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Energy Alternatives for the Transport Sector: The US and the EU Move in Different Directions (ARI)

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Theme: This ARI looks at the current developments in alternative fuels/technologies for road transport in the framework of rising international prices for conventional fuels and climate change mitigation efforts.

Summary: High crude oil prices during the last four years, and the warning by the IEA that there might be a relative shortage of liquid fuels by 2015, is prompting governments and the transport industry to look for alternative fuels/technologies. These would start reducing the dependence of the transport sector on liquid fossil fuels, thus decreasing the economic risks associated with the price volatility of conventional oil-derived fuels. This ARI analyses two alternative energy/technology options and their potential: natural gas and electricity. Recent developments in some regional natural gas markets, where an important price differential between oil and gas is developing, could prompt this resource to become an important option for road transport. On the other hand, after the spate of announcements of new electrical vehicles and bold market objectives, the 'electrical revolution' seems to be entering a reflection period. Governments and the manufacturing industry, especially in OECD countries, are evaluating how to achieve the ambitious goals set they have set for themselves in the most economically efficient way. The deployment of these alternatives could have significant implications for international efforts to mitigate climate change. Will local conditions and policies favour one option over the other?

Analysis: Today, transport accounts for around 19% of global energy use and 23% of energy-related CO_2 emissions. These shares are expected to rise in the future. Oil accounts for 95% of final energy use for transport, while road transport accounts for 75% of total transport energy use. This is a unique situation in a vital sector for the world economy: 70% of world oil is refined into transport fuels, while the rest goes into fuel oil for power generation and heating, feedstock for petrochemicals, lubricants, waxes, etc. Due to oil's high prices in the international energy markets since 2005, it has started to be progressively phased out in several sectors, significant examples being the OECD power and industrial sectors. In the transport sector alternatives to oil derived fuels have started to appear in recent years.

Under the baseline scenario of the International Energy Agency, transport demand, driven by continued strong population and income growth in developing countries, is expected to increase on average by 1.6% a year between 2010 and 2050. From today's 1,000 million light duty vehicles (LDVs) the world is expected to reach 1,800-2,000 million LDVs in 2050. China and India's huge and growing populations are rapidly motorising by increasing rates of vehicle ownership. In 2009 China overtook the US as the world's

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largest auto market with 13.5 million vehicles sold vs 10 million in the US. In 2010, Chinese sales reached 18 million, 23% of total world sales.

In order to fuel the global transport fleet the global production of liquid fuels is currently about 85 million barrels per day. The IEA has estimated that in order to keep with the expected rise in fuel demand, an additional 45 million barrels per day –approximately four times the capacity of Saudi Arabia– will be needed. The expected supply gap left by the decline of conventional oil production will have to be met by developing new fuels, more efficient technologies, and new energy carriers. This paper will try to assess what is the current situation with two emerging alternatives for the road transport sector: natural gas and electricity.

Natural Gas: Finally Entering the Transport Race?
The International Energy Agency (IEA) and the Massachusetts Institute of Technology (MIT) have both released reports in the first half of 2011 exploring the potential for and impact of a major expansion in global usage of natural gas, given the current re-evaluation of global supplies. The reason behind this reassessment of the role of natural gas in future world energy scenarios lies behind the recent unconventional gas developments in the US. Both reports focus primarily on the increased use of natural gas in power generation, but to a certain extent they also explore the foreseeable impact of increased natural gas use on transport.

The IEA study cites a number of benefits for natural gas vehicles, including fuel-cost savings, reduced greenhouse-gas emissions and local air-quality improvements, noise reduction and, in some cases, improved energy security. The report stresses that, specific benefits and their value, depend on national or local circumstances. On the other hand, although natural gas is considered the cleanest burning fossil fuel, additional greenhouse-gas emissions arise during production and transport, through venting, leakages, accidents or flaring. According to the World Bank, in 2010 an amount equal to 4% of marketed gas output was flared. Additionally, in the US, increasing shale gas production and exploration have sparked public concerns about the environmental impact of the technique used to extract shale gas (hydraulic fracturing). In the EU, France has prohibited this type of extraction technique.

