The ETP Model
Functioning and Links to the MoMo Model

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Topics

- The Energy Technology Perspectives model
- Example results: biofuels and hydrogen FCVs
- Conclusions and recommendations

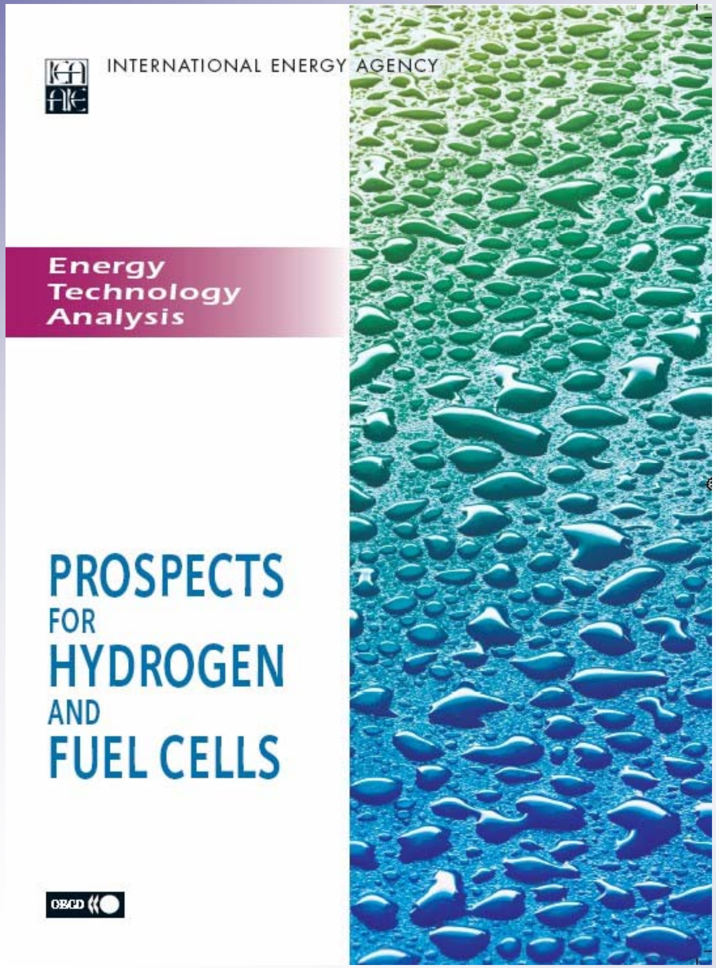
The Energy Technology Perspectives Project

- Started about 5 years ago
- Goal is to enhance energy technology policy making
- Core activity of the Energy Technology Policy Division
- 100% funded through voluntary contributions

Typical questions

- What can technologies available today contribute to meet energy policy targets?
- What new technologies should we develop to meet energy policy targets?
- What kind of policies are needed (R&D, deployment, investment support)?
- What is the role of industry, what is the role of government?

ETP Technology Policy Modelling Studies



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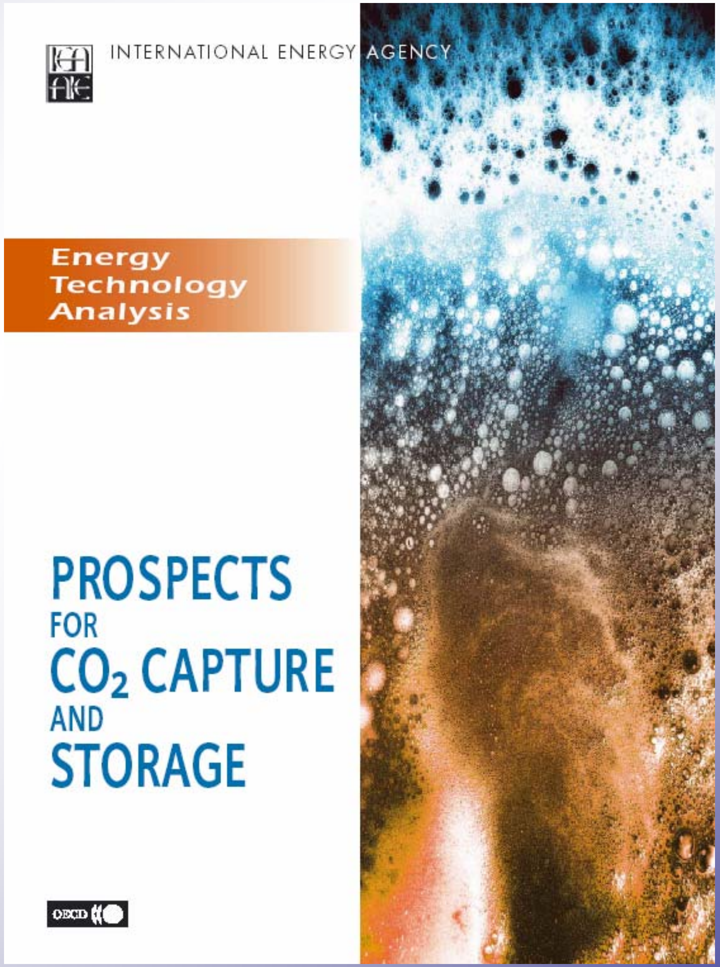

