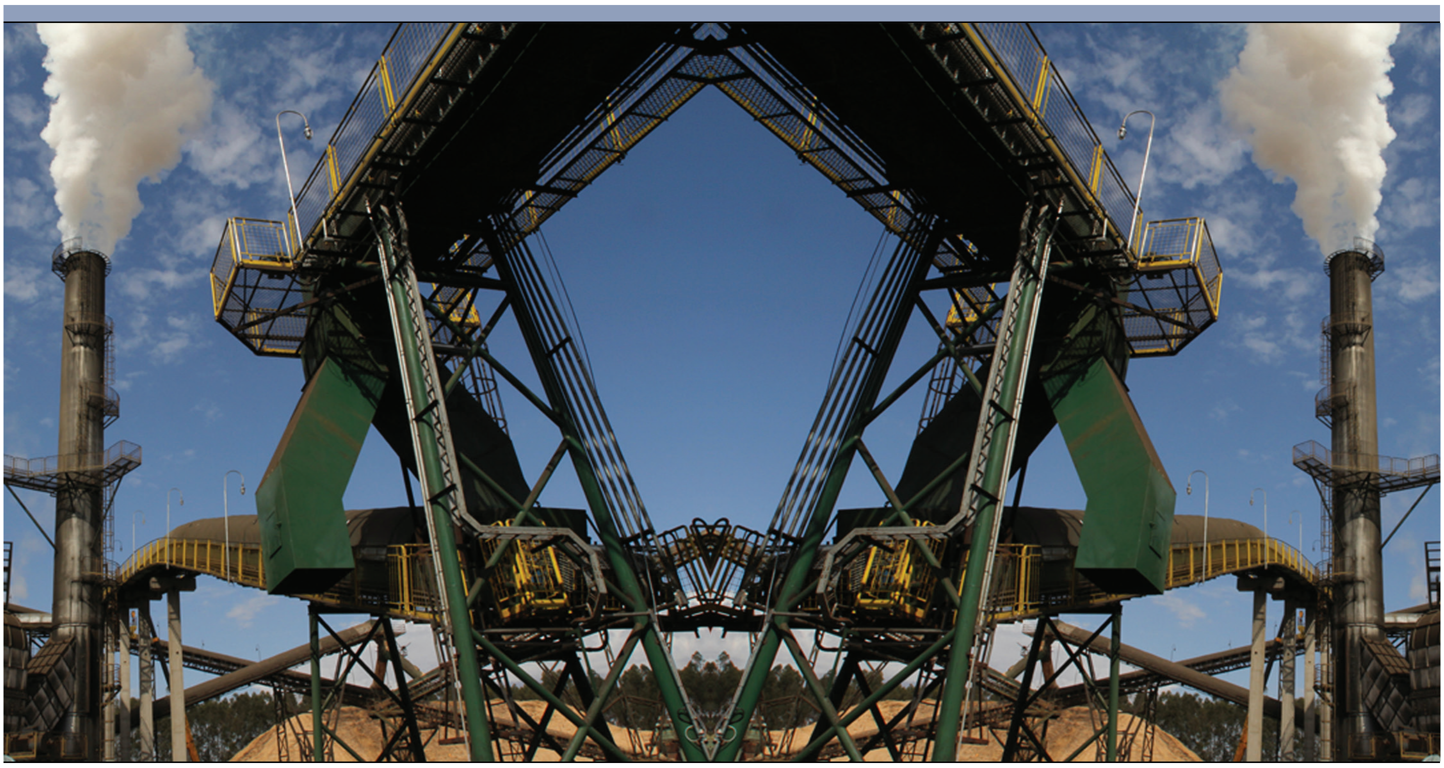
Bioenergy & the future of Ethanol

A view beyond the Americas: What might Asia demand?

October 2012










CZARNIKOW

Cass Business School
CITY UNIVERSITY LONDON

Contents Page

Contents Page

1

Introduction and background

In 2010 we published the first of our series of outlook papers, which projected future demand for sugar to 2030 building upon the UN's projections for global population growth. The paper highlighted the growth in demand that will come from the Asian economies and those in Central Africa as a result of rising populations and growing economies. With sugarcane today part of the global energy market as well as part of the food market we wanted to understand how these same macro economic dynamics would impact demand for bio-energy. Global demand for commodities is rising and what is clear is that the demand for energy is growing in much the same way as the demand for food. In order to examine growth in energy demand Czarnikow decided to partner with Cass Business School and model the outlook for energy demand to 2030.

Today demand for bio-fuels is dominated by the Americas. In the United States the Renewable Fuels Standard (RFS) sets out a clear path way for the increased use of bio-fuels and the United States is already the largest global user of bio-ethanol as a result of this policy. In Brazil, the economic framework and distributor network has long been in place to support strong bio-ethanol consumption and, as we have already modelled in our paper **Brazil's Need for Growth: The call for investment capital,** the potential for significant growth in use is a challenge for the sector given the scale of investment required. What we therefore wanted to understand from Cass was from where the additional demand for energy would come from and how that could relate to both demand for bio-fuels and bio-energy.

The linkage between agriculture and energy has always been present as biomass provided the world's energy prior to the development of fossil fuels. During the past century fossil fuels came to increasingly dominate and with the advent of mechanised farming the relationship swung full circle with fossil fuels powering agricultural development. That relationship is now changing again as the value of bio-energy is being recognised. Today the sugar industry uses cane bagasse as power with some mills today in a position to generate and export surplus electricity. Cane as biomass is where the future of the industry is likely to be found, especially if new technologies can result in the commercial recovery of sugars from cellulose. This is important given the demands that a growing global population will place upon land use.

During the past decade there has been a huge surge in demand for commodities led by fast paced economic growth in non-OECD countries. Industrialisation, urbanisation and rising incomes in these countries has changed the energy market and there has been a surge in demand for energy led by non-OECD markets. As a consequence the focus of this paper and its supporting analysis has been on the fast growing markets in Asia that are behind that growth and ethanol's role in the future of fuel.

2
Executive Summary

- The global market for crude oil has been rising at a CAGR (compound annual growth rate) of 1.28% between 2000 and 2011.
- Growth in OECD markets has been relatively flat. Consequently non-OECD countries have become the principal determinants of the future shape of the energy market.
- The growth markets of Asia, in particular China and India, are largely behind the rise in primary energy demand and have the potential to consume significantly more primary energy than they do today.
- We have modelled future requirements for transport fuels based upon Asian Development Bank, FAO and USDA sources after having established relationships in individual countries between consumption and explanatory variables such as GDP / capita and population growth.
- We forecast that demand for transport fuels from the 10 Asian economies modelled in this paper will rise from 365mln toe in 2010 to around 1bln toe in 2030.
- Our projected scenario for bio-ethanol usage taking into account minimal mandate levels and discretionary usage indicates that demand can rise from 6bln litres today to around 55bln litres by 2030. This would place Asian ethanol consumption ahead of Brazilian and US levels of ethanol consumption today.

Gasoline:
1.065 metric tonnes of gasoline = 1 tonne of oil equivalent (toe)
1 metric tonne of gasoline = 1.35 cubic metres (cbm) or 1,350 litres of gasoline
1.438 cbm or 1,438 litres of gasoline = 1 toe

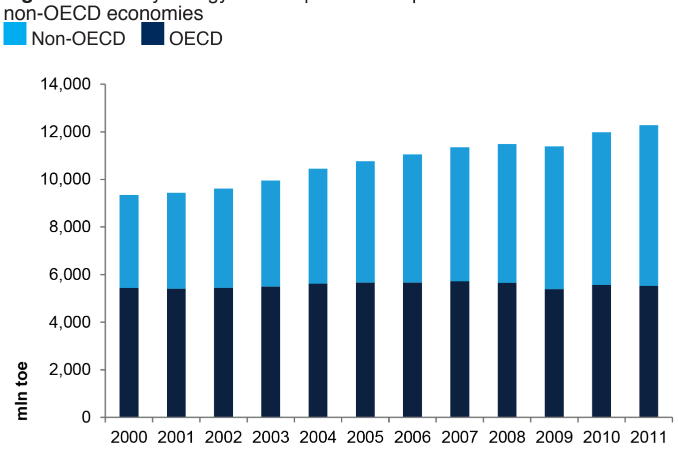
Diesel:
1.035 metric tonnes of diesel = 1 tonne of oil equivalent (toe)
1 metric tonne of diesel = 1.18 cubic metres (cbm) or 1,180 litres of diesel
1.221 cbm or 1,221 litres of diesel = 1 toe

Oil:
While barrel equivalents are dependant on quality, and while oil volumes are typically referred to in barrel terms for reporting purposes, the oil barrel has a volume of 42 US gallons:
1 oil barrel = 42 US Gallons = 0.159 cbm or 159 litres

3
A sea change in energy consumption

The 2000s witnessed unprecedented growth in the world economy, led by emerging economies, particularly those in the Asia-Pacific (APAC) and exceptionally so by China. This growth has been primarily led by exports of manufactured goods and required vast amounts of primary commodities to be redirected towards these new emerging economies. The ongoing expansion of the key emerging economies is evident not only in their rate of economic growth, but also in the way their energy consumption needs have developed. This has necessitated the sourcing of vast amounts of energy, which has brought about a sea change in the current state of the industry, as well as its future outlook.

Figure 1: Primary energy consumption development: OECD vs. non-OECD economies

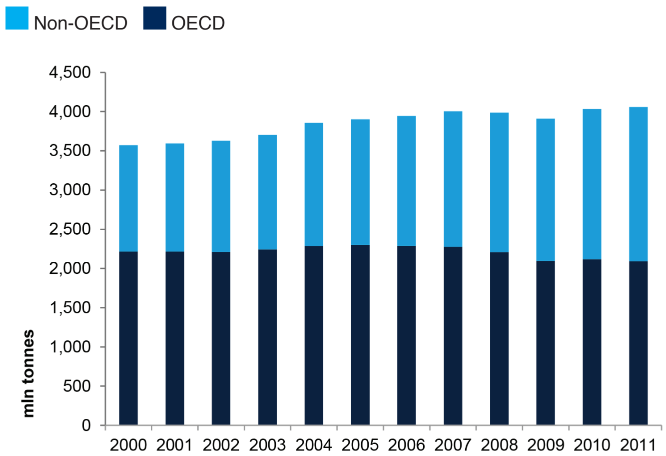


Between 2000 and 2011, the balance of energy usage between OECD and non-OECD countries has reversed. In 2000 OECD countries consumed 5,435mln toe (metric tonnes of oil equivalent) of primary energy (58% of the total), while non-OECD countries consumed the remaining 3,920mln toe (42%). In 2011, the total primary energy consumed worldwide was 12,275mln toe (30% higher than at the beginning of the millennium) and the order has reversed: 45% is now consumed by OECD and 55% by non-OECD.

Behind these headline statistics, lies the remarkable growth of the Chinese economy, followed by India and several other Asian economies, several of which are mentioned in this report. During the period 2000-2011, Chinese primary energy consumption increased by a total of nearly 160%, with a CAGR of 9%. In 2011, China consumed 2,613mln toe of primary energy, the world's biggest consumer (having surpassed the US in 2009), accounting for 21% of world primary energy consumption, almost 40% of non-OECD consumption and almost half that of the OECD. India has a relatively more modest, but still impressive, development path. Over the same period its primary consumption went from 296mln toe to 559mln toe, an increase of nearly 90%, or a 6% CAGR. It now accounts for 5% of world primary energy consumption, 8% of non-OECD consumption and 11.5% of APAC. India overtook Japan as a primary energy consumer in 2004, having done so for the whole of Africa seven years earlier.

A lot of this growth in primary energy needs has been fuelled by coal, especially so in China and India, who are large coal producers themselves and use the commodity to generate well over half of their electricity. However, the other two important hydrocarbons, oil and natural gas, have also grown very rapidly in importance. We have focused on oil and refined products, as these are the commodities feeding straight into the road transportation sector, which is directly linked to bio-fuels.

Figure 2: Oil consumption development: OECD vs. non-OECD economies



In 2000, the world consumed just over 3,500mln tonnes of oil, about 62% of it in OECD countries.

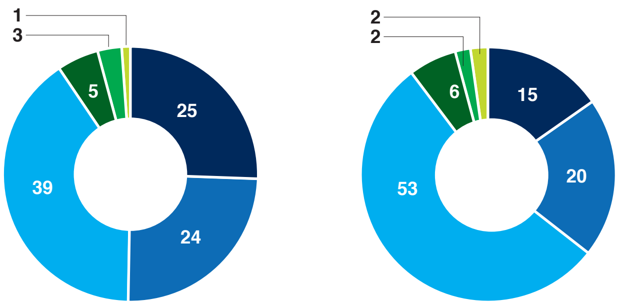
By the beginning of the next decade, the balance has rapidly shifted to non-OECD countries, who now consume about 49% and have increased their overall oil consumption by nearly 50%.

This remarkable growth rate has completely changed the picture of the oil industry, which looks to emerging economies as the main, if not only, source of future growth.

