

Riding the 7 Cs

Understanding the 7 rules to establishing LNG as a Road Transport Fuel

**By
Nick Allen
Director
Navigant Consulting
United Kingdom**

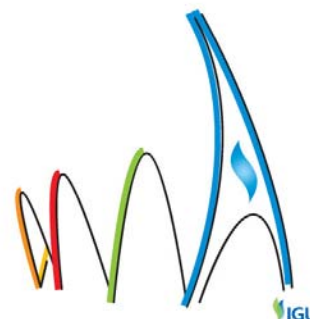


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Background

Road transport, the function of moving people and goods from A to B along highways and bi-ways, has been a fundamental building block of economic prosperity over the last 100 years. Over this time, the transport value network¹ has developed into a vast, complex, highly inter-dependent and sophisticated system of vehicles, fuels, roads, refuelling facilities, logistics and more recently IT infrastructure. It is understanding the difference between a value network and the supply chain. The latter is the linear elements of the chain that a product moves through from source to end customer. The latter includes all the ancillary providers that support the market for the product.

Over time the value network has evolved through waves and waves of innovation, but fundamentally around a core anchor of liquid gasoline and diesel. Vehicles has become more efficient and safer, roads more durable (and safer), refuelling facilities faster and more convenient, and logistics more sophisticated, but fundamentally the fuel of choice has been remained predominantly diesel for heavy duty transport and a mix of diesel and gasoline for light duty (geography dependent). There is no magic to this – it has been this consistency that has allowed many of the other elements of the value network to innovate in the knowledge that they are not investing in redundant legacy assets. In turn, that was underpinned by a dominance of crude oil as the primary energy source of choice.

The use of natural gas in vehicles stretches back to the advent of the internal combustion engine in 1860, but the growth of natural gas vehicles has varied significantly by country. CNG vehicles have emerged as significant parts of the vehicle mix in Venezuela, Pakistan, Iran, Brazil, India and the Middle East. However, LNG as a heavy duty transport option has

¹ "...a collection of upstream suppliers, downstream channels to market, and ancillary providers that support a common business model within an industry" Christensen, C.; *The Innovator's Dilemma: The Revolutionary Book that Will Change the Way You Do Business*, Collins Business Essentials

mostly focused on buses, where the supply chain is relatively simple, with vehicles refuelled through a home base. In addition, the nature of the owner-operator structure for heavy duty vehicles in many markets has made the economics challenging.

However, these fundamentals are being challenged. The emergence of cheaper shale gas and the need for accessible and scaleable lower emission solutions (supported by vehicle and fuels regulation) has created the conditions for the emergence of new vehicle and fuel solutions, be they electron or gas based, each requiring unique "refuelling" infrastructures.

Scaling these solutions requires a fundamental broadening of the gasoline/diesel derived value network into a 21st century transport value network, able to serve a broader set of fuel and vehicle choices, which presents fundamental challenges.

The level of interest in LNG as a heavy duty transport solution started to grow at the end of the last decade, encouraged by the emergence of shale gas and the knowledge that of the two options, LNG is potentially a more attractive offer for long haul trucks, given its ability store 2.5 times as much equivalent energy in the same volume compared to CNG.

However, the players in the value network have faced substantial challenges in developing the market. Despite developments in the California, Canada's green corridors and in France, Germany and The Netherlands, progress has been slow. Navigant Research's recent report on Natural Gas Vehicles² predicted limited growth in LNG heavy duty vehicle sales in the next 10 years. That raises the question, what would it take to change the paradigm and accelerate the creation new markets for LNG as a heavy duty transport fuel?

Aim

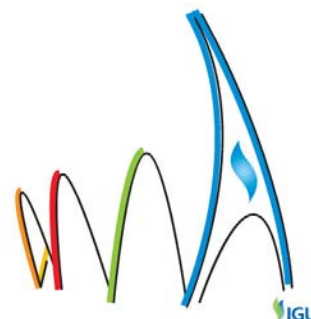
The aim of this presentation is to introduce a framework of the 7Cs - 7 rules to establishing LNG as a Road Transport Fuel. These are drawn from learnings in other sectors and understanding the challenges in the LNG transport sector. The presentation will outline what they are and why are they relevant.

