UKpia

Fuelling the UK's future -
the role of our refining and downstream oil industry

UKpia Fuelling the UK's future

www.ukpia.com November 2011

About **UKPIA**

UKPIA represents the non-commercial interests of and speaks for ten companies involved in the UK downstream oil industry, whose activities cover refining, storage and distribution, and marketing of petroleum products. UKPIA members:

- own the 8 main UK oil refineries that processed 73 million tonnes of crude oil and produced 75.4 million tonnes of refined products in 2010 *(Source: DECC- DUKES data)*
- supply close to 90% of the inland market for petroleum products; and
- own around 2,200 of the 8,787 filling stations in the UK.

Our members are:

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President's introduction

The publication of 'Fuelling the UK's future- the role of our refining and downstream oil industry' is an important contribution to the debate on the crucial issue of the UK's future sources of energy, and the role of downstream oil and refining in particular. It follows on from our 2006 report 'Meeting our energy needs: The Future of UK Oil Refining' that outlined the many challenges the industry faced and which since then have become even more pressing.

The industry recognises the Government's ambitions integral to policies underpinning carbon reduction targets. However, the transition to a lower carbon environment whilst continuing to meet the future energy requirements of a diverse range of consumers in a way that addresses security of supply, is a huge challenge. Not only does it require open debate of the various policy measures and actions expected to achieve these reduction targets, including impacts upon consumers in terms of costs and lifestyle changes, but also a clear idea of what energy security means in each sector. Ongoing engagement between government, industry and stakeholders will be necessary so that solutions adopted are kept under review in the light of technology developments and operational experience, to ensure solutions remain effective and any unintended consequences are addressed.

The International Energy Agency's New Policies Scenario in the World Economic Outlook 2010 envisages that in 2035, even with a range of measures to improve efficiency and reduce carbon emissions, oil will still be meeting over 80% of the EU's transport fuel requirements.

It is clear that oil will remain an important energy source for the UK in the future. The UK downstream oil industry, of which the refining sector is the major element, makes a vital contribution to the UK's economy. However, in common with the refining industry in the rest of the EU, it now faces a combination of factors the response to which will be critical in shaping its future direction and capability.

Given the right policy environment, the UK refining and downstream oil sector can continue to play a pivotal role in the future as a reliable, resilient and secure source of transport fuels and other vital industrial feedstocks.

UKPIA and its members look forward to continuing to work with government and policymakers to achieve this goal.

Brian Worrall

UKPIA President November 2011.

Fuelling the UK's future - in brief

- *energy demand globally is growing and will continue to do so, especially in non-OECD countries*
- *UK energy demand is likely to show little growth or even decline in some sectors*
- *meeting rapidly growing global energy demand poses considerable challenges requiring significant investment*
- *in all scenarios (Global and UK), hydrocarbon fuels will remain the major energy source for several decades*
- *oil isn't running out yet but like many other raw materials is a finite resource, so greater emphasis on improving energy efficiency will be integral to underpinning future energy security, while delivering cost effectively emissions' reductions*
- *a whole range of fuels and technologies will be required as part of the future energy mix*
- *moving to alternatives takes time and needs a consistent, clear policy framework based on sound science and cost effectiveness*
- *since technology alone cannot deliver all the carbon savings required under legislative and other frameworks, major changes in consumer behaviour and lifestyle will be required to meet emissions' reductions; Government should strive for open debate of the costs to industry and consumers associated with meeting these targets, alongside the expected benefits.*
- *the UK oil refining industry is a valuable asset making a significant contribution to the UK's economy with a long record as a reliable source of energy and industrial feedstocks, creating wealth, and supporting employment and skills*
- *the industry is facing major challenges; refining output needs to adapt to changing demand patterns and legislation but uncertainties about the impacts combined with a tough commercial climate make the investment case difficult*
- *in shaping its future energy strategy, the Government has to consider the UK's requirements for a robust and resilient energy sector and formulate policy that will help deliver this objective*
- *oil refining will continue to be a vital part of the energy mix but without coherent policy direction, parts of the sector may be at risk resulting in unintended consequences for energy supply and resilience.*

Executive summary

1. Global energy demand continues to grow

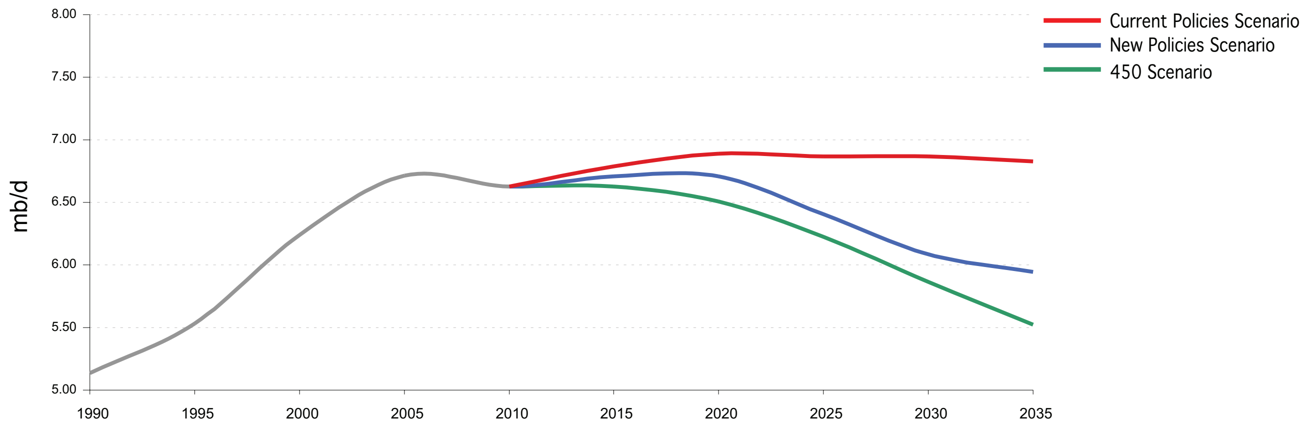
Globally, demand growth for oil will remain strong through to 2035, largely from developing economies, but is forecast to fall in the UK and other OECD countries.

The International Energy Agency (IEA) forecasts that oil will continue to play a major part in meeting the energy needs of the world and Europe to 2035 and beyond.

European primary oil demand under the IEA's 'New Policies Scenario' (which reflects broad policy commitments/plans adopted or announced by mid 2010) is estimated to decline slightly from 12.7 million barrels per day in 2009 to 10.4 mb/d by 2035, excluding biofuels. For the transport sector, this translates to a real per capita reduction in oil consumption but oil products are still forecast to be meeting around 82% of EU transport demand in 2035.

Table ES1: EU oil demand - transport sector under the three policy scenarios

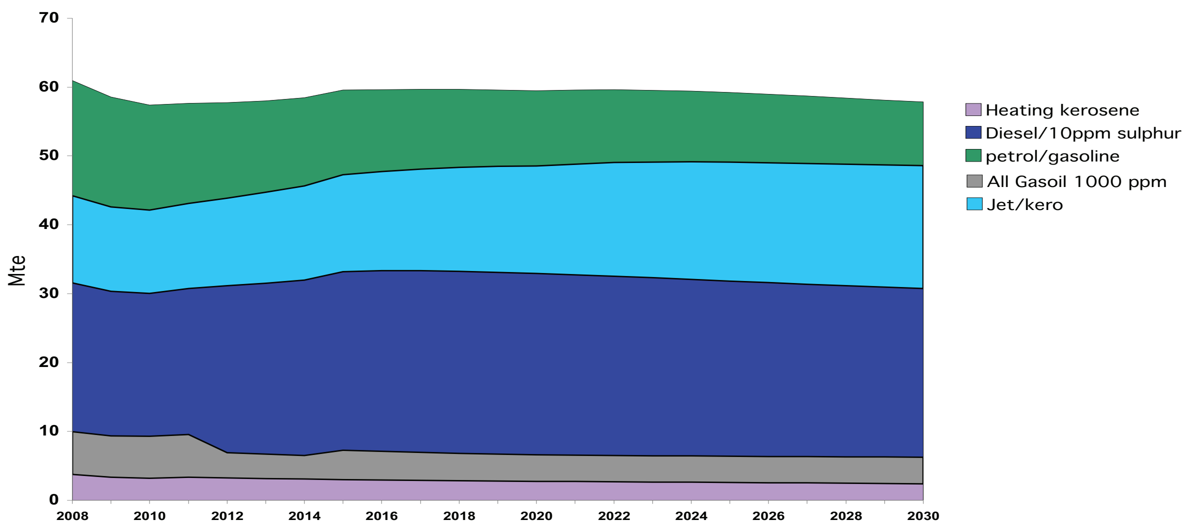
(See Annex 2 for an outline of IEA Scenarios)



(Source: IEA World Economic Outlook, 2010)

In the UK future total demand for petroleum products is likely to plateau or fall. Demand amounted to 71.5 million tonnes in 2010 (72.6 million tonnes 2009) - equivalent to a third of the UK's total primary energy requirements. The vast majority, 65.4 million tonnes (90%), was used as fuel *(Source: DECC Energy Markets Outlook 2010).* Of this, road transport accounted for 62% of demand with aviation accounting for 17%. Although there was a reduction in overall transport fuel demand during the severe economic downturn between 2008-2009, with little recovery since, petroleum products are forecast to play a major role in meeting the UK's forecast future fuel requirements to 2030 and beyond.

Table ES2: UK refined product demand to 2030



(Source: Wood Mackenzie, modified for MARPOL VI)

Usage of other fuels or energy sources, such as renewables, will increase in the future. However, their proportion of the whole will be small in comparison to that of oil to 2035 and beyond. Even by 2050, biofuels are projected to account for only 27% of global transport fuel needs. *(Source: IEA Biofuels for Transport-Technology Roadmap 2011)*

2. Meeting energy demand requires substantial investment.

Globally, US$8 trillion investment is needed between 2009 and 2035 to find, produce, ship and refine oil under the IEA 'New Policies Scenario'

Meeting the projected global energy demand increase is a major challenge. This investment includes US$979 billion in global refining, of which $81 billion is anticipated by the IEA to be made in the EU. However, this excludes investment to meet tighter fuel specifications, which has absorbed most of the refinery investment in Europe over the last two decades, and averaged US$6 billion per annum. *(Source: EUROPIA/Purvin & Gertz).* Investments of this magnitude require significant commitment on the part of refining companies. Given the volatile nature of earnings from the refining sector and the capital intensive nature of refinery upgrade projects, it is critical that investors have confidence in the policy and legislative frameworks in place in the EU and the UK. This means ensuring there is a level playing field within the EU and that competitive disadvantages with non-EU refineries, linked to legislation, are taken into account.

3. Oil isn't running out but is a finite resource, like many other raw materials.

The estimate of global proven oil reserves at the end of 2009 was 1,354 billion barrels
(Source: IEA WEO Outlook 2010/Oil & Gas Journal)

This represents a doubling in reserves since 1980 and a one-third increase in the last decade. This is equivalent to approximately 45 years' oil supply based on 2009 consumption. To date, the oil industry has a history of growing reserves and production capability to meet world demand.

4. Role and benefits of UK refining

The UK oil refining and downstream industry has a long track record as a reliable supplier of energy, refined products and feedstocks to a wide range of industrial sectors. It is a valuable asset that keeps the nation moving, helping to create wealth, and supporting employment and skills.

With oil continuing to be an important energy source in the future, an indigenous oil refining industry will remain a valuable asset to the UK. Despite the many challenges the industry faces, it can continue to play a pivotal role in the future as a reliable, resilient and secure source of transport fuels and vital feedstocks for other industrial sectors. Many of these sectors, such as petrochemicals, lubricants, paints and solvents, road and construction, steel and aluminium smelting, are heavily reliant upon these feedstocks provided by the refining sector, which in many cases would be difficult to replace.

The UK derives a number of significant benefits from having a competitive domestic refining industry. These include:

- substantially enhanced supply security and resilience:
  - the international crude oil market is far larger than that for refined products so a domestic industry potentially enables a rapid response in an emergency affecting crude or refined product supply;
  - further refinery closures in Europe may reduce liquidity in the refined products market
- consumer benefits from availability of high quality fuels at competitive prices
- increased flexibility in meeting fuel quality requirements rather than being wholly reliant upon specifications from overseas plants for early introduction of cleaner fuels e.g. 10ppm 'sulphur free' petrol and diesel
- a substantial contribution to the UK economy as a whole, and to regional economies
  - the added value of UK refining in the event of international market failure is estimated at £260 billion per year *(Source: Deloitte 2010 study for DECC ' Downstream oil-short term resilience and longer term security of supply')*
  - a large UK refinery is estimated to inject around £60 million per year into the local economy *(See Valero Pembroke Case Study Chapter 3)*
- supporting the employment of 150,000 people, many with specialist skills, technological expertise in key trades and chemical/electrical/mechanical engineering disciplines

- the supply of petroleum feedstocks to other key industrial sectors including plastics, paint, fibres, pharmaceuticals, building materials, aluminium and steel. Just one of these sectors - the UK petrochemicals industry - has a turnover of £50 billion per annum, employs 214,000 people and has a trade surplus of £5 billion *(Source: Chemical Industries Association)*
- high quality petrol and diesel that helps improve air quality throughout the UK, by enabling the use of advanced vehicle technologies

Maintaining these benefits to the UK requires a strong, domestic oil refining base. If investment is not made in UK refineries to enable them to keep up with changing consumer demand, the UK can import products in deficit and export products in surplus. However, a growing dependence on imports/exports could result in:

- reduced security of supply as imported products may be less quickly and easily available in times of emergency or crisis - the UK may not necessarily be able to secure internationally traded products to meet domestic demand
- pressure on the profitability of UK refineries which in future periods of poor refining margins may lead to further UK refinery closures
- the UK balance of payments being adversely affected
- the added value of UK refining being captured in part by overseas refineries

5. Meeting future energy demand

Oil products will remain the major energy source for the transport sector for decades to come due to the time taken to develop and introduce alternative fuels and technologies.

Reducing carbon emissions under legislative and other frameworks whilst meeting our energy needs in a secure way will require all options being kept open to ensure the UK has access to diversified energy supply sources.

In some industrial sectors, petroleum-derived feedstocks may be difficult or impossible to substitute with alternatives.

For technical and practical reasons - including their relative low cost and unrivalled scale - in comparison to alternatives, engines powered by petroleum fuels have been predominant in road, aviation and marine transport for over a century, and will remain so for several decades.

A range of alternative fuels are starting to be introduced in the UK and the rest of the EU and will continue to develop alongside petroleum-derived fuels as the energy supply mix evolves. However, many of these alternatives require time to turn them into commercially viable solutions. At the moment, most are neither available on a scale to match petroleum products nor cost competitive and thus may require either taxpayer funded subsidies (directly or indirectly) or policy measures to encourage their uptake in the future.

Also since technology alone cannot deliver all the reductions envisaged, focus should be maintained on encouraging energy efficiency and responsible use of energy in all sectors. For the transport sector most efficiency gains will come from vehicle technology and fuel improvements.

Behavioural change, allied to technology innovation, will become increasingly significant in helping to meet carbon reduction targets. Legislation to introduce a strong element of compulsion by management of demand (for example 'pay as you go' road pricing) is likely to prove unpopular unless linked to a reduction in other road taxes. Policy that encourages change is more likely to prove acceptable, even though the end results may take longer than mandated solutions.

Government should strive for open debate of the costs to industry and consumers associated with meeting carbon reduction targets, alongside the expected benefits.

6. The refining sector faces challenging conditions, through a combination of low returns, additional investment requirements to meet tightening environmental standards and product specifications, and increased competition from refineries in Asia.