3
A sea change in energy consumption continued

Another sign of this paradigm shift is the direction of oil and refined products export:

Figure 3: OPEC Oil Export Split:2000 vs. 2011



Export Split 2000

Europe	25%
North America	24%
Asia Pacific	39%
Latin America	5%
Africa	3%
Middle East	1%

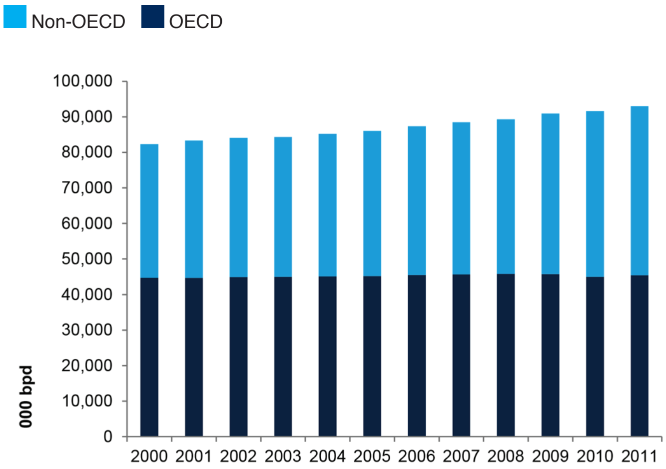
Export Split 2011

Europe	15%
North America	20%
Asia Pacific	53%
Latin America	6%
Africa	2%
Middle East	2%

In 2000, OPEC exported at a rate of 21.5mln bpd, 50% of which went to North America and Europe and 39% to APAC. By 2011, OPEC exports have grown by nearly 30% to 27.7mln bpd, with 53% destined to APAC, which has been the only growth area, whereas Europe and North America have either declined or stagnated. It is not surprising, therefore, that the major Middle East oil exporters look primarily to the east for the majority of established business, as well as new opportunities. The emerging economies of China and India have become probably more important than the traditional APAC importers of Japan and South Korea.

Alongside this increase in oil consumption and trade, another change is taking place – the establishment of new refining capacity in Asia.

Figure 4: Refinery Capacity: OECD vs. non-OECD economies



In 2000, world refining capacity stood at just over 82mln bpd, with 54% located in OECD countries. By 2011, refining capacity had increased to just over 93mln bpd, with non-OECD countries having turned the tables and accounting for 51% of this capacity. **During the last decade refining capacity has in fact declined in Europe and North America, where planning legislation and profitability prospects have been quite prohibitive.** In contrast, the biggest expansion of refining capacity has been in Asia (led by China and followed by India), the Middle East and Africa.

Refining is being relocated either to the point of consumption growth, or the point of crude oil production, with a view to exporting the higher value refined products to these very same points of growth. It is also interesting that a lot of new refining capacity is 'complex', i.e. geared up for producing higher proportions of high value refined products (such as motor gasoline and diesel) from a range of different crude oil qualities, from light sweet to heavy sour grades. So in addition to relocating and redirecting capacity to the emerging markets of Asia, refiners are embedding the ability to switch from heavier products (such as fuel oil) which are mainly used in industry, to middle and light distillates. This move has been driven by evolving consumption patterns and in anticipation of **road (and also air) transportation use starting to grow at a faster pace.**

The overall picture of most of the previous decade was one of unmitigated growth in emerging economies, stagnation of developed economies, and an overall shift in the balance of economic power towards non-OECD countries. Resulting from this was the rapid change of the balance in energy consumption, driven by the changing economic circumstance of several emerging economies, particularly so in APAC.

3
A sea change in energy consumption continued

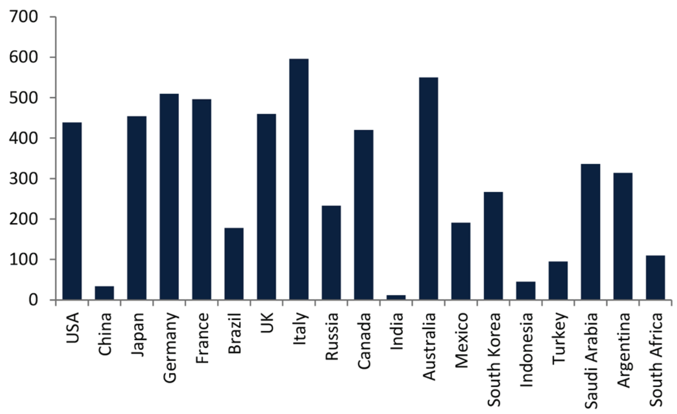
Impact of the Global Financial Crisis

One of course cannot underestimate the gear-shift precipitated by the financial crisis of 2008 and the world economy slowdown in 2009. Emerging economies around the world remain apparently resilient and continue to develop, and so do their energy needs. This statement cannot remain unqualified, however. Over the last six months or so, there are signs that the pace of growth, especially in the larger of the emerging economies, is slowing down, possibly quite considerably. The days of double-digit growth in China appear to be a thing of the past and this and other emerging economies will probably have to settle for much slower growth.

On the other hand, it is reasonable to expect that the internal structure of these emerging economies will also change, as they mature and start consuming some of the income they have accumulated from their export-driven growth of the last decade. The expected increase in GDP per capita and disposable income should lead to higher consumption and some of the key consumer goods are passenger cars and Light Duty Vehicles (LDV) in general, which in turn should influence heavily the consumption of gasoline and diesel.

As the fast growing Asian economies gradually switch from export-led to consumption-led growth, so will their need for electrification and electricity consumption along with transport fuels. With levels of vehicle ownership still low the potential for a significant acceleration in demand could well be underestimated.

Figure 5: Passenger cars per 1,000 people



4
Bio-ethanol overview

Ethanol can be produced from fossil fuels and biomass. It is the use of bio-ethanol that is seeing the fastest growth and is a key driver in the future shape of the corn and sugar markets and the interplay between the energy and agricultural sectors.

The Model T by Henry Ford, the first mass-produced car in the United States, was also originally designed to run on ethanol. However, the expansion of oil exploration and development at the start of the 20th century pushed bio-fuels to the sidelines.

Fossil fuels continued to dominate the liquid transportation fuel markets until the 1930/40s when shortages in Germany, England and the United States led to a partial reintroduction of biofuels for transport. However, in the post war period fossil fuel supply was soon able to match gasoline demand and the need for bioethanol once again faded.

Recent interest in bio-ethanol dates from the 1970s due to concerns over global warming and CO_2 emissions, the oil shocks of the 1970s and 1980s led to renewed interest in biofuels, in particular ethanol production.

Brazil has been the leading proponent of bio-ethanol since the introduction of Pro-Álcool by the Government in response to the oil spike of 1973. By the 1980s the programme was well established though supply problems in the 1990s dented confidence in ethanol cars. Policy then saw a shift from pure hydrous ethanol to anhydrous blends, which today specify an inclusion rate in gasohol of between 18% to 25% of anhydrous ethanol.

The global fuel ethanol market has increased significantly over the past decade and has been dominated by the Americas and has been rising at a CAGR of approximately 20% since 2004. Today the US is the largest fuel ethanol market, where demand is mandated by the Renewable Fuels Standard (RFS) while in Brazil discretionary demand for hydrous ethanol is of greater significance than mandated demand for anhydrous ethanol.

The introduction of flex-fuel technology in 2003 re-invigorated the ethanol sector with the launch of the FFV (flex fuel vehicle), in particular in the 1.0 litre popular car segment from 2005, which also coincided with the rapid growth in the Brazilian economy boosting total car sales. From 2003 until September 2012 Brazil has added in excess of 17.5mln FFVs. Since 2007, approximately 85% of cars sold in Brazil have been FFVs, which currently account for around 60% of the total light vehicle fleet and are expected to reach 76% by 2020. This growth in the FFV fleet has opened up a huge potential market for ethanol demand, at times when pricing signals favour hydrous ethanol at the pump.

Between 2007 and 2009 there was a large expansion in hydrous demand in Brazil driven by unrelenting growth in the FFV fleet. During this period, hydrous pump prices were below the 70% indifference level in the majority of Brazilian states, the key incentive point for Brazilian motorists to consume hydrous ethanol at the pump and often around the 55% level. The result of this was that hydrous ethanol in the Centre-South (CS) Brazil had a 37% share of the total fuel market by the end of 2009 before the rise in sugar prices pulled supply towards the food market.

Today the US is world's largest ethanol market, which has been achieved initially through mandates and subsidy but basis current economics and ethanol's use as an octane is currently economically viable. The US produces and consumes more bio-ethanol than any other country. Over the past decade demand for corn to produce ethanol has grown by 650% with ethanol consumption growing by this same proportion to reach 50bn litres in 2011. Growth has been driven by the introduction of the Renewable Fuels Standard in 2006 and the VEETC blending credit, which has since expired, with US ethanol becoming commercially viable despite the lower yield per acre of corn-based ethanol versus cane.

Ethanol produced from corn and from cane is regarded as a first-generation technology though given the lower CO_2 emissions of cane ethanol it is regarded as an advanced fuel by the US EPA (Environmental Protection Agency) in the implementation of the RFS. Other feedstocks such as sugar beets and cassava are also used. First-generation biofuels are characterised by mature and proven technologies, which have produced a product that can be readily integrated within the existing fuel supply chain.

However, there is considerable interest in the development of second generation bio-fuels utilising new process technologies with the objective of increasing product yield from the same biomass or using alternative feedstocks that are not seen as being in competition with the food chain. Under the RFS cellulosic ethanol is today mandated to deliver 1bln gallons of fuel though as production in 2013 is expected to amount to perhaps 20mln gallons this is likely to be reduced significantly.

In the last decade food prices for corn, soybeans and wheat have risen between 50-70% according to the USAID. While the role of biofuel production, specifically that of ethanol, is difficult to

4 Bio-ethanol overview continued

assess in the rise of food prices, experts from a variety of institutions, such as the World Bank and OECD, hypothesize that biofuels account from anywhere between 23-75% of the increase in the weighted average grain prices. However, as the rise in grains prices has also been due to a move away from a subsidised to a demand supported environment the absolute price level has become more significant in terms of farmer earnings.

Though both Brazilian cane yields and US Corn yields are currently below trend the ability to improve productivity and reduce costs exists within the existing framework. Despite being produced in parallel with food crops the potential for growth in cane ethanol is also yet to be fully developed as the area under cane in the Centre South of Brazil of 7m ha is around 10% of the Brazilian government's assessment of land, based on the research paper "Zoneamento Agroecologico da Cana-da-Acucar" that can be sustainably developed into cane area. Even within the long established environs of Sao Paulo state the potential to double area under cane exists.

In addition to growth in area, there is also significant scope to raise productivity. A return to normal yields in Brazil would deliver a 20% improvement in productivity while in the US agricultural yields in the 12/13 season are 30% down on their peak, again illustrating the scope from growth. Further the IEA believes that "new more efficient enzymes, improvements of Dry Distillers Grains with Solubles nutritional value, and better energy efficiency can raise the conversion efficiency and reduce production costs" (IEA, 2011b, p. 35).

Though there is considerable interest in developing new process technology that will be able to deliver a step change in bio-ethanol production most developments and efficiencies are likely to continue to come from small improvements on existing processing systems. New pre-treatment techniques using enzymes prior to fermentation and crushing are improving output and lowering energy consumption. This combined with other value added improvements such as using waste bio-mass for power generation is addition to the efficiency of modern bio-refineries and cost reduction. Today around 25% of mills in the CS of Brazil are structured on this basis.

4.1 2nd Generation

A broad interpretation of second-generation biofuels is that these are derived from a variety of non-food based feedstocks. Governmental policy has been a key driver in the development of renewable fuel production and legislation has been dominated by first generation biofuels though longer term requirements will shift the focus from first-generation fuel to second-generation fuels. The RFS in the US is consequently one of the critical drivers in the commercial development of advanced and cellulosic biofuels.

Through a variety of different treatment processes it is possible to extract plant sugars from the cellulose in feedstock and then, through a similar fermentation process, into ethanol. Predominantly there are two types of feedstock associated with second-generation production:

- agricultural waste, such as husk stems and leaves; and
- biomass such as wood chips.

Despite a number of advantages, there are key barriers in place for the implementation and viability of second-generation biofuels. Notably, as outlined by the IEA:

- high cost of research and development,
- high costs of production,
- supply chain issues,
- lack of consumer acceptance of biofuels, and
- misunderstanding of the environmental impact of biofuel production (Sims, Taylor, Saddler, & Mabee, 2008, p. 37)

While the IEA, and others, believe that second-generation biofuels and bio-ethanol in particular have a role to play in the future of the biofuel economy, commercial viability remains yet to be proven. Though commercial plants are today coming online, only 20,000 gallons of cellulosic ethanol have so far been produced against the EPA's RINs (D3) quota for second generation fuels.

Several technological hurdles need to be overcome for second generation fuels to become commercial - increasing the efficiency and lowering the cost of converting ligno-cellulosic feedstocks to ethanol is critical. There are further concerns surrounding the construction of scalable supply chains for feedstock though for established bio-industries such as sugar-milling it should be relatively straightforward to integrate within the existing processing platform and hence create competitive advantage.

A further step forward is the development of "drop-in fuels" that have the potential to become better integrated within the energy supply chain.

Sugar is currently seen as the key building block in creating bio-based hydrocarbons with molecular characteristics much more similar to those fossil fuels already used to power planes, trains and automobiles. These fuels are defined as drop-in fuels as, in contrast to ethanol, they can be incorporated with greater ease into the existing fuel infrastructure.

4
Bio-ethanol overview continued

Drop-in fuels appear to be emerging as energy companies face logistical hurdles with current bio-fuels. The key challenge is how biomass-based fuels can integrate into the existing fuel infrastructure - and drop-in fuels provide many of the solutions.

Drop-in Fuel production processes from plant sugars:

- **Microbial:** fermentation process producing an array of oils rather than alcohol-based product which can be further refined to produce drop-in fuels or other chemicals.
- **Biocatalytic:** a process whereby sugar molecules are ‘cracked’ using enzymes in order to produce an array of products.
- **BioButanol:** a process whereby alcohol-based products are produced, they are typically more flexible in their usage.
- **Algal:** a fermentation process where algae is used to produce algae-based oils, which can be refined to produce drop-in fuels.

With the sugar molecule seen as the most effective building block for these types of products, most of the attention is directed towards Brazil, given a ready supply of cane sugar. However, as the technology has yet to be fully developed on a commercial scale, there is today a less optimistic view of the scale of demand for sugar and ethanol to produce new products. Nevertheless, we continue to see strong interest in them from the chemical sector due to the high margins potentially available.

