



Big Solutions for Big Problems

Automotive World Briefing

The Global Oil Paradox: Transforming the Automotive Industry

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Director

21st October, 2008

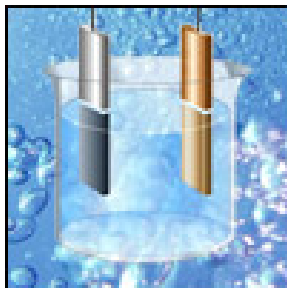
E4tech's perspective

- Consultancy, established 1997
- Based in the UK and in Switzerland
- Strategy, business support, technology review and policy input
- Technically-informed, business/policy focused
- Clients include industrial companies, government, technology startups, investors

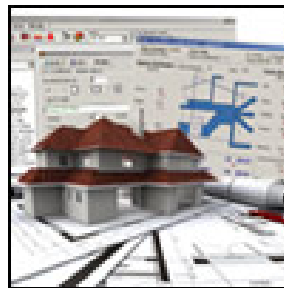
Fuel cells



Hydrogen



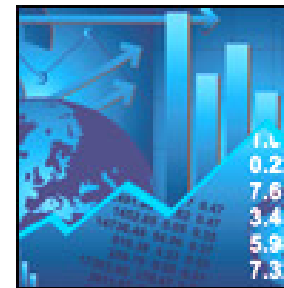
Sustainable Buildings



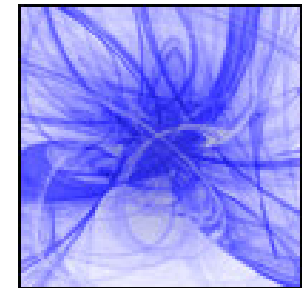
Bioenergy



Energy Systems



Novel Energy



Today

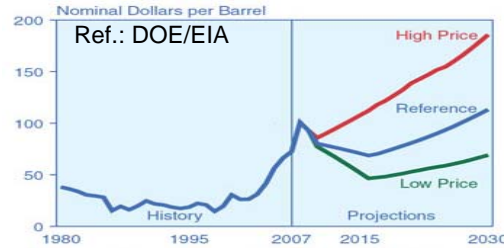
Big problems

System level options

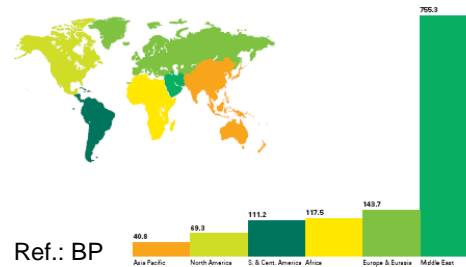
Big solutions?

Road transport is facing several megatrends

Energy costs



Energy security



Pressure for changes to the road transport energy system



Transport emissions & climate change



Ignoring the future will hurt you in the end

Coming down the line...