Methods

The presentation draws from extensive experience of the author in the introduction of liquid road transportation fuels in markets across the world.

It outlines the key evolutionary developments in liquid transport fuels over the past 100 years and highlight the key milestone moments around the world (lead removal, desulphurization, dieselization etc.), and what has been learnt from these, and highlights some of the successful and least successful examples, draw out the learnings.

² Navigant Natural Gas Vehicles Report, 4Q 2014



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It then walks through the 7 steps one by one, defining each one, outlining its importance, and identifying the specific challenge for LNG. Whilst used to articulate a roadmap for heavy duty LNG, it is equally applicable to other new low carbon solutions, such as hydrogen fuel cell vehicles and electric vehicles.

Results

Understanding history

To understand some of the challenges in evolving the value network, we can turn to some of the learnings from the relatively simple milestones in the evolution of the anchors in the value network – the fuels. Whilst these learnings are predominantly drawn from the light duty sector, there is a case to say that the insights are directly applicable to the heavy duty sector.

In the 20th century three of the major milestones in fuel evolution were lead removal, desulphurisation and the introduction of bio-fuels. Space does not provide the luxury to articulate in detail the specific changes required involved in each. However, a number of learnings can be drawn from these introductions.

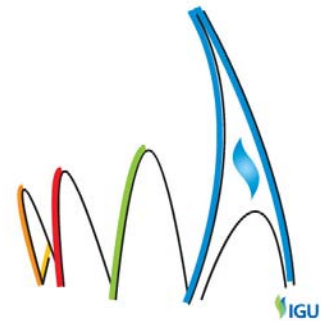
Firstly, all key stakeholders need to be aligned and agreed on the specification of the change – regulators play a key role in defining the specific fuel regulation that then creates the framework which allows commercial player along the value chain to invest accordingly.

Second, co-ordination between players across the value network to align the timing of introduction is key. Investment by one commercial player too far ahead of the introduction leads to capital inefficiency – investing too late delays the benefit capture (be that financial or environmental) and potentially vehicle damage through miss-fuelling (as in the case of lead removal).

Third, in some cases there needs to be a solution for the legacy fleet, as in the case of lead removal. Built on the law that the incumbent is king, where the new fuel is not compatible with all vehicles (usually the legacy fleet), a solution obviously needs to be available.

Finally, this brings us to the final and probably most critical learning – the critical need to inform and educate all stakeholders well in advance of introduction so that any customers for whom the new fuel is not appropriate, need to be clearly aware.

A simple yet prescient case to consider is the relatively benign introduction of E10 in Germany in 2011. In response to European fuel regulation, a specification was set to blend 10% ethanol into road transport gasoline, with the support of the German government, OEMs, and fuels suppliers. However, the introduction was deemed a “fiasco” by motoring experts and the media. The root cause of the issue was that whilst only a minority of



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vehicles were non-E10 compatible, customer were not sufficiently informed whether there vehicle was one of the few exceptions. Most critically, this information was not available to customers at the pump at the point of introduction.

Simply, insufficient alignment across all stakeholders (OEMs, fuel suppliers, consumer groups, government, motoring organisations) created the environment for concerns to exist that a motorists car could be damaged if they miss-fuelled with E10. This very quickly resulted into significant consumer backlash, with surveys showing that up to 70% of customer rejecting the fuel at the forecourt. After substantial recovery activity, a level of customer confidence recovered, but the product never achieved the level of penetration aspired at launch. What was most surprising in this case is the fact that in stood in contrast to the way Europe had successfully managed the phase out of leaded fuel across multiple markets.