5
Bio-diesel overview

Biodiesel is made from vegetable oil or animal fats and can also be produced from recycled cooking oils and foodstuffs. Liquid biofuels have a history that is closely tied to transport and fossil fuels. Early combustion engines, such as Rudolf Diesel's, were originally designed to run on a variety of biofuels including peanut oil and vegetable oil.

Feedstocks used today includes oil from annual crops (e.g. soybean and rapeseed), perennial crops (e.g. oil palm, jatropha and coconut), waste cooking oil, and fish and animal fats. In general, 5% biodiesel is blended with conventional diesel to produce B5, though up to 20% blend (B20) could be used in standard diesel engines. Pure biodiesel (B100) can only be used in specially modified engines.

Yields from first generation fuels vary between feedstocks. Oil palm and coconut have the highest yields among first generation feedstocks. Compared to developed countries, many tropical developing countries have greater potential in terms of biomass production and thus lower cost of production. Even though there is a wide variety of highly productive biodiesel feedstocks available in tropical developing countries, the choice of feedstock is not strictly determined by its oil yields, cost of production or potential for greenhouse gas (GHG) emissions reduction. Instead it is based on existing feedstock production and process infrastructure. For example, Indonesia and Malaysia have a competitive advantage in growing palm trees, and the Philippines in coconut trees, and these plants naturally become their primary feedstock for biodiesel production.

Jatropha has recently been seen as the major potential biodiesel feedstock from non-edible sources and there are a number of projects around the world focused on this feedstock. This is because jatropha seeds are poisonous to human and animals, though it has relatively high oil content. It is a perennial plant with a lifespan of 30 to 50 years, and which can be grown at altitudes of up to 500 meters. Jatropha is suitable for countries where there are water shortages, since it only requires annual rainfall of as low as 300mm and on wastelands. Once the jatropha plant starts producing yield, typically after three to five years, harvesting is possible every six to twelve months. Although it may not need significant amount of water or high quality soil, the production of seeds and oil yields still benefits accordingly. Hence, to improve production and yield, more water and fertilisers are required.

Table 1 shows that jatropha is less efficient than palm oil and coconut in terms of biodiesel produced per hectare, however it has a higher yield per ton of feedstock.

Table 1: Comparison on biodiesel yields from various feedstocks

Feedstock	Litres biodiesel per hectare	Litres biodiesel per ton feedstock
Crude palm oil	4900	230
Coconut	2776	130
Jatropha	1200	224
Rapeseed	1188	392
Sunflower	954	418
Soybean	522	183

Source: FAO 2008; Johnston et al 2009

Table 2 shows that yields may vary between countries, and oil yield from jatropha with irrigation can be as high as four times those without irrigation. Oil palm in Malaysia has the highest oil yield of 20.5MT per hectare compared to its neighbouring countries, Indonesia and Thailand. Since jatropha seeds have to be harvested manually, jatropha-biodiesel production is labour intensive and thus creates low skilled employment opportunities, which may be valued by some developing countries in Asia. Currently, jatropha seed oil is able to produce yields ranging from 400 to 2,200 litres of biodiesel per hectare. Such variation is due to limited long-term observations of trial crops and also to the limited scale of those trials which do exist.

Table 2: Biodiesel feedstock yields in Asia

Crop	Country	Metric tons per hectare
Oil palm	Indonesia	17.0
Oil palm	Malaysia	20.5
Oil palm	Thailand	17.6
Oil palm	China	13.9
Soybean	China	1.8
Soybean	India	1.0
Rapeseed	China	1.8
Jatropha	With irrigation	8
Jatropha	Without irrigation	2

Source: FAOSTAT 2009; Jatropha Work 2009

5 Bio-diesel overview continued

5.1 2nd generation

With non-food crops such as jatropha and also waste cooking oils already used in the production of bio-diesel, it is already clear that bio-diesel is into the realm of 2nd generation fuels. In this context, it is interesting that the RFS values the contribution of biodiesel 50% higher (expressed in terms of RIN value) than ethanol though the driver behind the RFS is energy content as opposed to environmental. However, it is also possible that new technologies could enhance yields. Using a thermochemical process, all the organic part of biomass including the lignin could be converted into fuels while also broadening the range of biofuels produced to suit needs from aviation to marine. Due to high initial and maintenance costs associated with the equipment used to produce thermochemical biofuels, a high level of feedstock is needed in order to obtain optimal efficiency.

6
Methodology

In order to understand future demand for biofuels we have begun by looking at total demand for transport fuels.

We have used a parsimonious, top-down approach linking energy demand to income and population changes and constructed a best fit model to forecast road fuel consumption.

6.1 Data

All data used to create the base model are from publicly available sources, such as the World Bank, UN and FAO. We have taken GDP per capita (in constant 2005 US dollars, PPP-adjusted to take into account the purchasing power of the same dollar in the different economies), road gasoline fuel consumption and road diesel fuel consumption.

For our forecasts, we have used GDP and population forecasts produced by national and international organisations, such as the Asian Development Bank, FAO, USDA and PwC.

Finally, we have based our assumptions on information available from national bodies in individual countries regarding existing renewables mandates and targets between now and 2030 as well as our own analysis of underlying discretionary demand based upon current consumption patterns and their deviation from mandated levels.

6.2 Modelling

To build the model we used a three-stage method to develop our forecasts.

To begin we sought to identify a meaningful relationship between the explained variables (road fuel consumption – gasoline and diesel) and the explanatory variables (GDP per capita and population, occasionally oil prices). To do this, we first ran a number of econometric tests on the variables and ascertain that all of the variables were non-stationary, i.e. they had a positive drift (trend) and tended not to fluctuate around a long-term mean (non-mean reverting). This is quite common for data series such as GDP and population and often for consumption series.

In the presence of non-stationarity, normal regression estimations (using OLS methodology) are meaningless and could lead to spurious regression results.

With the base relationship established we then cross checked whether there was a meaningful long-run relationship between our variables, even though the series were non-stationary (i.e. looking for any co-integrating relationships between our series). Once we established that such relationships did exist, we used co-integrating regression methodology to describe this long-run relationship more accurately, and we ran all our regression equations for the period 1980 to 2010.

Once we had the regression results, we applied a series of econometric diagnostic tests to check our actual values (our data points) and fitted values (where the model predicts these points should have been), as well as the residuals (the difference between the two), in addition to a more general sense check.

6.3 Forecasting

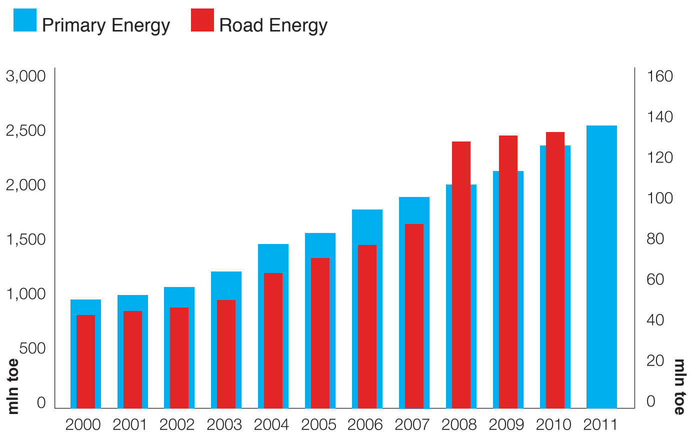
The forecasts that have generated our underlying consumption variables (road gasoline, road diesel) have been constructed from the most suitable recent projections for GDP per capita and population. For population we have used forecasts provided by UN/FAO, a low and a high case scenario for GDP per capita produced by the Asian Development Bank (for Asian economies) and a middle case scenario for GDP per capita produced by the USDA. We use the estimated coefficients of our cointegrating equations to produce forecast values for each of the three GDP scenarios, for each country. Using this approach we have built forecasts of gasoline and diesel.

Having established the base line forecasts for each of our underlying consumption variables, we have then constructed scenarios based on the existing share of biofuels in total road fuel consumption and extrapolated according to existing mandates, future targets, and our own projections for discretionary use.

7.1
Country focus China

In 2000 China consumed just over 1,000mln toe of primary energy, less than half of the world's largest consumer, the United States. In 2008 China doubled that figure to 2,041mln toe and in 2009 it surpassed the US as the world's largest energy consumer with 2,200mln toe. The latest (2011) figures place it firmly at the top of energy consumers, with 2,613mln toe, clearly ahead of the US and consuming more energy than the whole of the EU. Most of this primary energy comes from coal (70% in 2012), followed by oil, hydroelectricity, natural gas and finally nuclear and renewables.

Figure 6: Chinese primary vs. road energy consumption

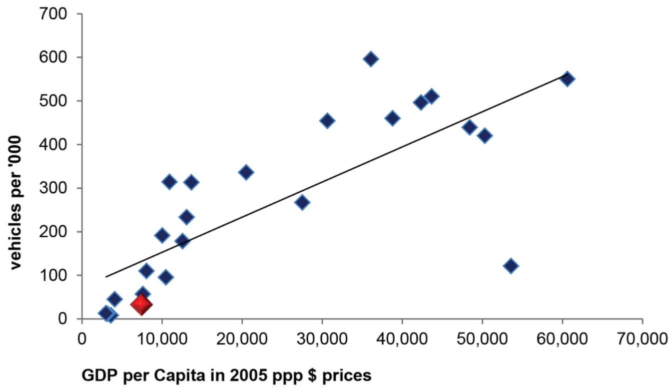


Only a relatively small part is used in road transportation (approx. 5-6% currently), which is quite low when compared with economies further down the development path (e.g. in the UK it is closer to 20%).

A number of other metrics show that China is still in its infancy with respect to the development of its automotive industry and the commensurate consumption of transportation fuels and, by extension, biofuels.

Passenger car ownership is substantially lower that any developed economy, with less than 50 vehicles per 1000 people. The level of GDP per capita, although rapidly rising since 2000, still remains at very modest levels of $7,400 (in 2005 PPP prices), which leaves open the possibility of much more growth to come.

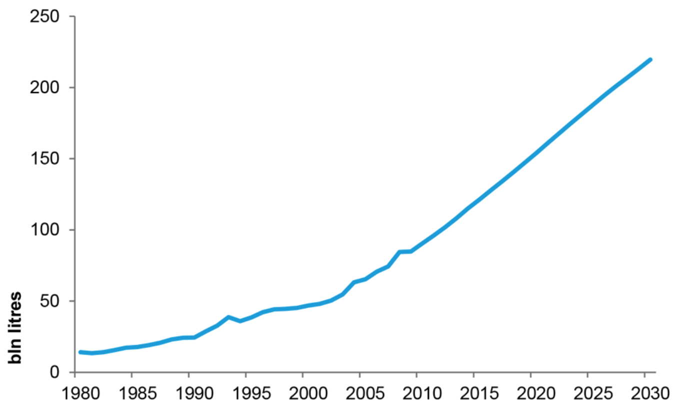
Figure 7: Chinese vehicles per '000 as a relationship with GDP per capita



7.1.1 Refining and oil products

Between 2000 and 2011 capacity has doubled from 5.4 to 10.8 mln barrels per day and from 2012 to 2016 refining capacity is set to increase by a cumulative 20% or 3.3mln bpd, with the total in 2016 estimated at 13.2mln bpd. The industry consensus is that China is trying to control the pace of expansion, in order to match the available supply with demand, but also with a view to eliminating smaller, less efficient plants, in favour of larger more complex units.

Figure 8: Projections for Chinese gasoline demand to 2030



7.1.2 Ethanol

Expansion in refining implies that the competition with biofuels will be stiff. Growth in demand for ethanol and biodiesel relies very much on general road fuel (gasoline and diesel) consumption growth as we have modelled supported by mandates and also the potential for discretionary usage.

China's ethanol production effectively started in 2004 and in 2012 is forecast to be around 2.4bln litres .

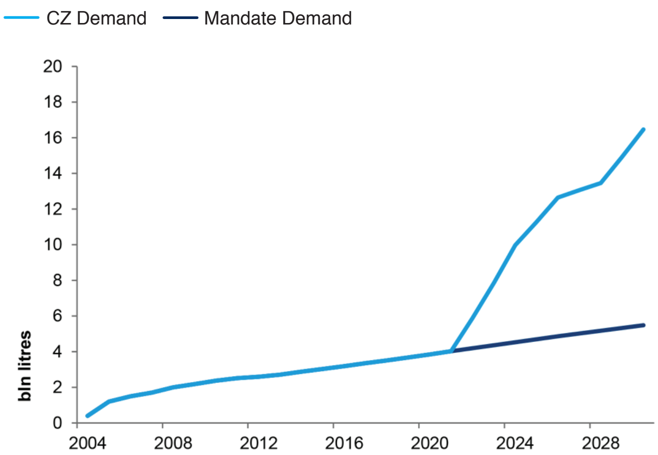
7.1
Country focus China continued

This is approximately 2.5% of total gasoline used in the road sector and far off initial aspirations of a 10% inclusion rate. There are five fuel ethanol plants, four of which use grain (corn and wheat) and one which uses cassava.

Most of the production comes from the grain plants, but the potential for growth is limited as a result of government caps on the diversion of corn to non-food use as a result of China's swing from a net-exporter of corn to a net-importer in 2009.

