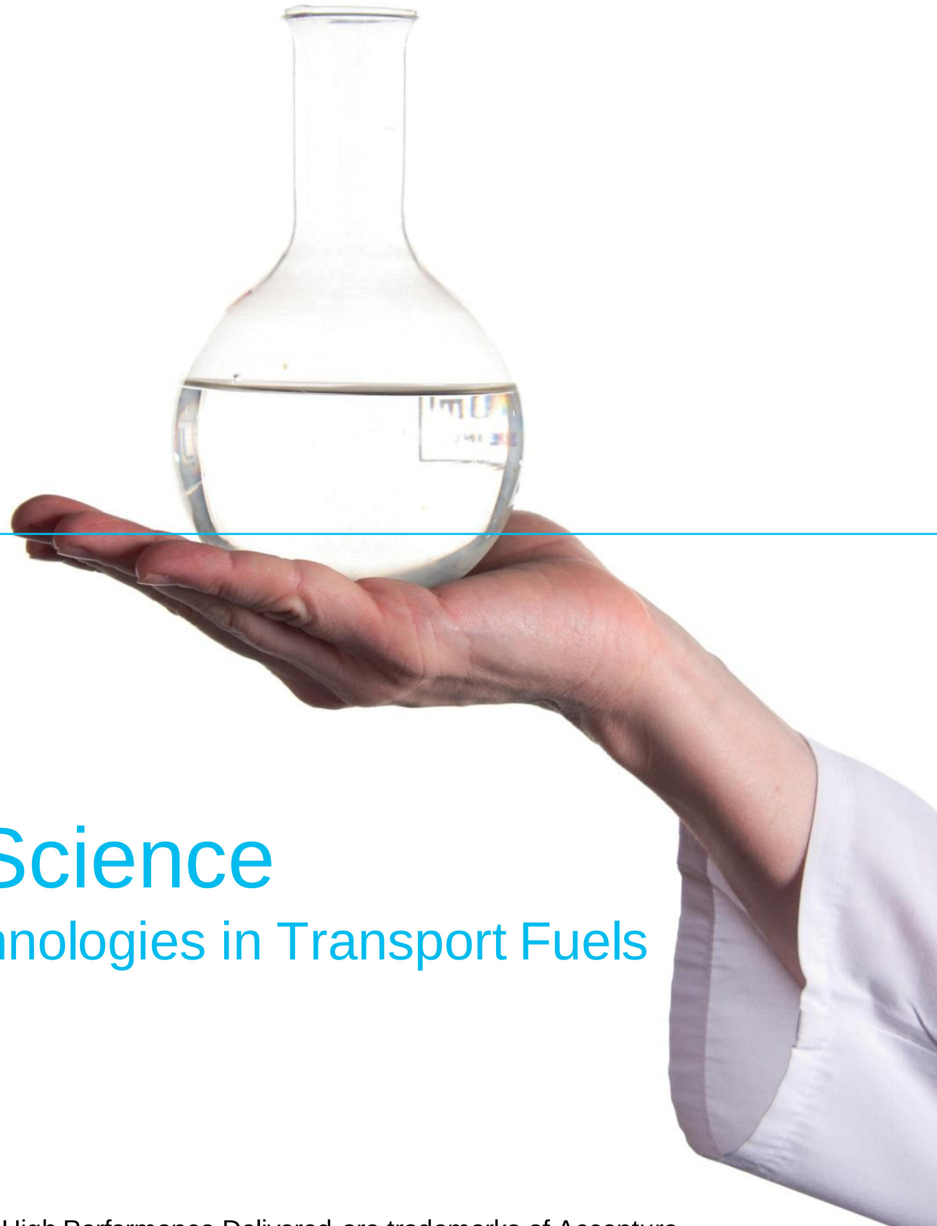


High performance. Delivered.

Betting on Science

Disruptive Technologies in Transport Fuels

March 2010

Report objectives and scope

12 Technologies

Evolution

- Next generation internal combustion engine
- Next generation agriculture
- Waste to fuel
- Marine scrubbers

Revolution

- Sugar to diesel
- Butanol
- Biocrude
- Algae
- Aviation biofuels

Game Changer

- PHEV engines and batteries
- Charging
- Vehicle to Grid

25 Companies

transonic combustion
gevo
TULA
Butamax Advanced Biofuels LLC
Licella
ceres the energy crop company
LS9, INC.
solazyme
GENENCOR A Danisco Division
SOLIX ALGAE TO ENERGY
UOP A Honeywell Company
GlycosBio RENEWABLE BIOPRODUCTS
better place
novozymes Rethink Tomorrow
LG
BMW
POET
LanzaTech
GRIDPOINT
KRYSTALLON Towards a cleaner world
AMYRIS
MAGICC Mid-Atlantic Grid Interactive Cars Consortium
PetroAlgae
ENSYN fueling the future.
Coulomb Technologies Fueling the Electric Transportation Industry