At present, there are important barriers limiting the growth of natural gas vehicles (NGVs), of which the lack of refuelling infrastructure is probably the most significant. Another barrier is the higher purchase price or conversion cost. The report notes that NGVs presently account for less than 1% of total world road-fuel consumption and less than 1% of total world gas demand. Also, more than 70% of all NGVs and one-half of all fuelling stations can be found in just five countries: Pakistan, Iran, Argentina, Brazil and India.

The IEA expects the uptake of NGVs to remain limited unless there is a significant increase in the availability of refuelling infrastructure. The most likely source of demand growth is notably in non-OECD Asia and Latin America. The IEA sees natural gas as a potentially viable alternative to gasoline and diesel also in North America, where abundant supplies of unconventional gas are expected to hold gas prices down in coming years.

The IEA report finds that a combination of government policies and lower wholesale gas prices could result in around 70 million NGVs in the world fleet in 2035. According to it, the greatest scope for deployment of NGVs is in commercial, freight and public vehicle fleets, since provision of the necessary refuelling infrastructure can be more easily

accommodated for fleets like urban buses. Additionally, the higher usage of fleet vehicles improves the economics of ownership of an NGV, provided that a pricing differential exists between gas and gasoline or diesel. For example, in the US, the MIT report finds that with a US$1.5 fuel price spread between gasoline and CNG fuel on a Gallon of Gasoline Equivalent (gge) would make the payback time for CNG LDVs less than three years, thus making them a viable economic option.

A high-impact, low-probability (HILP) analysis in the report assumes that NGVs could sum up to 10% of total vehicle sales worldwide by 2035 and reach around 186 million vehicles.

Natural Gas, the Future for US Mobility?
According to the MIT report, which is focused on the US, albeit within a global context, natural gas use in the transportation sector is likely to increase. The writers of the study conclude that, while compressed natural gas (CNG) will play a role, particularly for high-mileage fleets, the chemical conversion of gas into some form of liquid fuel may be the best pathway to significant market penetration.

In the US, only 0.15% of natural gas is used as a vehicle transportation fuel; 32% of consumption is in the industrial sector and 35% is in the residential and commercial sectors. Globally, natural gas vehicles are a small fraction, on the order of 1%, of the close to 900 million vehicles in the vehicle fleet.

Using optimistic cost estimates for CNG vehicles, the carbon policy scenario developed in the report projects a 20% penetration into the private vehicle fleet by 2040 to 2050. Recently-enacted state low-carbon fuel standards (eg, California) might provide additional motivation for the market penetration of NGVs.

Additionally, the MIT report finds that the potential for natural gas to reduce oil dependence could be increased by conversion of natural gas into liquid fuels that can be stored at atmospheric pressure like methanol. Methanol has the lowest cost and lowest GHG emissions, but requires some infrastructure modification and faces substantial acceptance challenges. On the other hand, natural gas derived gasoline and diesel have the advantage of being drop-in fuels, but carry a higher conversion cost.

The abundant supplies of unconventional gas in North America are expected to hold gas prices down in the coming years. Thus natural gas is seen as a potentially viable alternative to gasoline and diesel. In the US, the New Alternative Transportation to Give Americans Solutions (Nat Gas Act) is currently under debate in Congress. It would provide incentives for passenger cars and trucks to run on natural gas as well as for home refuelling stations. Additionally, the federal Government is discussing a plan for newly purchased federal government vehicles to run on alternative fuels from 2015. More stringent emissions standards could also encourage faster deployment of NGVs.

Synthetic Diesel from Natural Gas, the Pearl GTL Plant in Qatar a Significant Step into a World-wide Development of Gas-to-liquids?
Qatar Petroleum and Shell announced in March 2011 the first flow of offshore gas into the Pearl GTL plant located in Qatar. The Pearl GTL project was launched in July 2006. It consists of two offshore platforms 60 km off the coast of Qatar, connected by pipeline to the largest gas-to-liquids plant ever built. According to the owners of the plant, once fully operational, Pearl will use 1.6 billion cubic feet of gas per day from the giant North Field, which will be processed to generate 120,000 barrels per day of condensate and natural

gas liquids and 140,000 barrels per day of gas-to-liquids (GTL) products. GTL products will be marketed as high quality, clean burning oil products, such as gasoil, kerosene, high specification lubricants base oils and chemicals feedstock. For Qatar, the plant is of vital interest as its oil production is expected to decline by as much as 0.5 M b/d by 2012 compared with 2007.The conversion of the country's immense gas reserves into synthetic fuels thus becomes of critical importance for the economy of Qatar.