On the demand side there is huge potential for growth in fuel usage. We have found that GDP per capita and population have a strong long-term relationship with gasoline (and diesel) consumption and based on this relationship we have built a number of scenarios about the path that gasoline and ethanol consumption may take. Currently there is no formal mandate across the country regarding the use of ethanol though, since 2008, in six provinces (Heilongjiang, Jilin, Liaoning, Henan, Anhui and Guangxi) and 27 cities in Hubei, Hebei, Shandong and Jiangsu gasoline has to have an E10 content. However, there is potential for increased blending on a discretionary basis, which could see a rise in usage towards E10 levels based upon ethanol's value as an octane in fuel blends. In addition, China's increasing affluence and global status is also likely to see a greater focus on clean emissions, which could ultimately see bio-ethanol being blended for its value as an oxygenate. Under this scenario we believe that demand will rise from 2.5bln litres to in excess of 16bln litres by 2030 with an average blend of around 7.5%, assuming that China permits imports of bio-ethanol.

Figure 9: Projections for Chinese ethanol demand to 2030



7.1.3 Biodiesel

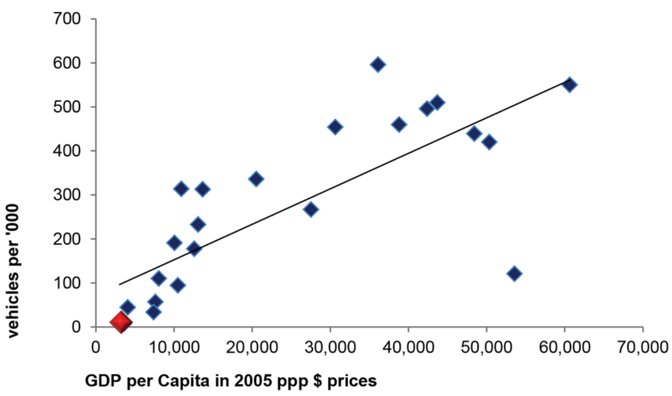
Diesel consumption has traditionally been lagging behind gasoline, but in the last five years it has run ahead. Diesel is mainly used in HDVs (heavy duty vehicles), including trucks, vans and buses, but also on rail transportation. Of this diesel consumption only a minute amount is attributed to biodiesel, less than half a percent. In 2012, the USDA estimates that about 500,000 metric tons (440k toe) of biodiesel were produced, only a fraction of the estimated 3mln metric tonnes production capacity. The main feedstock is waste cooking oil or residue from vegetable oil crushers. There is continued uncertainty as to the future of biodiesel production, as there are no clear mandates for either consumption or production and no government subsidy or tax exemption.

7.2
Country focus India

India has experienced rapid economic growth from 2000. Per capita GDP rose from about $1,700 in 2000 to $3,200 in 2011 (in 2005 PPP prices), almost doubling in a decade and has driven the increase in primary energy consumption which has risen at a CAGR of 5% since 2000. In 2011, India consumed nearly 560mln toe of energy, placing it fourth in the world, behind China, USA and Russia. Most of this energy comes from coal (53%), then oil (29%) and gas (10%), with only a very modest amount (8%) coming from hydroelectricity nuclear and renewables.

About 8% of total primary energy is used in the transport sector, which is comparable to China but still very modest when compared to developed economies. India is also at a relatively early stage in its automotive sector, its consumption of transportation fuels and biofuels. Passenger car ownership is substantially lower that any developed economy, with less than 20 vehicles per 1000 people.

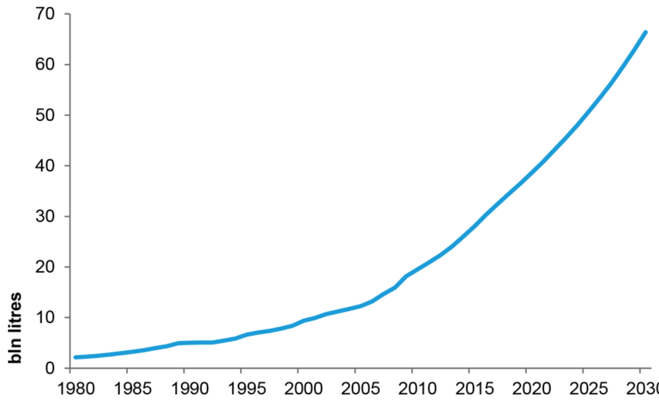
Figure 10: Indian vehicles per '000 as a relationship with GDP per capita



7.2.1 Refining and oil products

India has seen significant investment in refining capacity. Between 2000 and 2011 India's refining capacity increased by nearly 70%, from 2.26mln bpd to 3.8mln bpd. For the five years to 2016, India is expected to be the nation with the second largest additional refining capacity, after China, in the region. About 2.5mln bpd of additional capacity is being planned, consisting of a combination of new CDUs (Crude Distillation Units), upgrading of existing facilities and desulphurisation plants. This would imply a total estimated capacity of ca. 6.3mln bpd by 2016, quite a lot of it complex capacity, which has the additional advantage of being able to extract more of the better quality products, such as gasoline and low sulphur diesel.

Figure 11: Projections for Indian gasoline demand to 2030

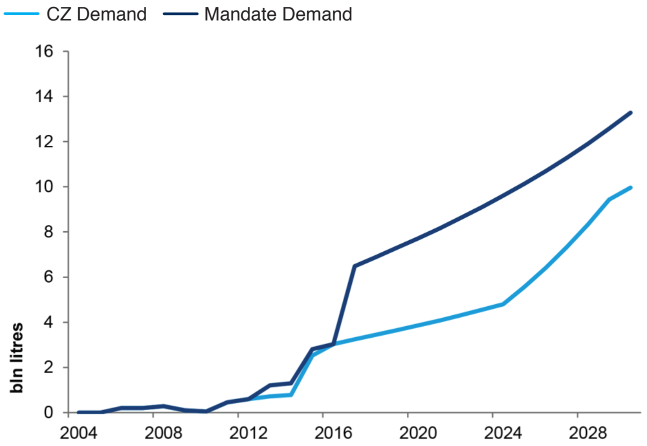


7.2.2 Ethanol

India is one of the world's largest sugar producers and is consequently well placed to develop a significant bio-ethanol industry through improvements in cane productivity and enhance earnings from molasses, which is currently used to produce ethanol. The government has an ambitious national biofuel policy targeting 20% of fossil motor fuel consumption by the end of 2017. However, in practice India is far from that target. The share of ethanol in gasoline consumption is around 3% which is below the 5% blending mandate. One of the major problems has been the development of a stable commercial market between producers and the oil majors, given strong commercial demand for potable ethanol. While the government is targeting a 20% mandated blend we believe that actual implementation will be much more modest and have therefore run our projections based upon a more gradual increase to 2030 reaching 15% inclusion rates with improvements in vehicle technology.

7.2
Country focus
India continued

Figure 12: Projections for Indian ethanol demand to 2030



7.2.3 Biodiesel

At the same time as ethanol, the Indian government is also promoting biodiesel, having set the same ambitious blending target – 20% by 2017. However, the reality is much harsher. India produces very small quantities of biodiesel, some 87k toe in 2010 (ca. 100,000 metric tons; 12.5mln litres), which has barely made a dent to the overall diesel consumption for road transport (let alone any other sector of the economy utilising diesel, such as agriculture).

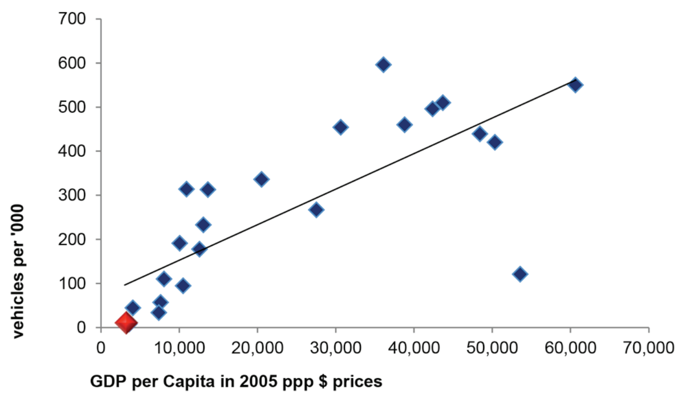
The fundamental issue is the uncertainty surrounding biodiesel production and the ability of the government to reach its targets. The government wants to expand biodiesel production primarily from non-food crops that are grown on land not designated for food production. Jatropha fits this description and there is currently a very ambitious target of planting between 11-13mln ha of jatropha by the end of the current year. The typical jatropha seed yield is around 2.5 tons/hectare and assuming a 30% biodiesel recovery rate thus assuming that 12mln ha are indeed planted, they would be expected to yield 9mln mt or 7.9mln toe, which could theoretically come close to covering the 5% mandate by 2030.

7.3
Country focus Indonesia

Indonesia has the world's fourth largest population, after China, India and the US. This population has been increasing by about 2-3 million people every year with the UN/ FAO forecasts estimating the population to increase from the current 240 million to 280 million by 2030. Indonesia also has one of the world's fastest growing economies. Between 2000 and 2011, GDP per capita increased by 3.5 times, spurred primarily by the export growth of its extractive industries. During the last decade Indonesia dropped out of OPEC as its oil production dwindled. However, at the same time it has become the world's second largest exporter of coal and sixth largest exporter of gas.

Indonesia primary energy consumption increased by 50% between 2000 and 2011. The transport fuel sector's energy consumption has kept pace, also rising by 50%, while vehicle ownership is also increasing rapidly, although overall the number of vehicles per 1000 people is still quite modest, but comparable to other developing economies in the region. In terms of fuel use, gasoline has shown a more rapid increase since 2000, whereas diesel has also grown, but at a more steady pace.

Figure 13: Indonesia vehicles per '000 as a relationship with GDP per capita

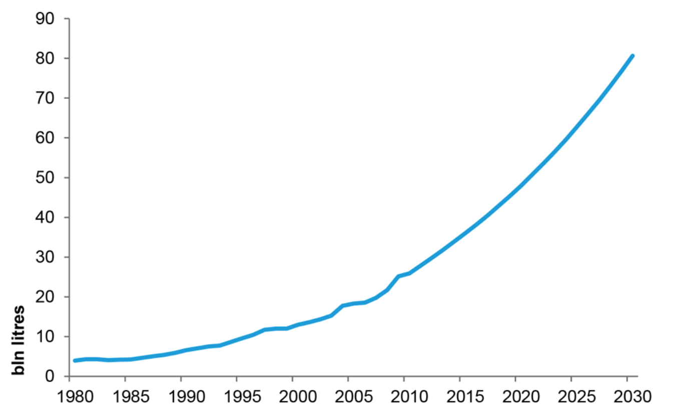


7.3.1 Refining and oil products

Indonesia has just over 1mln bpd of refining capacity. Refinery output goes primarily to the domestic market, but meets only about 70% of domestic consumption. State owned Pertamina target self-sufficiency in oil products by 2017, and in the last few years has announced several refinery upgrade, expansion and greenfield projects in support of this goal. However, most of these projects have been delayed, as low refining margins and lack of government financial incentives have deterred investment from international partners.

With this in mind, there is scope for the expansion of biofuels which may go some way in covering at least domestic transport fuel requirements and perhaps even generate exports to other Asian economies.

Figure 14: Projections for Indonesian gasoline demand to 2030



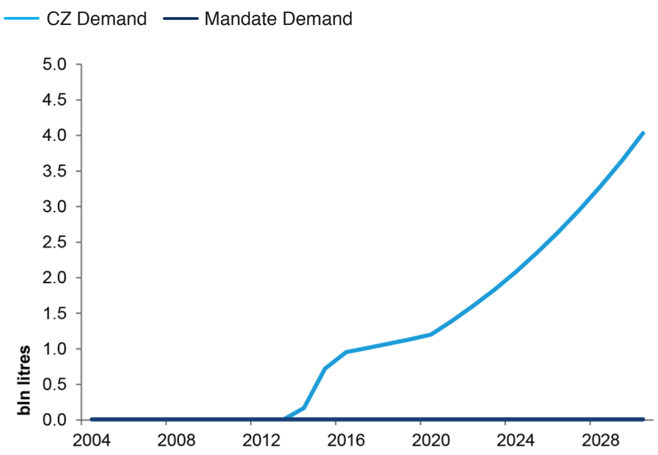
7.3.2 Ethanol

Indonesia produces ethanol for industrial purposes and export but has not developed a blending programme in gasoline in any meaningful way. This is due to a disagreement between the Ministry for Energy and Mineral Resources and the fuel ethanol producers on the way the market price index is formulated. Producers prefer leaving production facilities idle or producing industrial ethanol to selling fuel ethanol to Pertamina at uneconomical prices.

Whilst there has been speculation that an ethanol mandate could be introduced, we have not included this in our modelling. We believe that Indonesia will start to incrementally increase discretionary use up to 5% by 2030 for clean air aims and as a cheap source of octane.

7.3 Country focus Indonesia continued

Figure 15: Projections for Indonesian ethanol demand to 2030



7.3.3 Biodiesel

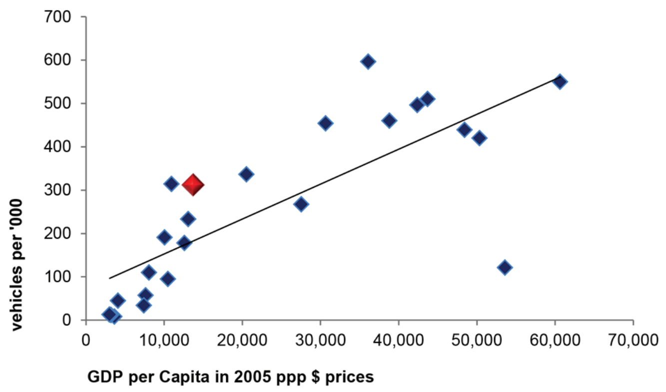
Indonesian biodiesel production, primarily from palm oil, is thriving. In 2010 biodiesel production was approximately 460mln litres (405,000 tons, 356k toe) and for 2011 production is estimated at 650mln litres (ca. 572,000 tonnes, 503k toe), an increase of 40%.