6.1 Challenging returns

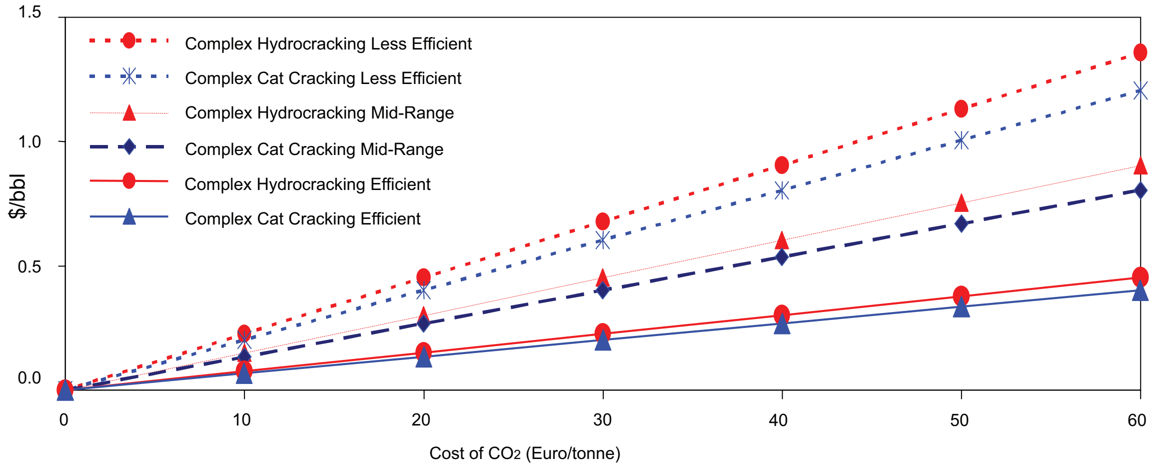
Energy analysts Wood Mackenzie forecast that weak refining margins in NW Europe will continue during the current decade. Their analysis for the EU Commission (Wood Mackenzie/Ricardo report October 2010: *'Impact of biofuels* on oil refining') showed that 29 of the 96 refineries in the EU did not generate a positive net cash margin (product value, less cost of crude oil and cash operating expenses) in mid-cycle market conditions.

6.2 Investing for tightening environmental standards.

The EU Emissions Trading System affects all EU refineries. Phase III of the scheme from 2013 will bring substantial extra cost to UK refineries for purchased allowances based on an efficiency benchmark according to refinery complexity. At an allowance cost of €15 CO_2 per tonne (~£13) this represents an additional immediate cost to UK refining of €86 million (£75million) per year from 2013, rising potentially to €230 million (£200 million) a year at €50 CO_2 per tonne (UKPIA estimates). These allowance costs are not faced by competing non-EU refineries.

The impact of these incremental costs upon refinery margins is illustrated in Chart ES3. Taken from the Purvin & Gertz report for the Department for Energy and Climate Change (DECC), this indicates that cat cracking/hydrocracking refineries with mid-range efficiency or below could incur incremental costs of between $0.2 to $0.4 per barrel based on carbon at €15-17 per tonne of CO_2.

Table ES3: Estimated impact of EU ETS Phase III



(Source: Purvin & Gertz study for DECC June 2011)

In addition, UK refineries face some environmental and safety standards that are already tighter than elsewhere in Europe, as well as UK-only legislation.

Examples of UK-only legislation include the CRC Energy Efficiency Scheme (CRC) and proposals to amend the Climate Change Levy (CCL) and introduce a minimum floor price for carbon. At present, in most cases, fossil fuels used to generate electricity are exempt from CCL.

The CRC is a mandatory UK scheme designed to encourage energy efficiency by large non-industrial public and private sector energy users through a system of a CO_2 emissions cap and allowances with auctioning. The scheme is complex and administratively burdensome but following the Comprehensive Spending Review in October 2010, auctioning revenues now go to HM Treasury rather than to participants in the CRC. The scheme has therefore become an additional tax on public and private sector energy users. The Government's intention to simplify the scheme and exclude installations covered by the EU ETS is welcomed.

In addition, the UK downstream oil sector faces UK-only policy enforcing far higher secondary and tertiary containment measures at large oil storage terminals. These are stricter than those that either EU or global competitors face. As currently envisaged, these measures if fully implemented, regardless of risk factors or other criteria, could require capital investment of hundreds of millions of pounds over an extended period with likely significant impact on oil supply infrastructure.

6.3 Investing to meet tightening product specifications.

Meeting tighter product specifications, particularly reducing sulphur content in a wider range of fuels, requires refiners either to use more expensive low sulphur crude oil or to invest in new hydro de-sulphurisation or hydro-cracking units to process and upgrade less expensive but higher sulphur crude oils. These units are major investments in the order of £300-700 million or more for each refinery and take several years to plan and build.

6.4 Increasing competition from Asia

Increasingly, UK refineries are facing competition from new large refineries in Asia designed to maximise the output of middle distillate products with a low proportion of heavier residue products. These refineries in the shorter term have a substantial export capability, as their local demand is still developing, so represent significant competition to UK refineries.

7. Conclusions and policy recommendations

Oil will remain a significant energy source globally and for the UK for decades to come. The UK downstream oil industry and the refining sector has for many years been a reliable, secure and competitive source for the key products upon which the UK relies.

The number of UK refineries has declined from eighteen in the late 1970s to eight currently, in response to changing market conditions and demand. One UK refinery closed in 2009 and of the eight remaining operational refineries, two have been sold to new owners in 2011 and a further two remain for sale. Once a refinery closes it rarely re-opens, although depending upon location and other commercial and environmental considerations, it can be converted to an import and storage facility.

Clearly market and commercial considerations are important influences but in order to help ensure the continued competitiveness of the refining industry in the UK, the Government must seek to apply policies that do not place it at a commercial disadvantage to overseas competitors. Furthermore, this may require the Government to lobby strongly at EU level to address these issues and the impacts on UK industry. This is especially important given that the EU and the UK have taken a lead on measures to address climate change, which is a global issue requiring all countries to address their greenhouse gas emissions.

UKPIA and its members believe strongly that a healthy, robust oil refining industry is a vital element of the nation's future secure supply of competitively priced petroleum products (transport fuels, chemical feedstocks, heating oils, etc). They wish to continue working with the Government at a high level to deliver this, building upon the collaborative work with the Department for Energy and Climate Change on UK refining and infrastructure.

Oil and oil products will continue to provide a major share of our energy supplies for the foreseeable future. For this reason it is vital that all options are kept open on a range of fuels and technologies to meet the future energy needs of the UK's consumers.

The challenge is to ensure that in the coming decades the UK continues to have access to affordable, secure supplies of the required oil products as both sources of crude oil and consumer demand change. The UK can meet any shortfall in its needs by importing more products (jet fuel and diesel) and exporting surplus products (petrol and fuel oil) so long as those markets remain available, or alternatively by investing in UK refineries. UKPIA and its member companies believe that the challenge will be best met with a strong domestic oil refining industry with close links to the European and global oil markets.

Conclusions and policy recommendations

To help achieve this objective, UKPIA seeks a legislative environment that:

- is based on constructive open dialogue to help reach solutions that meet policy objectives
- is realistic and practical
- is based on sound science and cost effectiveness
- provides a level playing field throughout EU member states and avoids placing UK refineries at a competitive disadvantage in relation to its EU and non-EU competitors
- is flexible and developed on a timescale that engenders investor confidence
- is reviewed periodically in the light of technical and scientific developments

and is allied to a policy vision that helps maintain security of energy supply and resilience, to support the UK economy.

1. Energy supply and demand overview

1.1 Global energy overview

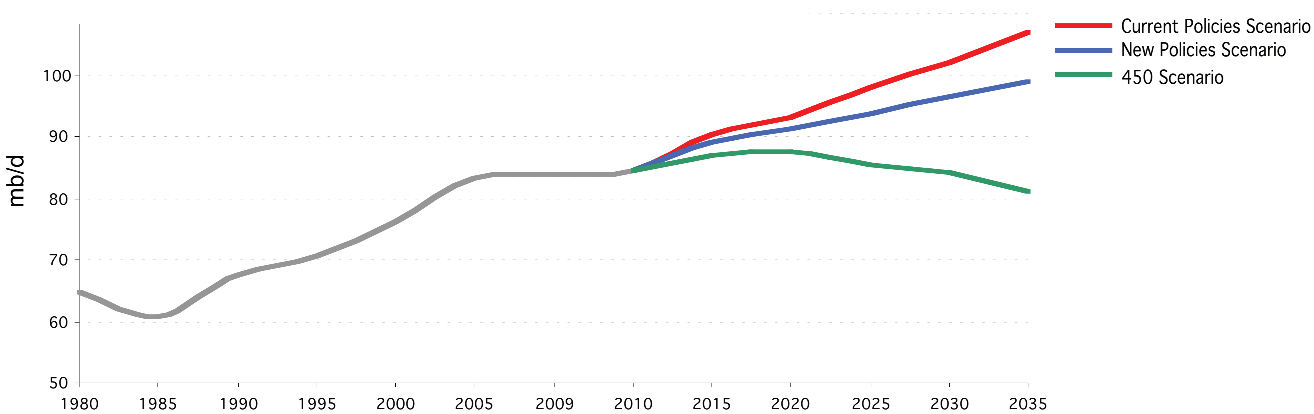
Globally, demand growth for oil and energy generally will remain strong through to 2035, largely from developing economies, but is forecast to fall in the UK and other OECD countries, according to scenario projections contained in the International Energy Agency's World Economic Outlook 2010.

This presents a huge challenge in continuing to provide secure, affordable sources of energy supply in the future while also meeting substantial carbon reduction targets required by legislators.

By 2035, the IEA's 'New Policies Scenario' estimates that global primary energy demand is likely to be about 36% per cent higher than in 2008. Most of this additional demand will be driven by population growth, higher living standards and expanding non-OECD economies, particularly China, India, the Middle East, Asia and Latin America. This growth is expected to be met largely by fossil fuels- oil, gas and coal- and IEA forecasts indicate that oil is still likely to be the single most important source globally for transport fuels in 2035.

The IEA 'New Policies Scenario' is based on global action to stabilise CO_2 emissions by 2020 and achieve a 34% reduction by 2035. Primary oil demand of OECD countries is expected to decline by 15% under this scenario compared with 2009 and that of non-OECD countries to increase by 52%. (See Annex 2 for an outline of the IEA scenarios)

Chart 1.1: Primary world oil demand under the three policy scenarios



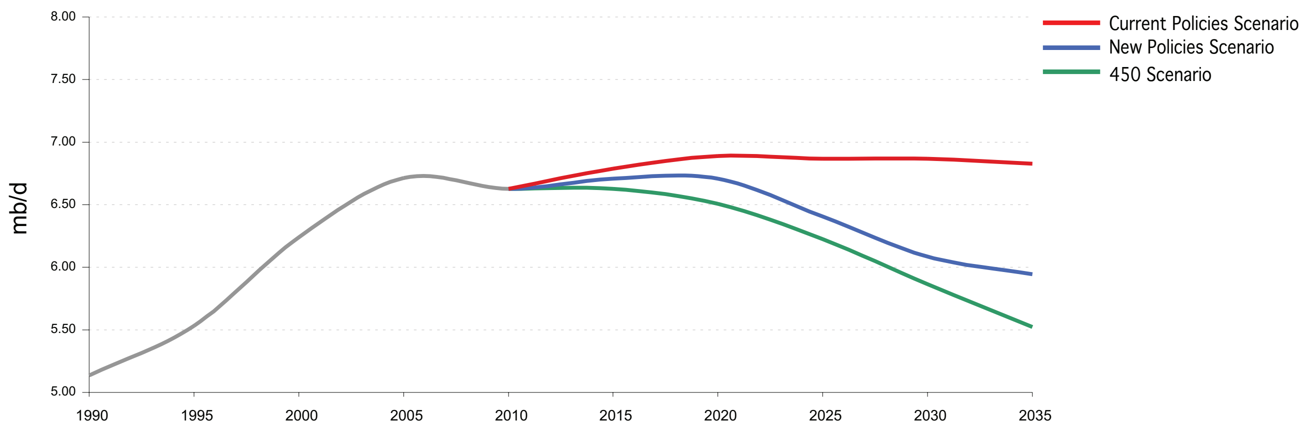
(Source: IEA World Economic Outlook, 2010)

Although a variety of alternative sources and renewables should start to be significant, particularly for power generation, the IEA observed that the demand projections under the 'New Policies Scenario' were regarded as achievable but challenging.

European primary oil demand is estimated to decline slightly from 12.7million barrels per day in 2009 to 10.4mb/d by 2035, excluding biofuels. For the transport sector, this translates to a real per capita reduction in oil consumption but oil products are still forecast to be meeting around 82% of EU transport demand in 2035.

For road transport, reductions are expected to be achieved through adoption of biofuels, improved fuel efficiency, hybrid/hybrid plug-in vehicles and electric vehicles, as well as transport mode shifts.

Chart 1.2: EU oil demand - transport sector under the three policy scenarios

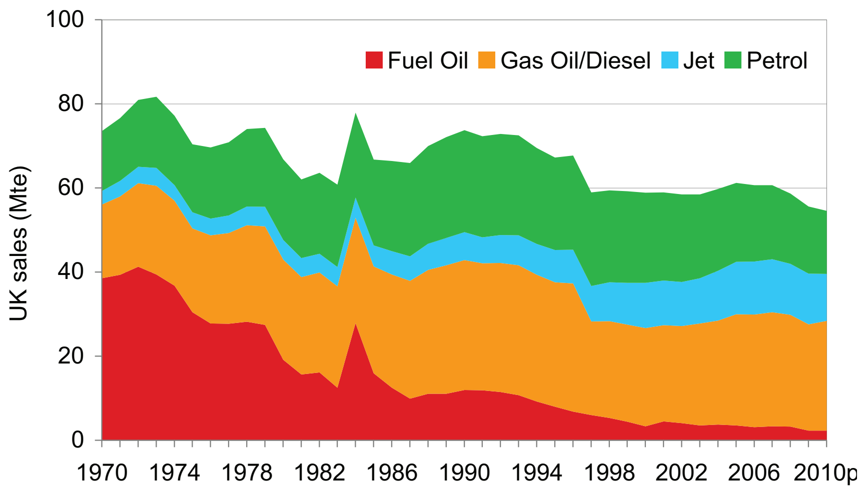


(Source: IEA World Economic Outlook, 2010)

1.2 UK oil supply/demand and future forecasts

Historically, UK demand has been biased towards petrol with investment at refineries geared to meeting this demand. However, UK petrol demand peaked in 1990 and has been in slow decline ever since. Diesel demand has been increasing, reflecting increased movement of goods by road and the shift towards diesel powered cars over the last two decades.