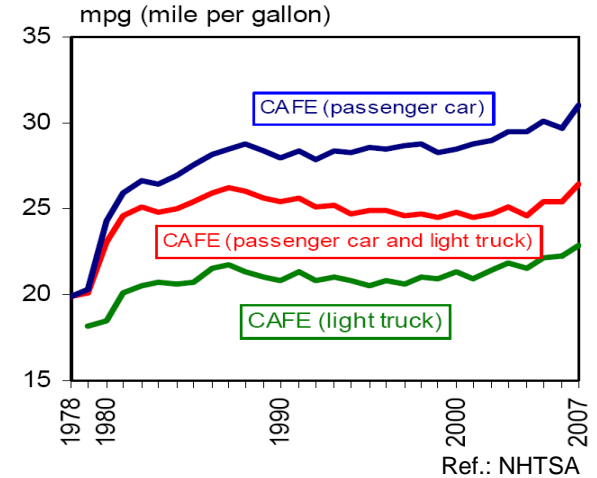


Evening Star
Born: 1960, UK
Life expectancy: until 1980s

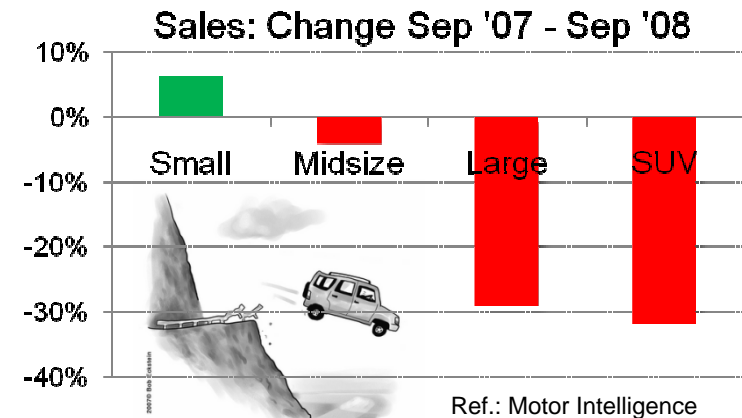


Died: 1965
Cause of death: diesel

CAFE regulations



US SUV sales tumble



Slide 5

DH3

may want to include some sales figures of Toyota overtaking the big three and perhaps their product mix to ram this home?

David Hart, 19/10/2008

Big problems

System level options

Big solutions?

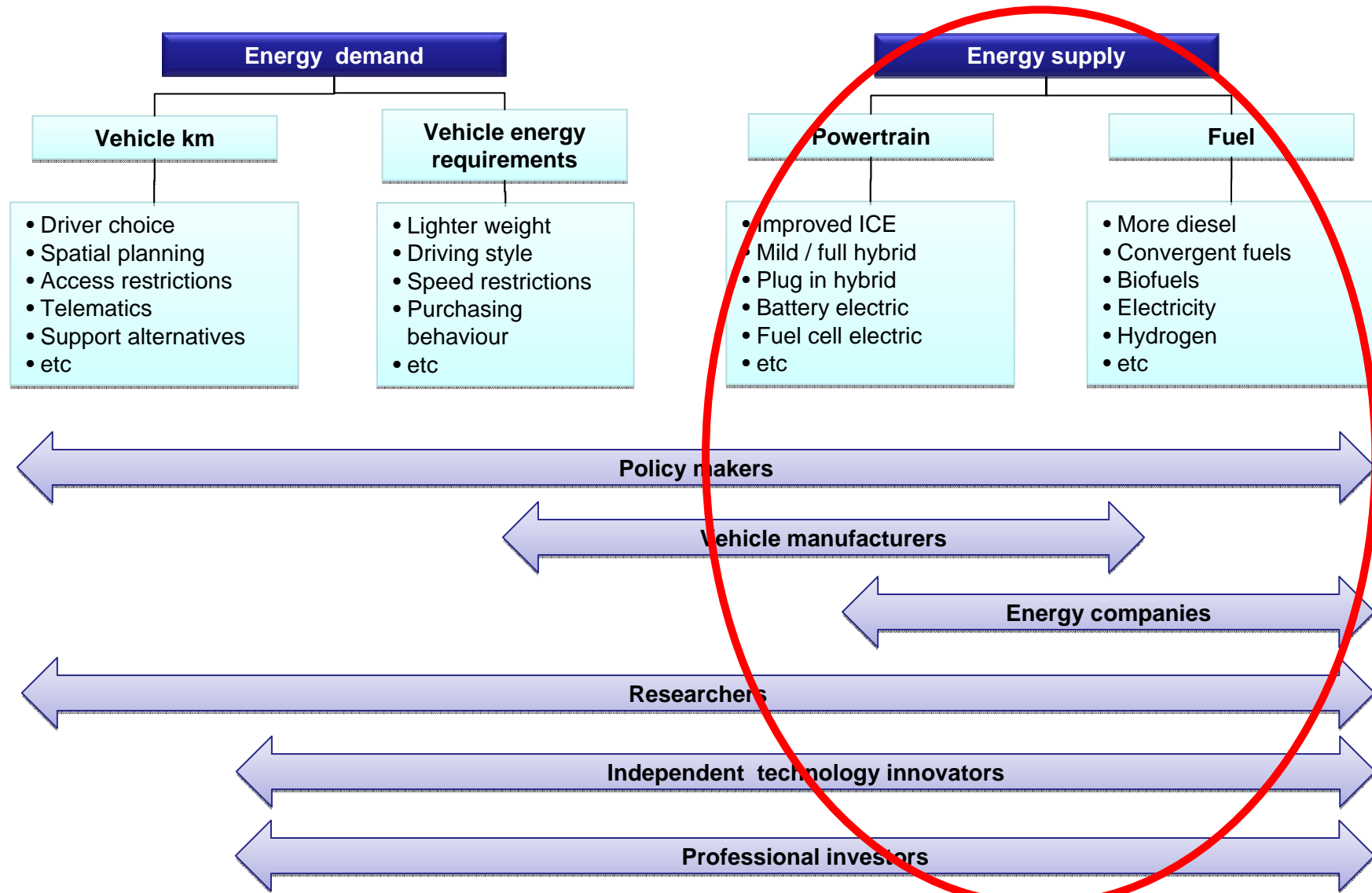
Slide 6

DH4

either last slide of previous section or first slide of this one should at least outline the links between and potential decoupling of emissions/security of supply/fuel type, as the first slide simply says resources and climate change are a problem.