The vast majority of this increase is targeted to the export market. In 2010 Indonesia consumed around half of its production, with the other half exported mainly to other Asian countries. Indonesia has significant potential for growth with the USDA estimating that there are 22 biorefineries with a total capacity of just short of 4bln litres (ca. 3,100k toe), which implies that less than 20% of capacity is in use so far. Today, domestic Indonesian consumption of biodiesel is just below 2% of total road diesel consumption. Although there are official mandates for B10 by 2010, B15 by 2015 and B20 by 2020, it would not seem prudent to believe that these will be realised despite the potential.

7.4
Country focus Malaysia

Malaysian GDP per capita has risen by around 30% between 2000 and 2011. In terms of vehicle ownership and fuel consumption, Malaysia is rather more developed and closer to the more mature economies of Japan and S. Korea. Passenger car ownership has accelerated from 225 in 2003 to 313 in 2010 (per 1000 people), lower than Japan, but higher than S. Korea and much higher than both China and India. Gasoline and diesel consumption for road use have also increased considerably, some 40% since 2000.

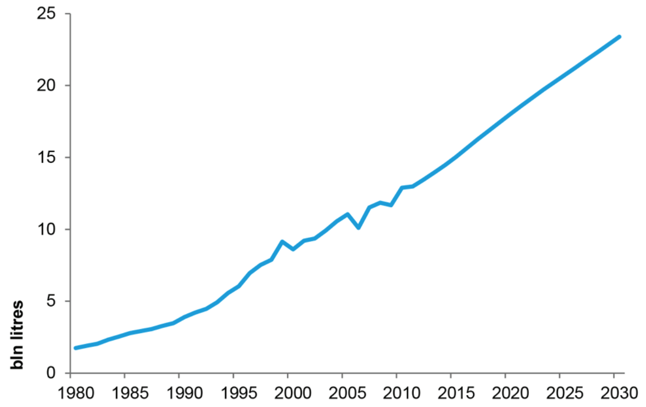
Figure 16: Malaysia vehicles per '000 as a relationship with GDP per capita



7.4.1Refining and oil products

Malaysia's economy is very much interlinked with the energy sector. It is an important oil and gas producer in the region, with its national company, Petronas, active not only domestically but in joint ventures abroad as well. Malaysia's own production comes from a number of offshore fields but it has started a slow decline since 2004. At the same time, consumption has trended upwards, with only small temporary dips. Although there is still surplus production, Malaysia may have to look for alternative sources of energy, especially liquid fuels. According to the Oil & Gas Journal, in 2011 Malaysia had about 538.5k bpd of refining capacity at seven facilities. The country invested heavily in refining activities during the last two decades with a view to decreasing its reliance on neighbouring Singapore for refined products.

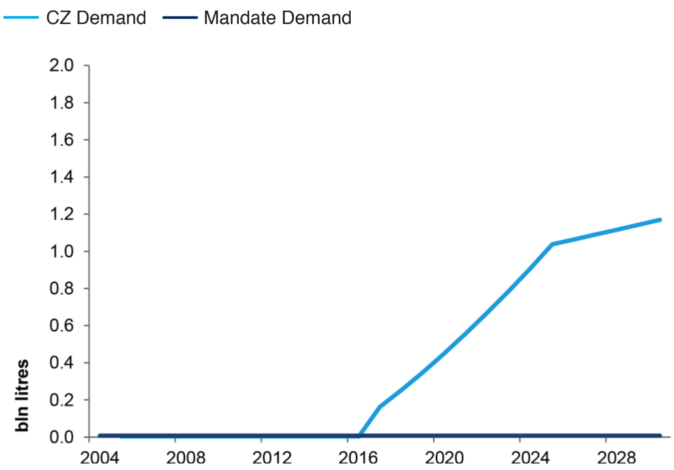
Figure 17: Projections for Malaysian gasoline demand to 2030



7.4.2 Ethanol

There is no mandate or indeed any incentive to produce or consume ethanol in Malaysia. There are still substantial subsidies for gasoline, which completely disincentivise the consumption and production of ethanol. Under current conditions and with the developments currently in the pipeline, we believe biofuels will find it quite difficult to expand their role as a transport fuel. However, there could be some discretionary demand emerging by the end of the decade and by 2030 we have assumed that this increases to 5% reflecting ethanol's contribution as an octane.

Figure 18: Projections for Malaysian ethanol demand to 2030



7.4 Country focus Malaysia continued

7.4.3 Biodiesel

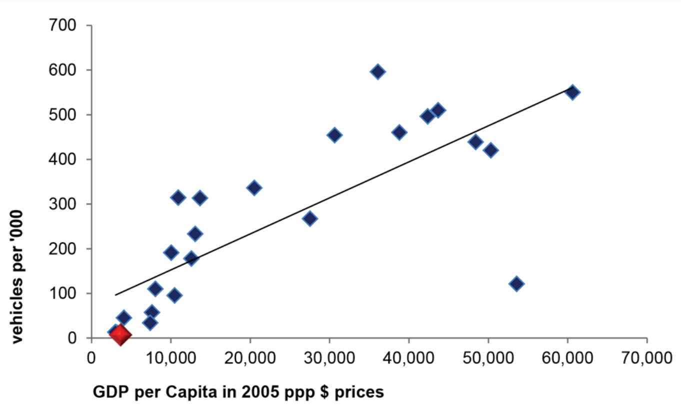
Malaysia has a developed market for biodiesel though the future of biodiesel does not look that promising. Malaysia has ample supply of palm oil, which is the main feedstock, as jatropha usage is only experimental. In 2008 and 2009 biodiesel production stood at ca. 170 and 195k toe respectively, with over 90% of it exported demand to the EU and US markets, as well as Indonesia. Since the introduction of the new RFS2 in the US, that export market has all almost disappeared until a new assessment of the GHG lifecycle of palm oil is completed. Imports to the EU are still permitted and Indonesia has now become the main customer for Malaysian palm oil.

In the domestic market, the government has put in place a B5 mandate since 2010, but implementation has been slow. Currently, biodiesel accounts for less than half a percent of road diesel consumption. The current subsidised prices for both gasoline and petroleum diesel hardly provide any incentive for further consumption or production of biodiesel and the outlook of the sector is uncertain.

7.5 Country focus Philippines

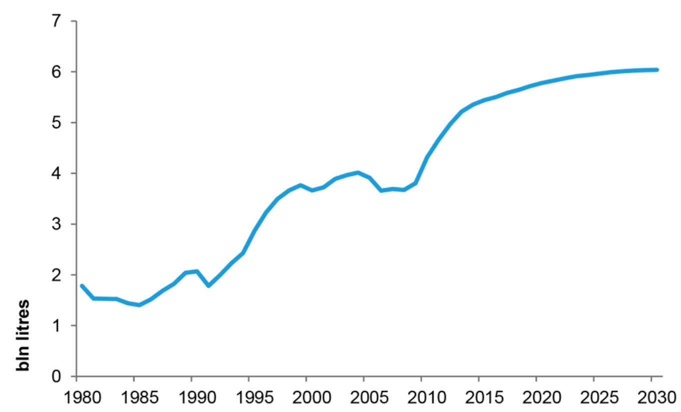
Philippines registered only very modest economic growth in the 2000s, by Asian standards, with GDP per capita increasing by 35% between 2000 and 2011 - a CAGR of less than 3%. Primary energy consumption showed even more modest growth at less than 1% a year while passenger car ownership is extremely low with less than 10 vehicles per 1000 people.

Figure 19: Philippines vehicles per '000 as a relationship with GDP per capita



The country depends heavily on oil and refined products, most of which it has to import. It also utilises coal (most of it imported) and natural gas. The Philippines has pushed forward with renewable fuels, which account for 40% of primary energy supply. Within the renewables group, the biggest contribution is made by geothermal energy, followed by solid biomass and smaller contribution from hydroelectricity, wind, solar and biofuels.

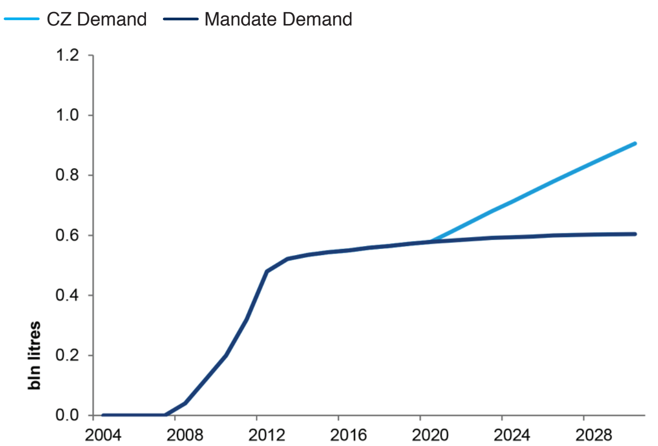
Figure 20: Projections for Philippines gasoline demand to 2030



7.5.1 Ethanol

The Philippines began a national bio-ethanol program in 2005, by initially building one sugarcane-based plant that could produce 25 million litres of ethanol per year. In 2007, the government instated an E5 mandate, with a target of E10 by February 2011 by the NBB (National Biofuels Board) in order to help entice investment into building more ethanol plants. The initial goals were to meet the mandate using domestic production. However, with demand running at over 400 million litres per annum, the current capacity of 79 million litres will not be nearly enough. Domestic production has struggled to complete with imports in meeting the E10 mandate and consequently the government is intending to prohibit imports in support of the domestic industry but conditional on sufficient domestic capacity to meet demand. In our projections we have assumed that the 10% mandate continues through to 2030 but in a more aggressive scenario we could see a push towards a higher blend rate of 15% with improvements in vehicle technology.

Figure 21: Projections for Philippines ethanol demand to 2030



7.5.2 Biodiesel

The feedstock of choice for biodiesel production in the Philippines is coconut methyl ester (CME), which the country produces in large quantities.

In 2010, there were 12 Department of Energy-accredited CME biodiesel producers, according to the National Biofuels Board (NBB) 2010 report, with a combined annual capacity of approximately 400 M litres. Of the 12 plants, however, only eight were in commercial production in 2010. By early 2011, there were only 7 biodiesel producers, according to the NBB report. Despite the reduction in the number of CME plants, biodiesel production is expected to remain fairly flat since 2009 or when the 2 percent

7.5 Country focus Philippines continued

blend was implemented, indicative of the local coconut industry's capability to provide the adequate biodiesel feedstock. Roughly over a third of overall CME production capacity is being devoted for biodiesel production.

In addition to CME the government also considers the use of jatropha as a potential biodiesel feedstock. It plans to cultivate jatropha on around 2mln hectares of unproductive land nationwide in order to allow 5,600mln litres of biofuel to be produced in the coming twelve years.

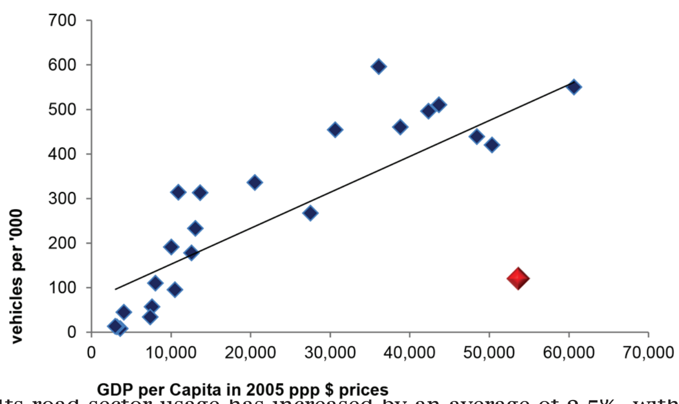
The Philippine government had required the use of coconut biodiesel by all government vehicles even before the biofuels act was signed in 2007. In addition, the successful transition from B1 to B2 in 2009 raised hopes that mandate would be increased to B5 sooner. To date, however, progress has been slow. Current government targets are for a gradual transition to B5 by 2016, then B10 by 2025 and eventually B20 by 2030.

7.6
Country focus Singapore

Though Singapore is not an OECD member it cannot be classed as a developing Asian country. With the highest per capita GDP in APAC, it is in quite a unique position in the region. For a nation with very little access to energy resources, it has a formidable presence in the refining sector, with a capacity of 1.4mln bpd.

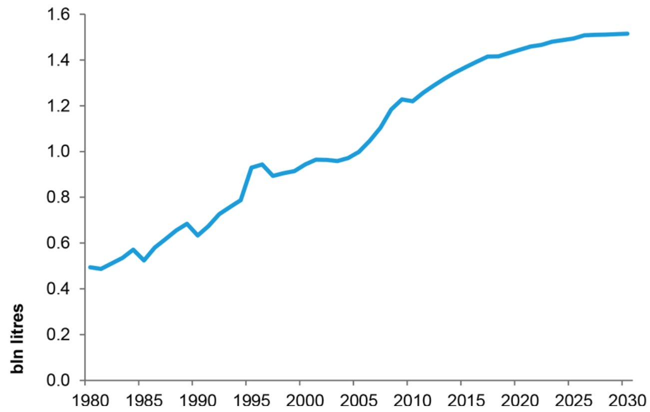
Singapore's economy has benefited from regional economic growth achieving a CAGR of 3% between 2000 and 2011. With just over 120 cars per 1000 people, its car ownership is more advanced than many of the other regional economies, but still lagging behind more mature economies and very low in terms of GDP per capita, which is in part a reflection of its limited geographic space, emphasis on public transport systems.

Figure 22: Singapore vehicles per '000 as a relationship with GDP per capita



Its road sector usage has increased by an average of 3.5%, with road diesel increasing at a slightly higher pace of 4% and gasoline at 3% annually. Given limited space and taxation incentives in favour of efficient vehicles we expect Singapore's demand for gasoline to demonstrate an S curve in its growth path and see demand flattening from 2020.