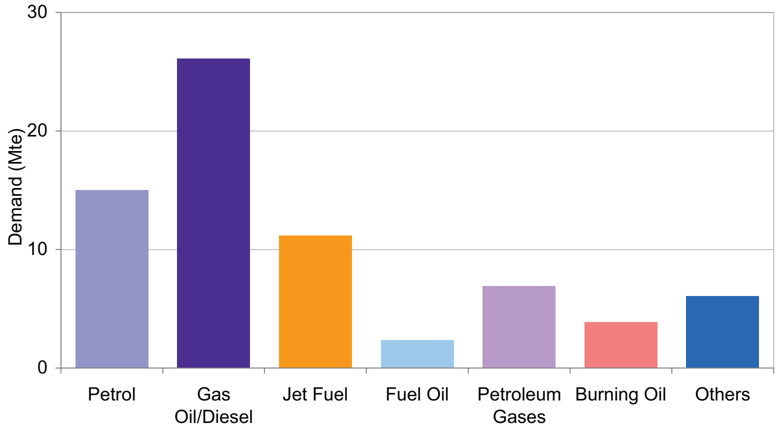
Chart 1.3 Changes in UK fuel demand 1970-2010



(Source: DECC, DUKES)

There has been a reduction in overall transport fuel demand during the severe downturn in the economy in the period 2008-2009, with little recovery since then. Future demand is very much linked to economic growth but it is clear that efficiency gains from improvements in both petrol and diesel vehicles have helped offset fuel demand growth linked to the increased mileage covered by vehicles over the past decade *(Source: DfT Annual Road Traffic Estimates 2010).*

Chart 1.4 UK fuel demand 2010



(Source: DECC, DUKES)

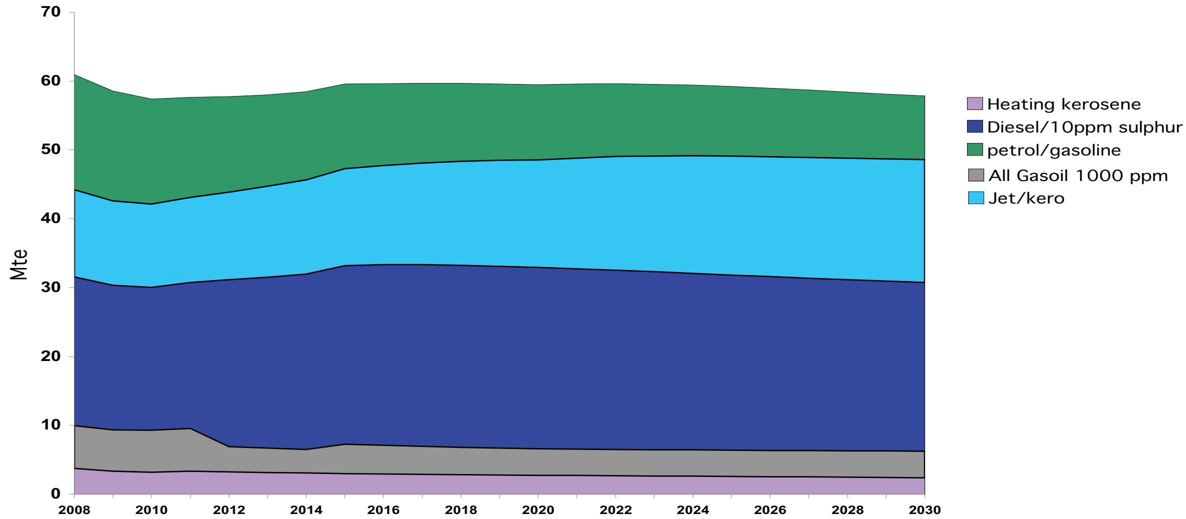
Oil demand amounted to 71.5 million tonnes in 2010 (72.6 million tonnes 2009) - equivalent to a third of the UK's total primary energy requirements. The vast majority, 65.4million tonnes (90%), was used as fuel *(Source: DECC Energy Markets Outlook 2010).* Of this, road transport accounted for 62% of demand (around 41billion litres of petrol and diesel) with aviation accounting for 17%.

Despite these changes and the development of alternative fuels and energy sources, petroleum products are forecast to play a predominant role in meeting the UK's future fuel requirements.

For refining in the UK and the EU, the shift in demand from petrol to diesel is increasingly significant, contributing to a growing structural imbalance in product supply/demand, with the UK becoming a net importer of diesel in 2006.

Historically, refinery investment has been geared to increasing petrol output but UK demand for petrol has been in steady decline since the peak in 1990. Demand for fuel oil for power generation has collapsed, largely substituted by gas, with the result that surpluses of petrol and fuel oil produced by UK refineries are exported.

Chart 1.5: UK refined product demand to 2030



(Source: Wood Mackenzie, modified for MARPOL VI)

By 2030, overall oil product demand (including biofuels) in the UK is projected to reduce slightly in comparison with 2008. (See Wood Mackenzie Chart 1.5). Overall road transport fuel demand under the base case scenario is expected to increase to 42 million tonnes per year (37 million excluding biofuels) from the current 41 million tonnes. The implications of variations in demand across fuel type are covered in Chapter 5. However, demand for petrol (barring any significant policy change in fuel duty policy) and heating oil is projected to decline, countered by continued demand growth for diesel and jet fuel. Of increasing significance (and uncertainty) from 2015 is the change in marine fuel specifications under MARPOL VI rules which potentially will increase demand for middle distillate and reduce further the market for heavier bottom of the barrel products previously used in the marine sector.

2. Energy and investment

Globally, US$8 trillion investment is needed between 2009 and 2035 to find, produce, ship and refine oil under the IEA 'New Policies Scenario'

2.1 Oil reserves

Oil isn't running out but is a finite resource, like many other raw materials.

The estimate of global proven oil reserves at the end of 2009 was 1,354 billion barrels *(Source: IEA WEO Outlook 2010/Oil & Gas Journal),* equivalent to 45 years' oil supply based on 2009 consumption. This represents a doubling of reserves since 1980 and a one-third increase in the last decade; 50% of the increase in the last decade is attributable to unconventional resources and the remainder from revisions of reserves in some OPEC countries.

Energy analysts have linked some of the recent oil price spikes to a mismatch in demand and supply, partly tracing its roots back to an earlier decade of low oil prices when oil and gas exploration investment was constrained. Invariably there have been periods of mismatch in supply and demand given the complexity of global markets, and not least since new oil supply sources, as opposed to short term production increases, take time and substantial investment to bring on stream.

2.2 Meeting energy demand requires substantial investment

Meeting the projected global energy demand increase is a major challenge. The IEA estimates that for oil alone, the associated additional investment along the oil-supply chain in the period 2010-2035, is US $8 trillion. Much of this (85%) is anticipated to be focused upon oil and gas exploration and production. The global downstream oil sector accounts for a modest proportion of this projected investment at $979 billion, most of which is expected to take place largely in non-OECD countries where increased demand for oil products will be focused.

2.3 Refinery investment

In the EU, refining sector investment over this period is forecast by the IEA to amount to US $81 billion. However, this excludes investment to meet tighter fuel specifications, which has absorbed most of the refinery investment in Europe over the last two decades, and averaged US$6 billion per annum. *(Source: EUROPIA/Purvin & Gertz).* Investments of this magnitude require significant commitment on the part of refining companies.

Given the combination of the current commercial climate, the outlook for refining in the UK and the rest of the EU, and the substantial cost of upgrade projects (a hydro cracking unit typically cost upwards of £500 million, depending upon size, complexity and integration with existing refinery units), it seems unlikely that such investments will be made in the foreseeable future.

Indeed, other than the recently completed HDS3 project at Total UK's Lindsey Oil Refinery, many of the previously announced upgrades to refineries in the EU have either been cancelled or deferred. *(See European Commission paper 2010 'Refining and the Supply of Petroleum Products in the EU' Annex 4 and 2010 report from Wood Mackenzie, 'Grim times for European refining').* Furthermore, the lead time between feasibility study and commissioning of major new plant can be between 5-7 years.

Table 2.1: European refinery upgrades cancelled/deferred

Country	Refinery	Company	Project	Status
Hungary	Duna	MOL	Major upgrading project to increase diesel production: New Hydrocracker; VDU & CDU expansion; coking capacity increase	Delayed/remains firm
Germany	Wilhelmshaven	ConocoPhillips	2009 Upgrade programme to coker & hydrocracker	Cancelled; refinery closed. Conversion to storage terminal
Italy	Sarroch	Saras	Revamp to visbreaker and MHCU to increase diesel output	
Croatia	Rijeka	INA	Coker project	Delayed; unlikely to proceed
Turkey	Aliaga	Turcas/SOCAR	Grassroots refinery project	Previously delayed; due to start 2011
Finland	Porvoo	Neste Oil	New isomerisation unit	Delayed/now uncertain
Sweden	Preemraff Lysekil	Preem	Heavy oil project	Delayed/now uncertain
Bulgaria	Neftochim Burgas	LUKOIL	Expansion of CDU as part of third phase upgrade programme	Delayed/now uncertain
Lithuania	Orlen Lietuva	PKN Orlen	Coker project cancelled by additional hydrocracker under consideration	Coker cancelled. Upgrades uncertain
Spain	Cartagena	Repsol YPF	Major upgrade ongoing but construction of C5/6 isomerisation unit cancelled	Isomerisation plant cancelled
Italy	Taranto	ENI	Taranto plus project: VDU/CDU capacity increase and diesel desulphurisation unit	Cancelled

(Source: Wood Mackenzie 2010 'Grim times for European refining')

The challenges facing UK refining are covered in more detail in Chapter 5. However, policy frameworks in the EU and the UK are critical to investor confidence. This means ensuring there is a level playing field within the EU and that competitive disadvantages with non-EU refineries, linked to legislation, are taken into account.

3. UK oil refining industry: role and benefits

The UK oil refining and downstream industry has a long track record as a reliable supplier of energy, refined products and feedstocks to a wide range of industrial sectors. It is a valuable asset that keeps the nation moving, helping to create wealth, and supporting employment and skills.

With oil continuing to be an important energy source in the future, an indigenous oil refining industry will remain a valuable asset to the UK. Despite the many challenges the industry faces, it can continue to play a pivotal role in the future as a reliable, resilient and secure source of transport fuels and vital feedstocks for other industrial sectors. Many of these sectors, such as petrochemicals, lubricants, paints and solvents, road and construction, steel and aluminium smelting, are heavily reliant upon these feedstocks provided by the refining sector, which in many cases would be difficult to replace.

3.1 Overview of the UK industry

UKPIA members supply just under 90% of the inland demand for petroleum products and own or operate:

- 8 crude oil refineries with the 4th largest refining capacity in Europe
- 1500 miles of privately owned oil product pipelines, supplemented by a government owned system linking major airfields in the UK
- 39 major distribution terminals (with over 100 smaller terminals, many owned by independent operators)
- Around 2,200 of the UK's 8,787 service stations; and
- support the employment of 150,000 people connected with the downstream oil sector

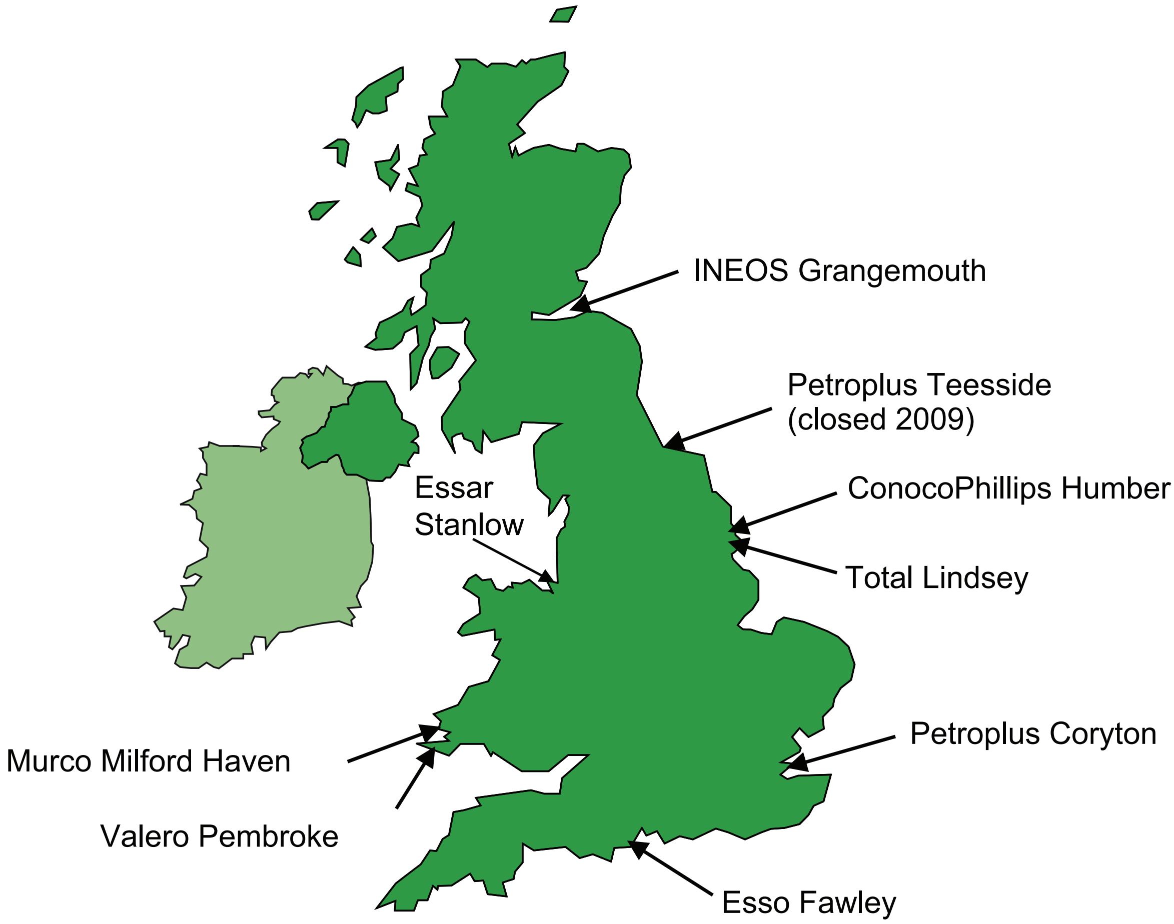
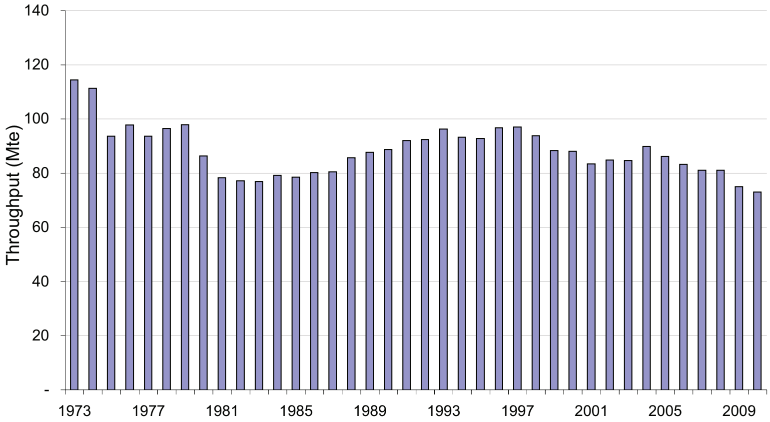


Figure 3.1: Map of UK refineries

The oil refining industry in the UK, and the associated supply and distribution network, has evolved over many years. Much of the expansion in refining capacity came in the period from the mid 1950s to early 1970s, with the bias towards provision of petrol for cars and fuel oil for power generation. Since the early 1970s, demand for fuel oil has significantly reduced with the move to gas powered power stations; in the last two decades demand for middle distillates, such as diesel and jet fuel, has increased to the point that it exceeds the supply capacity of UK refineries, and petrol demand has steadily declined since the peak reached in 1990.

Changing patterns of demand combined with the legislative background and more recently volatile commercial conditions, have increased the pressures upon the refining sector. Since 1990, three oil refineries have closed, the most recent in 2009; of the eight remaining operational refineries, two have changed hands in 2011 and buyers are being sought for a further two.

Chart 3.2: Refinery throughput 1973-2010



(Source: DECC, DUKES)

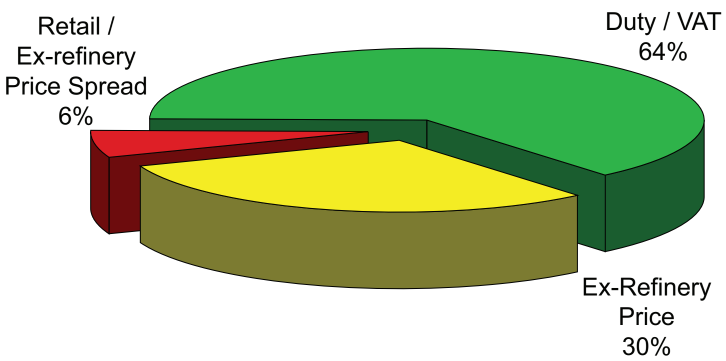
3.2 Benefits

3.2.1 Consumers and the economy

The downstream oil industry has a reputation for responding positively to UK policy initiatives. Examples include early introduction of cleaner fuels - the move to 50ppm sulphur and subsequently 10ppm 'sulphur free' petrol and diesel. These changes contributed to improved air quality throughout the UK by enabling the introduction of advanced vehicle technologies. The industry has also acted in a timely manner with the introduction of biofuels under the Renewable Transport Fuels Obligation.

