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Voice-of-the-Future: Assessing the Impact of the "Hydrogen Economy"

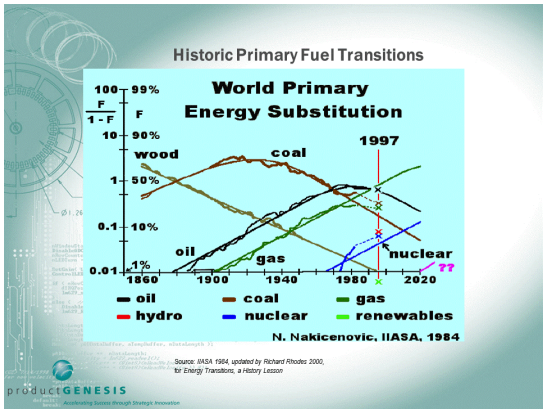
Company: *American icon in off-road equipment for agriculture, construction, forestry and turf care*

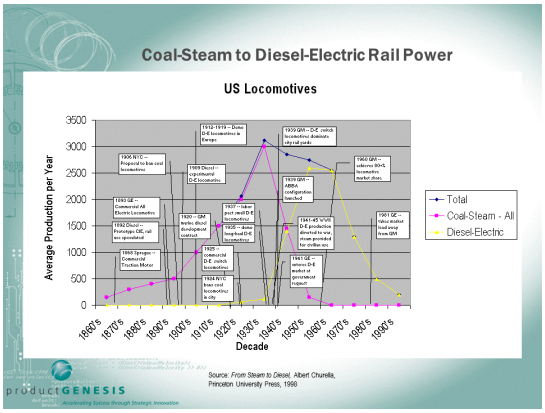
Category: *Diesel powered off-road work vehicles*

Challenge: Concerned with increasing discussion in the popular press about alternative fuels (hydrogen) and the imminent advent of fuel cell technology, the company wanted an assessment of the likelihood, timing and potential impact of a broad-based "Hydrogen Economy" on their core businesses. Specifically, they wanted a more detailed understanding of potential opportunities and threats to their extensive range of products based on diesel fuel and internal combustion engine power plants. They wanted an assessment of what should be done tactically to prepare for them in the near-term, and strategically to plan for potential disruption in the long-term.
While the "Hydrogen Economy" was the top of mind question, the overarching question was disruption threats (and opportunities) in alternative fuels and power plants.

Diagnosis: With recent advances in hydrogen-based fuel-cell technology having garnered national press, industry as a whole had noticed the potential impact of alternative fuels, particularly hydrogen. During initial visits to the customer's R&D labs, the excitement surrounding fuel cells was palpable. The client had already committed to exploratory investments (millions of dollars) in fuel cells and related drive train components, and there was a significant constituency that was lobbying for very aggressive expansion of fuel cell development funding.
Be really cautious about heavily hyped technologies; don't fall in love with the bright shiny new toys.

Methodology: The process of evaluating the likelihood and nature of a "Hydrogen Economy" used a Voice-of-the-Future (VOF) methodology. VOF relies on the identification of leading indicators that can be measured to ascertain the likelihood and timing of potential disruptive changes. The goal is to separate the hope and the hype from the reality of where markets and technologies might really be headed. We started with the identification of a series of underlying conditions and drivers thought to spur the adoption of alternative fuels and alternative power plants. The identification of these drivers and research about each was completed using existing literature as well as interviews conducted with industry and public policy thought leaders. Past examples of fuel and power plant transformations were analyzed to understand the nature and timing of drivers for change.





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Factors that were identified as potential drivers of the "Hydrogen Economy" included: public policy initiatives, economic and environmental imperatives, power plant technology, fuel storage technology, infrastructure technology, primary energy source cost and availability, environmental impact, and the interests/behavior of key industry stakeholders (e.g. automotive companies, energy extraction companies, energy distribution companies, etc.).
Every potential driver is not an actual drivers – each potential driver needs to be evaluated carefully to see if it is strong enough to actually create change.

A probabilistic model (Scenario Model) was developed to assess the likelihood of several scenarios that could result from the interplay of the identified drivers. These scenarios characterized in detail the environment in which the client could be operating by the end of the planning horizon. Leading indicators were used to calibrate the rough likelihood of each scenario.

A detailed model (Application Model) was developed to indicate which power plant (fuel cell, hybrid-electric, and internal combustion, etc.) and fuel (gasoline, diesel, natural gas, LPG, hydrogen, battery electric, etc.) combinations were best suited to a comprehensive set of vehicle applications under each of the potential scenarios. Application data was derived from the USEPA Non-Road Emission Model covering more than 350 different off-road vehicles and their typical use case. Suitability was determined by correlating the attributes of various power plant/fuel combinations with the critical requirements of the applications under consideration.
Publically available datasets can be invaluable in evaluating large arenas for VOF screening. "Good enough" data is generally sufficient for the task.

The combined model (Market Opportunity Model) generated a forecast of the potential for each technology combination over the planning period. This allowed the client to prioritize and scale technology investments accordingly. An intuitive interface allowed the client to periodically update the forecast based on new information or events.

Results: The scenario model indicated that a ubiquitous hydrogen infrastructure (i.e. for passenger vehicles) or even localized infrastructure (for fleets) was unlikely to develop within the client's planning horizon. This was because no single combination of technology and infrastructure was projected to deliver the level of cost-effectiveness, greenhouse gas reduction and energy independence sufficient to justify the huge investment in a nationwide hydrogen fuel infrastructure. (And the investments needed, a leading indicator, had simply not started). Also, hydrogen was determined to be a poor fuel choice for highly distributed off-road vehicles. The needed fueling infrastructure was complex and not suitable to on-site delivery, and the energy storage capacity of hydrogen, important for work vehicles running 18 hours per day, was low, resulting in frequent refueling needs.
Although there were good reasons for automotive industry interest in hydrogen fuel, these did not translate to off-road vehicles – it is a poor match in these applications.

The models did indicate that certain off-road applications would benefit from key attributes of some alternative power plant configurations such as diesel or LPG fueled hybrid-electric power plants in the near-term. In fact, several hybrid-electric configurations were indicated as far better matches than diesel engines for power plant needs in several classes of off-road work vehicles. Fortunately, investment made in R&D for electric drivetrain components for fuel cell powered vehicles (electric drives, power distribution and storage, controls) could be repurposed for hybrid-electric vehicles. Based on these findings the company made appropriate investment redirection in programs to develop new power plant architectures to enhance existing product lines and penetrate new opportunities.

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The threat of disruption (and opportunity by getting there first) was real, but not from the technical direction the company was pursuing.

The company employs the VOF toolset to continually reassess the trajectory of alternative power plant adoption based on currently available data.

Using the VOF methodology, the company avoided an uncritical rush into a large fuel cell and hydrogen fuel investment. Instead they identified a sequence of more modest investments that simultaneously offer near-term return and preparedness for new power technologies. Several new, premium product lines have been developed that utilize advanced hybrid-electric power plants to better satisfy the usage requirement of important customer segments.