10 Markets

Things to keep in mind

- Competing views- the scientists don't agree with each other
- All the technologies are IN PLAY today
- There are many more that we did not include- eg. hydrotreating renewable diesel, FT, hydrogen
- Not 1 winner (will differ by market), but not 100+ different technologies either
- 80% of the most important data/content is in the minds of the scientists in the companies and research centres (vs. in papers)

5 Key Messages

(out of 10 in the report)

Key Message #1: The improvement potential of many existing technologies is underestimated

- Increasing yields without significantly increasing land use
- Rewarding improvements in water and energy use
- Supporting the use of waste to create energy or fuel
- Continuing roll-out of higher-efficiency standards

Corn Yield Trends			
(Bushel Per Acre)			
	1990	2000	2005
World Average	**59**	**70**	**75**
USA	**113**	**137**	**149**
Argentina	**60**	**93**	**109**
China	**74**	**78**	**80**
Brazil	**33**	**47**	**54**
India	**23**	**29**	**31**
Sub-Saharan Africa	**22**	**24**	**25**

Source: Ceres, Monsanto/Doane Forecast

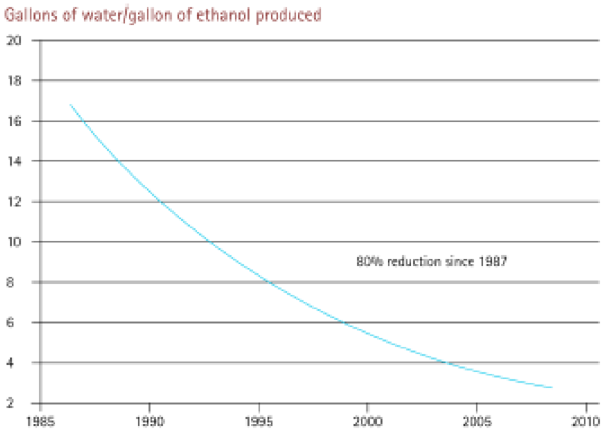
"Already, farmers in Iowa are producing as many as 200 bushels an acre. Mr Grant (from Monsanto) believes that 300 bushels are achievable by 2030" (source: "The parable of the sower", Nov 19th 2009 | ST LOUIS, From The Economist print edition)

"I do think 300 is attainable as a national average. Using corn, cobs and a portion of the stover we should be able to yield over 1000 gallons of ethanol per acre - as opposed to 450 today" (source: Accenture interview with farmer/ethanol producer)

Both sugar cane and corn will continue to improve significantly, in yield, water and energy use

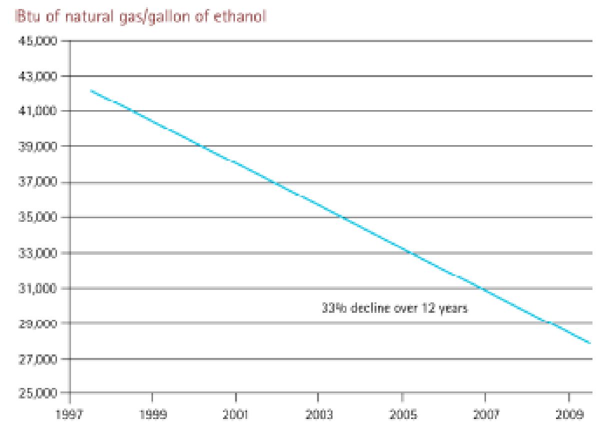
POET: 80% reduction in water use in the last 20 years and 33% reduction in energy in the last 12

Figure 21. POET plants: Water use versus ethanol production



Source: POET LLC, Used with permission

Figure 22. POET plants: Natural gas consumption trend in ethanol production



Source: POET LLC, Used with permission

Key Message #2: Genetic engineering is transforming biofuel production

Examples (non-exhaustive)

- Genetically engineered feedstocks that increase the yield density and reduce the intensity of pre-treatment and required enzyme
- A "diesel" solution through synthetic biology that allows sugar cane to be converted into a clean diesel
- Microbes that have been able to overcome the toxicity challenges of converting starches and sugars to butanol
- Genetically modified algae that have higher yields and are lower cost to cultivate, harvest and extract

