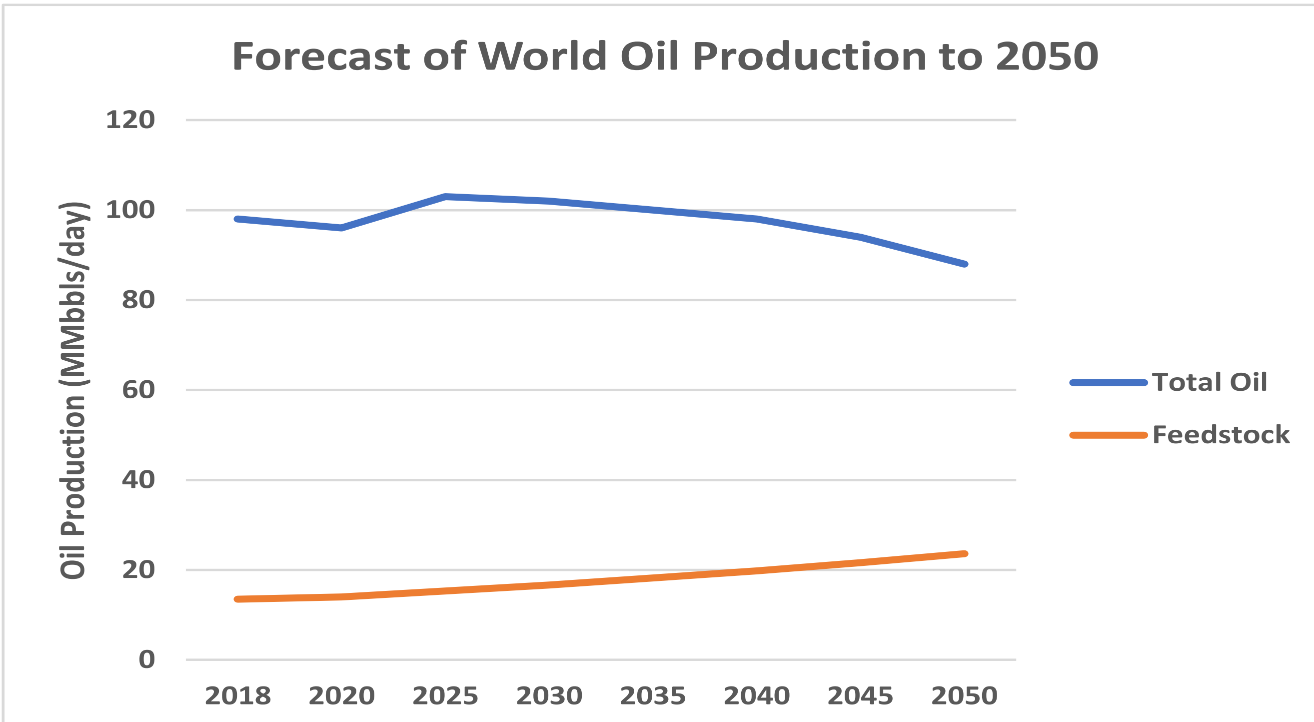
The crude oil industry will gradually transform from an industry producing fossil fuels to producing feedstock, primarily, LPG, ethane and naphta for the petrochemical industries.

It is estimated that the petroleum production for feedstock production will increase from about 14% today to 27% by 2050.

As mentioned before the natural gas industry will probably loose its role in producing ammonia and methanol to green hydrogen.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Reduction of role of fossil fuels



The forecast shows how feedstock production will increase to about 27% of the total oil production by 2050.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Reduction of role of fossil fuels

What is remarkable is that petroleum companies actually do not participate in a major way in the petrochemical industries.

In their Oil 2020 report, the IEA lists the petrochemical projects under construction or planned for development. The total new capacity is estimated to be 38.4 million tons per year.

Of this total the major international petroleum companies represent only 5 million tons or 13%, consisting of plants in the United States and South Korea, while other petroleum companies in China, Russia, Asia and Canada represent 8%.

The petrochemical industries are highly competitive and it will therefore be difficult for petroleum companies to diversify in a major way into these industries in order to increase their role.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

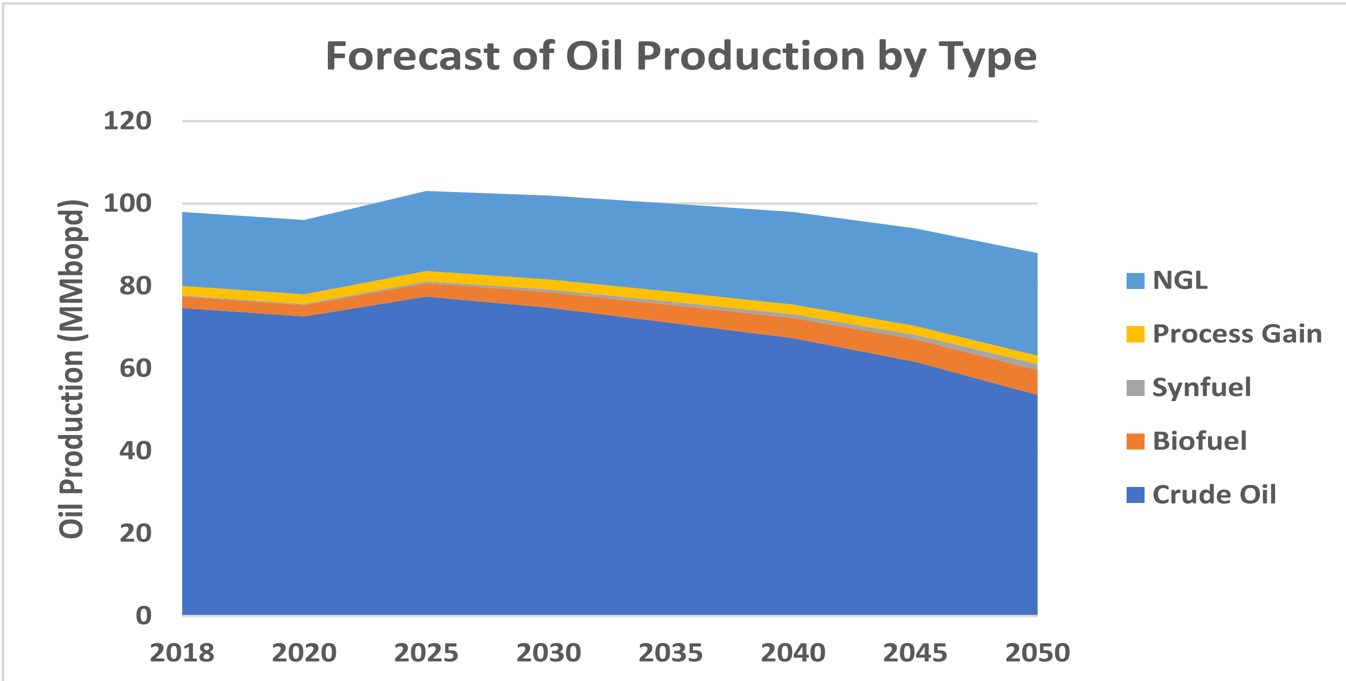
Reduction of role of fossil fuels

Ownership of New Petrochemical Plants		
	Total	Oil Companies
	k tons/year	k tons/year
United States	9481	4300
China	9200	740
Russia	3720	420
Other	15979	2590
TOTAL	38380	8050

Ownership of new petrochemical plants based on IEA data.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

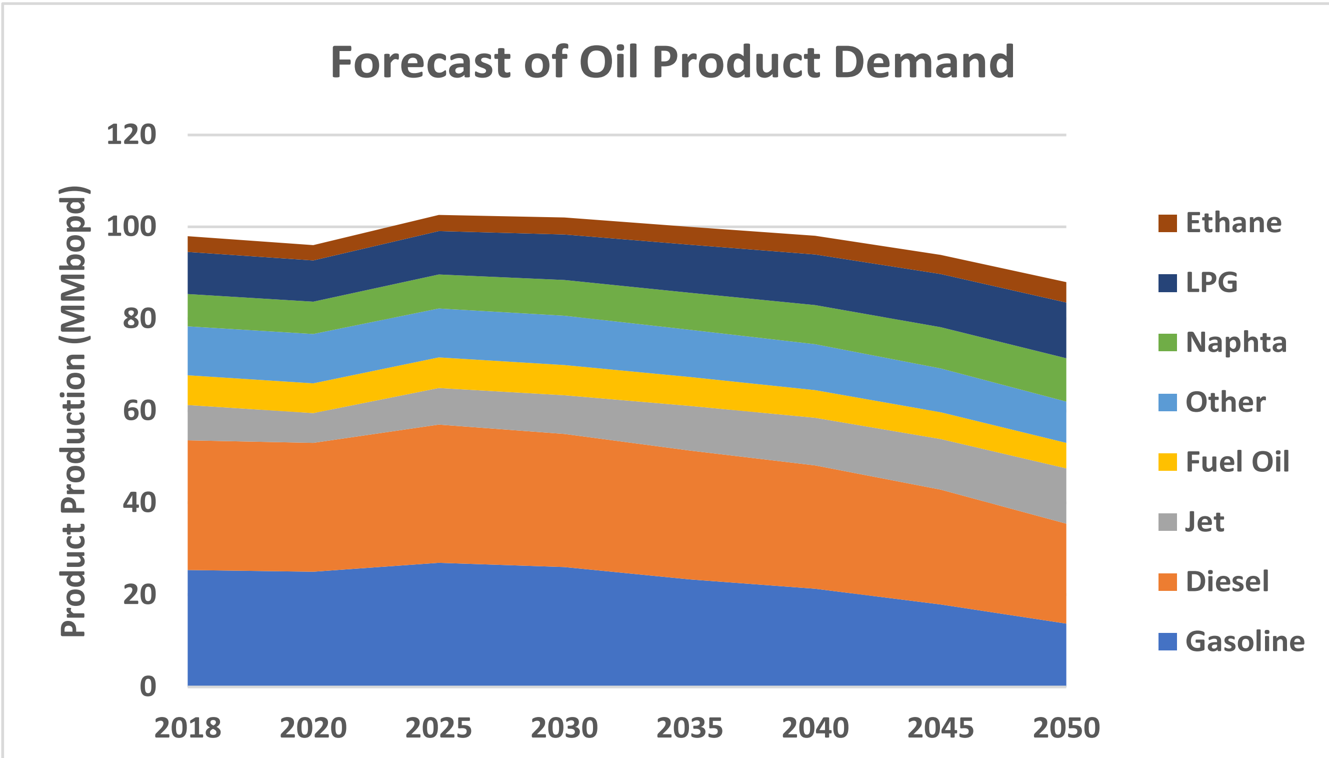
Overview of Oil Supply and Demand



The chart shows how NGL's (including condensates) and biofuels will make an increasingly important contribution to the world oil supply. Actual crude oil production will decline from 75 MMbopd in 2018 to 54 MMbopd in 2050.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Overview of Oil Supply and Demand



The chart shows how gasoline, diesel, fuel oil and other petroleum products will decline, while jet fuel, naphta, LPG and ethane will increase. The steepest drop is in gasoline demand due to EV's and cars running on hydrogen. In general crude oil production will change from an emphasis on light crudes to an acceptance of heavier crudes.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

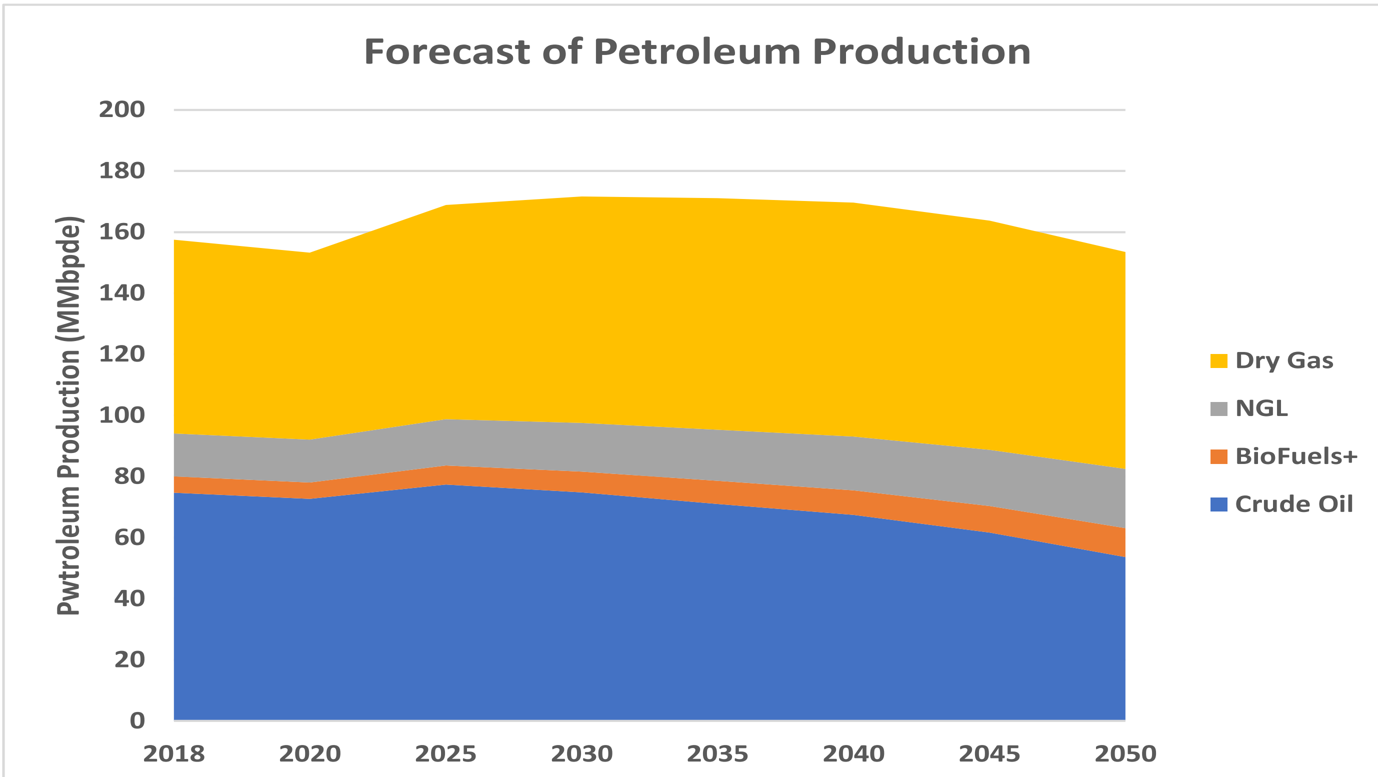
Increased Role of Rich Gas

The petroleum industry will be increasingly oriented to the production of rich gas, which is gas that contains condensates and large quantities of natural gas liquids (LPG, ethane and pentanes+), assuming that green hydrogen will not yet play a large role in producing feedstock for the petrochemical industries.

On a MMbopd equivalent basis the production of dry gas plus NGL's will be more than double that of crude oil production. It is likely that OPEC will benefit by significantly increasing its NGL production.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

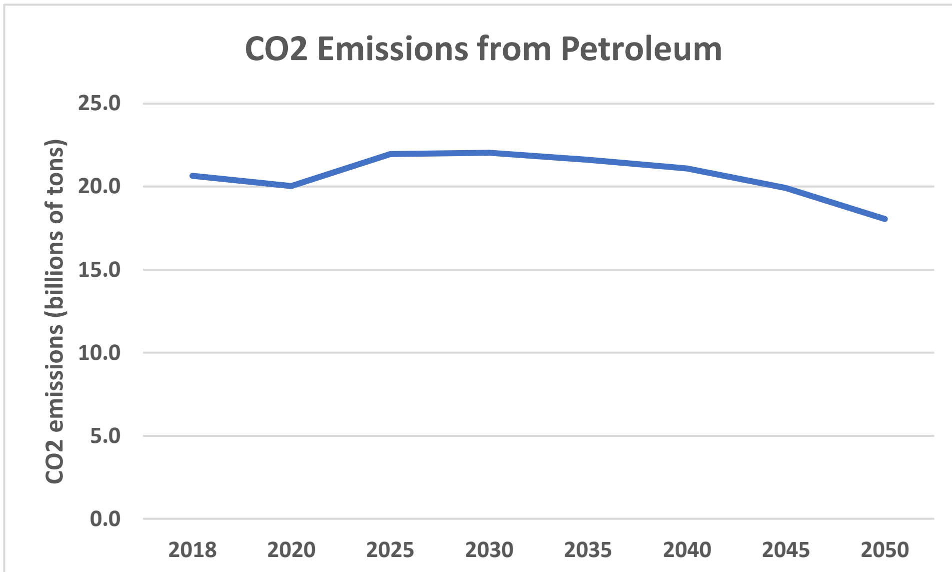
Increased role of Rich Gas



The production of crude oil production will reduce from 75 to 54 MMbopd. The role of gas, in particular rich gas (natural gas rich in condensates and NGL's), will increase to 90 MMbopd equivalent. (Biofuels+ relates to biofuels, synfuels and processing gains). Overall petroleum production will reduce from 158 in 2018 to 153 MMbopd equivalent in 2050 (NGL's are included based on their energy content).