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Energy Technology Perspectives ETP

- Bi-annual technology office publication
- 1st version will be issued April 2006
- 2nd version in 2008 also part of G8-deliverables
- Focus on technology RD&D and investment
- Complements the World Energy Outlook
- Includes detailed technology assessment and scenario analysis
- Shows affordable and feasible technology pathways for CO_2 emissions reduction and enhanced supply security

Energy Technology Perspectives Model

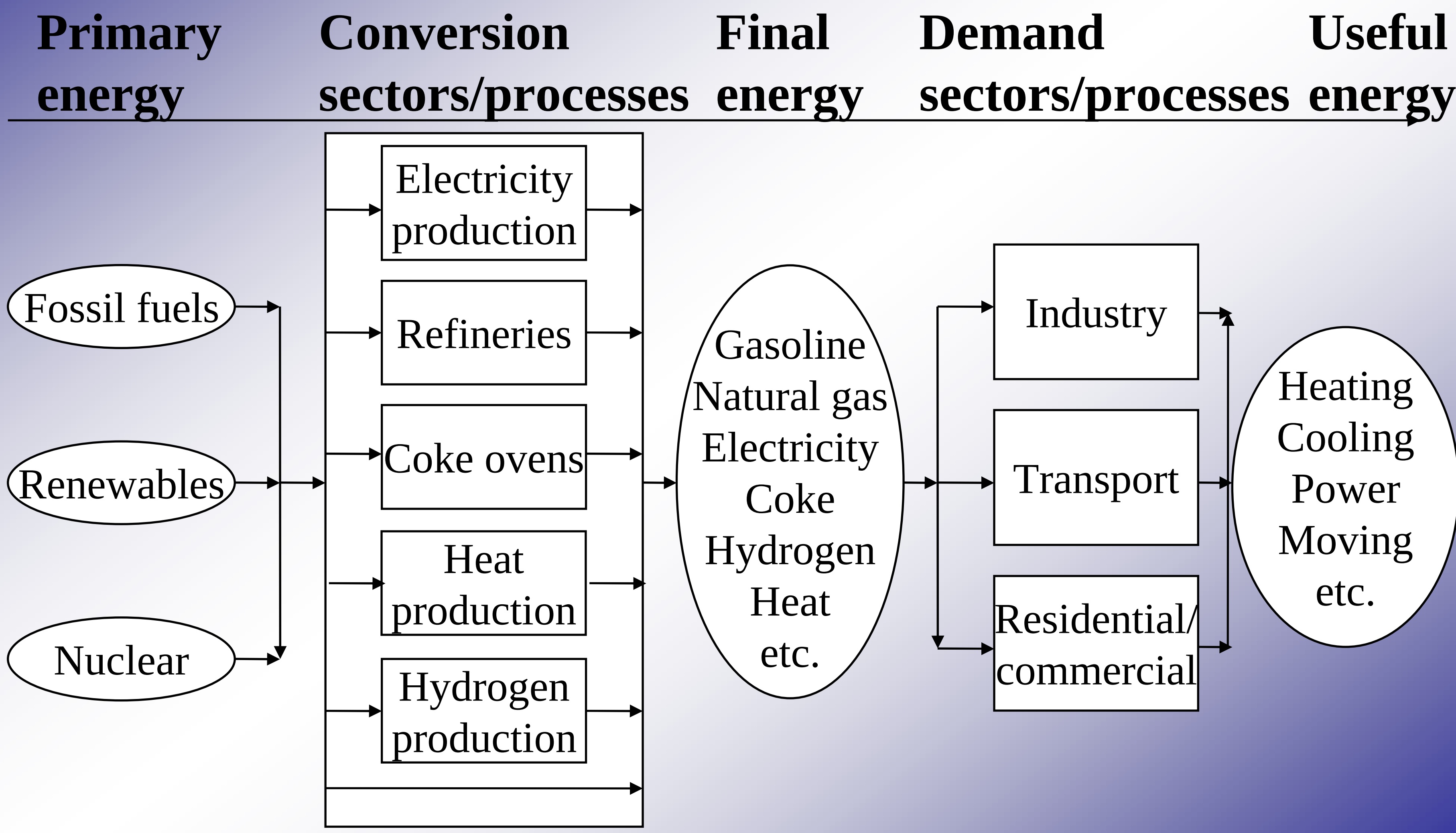
- MARKAL type model
- Developed and refined by the Energy Technology Systems Analysis Implementing Agreement during the past 25 years
- Long-term (2050) analysis of energy technology policy issues
- Least-cost decision making, ideal market
- Linear programming
- Full coverage of energy system (global, supply and demand side)
- Extensive technology database (1000 technologies)
- Calibrated to World Energy Outlook Reference Scenario