David Hart, 19/10/2008

An energy system response is required



Slide 7

DH5

ellipse is to suggest that demand is someone else's discussion, we'll focus on supply?

David Hart, 19/10/2008

Supply-side options for changes to the energy system

Qualitative assessment of main supply side options

Fuel	Fossil liquid	1G biofuels	2G+ biofuels	Gasoline / diesel	Electricity / fossil	Electricity	Hydrogen
Powertrain	Efficient ICE	ICE	ICE	Hybrid EV	Plug in Hybrid EV	EV	Fuel cell vehicle
CO2 reduction per vehicle	+	?	?	+	+	++	++
Primary energy availability	-	-	+	-	+	+	+
Primary energy security-	-	+	++	-	+	++	++
Cost per km potential	++	+	?	+	?	?	?
Infrastructure upheaval	++	+	+	++	?	-	-

No regrets move, but limited long term potential

Limited overall resource. Sustainability concerns

Interesting potential, some CO2 issues remain

Potentially useful transition technology

Quite low CO2 with good range. Cost?

Potentially low CO2. Cost? Range? Infrastructure?

Potentially low CO2, Cost? Infrastructure?

2G+ biofuels are developing fast, but commercial production is 5-10 years away

Development status	Basic and applied R&D	Demonstration	Pre-commercial	Supported commercial	Commercial
Lignocellulosic ethanol					
Lignocellulosic butanol					
Gasification -FT liquids					
Pyrolysis derived fuels					
Algae					



Verenium
(lignocellulosic ethanol)