TRANSFORMATION OF THE PETROLEUM INDUSTRY

CO2 emissions from Petroleum



As a result of the increased importance of natural gas in the petroleum production, the CO2 emissions will slightly reduce from 20.8 billion tons in 2018 to 18.1 billion tons in 2050. This is below a scenario based on the Pledges made under the Paris Agreement, but well above the reductions required under the 2 degrees Celsius scenario. (This chart does not include coal or other greenhouse gases (GHG)).

TRANSFORMATION OF THE PETROLEUM INDUSTRY

CO_2 emissions

The conclusion is that based on the scenario developed in this presentation the CO_2 emissions from the use of petroleum will only decline from 20.8 billion tons in 2018 to 18.1 billion tons in 2050.

This conclusion is reached despite the assumptions that:

-- renewable energy will significantly penetrate power production and replace almost all fossil fuels,

-- low cost green hydrogen will play an important role in replacing oil and gas and replace all current industrial hydrogen,

-- the petroleum industry will increasingly produce feedstock instead of fossil fuels,

TRANSFORMATION OF THE PETROLEUM INDUSTRY

CO_2 emissions

(continued);

-- road vehicles will largely convert to EV's and hydrogen,

-- natural gas for buildings will reduce,

-- some marine transport will convert to hydrogen, and

-- a percentage of air transport will be based on biofuels, synfuels and some electricity.

The remaining CO_2 emissions are so large that it is unrealistic to assume that most of it can be offset by carbon capture and storage. This means that if the world wants to achieve the goal of net zero CO_2 emissions by 2050, very strong additional measures will be required, which would have a very large impact on the petroleum industry and be a very significant future risk element.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

CO_2 emission targets set by Companies

It should be noted that a number of large integrated European petroleum companies have now set their own CO_2 emissions targets for 2050.

The results are tabulated by the Transition Pathway Initiative ("TPI"), which advises investors about the progress companies make in accordance with the Paris Agreement.

TPI reports the results based on information by the companies as well as their own adjustments, the main adjustment that TPI makes is including the CO_2 emissions that would be derived from the petroleum products, electricity and renewable energy sold by the companies. Adjustments are made for biofuels and for products sold as feedstock.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

CO_2 emission targets set by Companies

The TPI results are provided as tons of CO_2 emitted per TeraJoule products sold (“carbon intensity”).

In 2015 the intensity was typically in the range of 65 to 75 tCO_2/TJ.

Companies can reduce their carbon intensity by:

-- using less fossil fuels in producing the products to be sold,

-- selling more non fossil fuel energy (renewable electricity, green hydrogen, biofuels and green hydrogen based synfuels),

-- increasing natural gas sales versus oil sales,

-- increasing carbon capture and storage, and

-- employing other offset mechanisms (planting trees).

TRANSFORMATION OF THE PETROLEUM INDUSTRY

CO_2 emission targets set by Companies

Carbon Intensity by 2050 (tons CO_2/TJ)	
BP	53
Paris Pledges	49
Repsol	35
Total	30
ENI	29
Shell	25
2 Degrees	19
Below 2 Degrees	7

The TPI information indicates that some European large oil companies have aggressive carbon intensity targets. Shell would almost achieve the Paris Agreement goal for 2 degrees Celsius of 19 tons CO_2/TJ. Companies from the United States and other countries have not set similar targets.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Structure of the Petroleum Industry

The movement from a $ 60/bbl to a $ 50/bbl or even $ 40/bbl scenario will have a deep impact on the structure of the petroleum industry.

The profitability of oil field development, and as a result exploration, will be affected. The profitability can be measured in different ways. In the following chart it is measured as the PIR10, which stands for the Profit to Investment Ratio @ 10%. This is the ratio of the Net Present Value @ 10% divided by the total capital investment over the life of the field also discounted at 10%.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

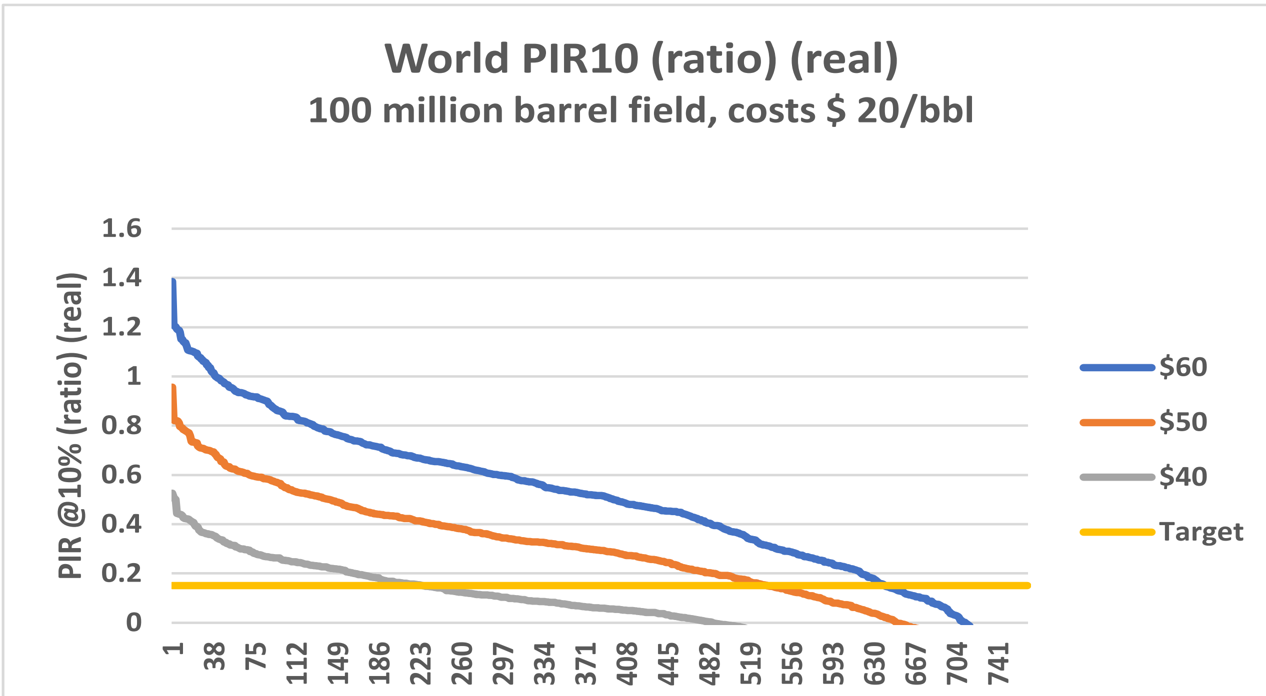
Structure of the Petroleum Industry

The profitability of oil field development is very much impacted by the fiscal terms. Van Meurs Energy has develop a world data base of 768 fiscal systems from all countries that have petroleum leases, licenses or contracts with the petroleum industry.

Therefore the profitability can be measured on a worldwide basis, by ranking the fiscal systems from the most profitable to the least profitable. The following chart assumes that oil companies would have a minimum target PIR10 of 0.15. Of course, at a PR10 or less than 0, it means that the field makes less than 10% IRR.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Structure of the Petroleum Industry



The chart illustrates how of 768 fiscal systems, assuming a minimum PIR10 of 0.15, a 100 million barrel fields costing $ 20/bbl would be economic in 642 system at $ 60/bbl, 535 systems at $ 50/bbl and only 227 systems at $ 40/bbl. It should be noted that on a long term basis also costs can be expected to be lower and therefore the overall effect is less dramatic than indicated in the chart

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Structure of the Petroleum Industry

The chart shows how for a 100 million barrel field at $ 20/bbl, 642 fiscal systems would be economic at $ 60/bbl. (The systems that are uneconomic are typically in countries with lower costs and would therefore be economic at such lower costs.) At $ 50/bbl in total 535 fiscal systems are economic and at $ 40/bbl only 227 systems.

This indicates that based on our price forecast oil field development and in particular exploration, would be negatively impacted, in particular once prices move to the $ 40/bbl level.

The actual result would be less severe than indicated in the chart, because with lower prices, usually costs will also decline and in the long term lower costs can be expected as a result of technological improvements.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Structure of the Petroleum Industry

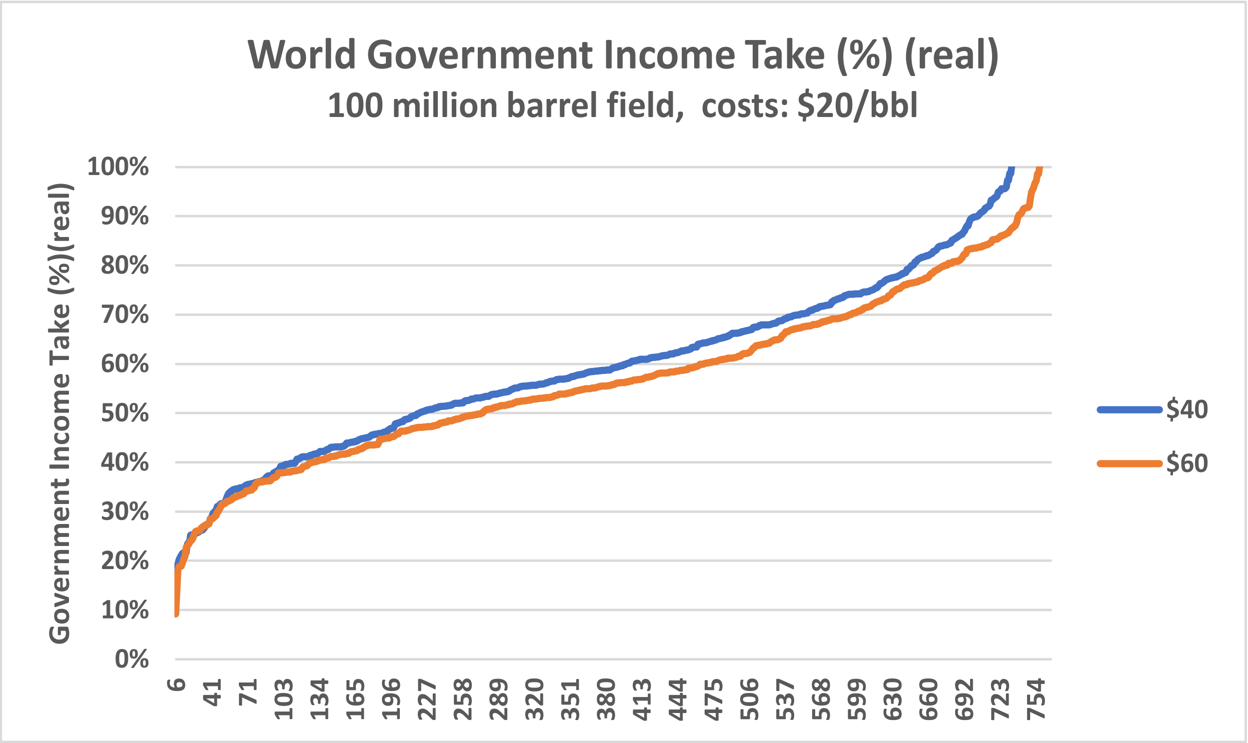
It should be noted that the negative impact on world development and exploration, is in part the result of the fact that fiscal systems are not structured to deal with this situation.

The following chart shows the Undiscounted Government Income Take ("GIT0") on the same worldwide basis.

(For a detailed explanation of government take, see the start of the section on "Fiscal Systems").

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Structure of the Petroleum Industry



The chart illustrates how the GIT0 is higher under $ 40/bbl than under $ 60/bbl. This means that governments actually harm the ability of companies to develop and explore for oil if oil prices decline.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Structure of the Petroleum Industry

The chart shows how the GIT0 at $ 40/bbl is actually higher than under $ 60/bbl. This means the fiscal structure of most governments actually harms the ability of petroleum companies to explore and develop under lower prices. Such a fiscal system is called a price regressive system.

Therefore, it can be recommended that those countries that are interested in maintaining exploration and development under low oil prices change their fiscal terms to a price progressive system under low oil prices. This matter will be discussed in more detail later in the presentation.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Structure of the Petroleum Industry

As discussed earlier, hydrogen can be transported through the same gas pipeline and distribution network as natural gas, even in combination with natural gas.

The combined production of natural gas and hydrogen is anticipated to increase over the next 30 years.

It can therefore be expected that the gas pipeline and distribution network will expand.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Structure of the Petroleum Industry - Summary

Based on the forecasts in this presentation, the structure of the petroleum industry can be expected to change rather significantly over the next 30 years:

-- petroleum exploration will decline significantly,

-- upstream oil and dry gas development will decline,

-- upstream rich gas development will expand significantly,

-- oil refining will decline,

-- gas processing will expand significantly,

-- oil and product pipeline transportation will decline, and

-- gas pipeline transportation and distribution will expand.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

ROE of the Petroleum Industry

Based on Bloomberg data the Rate of Return on Equity of the petroleum industry as gradually declined since 2005.

In 2005 it was typically a high 25%, by 2015 this was down to 8%, by 2019 it was back up slightly to 10%.

This year a very low ROE can be expected, probably at best 4%.

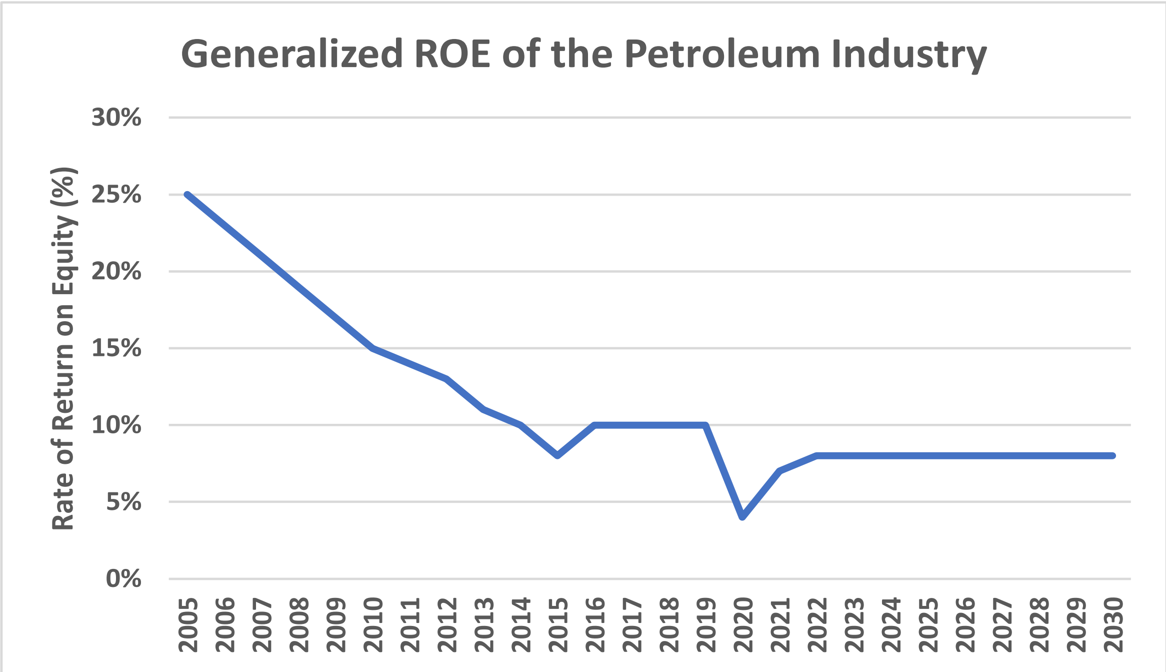
During the coming decade it is difficult to see a high ROE.

Contrary to the past, the petroleum industry as a whole is now under increased competitive pressure from renewables with low ROE's and easy entrance for non-oil companies.

The reduction of petroleum exploration reduces the competitive justification for high ROE's. It is therefore difficult to see how ROE's will go well over 8% in the next decade. This is a ROE similar to the renewable industries.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

ROE of the Petroleum Industry



The chart illustrates how the ROE can be expected to be about 8% during the next decade, similar to the renewable industries.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Conclusion

The risk profile of the petroleum industry will change dramatically during the next 30 years. Ten years ago the petroleum industry was unique due to the large role of exploration risk. From now on that risk will be less important as less exploration will be done.

However, two very significant business risks now affect the industry. In the short and medium term introduction of tougher climate policies could greatly negatively affect the industry. In the long term an unexpected low hydrogen price as a result of R&D would have massive negative impacts.

The conclusion is therefore that the petroleum industry becomes less attractive to shareholders: more risk and less profits.

INDUSTRY REORGANIZATION

Investment in Renewable Energy

The following pattern currently exist with respect to investment in renewable energy:

-- petroleum companies with a strong interest in diversifying, such as Shell and Total,

-- petroleum companies with a low or no interest in diversifying, such as Chevron and Rosneft,

-- power companies, most of which are interested in adding renewable energy to their portfolios,

-- companies investing in wind power, and

-- companies investing in solar power.

Each of these groups will be discussed.

INDUSTRY REORGANIZATION

Petroleum companies which are diversifying

The petroleum companies that have a strong interest in diversifying have rather different strategies in terms of the type of renewable energy they are pursuing.