Transportation Module

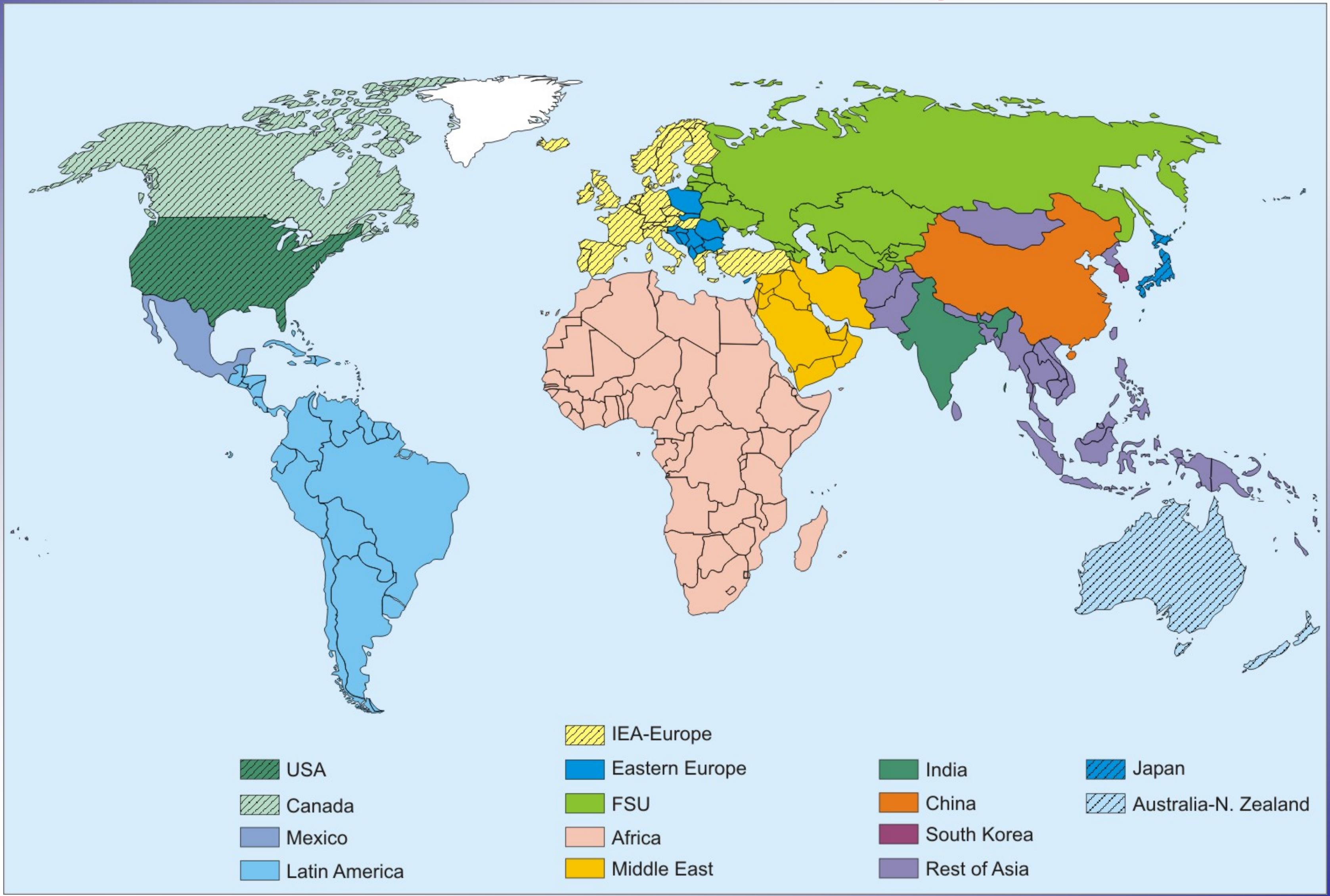
- Based on SMP/MoMo
  - MoMo spreadsheet with ETP model input data
  - Demand projections
  - Efficiencies