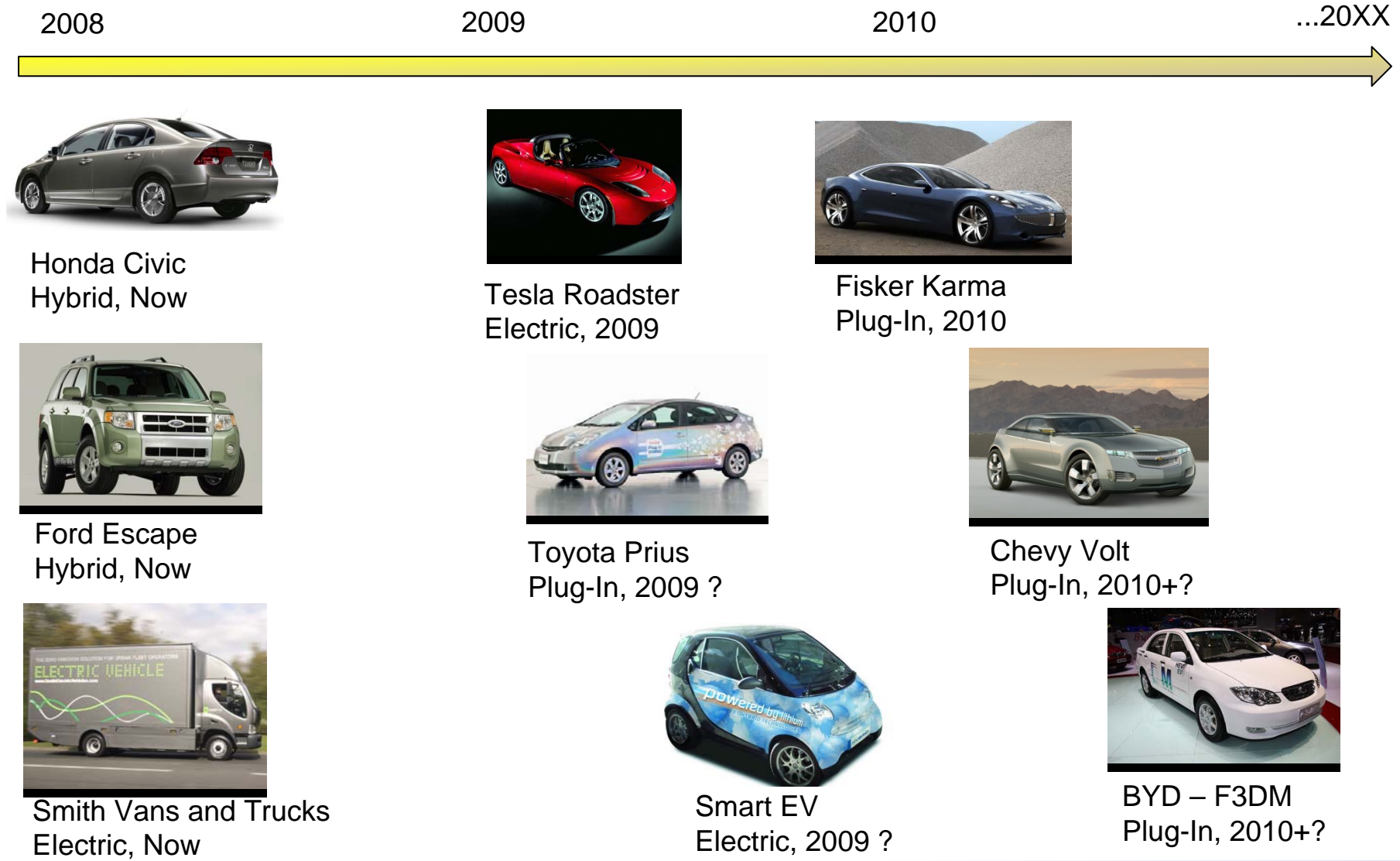


Pyrolysis oil



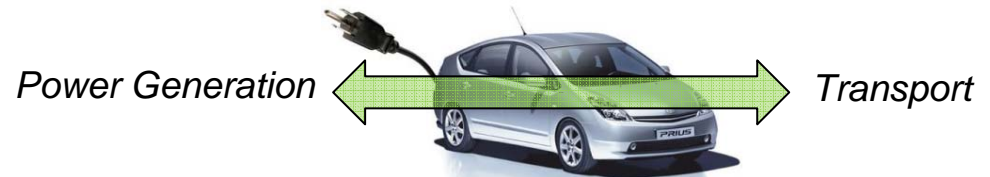
Algae production

Some EV/Hybrids are already commercial and plug-ins are being prepared for launch in the coming 5 years



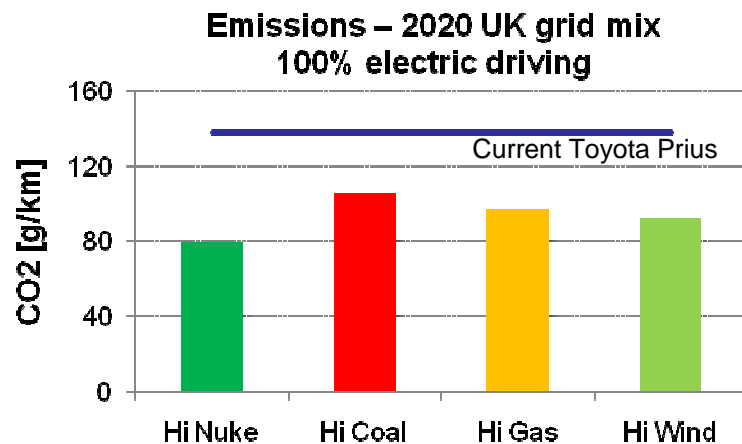
Plug-in hybrids and battery EVs present challenges and opportunities at the energy system level

Plug-in HEV and battery vehicles might link two critical elements of the whole **energy system**