GTL involves the chemical conversion of natural gas or other hydrocarbons into liquid fuel products such as methanol and diesel using the Fischer-Tropsch or FT process. It is expected that the Pearl GTL plant will give valuable experience on the commercial viability of GTL plants and the quality of the final products. The two other existing GTL plants, Bintulu in Malaysia and Oryx in Qatar, are in the 14,000-35,000 b/d range of production of liquid fuels.

What Next for Electrical Vehicles?
While natural gas is re-positioning itself as a valid contender in the race to substitute petroleum-derived fuels in the transport sector, the electricity option seems to be losing the initial momentum. According to a newly updated Electric Vehicle Roadmap report by the International Energy Agency, major car manufacturer announcements regarding future production plans for electric and plug-in hybrid electric vehicles (EVs and PHEVs) are far below sales targets set by countries.

According to the report, the EV and/or PHEV production plans announced from the car industry only add up to 0.9 million units by 2015 and about 1.4 million units per year by 2020. This figure is well below the aggregate national sales goals of about 1.5 million in 2015 and 7 million in 2020.

The IEA thinks that this is not necessarily a problem yet, but the situation might require close monitoring over the next one to two years. The situation could change for the better over the next few years if manufacturers make further announcements.

The vision of the EV/PHEV roadmap is to achieve by 2050 the widespread adoption and use of EVs and PHEVs. Together they would represent more than 50% of annual LDV sales worldwide. In addition to establishing a vision, this roadmap sets strategic goals to achieve it, and identifies the steps that need to be taken to accomplish these goals.

To achieve the roadmap's vision, industry and government would have to work together to attain a combined EV/PHEV sales share of at least 50% of LDV sales world-wide by 2050. By 2020, global sales should achieve at least 5 million EVs and PHEVs (combined) per year. The more aggressive scenario of the IEA (BLUE Map) suggests 7 million in 2020 and 49.5 M in 2035.

The roadmap includes other technology-specific goals, including the development of coordinated government strategies to support the market introduction of electric-drive vehicles by making them cost competitive and ensuring that adequate recharging infrastructure is in place by the next five to ten years. Reliable electricity supply must be available for EV/PHEV recharging and recharging stations must be easily accessible.

Another priority identified in the Roadmap is the reduction of battery costs as a critical factor for market entry and acceptance of EVs. In order to achieve a break-even cost with internal combustion engines (ICEs), battery costs must be reduced from the current

estimated range of US$500 to US$800 per kilowatt-hour (kWh) of storage at high volume, down to US$300 to US$400 per kWh by 2020, or sooner. R&D&D to improve battery durability and life spans that approach vehicle life spans is also imperative.

Understanding consumer needs as well as consumer willingness to change vehicle purchase and travel behaviour, and the development of performance metrics related to vehicle performance (eg, driving range) and technical characteristics (eg, battery requirements), will also be priorities for industry. Additionally, governments will have to set appropriate metrics for energy use, emissions and safety standards to address specific issues related to EVs, PHEVs and recharging infrastructure.

Europe Moves Forward in e-Mobility?
As an important step in the deployment of electricity as an alternative energy for transport, the European Commission has launched and partly financed the eMobility project, 'Greening European Transportation Infrastructure for Electric Vehicles'. Proposed by a coalition of eight partners led by the company Better Place, it is the first to date to be funded under the Directorate-General for Mobility and Transport's new de-carbonisation infrastructure category. The €4.95-million (US$7.1-million) award towards the €9.9-million (US$14.2-million) project comes under the Trans-European Transport Network (TEN-T) programme.