- Many MoMo data are taken from ETP database
- 15 regions
- New technologies and fuels in ETP technology library
- Region specific multipliers
- Region specific discount rates

Reference Energy System (RES)



15 ETP model regions



Value Added

- Proven, validated modelling framework
- Captures technological change
- Accounts for competing resource use (e.g. biomass, CO_2-free electricity)
- Accounts for competing technologies
- Endogenous fuel price response
- Carbon leakage effects
- Easy sensitivity and scenario analysis

A typical MARKAL/ETP study

- 50% of resources for technology data collection and assessment
- 25% for model analysis
- 25% for reporting
- Good data are the key for all good modelling
- One accepted MoMo/ETP/WEO transportation technology database needed
- “Modelling for insights, not for numbers”
- Understanding what determines the results is a key issue
- Therefore sensitivity and scenario analysis are essential

2 Results
Biofuels and Hydrogen FCVs

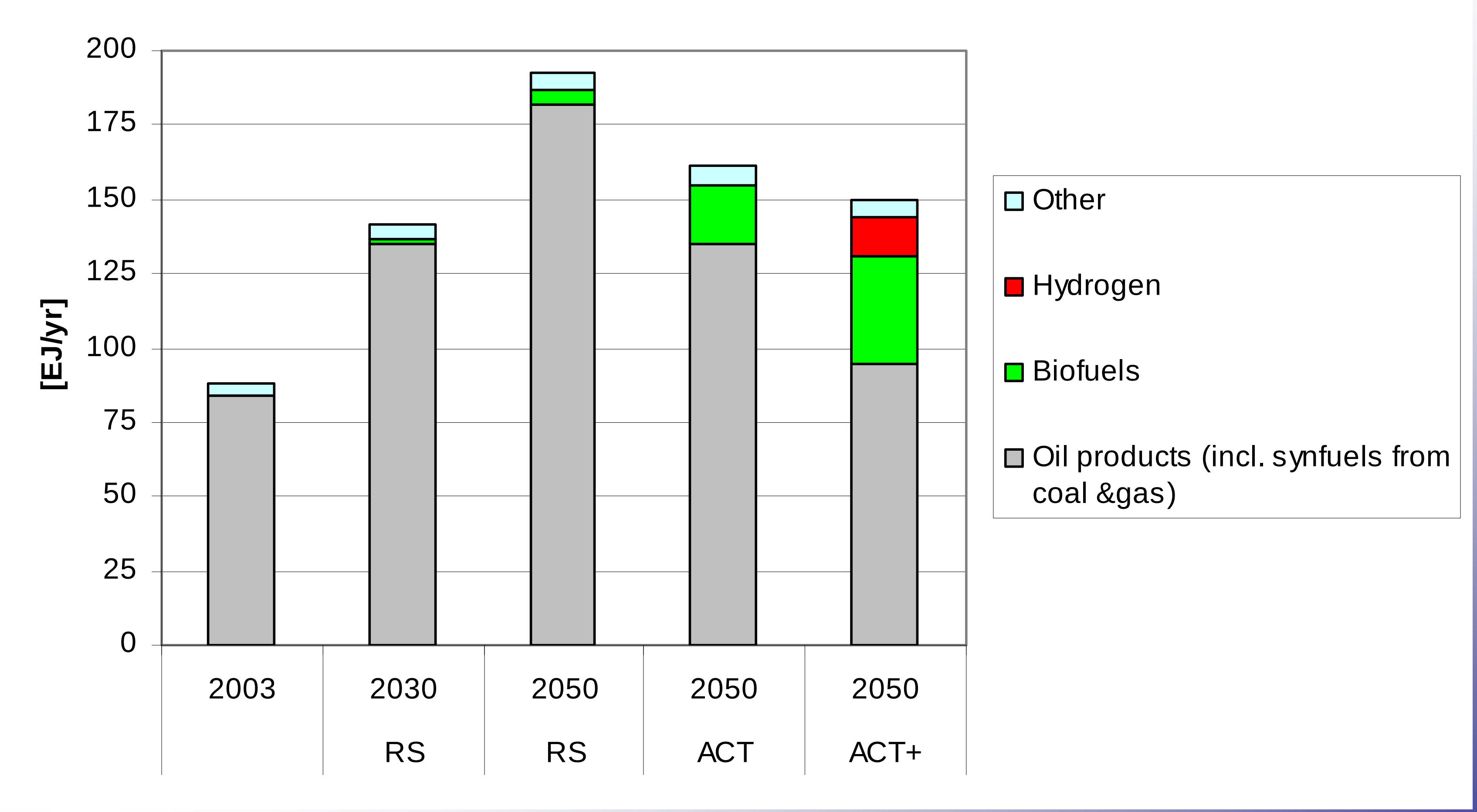
Issues

- Doubling of oil demand in BAU scenario
- Oil transportation fuel supply concerns
- CO_2 emissions
- Solutions
  - Fuel Efficiency (advanced ICEs, Hybrids, Fuel Cells)
  - Biofuels
  - Hydrogen FCVs

Many Solutions to the Challenge

Supply Security benefits	Emissions increase	Low or no reduction	Emissions reduction
High	Heavy oil Oil sands Oil shale FT-coal DME/MeOH coal	Enhanced oil recovery Non-conventional oil + CCS FT-coal + CCS DME/MeOH coal + CCS	Energy efficiency (e.g. hybrids, FCVs) FCV + H2 from coal (+CCS) nuclear or renewables Bioethanol FT-biomass CO_2- EOR (+CCS)
Low Or none	Refinery products from ME oil FT-natural gas CNG vehicles DME/MeOH natural gas	FT-natural gas + CCS DME/MeOH natural gas + CCS	Hydrogen from natural gas + CCS

Transportation fuel demand (model output)