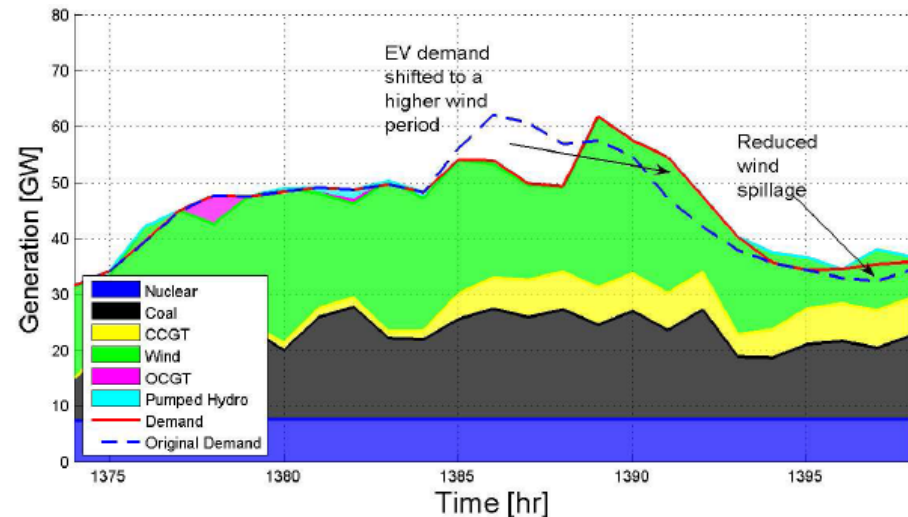
Challenges

- The build up of new power capacity is problematic
- System peaks: Charging a car is worse than the infamous kettle!
- Need to create a charging infrastructure
- Risk of bottlenecks in distribution/transmission
- Need to find cost-environmental optimal solutions. Is it going to be really *green*?



Opportunities

- Demand Side Management
 - Support the penetration of renewable: fuel the cars when the wind is blowing
 - Postpone new plant investments
- Vehicle-to-grid (V2G): a new business model for drivers, fleet management and utilities
 - Provide ancillary services to the grid



Hydrogen fuel cell vehicles are the main alternative to (H)EVs, though mass rollout is not expected before 2020 in any case

EV & plug-in HEV advantages

- EV travels further per unit of primary energy (battery more efficient than hydrogen)
- Hybridisation increases range, but may reduce CO2 benefits
- Infrastructure requirements simpler for EV than H2, especially for HEV
- Could provide electricity system advantages
- Currently lower cost than FCV, battery cost dominates
- Rollout planned in coming 10 years

Fuel cell / hydrogen advantages

- Fuel cell plus hydrogen storage is lighter than batteries for a given vehicle range
- Hydrogen refuelling is quicker than EV recharging
- Less toxic materials are required for fuel cells than batteries
- Electricity system may not be able to cope with EVs, but H2 can be stored
- Cost growth is not linear with vehicle range / performance
- Rollout planned after 2020

In practice both options are being pursued. They may be complements or substitutes