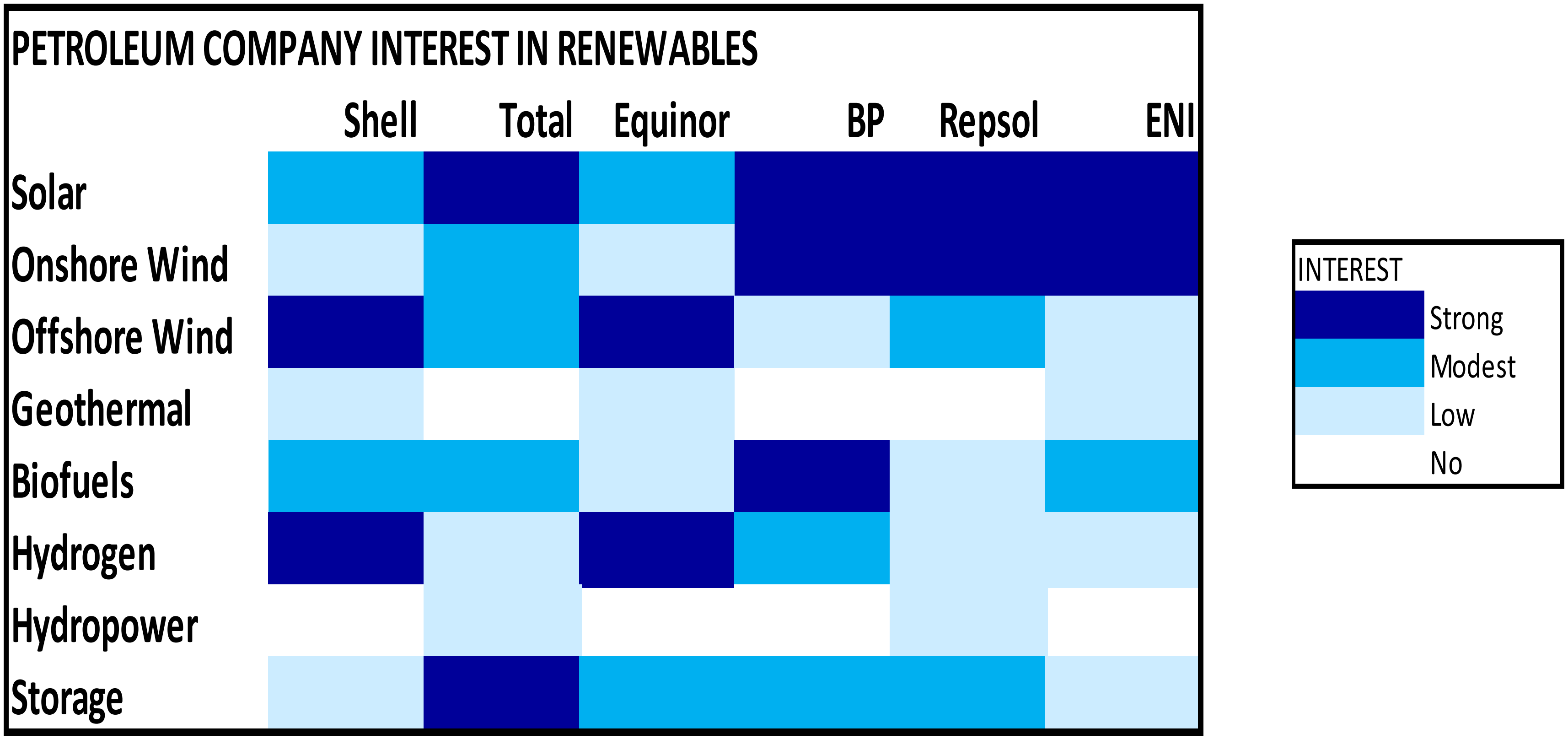
The type of renewables they are diversifying to and the research and development they are doing are different.

The following slide illustrates these differences. The chart lists strong, average, low or no interest. This is the interest within each company, not on a global basis.

The slides thereafter provide a brief summary of each of the petroleum companies.

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Petroleum companies which are diversifying



The chart illustrates that in general petroleum companies are not interested or have a low interest in geothermal power and hydropower, while all of them have a modest or strong interest in solar energy.

INDUSTRY REORGANIZATION

Petroleum companies which are diversifying

Shell:

-- investing heavily in offshore wind such as the Borssele 3&4 project (731 MW) (the Netherlands), offered a record low price of 5.8 cents/kWh for a 804 MW windfarm offshore Massachusetts.

-- has several onshore wind farms in the USA,

-- has a large number of hydrogen stations for road vehicles in Germany and other countries

-- produces ethanol through Raizen in Brazil and is investing in advanced biofuels research in India

-- bought 44% of the shares of Silicon Ranch with 880 MW solar,

-- investing in the Rotterdam green hydrogen project based on wind and plans a 800 million kg/year hydrogen project by 2040.

INDUSTRY REORGANIZATION

Petroleum companies which are diversifying

Total:

-- built the largest lithium-ion battery storage in France-Dunkirk,

-- will install 20,000 EV charging points in the Netherlands,

-- acquired a stake in the 96 MW Erebus floating wind project,

-- was awarded 131 MW solar projects in the latest bid round in France,

-- is investing in an 800 MW solar project in Qatar,

-- installed 16 MW solar – 10 MW storage project in New Caledonia,

-- has a 0.5 million ton biorefinery in Southern France, and

-- is participating in a green methanol project in Leuna, Germany.

INDUSTRY REORGANIZATION

Petroleum companies which are diversifying

Equinor:

-- is building the large Hywind floating wind farm offshore Scotland and is participating in a large number of offshore wind projects,

-- will supply blue hydrogen to the Magnum powerplant in the Netherlands; this is hydrogen produced from natural gas, but with CO2 capture and storage,

-- is considering a geothermal investment in Iceland,

-- is co-investor in the 162 MW Apodi solar plant in Brazil, with more solar investments planned,

-- has invested in a Swedish biofuel plant using wood pellets, and

-- has invested in the 1 MW Batwind storage project in Scotland.

INDUSTRY REORGANIZATION

Petroleum companies which are diversifying

BP:

-- is 50% shareholder of LightsourceBP, one of the largest solar companies in the world with a capacity goal of 10,000 MW by 2023,

-- is carrying out study for a green hydrogen plant in Australia,

-- operates 9 onshore windfarms with a total capacity of 1,679 MW in the US,

-- has a feedstock agreement with a 36,000 bopd biodiesel plant in Oregon, and

-- has a 50% interest in BP Bunge Bioenergia of Brazil, producing 26,000 bopd of ethanol and 1200GW of biomass electricity per year, from sugarcane.

INDUSTRY REORGANIZATION

Petroleum companies which are diversifying

Repsol:

-- is developing 3 solar projects in Spain; in total 595 MW,

-- is developing 26 onshore wind projects in Spain with a total capacity of 860 MW,

-- they operate 12 hydropower projects in Spain,

-- are developing a 25 MW offshore floating wind farm off Portugal,

-- is carrying out research for a hydrogen plant based on solar, and

-- is investing in Ampere Energy a battery storage start up.

INDUSTRY REORGANIZATION

Petroleum companies which are diversifying

ENI:

-- is building a 10 MW solar facility in Pakistan, a 34 MW project in Australia, a 5 MW plant in Tunisia, as well as a plant in Algeria,

-- hopes to achieve in total 3,000 MW capacity in various countries by 2023,

-- is building a 48 MW onshore wind farm in Kazakhstan,

-- is successfully operating an inertial sea wave energy converter offshore Ravenna, Italy, and

-- has a pilot plant in Ragusa to convert CO2 from petroleum operations with sun light in a bioreactor with algae to produce bio-diesel.

INDUSTRY REORGANIZATION

Pipeline companies

Companies do not have to be integrated petroleum companies to diversify. The Canadian oil and gas pipeline company Enbridge has massively invested in renewables as follows:

-- 21 wind farms of 3,912 MW capacity, of which 4 are offshore wind farms in Europe and the others are onshore farms in North America

-- 4 solar projects of 152 MW, with remarkably 3 in Ontario,

-- 5 waste heat recovery facilities from pipeline compressor stations producing power,

-- a geothermal project of 22 MW in Oregon, and

-- a 2 MW hydropower project in Ontario

INDUSTRY REORGANIZATION

Petroleum companies which are not diversifying

There are various petroleum companies with only a limited interest or no interest in diversifying, such as:

-- ExxonMobil, with only small wind and solar projects, but with a strong emphasis on algae research to produce biofuels,

-- Chevron, with small solar, wind and biofuel projects and a 49 MW geothermal project in California,

-- Petrobras, with a large ethanol operations,

-- Lukoil, with 298 MW of hydropower in Russia and some small wind and solar projects in Romania,

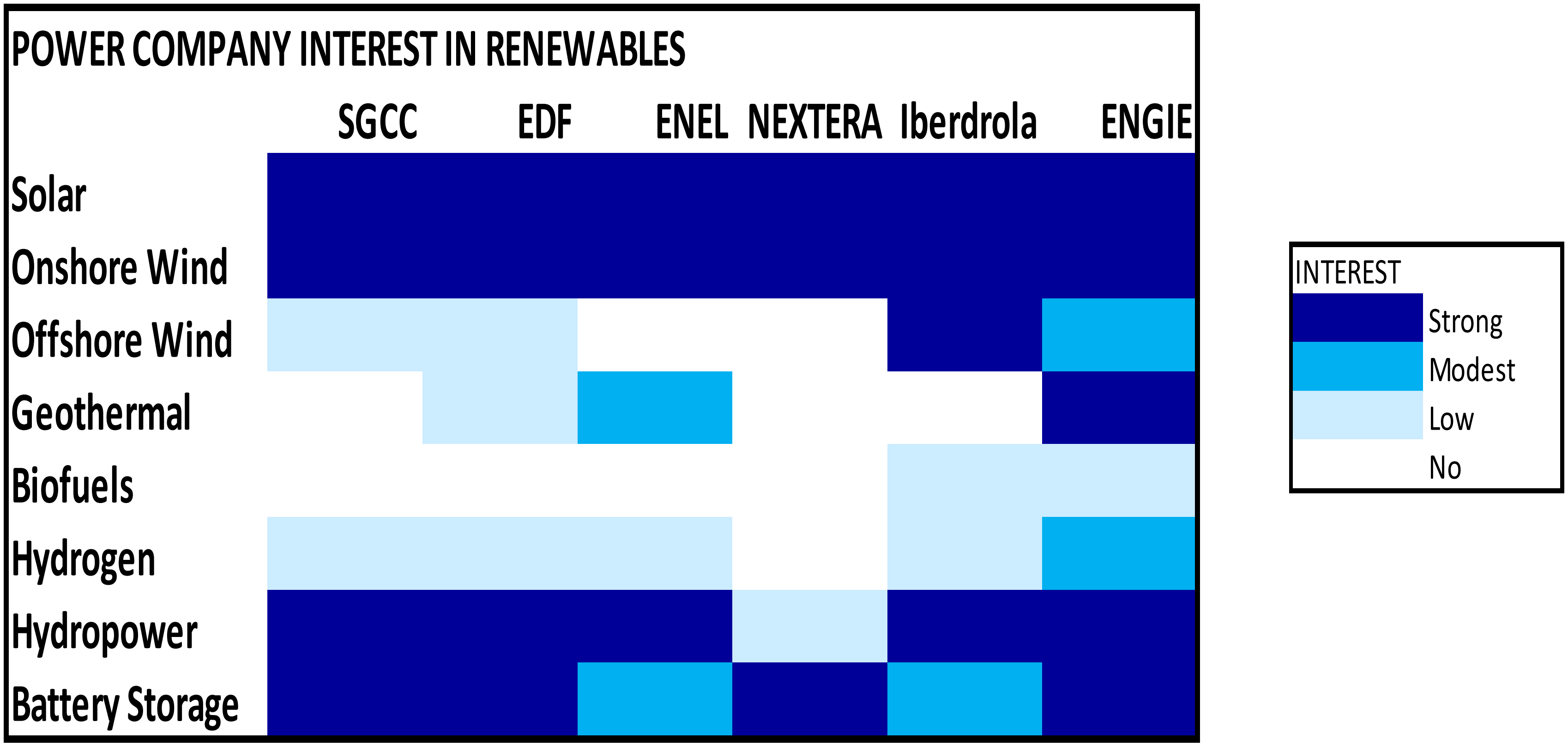
-- Rosneft,

-- OMV, and

-- Phillips 66

TRANSFORMATION OF THE PETROLEUM INDUSTRY

Power Companies



The chart illustrates that in general power companies have a low interest in biofuels and a limited interest in hydrogen production. Power companies are strongly interested in solar and onshore wind and most are interested in hydropower (in particular pumped power) and battery storage.

INDUSTRY REORGANIZATION

Power Companies

State Grid Corporation of China (SGCC):

-- has installed 13,440 MW of onshore wind power (2017 data),

-- has installed 48,770 MW of solar PV (2017 data),

-- has 8,400 MW pumped storage and considerable other hydropower (2017 data),

-- has a small offshore wind project,

-- has a storage project of 36 MWh based on BYD lithium iron phosphate batteries, combined with 100 MW of wind and 40 MW of solar, and

-- is designing a hydrogen storage site.

INDUSTRY REORGANIZATION

Power Companies

EDF of France:

-- has a company called EDF Renewables with over 10,000 MW of solar, onshore wind and storage capacity in North America,

-- operates 1070 MW of 2 hydropower projects in Laos,

-- has geothermal projects in Guadeloupe and France,

-- created a company Hynamics for the production and distribution of hydrogen and owns an electrolyser company, and

-- is the largest hydropower company in Europe with 20,000 MW of hydropower in France and additional projects in other countries.

INDUSTRY REORGANIZATION

Power Companies

ENEL of Italy:

-- ENEL Green Power produces over 100 TWh of renewable energy from 43,000 MW of managed installed capacity in 29 countries in five continents consisting mainly of onshore wind and solar PV,

-- is not involved in offshore wind,

-- installed 4.8 MW/16.4 MWh battery storage capacity in New York and 22 MW in Cremzow, Germany,

-- has produced the first transportable microgrid 100% renewable energy in Chile consisting of 125 kW solar PV, 450 kW hydrogen storage and 132 kW of lithium-ion storage, and

-- is installing the first cooling-heating-power biomass plant in Italy.

INDUSTRY REORGANIZATION

Power Companies

NEXTERA of the US:

-- of its total power capacity of 28,400 MW in the USA, has 3,100 MW of solar PV and 16,000 MW of onshore wind,

-- not involved in offshore wind,

-- has 140 MW of battery storage,

-- has no hydropower, except considering a pumped storage projects in California, and

-- is not involved outside the USA.

INDUSTRY REORGANIZATION

Power Companies

IBERDROLA of Spain:

-- has 53,400 MW of installed capacity worldwide of which 70% is renewable energy,

-- participates actively in offshore wind, is participant in the 3,100 MW East Anglia offshore project,

-- has large onshore wind projects in Latin America,

-- is constructing an 1158 MW hydropower project in Portugal,

-- is constructing a large 590 MW solar project in Spain,

-- is constructing an algae biomass plant in Mexico, and

-- is constructing the first 3MWh battery storage project in Spain.

INDUSTRY REORGANIZATION

Power Companies

ENGIE of France,

-- has 103,000 MW installed power capacity of which 21,500 MW is renewable energy and 20,000 MW of hydropower.

-- has onshore wind generation in a large number of countries,

-- has a floating wind farm of 25 MW offshore Portugal,

-- provides 100 GWh of geothermal heat in the Paris area,

-- has a 4 MW/16MWh battery storage project in Colorado,

-- will in 2022 supply Heathrow with biomethane, and

-- has a combined solar/storage project in Corsica,

INDUSTRY REORGANIZATION

Wind Companies

It is relatively easy to enter the wind energy market, since there are highly organized wind turbine suppliers. There are already more than 2000 owners of wind farms in the world. The largest are:

-- Orsted – 25,343 MW,

-- Scotish & Southern – 15,754 MW,

-- Copenhagen Infrastructure Partners (“CIP”) – 14,280 MW,

-- Vattenfall – 11,176 MW,

-- China Datang Corp – 8, 966 MW and a variety of other large Chinese wind farm owners,

-- Acciona Energia – 8,095 MW, and

-- Scotish Power – 5,982 MW.

INDUSTRY REORGANIZATION

Solar Companies

It is very easy to enter the solar energy market.

In fact many countries now offer feed-in tariffs for home owners that want to deliver solar energy to the grid. India does the same to assist farmers.

There are already thousands of small solar companies with their own solar farms.

However, private solar producers do not need to be small. An example is ACWA who offered the lowest solar price in the latest auction in Dubai of 1.6953 cents/kWh for a 900 MW project.

INDUSTRY REORGANIZATION

The Role of the Petroleum Industry in Future Renewable Energy

Based on the above analysis it is now possible to obtain an idea about the role of the petroleum industry in the future renewable energy industries.

Onshore Wind and Solar PV

It is clear that the onshore wind and solar PV market is already occupied by the large power companies and wide variety of wind and solar farm owners. In fact each of the 6 reviewed large power companies already produces more onshore wind and solar than the 6 reviewed petroleum companies combined.

It will be very difficult for the petroleum industry to enter these markets on an operational basis, other than occasionally buying a share in a successful independent wind or solar operator; as Shell did with Silicon Ranch and BP with Lightsource BP.