Over the last decade, the UK pre-tax price of petrol and diesel has been consistently amongst the cheapest in the EU *(Source: Wood Mackenzie: comparison of major brands)*, partly because of the well developed refining/distribution infrastructure allied to efficient export/import facilities. In recent years, the rise in underlying crude and product prices has slightly reduced the proportion of the cost price made up by duty and VAT, despite increases in the tax element. Of the average major brand pump price of 117.3 pence per litre in 2010, duty and tax accounted for just under two-thirds of the total.

Chart 3.3: Average major brand pump price 2010



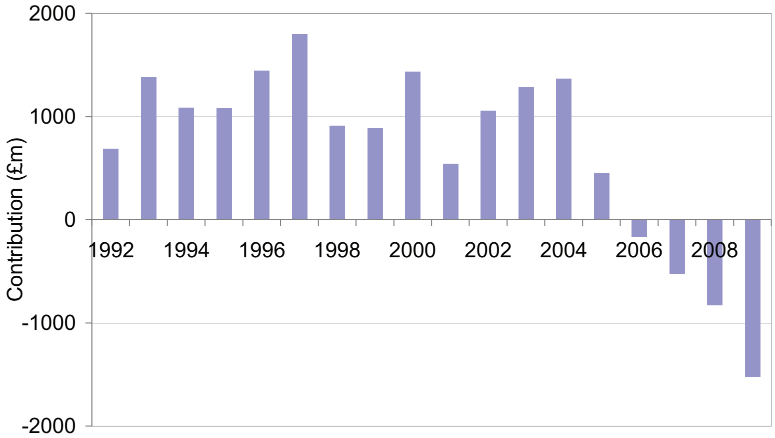
(Source: Wood Mackenzie)

The capacity and efficiency of the country's refining and distribution infrastructure is a significant factor in helping to deliver these benefits. The industry has made significant investment (an average of £550 million per year over the 10 years to 2009) to develop and maintain this infrastructure and meet tighter operational, safety and environmental standards as well as delivering cleaner fuels.

The overall value of UK refining to the UK economy is difficult to estimate but broadly encompasses the value of the output of finished products from refineries less the cost of crude oil/intermediary feedstocks processed (net refining benefit). A Wood Mackenzie study in 2007 for DECC *(Review of UK Oil Refining Capacity)* placed a value of over £1.5 billion per year to the UK from refining output. A 2010 study for DECC by Deloitte *(Downstream oil-short term resilience and longer term security of supply),* attempting to value the UK GDP impact of a potential supply disruption and market failure, put an aggregated annual value of £260 billion upon UK refining output.

In the five years to 2006, the refining sector made a significant net contribution to the UK balance of payments by exporting finished products overseas. The increase in net diesel imports since 2006 has reversed this trend but UK refineries export substantial volumes of petrol to countries that include the USA, Ireland and mainland Europe. However, both structural and demand changes pose threats to these export sectors and combined with the growing level of finished product imports, represent an additional strain on the UK's balance of payments.

Chart 3.4: Oil refining contribution to the UK's balance of payments



(Source: DECC)

UK refineries, as well as making a sizeable contribution to the national economy, form a substantial part of each of their local economies. Data from a UKPIA member company indicates that each large refinery injects approximately £60 million into the local economy each year. In many instances, given the location of these refineries and in some cases the comparative lack of other large scale industrial activities, their loss would have a major impact upon the local economy of these areas.

The oil industry supplies vital feedstocks to the UK's 3,000 chemicals businesses which have a combined turnover exceeding £57 billion per annum, employ over 180,000 people and represent around 12% of value added in manufacturing, equivalent to 1.5% of the UK's GDP. *(Source: CIA 2009 data).*

The industry also meets the UK's compulsory oil stocking obligations (67.5 days of inland market demand) in compliance with EU/IEA requirements. This entails additional tankage over and above operational requirements and is an additional working capital cost. In the future the 67.5 days obligation will increase as the present derogation, associated with UK North Sea oil production, is removed around 2020.The industry meets the UK's stocking obligation at no cost to the Exchequer.

3.2.2 Security of supply

Currently the domestic UK oil refining industry, with its good links to other European refiners and access to North Sea crude oil (from both the UK and Norwegian sectors), provides the UK with a secure, reliable and economic source of transport fuels and other petroleum products. As supplies of crude oil from the North Sea decline, the UK's security of supply for oil products can be maintained by a strong and healthy refining sector, able to process a range of crude oils from diverse sources, domestic or overseas.

The market for refined petroleum products is global by nature, and although domestic production of key fuels gives added flexibility in the event of external disruptions or emergencies, in recent years the growing deficit in middle distillate products- diesel and aviation fuel- has resulted in an increased level of imports.

Crude oil and oil products, which can be easily stored, therefore deliver excellent security of supply against a wide range of scenarios. At the moment, the UK's comprehensive infrastructure of refineries, pipelines, storage terminals, delivery logistics and service stations ensures a robust and dependable supply for the country. This infrastructure can provide a quicker and more flexible response to maintaining energy supplies in the event of disruption or emergencies. This was clearly demonstrated after the incident at Buncefield in December 2005, which significantly cut road fuel supplies to the South East of England and jet fuel supplies to Heathrow Airport. However, the loss of much of the road fuel capacity of Buncefield since then has reduced the resilience of road fuel supply in the area served.

Increased reliance upon imported products is a feasible solution to meeting the product imbalances from external sources that the UK faces; many other EU countries are in a similar position of increased import reliance. However, the extent to which this may compromise the UK's security of energy supply and resilience remains uncertain and is highly dependent upon the accuracy of assumptions about global future demand increases, product mix and surplus refining capacity. Although closed refineries in suitable locations may be modified (subject to commercial factors) to become import and storage terminals, an increase in product imports and exports at existing refineries has implications for import jetty and storage capacity as well as the UK's ability to meet compulsory oil stocking obligations from domestic sources.

Given the greater liquidity of the global crude oil sector, a strong refining and distribution base enhances the UK's ability to react with maximum flexibility to both domestic and worldwide supply crises by optimising its crude oil conversion and storage capability. The alternative is a greater reliance on imports, which themselves may be subject to local pressures and supply chain vulnerability particularly for 'in demand' middle distillate products. These pressures could become greater in the future with the likelihood of further refinery closures in the EU and, coupled to increasing demand from Asia, could reduce liquidity of supply.

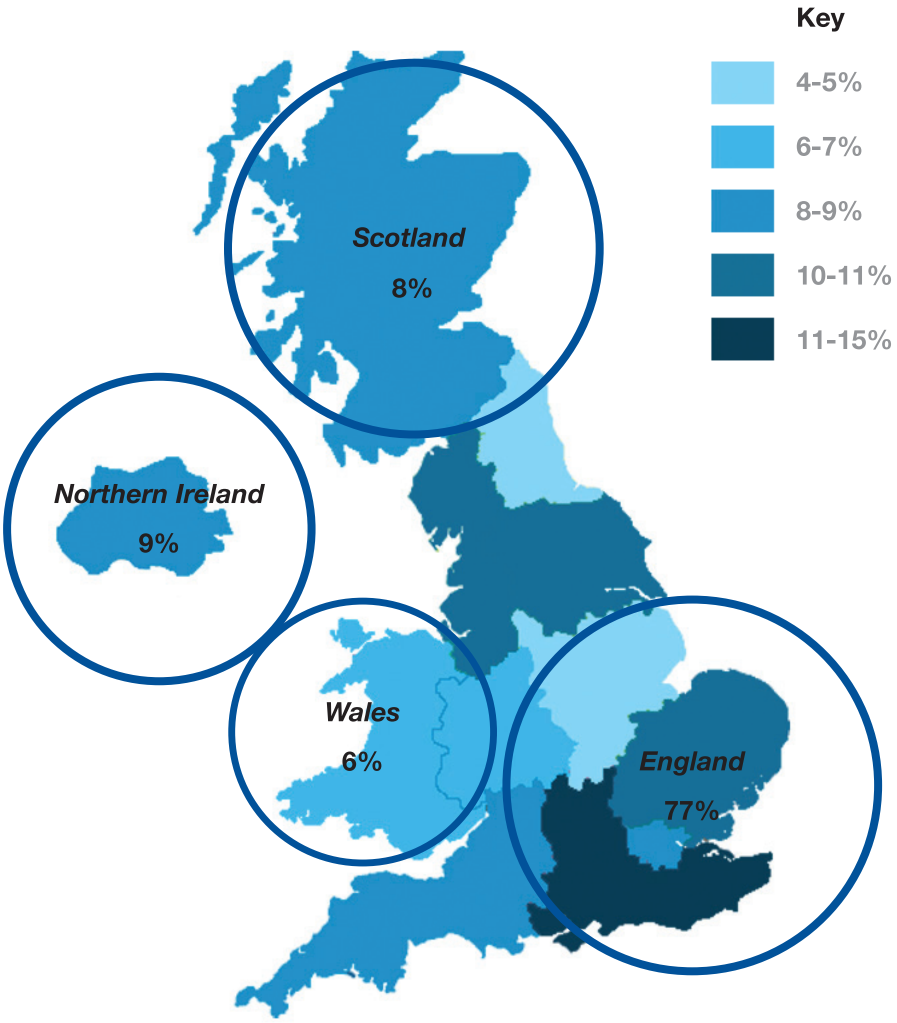
The Government recognises these challenges and DECC, in conjunction with the industry, have been working on a study looking at UK refining and distribution infrastructure resilience.

3.2.3 Employment, skills, technological expertise and other industries

The oil refining industry has been a significant UK employer and source of innovation for many years. Some of the innovations include the UK privately owned pipeline infrastructure, computer controlled logistics and terminal sharing by companies.

UK refineries provide direct and indirect employment and training for skilled workers. The downstream oil sector as a whole supports the employment of over 150,000; an estimated 53,300 people directly in oil refining, terminals and operations, distribution, filling stations and head offices plus a further 97,000 estimated for the contractor workforce and supporting roles. *(Source: Cogent Sector Skill Council)*

Chart 3.5: Cogent employment distribution for the downstream oil industry



Region and Nation	Employees	
East	5,135	10%
East Midlands	2,921	5%
London	4,140	8%
North East	2,055	4%
North West	6,044	11%
South East	7,884	15%
South West	4,101	8%
West Midlands	3,472	7%
Yorkshire and N Lincs	5,360	10%
England	41,110	77%
Scotland	4,165	8%
Wales	3,021	6%
Northern Ireland	5,000	9%
Total*	53,296	100%

*industry estimates can exceed ABI employee and employer data due to contractor workforce and SIC limitation. Cogent has estimated an additional 97,000 employees for the Petroleum workforce.

Refineries bring income and employment to the areas where they operate and in some cases there may be limited alternative opportunities for jobs of a similar level of skill or income.

The UK oil refining industry also fosters skills, knowledge and expertise in associated scientific, engineering and technical disciplines associated with refining, fuel technology, lubricants and environment. Historically, the UK has produced a significant number of chemical and mechanical engineering graduates (both UK and overseas nationals). With declining demand for graduates from the refining and petrochemical sectors, engineering schools have contracted and the viability of a number of university engineering courses could be at risk, despite the efforts of organisations such as Cogent. The retention of this expertise and development of this knowledge base within universities and elsewhere is vital if the UK is to play a lead role in refining and other evolving alternative energy technologies in the future.

In addition to creating employment in its own right, the UK's domestic refining capability creates wealth and employment in related petrochemicals and manufacturing industries. Essential products include aviation and marine fuels; fuel oil for power generation; heating oil for homes, hospitals, factories and schools; petroleum gases, used mainly in industry but also as an alternative motor fuel; butyl rubber for a wide range of applications; bitumen for roads and roofing; petroleum coke, used in steel making and aluminium smelting, and lubricants for all kinds of engines and machinery.

3.2.4 Environmental benefits

UK oil refineries have a record of responding positively to Government policies aimed at early adoption of cleaner fuels in support of new vehicle exhaust clean-up technologies. Unleaded petrol and ultra low sulphur fuels were all launched in the UK in advance of many other EU countries. Such flexibility for future changes could be lost if the UK was heavily reliant on imports.

Over the 10 years to 2009, an average of £550 million per year has been invested in refining, distribution and marketing fixed assets. This has mainly been aimed at reducing the environmental impact of products and operations, process safety enhancements, improving energy efficiency at refineries through improved energy management of refinery processes and construction of Combined Heat and Power (CHP) units *(Source: UKPIA aggregated survey of published financial accounts).* Around £600 million of this was associated with the move to sulphur free diesel and petrol.

This strong local supply base is essential to retaining technical expertise, stimulating innovation within UK manufacturing and preventing its disappearance overseas. As in many other areas of UK manufacturing, this may not have an immediate impact, but a cumulative effect since skills, expertise and innovative new technologies would be lost to overseas competitors. The oil industry also underpins a number of service industries such as engineering contractors. In the absence of a UK refining industry these support services are likely to go overseas, while some smaller local subcontractors could be driven out of business.

Case Study Valero Pembroke refinery economic & community contribution

Background

The refinery, officially opened in 1964, is located on 550 acres (223 hectares) in West Wales in a coastal location adjoining the Pembrokeshire Coast National Park.

It has a refining capacity of over 10 million tonnes per year and is capable of processing 220,000 barrels of crude oil per day ranking as the fourth/fifth largest in the UK. Output comprises about seventeen different products, including petrol, diesel fuel, kerosene and liquefied petroleum gas petrochemical feedstocks. Pembroke produces 3.5 million gallons of petrol each day, which is about 50 percent of the refinery's total production. Finished products are distributed by a mixture of pipeline (to the Midlands and Manchester), road and sea.

It is the longest established energy company on the Haven waterway. The crude oil terminal is capable of handling tankers of 275,000 tonnes deadweight.

Around 560 Valero employees and 820 contractors are on site each day with considerable increase in numbers when the refinery carries out planned shutdowns or turnarounds. It is the largest private sector employer in the county, second only in size to the public sector employees of the local authority. It is the largest client of the Milford Haven Port Authority.

Workforce

There are 560 employees many of whom live nearby.

Modern apprenticeships are offered in process operations, instrumentation, electrical or mechanical maintenance. The recent intake attracted 121 applicants for 12 positions and there are 44 ongoing apprenticeships.

Four Valero bursaries are offered each year.

Impact across Wales

Contractors from across Wales and the UK supply a wide range of services to the refinery, including roofing, air conditioning, IT support, water management, lifting equipment, structural and building services, electrical instrumentation, and multimedia services.

In 2009, Valero Pembroke interacted with 85 local companies. The overall value of this spend to those businesses is £24.5 million per year.

In total, around 900 companies provide services to the refinery.

Financial contributions

It is estimated that each employee's remuneration may sustain a further 4.5 jobs in the Pembrokeshire economy. Approximately £65 million is injected into the local economy each year through salaries, business rates and local labour.

Community support

For over 20 years the Pembroke Refinery has been well known for its support of the communities within the county with particular focus on culture, education, sport and human need. Pembroke Refinery also supports Welsh National Opera.

Its support of Pembrokeshire Sport (the county council's sports development arm for school and community sport) is the longest running sports partnership in Wales.

Music and cultural festivals in the county's main towns are part of the refinery's community engagement and the refinery's additional sponsorship enables visiting leading orchestras to entertain local audiences. The refinery was awarded the Wales partnership award in the Prince's Trust annual "Celebrate Success" awards for its environmental partnership creating the Pwllcrochan Environmental Centre. The centre is now a resource for the community and hundreds of school children from local schools visit throughout the year. The refinery's partnership with the Pembrokeshire Coast National Park affords educational opportunities for children from across the county to study wildlife and biodiversity at this unique centre.

4.1 Introduction and background

Reducing carbon emissions under legislative and other frameworks whilst meeting our energy needs in a secure way, will require all options being kept open to ensure the UK has access to diversified energy supply sources. In some industrial sectors, petroleum-derived feedstocks may be difficult or impossible to substitute with alternatives.

Chapter 1 examined future supply and demand forecasts to 2030 broken down by fuel type (Chart 1.5), which indicates that overall UK fuel demand for transport (excluding biofuels) is likely to plateau or fall, due to a decline in road fuel demand only partially offset by the aviation sector. However, uncertainties remain as to the future product demand split because of macro-economic factors and a wide range of legislative policy impacts.