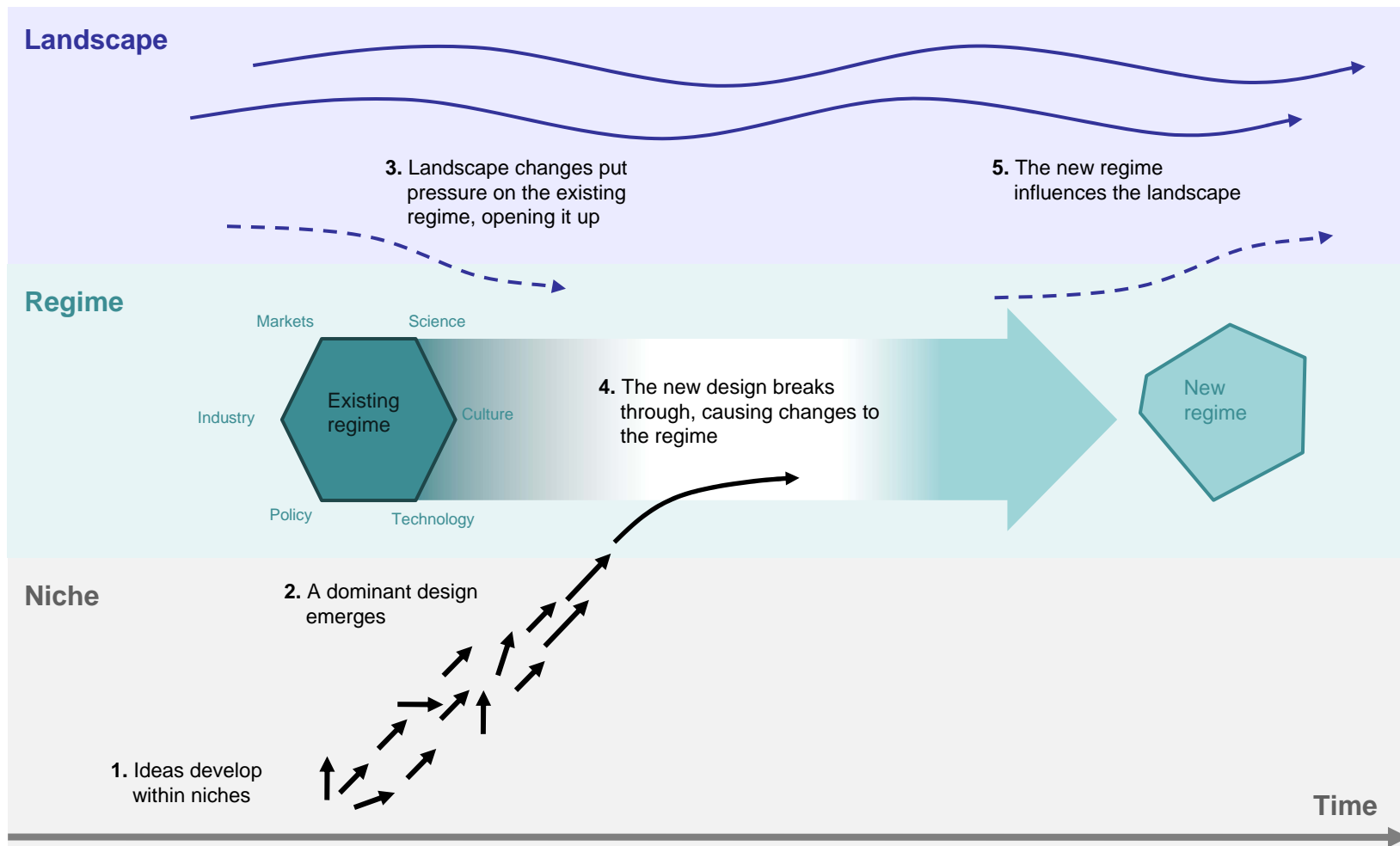
Big problems

System level responses

Big solutions?

Options become solutions as they migrate from niches to the regime and landscape levels

The Multi Level Perspective of System Transformation



Source: Geels and Schot, 2007

Slide 14

DH6

Not sure how this will be presented, but maybe an idea to mention it earlier as suddenly getting into innovation theory may take audience time to adjust to

David Hart, 19/10/2008

All aspects of the regime level will be altered by changes to vehicle energy systems

	Observations for new vehicle energy systems
Science	<ul style="list-style-type: none"> • New disciplines coming to the fore – e.g. biology, materials science. • Breakthroughs still required to achieve cost targets e.g. FC materials
Technology	<ul style="list-style-type: none"> • Vehicle design will alter to accommodate new energy systems • Links between vehicle and off-board technology will be crucial (e.g. charging infrastructure) • Scale economics for each energy system are different • Agile new companies will innovate where larger firms do not
Policy	<ul style="list-style-type: none"> • Long term, clear, outcome-focused policy required by actors • CO2 increasingly recognised by policy instruments, though road transport CO2 is hard to reduce compared with some other sectors • Energy security less clearly supported by policy than government edicts (e.g. nuclear)
Culture	<ul style="list-style-type: none"> • How and where vehicles are used may change as electrification provides new functions • Vehicle range expectations may adjust • Is the age of emotional attachment to cars coming to an end?
Industry	<ul style="list-style-type: none"> • Weak profitability threatens all R&D • Deep pockets will be needed by all actors • Plug in vehicles and hydrogen electrolysis open the door for power utilities • New powertrains may enable OEMs to regain control of servicing over the vehicle life
Markets	<ul style="list-style-type: none"> • Consumers may purchase part of the vehicle and lease the rest – e.g. batteries, platinum • In a multi fuel/powertrain future there may be many more submarkets with dedicated products (e.g. city, suburban, long distance, rural)

In summary....

- The pressure for change is **too big to ignore**
- Change needs to take place at the vehicle **energy system level**
- There are **numerous technical options**; none is the obvious winner, though some are closer to market than others
 - Improved **internal combustion engines** are an obvious first step
 - **Biofuels** likely not to be the silver bullet
 - **Hydrogen** fuel cells imply a major system revolution
 - **Plug-in** vehicles require massive demand side management
 - **Plug-in hybrids** likely to play a bridging role, whatever the end game
- After a century of little change, the **regime** and ultimately the **landscape of vehicle energy systems is changing**.
- This implies significant changes in **far more than just science and technology**.