The project envisions the analysis, testing and deployment of a multi-transport mode network using the current road infrastructure and railways, coupled with an electric car charging network of battery switch stations and charge spots powered by renewable energy along with intelligent transport systems.

The project's purpose is to serve as a technology roadmap for creating a pan-European electric car network. Six European Ministries of Transport –Denmark, The Netherlands, Austria, Spain, Belgium and Luxembourg– have endorsed the project during its application phase.

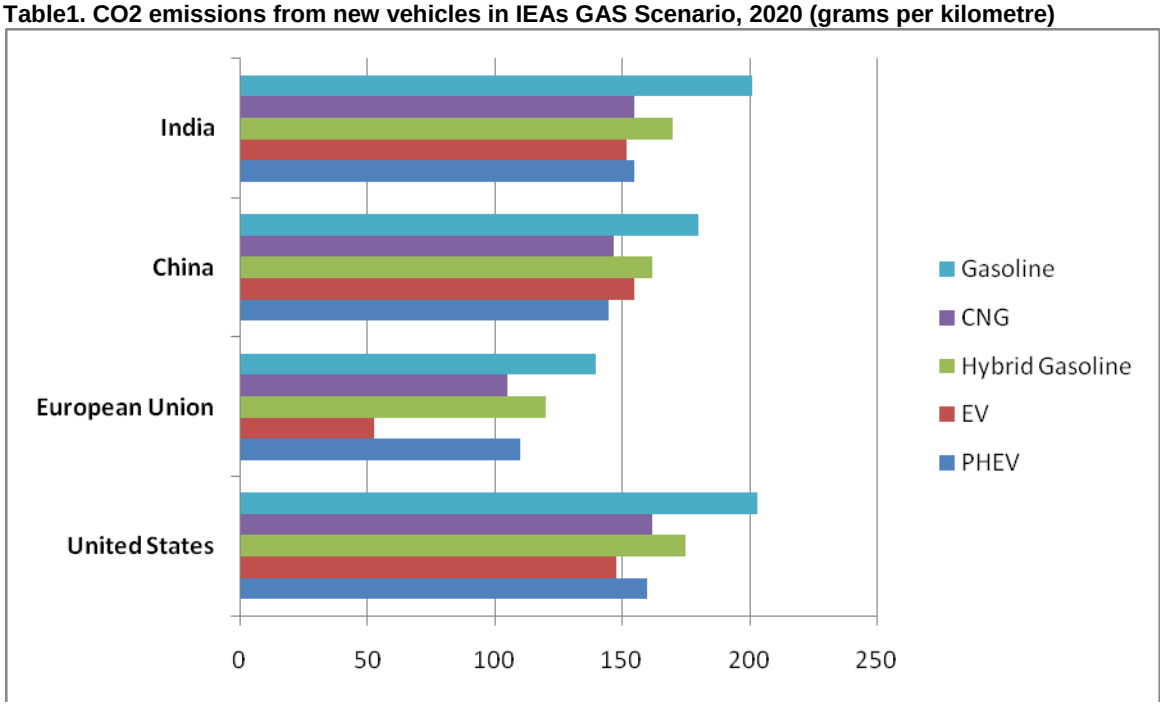
Together with Better Place as project coordinator, the consortium includes FCC Construccion SA of Spain; Verbund AG of Austria; the City of Copenhagen; Elia System Operator S.A. of Belgium; Technical University of Denmark; the City of Amsterdam; Public Research Center Henri Tudor of Luxembourg; and DSB Kommerciel of Denmark.

One of the project highlights is the debut of Europe's first commercial battery switch station in Denmark. The battery switch station is part of a national network of battery switch stations and charging points being deployed across Denmark this year, with an initial commercial launch of eMobility services scheduled for the end of the year.

Implications for Climate Change Mitigation Efforts
One of the surprising findings of the IEA study is that Compressed Natural Gas (CNG) vehicles may emit less CO_2 per km than electric vehicles (EV) or plug-in hybrid vehicles (PHEV), depending on the fuels used to produce electricity. It is forecasted that in 2020, CNG cars will emit less CO_2 per km than PHEVs in all the regions, with the assumption that 10% of the vehicle-kilometres of PHEVs are electrically driven. They would also emit less CO_2 per km than EVs in China, because almost 75% of the electricity is produced in coal power stations. In India, CNG vehicles and EVs would emit about the same amount of CO_2/km, while in the US EVs CO_2 emissions would on average be less than CNG vehicles.