For technical and practical reasons, engines powered by petroleum-derived fuels have predominated in road, aviation and marine transport for over a century and will remain so for several decades. The advantages of these fuels are that they are easily manageable, affordable, familiar to consumers, and deliver a specific energy content that helps give engines a good power-to-weight ratio allied to a long range between refuelling.

A range of alternative fuels are starting to be introduced in the UK and will continue alongside petroleum-derived fuels as the energy supply mix evolves.

However, many of these alternatives require time and substantial investment to turn them into commercially viable solutions. At the moment most are neither available on a scale to match petroleum products nor cost competitive and thus may require either taxpayer-funded subsidies (directly or indirectly) or policy measures to encourage their uptake in the future.

Comparison of the GHG savings from different energy sources and vehicle technologies is a highly complex but vital part of measuring carbon emissions. It entails analysis of whole life-cycle emissions associated with producing the fuel and use in a vehicle, commonly called 'wells-to-wheels' analysis, rather than the emissions solely at point of use - 'tailpipe' emissions. Annex 3 contains a chart summarising the main WTW comparisons of fuels based on research undertaken by the European Commission's Joint Research Centre, Concawe and Eucar. This should be read in conjunction with the JRC/Concawe/EUcar study *(http://ies.jrc.ec.europa.eu/uploads/media/WTW_Report_010307.pdf and V3.1 JEC Concawe TTW 07102008)*

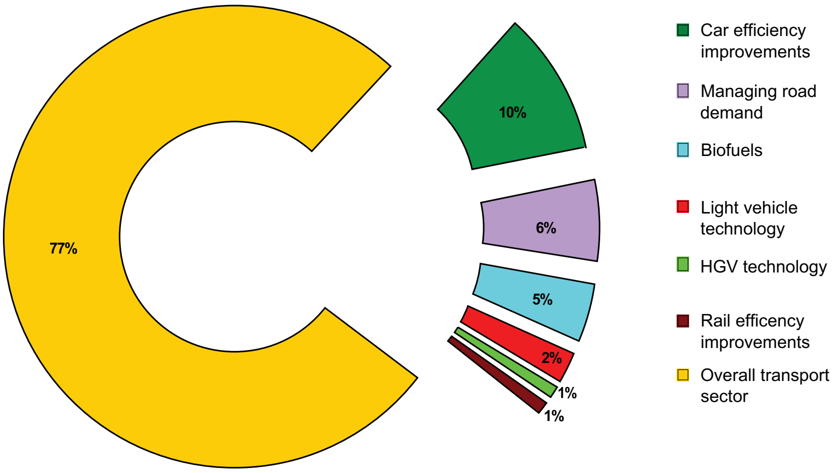
All transport sectors are expected to meet carbon reduction targets through a combination of energy efficiency improvements and new fuels and technologies. These targets have significant implications for overall oil and products' demand and the future shape of the UK refining sector.

Behavioural change, allied to technology innovation, will become increasingly significant in helping to meet legislative carbon reduction targets. Focus should be maintained on encouraging energy efficiency and responsible use of energy in all sectors and the Government should strive for open debate of the costs to industry and consumers, alongside the expected benefits.

4.2 Future CO_2 projections from transport

Chart 4.1 below contains an indication of how the target of reducing surface transport CO_2 emissions by 39 million tonnes per year by 2020 might be met.

Chart 4.1: Transport CO_2 emissions-road map to 2020



(Source: CBI 'Going the distance' 2009)

The main contributors are seen as car technology improvements, managing road demand (directly and via fiscal measures), biofuels, improved efficiency from light commercial vans and heavy goods vehicles.

In the UK, the main reduction in CO_2 emissions derived from transport fuels is envisaged to be based upon introduction of biofuels blended with conventional petrol and diesel. The Renewable Transport Fuel Obligation, which commenced in April 2008, requires fuel suppliers to meet a 5% by volume biofuel content in road fuels in 2013/14, which fuel suppliers are on target to meet, progressing from a base of 2.5% in 2008/9. This legislation will be amended in 2011 by the implementation of the 2008 EU Directives on Renewable Energy (RED) and Fuel Quality (FQD). These effectively mandate greater use of biofuels and alternative energy by the year 2020. Under the RED a 10% by energy biofuel target for the transport sector has been set, with the FQD also requiring fossil fuel suppliers to reduce their GHG emissions by 6%. The RED rules will require tighter reporting of carbon saving and sustainability. Also Indirect Land Use Change (ILUC) will have to be taken into account.

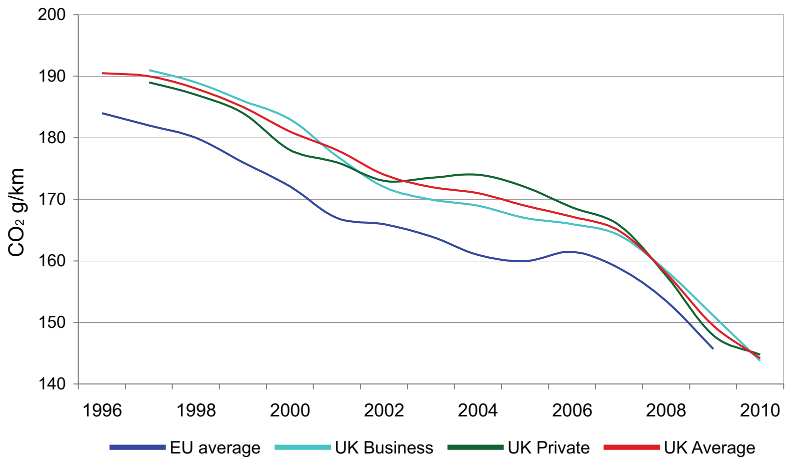
4.3 Road transport

4.3.1 Technical progress

Internal combustion engines, despite improvements in technology, are still only 25-30% efficient depending upon the fuel. Gains in vehicle efficiency through powertrain improvements, reduction in vehicle weight, drag and rolling resistance, and energy recovery/storage systems have scope to further reduce fuel consumption over the coming decades. These improvements will be augmented and facilitated by alternative fuels.

The level of CO_2 emissions from cars in the UK has been virtually flat since 1990-2008 but those from vans and HGVs have increased by 64% and 3% respectively. Overall the transport sector in the UK accounts for 22% of total CO_2 emissions *(Source: National Atmospheric Emissions Inventory 2007).*

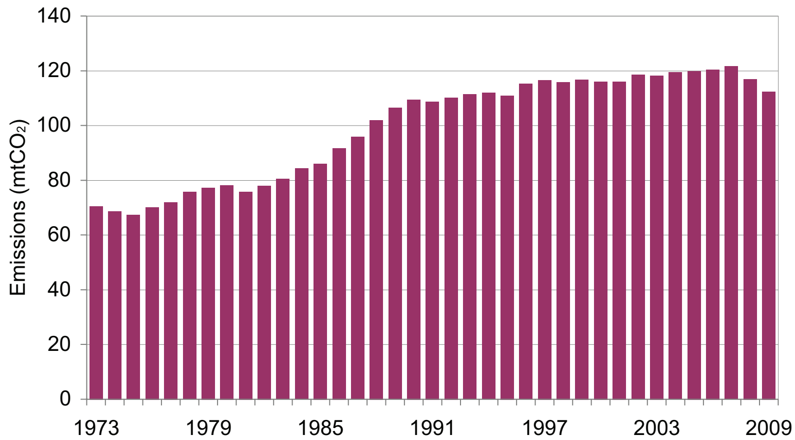
Chart 4.2: Average CO_2 emissions from new cars



(Source: SMMT/EC)

UK average new car CO_2 emissions have declined more rapidly since 2006 through a combination of more efficient vehicles and a move to diesel power despite an increase in the number of registered vehicles and miles driven until the recession of 2008-9.

Chart 4.3: Road Transport CO_2 emissions



(Source: DECC/AEA figs)

4.3.2 Fuels - conventional, biofuels and gaseous

A range of alternative transport fuels is available in addition to conventional petroleum-derived fuels, including biofuels (including biogas), liquid petroleum gas (LPG), compressed natural gas (CNG) and hydrogen, although the latter has very limited availability.

Biofuels

At the moment the main biofuels are conventional 'first generation' biofuels derived from processes using food crops, vegetable and animal oils as feedstocks. Advanced biofuels, so called 'second generation', are fuels produced using a range of technologies. For example, ethanol produced by breaking down the lignocellulose in straw/wood and then fermenting this to produce ethanol and biodiesel from Fischer-Tropsch synthesis of gases obtained from gasification of woody biomass. These advanced biofuels can increase fuel production per hectare and have the potential for greater CO_2 reductions, depending upon the treatment of co-products, (including heat obtained from the processes used), also avoiding indirect land use change (ILUC) associated with some first generation biofuels. The use of advanced biofuels may also avoid some of the technical issues associated with first generation fuels making this a more acceptable solution for motor manufacturers and consumers alike.
(See Annex 5 for an outline of first and second generation biofuels)

Meeting the requirements of the EU Renewable Energy Directive for a biofuel content of 10% by energy by 2020, poses some logistical issues on forecourts in addition to the technical issues associated with biofuel production. This will probably mean two petrol and two diesel grades on forecourts that have available tankage flexibility; high and low bio-blend grades to meet the fuel specification needs of current vehicles on the road and the higher blend capabilities of new vehicles coming to market:

Petrol
- E5 - current & 'protection grade' in future
- E10 - potentially available post 2012
- E15+ - potentially available around 2015

Diesel
- B7-current & 'protection grade' in future
- B12+ -potentially available around 2015

Fuel standards are agreed EU-wide and need to be consistent with the capabilities of the range of vehicles on the road. For consumers, the introduction of new fuels needs to be relatively seamless. Making sure consumers use the correct blend will be central to meeting regulatory targets for renewable fuels and energy reduction, whilst at the same time avoiding potential damage to engines from the use of an inappropriate fuel.

Gaseous fuels

LPG (propane and butane gases derived from refining), LNG (Liquified Natural Gas) and CNG (compressed natural gas, mainly methane) have been used to a limited extent in internal combustion engines for some years. They have advantages in terms of improved local air quality but their use to date has largely been based upon fiscal incentives.

For vehicles, dedicated storage and refuelling facilities are required, combined with on-board fuel tanks that are heavier and larger than those required for conventional petrol or diesel. This has tended to limit uptake. In car applications, LPG or auto-gas has been used in combination with petrol to give the vehicle a bi-fuel capability.

Hydrogen as a fuel either in an internal combustion engine or as an energy source for a fuel cell, faces a large number of challenges related to cost, storage and production of hydrogen. Demonstration vehicles and fuelling infrastructure have been produced in recent years but research by the oil industry, vehicle manufacturers and research bodies is ongoing to overcome some of the technical and cost hurdles.

4.3.3 Future fuel developments

Fuels

Future developments in alternative fuels include 'second generation' biofuels converting biomass into liquid fuels (BTL) via lignocellulosic processes or gasification of woody waste or straw by Fischer-Tropsch, and 'third generation' processes such as photosynthesis of algae or microbes to produce biofuel blending components.

The use of biomass has advantages in terms of not using land for food crops and better incorporating waste streams but has the disadvantage that generally large volumes of material are required so proximity to the process plant is vital.

Although only at the preliminary demonstration stage, photosynthetic algae processes have a number of potential advantages. They can be grown using land and water unsuitable for plant or food production, absorb CO_2 during the development phase and can produce bio-components with similar make-up to petroleum products, facilitating blending with conventional fuels such as aviation kerosene.

Hydrogen fuel-cell powered vehicles (FCVs) continue to be developed by a number of manufacturers, as well as vehicles using hydrogen as a liquid fuel in a modified internal combustion engine (ICE). FCVs have the potential to deliver low emissions of greenhouse gases with some hydrogen production routes, whilst overcoming some of the performance and range limitations of battery electric vehicles (BEVs). However, the processes of extracting hydrogen from source material such as natural gas or water are energy intense so, as with BEVs, Wells-to-Wheels CO_2 savings require the use of zero carbon or low carbon renewable/CCS energy sources. Safe fuel distribution and storage remains a major hurdle for hydrogen as an entirely new, expensive distribution infrastructure would be required. Furthermore hydrogen still requires improvements in reliability and reductions in production / distribution costs. For these reasons, the widespread use of FCVs in road transport still looks some way off and they may have more potential in the shorter term for small scale portable power applications.

4.3.4 Vehicle and engine developments

A study by Ricardo in 2010, a leading global provider of product innovation and engineering solutions in the transportation sector, outlined a powertrain technology roadmap indicating the type of technology and alternative energy developments that are likely to make contributions to improved vehicle efficiency and reduced emissions. It highlights the fact that incremental powertrain improvements are the most cost-effective route to improving efficiency and reducing CO_2 emissions, with petrol and diesel engines having a significant cost advantage in relation to other options.

Ricardo's global predictions indicate that by 2030 hybrid and plug-in hybrid vehicles (PHEV) are expected to grow in market share mainly at the expense of diesel vehicles, due to emission cost compliance factors, with electric vehicles (EV/BEV) starting to grow from 2012.

4.3.5 Likely pathways to a more diverse energy mix in road transport

In the context of the UK market, a report for the Government was commissioned from the New Automotive Innovation and Growth Team (NAIGT) in 2009 to look at the challenges and opportunities for the UK motor industry over the next 20 years, arising from the move to a lower carbon future.

The technology roadmap identified the technologies required to deliver one of the key drivers for the automotive sector, namely CO_2 reduction, and broadly echoes the findings of the Ricardo study. *(see NAIGT report http://www.bis.gov.uk/files/file51511.pdf)*

4.3.6 Electric vehicles

Electric vehicles fall into two main categories; full battery electric vehicle (BEV) and plug-in hybrid (PHEV) that work in conjunction with an internal combustion engine (ICE).

The advantage of a BEV is that it has zero tailpipe emissions compared with a vehicle powered by an internal combustion engine using fossil fuel. This brings benefits for local air quality as well as reducing noise pollution. For these reasons and to reduce fossil fuel dependence, government policy in the UK is aimed at fostering the uptake of electric vehicles.

The zero emissions, however, are only at the point of use; in order to charge the battery, electric power is required that in turn will have generated CO_2 emissions at a power station unless the source is wholly renewable or zero carbon. The use of well- to- wheels studies is therefore essential to give a fair comparison between options with different patterns of emissions from use and production. (See Annex 3)

Consumer resistance to electric cars is a major hurdle. They give good acceleration allied with low noise but generally have a lower sustained speed capability, carrying capacity and range in comparison with a petroleum fuel powered vehicle. This is because of the lower specific energy of batteries currently available and the weight of the battery power pack. The initial purchase cost is higher than a conventional car, (requiring consumer subsidies to encourage uptake), although the cost of overnight re-charging is low. However, with current battery technology, full re-charging can take a significant time and for this reason electric vehicles are more suited at the moment to urban or shorter range commuter type journeys, rather than long journeys.

The main technical challenges with current battery technology are performance, payload, range, cost and battery life, linked to the trade off between the battery energy density (driving range) and power density (charging/discharge rate). BHEVs may be an interim step to overcoming some of the performance/range problems until such time as a step-change from current leading lithium-ion battery technology to the next generation advanced lithium-ion batteries is achieved.

There are also wider implications for power generation and grid distribution, infrastructure for re-charging, as well as the availability of some of the raw materials used in batteries and electric motors.

For these reasons, and barring a major breakthrough in energy storage and cost, it seems unlikely that BEVs can make a major contribution to reduced global CO_2 emissions within the next 15 years. This view is supported by the IEA World Economic Outlook 2010 'New Policies Scenario' that forecasts that EVs and BHEVs will account for less than 3% of new car sales globally by 2035.

4.3.7 Heavy goods vehicles and buses

Heavy goods vehicles (HGVs) account for around 20% of road transport CO_2 emissions *(DfT Road Freight Statistics 2007)* and along with vans/light goods vehicles have been the main growth area.