Another often sited example of where a game changing technology was undermined by the difficulty in successfully co-ordinating the key players in the value network was the aborted introduction of run-flat PAX tyres in 2005³. In 2005 Honda announced that they would introduce the PAX tyres on part of their mini-van series, a product that came out of an alliance between Michelin and Goodyear. Despite the ground breaking nature of the product, existing and new players in the value network were not prepared or able to deliver the required additional services that were important to support the product, most critically the service garages who needed complex new equipment and training. As in the case of the E10 in Germany, the absence of these key elements undermined customer confidence, and ultimately development of the PAX system ceased in 2007 as a consumer offer. It did subsequently experience success however as a solution for the military, where greater control of the value network elements can be achieved.

Strategic framework

The strategic framework for creating a gas-in-transport sector consists of 7 golden rules – *conditions, convene, collaborate, content, conceptualize, commercialize, and co-ordinate & conduct*. Each will be explained in detail. For this presentation, the focus will be on LNG as a heavy duty solution, but the framework is equally relevant to CNG in the light duty sector.

Whilst much of the framework appears obvious and undeniable common sense, our learnings across multiple energy sectors is that comprehensive frameworks are effective in guiding the required development to manage the evolution of markets that operate with complex supply chains.

³ The Wide Lens – A new strategy for innovation, Ron Adner, 2012

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That said, not every rule is of equal importance, and not every rule is critical in all situations, but some are fundamental.

Finally, the intention is not to drill down into each rule in extensive detail, but to introduce the framework and each rule, and illustrate the relevance through animated examples.

Rule 1 – Fundamental Market Conditions

One of the fundamental rules is that of compelling market conditions. The starting point for an assessment of the potential to establish a gas in transport sector needs to be an understanding whether the trilogy of *market fundamentals* exist in a geography to support the initiation of the opportunity – *stimulants, economics, product*. Without these inter-related elements, invariably there is no case to proceed.

The entry point is to understand whether the two core *stimulants* are in place or are planned to be in place – technology and industry capability, and legislation.

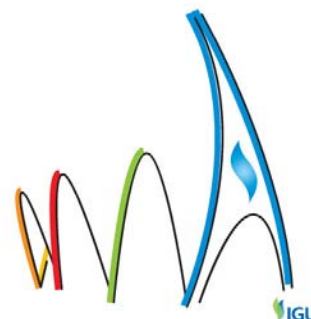
In terms of technology and industry capability, a key question is whether the current available technology supports the promotion of LNG in road transport vs. the alternatives (hybrids, advanced diesel etc.) and whether the LNG supply structure is in place or predicted.

Turning to legislation, in the case of the majority of new fuel introductions it provides either the mandate to require its introduction and/or the incentive to enable it to be commercially viable. In the case of LNG for heavy duty transport, a key question is whether there is the existing national, regional or local legislation that would actively promote switching to LNG as a heavy duty transport fuel. Incentives can be applied at different parts of the supply chain from incentivizing suppliers (i.e.: LCFS) or vehicle purchase.

Beyond these catalysts, the fundamental economics need to be sufficiently attractive to support the case. Two of the critical questions for commercial players is whether there is sufficient potential scale to support the required level of investment – the materiality test – and whether the market pricing fundamentals will support customer conversion from the diesel incumbent to LNG. In traditional product markets, these economics tend to relate to one or two players.

However, given the complexity of the value network, and the criticality of aligned timing of investment, there needs to be a clear understanding early on that there is sufficient margin for each key player in the value network to support the necessary investments.

For LNG this is critically important, given the complexity of the players involved, including the specialist vehicle technology providers, vehicle manufacturers, vehicle owners and operators, and those involved in the gas supply chain from liquefaction through to “retailers”



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of the fuels. The critical financial driver is the current and future available spread between the liquid and gas fuel prices – i.e.: between the West Texas Intermediate (WTI) crude price and the Henry Hub gas price, as it is this spread that fundamentally creates the driver for vehicle switching from liquid to gas. At the initial stage, you need a benchmark understanding of the required spread to create sufficient value end-to-end to justify initiating the project. One learning is that the factoring in of government incentives to support the financial case creates a level of risk as incentives are vulnerable to regulatory change.

