



Exploring the diffusion of fuel-cell cars in China

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Introduction

- **Background:**
 - Environmental problems in China
 - Young and rapidly growing car market
 - Advantages of fuel cell cars (efficiency, emissions, noise level)
 - PSI: research on fuel cells, and involvement in the CETP program
- **Aim of the research:**

To explore the diffusion of fuel-cell cars on the Chinese market, by use of the MARKAL-model, and in forms of scenarios, after an analysis of various fuel-cell options and other (new) competing powertrain systems, and after analysing a set of technological, economical, political, social and environmental forces in relation to the Chinese automobile market.

Methodology

- **Scenarios:** *“a tool that describe pictures of the future world within a specified framework and under specified assumptions.” (EU, 1994)*
- **This study:**

Exploration: scenarios + computer model (MARKAL)
Methodology is a combination of the ones from:

 - Ogilvy and Schwartz (1995); multi-disciplinary scenario-approach (Shell)
 - The ETSAP family of models; aimed at quantitative analyses

Actor Analysis

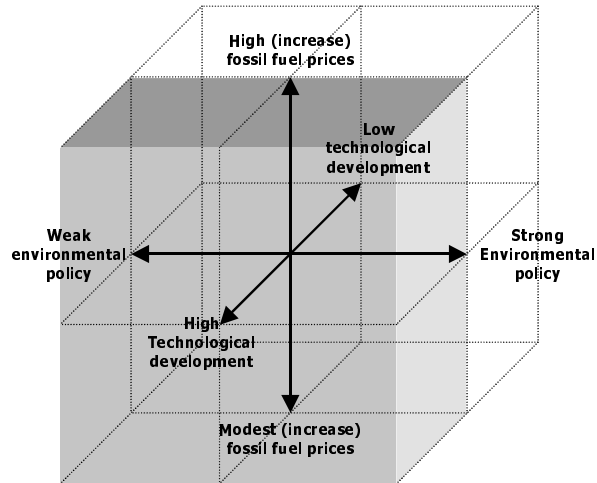
- **Activities of groups and actors result in sociotechnical configurations (technological artefacts + social relations)**

- **Main actors influencing the diffusion of fuel-cell cars:**
 - **government (local & state)**
 - **oil companies**
 - **car manufacturers and**
 - **customers**

List of key factors and driving forces behind the diffusion of fuel-cell cars in China

Technology	Society
1. Improving efficiency	11. Growing population
2. Lower car emissions	12. (International) crises
3. Solving technological problems	13. Willingness to pay new infrastructure (H2, MeOH)
	14. Growing environmental awareness
Economics	15. Reducing hydrogen storage concerns
4. Increasing price of oil (and gas)	16. Increasing customer preferences
5. Growing GDP	
6. Decreasing FC investment costs	Politics
7. Blocking of foreign cars	17. Stimulating car ownership
	18. Dependency of foreign energy suppliers
Environment	19. Increasing emission control
8. Increasing energy demand and supply	20. Increasing regional influence
9. Shortage on fossil fuels	21. Development of public transport
10. Shortage on water	

Three scenario-axes with reduction to four scenarios



General assumptions of all scenarios: Increasing car demand, growing GDP, moderate population growth, high coal supply

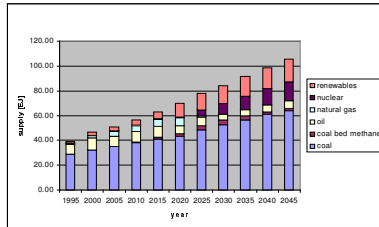
Specific Scenario Input for MARKAL

Parameter	Hybridization	H2-Economy	Environmental Reformation	Self-Sufficiency
Advanced technologies in China + low-costs FC	available	available	available	available
High fossil fuel prices	-	2025: prices * 2 after 2025: prices * 4	-	2025: prices * 2 after 2025: prices * 4
Emission control	-	-	66 GtC for 1995-2050	66 GtC for 1995-2050