A shift to other transport modes offers limited scope to reduce HGV/LGV fuel demand given the complexities of modern distribution and freight movements. For this reason, emphasis is upon reducing the emissions of vehicles. Areas of focus are upon aerodynamics, engine efficiency, low rolling resistance tyres, transmission systems and hybrid drive systems as well as energy recovery/storage systems.

A recent Ricardo study *(Ricardo study for DfT/Low Carbon Vehicle Partnership (http://www.lowcvp.org.uk/),* based on a 1,500 kilometres UK test route, concluded that 52% of HGV vehicle energy consumption is used in overcoming rolling resistance and 35% to overcome aerodynamic drag, so action to improve these aspects of performance could have a significant effect upon fuel consumption.

Similar technology is applicable to buses and in addition buses may be more appropriate for introduction of hybrid drive where they are operating in an urban environment.

4.4 Aviation

4.4.1 Aviation fuel demand and alternative fuels

Aviation turbine fuel (Avtur, commonly referred to as jet fuel) is a middle distillate kerosene product, produced to very exacting internationally agreed quality standards in order to meet the tough operating conditions under which aircraft operate.

The move to mainly jet powered aeroplanes, combined with higher living standards and the expansion in lower cost airlines has resulted in jet fuel demand growing strongly over the last 30 years. UK demand has increased substantially from 8 million tonnes in 1997 to 11.1 million tonnes in 2010 (down from the peak of 12.6 million tonnes in 2007), partly because of the position of international hub airports in London and a high proportion of long-haul flights.

Increasingly, this demand has been met by imports, mainly from the Middle East which in recent years have been averaging 6 million tonnes per year, equivalent to ~40% of UK jet fuel consumption.

In 2007, the DFT published its *UK Air Passenger Demand and CO_2 Forecasts to 2030,* which were updated in 2009 and in August 2011 in the light of GDP projections, oil price and other influences. The central forecast for passenger numbers indicates a near doubling by 2030 versus 2005. The implications for fuel demand are less certain because of variables such as future airport capacity (extra runway capacity), aircraft fuel efficiency improvements, aircraft size/mix and modal switches particularly for short-haul flights, as well as considerations such as environmental impact and GDP growth. This is the subject of ongoing work by a joint DECC/DfT industry task force and although still incomplete in the light of recent policy indicators, it is estimated that UK demand for aviation fuel will increase to around 19 million tonnes by 2020 and 23 million tonnes per year by 2030. *(DECC/DfT)*

Research into possible alternatives to conventional jet kerosene fuel is ongoing. However, understandably the aircraft industry and its suppliers are very conservative about matters affecting safety. They also have very significant capital investment in engines, aircraft and fuel systems. Therefore, ideally, alternative fuels need to be ‘drop in’ replacements, meeting existing specifications and providing equivalent engine and system performance, component life, maintenance frequency and storage and handling characteristics.

The UK Climate Change Committee projections of scenarios for biofuel penetration in aviation, based on data from IEA and E4tech and the recent European Commission funded SWAFEA (Sustainable Way for Alternative Fuel and Energy in Aviation) study, indicates limited penetration before 2030.

4.4.2 Policy influences upon demand

The UK Government has set a challenging target to reduce CO_2 emissions from aviation to below 2005 levels by 2050 by a combination of market-based measures (inclusion of aviation under the EU ETS from 2012 onwards), more efficient aircraft, alternative fuels and improved ground control /air traffic management. The DfT issued a consultative scoping document in 2011, *'Developing a Sustainable Framework for UK Aviation',* seeking views on the way forward.

Action in this sector will dovetail with EU level initiatives such as The Advisory Council for Aeronautics in Europe (ACARE) projects targeted to reduce CO_2 emissions of new aircraft by 50% (per passenger kilometre) in 2020 in comparison with 2000. These reductions are projected to come from airframe improvements (25%), engine efficiency (15-20%) and air traffic management (5-10%). The recent publication of the European Commission's *'Flightpath 2050'* study seeks to stretch these targets further to a 75% reduction in CO_2 emissions per passenger kilometre by 2050.

4.4.3 Technical developments

A study by the International Air Transport Association in 2009 *(IATA study 'A global approach to reducing aviation emissions')* gave an indication of the likely contribution of new technologies to improved energy efficiency and reduced emissions up to 2020 and beyond.

As part of the ACARE project further reductions by 2020 are planned through redesign of airspace corridors, improved ground operations and better air traffic control, all designed to reduce inefficiencies, delays and taxiing time on the ground.

4.5 Rail

4.5.1 Diesel/Gas oil demand

Around 40% of the UK rail network is electrified covering the busiest main lines and commuter routes. However, there remains substantial parts of the network - for example services to the West and far SW of England, cross-country and some freight - which is still reliant upon diesel/diesel-electric power. Current consumption of diesel/gas oil for this sector amounts to ~0.6 million tonnes per year. *(Source: DECC, DUKES/UKPIA)*

The Government has plans to electrify further parts of the network with the greatest passenger numbers. However, it is unlikely, given the technical challenges and economics, that diesel powered trains will be wholly phased out from the network.

4.5.2. Technical developments

The gas oil used to power diesel trains will move to a lower sulphur specification in 2012, with a biodiesel content similar to that of road diesel. However, there is little scope in the medium term to increase the biofuel content of gas oil beyond the current equivalent B7 road grade.

Rolling stock design is focussing upon more efficient bi-mode diesel/electric power, regenerative braking and lighter construction together capable of delivering up to 15% fuel consumption reduction in comparison with current rolling stock. *(Source: DfT)*

4.6 Marine

4.6.1 Bunker fuel demand

Marine bunker fuel demand (heavy fuel derived from heavy bottom of the barrel output from refineries) has been very much driven by the development of international trade, with the emergence of China and the Far East as significant manufacturers of consumer and capital goods. Shipping offers comparatively high efficiency in terms of CO_2 per tonne of freight. UK shipping accounted for 7% of UK transport GHG emissions *(Source: National Atmospheric Emissions Inventory 2007).*

UK bunker fuel demand was 2.1 million tonnes in 2009 *(Source: DECC, DUKES)*, but much of the refinery output of heavy fuel oil for bunkers is exported. EU marine bunker fuel demand is likely to continue growing and is forecast to be around 50-57 million tonnes by 2020 *(Source: ENTEC study).* However, a key concern for refineries is the future specification of marine fuel and whether it will move to a middle distillate type specification (closer to diesel) or remain orientated to heavy fuel oil. This is driven by legislation, effective in the period from 2015 onwards requiring lower sulphur content in Emission Control Areas (ECA) and proposed changes in 2020 under IMO MARPOL VI. These changes will potentially increase refinery CO_2 emissions in producing lower sulphur fuel and reduce the available refinery pool of middle distillate diesel. An alternative may be to install on-board systems to remove sulphur emissions from ship exhaust stacks.

4.6.2 Technical developments

Current measures to improve the fuel efficiency of ships are focused on areas such as improved rudder and propeller design, reducing hull drag through better design and use of low friction paints, waste heat recovery, LNG powered auxiliary power units, optimised water cooling/re-circulation and slower steaming speeds combined with better routing according to weather patterns or conditions. These measures individually are estimated to deliver fuel savings of between 2-12% *(Source: Greenship).*

The International Maritime Organisation (IMO) is also involved with a range of stakeholders examining alternative fuels and power systems assisted by wind, solar and fuel cell sources, to improve efficiency and further reduce energy consumption of ships. The Marine Environment Protection Committee (MEPC) of IMO is working to achieve adoption of non-prescriptive energy efficiency ship design measures and energy planning that could be adopted under MARPOL VI.

Currently ISO fuel standards do not include biofuel blends although marine bunker fuel specifications are changing from 2015 onwards to lower sulphur content as noted above.

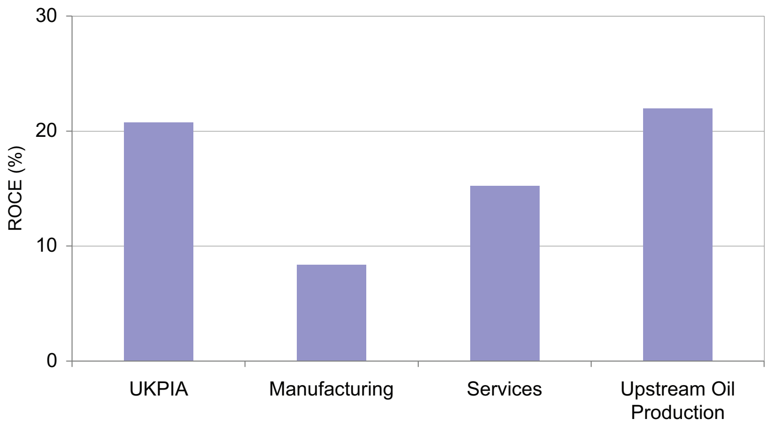
5.1 Current and future challenges

The refining sector faces challenging conditions, through a combination of low returns, additional investment requirements to meet tightening environmental standards and product specifications, and increased competition from refineries in Asia.

5.1.1 Weak commercial climate and low investment returns

The financial returns in oil refining and marketing have usually been low, certainly in comparison with upstream oil and gas production, the manufacturing sector as a whole or the retail/consumer sectors. The return on capital employed of UKPIA member companies has averaged 8.1% over the period 1991 to 2009.

Chart 5.1: UKPIA members' average return on capital employed (ROCE)



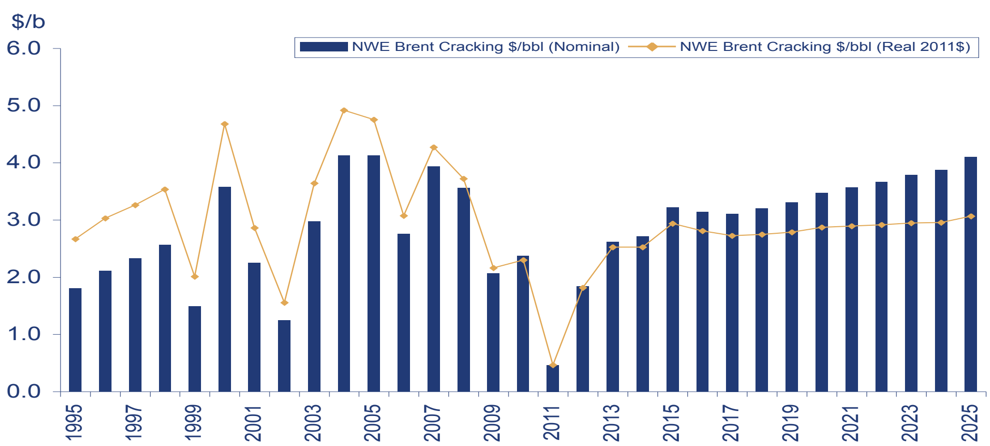
(Source: UKPIA/ONS)

These low returns and competitive market conditions have focussed companies on making their refining and marketing operations as efficient as possible but have also triggered other responses including withdrawal from all or parts of the sector.

Energy analysts Wood Mackenzie in a number of studies forecast that weak refining margins in NW Europe will continue during the current decade. Their more recent analysis for the European Commission *(Wood Mackenzie/Ricardo report October 2010; 'The impact of biofuels on oil refining')* showed that 29 of the 96 refineries in the EU did not generate a positive net cash margin (product value, less cost of crude oil and cash operating expenses) in mid-cycle conditions.

The updated 2011 Wood Mackenzie forecast projects that these weak conditions are likely to persist.

Chart 5.2: NW Europe Complex refining margins- Brent crude



(Source: Wood Mackenzie 2011)

*Oil refineries are classified as **simple (hydro-skimming)**, **complex** or **deep conversion***

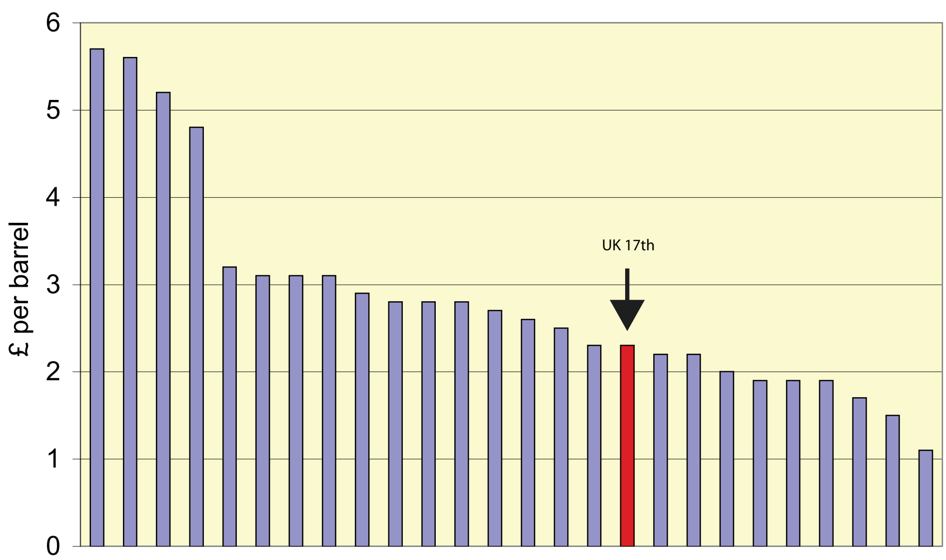
simple or hydro-skimming refineries have limited capacity to convert unwanted residual heavy products such as fuel oil to higher value transport fuels that the UK needs. They cannot mirror current UK market demands and tend to be less profitable

complex refineries have extra processing equipment, so that they can convert some of the residual fuel oil components to transport fuels. By careful use of low residue crude oils, such as those from the North Sea, fuel oil production can be limited bringing output more in line with current UK demand

deep conversion refineries can convert most or all of the fuel oil to lighter transport fuels, hence they are more closely aligned to meeting current and future demand patterns from a wider range of crude oils. They can also process cheaper crude oils so could potentially be more profitable in the future (see also Annex 6 for a diagram of a typical complex refinery)

Their study for DECC ('Global Refinery View 2008') also highlighted that UK refineries mostly rank below the average of EU refineries in terms of net cash margin. This is because of their configuration, their greater reliance upon North Sea crude oils and the fact that they operate in a competitive market open to international competition.

Chart 5.3: Wood Mackenzie ranking of EU refineries based on Net Cash Margin



(Source: Wood Mackenzie 'Global Refinery View 2008'-based on 9 operational UK refineries at that time)

5.1.2 Legislative climate in the EU and the UK

A challenge for the UK downstream sector as a whole is the legislative environment under which it operates, much of which does not affect non-EU competitors or in some cases, because of UK-only legislation, affecting only UK operations.

The recent focus of legislation in the EU and the UK has been on climate change and reducing greenhouse gas emissions. At the EU level, a target of a 20% reduction in GHG emissions by 2020 (in comparison to 1990 levels) has been set. The UK is pursuing a challenging target for a 34% reduction by 2020 and 80% by 2050, underpinned by carbon budgets within the statutory framework of the Climate Change Act, with advice from the Climate Change Committee.