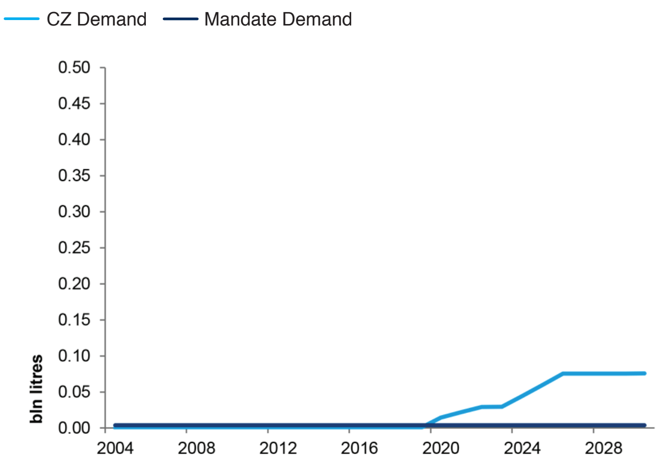
Figure 23:Projections for Singapore gasoline demand to 2030



7.6.1 Ethanol

Ethanol consumption is practically non-existent. However, unlike Malaysia, gasoline prices are high and there is consequently an opportunity for more ethanol use blended as a gasoline feedstock. In our projections we have assumed a low level of discretionary ethanol blending driven by improvements to fuel quality and reduced emissions rising to 5% by 2030.

Figure 24: Projections for Singapore ethanol demand to 2030



7.6.2 Biodiesel

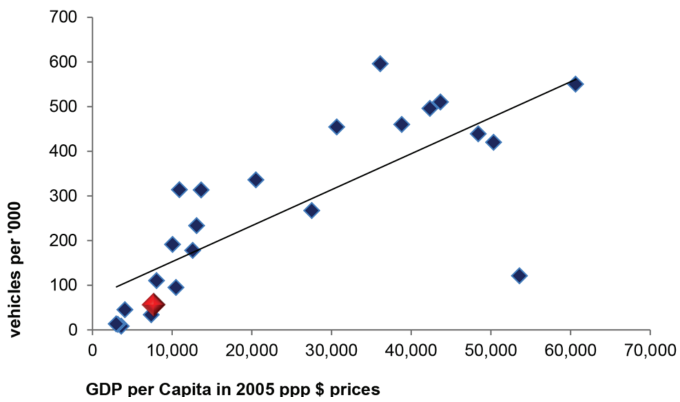
There is a modest pilot scheme for the use of biodiesel which has been running for the last 5 years. Only a very small amount of biodiesel is currently being used for road transport, around 0.12% of the total road diesel consumption.

7.7
Country focus Thailand

Thailand has typically enjoyed a 4% CAGR within the last decade though has experienced significant disruption arising from the Global Finance Crisis in 2008/09 and more recently floods in late 2011.

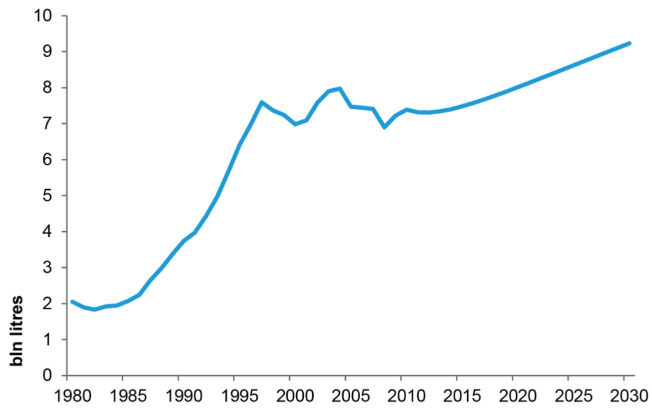
Passenger car ownership is substantially lower than any developed economy, though is higher than China with over 50 vehicles per 1000 people, despite comparable levels of GDP per capita income.

Figure 25: Thailand vehicles per '000 as a relationship with GDP per capita



Thailand already has an established transport fuel market. However, as our demand model has not identified a strong consumption response to per capita GDP growth as we have seen for China, our projections for Thailand consequently suggest that the country has experienced an S curve in its demand for Gasoline. This seems unusual but perhaps reflects the challenges that Thailand faces in terms of vehicle congestion and existing transport networks, in addition to the recent disaster and setbacks the country has faced. Long run improvements in infrastructure, and a rebound in growth, could consequently change the shape of these quantitative projections:

Figure 26: Projections for Thai gasoline demand to 2030



7.7.1 Refining and oil products

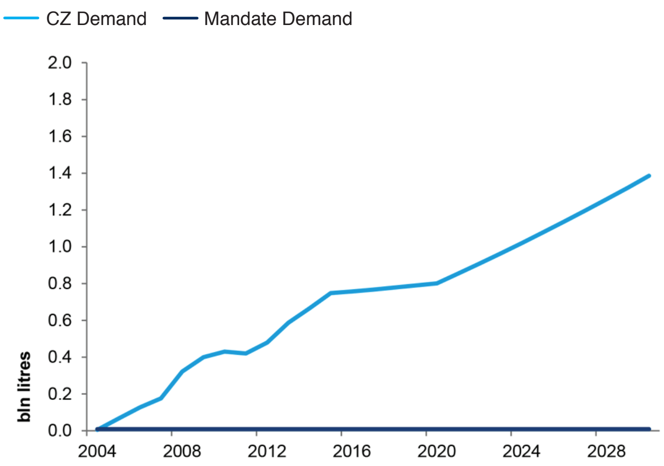
Thailand's refining capacity has expanded. Between 2000 to 2011 its refining capacity increased by 45% with 8 refineries operating today and total capacity of 1.3mln bpd. Only part of this capacity is being utilised though, with gross refinery output less than 1mpd and about a fifth to a quarter of this throughput exported. There are no current plans for further refinery expansion, although the level of exports may be affected as the country is trying to rebuild its economy after the 2011 floods and is likely to absorb more of its refinery output domestically.

7.7.2 Ethanol

Thailand has a firmly defined policy on biofuels, particularly bioethanol, which in part reflects its strengths as a sugarcane producer and exporter. The Government has a new 10-year Alternative Energy Development Plan (2012-2021) to boost ethanol consumption and has a target of 9.0mln l/d by 2021 which is a challenge as current consumption is around 1.2-1.3mln l/d." (USDA, 2012c). However, there are no explicit mandates for ethanol use through taxation and fuel standards, including the end of regular gasoline sales, have created one of the largest markets for bio-ethanol in Asia with current demand estimated at around 450mln litres. Despite favourable market conditions ethanol demand is below capacity and as a result Thailand is currently an exporter. Under our modelling to 2030 we assume that no definitive mandate is introduced in Thailand, but that demand continues to grow reaching a 15% blend by 2030.

7.7 Country focus Thailand continued

Figure 27: Projections for Thai ethanol demand to 2030



7.7.3 Biodiesel

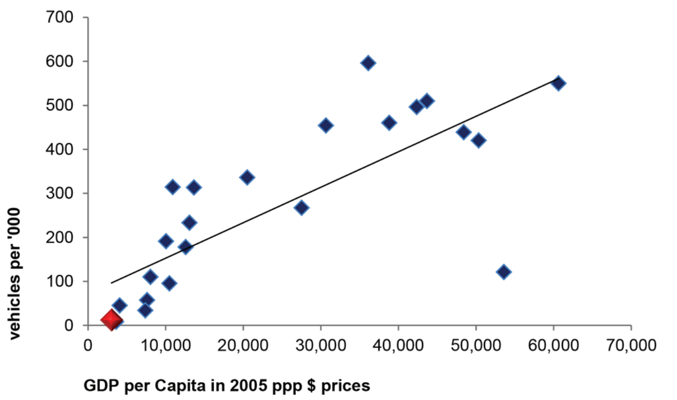
In parallel to its ethanol policy, the Thai government is also promoting the consumption of biodiesel, primarily from Crude Palm Oil (CPO), but also from waste vegetable oil. Currently biodiesel accounts for about 4% of road diesel consumption, but the government is setting ambitious targets for the future. More specifically, it has revised up its B100 consumption target to 5.97 mln liters/day by 2021, as compared to 4.50 million liters/day in the previous Biodiesel Development Plan. However, as production capacity is limited to about 1.6mln l/d, the targets outlined look very ambitious indeed.

Whatever the domestic consumption of either ethanol or biodiesel is, however, the government aims to boost production of both biofuels in order to promote substitution of its domestic gasoline/ diesel consumption, as well as boost exports, primarily to other APAC economies. This is definitely a country to watch.

7.8
Country focus Vietnam

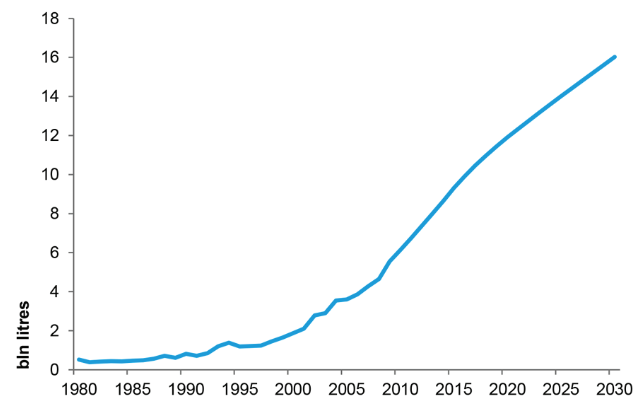
About a third of Vietnam's energy consumption is from traditional biomass and waste with 70% of the country's population living in rural areas, and agriculture still accountable for a sizeable portion of the country's GDP. Not surprisingly Vietnam has extremely low levels of passenger car ownership by South East Asian standards with levels comparable with India. The level of GDP per capita is at a very modest $3,013 (in 2005 PPP prices), which leaves open the possibility of much more growth to come.

Figure 28: Vietnam vehicles per '000 as a relationship with GDP per capita



Nearly 60% of the biomass is consumed by households, and Vietnam is currently promoting greater use of biofuels to replace some of its fossil fuel consumption. Nearly one-quarter of Vietnam's domestic energy consumption comes from oil, with hydropower (10%), coal (20%), and natural gas (11%) supplying the remainder. As the country continues industrializing and installing greater power capacity, Vietnam is seeking to develop all its natural resources. As the country's economy grows it is expected to experience rapid growth in gasoline demand:

Figure 29: Projections for Vietnamese gasoline demand to 2030



Vietnam currently has one operating refinery, but hopes to expand capacity within the next decade in the interests of reducing import dependency for oil products and fostering economic development in the north and central regions of the country where the proposed projects are located. However, the projects have encountered several delays stemming from financial, contractual, and land clearing challenges.

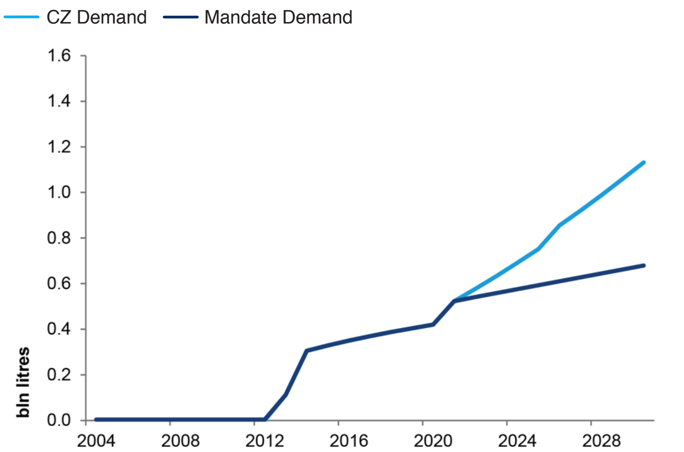
7.8.1 Ethanol

Ethanol production is still relatively new in Vietnam, with the first bio-ethanol factory coming online in 2009. The predominant raw material for bio-ethanol production is the cassava (tapioca) plant.

Only 5% of the produced bio-fuel is intended for the domestic market, with the remaining to be exported through Petro Vietnam's joint stock company. As of 2011, total annual output is approximately 200mln litres from two ethanol facilities. Another three factories, with total capacity to add another 300mln litres to current production, should be online before the end of 2012.

There is speculation of a potential E5 mandate coming into play in 2013, which we have used for our projections though aligned with a target of 500mln litres by 2020 we see this rising to a 6% blend rate, while modelling increased discretionary use.

Figure 30: Projections for Vietnamese ethanol demand to 2030



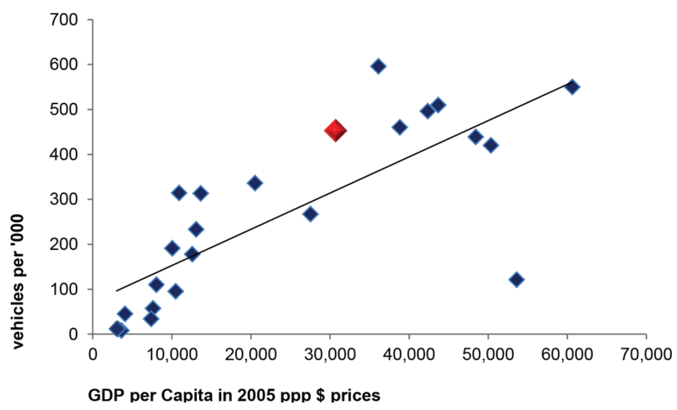
7.8.2 Biodiesel

Currently Vietnam does not register any biodiesel production. However, it has growing potential due to the country's fast growing economy. Candidate feedstocks for biodiesel production are plants such as coconut, jatropha, peanut, cassava, and animal products such as catfish fat. However, food security and land availability could put a limitation on any plans for biodiesel production.