INDUSTRY REORGANIZATION

The Role of the Petroleum Industry in Future Renewable Energy

It can therefore be predicted that petroleum companies will only be able to obtain a small share of the onshore wind and solar PV markets, probably less than 10%.

<u>Offshore Wind</u>

Petroleum companies are better positioned to capture a share of the offshore wind market. In fact, as was demonstrated many power companies are not interested in this market and small operators cannot enter. With the knowledge of offshore technology, petroleum companies have a competitive advantage. The efforts of Shell, Equinor, Total and Repsol to play a significant role in offshore wind may therefore be successful. However, there will be competition with the current large independent offshore wind providers (Orsted, CIP, Vattenfall,etc).

INDUSTRY REORGANIZATION

The Role of the Petroleum Industry in Future Renewable Energy

<u>Geothermal</u>

Power companies and independents have already largely cornered this market and petroleum companies do not appear particularly interested.

<u>Biofuels</u>

Petroleum companies are well positioned to capture a significant share of the biofuels market. Supplying biofuels as part of regular petroleum product distribution is a logical business. In particular advanced biofuels could play a more important role, such as through large scale algae production, as is promoted by ExxonMobil. Power companies are not interested in this market.

INDUSTRY REORGANIZATION

The Role of the Petroleum Industry in Future Renewable Energy

Green Hydrogen

If the cost of producing green hydrogen comes down as predicted in this presentation, the integrated green hydrogen business becomes the logical "home" for the petroleum companies. The integrated green hydrogen business would consist of producing hydrogen from wind and solar, distributing the hydrogen through pipeline and distribution systems to power plants, industries and homes for heating and other purposes and setting up the hydrogen distribution stations for road vehicles and marine vessels. At low cost, green hydrogen could be the basis for synthetic gasoline, diesel, jet fuel and feedstock. The business will look very much like the integrated petroleum business with upstream, midstream and downstream.

INDUSTRY REORGANIZATION

The Role of the Petroleum Industry in Future Renewable Energy

<u>Hydropower</u>

The hydropower market is very well controlled by the current large and small power producers and is well integrated with the business of producing and selling electricity. It is therefore, that the petroleum industry will not get a significant share of this market. Petroleum companies are not interested in this market.

<u>Utility Scale Battery Storage</u>

Power companies and independents, such as Tesla, are more interested in this market than most petroleum companies and are often better positioned to capture this market, when integrated with battery production. Petroleum companies may gain a small share of this market where it integrates well with the future petroleum and renewable operations.

INDUSTRY REORGANIZATION

The Role of the Petroleum Industry in Future Renewable Energy

<u>Conclusion</u>

It can be concluded that the large power companies and large petroleum companies, as well as smaller wind and solar companies will overlap in producing renewable energy, with different roles being played by the various participants.

Power companies will concentrate on onshore wind, solar, hydropower and battery storage.

Petroleum companies will concentrate on offshore wind, biofuels and hydrogen production.

Smaller wind and solar companies will focus on onshore wind and solar.

In total it will be a very competitive environment

INDUSTRY REORGANIZATION

The Role of Government in Future Energy

The role of Government has to change with the changes in the energy sector.

The past concept was that petroleum companies and power companies fulfilled rather separate and distinct roles. From a government point of view they were managed separately.

In the future governments will need to manage the energy sector as a single sector with both petroleum and power companies producing ever increasing amounts of renewable energy. Economic growth will be determined by how successful governments are in supplying energy at the lowest possible costs. This means an optimal integration of all players in the sector.

INDUSTRY REORGANIZATION

The Role of Government in Future Energy

This means the governmental structure has to change in some countries. Rather than having petroleum and power in separate ministries, they should be managed in a single ministry, with directorates for petroleum, renewables and power, and where coal still plays a role, a directorate for coal.

Preferably there should be an energy planning department, although the market forces should be permitted to play the prime role in shaping the future. Implementation of climate change and energy efficiency policies belong also in this ministry.

In the following slides the current structures of some important petroleum producing countries will be reviewed. A large number of countries have already the recommended structure.

INDUSTRY REORGANIZATION

The Role of Government in Future Energy

Following are examples of countries which do not have the recommended structure:

-- Saudi Arabia has a Ministry for Energy and for Water and Electricity. “Energy” primarily relates to petroleum,

-- Angola has a Ministry of Petroleum and for Water and Energy,

-- Qatar has a Ministry of Electricity and Water and one for Energy and Industry. “Energy” again means petroleum,

-- Nigeria has a Ministry of Petroleum and for Power, Works and Housing, and

-- the United States has a Department of Energy, but the management of the offshore petroleum and wind licenses is done in the Bureau of Ocean Energy Management (“BOEM”), a unit of the Department of the Interior.

INDUSTRY REORGANIZATION

The Role of Government in Future Energy

Following are examples of countries which do have the recommended structure:

-- Mexico has a Secretary of Energy, with departments for Hydrocarbons and Power, as well as for R&D, energy policy and promotion of renewable energy,

-- Algeria has a Ministry of Mines and Energy, which includes, apart from mines, departments for hydrocarbons, electricity and gas distribution, renewable energy and environment,

-- Brazil has a Ministry of Mines and Energy, apart from mines, dealing with hydrocarbons as well as electricity,

-- Canada (Federal) has a Department of Natural Resources, that includes oil, gas, electricity and renewable resources, as well as departments for climate change, energy efficiency and R&D.

INDUSTRY REORGANIZATION

The Role of Government in Future Energy

(continued):

-- Indonesia has a Ministry of Energy and Mineral Resources, which includes, apart from mines, departments for oil and gas, electricity, renewable resources and energy conservation, coal ad R&D.

-- the Netherlands has a Ministry of Economic Affairs and Climate Policy, which among many other functions includes electricity, gas and oil, sustainable heating and subsurface policies, climate and the Groningen surface structures project (do to the earthquake damage of gas production)

-- Norway has a Ministry of Petroleum and Energy, which includes directorates for Petroleum and for Water and Energy (in the case of Norway most electricity is from hydropower).

INDUSTRY REORGANIZATION

The Role of Government in Future Energy

(continued):

-- Peru has a Ministry of Energy and Mines, with vice-minsters for petroleum and for electricity, as well as for mines,

--the UK has a department for Business, Energy and Industrial Strategy, which among many other functions includes oil, gas and electricity, energy efficiency and heat, low carbon generation, electricity and gas networks, energy and climate, climate change and smart meters and smart systems,

-- Russia has a Ministry of Energy, which deals with oil and gas, electricity, peat, shale resources, pipelines, renewable energy resources and petrochemical industries.

POLICIES

Energy Transition Policies

Assuming a country creates a Ministry for Energy, the next issue is than what the policies should be.

The following energy transition policies have as goal to manage an effective energy transition and achievement of climate goals resulting in fossil fuel production and consumption well below the levels forecasted in this presentation.

POLICIES

General Transition Policies

The general transition policies will consist of:

1. Maintain an effective petroleum industry,
2. Promote midstream gas operations and feedstock production,
3. Carbon trading and carbon tax,
4. Eliminate subsidies and export duties,
5. Change petroleum land management,
6. Promote gas over oil and coal,
7. Reduce flaring and increase carbon capture and storage, and
8. Increase R&D.

POLICIES

Maintain an effective petroleum industry

Even if we would manage to eliminate all fossil fuels by 2050, we still need a significant amount of oil and gas as feedstock for petrochemical industries, fertilizers and other purposes.

However, it is likely that we will still need some jet fuel, marine bunker and natural gas for a variety of industries that are difficult to convert, such as the cement industry and iron and steel industry.

It is therefore likely that even with achievement of the 2 degrees scenario, we would still produce by 2050 about 35 MMbopd of crude oil and NGL's and 2000 Bcm of natural gas. This is still a large size petroleum industry.

POLICIES

Maintain an effective petroleum industry

At the same time is likely that by 2050 the petroleum industry will be a major contributor to the production of offshore wind, biofuels, hydrogen and possibly synthetic fuels.

In order to realize this production of renewable energy, investments of billions of US $ will be required. The petroleum industry would have to make maximum use of their skills of promoting large projects to realize these goals.

Therefore, the policy should be to maintain a healthy and efficient petroleum industry based on competitive practices and an effective regulatory system.

POLICIES

Midstream gas and feedstocks

As indicated in the presentation, natural gas and hydrogen can use the same gas pipeline and distribution infrastructure. Also in the medium term a more widespread availability of gas will assist the development of wind and solar. Therefore, it is in the interest of the countries to establish this infrastructure.

This can be done in various ways. The ministry or regulator can establish a system of attractive pipeline tariffs and facilitate the acquisition of right of ways. Gas power generation should be coordinated with pipeline construction. Taxation should only be generally applicable taxes and some tax incentives could be applied.

POLICIES

Midstream gas and feedstocks

Countries with relatively significant low cost natural gas resources could promote the production of ammonia and related urea. The main cost of the ammonia is the natural gas. Therefore, the availability of low cost natural gas is a competitive advantage for producing ammonia.

However, it cannot be recommended to require petroleum companies to create artificial low gas prices through price controls. Such policies are usually not sustainable. The goal should be to establish long term industries. Attractive fiscal provisions for gas production and possible tax incentives for establishing ammonia plants are better mechanisms.

POLICIES

Midstream gas and feedstocks

Countries with relatively significant rich gas resources could promote the production of petrochemical industries. Again the costs of feedstocks are important. Therefore, relatively low cost NGL availability is an advantage.

Again price controls cannot be recommended, since this is not a long term sustainable solution.

Attractive fiscal systems for NGL's and possible fiscal incentives for establishing petrochemical industries are the better policies.

POLICIES

Carbon Trading and Carbon Tax

Detailed information about carbon trading and taxation can be found in the annual World Bank Report, called "State and Trends of Carbon Pricing". The information in this presentation is based on the 2019 report.

In total there are 57 carbon pricing initiatives around the world, covering 46 national ad 28 subnational jurisdictions.

The carbon price varies between a low of about \$ 1/tCO2e (ton CO2 equivalent) in Mexico to \$ 127/tCO2e in Sweden, covering 11 GCO2e or about 20% of the world emissions (includes all GHG). About \$ 44 billion in carbon pricing revenues was received by Governments. The World Bank is concerned that most countries are well under the recommended level of carbon pricing.

POLICIES

Carbon Trading and Carbon Tax

An economically attractive way to reduce CO_2 emissions is to establish a CO_2 trading system, whereby "permits to pollute" are traded among companies (an Emissions Trading System, "ETS"). Companies who are aggressively pursuing the reduction of carbon emissions will be rewarded by being able to sell their permits, while companies that are slow in reductions have to purchase more permits.

Europe established an ETS, which crashed in 2016 as a result of having handed out too many permits. However, with the intervention of the European Parliament, the market has now recovered and the average carbon price December 2019 was 25.97 Euros per ton CO_2.

POLICIES

Carbon Trading and Carbon Tax

An ETS is difficult to establish, since it requires a sophisticated approach to handing out permit to pollute and to establish the market. Carbon taxes are a simpler mechanism. Therefore, a number of countries has established carbon taxes.

In order to achieve the goals of the Paris Agreement the carbon price has to be between \$ 40 and \$ 80 per ton CO2 in 2020 and \$ 10 higher in 2030, as recommended in the Carbon Pricing Leadership Coalition ("CPLC") Report.

The recommendable carbon price for later years depends very much of the future costs of green hydrogen. If by 2050 a price level of less than \$ 1/kg can be achieved the 2030 range could also apply to 2050.

POLICIES

Carbon Trading and Carbon Tax

It can therefore be recommended that countries adopt the CPLC carbon tax ranges.

It is important to introduce these new taxes in a manner that is revenue neutral. In other words the extra revenues to be received by government should be offset by reductions in other taxes and levies, to maintain the same tax level on the population; with special protection of low income citizens.

The Canadian province of British Columbia has successfully followed this approach and started with a Can $ 30/ton tax in 2008 to be increased to Can $ 50/ton by 2021. Fuel consumption in the province has dropped by 16%, while the economy of the province has continued a strong growth.

POLICIES

Carbon Trading and Carbon Tax

It should be noted that in some countries with production sharing contracts, the introduction of carbon taxes would be prohibited because of fiscal stability provisions. It is therefore essential that modern petroleum contracts exclude the following taxes from fiscal stability (unless discriminatory against the contractor):

(a) generally applicable taxes, such as corporate income tax,

(b) levies, taxes or payments to comply with modern principles in respect of environment, labor laws, health and safety, and

(c) new taxes, levies or duties to implement commitments with respect to climate change under the Paris Agreement and other international agreements.

POLICIES

Eliminate subsidies and export duties

It is obvious that under a rational climate policy the first objective should be to eliminate actual and implied subsidies of fossil fuels. This means the elimination of:

1. **actual subsidies to consumers,**
2. **domestic market or domestic supply obligations,**
3. **price controls resulting in artificially low prices, and**
4. **Export duties.**

POLICIES

Eliminate subsidies and export duties

Actual subsidies for oil, gas and fossil fuel based electricity to consumers is still a massive issue around the world. The IEA estimates that in 2018 the total amount of subsidies was about $ 400 billion in 25 countries, in some cases representing a large share of the GDP. Following are examples:

-- Iran - $ 69.2 billion

-- Saudi Arabia - $ 47.7 billion

-- China - $ 43.3 billion

-- Russia - $ 36.2 billion

-- Indonesia - $ 31.3 billion

-- Egypt - $ 26.5 billion

POLICIES

Eliminate subsidies and export duties

It should be noted that such subsidies create often a substantial burden on the government budget with the result of not being able to fully commit to other matters such as education and infrastructure development.

As a result of the low oil prices the subsidies will automatically become significantly less in 2020.

This creates a possibility of eliminating or reducing such subsidies.

Nigeria had until March 2020 considerable subsidies on motor gasoline. These have now been eliminated.

POLICIES

Eliminate subsidies and export duties

Some countries, such as Nigeria, Malaysia, Indonesia and Egypt, have domestic market or domestic supply obligations, requiring petroleum companies to supply the domestic market on the basis of low prices.

It is a logical obligation for petroleum companies which operate in any country to supply the domestic market. Domestic markets are sometimes more complex to enter than simply exporting oil or gas.

However, companies should not be required to supply these markets for artificially low prices or for pricing regimes that would not reasonably bring forward an adequate supply on an economic basis.

POLICIES

Eliminate subsidies and export duties

Some countries, such as Saudi Arabia, Angola, Venezuela and Algeria have very low regulated prices for associated natural gas or even non-associated natural gas.

Such policies are not consistent with an effective energy transition policy.

Prices should be at a level that brings adequate supplies forward to the domestic market on a fully economic basis. In this respect it should be noted that even the collection, transport and processing of associated natural gas requires considerable investment and associated gas therefore cannot be "free".

POLICIES

Eliminate subsidies and export duties

A number of countries have significant export duties, such as Russia, China, Malaysia, Vietnam and Argentina.

Export duties mean by definition lower domestic prices than international prices. This is therefore a mechanism of indirectly subsidizing domestic markets.

It can be recommended to eliminate such export duties. Argentina and Russia have both made significant progress in this area.

Eventual elimination and replacement of export duties by an adequate fiscal structure, to maintain government revenues, can be recommended.

POLICIES

Petroleum land management

As indicated earlier by 2050 the world will still have a petroleum industry producing significant volumes of crude oil and natural gas. Therefore, countries can still benefit from the economic rent and economic activity of the petroleum industry by making acreage available in licensing rounds or based on application systems.

It is a good policy, however, to avoid offering areas with a high social or environmental costs, such as rain forest areas.

Also, in anticipation of ever lower oil and gas prices, promotion of expensive areas such as Arctic areas, ultra-deep water, extra-heavy oils, etc. should be avoided.

POLICIES

Petroleum land management

An important issue is the duration of leases, licenses and contracts.

In North America and Europe it is typically the practice that licenses and leases can be continued until the exhaustion of the resource with renewals being granted under prevailing conditions.

In countries with production sharing contracts and other contractual arrangements, contracts often have a finite duration, including one or two possible renewals. The worldwide average, total duration is about 32 years.

POLICIES

Petroleum land management

The idea of finite contracts is that it encourages a company to produce the petroleum rapidly. It is sometimes contemplated that at the end of the contract the national petroleum company takes over and becomes 100% owner or that a bid round be held to get improved terms for the remainder of the contract.

None of these concepts makes sense under petroleum transition policies. Petroleum should be produced at the most economic rate, resulting in the highest recovery factor. By 2050 national petroleum companies are unlikely to find an attractive environment to continue petroleum operations, while it cannot be expected that high bids will be received at that time for producing fields.

POLICIES

Petroleum land management

It can therefore be recommended that also in countries with contractual arrangements, contracts will continue to be renewed until the exhaustion of the resource.

In particular in countries were production is linked to increased fertilizer and petrochemical production it is of importance that oil and gas production continuous normally in order to provide incentives to petroleum companies to invest in the related midstream facilities.

It is also of great importance that petroleum companies take full responsibility for proper decommissioning and abandonment upon the exhaustion of the resource.

POLICIES

Promotion of gas over oil and coal

CO2 emissions associated with the burning of one million Btu are as follows:

-- 98 kg for coal,

-- 77 kg for oil, and

-- 58 kg for natural gas.