In the EU, by contrast, CNG vehicles would emit twice as much CO_2/km as electric ones. This is because of the low carbon intensity of electricity generation, which is projected to fall to 235 kg CO_2 per MWh by 2020, thanks to the widespread deployment of renewable energy technologies, like wind and solar, driven by the EU's efforts to curb CO_2 emissions. This compares with electricity generation carbon intensities of 480 kg CO_2/MWh in the US, 605 kg CO_2/MWh in China and 675 kg CO_2/MWh in India.

Table1. CO2 emissions from new vehicles in IEAs GAS Scenario, 2020 (grams per kilometre)



Source: IEA, 2011.

If NGVs achieve a 10% market penetration by 2035 it would have a significant impact on fossil-fuel demand and a lesser impact on emissions. Demand for natural gas would increase by around 320 bcm in 2035, compared with the New Policies Scenario of the IEA, and oil demand would decrease by 5.7 mb/d, more than 12% of global oil demand in the road-transport sector in 2035. As a result, CO_2 emissions from that sector would drop by 165 Mt in 2035.

On the other hand, GTL fuels have well-to-wheels CO_2 emissions that are slightly higher (about 10% according to the European Commission Joint Research Centre) than those for conventional fuels. So, while the large scale deployment of CNG and of electricity as energy alternatives for transport, if used as substitutes, could result in most regions in reductions of CO_2 emissions, the use of GTL fuels would, on the contrary, have a net increase effect on global emissions. However, if the increased use of natural gas and electricity for transportation will only be covering the additional energy demand that is expected to arise especially in developing countries, these energy alternatives will not be contributing to reduce CO_2 emissions. Only with strong international and national policies that will ensure there is a real 'substitution effect' could natural gas and electricity become meaningful tools for global efforts to mitigate climate change.

Conclusions: Expected high prices for crude oil and a significant price differential between oil and natural gas in regional markets are starting to make investments in natural gas and electricity transport alternatives, more attractive in the medium-long term.

Drop-in alternatives to conventional fuels, such as GTL fuels, might also become an important option, especially for countries with important gas reserves, like the US and some Arab states. The high investment costs in infrastructure necessary for the deployment of CNGs and EVs might also be a factor that would favour the use of GTL fuels. However, the development of GTLs might entail an increase in CO_2 emissions thus not contributing to global efforts to mitigate climate change. From the point of view of sustainability, the studies analysed in this paper seem to indicate that a large deployment of NGVs by 2035 would have a significant impact on fossil-fuel demand but a lesser impact on emissions.

On the other hand, when it comes to the future of electricity in road transport, car manufacturers seem to be waiting for governments to set up the necessary policies and infrastructure for a widespread launch of this type of vehicles, before committing to further industrial developments.

According to the IEA and MIT scenarios on natural gas and electrical vehicles, the sum of both options could be equivalent to about 40% of the expected market for LDVs. Starting from a current market size of less than 2% many steps have to be taken and hurdles be overcome before the objectives in these scenarios can become a reality.

While the US might have a greater potential for natural gas vehicles (also given its newly-enhanced unconventional gas reserves), the EU seems to be more determined to develop the electrical option for its transport needs in accordance with its climate change and renewable energy policies. However, for the moment, it seems premature to try to pinpoint what will be the future development of these two alternatives or whether one will prevail over the other. In the short and medium term it will depend on local factors and governmental policies. And in the longer term, given the globalisation of mobility markets, most probably both options will be deployed in all regions to a certain extent.

In terms of CO_2 mitigation efforts, in order for these two alternatives to become a useful option, strong policies will need to be adopted in order to ensure that their deployment results in a decrease in emissions (substituting conventional fuels), instead of an increase of existing levels (adding to current consumption of fossil fuels in transport).

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