7.9
Country focus Japan

Japan is a mature OECD economy with similar slow growth rates to the typical developed economies. However, its GDP per capita is the second highest in APAC, after Singapore. As expected from an OECD country, the level of passenger vehicles per 1000 people is high, at around 454.

Figure 31: Japan vehicles per '000 as a relationship with GDP per capita

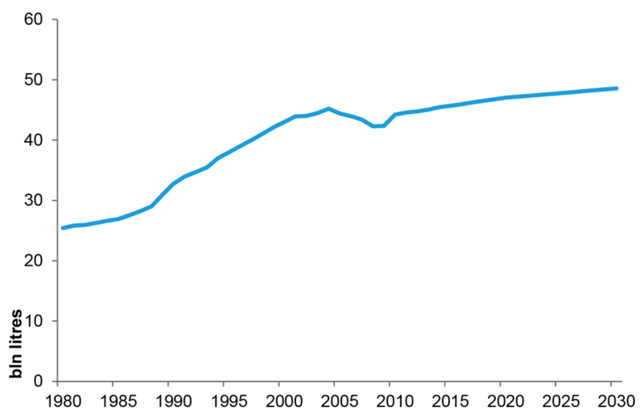


In terms of energy, Japan is poor in domestic resources and has built its economic growth on the basis of raw material imports from around the world. It is the third largest oil consumer in the world behind the United States and China and the third-largest net importer of crude oil. It is the world's largest importer of liquefied natural gas (LNG) and second largest importer of coal. In light of the country's lack of sufficient domestic hydrocarbon resources, Japanese energy companies have actively pursued participation in upstream oil and natural gas projects overseas and provide engineering, construction, financial, and project management services for energy projects around the world.

To mitigate its dependence on imported hydrocarbons Japan pursued an active nuclear generation policy. However, following the fallout of the recent Fukushima disaster, which has wreaked havoc to Japan's long term energy policy in addition to the devastation and human tragedy, nuclear generation is now planned to be phased out over a period of thirty years, which has placed national energy ambitions to reduced reliance on fossil fuels in doubt. It is now likely that Japan will explore more sustainable forms of alternative energy which could see a whole raft of renewable options, both for electricity generation, as well as biofuels for transportation.

Nonetheless, with a static and ageing population, as well as a saturated market, we see growth in total fuel demand as marginal, reflecting how far the country is along the S-curve of consumption.

Figure 32: Projections for Japanese gasoline demand to 2030



7.9.1 Refining and oil products

Japan has the second-largest refining capacity in the APAC region after China at 4.7mln bpd. In recent years, the refining sector in Japan has been characterized by overcapacity since domestic consumption has declined due to the contraction in industrial output and the decline in transport fuel demand due to the stagnation in personal incomes. As a result, Japan bucked the trend in Asia Pacific and in fact scaled back refining capacity by 560k bpd between 2000 and 2011. In addition to declining domestic demand, Japanese refiners must compete with new state-of-the-art refineries in emerging Asian markets.

7.9.2 Biofuel policies

The Japanese government unveiled its first biomass plan, "Biomass Nippon Strategy" in 2002. It was updated in 2008, putting focus on cellulosic biofuels as a future source of Japan's biofuel production. In the last few years, higher food prices have put this policy under considerable criticism, but the government seems resolute to continue its biofuels policy, with the dual aim to reduce the almost exclusive dependency on fossil transportation fuels and to reduce GHG emissions by 6% from the 1990 level by 2012.[1] Given Japan's limited capacity for agricultural production, Japan will need to complement domestic output with imports as well as looking towards advanced technology and 2nd generation biofuels in the near future.

In the spirit of trying to decrease reliance on fossil fuels for transportation, the government has set a goal to introduce 500 mln litres of biofuels on a oil equivalent basis by 2017 and to produce next generation biofuels domestically by 2015. In addition to this target, the government believes that it will be able to produce 6bln litres of biofuels domestically by 2030. This will

[1] According to the BP Statistical Review of World Energy (2012), Japan's CO2 emissions from fossil fuels (oil, gas, coal) had in fact increased from their 1990 levels by 9.5%, despite the slowdown in economic activity after the 2008-9 financial crisis.

7.9 Country focus Japan continued

be partly realised with the use of molasses, off-spec rice, rice straw, construction waste, sugar cane, sugar beet, crop and forestry residues.

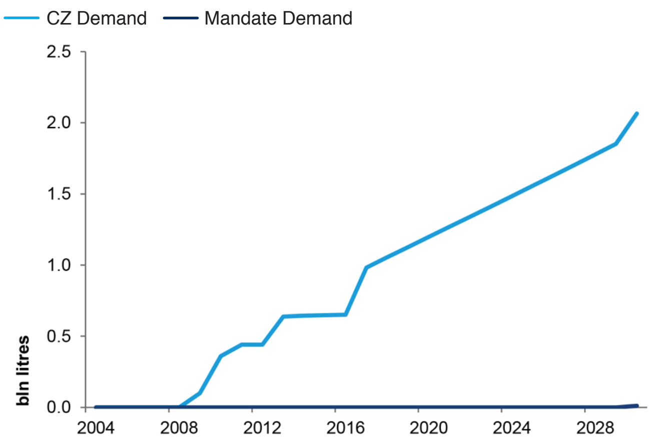
In 2008, Japan passed the Law to Promote the Usage of Biomass Resources to Produce Biofuels, which provides financial assistance in the form of interest free-loans for 10 years and tax breaks for farmers and biofuel manufacturers. Property taxes are halved over a 3-year period for newly built biofuel facilities. Also, a small tax reduction is offered if a fuel contains 3% bioethanol. More recently, the import tariff on bio-ETBE (ethyl-ter-butyl ether) has been removed, to encourage its use as a gasoline oxygenate.

7.9.3 Ethanol

Japan started blending ETBE in 2007, focusing on its production over that of ethanol due to the ease with which it could be incorporated into existing infrastructure. Typically, 1 litre of ethanol is combined with 1.9 litres of butanes, which are isomerized and dehydrogenised to produce 2.4 litres of ETBE. In 2012, as much as 360 mln litres will be used indirectly by ETBE. Further forward we expect to see a significant increase in the demand for ethanol for ETBE as the Japanese look to meet the target of 500 mln litres of biofuels on an oil basis by 2017 (the equivalent of 1 bln litres of ethanol), while the potential for a move to 3% is under consideration.

Under our modelling we expect demand to reach their target level of 500 mln litres by 2017, and run a conservative scenario of 3% blending by 2030. While this may seem small in comparison to other APAC countries in this study, the depth of Japanese gasoline demand ensures that this is a significant development by global standards. If Japan were to blend at 10% in 2030, ethanol demand would rise to 7bln litres.

Figure 33: Projections for Japanese ethanol demand to 2030



7.9.4 Biodiesel

According to EIA data, Japan produced and consumed 300 barrels of biodiesel per day (approximately 17.4mln litres) in 2010. USDA data, on the other hand, estimates consumption for the same year at 14,000 metric tons (ca. 15.9mln litres). According to the Ministry of Agriculture, Forestry and Fisheries, there are 80 bio-diesel refineries that receive its financial assistance.

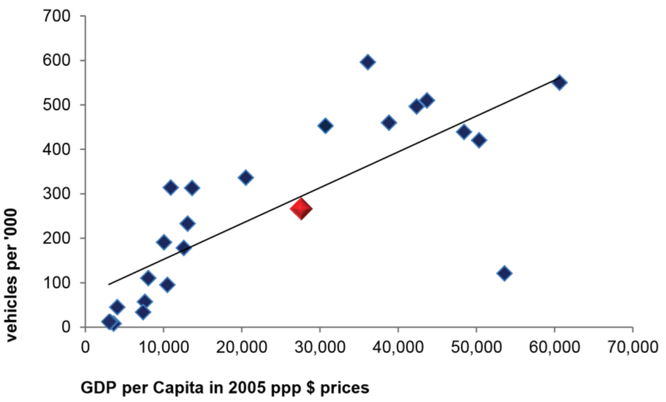
A number of alternative feedstocks are being used, including used cooking oil, rapeseed oil and palm oil. In Japan's transportation sector, most of the vehicles use gasoline instead of diesel except logistics/freight companies. About a third of road energy consumption is diesel, while road diesel consumption accounts for ca. 55% of total gas/diesel oil consumption in the country.

There is no official mandate for blending biodiesel, but the government has indicated that the blending ratio should be less than 5%, in order to ensure that the fuel meets safety and gas emissions standards for existing vehicles. This new requirement was added to the Light Oil Standard under the Quality Control Law and became effective in March 2007. In Japan, because 100% biodiesel fuel (B100) is not subject to the light oil transaction tax, many regional governments have initiated measures to use competitive B100 for their vehicles, such as dustbin lorries. However, some have pointed out that problems may occur because automobiles distributed in Japan are not designed to use B100. Despite the various limitations, the government hopes to promote clean diesel vehicles, as diesel fuel is more energy efficient than gasoline fuel and CO2 emissions are lower. Tax breaks for clean diesel vehicles were introduced in 2009 and Sulphur-free diesel oil was introduced in the market in 2005 and is currently available nationwide. Overall, however, the government seems to be focussing much more on ethanol and ETBE, as discussed in the previous section.

7.10
Country focus South Korea

South Korea is a dynamic industrialised economy. It has the third largest GDP per capita in Asia Pacific and is in the top 30 in the world. Between 2000 and 2011, Korea's GDP per capita increased by 47%, a CAGR of 3.5%. Its appetite for energy has followed closely its economic growth. In 2011 there was approximately 1 passenger vehicle for every 4 people in South Korea (267 per thousand people):

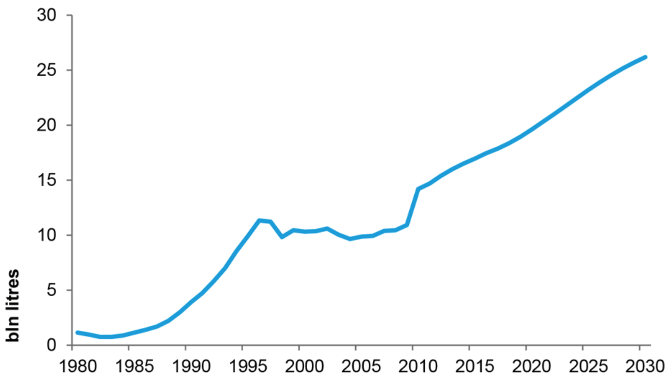
Figure 34: South Korean vehicles per '000 as a relationship with GDP per capita



Standing at a total of 26mln toe in 2011, South Korea's primary energy consumption was a tenth that of China and ranked in fourth place in Asia Pacific behind China, India and Japan. Between 2000 and 2011, its energy consumption increased by nearly 40%, or by a CAGR of 3%, closely following the rate of its GDP growth. This was less than the average for non-OECD countries overall and APAC countries specifically, but higher than the OECD average (of which Korea is a country member) and higher than Japan, its closest rival.

Reflecting its status as an OECD country, and its potential for future demand growth, the analysis suggests Korean gasoline consumption could continue to grow in a fairly linear fashion over the years to come:

Figure 35: Projections for South Korean gasoline demand to 2030



Its lack of domestic reserves makes Korea one of the top energy importers in the world. The country is the fifth largest importer of crude oil, the third largest importer of coal (steam and coking), and the second largest importer of liquefied natural gas (LNG). South Korea has no international oil or natural gas pipelines, and relies exclusively on tanker shipments of LNG and crude oil.

Korea consumed ca. 2.5mln bpd of oil in 2011, mostly imported from the Middle East (87%), making it the eighth largest consumer of oil in the world. Following a period of rapid growth that lasted through the 1990s, the country's oil consumption has remained relatively steady over the past decade, averaging about 0.5% growth on an annual basis through the 2000s.

7.10.1 Refining and oil products

Despite its lack of domestic energy resources, Korea is home to some of the largest and most advanced oil refineries in the world, six in total. Their refining capacity in 2011 was almost 2.8mln bpd.

According to the US Energy Information Administration (EIA, 2011), Korean refineries are increasingly producing more light clean products as a result of refinery upgrades that have taken place in recent years. The increasing sophistication of the Korean refining market is likely to increase capacity utilization, which is already quite high for some refineries. As a result, Korea is expected to remain a leading refiner in its region, with significant exports to China, Singapore, and Indonesia.

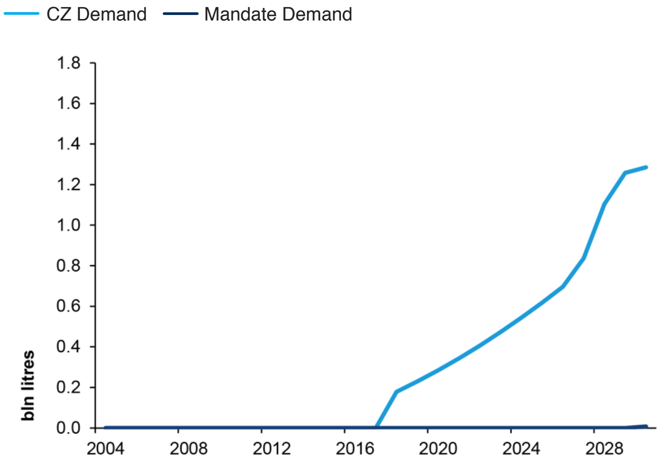
7.10.2 Ethanol

At present, no ethanol has been introduced into the gasoline pool. In 2009, the Ministry of Knowledge and Economy determined that with infrastructure adjustments, E3 could be introduced, but the pilot program was delayed due to high grain prices relative to the price of oil. Given the current situation, it seems that any kind of ethanol policy in Korea may still be years away from being

7.10 Country focus South Korea continued

implemented. In our modelling we have assumed no mandated ethanol usage, though we have factored in a gradual increase in discretionary use towards 2030 as refiners look to octane enhancers in order to improve fuel quality and specifications.