However, the problem for the downstream sector in the UK, in common with many other manufacturers, is the increasing complexity and overlap in a range of policies designed to reduce GHG emissions. These include the following (not all of which apply directly to the UK downstream sector):

- EU Emissions Trading Scheme
- EU Renewable Energy Directive
- EU Fuels Quality Directive
- EU Industrial Emissions Directive
- UK CRC Energy Efficiency Scheme
- UK Climate Change Levy/Climate Change Agreements (and proposals for reform of the Climate Change Levy as a carbon price support mechanism)
- UK Renewables Obligation
- UK Renewable Heat Incentive (as originally proposed with levy on refinery fuel)

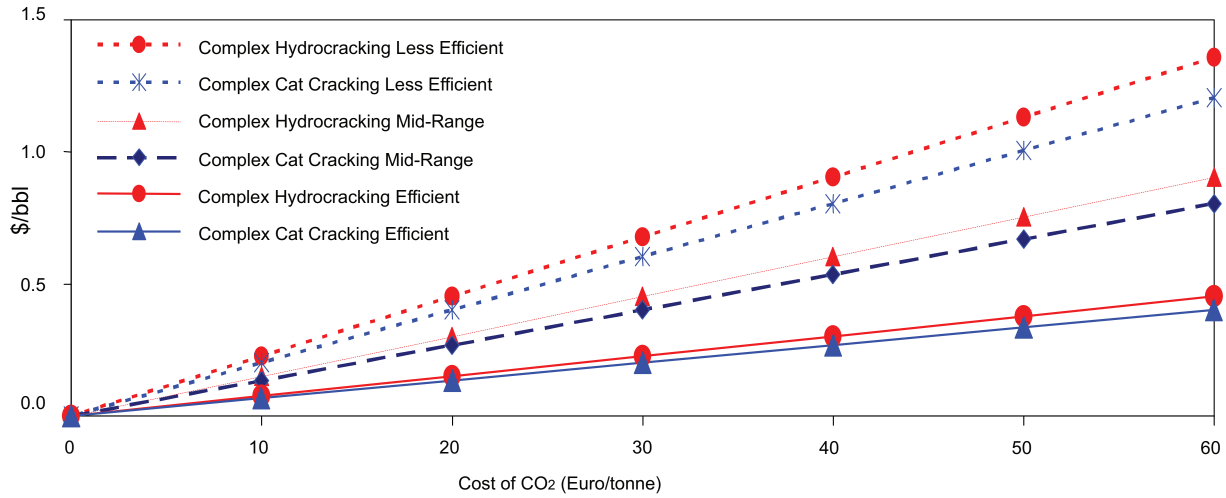
5.1.3 Investing for tightening environmental standards

Much of the recent investment in UK refining has been aimed at meeting stricter environmental standards, tighter fuel specifications and enhanced process safety. This investment has not increased refinery output significantly or improved the profitability of UK oil refineries. Combined with uncertainty over the future policy framework and the cost of meeting legislation, this may lead to investment being delayed or permanently shelved, as importing products rather than building new processing equipment may be a more attractive option.

The EU Emissions Trading System affects all EU refineries. Phase III of the scheme from 2013 will bring substantial extra cost to UK refineries for purchased allowances, based on an efficiency benchmark of EU refineries according to refinery complexity. At an allowance cost of €15 CO_2 per tonne (~£13) this represents an additional immediate cost to UK refining of €86 million (£75 million) per year from 2013, rising potentially to €230 million (£200 million) a year at €50 CO_2 per tonne (UKPIA estimates). These allowance costs are not faced by competing non-EU refineries.

The impact of these incremental costs upon refinery margins is illustrated in Chart 5.4. Taken from the Purvin & Gertz report for DECC, this indicates that cat cracking/hydrocracking refineries with mid-range efficiency or below could incur incremental costs of between $0.2 to $0.4 per barrel based on carbon at €15-17 per tonne of CO_2.

Chart 5.4: Estimated impact of EU ETS Phase III



(Source: Purvin & Gertz study for DECC June 2011)

In addition, UK refineries face some environmental and safety standards that are already tighter than elsewhere in Europe, as well as UK-only legislation.

Examples of UK-only legislation include the CRC Energy Efficiency Scheme (CRC) and proposals to amend the Climate Change Levy (CCL) and introduce a minimum floor price for carbon. At present, in most cases, fossil fuels used to generate electricity are exempt from CCL. Removal of the exemption from CCL for fossil fuels burnt in refinery CHP units, as originally proposed in the CCL review, would represent a large new cost to UK refineries.

The CRC is a mandatory UK scheme designed to encourage energy efficiency by large non-industrial public and private sector energy users through a system of a CO_2 emissions cap and allowances with auctioning. The scheme is complex and administratively burdensome but following the Comprehensive Spending Review in October 2010, auctioning revenues now go to HM Treasury rather than to participants in the CRC. The scheme has therefore become an additional tax on public and private sector energy users. The Government's intention to simplify the scheme and exclude installations covered by the EU ETS is welcomed.

In addition, the UK downstream oil sector faces UK-only policy enforcing far higher secondary and tertiary containment measures at large oil storage terminals. These are stricter than those that either EU or global competitors face. As currently envisaged, these measures if fully implemented, regardless of risk factors or other criteria, could require capital investment of hudreds of millions of pounds over an extended period with likely significant impact on oil supply infrastructure.

5.1.4 Investing to meet tightening product specifications

Meeting tighter product specifications, particularly reducing sulphur content in a wider range of fuels, requires refiners either to use more expensive low sulphur crude oil or to invest in new hydro de-sulphurisation or hydro-cracking units to process and upgrade less expensive but higher sulphur crude oils. These units are major investments in the order of £300-700 million or more for each refinery and take several years to plan and build.

Transport fuels (jet, automotive diesel and petrol) have become the major use of oil in the UK and now account for two thirds of the sales of oil products. The percentage is even higher if off-road (rail, agriculture, construction) and marine fuels are included. In the future, Wood Mackenzie expect the percentage of demand for transport middle distillate fuels to grow further as demand for jet fuel and diesel increases and the changes in marine fuels in SECA areas from 2015 and MARPOL VI from 2020 (but subject to review in 2018) start to impact, exacerbating the existing supply/demand imbalance.

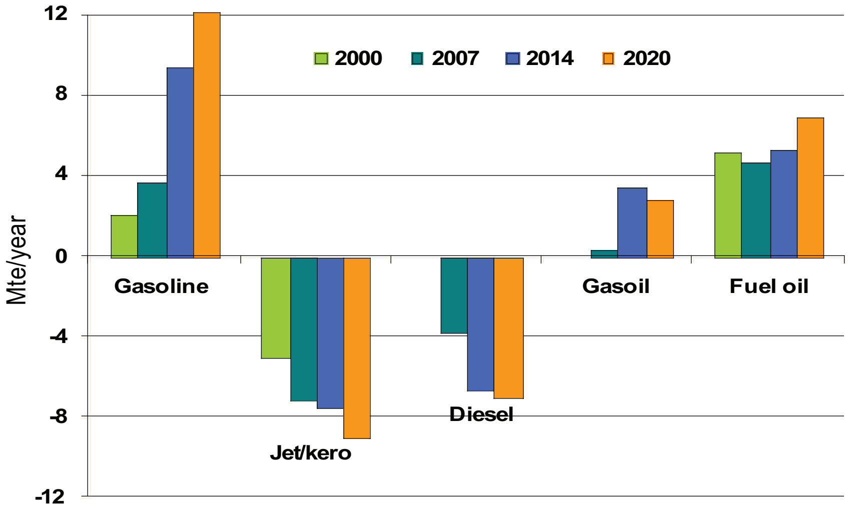
Investment demands have also increased as a result of meeting biofuel obligations initially under the RTFO and from the end of 2011 in moving towards meeting the 2020 targets of 10% by energy biofuel requirements of the Renewable Energy Directive and the 6% reduction in GHG emissions under the Fuels Quality Directive.

5.1.5 Imbalance between consumer demand and refinery output

A major challenge for the industry is that refinery output has been misaligned with product demand. Demand for middle distillates, mainly diesel and jet fuel, continues to increase, whilst demand for petrol continues to decline. This is expected to be exacerbated further by some ethanol substitution under the RTFO and RED legislation mandating biofuels.

DECC/ Wood Mackenzie projections indicate that the UK will become increasingly in deficit for jet/kerosene, so will need to draw supplies from the Middle East, Mediterranean and new Asian refineries. The diesel deficit is projected to increase with more demand for road fuels and the requirement to de-sulphurise fuel for off-road applications from 2011; the latter will generate a gas oil surplus although more will be needed for the marine sector with the change in fuel specification to 1000ppm sulphur in Emission Control Areas (ECAS) in 2015. Wood Mackenzie forecast that the fuel oil surplus is likely to continue to increase but at a much lower rate, excluding the possible impact of IMO MARPOL VI regulations changes in 2020 which are subject to review in 2018.

Chart 5.5: Fuel imports/exports to 2020



(Source: Data based on DECC/HMRC tables (includes refinery feedstocks). Diesel production based on Wood Mackenzie estimates using 2007/8 balances.)

Demand for non-energy uses of oil such as bitumen, greases, lubricating oil, electrode coke and petrochemical feedstock are expected to remain strong with cycles linked to economic activity, although the petrochemical sector faces growing competition from lower cost producers in the Middle and Far East.

5.1.6 Changing composition of refinery ownership

After many years of comparative stability in the ownership of UK refineries, the composition has been changing in the light of the current commercial climate and the future outlook, with a move away from predominantly fully integrated major international oil companies to specialist merchant refiners.

5.2 International competition and carbon leakage

There is a well developed international trade in refined products globally; in NW Europe the refineries and terminals of Antwerp and Rotterdam form an important focus.

The UK receives imports of diesel/gasoil from Russia and jet fuel from the Middle East, and exports a substantial share of its surplus petrol to the USA. At the moment, imports still represent a comparatively small proportion of supply (<15% for diesel/gas oil). Although trade in all major refined products has risen over the last five years, the cost of transporting refined products is low relative to their value so does not represent a barrier to trade.

In addition to existing competition from Russia, new large scale refining capacity is coming on stream in India and the Middle East designed to produce fuels that meet EU specifications. These new large scale complex refineries are designed from the outset to meet current and future market requirements through processes that minimise production of heavier ‘bottom of the barrel’ residues. None of these locations faces the same degree of legislative burden as the UK or the rest of the EU, particularly in relation to carbon reduction targets or other controlled emissions and environmental standards.

UK refineries therefore face added cost burdens leading to ‘carbon leakage’ - i.e. substitution of UK/EU refined products by imports from refineries outside the EU that do have to meet the same carbon regulations/targets but their products, when imported to the UK, compete directly with products produced by UK refineries.

5.3 ‘Demand destruction’

Structural, legislative and technical changes affecting the UK are effectively destroying demand, mainly in the road transport fuels market, rather than temporarily deferring demand as happens during a downturn in an economic cycle. These changes arise from factors such as more efficient vehicles, transport mode changes and shifts to alternative fuels and energy sources.

6. Conclusions and policy recommendations

Oil will remain a significant energy source globally and for the UK, for decades to come. The UK downstream oil industry and the refining sector has for many years been a reliable, secure and competitive source for the key products upon which the UK relies.

The number of UK refineries has declined from eighteen in the late 1970s to eight currently, in response to changing market conditions and demand. One UK refinery closed in 2009 and of the eight remaining operational refineries, two have been sold to new owners in 2011 and a further two remain for sale. Once a refinery closes it rarely re-opens, although depending upon location and other commercial and environmental considerations, it can be converted to an import and storage facility.

Clearly market and commercial considerations are important influences but in order to help ensure the continued competitiveness of the refining industry in the UK, the Government must seek to apply policies that do not place it at a commercial disadvantage to overseas competitors. Furthermore, this may require the Government to lobby strongly at EU level to address these issues and the impacts on UK industry. This is especially important given that the EU and the UK have taken a lead on measures to address climate change, which is a global issue requiring all countries to address their greenhouse gas emissions.

UKPIA and its members believe strongly that a healthy, robust oil refining industry is a vital element of the nation's future secure supply of competitively priced petroleum products (transport fuels, chemical feedstocks, heating oils, etc). They wish to continue working with the Government at a high level to deliver this, building upon the collaborative work with the Department for Energy and Climate Change on UK refining and infrastructure.

Oil and oil products will continue to provide a major share of our energy supplies for the foreseeable future. For this reason it is vital that all options are kept open on a range of fuels and technologies to meet the future energy needs of the UK's consumers.

The challenge is to ensure that in the coming decades the UK continues to have access to affordable, secure supplies of the required oil products as both sources of crude oil and consumer demand change. The UK can meet any shortfall in its needs by importing more products (jet fuel and diesel) and exporting surplus products (petrol and fuel oil) so long as those markets remain available, or alternatively by investing in UK refineries. UKPIA and its member companies believe that the challenge will be best met with a strong domestic oil refining industry with close links to the European and global oil markets.

Conclusions and policy recommendations

To help achieve this objective, UKPIA seeks a legislative environment that:

- is based on constructive open dialogue to help reach solutions that meet policy objectives
- is realistic and practical
- is based on sound science and cost effectiveness
- provides a level playing field throughout EU member states and avoids placing UK refineries at a competitive disadvantage in relation to its EU and non-EU competitors
- is flexible and developed on a timescale that engenders investor confidence
- is reviewed periodically in the light of technical and scientific developments

and is allied to a policy vision that helps maintain security of energy supply and resilience, to support the UK economy.

The UK oil refining industry remains keen to continue working with government. Firstly, to address the impact of legislation on issues around security of supply, supply/demand imbalance and supply resilience. Secondly, to identify the best way of ensuring that the oil industry's contribution to the Government's ambition of secure, clean, affordable energy for the long term is achieved alongside a continued contribution to the UK's economy.

Annex 1. Glossary of terms

APU	- Auxiliary Power Unit
B7, B10 etc	- 7%,10% etc by volume FAME/diesel blend
BOPD	- barrel (bbl) of oil per day (42 US gallons; ~34.97 Imp gallons; ~159 litres)
BEV	- Battery electric vehicle
BTL	- Biomass-to-Liquids
CCS	- Carbon Capture and Storage
CNG	- Compressed Natural Gas
Cat cracker	- fluid catalytic cracker; unit converting high-boiling point crude feed to gasoline
CO_2	- Carbon Dioxide
CONCAWE	- CONservation of Clean Air and Water in Europe - oil industry research body
CRC	- CRC Energy Efficiency Scheme
DECC	- Department for Energy and Climate Change
DfT	- Department for Transport
DEFRA	- Department of Environment, Farming and Rural Affairs
DUKES	- Digest of UK Energy Statistics
ECA	- Emission Control Area (formerly Sulphur Emission Control Area SECA)
E5, E10 etc	- 5%, 10% etc volume ethanol/petrol blend
EUCAR	- European Council for Automotive Research and Development
EU ETS	- EU Emissions Trading System
FAME	- Fatty Acid Methyl Ester
FC	- Fuel Cell
FCC	- see cat cracker
FCV	- Fuel Cell Vehicle
FQD	- Fuels Quality Directive
FT	- Fischer-Tropsch
GHG	- Greenhouse Gas
G/Km CO_2	- gramme of CO_2 per kilometre
GTL	- Gas-to-Liquids conversion process
H2	- Hydrogen
HVO	- Hydrogenated vegetable oil
Hydrocracker	- Process unit within a refinery which increases yields of diesel
HEV/Hybrid	- IC vehicle in combination with a battery powered electric motor(s)
IEA	- International Energy Agency
ICE	- Internal Combustion Engine
ILUC	- Indirect Land Use Change
IMO	- International Maritime Organisation
JRC	- Joint Research Centre of European Commission
LPG	- Liquefied Petroleum Gas
Mboe	- Million barrels of oil equivalent
MtC	- Million Tonnes of Carbon
Mte	- Million tonnes (metric)
Mtoe	- Million tonnes oil equivalent
NG	- Natural Gas
NOx	- Oxides of nitrogen
NRMM	- Non-road Mobile Machinery
PHEV	- Plug-in Hybrid electric vehicle
PM	- Particulate matter
RED	- Renewable Energy Directive
Ricardo	- Leading automotive engineering specialists
RTFO	- Renewable Transport Fuel Obligation
SFD	- Sulphur free diesel (<10ppm sulphur)
SFP	- Sulphur free petrol (<10ppm sulphur)
TTW	- Tank to Wheels
Tonne	- metric tonne
UKPIA	- UK Petroleum Industry Association
WTT	- Well to Tank
WTW	- Well to Wheels

Annex 2. IEA Policy Scenarios

The IEA scenarios referred to are contained in the IEA World Economic Outlook 2010.

Current Policies Scenario

This scenario is based on the world as it was in 2009, with inclusion of policies adopted formally by mid 2010. New global agreements are not part of this scenario generally and specifically global measures to reduce CO_2 emissions beyond the Copenhagen Agreement are not included and that subsidies for fossil derived energy continue in some countries. Forecast oil demand in 2035 is projected to grow to 107.4 mb/day.