This means that emphasizing the production of natural gas over oil and coal is generally beneficial.

Also natural gas will over the next decade(s) integrate well with increased solar and wind production in order to provide electric grid stability during periods of no sun and no wind (until utility scale battery storage becomes cheaper).

POLICIES

Promotion of gas over oil and coal

It should be emphasized that during the production of associated gas with oil and non-associated gas, it is a great importance to have very strict provisions to avoid the escape of methane in the atmosphere.

This is an area were countries have to significantly improve performance.

Based on the 100 year Global Warming Potential ("GWP") one kg of methane has the same global warming effect as 25 kg of CO_2.

The production of natural gas over oil can be emphasized through the fiscal terms or through the licensing process.

POLICIES

Promotion of Gas over Oil and Coal

Table 6.10.1. Jurisdictions with Gas-Favourable Fiscal Terms

Argentina	Egypt	Malaysia	Senegal
Australia	Ethiopia	Mali	Sierra Leone
Belize	France	Morocco	South Sudan
Benin	Ghana	Nicaragua	Sudan
Brunei	Guatemala	Niger	Tanzania
Cambodia	India	Nigeria	Thailand
Cameroon	Indonesia	Oman	Trinidad & Tobago
Canada - Alberta	Iraq - Kurdistan	Pakistan	Tunisia
Canada - British Columbia	Kazakhstan	Papua New Guinea	USA-Arkansas
Canada - Nfld. & Lab. (Proposed)	Kyrgyzstan	Paraguay	USA-Louisiana
Canada - Nova Scotia	Laos	Poland	USA-Michigan
Central African Republic	Latvia	Portugal	USA-North Dakota
Chad	Lebanon	Qatar	Venezuela
China	Liberia	Russia	Vietnam
Colombia	Libya	Sao Tome & Principe	Zambia
Cote de I'voire	Madagascar	Saudi Arabia	

Explanation:
Gas-Favourable means that the fiscal systems include fiscal features which are lower for gas than for oil, such as lower royalties for gas than for oil. In case of sliding scales sometimes the system includes an attractive energy conversion factor for gas. Production sharing contracts could have lower profit gas and higher cost gas. Windfall profit features, excise taxes or other taxes may apply to oil but not to gas. Some favorable features apply to shale gas or CBM.

The above table shows a table from a Van Meurs report illustrating the jurisdictions that have already gas-favorable fiscal terms.

POLICIES

Reduce flaring

Non-routine flaring is integral to petroleum operations for well testing, facilities overhaul, safety and other reasons. Nevertheless, such non-routine flaring should result in carbon taxes and possible other payments in order to encourage the minimum amount of flaring.

Routine flaring should be prohibited and subject to penalties. Sometimes, gas contains significant quantities of CO2. Such CO2 is removed. Venting of such CO2 should also be prohibited.

Unfortunately, routine flaring is still occurring in considerable amounts. For instance, Nigeria still flares almost a billion cubic feet per day.

POLICIES

Promote carbon capture and storage

Considerable efforts are being undertaken by a wide variety of petroleum companies and power companies to promote carbon capture and storage (“CCS”).

Such efforts should be promoted by governments.

Carbon taxes are an inducement, but at this moment CCS is rather expensive and therefore other more stringent measures are required, such as simply prohibiting CO2 emissions as part of the approval of a project.

CCS does not have to be associated with fossil fuels. It can be done directly based on a variety of methods.

POLICIES

Promote carbon capture and storage

Methods of CCS are:

-- Post-Combustion technologies: there are at least 18 different post-combustion technologies which remove CO_2 from the flue gases associated with the burning of the fossil fuels,

-- Pre-Combustion technologies: there are 5 different technologies where coal, oil products or gas are first converted to CO_2 and Hydrogen, the CO_2 is removed and stored and the hydrogen is burned.

-- Oxy-combustion: there are 5 different technologies whereby the flue gases are recycled with oxygen for the subsequent burning of fuels, thereby increasing the CO_2 content and make it more economic to recover the CO_2

POLICIES

Promote carbon capture and storage

Methods of CCS are:

-- Solid Looping Technologies: there are 10 different processes, whereby flue gases are fed over calcium lime (CaO) and the resulting product is subject to a calcination reaction, creating almost pure CO2 that can be stored; in fact one of the processes can be integrated with cement production.

-- A Canadian company called Carbon Engineering, backed by Bill Gates, captures CO2 directly with machines from the air for storing or to produce synthetic fuels together with hydrogen.

-- An area of intense research are metal-organic frameworks ("MOF"), which are specially designed materials that can take water or certain gases out of the air.

POLICIES

Promote carbon capture and storage

Methods of CCS are:

-- Sheffield University is working with powdered basalt scattered over the soil, which is a good fertilizer and increases the amount of CO_2 that can be captured by the soil about 4 times.

-- BECCS, combining bioenergy with CCS: growing trees, producing electricity with wood pellets and capture the carbon emissions; or base the same on other biomass.

-- there is a wide variety of other relatively low cost bioenergy based processes, such as processes based on charcoal. In fact, after the COVID-19 makes Panama accessible, Van Meurs Energy will be testing this year a solar-carbonization process.

POLICIES

Promote carbon capture and storage

As will be obvious from the above examples breakthroughs in CCS could dramatically change the path of energy transition by making regular fossil fuels acceptable for power generation or industrial use.

Processes that could simply take CO2 out of the air economically (against carbon prices) anywhere in the world could have a very significant impact.

This could significantly increase the possibility for a successful energy transition.

POLICIES

Promote carbon capture and storage

The promotion of CCS is in particular important where certain industries, such as the cement industry, will be unable to avoid releasing large volumes of CO2.

In this respect Equinor, Shell and Total are constructing the "Northern Lights" project that will take the CO2 from a cement factory and other Norwegian industries to a terminal on the West coast of Norway and ship it in liquid form by pipeline to inject this in a special well drilled for this purpose to a specific reservoir for permanent storage. The reservoir is 2500 meter deep and located South of the Troll field.

POLICIES

Promote R&D

As will be obvious from this entire presentation further R&D will dramatically impact on the energy transition framework. R&D efforts are very important in:

-- increasing solar panel efficiency,

-- wind power efficiency,

-- creating improved cheap batteries,

-- producing cheap hydrogen,

-- finding ways for cheap CCS, and

-- development of entirely new concepts.

Therefore promotion of R&D as is currently done by a wide range of governments and companies is the key to a successful future.

FISCAL SYSTEMS

Government Take

In this section dealing with Fiscal Systems often the concept of "Government Take" will be used. It is therefore useful to provide a brief explanation. The Government Take ("GT") is being calculated as follows:

GT = (government revenues/(gross revenues – costs))x 100%

The GT can be calculated for a field. For instance, assume the following: the government revenues from the field are \$ 700 million, the gross revenues are \$ 2 billion, the capital expenditures are \$ 700 million and the operation costs are \$ 300 million. In this case the GT is:

GT = (700/ (2000 – 700 – 300)) x 100% = 70%.

FISCAL SYSTEMS

Government Take

The GT can be calculated for a field, a contract area or a jurisdiction. It can also be calculated for a part of the cash flow, such as the last 5 years.

Where the government engages in state participation, the government take is usually determined in two parts:

-- the government income take ("GIT"),

-- the government participation take ("GPT"),

-- both together are the total government take ("GTT").

The government take can be determined on an undiscounted cash flow or a discounted cash flow, for instance, discounted at 10%. This results in the Undiscounted Government Total Take ("GTT0") or the 10% Discounted Government Total Take ("GTT10").

FISCAL SYSTEMS

Government Take

The GTT0 can be based on a current (nominal, money of the day) cash flow or a constant dollar (real) cash flow.

The GTT0 can be determined for a field that is already discovered, which means the government take is un-risked, or the GTT0 can be calculated for an exploration project. In this case it is called the Risked GTT0. In order to determine the Risked GTT0, two cash flows need to be created: the dry hole cash flow and the discovery cash flow. If there is an 80% probability of a dry hole and 20% probability of a discovery, the two cashflows are combined into a single cash flow; created by adding 80% of the dry hole cash flow to 20% of the discovery cash flow. The Risked GTT0 is than determined based on this single combined cash flow.

FISCAL SYSTEMS

Level of Government Take

The level of GTT0 that can be obtained for any prospect or field, depends on the quality of the resource.

The quality depends on:

-- the geology: do we have large prolific reservoirs expected with high well productivities with easy to produce light oil, or are we dealing with small reservoirs with low well productivities and heavy oil,

-- the geological risk: for prospects, the geological risk is very important,

-- the costs: this means the cost of exploring, developing and producing the fields,

FISCAL SYSTEMS

Level of Government Take

(continued):

-- the price: for oil this is usually the international oil price, for natural gas it depends on the market conditions,

-- the distance to market: are we dealing with oil or gas located in frontier areas far from the market, with high transport costs, or are the fields within the market area, and

-- "above ground" risk: are we dealing with a country that is associated with high "above ground" risk, such as nationalization risk, balance of payment problems, labor unrest, etc., or is the field located in a country that is considered politically stable (it should be noted, however, that petroleum companies seem to have a remarkable ability to enter high risk countries if the geology is good).

FISCAL SYSTEMS
Level of Government Take

The level of government take depends largely on the market forces.

Many governments use licensing rounds whereby the level of government take is a bid item, which can be bid for the highest bonus, royalty, profit share or profit oil/gas share.

Other governments set the government take by legislation, but in that case it still depends on the market whether or not petroleum companies want to invest on this basis.

If there is only modest interest in the resource, a simple application system can be used to allow companies that are interested to enter the country. In this case the fiscal system needs to fix the terms.

FISCAL SYSTEMS

Level of Government Take – Government Revenue Optimization

Some governments set a specific fiscal system by legislation, applicable to all licence or contract areas.

This does not optimize the government revenues, if there is sufficient interest in the resource, because the fields that are not economic under these terms will not be produced, while at the same time very prolific fields may result in windfall profits.

A better system is to set a relatively low minimum government take and require companies to make competitive bids for each block. In this way the government receives the full market value for each block (assuming there is competitive interest in the blocks). The system can than be further optimized by designing an optimal structure of the fiscal terms as will be discussed later on.

FISCAL SYSTEMS

Level of Government Take

If governments apply the recommended optimization strategy for each block, the country will not have a specific government take.

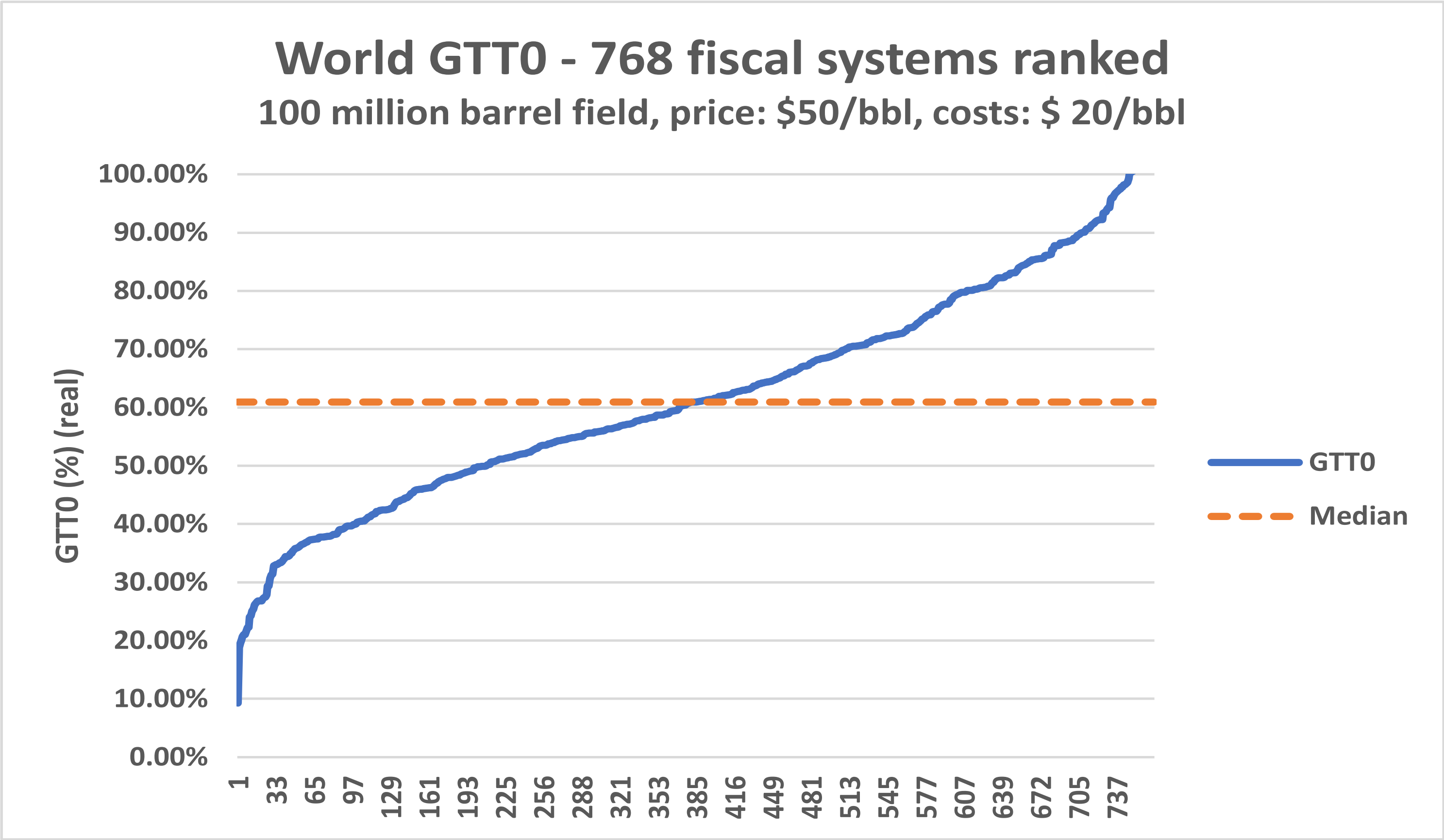
In fact, there could be a wide range of different levels of government take in the same jurisdiction.

Van Meurs Energy keeps track of the levels of government take and therefore there are more “fiscal systems” in the world than governments of jurisdictions. The current data base contains 768 fiscal systems.

The following chart shows the range of government takes of these fiscal systems.

FISCAL SYSTEMS

Current level of Government Take



The above chart illustrates how the current government takes ranges from a low of 9% to a high of over 100%. The median value for the field size, price and cost level indicated is 60.9%.

FISCAL SYSTEMS

Level of Government Take

SAMPLES FROM 768 FISCAL SYSTEMS (100 million barrel field, price: $ 50/bbl, costs:$20/bbl)			
RANK	FISCAL SYSTEM	GTT0	AREA
1	HUNGARY: EOR	9.25%	Onshore
13	PORTUGAL-ON(Gen)	25.05%	Onshore
87	NICARAGUA: General and Equinor (2015)	39.04%	Onshore
174	San Tome & Principe - PSC-Block-12(2016)	47.71%	Shallow Water
240	AUSTRALIA-ON(Queensland)	52.06%	Onshore
321	MOZAMBIQUE: DW(>500)	56.84%	Deep Water
380	NAMIBIA: ON&SW&DW-Pre-1999	60.89%	Onshore
425	PAKISTAN-SW (<200)	62.94%	Shallow Water
501	EGYPT: DW-2016Terms	69.06%	Deep Water
580	ANGOLA-Off(UDWPSC-B46)	75.90%	Deep Water
648	OMAN: Triton PSC (Block 22 - 1996)	83.06%	Shallow Water
702	LIBYA-Oil: ON-EPSA IV - Example #2	89.09%	Onshore
756	IRAQ-MOO-5thRound	103.07%	Onshore
768	IRAN: ON - Buy Back Contract (2002 terms)	200.00%	Onshore

The above chart provides samples from the ranking on the previous slide. It illustrates how a higher government take is associated with fields and blocks that represent a more attractive resource. Iraq and Iran are higher than 100% because these systems relate to resources that are lower costs than $20/bbl.

FISCAL SYSTEMS

Future level of Government Take

The future government take depends entirely on the development of the cost levels.