The final piece of the trilogy is product – looking across the LNG supply chain, is there appropriate access to product, either through domestic supply or import capabilities?

Rule 2 – The Power to Convene

Assuming the market *fundamentals* indicate that the conditions are right to create an LNG-in-Transport market, then the other rules can be applied.

Given the complex nature of the value network surrounding LNG in transport, rarely can a single player consider the opportunity in isolation. There needs to be a catalyser with the vision to see the opportunity, and the ability to convene sufficient key players across the value network with a motivation to see the market created. Invariably that would include players associated with vehicle production and conversion, LNG supply chain players, and LNG refuelling infrastructure players (i.e.: fuels retailers). Each player will be concerned about the issues and risk associated with the creation of this new market, most notably whether there will be sufficient sustained margin to support capital investment, whether the other players would be willing to make the required investments at the right time. This is the inevitable *chicken and egg* issue. The catalyser needs to be able to help ensure that there is sufficient senior level commitment within each of the players' organisations to build and sustain momentum.

Rule 3 – Promoting Collaboration

Once the players have demonstrated commitment, the catalyser plays a critical role in facilitating collaboration between them. Collaboration is a behaviour and rather than an end destination, and early engagement and collaboration builds a shared understanding of the ultimate prize, that it will almost certainly only be realized if all are successful, and from this a developing commitment to a shared success. A key objective of this early stage collaboration is the building of trust between the players themselves and with the catalyser. One of the key requirements here is to help ensure that no single player has the ability to exert preferential power over the others, which requires the catalyser to have independence from all of the players. This is why, where one of the players has been the initial catalyst, they need the maturity and confidence to bring in a third party to take forward the collaboration.

Rule 4 – Understanding the Challenges

Invariably, one of the key drivers of strong and successful commercial organisations is their ability to understand and be ruthlessly focused on their own part of the market, be that developing vehicles, building and operating retail stations, and on occasions leveraging their strength over other players in the value chain to their advantage. However, when they turn to an opportunity that requires collaboration, they learn that it is critical to really understand the technical, financial, commercial and operational challenges the other players face, and their role in positively or negatively influencing this.

In the case of E10, the retailer could have better understood the needs of customers in terms of whether their vehicles were compatible, and the OEMs therefore understanding that retailers would face this challenge, and working together to ensure the information was widely available in advance of the launch.

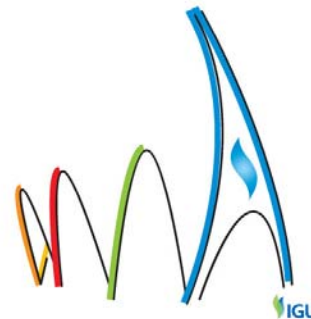
In the case of PAX, the OEM had the opportunity to better understand the challenges faced by the service garages, and ensure they were prepared for the introduction of the new product. For LNG in transport, challenges include understanding the complex relationships between vehicle owner and the financing arrangements around this, and the vehicle operator, who are often different. The operators of refuelling sites often face the challenges of committing significant capital in advance of wide penetration of vehicles.

Rule 5 – Conceptualise the solution

To bring the solution to market requires multiple players to execute inter-related activities, often at the same time. The LNG supply chain needs to be fully established, the vehicles need to be available, customers need to be identified and demand created, and the refuelling infrastructure needs to be developed. Even on a small geographic scale, this is a significant challenge. As proven in the case of PAX, the end-to-end integrated offer needs to be conceptualized and all players understanding their role in delivering that offer. In the case of LNG, the vehicles need to be promoted to both the purchasers and users (if they are different) and success will require the OEM to be able to sell the whole solution, including the location of refuelling facilities. That requires that these facilities are in the right location for the customers. It is this inter-related nature of the elements that demands that the players come together and conceptualise the complete system – both its initial incarnation and how it will develop. The catalyser plays an important role in facilitating this.