Figure 36: Projections for South Korean ethanol demand to 2030



7.10.3 Biodiesel

As the green energy market is set to grow in Korea, biodiesel is becoming particularly important as the government is strongly supporting it as an alternative to fossil fuels. However, biodiesel consumption is still very new in its domestic market, and is hampered by the lack of land required to produce the domestic feedstock for biodiesel production. The country imported more biodiesel and/or feedstock from other countries than domestic production, but now it has been gradually shifting its dependence away from fossil oil products and focus more on biodiesel development as two-thirds of its transportation industry relies on diesel.

The country began a biodiesel demonstration project in 2002, and in 2011 produced 294k toe (380mln litres). Biodiesel shows great potential for future expansion as the government gradually raises the blending ratio. In addition to imported soy and palm oil, biodiesel feedstock is supplemented by domestic waste cooking oil, which accounts for 20-30% of the national biodiesel consumption.

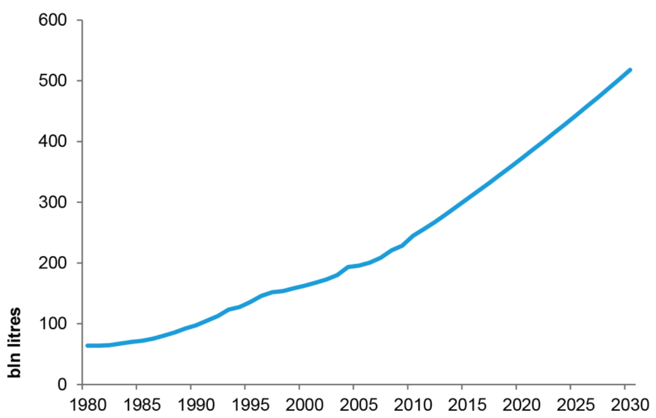
8 Conclusion

The outlook for biofuels consumption in emerging and developed APAC countries is promising. Demand for energy overall, whether for industry, transportation or domestic consumption will continue to increase at a fast pace, to at least 2030.

This will create considerable challenges for satisfying energy demand within APAC and also the wider global market, as this growth will place further strain on existing hydrocarbon supplies.

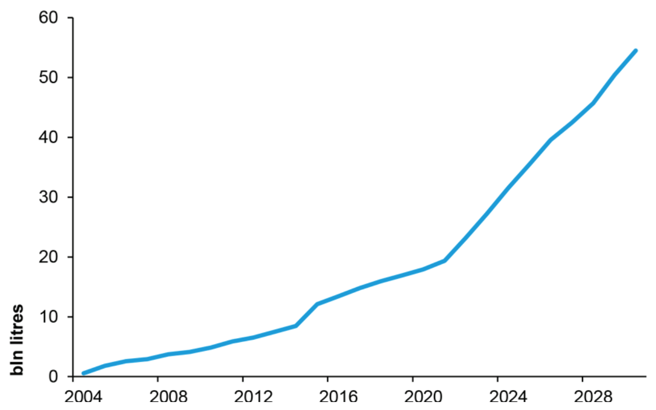
Among the countries analysed, **gasoline demand is projected to double to 520bn litres**, which is larger than the current US market, around 40% of global demand and 10% of global crude oil production.

Figure 37: Asian gasoline demand



Diesel use is forecast to experience even greater growth, **nearly trebling to 745bn litres**, around 40% of current middle distillate demand, and around 15% of global crude oil production.

Figure 38: Asian diesel demand



With the exception of the mature economies of Japan and Korea, all other countries exhibit low to very low levels of car ownership. As their economies grow, even at somewhat slower rates than in the past, consumer tastes will change and will continue to drive road fuel consumption.

Most countries are gearing up for the expected demand growth, by expanding or improving their refining capacities, with the aim to produce higher quantities of middle and light distillates such as diesel and gasoline. However, all of these countries are also looking at biofuels with increased interest. Environment and renewable aims mean that the majority of countries have at least some policies in place, although not all of them have firm mandates – they mostly have aspirations. Looking further forward, ethanol's role as an octane in expanding fuel markets will take on increased significance. In addition, as levels of affluence rise there will be greater focus on clean emissions, which will see bio-ethanol recognised for its value as an oxygenate.

8.1 Ethanol

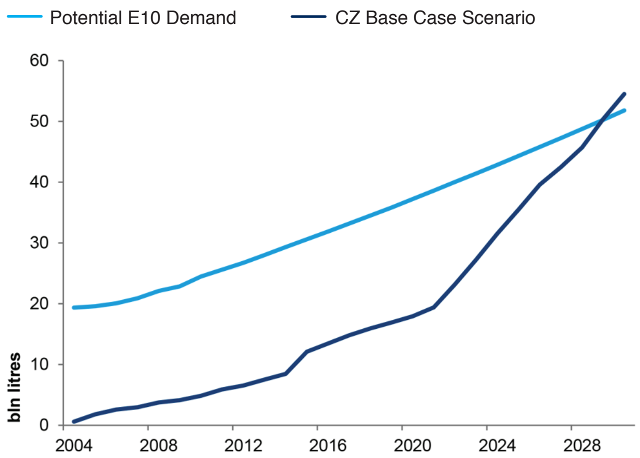
Our country-by-country case study in Asia has yielded a wide variety of results based on each country's economic history and current energy policy. In terms of gasoline consumption, China will continue to be the leading gasoline consumer in the APAC region and we expect the growth in consumption to continue to trend upwards. Japan, the second largest user of gasoline in the region, is expected to continue to experience very modest growth in its gasoline consumption. Consumption may even turn negative and, by 2030, we expect India to close the gap with Japan with its expanding economy. Other smaller nations in Asia will experience strong growth such that gasoline consumption will more than double, including Indonesia and Vietnam, a scenario that is consistent with the IEA in terms of other growing gasoline markets.

In terms of ethanol demand, China has the potential to be by far the largest market, if blending can exceed current limitations and imports permitted. However, if Indian policy can be resolved this market has the potential to be a significant force in the region.

In terms of policy and potential for growth in ethanol markets, many of the smaller Asian countries have very positive outlooks. If we were to consider all the APAC countries involved in this study, fuel ethanol would increase by 470% from current levels in 2015, and by 2030 demand would be 800% higher than current levels. This would be larger than current US demand, and around 60% of the current global demand.

8
Conclusion continued

Figure 39: Potential Ethanol Demand at E10



8.2 Biodiesel

We have also analysed the development of biodiesel in Asia, using a similar analysis to that for ethanol and given that most (but not all) countries usually have some targets in place for both. In addition, we have found that biodiesel could generate benefits for several Asian countries such as improvement in energy security, economic development, poverty reduction, employment creation.

Diesel is the most consumed fuel in the transportation sector. Whereas gasoline is exclusively consumed in passenger cars, diesel can be used in anything from a family car, to a van, bus or truck. There is certainly great scope to blend some of this with biodiesel, but only a few countries seem to have put emphasis on the promotion of biodiesel production and this is mainly for the export market.

The development of new types of fuels from the sugar molecule has the potential to shift the landscape. While sugar only currently competes with gasoline via the ethanol link, if drop-in fuels can be developed on a commercial scale new markets such as diesel will be opened, and for this reason, the projected growth in Asia could have great significance.

9
Bibliography

Balat, M., & Balat, H. (2009). Recent trends in global production and utilization of bio-ethanol fuel. *Applied Energy*, 86 (11), 2273-2282.

Blas, J., & Meyer, G. (2012, August 9). UN urges US to cut ethanol production. *The Financial Times*

BP. (2012). *Statistical Review of World Energy*.

Chisti, Y. (2008, January). Biodiesel from algae beats ethanol. Cell Press .

CIA. (2012). *World Factbook*. Retrieved 09 22, 2012 from https://www.cia.gov/library/publications/the-world-factbook/geos/th.html

Darzins, A., Pienkos, P., & Eyde, L. (2010). *Current status and potential for algal biofuels production*. IEA Bioenergy Task.

Dimitri, C., & Effland, A. (2007). Fueling the automobile: An economic exploration of ealy adoption of gasoline over ethanol. *Journal of Agricultural and Food Industrial Organization* , 5 (1), 1-21.

IEA. (2007). *Biomass for power generation and CHP*. Paris: International Energy Agency.

IEA. (2012a). *Energy technology perspectives 2012: Pathways to a clean energy system*. Paris: International Energy Agency.

IEA. (2011a). *Medium-term oil and gas markets*. Paris: International Energy Agency.

IEA. (2012b). *Renewables information*. Paris: International Energy Agency.

IEA. (2011b). *Technology roadmap: Biofuels for transport*. Paris: International Energy Agency.

IGES. (2008). Prospects and challenges of biofuels in Asia: Policy implications. In I. f. Strategies, *Climate Change Policies in the Asia-Pacific: Re-uniting Climate Change and Sustainable Development* (pp. 105-131).

OECD-FAO. (2011). OECD-FAO *Agricultural Outlook 2011-2020*. OECD and FAO.

Pate, R., & Hightower, M. (2008). Overview of biofuels from the energy-water nexus perspective and the promise and challenge of algae as biofuel feedstock. Sandia National Laboratories.

Sims, R., Taylor, M., Saddler, J., & Mabee, W. (2008). *From 1st to 2nd generation biofuels technology: An overview of current industry RD&D activities*. International Energy Agency, Bioenergy Secretariat, Paris.

USAID. (2009). *Biofuels in Asia: An analysis of sustainability options*. Unites States Agency for International Development.

USDA. (2012a). *China Peoples' Republic: Biofuels Annual*. Foreign Agricultural Service, Global Agricultural Information Service. United States Department of Agriculture.

USDA. (2011, June 30). *Japan: Biofuels Annual*. Retrieved August 20, 2012 from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/BIOFUELS%20ANNUAL_Tokyo_Japan_6-30-2011.pdf

USDA. (2012b, June 29). *Japan: Biofuels Annual*. Retrieved August 20, 2012 from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/BIOFUELS%20ANNUAL_Tokyo_Japan_6-30-2011.pdf

USDA. (2012c, June 29). *Thailand: Biofuels Annual*. Retrieved August 20, 2012 from http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Bangkok_Thailand_6-29-2012.pdf

USDOE. (2010, May). *National algal biofuels technology roadmap*. Retrieved August 20, 2012 from http://www1.eere.energy.gov/biomass/pdfs/algal_biofuels_roadmap.pdf

Disclaimer

Czarnikow Sugar Analysis
24 Chiswell Street
London
EC1Y 4SG
analysis@czarnikow.com

Contribution

Czarnikow Analysis
Toby Cohen
Henry Toller
Sebastian Grose-Hodge
Hannah Denton

Cass Business School
Michael Tamvakis
William Hubbard
Lei Li
Sui Ng
Qinyi Pi
Eden Rahman
Natália Gavino
Udit Mittal

CZARNIKOW GROUP
24 CHISWELL STREET
LONDON
EC1Y 4SG

T +44 (0)20 7972 6600
F +44 (0)20 7972 6699
WWW.CZARNIKOW.COM

DELHI | DUBAI | GUANGZHOU | LONDON | MEXICO | MOSCOW | NAIROBI | NEW YORK | TRINIDAD | SAO PAULO | SINGAPORE | TEL AVIV

DELHI
C.Czarnikow Sugar (India) Private Limited
JMD Regent Plaza, III Floor
M.G. Road
Gurgaon 122002
India

T 91 124 430 1011
F 91 124 430 1020

DUBAI
Czarnikow Group Ltd (Dubai Branch)
Office 106, Al Jawhara Building
Khalid bin Al-Waleed Road
PO Box 26558
Dubai
United Arab Emirates

T 971 (4) 355 4443
F 971 (4) 351 8482

GUANGZHOU
C. Czarnikow Sugar (Guangzhou) Co Ltd
Room 17B01
236 Zhong Shan 6th Rd
Guangzhou 510180
China

T +86 (20) 8130 1016
F +86 (20) 8130 1027

MEXICO
C. Czarnikow Sugar Mexico, SA de CV
Descartes 54 - 101
Col. Nueva Anzures, 11590
Miguel Hidalgo, DF
Mexico

T +52 (55) 5203 4041
F +52 (55) 5203 4054

MOSCOW
Czarnikow Sugar (Eurasia) Ltd,
8B Mozhaysky Val Street,
Moscow 121151,
Russia

T +7 (495) 213 3137
F +7 (495) 213 3137 (Extn.15)

NAIROBI
C. Czarnikow Sugar (East Africa) Ltd
Third Floor, I & M Bank House
Second Ngong Avenue
P.O. Box 10517
00100 Nairobi
Kenya

T +254 (20) 271 0312
F +254 (20) 271 0315

NEW YORK
C. Czarnikow Sugar Inc
780 Third Avenue
New York, NY 10017
USA

T +1 (212) 269 4600
F +1 (212) 269 0838

POINT LISAS
Czarnikow Group Ltd,
Trinidad & Tobago Branch
Building #2, DSM Warehouse Complex
Pacific Avenue Extension,
Point Lisas Industrial Estate,
Point Lisas, Trinidad
W. I.

T (868) 636 – 2893
F (868) 636 - 7008

SAO PAULO
Czarnikow Brasil Ltda
Rua Dr. Cardoso de Mello, 900 / Conjunto 91
Vila Olímpia - São Paulo - SP
CEP - 04548-003
Brazil

T +55 11 3376 - 0200
F +55 11 3376 - 0206

SINGAPORE
C. Czarnikow Sugar Pte Ltd
3 Phillip Street #14-01,
Royal Group Building
Singapore 048693

T + 65 6538 1854
F + 65 6538 1864

TEL AVIV
3 Golda Meir St.
Ness Ziona
74036
Israel

T (+972) 8866 6110
F (+972) 8866 6130