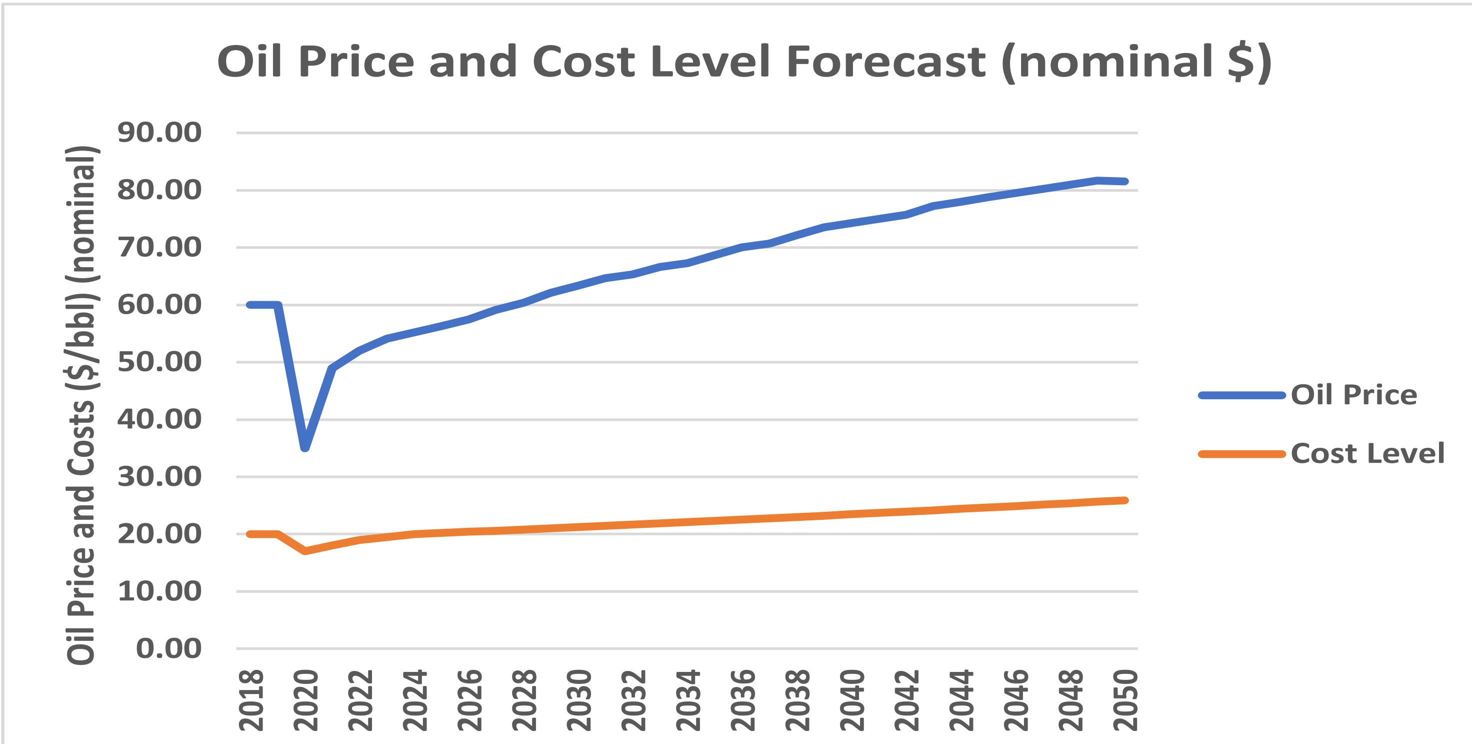
Over the last 50 years there has been a systematic lowering of costs in real terms due to the significant improvements in technology in the petroleum industry.

In other words, if the inflation rate is 2%, the costs for a particular activity in the petroleum industry may only increase 1% due to technology improvements. The long term effect of this is considerable.

This is illustrated in the next two charts.

FISCAL SYSTEMS

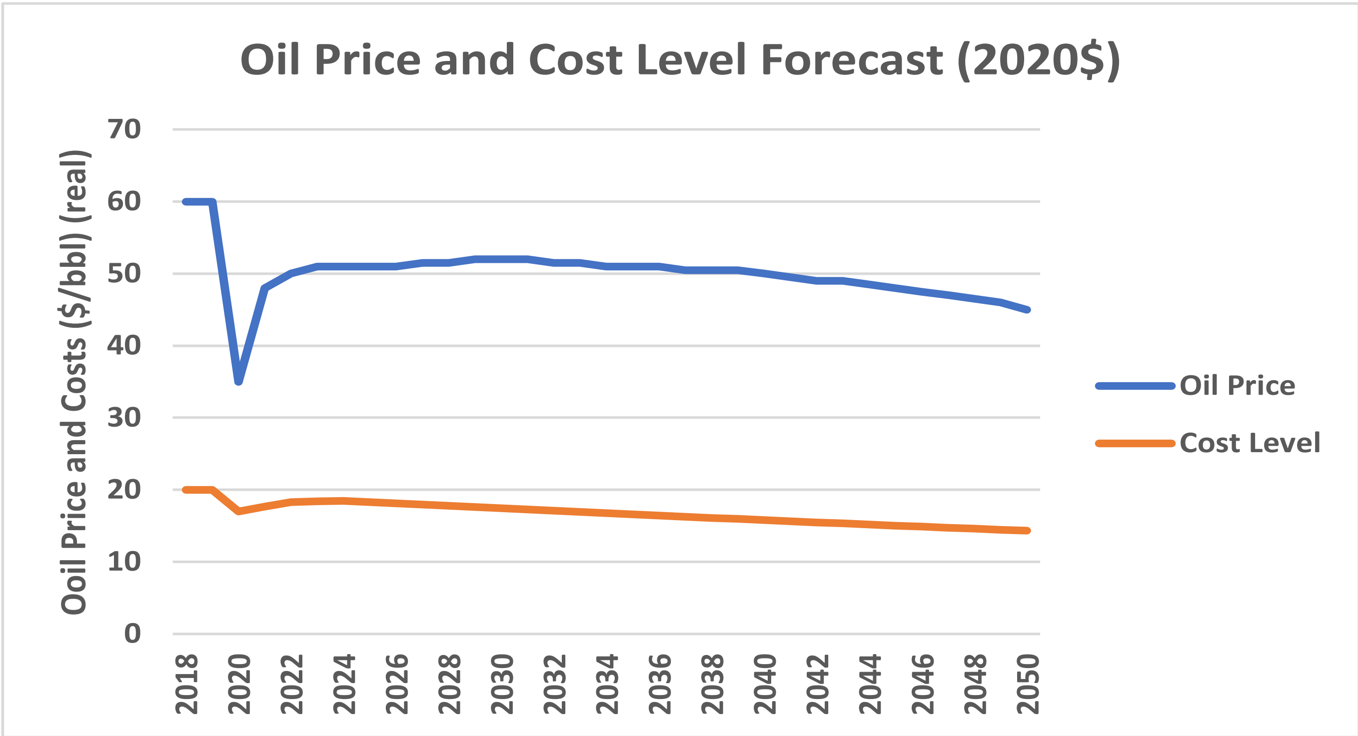
Future level of Government Take



The above chart illustrates the same price forecast as made earlier but now based on nominal (money of the day) terms. This is compared with costs increasing from $ 20/bbl by 1% per year from 2025 onwards (after a drop in costs due to lower oil prices). This means a well to a specific depth in a specific area that costs $ 20 million in 2019 will cost $ 25.9 million in 2050.

FISCAL SYSTEMS

Future level of Government Take



The same chart as in the previous slide indicates that based on constant 2020$, the well that costed $ 20 million in 2019 will cost only $ 14.3 million in 2050 in real terms.

FISCAL SYSTEMS

Future level of Government Take

The future level of government take will therefore I part depend on the development of the cost/price ratio in the petroleum industry for particular operations.

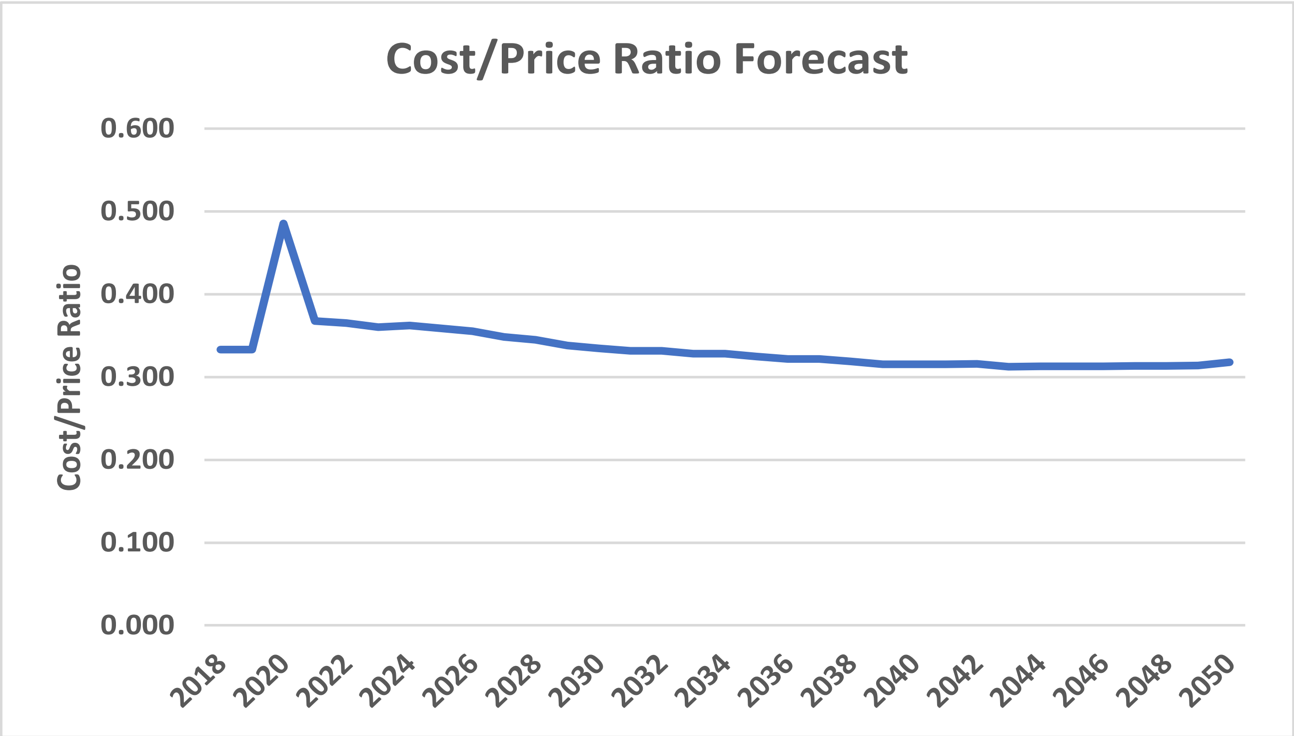
A higher cost/price ratio typically means that competitive market forces will create downward pressure on the government take.

Based on the previous slide, the cost/price ratio for the particular well to be drilled decrease from 33.3% ($20/$60) to 31.8% ($14.30/$45).

The following chart shows that after an initial strong increase in 2020 and the following years, the long term trend will be a decrease.

FISCAL SYSTEMS

Future level of Government Take



The above chart shows the cost/price ratio based on the previous cost and price projections. After an increase in the 2020-2025 period, the long term trend will be a decrease.

FISCAL SYSTEMS

Future level of Government Take

The future level of government take is primarily determined by the supply and demand for acreage.

Currently, there is a strong interest in supplying new acreage. The end of last year about 25 licensing rounds where in progress around the world.

The supply of acreage is difficult to predict. Faced with the possibility of a declining petroleum industry, governments may wish to benefit from their remaining petroleum potential by offering acreage. At the same time, some governments may decide that as a result of climate change it should be a policy to no longer offer petroleum blocks for exploration or development to the petroleum industry.

FISCAL SYSTEMS

Future level of Government Take

There have been considerable ups and downs in government take since 1974. Van Meurs Energy has over time systematically followed and analyzed these movements. Price movements have always strongly impacted on government take.

Based on this experience we make the following forecast of government take:

Assuming an increase in the cost/price ratio during the next 5 years and continued strong interest on the part of governments to offer acreage, a gradual decline in government take can be expected, possibly from the current 60.9% to about 55% in 2030. For the longer term, based on a lowering of the cost/price ratio, the government take may stabilize after 2030.

FISCAL SYSTEMS

Structure of the Fiscal Systems

In the following slides the structure of the fiscal systems will be discussed based on ten different criteria.

The structure of current systems will be illustrated.

The current structure of the fiscal systems of most countries is not adequate to deal with the future petroleum industry framework.

The recommended structure for the future framework will be discussed.

FISCAL SYSTEMS

Structure of the Fiscal Systems

FISCAL STRUCTURAL CLASSIFICATION				
Volume/Production Level and GTT0	Regressive	Neutral	Progressive	
Price Level and GTT0	Regressive	Neutral	Progressive	
Cost Level and GTT0	Regressive	Neutral	Progressive	
Profitability and GTT0	Regressive	Neutral	Progressive	
Timing of GTT0	Front End	Neutral	Back End	
Geological Risk and GTT0	Risk Averse	Neutral	Risk Supportive	
Marginal Project Incentive	High	Average	Low	
Cost Efficiency	High	Average	Low	Gold Plating
Price Efficiency	High	Average	Low	Inefficient
MER Efficiency	Enhancing	Average	Inhibiting	Reserve Loss

The above table illustrates the ten criteria with which fiscal systems can be classified.

FISCAL SYSTEMS

Analysis of volume, price, cost and profit progressivity

The progressivity of volume, prices and costs can be analyzed by regular sensitivity analysis, as follows:

-- volume sensitivity: doing sensitivity analysis on the size of the field, while keeping the price and costs constant,

-- price sensitivity: doing sensitivity analysis on price, while keeping the size of the field and costs constant,

-- cost sensitivity: doing sensitivity analysis on costs, while keeping the field size and price constant.

-- profit sensitivity: doing sensitivity analysis of profitability, while keeping the field size constant

FISCAL SYSTEMS

Fiscal Systems: Volume/Production Level and GTT0

Based on the size of the field or the production level (and assuming the costs and price stay the same) the GTT0 can be regressive, neutral or progressive, as follows:

-- Regressive: the GTT0 goes down with a higher volume, for instance, the system consists of a large bonus, a fixed royalty and corporate income tax (“CIT”),

-- Neutral: the GTT0 stays the same with a higher volume, for instance a system based only on a CIT,

-- Progressive: the GTT0 goes up with a higher volume, for instance systems with a sliding scale royalty or production sharing based on levels of production

FISCAL SYSTEMS

Fiscal Systems: Price Level and GTT0

Based on the price level (and assuming the costs and field size stay the same) the GTT0 can be regressive, neutral or progressive, as follows:

-- Regressive: the GTT0 goes down with prices, for instance, the system consists of a royalty-tax system,

-- Neutral: the GTT0 stays the same with a higher volume, for instance a system based only on a CIT,

-- Progressive: the GTT0 goes up with a higher prices, for instance systems with a sliding scale royalty based on price.

FISCAL SYSTEMS

Fiscal Systems: Cost level and GTT0

Based on the cost level (and assuming the field size and the price level stay the same) the GTT0 can be regressive, neutral or progressive, as follows:

-- Regressive: the GTT0 goes down with lower costs (the system becomes more profitable), for instance, the system consists of a fixed royalty and CIT,

-- Neutral: the GTT0 stays the same with a higher volume, for instance a system based only on a CIT,

-- Progressive: the GTT0 goes up with lower costs, for instance a system with a corporate income tax and uplift.

FISCAL SYSTEMS

Fiscal Systems: Profitability and GTT0

Based on the profitability (and assuming the field size stays the same) the GTT0 can be regressive, neutral or progressive, as follows:

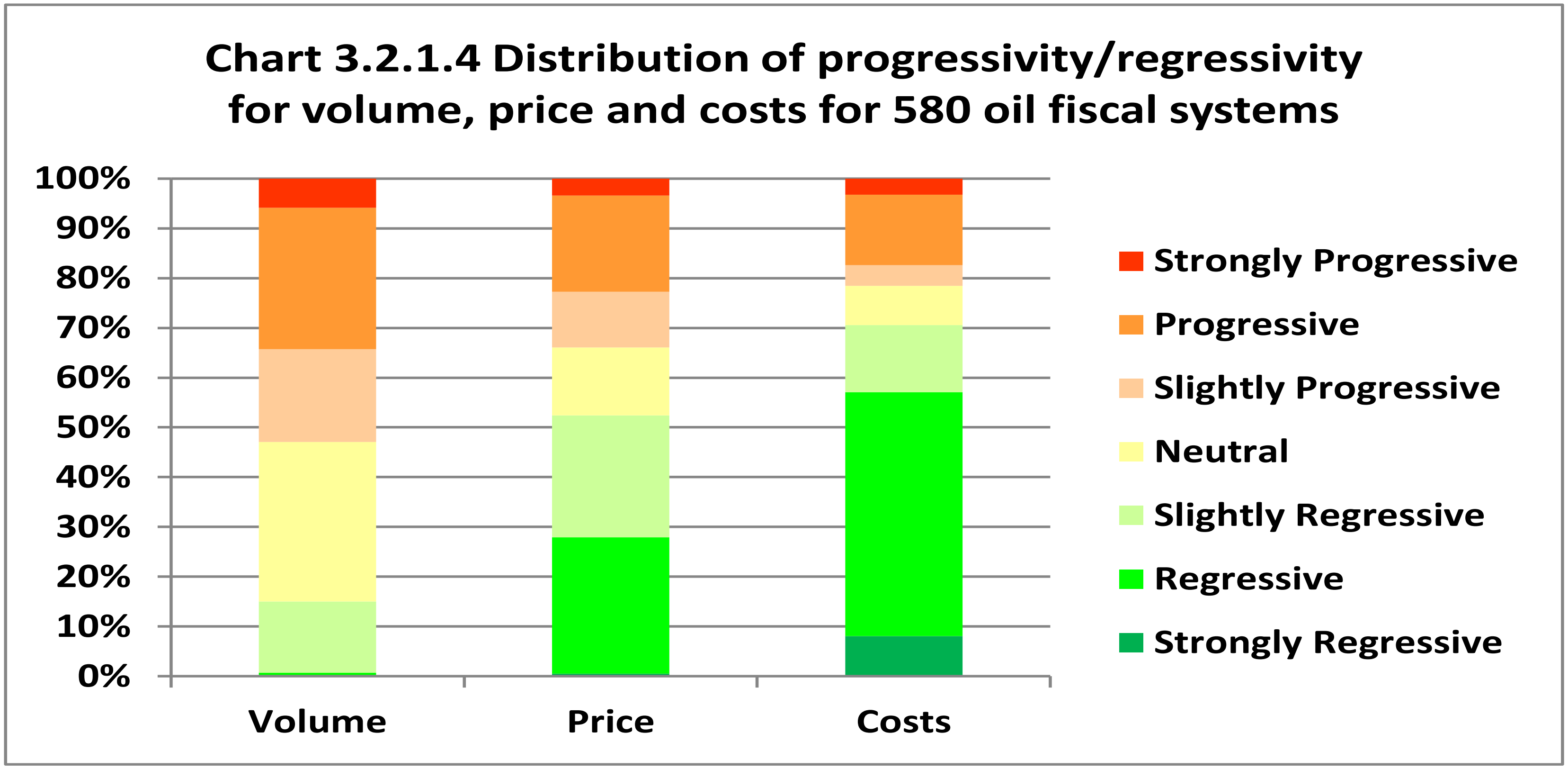
-- Regressive: the GTT0 goes down with higher profitability, for instance, the system consists of a fixed royalty and CIT,

-- Neutral: the GTT0 stays the same with the level of profitability, for instance a system based only on a CIT,

-- Progressive: the GTT0 goes up with higher profitability, for instance a system that varies with profitability; the profit percentage goes up with a higher IRR or R-factor.