Rule 6 - Commercialisation

In the conditions stage, a high level assessment of the overall available value in value network was established, to create the case to move forward. Once the system is conceptualized and all players understand the challenges, how to resolve them and



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ultimately what is required from them to realise the opportunity, the next critical stage is the development of the individual commercial business cases. Ultimately, all players need to make a sufficient return to support their investment.

A critical value equation is the relative payback of a HD LNG truck vs. the diesel alternative. Analysis by Navigant Research⁴, in the case of the US, the incremental cost of the LNG vehicle is recoverable in 2 years, and with fuel cost per mile being significantly cheaper, generates significant savings from that point on.

The catalyser plays a critical role in facilitating this process, understanding if and when the business case for one or more players is not sufficiently compelling. In some markets, this may then require engagement with government on the need for incentives, especially where LNG has a demonstrable benefit on CO2 emissions.

What is fundamental is that each player is realistic early on in the engagement of the achievable economics, and the catalyser plays a key role in driving this message. For example, if the refuelling infrastructure provider is overly optimistic on their site economics, and realizes late that they are unable to get the site costs down to the required level and hence are unable to deliver the required returns, the facilities will not be built, with the knock on effort of substantially undermining the overall offer. Another critical challenge in LNG is the changing arbitrage between LNG and crude prices, which as discussed up front is the critical driver of conversion. Ultimately, the players need the confidence that despite the inevitable movement in prices and the lack of direct linking between the two pricing structures in most market, they need confidence that in the medium term a sufficient spread will remain.

In the case of PAX, an assumption could be made that insufficient consideration was made on the needs of the service garages and specifically the importance of there being as compelling business case to invest in the necessary equipment. The absence of this investment led to the undermining of the product offer.

Rule 7 – conducting the orchestra

Finally, coming back to the catalyser, they play a critical role in conducting the process. With multiple commercial organisations working to execute their individual parts of the proposition, it is key that each player remains aware of, and confident in the progress of the other players. This is a significant challenge and one the catalyser has to play. This is often

⁴ Navigant Natural Gas Vehicles Report, 4Q 2014

a substantial programme management challenge, especially in LNG where the key players may be facing significantly different timelines to market.

Conclusions

So in conclusion, the pathway to creating an LNG in road transport sector in a geography is complex and unpredictable. History tells us that the introduction of new fuels and other transportation solutions is fraught with significant challenges. These involve a complex value network of players who need to each perform a role in delivering an integrated offer to customers.

The starting point is the confirmation that the fundamental market conditions are in place to create the case to progress. Then a 3rd party catalyser needs to be able to convene key players, drive early stage collaboration to create sufficient commitment. Players then to understand each other's challenges and to understand their role in creating and helping to address these challenges. It then requires the ability to conceptualise the overall integrated offer to customers, and to create a collective and individual commercial business cases. Sharing of value across the network to ensure all players make a sufficient return is critical. Finally, throughout this process the catalyser needs to be able to conduct the orchestra of players to ensure that all are able to deliver their part of the offer, and appropriately aligned.

As the cases of E10 in Germany and the PAX tyre system showed, the successful introduction of simple fuel products or complex tyre systems can be undermined by the failure to follow the 7 golden rules.

Whilst the 7 C's of Success have been applied here to help show the pathway to successfully introducing LNG in Transport, they can equally be applied to the development of other complex decarbonising transport solutions, including hydrogen fuel cells and electric vehicles, both of which involve complex value networks with multiple players in the value chain and significant capital investment by all players. What is clear though is that we will continue to see the innovative-minded players, facilitated by catalysers, working together to create new markets for low carbon transport solutions.

References

The Wide Lens, Ron Adner, Portfolio/Penguin, 2012

Navigant Natural Gas Vehicles Report, 4Q 2014