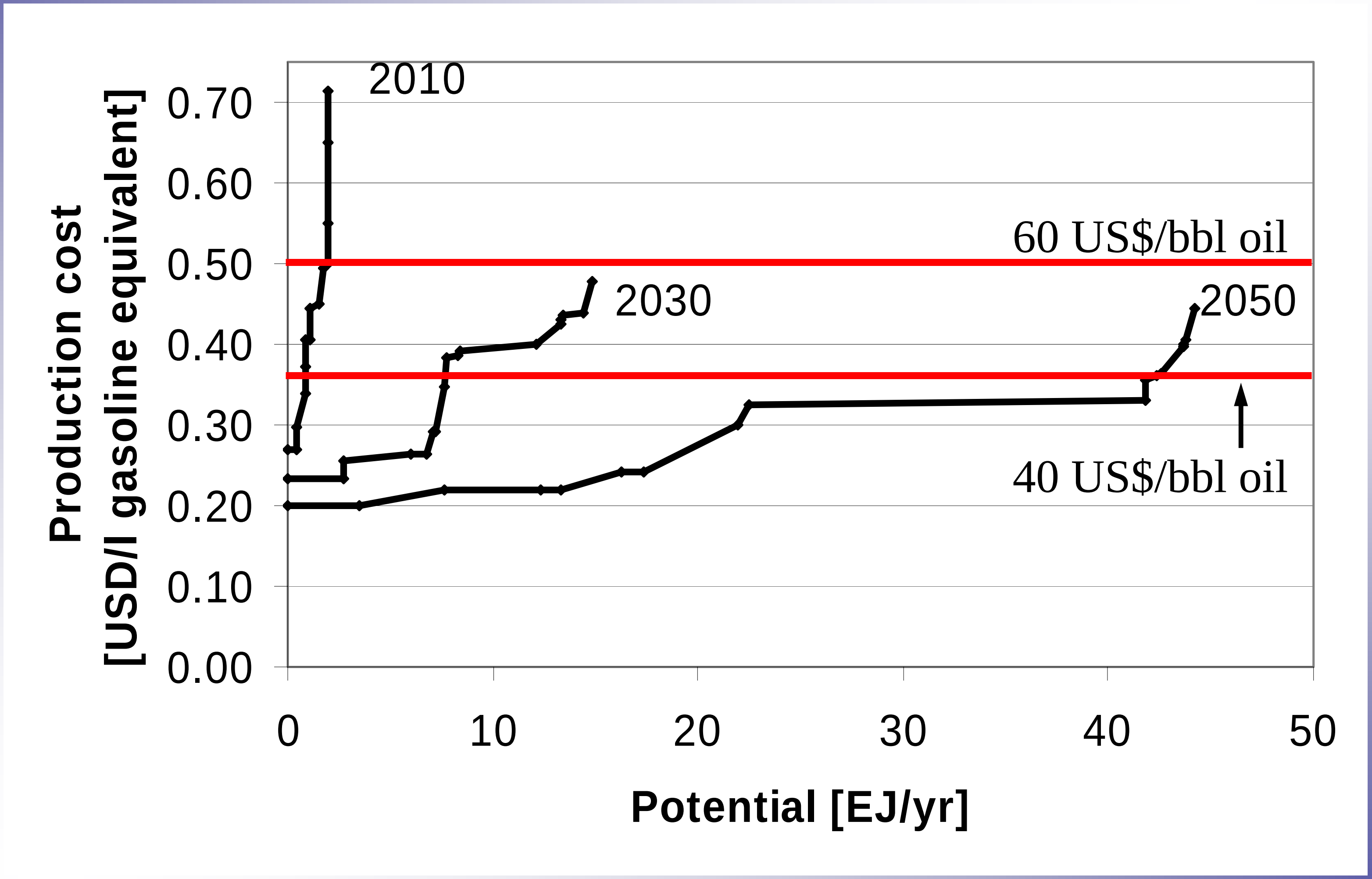
Key Biofuel Assumptions

- Includes ethanol from cane, wheat/corn, lignocellulosic biomass (wood)
- Includes RME and other plant oil derivatives, FT-biodiesel
- Also other types of biofuels (methanol, DME, syncrude)

Biofuel potentials are uncertain

- Starting from less than 1% biofuels today (<1 EJ/yr)
- Land & water availability is a constraint
- Food and biomaterials demand will increase
- But land productivity will increase as well
- Competing land use for afforestation, nature conservation, human habitations etc.
- Projections for 2050: 50-500 EJ primary biomass potential (200 EJ in model)
- *ETP model analysis suggests that biofuels represent the most effective use of scarce biomass resources*
- Better data and sensitivity/scenario analysis are needed

Global Bioethanol Supply Curves



Prolongued high oil prices and new technology will result in lots of alternative fuels