FISCAL SYSTEMS

Structure of the Fiscal Systems



The above bar charts from the Van Meurs Energy 2012 rating study show the distribution in terms of progressivity/regressivity for 580 fiscal systems in the world based on volume, price and costs. It shows how about half the systems are volume progressive, one third are price progressive and only about 20% are cost progressive (which include profit progressive systems).

FISCAL SYSTEMS

Fiscal Systems: creation of volume progressivity

Volume progressivity can be created in different ways:

-- the most common way of creating volume progressivity is to provide for royalty sliding scale or profit oil/gas sliding scales based on daily production levels.

-- such scales can also be based on cumulative production levels.

-- other ways are creating special volume based allowances, for instance for small fields.

FISCAL SYSTEMS

Fiscal Systems: Creation of volume progressivity

(continued):

-- The effectiveness of volume progressivity depends on whether or not there is an economy of scale. Therefore, it is often beneficial to combine volume progressivity with physical factors that indicate profitability.

-- volume progressivity always relates to higher profitability for a system based on well productivity. If two wells are drilled to the same depth in the same area and the well productivity of the first well is higher than the second, the first well is more profitable. Therefore it is a good system to relate volume progressivity to well productivity (production per well), or do a combination system between total field productivity and well productivity.

FISCAL SYSTEMS

Fiscal Systems: Creation of volume progressivity

(continued):

-- In offshore areas water depth is an important indicator of profitability and therefore volume progressive systems can be designed based on water depth.

-- Another factor that impacts on profitability is well depth. Deeper wells are more costly than shallow wells and therefore a volume progressive system could be designed around average well depth.

-- A system based on total field (project) progressivity cannot be recommended for shale oil or shale gas since for these type of resources the economy of scale is weak.

FISCAL SYSTEMS

Fiscal Systems: Effects of Volume progressivity

The effects of volume progressivity are the following:

-- Volume progressivity strongly promotes exploration. The attractiveness of exploration is strongly related to field size and in particular the total expected net present value of the field. Most exploration prospects are small fields. Therefore, if a government gives a better deal on small fields it will encourage exploration.

-- There is usually an economy of scale based on field size; larger fields are usually also more profitable. Therefore a volume progressive system automatically collects a higher rent on larger and more profitable fields. However, this is not always the case and therefore a system that combines volume progressivity with other factors such as well productivity, well depth and/or water depth will be more effective.

FISCAL SYSTEMS

Fiscal Systems: Effects of Volume progressivity

(continued):

-- Systems based on daily production levels often create a heavy burden on investors early in the cash flow, since this is the time when production levels are higher, but provides an automatic reduction of burden towards the end of the life of the field when annual operating costs become higher.

-- Systems based on cumulative production have the opposite effect.

FISCAL SYSTEMS

Fiscal systems: Creation of price progressivity

Creation of price progressivity:

-- price progressivity is usually created through royalty scales based on price, or so-called windfall profit taxes (which are in fact price sensitive royalties). This means the higher the price, the higher the royalty or tax.

-- it could also be created through sliding scales based on price related to other fiscal features, such as profit shares or special profit oil/gas shares over a particular price level.

-- what is an important issue is whether or not the price levels are adjusted for inflation or not. If price levels are not adjusted for inflation, the burden on investors can become too severe towards the end of a long duration contract, such as a 30 year contract.

FISCAL SYSTEMS

Fiscal systems: Effects price progressivity

The effects of price progressivity:

-- price progressivity in most fiscal systems is oriented to getting a higher share under high prices, but is not oriented to providing a lower share under low prices. For instance, the system becomes tougher for investors as prices increase over \$ 60/bbl, but does not become more attractive to investors below \$ 60/bbl.

In other words, the systems are price progressive under high prices but become price regressive under low prices, thereby inhibiting exploration and development under low prices.

FISCAL SYSTEMS

Fiscal systems: Creation of cost progressivity

Creation of cost progressivity:

-- a simple way to create cost progressivity is to apply a so-called "uplift" which is an extra percentage cost deduction, for instance with an uplift of 30% an investor is allowed to deduct 130% of its cost for tax, profit sharing or profit oil/gas.

-- usually uplifts are applied to capital expenditures only with a goal of encouraging investment, but a few fiscal systems also apply uplifts to operating expenditures (such the Newfoundland offshore terms).

FISCAL SYSTEMS

Fiscal systems: Effects cost progressivity

The effects of cost progressivity:

-- as will be discussed under Cost Efficiency, cost progressive systems have to be designed rather conservatively in order to avoid gold plating.

-- However, on this basis, cost progressive systems are an effective way to stimulate high cost petroleum developments and marginal fields,

FISCAL SYSTEMS

Fiscal systems: Creation of profit progressivity

Creation of profit progressivity:

-- profit progressivity can be based on total project profitability or yearly profitability.

-- profit progressivity related to project profitability is usually created through a sliding scale based on profitability applied to a tax, profit share, profit oil/gas share or other feature,

-- the project profitability could determined as the IRR or an R-factor; which is a profitability indicator based on a ratio.

-- yearly profit progressivity is based on a ratio based on yearly indicators.

FISCAL SYSTEMS

Fiscal systems: Creation of profit progressivity

Creation of profit progressivity:

-- project profitability systems have the disadvantage that the burden on investors is high at the end of the project, when the burden should be low in order to extend the life of the field.

-- to solve this problem, Mexico has designed a rather effective combination of a project r-factor with a yearly r-factor for their deep water blocks.

FISCAL SYSTEMS

Fiscal systems: Effects profit progressivity

The effects of profit progressivity:

-- as will be discussed under Cost Efficiency and Price Efficiency, profit progressive systems have to be designed rather conservatively in order to avoid gold plating.

-- However, on this basis, profit progressive systems are an effective way to collect windfall profits.

-- It is also an effective way to stimulate high cost petroleum developments and marginal fields,

-- the systems assist investors to survive periods of low oil and gas prices.

-- However, profit progressive systems applied to small fields strongly discourage exploration.

FISCAL SYSTEMS

Analysis of timing, geologic risk and marginal fields

The impact of timing, geological risk and marginal fields can be analyzed as follows:

-- timing: calculating the front end loading index ("FELI"), which is for a particular system and field, the discounted GTT10 minus the undiscounted GTT0 (when a 10% discount rate is applied),

-- geological risk: calculating the government risk sharing index ("GRSI"), which is the Risked GTT0 minus the Un-Risked GTT0,

-- marginal fields: through regular profitability analysis. It can typically be recommended to consider fields marginal if the cost/price ratio is at least 40%.

FISCAL SYSTEMS

Fiscal Systems: Timing and GTT0

With respect to the timing and GTT0 three levels can be realized:

-- front end loaded systems: the FELI is a positive number; these systems are created by bonuses, royalties, CIT with low depreciation rates, production sharing contracts with low cost limits. It means governments receive most of their revenues early in the cash flow.

-- neutral systems: the FELI is zero, for instance a CIT with 100% write offs will result in such a system,

-- back end loaded systems: the FELI results in a negative number; these systems are created by profit progressive systems.

FISCAL SYSTEMS

Fiscal Systems: Creation of back end loading

The creation of front end loading and back end loading is directly determined by the choices of the components of the fiscal system, as indicated in the previous slide.

However, additionally there are other mechanisms to increase back end loading if this would be the policy. Applying tax credits, uplifts and holidays all promote back end loading.

For instance, a royalty is typically a front end loaded feature, but by applying a royalty holiday of, for instance, 5 years after the start of production, it can be modified to a back end loaded system.

FISCAL SYSTEMS

Fiscal Systems: Creation and front end and back end loading

In general it can be recommended that countries with a low social discount rate would apply back end loading, while countries with a high social discount rate would apply front end loading.

However, the perception of future risk in the petroleum industry is usually an incentive for governments to front end load.

In particular, in the petroleum industry framework developed in this presentation, a policy of strong back end loading would be a high risk policy.

FISCAL SYSTEMS

Fiscal Systems: Effects of timing of GTT0

Obviously, for a particular level of GTT0 the more a government front end loads the higher the discounted GTT10 will become and the less attractive the fiscal system is for investment.

At the same time, the more attractive and secure the system is for governments. It is therefore that almost all governments in the world have front end loaded systems of various degrees; the UK has a back end loaded system.

There is an important trade off for governments: a less front end loaded system with a higher GTT0 could be just as attractive to investors as a stronger front end loaded system with a lower GTT0. In other words the government "pays" for front end loading by having to offer a lower GTT0.

FISCAL SYSTEMS

Fiscal Systems: Government Risk Sharing

The sharing of geological risk by governments can be classified as follows:

-- Risk Averse: in this case the GRSI is a positive number; a high GRSI is created by ring-fenced systems such as many PSCs.

-- Neutral: in this case the GRSI is zero; a system consisting only of a fully consolidated CIT results in this,

-- Risk Supportive: in this case the GRSI is negative; a system with strong features to promote exploration expenses, such as uplifts on exploration expenses creates such conditions.

FISCAL SYSTEMS

Fiscal Systems: Creation of different levels of GSRI

Risk averse systems are created were the GTT0 of the dry hole is less than the GTT0 of the discovery. For instance, if a government has a royalty and a consolidated corporate income tax of say 35%; the GTT0 on the dry hole will be 35%, since the dry hole will be deducted for CIT purposes. However, the GTT0 of the production of the discovery will be higher, for instance 45%. Therefore, the government participates less in the dry hole than in the discovery and the system becomes risk averse. The strongest risk averse system are where there are ring-fenced PSCs without CIT, or where the CIT of the PSC is also ring-fenced. Another way to create strongly risk averse system is by requiring high up front signature bonuses.

FISCAL SYSTEMS

Fiscal Systems: Creation of different levels of GSRI

Risk supportive systems are created where the GTT0 on the dry hole is higher than the GTT0 on the discovery. This is for instance the case in South Africa, which has a 100% uplift on exploration expenditures.

In general it can be recommended that countries with a large resource based should have a fiscal system with a low level of GRSI, or even be neutral or risk supportive, since in these countries encouragement by government of exploration will on average result in sufficient discoveries not to result in a net loss for government. Countries with a small resource based could be risk averse with a high GRSI.

FISCAL SYSTEMS

Fiscal Systems: Effect of different levels of GSRI

The level of the GRSI is the most important factor impacting on the exploration activity.

Most exploration in the world takes place in countries with a relatively low GRSI. All these countries will have consolidated CIT systems that permit the deduction of exploration expenditures for CIT purposes, and sometimes other consolidated taxes or profit sharing systems that permit the deduction of exploration costs.

There is still a considerable number of developing countries that have attractive petroleum potential, but are unable to attract significant exploration as a result of a GSRI that is too high.

FISCAL SYSTEMS

Fiscal Systems: Marginal Fields

The incentive to promote marginal fields can be classified based on the analysis of a field with a cost/price ratio of 40% or higher as follows:

-- High (Strong): the IRR (real) is higher than 15% and the PIR10 (real) is higher than 0.15,

-- Average: the IRR (real) is between 10% and 15% and the PIR10 (real) is between 0.00 and 0.15,

-- Low (Weak); the IRR (real) is less than 10% and the PIR10 (real) is negative.

FISCAL SYSTEMS

Fiscal Systems: Creation of strong Marginal Fields incentives

The development of marginal fields can be promoted through a variety of ways:

-- generally apply a relatively low GTT0

-- use cost or profit progressive systems,

-- reduce front end loading, through a variety of ways, for instance royalty holidays,

-- where marginal fields are associated with small fields, use volume progressive systems incentivizing small fields, and

-- where marginal fields include non-associated gas fields, use gas-favorable fiscal terms.

FISCAL SYSTEMS

Fiscal Systems: Effect of strong Marginal Field incentives

The obvious result of applying strong marginal field incentives is that more marginal fields will be developed.

It should be noted that it are precisely the marginal fields that create employment and business opportunities, due to the high costs of such fields.

Therefore, even if such fields are not major fiscal contributors, they do support economic development in general.

FISCAL SYSTEMS

Analysis of Cost, Price and MER Efficiency

The cost, price and Maximum Economic Recovery ("MER") can be analyzed in the following manners:

-- Cost Efficiency: based on the Cost Savings Index ("CSI"), which in turn is analyzed based on differential cost analysis; the Cost Savings Index is the percentage that an investor can keep of the savings achieved as a result of lower costs,

-- Price Efficiency: based on the Price Incentive Index ("PII"), which turn is analyzed based on differential price analysis; the Price Incentive Index is the percentage that an investor can keep of the benefit from obtaining a higher price, and

-- MER Efficiency: based on the MER Efficiency Index ("MEREI"), which in turn is calculated by dividing the GTT0 of the last 5 years of the field life over the GTT0.

FISCAL SYSTEMS

Fiscal Systems: Cost Efficiency

The Cost Savings Index can be qualified as follows:

-- High: the CSI is over 50%,

-- Average: the CSI is between 25% and 50%,

-- Low: the CSI is between 0% and 25%, and

-- Gold Plating: the CSI is negative.

FISCAL SYSTEMS

Fiscal Systems: Cost Efficiency Creation

The CSI is entirely determined by the choice of fiscal components.

A High CSI is typically created with a system that has important royalties and modest taxes, and could have strong volume or price progressivity; for instance the US terms in the Gulf of Mexico have a high CSI.

A Low CSI or Golf Plating is created by systems that are excessively cost or profit progressive. For instance, Norway has a low CSI due to the combination of high tax rates and uplifts. Countries that use IRR based scales usually feature Gold Plating or a very low CSI.

FISCAL SYSTEMS

Fiscal Systems: Effects of Cost Efficiency

The CSI has a very significant impact on the way petroleum companies operate.

Countries with a high CSI stimulate R&D and development of technology to produce petroleum cheaper and more efficient, because cost savings are significantly rewarded by government.

Countries with a low CSI stimulate the over-declaring costs since the impact of higher costs is largely absorbed by government and therefore over-declaring costs could be profitable.

Countries with Gold Plating in some cases stimulate incurring of excessive and unnecessary costs, since cash flow actually improve in this way.

FISCAL SYSTEMS

Fiscal Systems: Price Efficiency

The Price Incentive Index can be qualified as follows:

-- High: the PII is over 40%,

-- Average: the PII is between 20% and 40%,

-- Low: the PII is between 0% and 20%, and

-- Price Inefficiency: the PII is negative.

FISCAL SYSTEMS

Fiscal Systems: Price Efficiency Creation

The PII is largely determined by the GTT0. Generally, the higher the GTT0 the lower the PII, since the GTT0 is taken away from the price increase.

A high PII is therefore the automatic result of a low GTT0, while a low PII is the result of a high GTT0.

The PII is, however, furthermore influenced by any price progressive feature. If the price progressive feature is excessive, the PII could become much lower than the GTT0 would indicate, or could even become negative creating a price inefficient system.

FISCAL SYSTEMS

Fiscal Systems: Effects of Price Efficiency

Generally, with a high or average PII, the effect on the petroleum industry operations is relatively minor.

Once the PII becomes low or negative, there will be an increased incentive to try to transfer price oil or gas on exports or based on other schemes.

Particularly under a Price Inefficient system, if the company achieves a higher price the cash flow actually goes down. So, the company just as well will try to sell the oil or gas to a foreign subsidiary for an artificially low price.