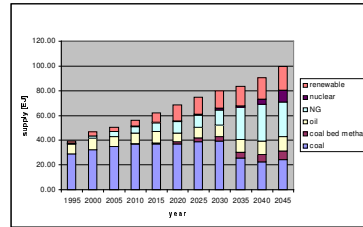


Primary Energy supply

Hydrogen Economy (high prices)

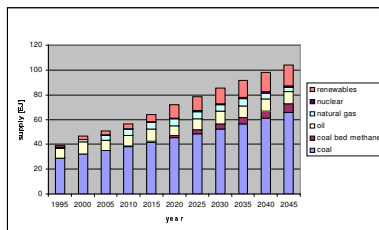


System innovation

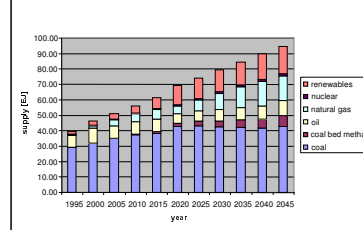


Environmental reformation (high C reduction)

Markets



Government



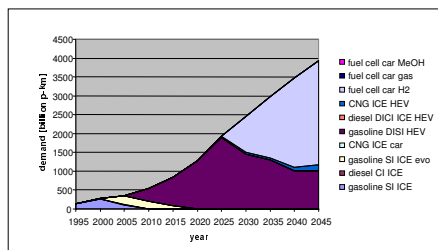
Hybridization

System optimization

Self-Sufficiency

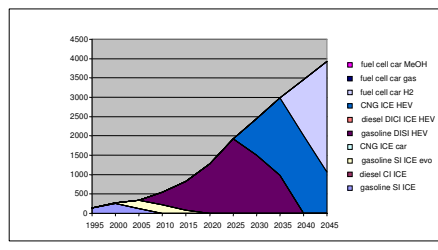
Allocation of power trains by case (billion p-km)

Hydrogen Economy (high price)



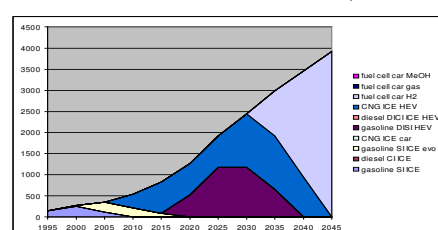
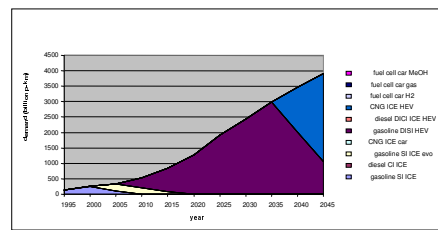
System innovation

Environmental reform (high C reduction)



Market

Government



Hybridization

System optimization

Self-Sufficiency

Sensitivity Analysis

- **Sensitivity analysis for hybrid and fuel-cell cars:**

- 1. Investment costs of the passenger cars:

- If investment costs become lower by \$ 600-700, the car dominates

- 3. emission levels

- CO₂ emissions have the strongest impact on the diffusion of fuel-cell cars in this model/database. Switching value: 70.5 GtC over period 1995-2050.

- 4. fossil fuel prices

- times 3 or less: no fuel-cell car diffusion

- times 5 or more: increase and fuel-cells take over the whole market

Conclusions

- The methodology used has combined successfully the qualitative scenario approach with quantitative optimisation methods but we need to better simulate the behaviour of actors
- Demand by 2050 will follow the high economic growth (\$7000/capita), moderate car ownership (e.g., 80 cars/ 1000 inhabitants) and a low population growth defining a market of 120 Mio Vehicles
- Diffusion of fuel-cell cars will first take off in industrialized countries. Main point is the (investment in) H₂/MeOH infrastructure and the solving of technological problems at low cost
- The government has to create boundary conditions for
 - fuel-cell car diffusion
 - emission control/reduction
- High economic growth and technological development in China are necessary conditions for the diffusion of FC cars (thus only after 2025)
- The diffusion process in the markets will be driven by technological development, energy resource scarcity or strict environmental government regulations