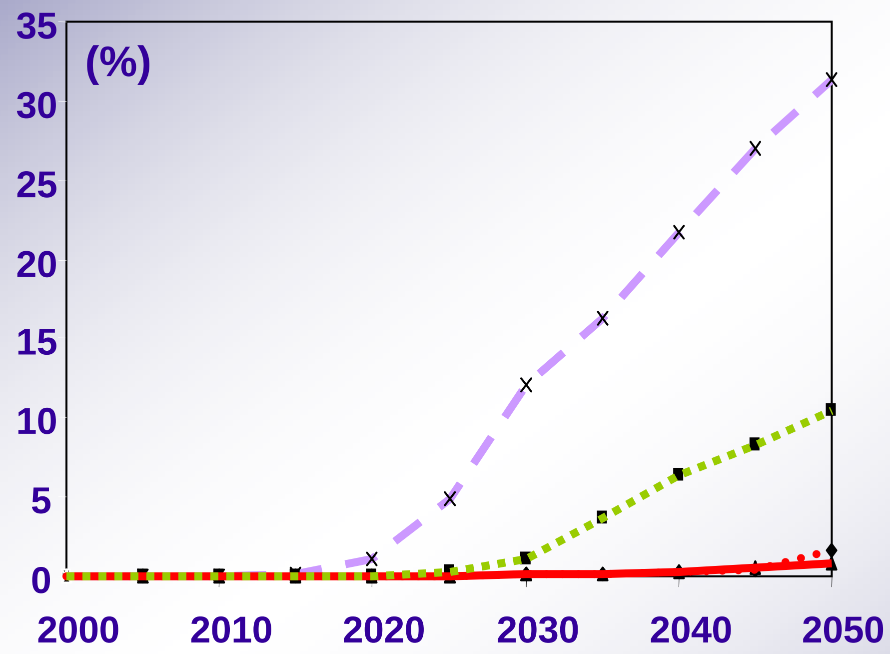
H_2 Supply Cost 2020/2030

- Today decentralized 30-50 US$/GJ
- Future decentralised gas reforming & electrolysis: < US$15-20/GJ (*)
- Later, centralised H_2 from gas & coal with CCS   < US$10-12/GJ
- Probably higher cost for nuclear, biomass and solar H_2
- Distribution/refueling may add 5-15 US$/GJ
- FCV efficiency is 2-3 times efficiency gasoline ICE
- Fuel cost/km driven can be comparable to oil transportation fuels

FCV Drive Systems Cost

- PEM with double current density 50 US$/kW
- Electronics, gas treatment etc. (BOP) 15 US$/kW
- Electric engines 15 US$/kW
- H_2 storage 15 US$/kW
- Total 100 US$/kW
- This is too expensive (+4000-5000 US$/car), further cost reductions are needed
- This will require additional R&D

H2 FCV Share



Scenario A – (ACT) Weak new CO_2 Policy with Tech. Development and Market

Scenario B - Strong new CO_2 Policy in Kyoto countries with Tech. Development

Scenario C - Strong new CO_2 Policy in Kyoto countries with Tech. Lag

Scenario D - (ACT+) - Strong new CO_2 Policy world wide, with Tech. Development

Impact on CO_2 & Security

- Living in the most favorable scenario w/o H_2/FC (Scenario D / ACT+)
  - + 5% total CO_2 emissions by 2050 (1.4 Gt)
  - + 2% total oil use (conventional + unconv.)
- 30% FCV are replaced by ethanol vehicles (10%), natural gas, FT synfuels, adv. ICEV, hybrids (20%)
- Need for a rapid expansion of other oil substitutes

Many important questions are not technical

- OPEC behaviour and future oil & gas prices
- Will CO_2 storage and nuclear be accepted
- Is the consumer prepared to pay more for energy efficient vehicles and new technology
- What will be the future energy policy (e.g. fuel tax exemptions, biofuel targets etc.)
- ETP model can be used for *what if*… type of analysis of these issues

4 Conclusions and Next Steps

- Technology portofolio approach needed
- Biofuels are important
  - Biomass availability
  - Closer look at lignocellulosic & FT-biofuel technology
  - Direct methanol/ethanol fuel cells
- More attention for emerging options:
  - Plug-in hybrids
  - Pressurized air ?
- Better cost curves for efficiency measures
- Sufficient attention for other modes than LDVs
- Estimate R&D budgets, learning investments and total investment needs

Software + operation