FISCAL SYSTEMS

Fiscal Systems: MER Efficiency

The MER efficiency can be qualified as follows:

-- MER Enhancing: the MEREI is less than 1.00,

-- Average: the MEREI is 1.00,

-- MER Inhibiting: the MEREI is higher than 1.00, and

-- Reserve Loss: Cash flows indicate an early termination of the field life due to a strong MER Inhibiting fiscal system compared to alternative fiscal terms.

FISCAL SYSTEMS

Fiscal Systems: Creation of an MER Enhancing System

An MER Enhancing fiscal system is a system where the burden on the investor is lessened towards the end of the field life. This can be done in a number of ways.

The most common way is through sliding scales based on daily production.

Other system are yearly r-factors, uplifts on operating expenditures, or reduction of tax rates over a level of cumulative reserve recovery (as applied in the Russian mineral extraction tax).

FISCAL SYSTEMS

Fiscal Systems: Creation of an MER Inhibiting System

Systems with fixed royalties are MER Inhibiting.

Profit progressive systems based on project profitability such as the IRR or project R-factor based systems could be strongly MER Inhibiting.

The same applies to price progressive systems that do not adjust for inflation.

Production sharing contracts with a cost limit are also MER inhibiting and could be very strongly inhibiting if the cost limit is low.

Most fiscal systems in the world are MER Inhibiting.

FISCAL SYSTEMS

Fiscal Systems: Effects of MER Efficiency

As can be expected, fiscal systems that are strongly MER Inhibiting usually result in reserve and production loss due to early abandonment of the field.

Systems that are MER Enhancing encourage petroleum companies to find ways to increase the recovery factor since it is attractive to do so.

FISCAL SYSTEMS

Fiscal Systems: Transformation of Fiscal Systems

In anticipation of a scenario with lower oil and gas prices the current world fiscal systems should be profoundly restructured to optimize the benefit for the various jurisdictions from the remaining oil and gas resources and to maintain a healthy petroleum industry.

This applies to Non-OPEC countries as well as those OPEC countries that aspire to maintain or increase oil and gas production, such as Nigeria and Angola.

In particular, governments should permit more flexibility during licensing round to maximize petroleum revenues and to permit the market forces to decide about the future level of GTT0.

The following slides provide the overview.

FISCAL TERMS

Transformation of the Fiscal Systems

TRANSFORMATION OF WORLD FISCAL SYSTEMS		
	CURRENT	FUTURE
Volume Progressivity	The world is mainly volume progressive or neutral	Somewhat more volume progressivity could be introduced
Price Progressivity	About one third of the world is price progressive for high prices, half the world is regressive	Most juridictions should become price progressive at low prices
Cost/Profit Progressivity	About 20% of the jurisdictions is cost/profit progressive and 70% regressive.	More jurisdictions should become modestly cost/profit progressive.
Timing of GTT0	The world is strongly Front End loaded	Front End loading should be reduced in particular in developed countries

The table shows an overview of the required fiscal changes. The most important change is that jurisdictions should increasingly become much more price progressive at low oil and gas prices.

FISCAL TERMS

Transformation of the Fiscal Systems

TRANSFORMATION OF WORLD FISCAL SYSTEMS (continued)		
	CURRENT	FUTURE
Geological Risk and GTT0	The world is strongly Risk Averse	Jurisdictions with large resource bases should become considerably less Risk Averse
Marginal Field Incentive	Most countries do not promote strongly marginal fields	Lower prices require that stronger provisions for marginal fields should be introduced
Cost Efficiency	Most systems in the world are cost efficient	Gold Plating should be removed
Price Efficiency	Almost all systems in the world are price efficient	Price Inefficiency should be removed.
MER Efficiency	Many systems In the world inhibit MER	MER enhancement should be significantly expanded

The table shows a further overview of the required fiscal changes. The most important change is jurisdictions with large resource bases should become less risk averse.

FISCAL TERMS

Transformation of the Fiscal Systems

TRANSFORMATION OF WORLD FISCAL SYSTEMS (continued)		
	CURRENT	FUTURE
Gas Fiscal favorability	Many jurisdictions have already gas-favorable fiscal systems.	The scope and level of gas-favorability should be significantly expanded
Oil GTT0	The current median world GTT0 at $ 50/bbl, $ 20/bbl costs for a 100 million barrrels field is 61%	Governments should create more flexibility in competitive bid rounds to maximize government revenue collection.

The table shows a further overview of the required fiscal changes. It is important that governments start to apply more flexibility during licensing rounds in order to determine the GTT0 based on market forces, rather than trying to adjust the government take based on pre-conceived ideas of what the government take should be.

FISCAL SYSTEMS

Transformation of Fiscal Systems - Components

Following is a discussion of the role of the various fiscal components in the fiscal transformation. It is assumed that carbon taxes will apply to the oil and gas burned and vented.

<u>Signature Bonuses:</u> should be eliminated or minimized. However, a secondary role in bid criteria can be useful as will be discussed below.

<u>Surface Rentals:</u> are meaningless amounts in most countries. Some strengthening can be recommended in order to improve acreage management.

<u>Royalties:</u> should be an important element in the design of price progressivity under low prices through royalty sliding scales based on price. Sliding scales for high price levels could be expanded. Price levels should be adjusted for inflation.

FISCAL SYSTEMS

Transformation of Fiscal Systems - Components

Royalties (continued): royalty sliding scales based on the level of production can be maintained , introduced or expanded. Physical parameters can be introduced, such as water depth, well depth and well productivity to make royalties more closely related to project economics. Royalties for gas should be lower than for oil. Royalties could also be lower for unconventional oil/gas and heavy oils. Royalties for frontier basins could be less. Royalty holidays may be introduced to promote marginal fields.

Corporate Income Tax: Jurisdictions that have currently a ring-fenced CIT should move to a consolidated CIT. Exploration and appraisal expenses should be expensed. Capital allowances based on a long duration of assets should be avoided.

FISCAL SYSTEMS

Transformation of Fiscal Systems - Components

<u>Corporate Income Taxes (continued):</u> Capital allowances should be permitted when costs are incurred rather than being based on an asset life system.

<u>Surtaxes/Hydrocarbon Taxes:</u> should be considered in a wider range of jurisdictions with a significant resource base. Such taxes should be consolidated. The taxes could have uplifts to make them cost progressive or production allowances to make them volume progressive. Exploration and appraisal costs should be expensed.

<u>Ring-fenced Resource Taxes</u>: Countries with a significant resource base could consider changing to Hydrocarbon Taxes. Otherwise, taxes could be maintained and include uplifts to create cost progressivity or R-factors to create profit progressivity.

FISCAL SYSTEMS

Transformation of Fiscal Systems - Components

(continued):

Windfall Profits Taxes: should be adjusted to ensure price progressivity at low prices and be lower for gas than for oil and should be adjusted for inflation.

Production Sharing: should include in the PSCs a separate consolidated CIT. Low cost oil/gas limits should be avoided. Profit oil/gas splits should be higher for oil than for gas. Profit oil/gas splits should feature progressive scales based on daily production, price and/or R-factors in order to create progressivity. Scales for unconventional oil/gas should be based on price or R-factors.

Export duties: should be phased out.

Use of IRR scales: should be phased out. These scales create Gold Plating in almost all countries that feature such scales.

FISCAL SYSTEMS

Transformation of Fiscal Systems - Components

(continued):

Use of R-factor scales: are recommended to create profit progressive systems. However, scales should be robust to avoid Gold Plating. The ideal R-factors should be a mixture of project based and yearly based ratios. R-factors should not be based on discounted cash flows.

Price progressive scales: should be adjusted for inflation.

State participation: should be de-emphasized. Jurisdictions should promote renewable resources rather than investing in oil and gas development. State participation in developed countries with a large resource base should feature full sharing of exploration risk, other countries could include carried interest provisions.

FISCAL SYSTEMS

Transformation of Fiscal Systems – Bid variables

As indicated earlier, the strategy to maximize petroleum revenues for the government depend very much on a successful bid system whereby prospects or fields are being offered with the widest possible economic characteristics to maximize production.

Furthermore, bid systems should be strictly transparent. This is best achieved with a single bid parameter, either based on a single parameter of a point system that can be self-assessed.

As far as fiscal systems are concerned, royalties, profit shares or profit oil/gas shares are the recommended variables. Governments may set minimums for different blocks in order to avoid an unacceptable low bid for a block. Bonus bids are typically not recommended.

FISCAL SYSTEMS

Transformation of Fiscal Systems – Bid variables

However, the recommended variables do not involve an initial outlay. This could result in over-bidding which could be detrimental. Therefore, a pre-established link with a signature bonus could avoid such conditions.

A bid on work commitments in terms of number of wells or work units could be recommended in a variety of circumstances. Basing work commitments on amounts expended cannot be recommended since this does not guarantee the work.

Combinations of fiscal terms and work can be based on a pre-determined point system that can be self-assessed by the bidder, so there is no uncertainty about the amount of points that is creating the winning bid.

PETROLEUM ENERGY ARRANGEMENTS

Introduction

The new petroleum industry framework could merit the creation of new types of petroleum arrangements (licenses, contracts).

It is likely that in a large number of jurisdictions the traditional petroleum licenses or contracts will continue to exist. If petroleum companies want to carry out energy activities related to renewable energy, they would do so under the regulatory regime established for such activities by the Ministry of Energy.

This creates a level playing field for all participants in the renewable energy sector and it would result in the lowest possible costs for renewable energy to the jurisdiction.

PETROLEUM ENERGY ARRANGEMENTS

Introduction

However, there may also be an advantage to a jurisdiction to make use of the attractiveness of the petroleum resources and the desire of certain petroleum companies to diversity to accelerate renewable resource development through the creation of petroleum energy arrangements (“PEA”).

There is a large number of possibilities. Two concepts will be discussed:

1. **To create a “Limited Scope Upstream PEA” that includes renewable energy activities that are a logical extension of the upstream petroleum activities, and**
2. **To create a “Wide Scope Midstream PEA” that is a comprehensive petroleum-renewable energy agreement.**

PETROLEUM ENERGY ARRANGEMENTS

Limited Scope Upstream PEA

Under a Limited Scope PEA, the licensee (or contractor) would have the exclusive right and obligation to produce oil and gas as well as renewable energy and to conduct CCS activities in the contract area.

It should be noted that the production of petroleum typically requires considerable energy, which could be equivalent to 2 – 7% of the total petroleum production.

Therefore, petroleum production results in considerable CO2 emissions.

PETROLEUM ENERGY ARRANGEMENTS

Limited Scope Upstream PEA-Renewable Energy

The license would require that the licensee shall use to the maximum extend possible renewable energy for energy use in the field.

The licensee would have the exclusive right to produce renewable energy in the contract area or to purchase renewable energy from third parties. If renewable energy is produced in the contract area the licensee shall have the right to sell excess production to third parties. The main objective of this right is to produce renewable energy in the contract area on a scale that is economic. The level would be approved in the field development plan. The third parties could be other petroleum companies operating in the area.

PETROLEUM ENERGY ARRANGEMENTS

Limited Scope Upstream PEA-Renewable Energy

The type of renewable energy that would be produced depends largely on the geographical conditions.

In offshore areas, it would be primarily wind energy, although also hydrogen based on wind could be produced.

In onshore areas, it would depend on geography and climate, and could be onshore wind, solar PV, solar heat, hydrogen or power and heat based on biomass (where such production does not interfere with agriculture).

If none of the production methods is practical, the renewable energy would have to be purchased.

PETROLEUM ENERGY ARRANGEMENTS

Limited Scope Upstream PEA-CCS

The carbon tax applies to any CO_2 emissions, however, where the field development plan requires the CCS of such CO_2, the flue gases shall be injected with a special injection well (or wells) drilled in the contract area into a separate reservoir and the licensee shall have the right to offer CO_2 injection services to other third parties who wish to inject CO_2. Third parties could be other petroleum companies operating in the area.

The amount to be delivered by third parties would depend on the injection capacity of the well or wells.

The injection well would also be used for injection of any possible flaring.

PETROLEUM ENERGY ARRANGEMENTS

Limited Scope Upstream PEA

The obligation for renewable energy production and CCS activities would be stipulated in the license.

The field development plan cannot be implemented unless it is approved by government. The license may set out certain criteria to be applied by government for field development plan approval.

The field development plan approval could be in phases or could be subject to amendments if certain conditions change.

Upon the exhaustion of the petroleum resources in the license area, the licensee should have the option to continue the renewable and CCS operations where that is profitable, sell the operations to other parties or be obliged to abandon the operations.

PETROLEUM ENERGY ARRANGEMENTS

Wide Scope Midstream PEA

The most important possible contribution that petroleum-energy companies can make to the future is in the midstream.

A large problem in the world is that in many developing countries the population simply does not have access to electricity. Without electricity you cannot develop an economy.

The reasons are often related to the complexity of putting integrated electricity delivery systems together, created by the current separation of the petroleum and power industries.

Power plants do not have the capacity to put LNG import schemes together or to create gas pipeline networks. Petroleum companies have no mandate to become independent power producers or power production conditions are uneconomic.

PETROLEUM ENERGY ARRANGEMENTS

Wide Scope Midstream PEA – Access to Electricity

COUNTRIES	ACCESS
Burundi	11.0%
Chad	11.8%
Burkina Faso	14.4%
Niger	17.6%
Malawi	18.0%
DRC	19.0%
Liberia	25.9%
Madagascar	25.9%
Sierra Leone	26.1%
South Sudan	28.2%
Guinea Bissao	28.7%
Mozambique	31.1%

COUNTRIES	ACCESS
CAR	32.4%
Rwanda	34.7%
Somalia	35.3%
Tanzania	35.6%
Zambia	39.8%
Zimbabwe	41.0%
Benin	41.5%
Uganda	42.6%
Angola	43.3%
Guinea	44.0%
Mauritania	44.5%
Ethiopia	45.0%

COUNTRIES	ACCESS
Haiti	45.3%
Lesotho	47.0%
Korea,DR	48.5%
Eritrea	49.6%
Mali	50.9%
Togo	51.3%
Namibia	53.9%
Nigeria	56.5%
PNG	59.0%
Sudan	59.8%

The tables show the percentage of the population that has access to electricity. It is based on the "Sustainable Energy for All" ("SE4ALL") data base of the World Bank. The tables show countries where the access is less than 60%.

PETROLEUM ENERGY ARRANGEMENTS

Wide Scope Midstream PEA

As can be noted, many of the nations where the population has limited access to electricity have at the same time high quality solar PV, onshore wind possibilities or low cost biomass.

For instance Somalia has one of best irradiation conditions and at the same time strong wind conditions along the entire coast line of the country. Nigeria has 427,000 MW of solar potential, in particular in the northern part of the country, which is 42 times the current total installed power capacity in the country.

What is noteworthy is that some of the countries are at the same time OPEC countries, such as Nigeria and Angola, or important (potential) oil and gas producers such as Uganda, South Sudan, Mozambique and PNG.

PETROLEUM ENERGY ARRANGEMENTS

Wide Scope Midstream PEA

The Wide Scope Midstream PEA would be petroleum-energy contracts that would optimize electricity, gas and other energy deliveries to a particular region on the principle that for the coming decades it is likely that the optimization would include natural gas.

The entire system would be optimized under a single arrangement. It could involve purchasing gas from some Narrow Scope Upstream PEAs in countries that have attractive natural gas resources. It could involve reduction of gas flaring. It would involve large scale infrastructure for gas development including gas processing plants and gas transportation and distribution networks for delivery to power plants and industries.   It could involve LNG imports.

PETROLEUM ENERGY ARRANGEMENTS

Wide Scope Midstream PEA

(continued):

The electricity component would optimize the supply of renewable energy from solar PV, CSP, onshore and offshore wind, geothermal, hydropower and power based on biomass.

It would involve the construction of gas power plants in addition to renewable power. It would also involve the transportation and distribution of electricity to individual consumers.

Where economic, it would involve the utility scale storage of electricity.

PETROLEUM ENERGY ARRANGEMENTS

Wide Scope Midstream PEA

Obviously, such massive undertakings would involve joint ventures of companies that can put such packages together. Capital requirements would be very large.

Such joint ventures could be combinations of:

-- large petroleum companies and large electricity companies,

-- joint ventures of large petroleum companies that wish to diversify,

-- joint ventures of large petroleum companies that wish to diversify combined with specialized solar and wind companies,

-- or other possible combinations.

PETROLEUM ENERGY ARRANGEMENTS

Wide Scope Midstream PEA

The main and serious problem of such undertakings is that it would be massive monopolies in a particular region of the country, even if the regions selected would be relatively small.

For instance, in Nigeria, it are mainly the northern states which do not have sufficient power and the population is large. There could be 20 or 30 PEA's.

The PEA would have to incorporate many of the requirements that otherwise would be separate regulatory requirements, in order to ensure that the entire system "hangs together". In other words the PEA may override certain laws and regulations and as a result a PEA concept may have to be approved by law.

PETROLEUM ENERGY ARRANGEMENTS

Wide Scope Midstream PEA

Because the PEA would practically be a monopoly, the PEA would have to include provisions that would prevent the abuse of monopoly power.

There would have to be provisions for existing power producers and possibly new power producers.

In order to ensure the lowest possible cost of electricity and energy, many of the components of the total project would have to be subject to competitive bidding.

Nevertheless, even under such conditions the monopoly power may be politically unacceptable in some countries or jurisdictions.

THANK YOU