New Policies Scenario

This central scenario takes account of the broad policy commitments and plans that have been announced. This includes national pledges to reduce greenhouse gases and plans to phase out fossil energy subsidies even where measures to implement these commitments have yet to identified. It anticipates that demand will grow steadily, reaching 99 million barrels per day (excluding biofuels), some 15 mb/day higher than in 2009, an increase of 18%. Around 57% of this growth is projected to come from China alone, while OECD demand is expected to fall by 6 mb/day. Global oil production is forecast to reach 96 mb/day, reaching a plateau by 2020 with natural gas liquids, unconventional oil and biomass sources increasingly meeting the difference.

Assumptions include:

Cautious implementation of the Copenhagen Accord commitments by 2020.

- Continuation of the European Union Emissions Trading System (EU ETS), and introduction of a cap-and-trade system in the rest of the OECD after 2020.
- Phase out of fossil-fuel consumption subsidies in all net-importing regions by 2020 (and, as in the Current Policies Scenario, in net-exporting regions where specific policies have already been introduced).
- Extension of nuclear plant lifetimes by 5 to 10 years with respect to the Current Policies Scenario, on a plant-by-plant basis.
- For 2020-2035, additional measures that maintain the pace of the global decline in carbon intensity - measured as emissions per dollar of gross domestic product, in purchasing power parity terms - established in the period 2008-2020.

450 Scenario

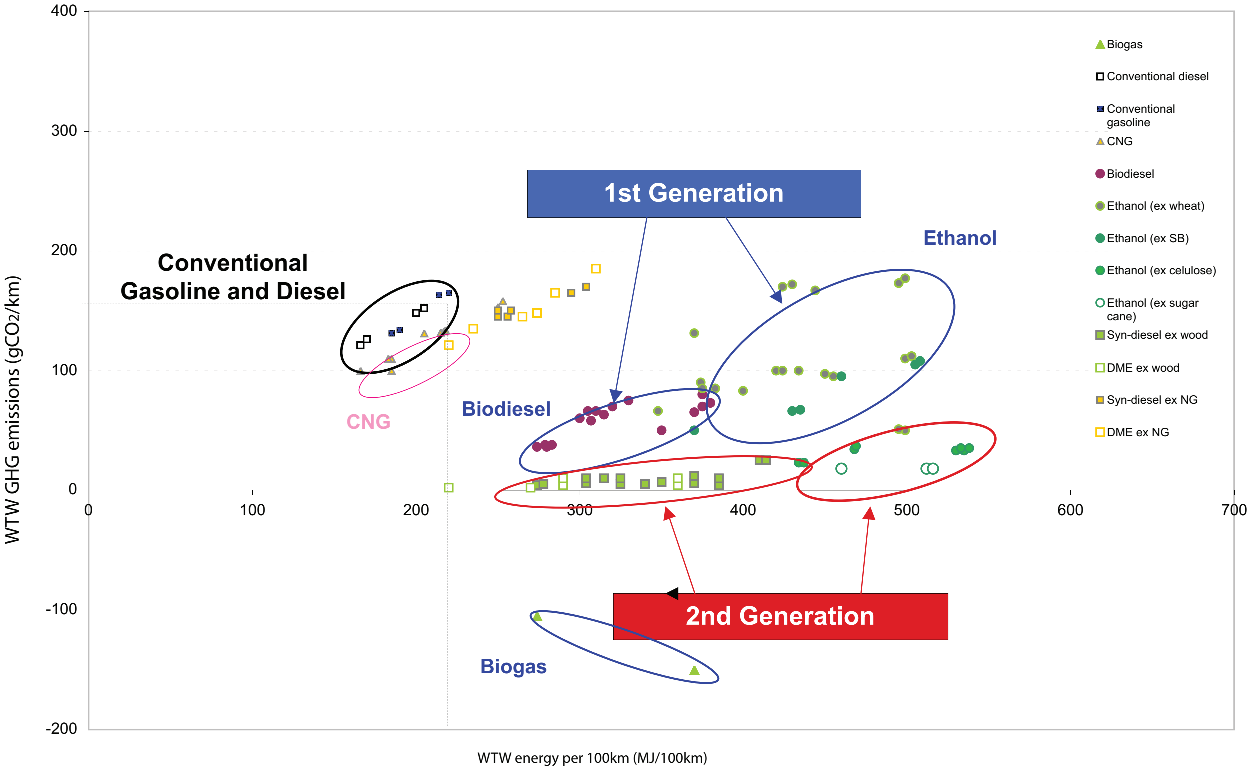
This scenario sets out an energy pathway consistent with the goal of limiting global climate change consistent with the 2°c goal through limitation of the concentration of greenhouse gases in the atmosphere to around 450 parts per million (ppm) CO_2 equivalent (CO_2e). This would require new global agreements and institutions along with the continuation of current initiatives and the overhauling of energy production and consumption globally. Both the developed world and developing economies would need to contribute to GHG reductions and a more global perspective enters diplomatic and political decision making.

In addition, the 450 Scenario takes into account all policies and measures included in the New Policies Scenario, some of which are assumed to be substantially strengthened and extended, plus the following:

- Implementation by 2020 of the high-end of the range of the Copenhagen Accord commitments where they are expressed as ranges.
- Cap-and-trade systems in the power and industry sectors, from 2013 in OECD+ countries and after 2020 in Other Major Economies (OME).
- International sectoral agreements for the iron and steel, and the cement industries.
- International agreements on fuel-economy standards for passenger light-duty vehicles (PLDVs), aviation and shipping.
- National policies and measures, such as efficiency standards for buildings and labelling of appliances.
- The complete phase-out of fossil-fuel consumption subsidies in all net-importing regions by 2020 (at the latest) and in all net-exporting regions by 2035 (at the latest), except for the Middle East where it is assumed that the average subsidisation rate declines to 20% by 2035.
- Extension of nuclear plant lifetimes by 5 to 10 years with respect to the New Policies Scenario.

Assumptions about population and economic growth are the same in each scenario. World population is assumed to expand from an estimated 6.7 billion in 2008 to 8.5 billion in 2035, an annual average rate of increase of about 1%.

Annex 3. Appendix 3. Analysis of JRC/Concawe/Eucar report V2c: Wells to wheels analysis of future automotive fuels in the European context.



Annex 4. GHG reduction targets

The UK has passed legislation - the Climate Change Act 2008 - which introduces the world's first long-term legally binding framework to tackle climate change.

The Climate Change Bill was introduced into Parliament on 14 November 2007 and became law on 26 November 2008.

The Climate Change Act creates a new approach to managing and responding to climate change in the UK, by:

- setting ambitious, legally binding targets
- taking powers to help meet those targets
- strengthening the institutional framework
- enhancing the UK's ability to adapt to the impact of climate change
- establishing clear and regular accountability to the UK Parliament and to the devolved legislatures.

Two key aims of the Act:

- to improve carbon management, helping the transition towards a low-carbon economy in the UK
- to demonstrate UK leadership internationally, signalling that the UK is committed to taking its share of responsibility for reducing global emissions in the context of developing negotiations on a post-2012 global agreement at Copenhagen in December 2009.

Key provisions of the Act

- A legally binding target of at least an 80 percent cut in greenhouse gas emissions by 2050, to be achieved through action in the UK and abroad. Also a reduction in emissions of at least 34 percent by 2020. Both these targets are against a 1990 baseline.

- A carbon budgeting system which caps emissions over five-year periods, with three budgets set at a time, to help stay on track for the 2050 target. The first three Carbon Budgets will run from 2008-12, 2013-17 and 2018-22, and were set in May 2009. The Government must report to Parliament its policies and proposals to meet the budgets, and this requirement was fulfilled by the UK Low Carbon Transition Plan published in July 2009.

- The creation of the Climate Change Committee (CCC) - a new independent, expert body to advise the Government on the level of carbon budgets and on where cost-effective savings can be made. The Committee will submit annual reports to Parliament on the UK's progress towards targets and budgets. The Government must respond to these annual reports, ensuring transparency and accountability on an annual basis.

- The inclusion of International aviation and shipping emissions in the Act or an explanation to Parliament why not - by 31 December 2012. The Committee on Climate Change is required to advise the Government on the consequences of including emissions from international aviation and shipping in the Act's targets and budgets. Projected emissions from international aviation and shipping must be taken into account in making decisions on carbon budgets.

- Limits on international credits. The Government is required to "have regard to the need for UK domestic action on climate change" when considering how to meet the UK's targets and carbon budgets. The independent Committee on Climate Change has a duty to advise on the appropriate balance between action at domestic, European and international level, for each carbon budget. The Government must set a limit on the purchase of credits for each budgetary period - for the first budgetary period, a zero limit was set in May 2009, excluding units bought by UK participants in the EU Emissions Trading System.

- Further measures to reduce emissions, including: powers to introduce domestic emissions trading schemes more quickly and easily through secondary legislation - the first use will be the CRC Energy Efficiency Scheme; measures on biofuels; powers to introduce pilot financial incentive schemes in England for household waste; powers to require a minimum charge for single-use carrier bags (excluding Scotland).

- A requirement for the Government to report at least every five years on the risks to the UK of climate change, and to publish a programme setting out how these will be addressed. The Act also introduces powers for Government to require public bodies and statutory undertakers to carry out their own risk assessment and make plans to address those risks.

- An Adaptation Sub-Committee of the Committee on Climate Change, providing advice to, and scrutiny of, the Government's adaptation work.

- A requirement for the Government to issue guidance by 1 October 2009 on the way companies should report their greenhouse gas emissions, and to review the contribution reporting could make to emissions reductions by 1 December 2010. A requirement also for the Government to use powers under the Companies Act 2008 to make reporting mandatory, or explain to Parliament why it has not done so, by 6 April 2012. Defra published the guidance for UK businesses and organisations on how to measure and report their greenhouse gas (GHG) emissions on 30 September 2009.

- A new requirement for annual publication of a report on the efficiency and sustainability of the Government estate.

At the EU level, legislation on energy and climate change is driven by the '20-20-20 by 2020' package of comprehensive measures aimed at reducing carbon dioxide emissions and ensuring that the EU has efficient and secure future supplies of energy, combined with global leadership in low carbon/renewable energy technologies. Published at the end of 2008, the package sets targets for EU member states of:

- Reducing GHG emissions by 20% in comparison with 1990 levels by 2020.

- Increasing renewable energy consumption to 20% by 2020
- Reducing primary energy consumption by 20% by 2020

A key component of this policy is the EU Emissions Trading System.

In 2010 the European Commission adopted its 'Energy 2020 - a strategy for competitive, sustainable and secure energy' paper, outlining energy priorities for the coming decade and at the end of 2011 is expected to publish its 'Roadmap for a low carbon energy system by 2050' with a challenging target of reducing GHG emissions by 80% in comparison with 1990 levels by 2050.

Annex 5. Biofuels

Classifications now used to distinguish between varying alternative fuels technology are in basic terms 'First-generation' and 'Second-generation' biofuels.

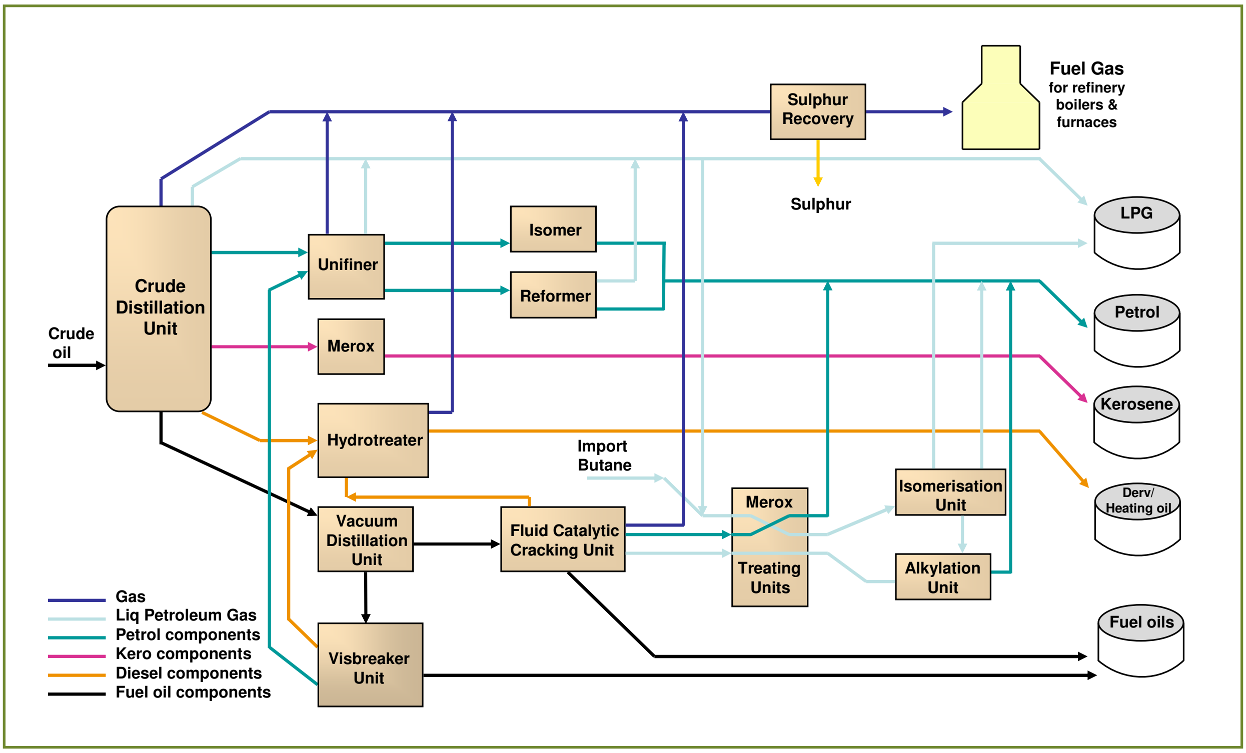
First-generation Biofuels *(seeds, grains or sugar)*	Second-generation Biofuels *(non-edible feedstocks)*
• Petroleum-gasoline substitutes - Ethanol or butanol by fermentation of starches (corn, wheat, potato) or sugars (sugar beets, sugar cane) • Petroleum diesel substitutes - Biodiesel by transesterification of plant oils, also called fatty acid methyl ester (FAME) and fatty acid ethyl ester (FAEE) * From rapeseed (RME), soybeans (SME), sunflowers, coconut, palm, jatropha, recycled cooking oil and animal fats - Pure plant oils (straight vegetable oil)	• Biochemically produced petroleum-gasoline substitutes - Ethanol or butanol by enzymatic hydrolysis • Thermochemically produced petroleum-gasoline substitutes - Methanol - Fischer-Tropsch gasoline - Mixed alcohols • Thermochemically produced petroleum-diesel substitutes - Fischer-Tropsch diesel - Dimethyl ether (also a propane substitute) - Green diesel

UN conference on Trade and Development - Biofuel Production Technologies (2008)

'First-generation' biofuels are made from sugar, starch, vegetable oil or animal fats using conventional technology with basic feedstock - such as seeds or grains - used for production. However, first generation biofuels have a number of important limitations in their ability to achieve oil-product substitution. Potential concerns include production sustainability, undue competition for land and water used for food and fibre production (which coincidently cause higher food prices), ILUC (indirect land use change - the unintended consequence of releasing more carbon emissions due to land use changes) and limited GHG reductions benefits (on-going reviews) especially relating to its high costs in terms of $/tonne of carbon dioxide avoided.

Some of these problems have been addressed by the development of 'second-generation' biofuels which share the feature of being produced from lignocellulosic biomass. This enables the use of non-edible feedstocks, i.e. agricultural and forest residues from non-food crop feedstocks. The feedstock used is usually lower in cost, and more widely available in terms of required terrain; potential energy crops can be grown on marginal and degraded land, therefore significantly limiting direct food vs. fuel competition, as food and fibre crops require better quality arable. It is widely reported that relatively high annual energy yields from dedicated energy crops, in terms of GJ/ha/yr, can be achieved from these crops relative to many of the traditional food crops currently grown for 1st generation biofuels.

Annex 6. Schematic of typical refinery processing units



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