Wider Applications Of Genetic Engineering

	Application	Examples of players
Feedstock	• Genetically modified crops, with improved characteristics: - Drought/disease resistance - Faster, improved yield, more uniform growth - Decreased nutrient requirement - Greater seed durability - "Single harvest only" growth	• Mendel • Ceres • Monsanto • Syngenta
Enzyme	• Genetically enhanced microbial enzymes that are: - More efficient: achieve higher sugar yields - More cost effective: requires lower dosage, lower temperatures - More resilient to range of inhibitors produced upstream • Crop-produced enzymes (hydrolytic enzymes to reduce subsequent pre-treatment)	• Genencor • Novozymes • Edenspace • Zymetis
Conversion	• Biofermentation/biocatalytic conversion: microbe-based conversion of either sugar-to-fuel (diesel, gasoline) or syngas-to-ethanol • Microbes are cheaper than conventional catalysts, continually regenerate, can be engineered to be tolerant to more impurities and operate at a broader range of temperatures/pressures	• Mascoma • QTEROS • Amyris • LS9, Inc. • Gevo • Solazyme
By/co-product upgrading and other products	• Engineered organisms produce chemicals, with increased yield and productivity • Upgrading of byproducts of biofuel production (e.g., glycerin) process using modified organisms for the fermentation process (cheaper than traditional petrochemical route)	• GlycosBio

Sugar cane clean diesel from Brazil and a pathway from corn to fungible fuel?

AMYRIS

- Amyris Signs Letters of Intent Agreements with Bunge, Cosan and Guaran with the purpose of partnering for the production of high value renewable specialty chemicals and fuelsdistributed by Amyris
- It intends to acquire a 40% stake in the Boa Vista mill, an ethanol-producing mill owned and operated by the São Martinho Group. The parties will work together to convert this mill to produce Amyris renewable products with first production targeted for the 2011-2012 harvest season
- Business model will be based upon a contract manufacturing approach, using Amyris' technology
- Two pilot plants, Emeryville and Brazil
- Commercial plant to operational in 2011, (32 mgpy)
- Amyris Fuels is the only US Environmental Protection Agency (EPA) registered biofuel, excluding ethanol and biodiesel

Source: Accenture Betting on Science, Amyris interviews, Amyris press release

LS9, INC.

gevo™

Butamax™ Advanced Biofuels LLC

- Utilizes an advanced microorganism (biocatalyst) and process technology for the fermentation phase
- Retrofit model (i.e., upgrading of existing ethanol plants) and a cost-competitive approach for upgrading current ethanol facilities into advanced biofuels facilities using the retrofit model
- Biobutanol can be made from many types of biomass, with potential feedstocks including corn, wheat, sugar cane, sugar beet , lignocellulosic
- Demonstration facility at the BP Saltend site in Hull, operational in Q3 2010; fully integrated biobutanol facility (40,000 gallons pa.)
- Road vehicle testing, with fleet trials of over 100 vehicles, covering a distance of more than 1.3 million vehicle road miles

Source: Accenture Betting on Science, Butamax interviews

Key message #6: Batteries are the "feedstock" of electrification and constrain its potential

Many Batteries, but pipeline beyond lithium for PHEV/EV is small

Battery/ Energy storage	Vehicle	Examples of Players
Lead acid	EV	JCI (Johnson Controls)
Nickel metal hydride	HEV	Panasonic (Prius) Sanyo Cobasys
Nickel zinc	HEV	PowerGenix
Lithium-ion (hard carbon - HC)	EV, small HV PHEV	EnerDel
Lithium-ion (lithium titanium oxide – LTO)	HEV	EnerDel
Lithium-ion (NCA - nickel-cobalt-aluminum)	EV, HEV, PHEV	Saft (joint venture with Johnson Controls) Toyota
Lithium-ion (Mn Spinel, natural graphite)	EV, HEV PHEV	LG Chem AESC
Lithium iron phosphate (LiFePO4)	EV, HEV PHEV	BYD
Lithium nanophosphate (Li4Ti5O12)	EV, HEV PHEV	A123
Ultrabattery (R&D)		CSIRO, Australia
Ultracapacitors (small)	EV	EEStor (Zenn Moto Company)

Many Performance Factors

- Energy density
- Power density
- Cost/kWh
- Life cycle
- Recharge time
- Safety

Many (Lithium) Challenges

- Expensive
- Scarce (Bolivia, Chile, China)
- Production concentrated in 3 countries (Japan, South Korea, China)
- Combustible

Solutions to cost and production are being found, but what about supply?

- Municipal financing
- Battery leasing
- Car sharing
- Significant congestion, parking and other subsidies
- Battery production plants announced in US and Europe
- “500/ kWh in 5 years” – Matt Rogers at the Baker Institute event on 26 January (10 years ahead of Accenture estimates)

Given the battery challenges, we believe the HEV and advanced ICE are important competing technologies to electrification and that PHEVs are much more likely than pure EVs

Key message #7: Electrification heralds two key players in transport fuels—utilities and battery manufacturers

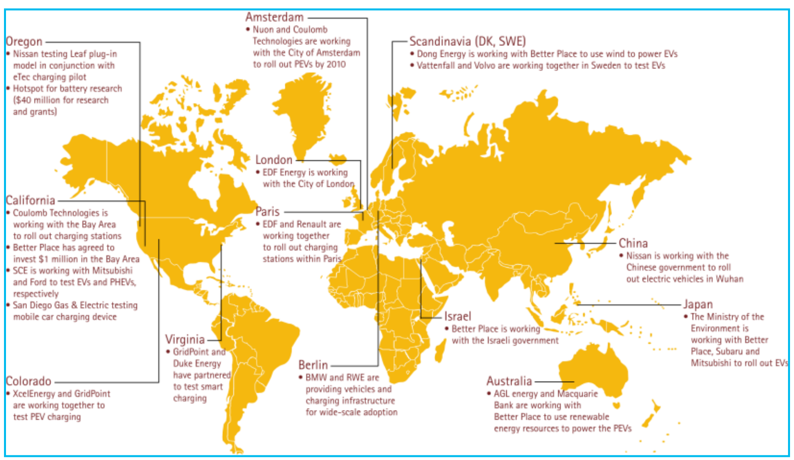
Many Diverse Players across the Electrification Value Chain

Generation | Distribution | Retail

Generation	Smart Grid	Battery storage	Charging Infrastructure	Comms Infrastructure	Plug-in Electric Vehicles	Billing System
		• A123 Systems • LG Chem • NEC	• Coulomb Technologies • GridPoint • Nu Element • ECOtality		• Tesla Motors • Th!nk • G-Wiz • Duracar	• Coulomb Technologies • GridPoint • Nu Element • ECOtality

Utilities → (Generation, Smart Grid) **Utilities** → (Comms Infrastructure) **Utilities** → (Billing System)

Municipalities → (entire value chain)



More than 15 pilots in 14 countries testing
- Capabilities
- Roles of different players
- Infrastructure requirements
- Technology
- Regulation and market models

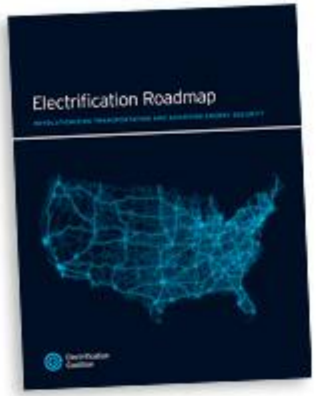
Different combination of players in each pilot

Different elements of the electrification value chain

Different operating models

The electrification consortiums are coordinated and powerful

- Leveraging close link between governments and utilities
- Recipients of significant stimulus in US, EU and China
- Stressing both energy security and green objectives
- Alliance between utilities and high tech (batteries and software) is powerful
- Industries delivering competing technologies - eg. biofuels, integrated oil on carbon and gas, are not aligned



Electrification Roadmap (Electrification Coalition)

- "By 2040, 75% of the vehicle miles traveled in the US should be electric miles"
- Members: **Cisco,** Aerovironment, Gridpoint, NRG Energy, Coda Automotive, **PG&E**, Rockwood Holdings, **Nissan,** Kleiner Perkins, Colulomb Technologies, **Johnson Controls-Saft**, Bright Automotive, **Fedex, A123 Systems**

Key message # 10: The trajectory of supply, demand and GHG footprint of transport fuels is being reshaped now

Evolution is cumulative, new technologies are added but existing ones continue to be improved

	<5 Years	5-10 Years	10-15 Years	15+ Years
Internal Combustion Engine	• OEM developments (e.g. VW Bluemotion)	• New gasoline technologies enter market	• 100mpg test car • Very efficient gasoline engines	→
Biofuels	• 1st AND 2nd • Waste to fuel • Butanol • Sugar to diesel	• New energy crops • Biocrude • Biorefineries • Advanced enzymes and deconstruction	• Algae • Combined pretreatrment, deconstruction and possibly even conversion steps	→
Electrification	• PHEVs become commercially available	• Batteries improve • Fast charging piloted and tested	• Scale-up starts	• V2G
Aviation	• Trial flights and debate continues	• Slow and limited roll-out of small blends • Expansion of production	• Roll-out at one or more hubs	• Volumes increase
Marine	• Scrubbers commercially available but limited take up as regulation not enforced	• Lighter, more efficient scrubbers • Start to integrate into ship design	• Economically competitive scrubbers • Wider deployment	• Volumes increase

Actions for high performance

Ongoing

- Close to government and policy makers
- Execution—project management excellence, supply chain optimization
- Contracting and risk management
- Market-specific strategy

NEW

- Place scientists and engineers in leadership positions
- Partnering and business model flexibility
- Know how active tracking of the market will change baseline assumptions
- Strategies to secure long-term and flexible capital