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Energy Technology Perspectives 2008 Transport Highlights

Lew Fulton, IEA

International Symposium on Future Challenges of
Transport and Environment

Berlin, 24-25 June 2008

Energy Technology Perspectives Publication 2008

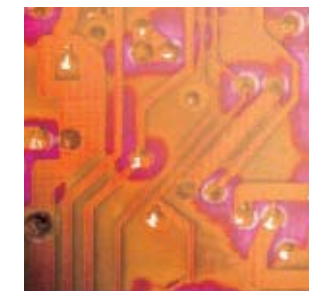
- **A Low CO₂ world: what it looks like and how to get there**
 - Short and medium term technology policy needs
 - Special attention for technology roadmaps
- **Scenario analysis**
 - Baseline WEO2007 Reference Scenario
 - Global stabilization by 2050 (ACT)
 - Global 50% reduction by 2050 (BLUE) – *consistent with WEO2007 450 ppm case*
- **Technology chapters:**
 - Power sector
 - End-use sectors



IPCC 4th Assessment Report

Conclusions approved by all UNFCCC signatory countries

Temperature increase	All GHG	CO ₂	CO ₂ emissions 2050 (% of 2000 emissions)
(°C)	(ppm CO ₂ eq.)	(ppm CO ₂)	(%)
2.0-2.4	445-490	350-400	-85 to -50
2.4-2.8	490-535	400-440	-60 to -30
2.8-3.2	535-590	440-485	-30 to +5
3.2-4.0	590-710	485-570	+10 to +60



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ACT Scenarios

- Energy CO₂ emissions in 2050 back to the level of 2005
- Revision of ACT as published in ETP2006
 - Options with a marginal cost up to USD 50/t CO₂ – worldwide (*model outcome*)
 - Cost estimate has doubled from ETP2006
- This implies a significantly adjusted energy system



BLUE Scenarios

- -50% energy related CO₂ in 2050, compared to 2005
- This could be consistent with 450 ppm (depending on post-2050 emissions trends)
- Options with a marginal cost of up to USD 200/t CO₂ needed (*model outcome*)
 - Significantly higher cost with less optimistic assumptions
- BLUE is uncertain, therefore a number of cases needed
- BLUE is only possible if the whole world participates fully
- This implies a completely different energy system



Transport Scenarios

- **Baseline – business as usual through 2050**
- **ACT – measures costing up to \$50/tonne; stabilization of CO2**
 - Efficiency measures dominate
- **BLUE – measures costing up to \$200-500; reduction of global CO2 to below 2005 levels with downward trend**
 - **BLUE Map – mix of biofuels, fuel cell vehicles (FCVs), and electric vehicles (EVs) for cars and light trucks in 2050**
 - **BLUE Conservative – no FCVs or EVs (only plug-ins)**
 - **BLUE FCV Success – FCVs dominate by 2050**
 - **BLUE EV Success – EVs dominate by 2050**

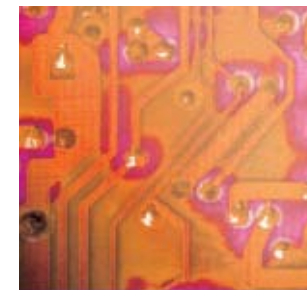
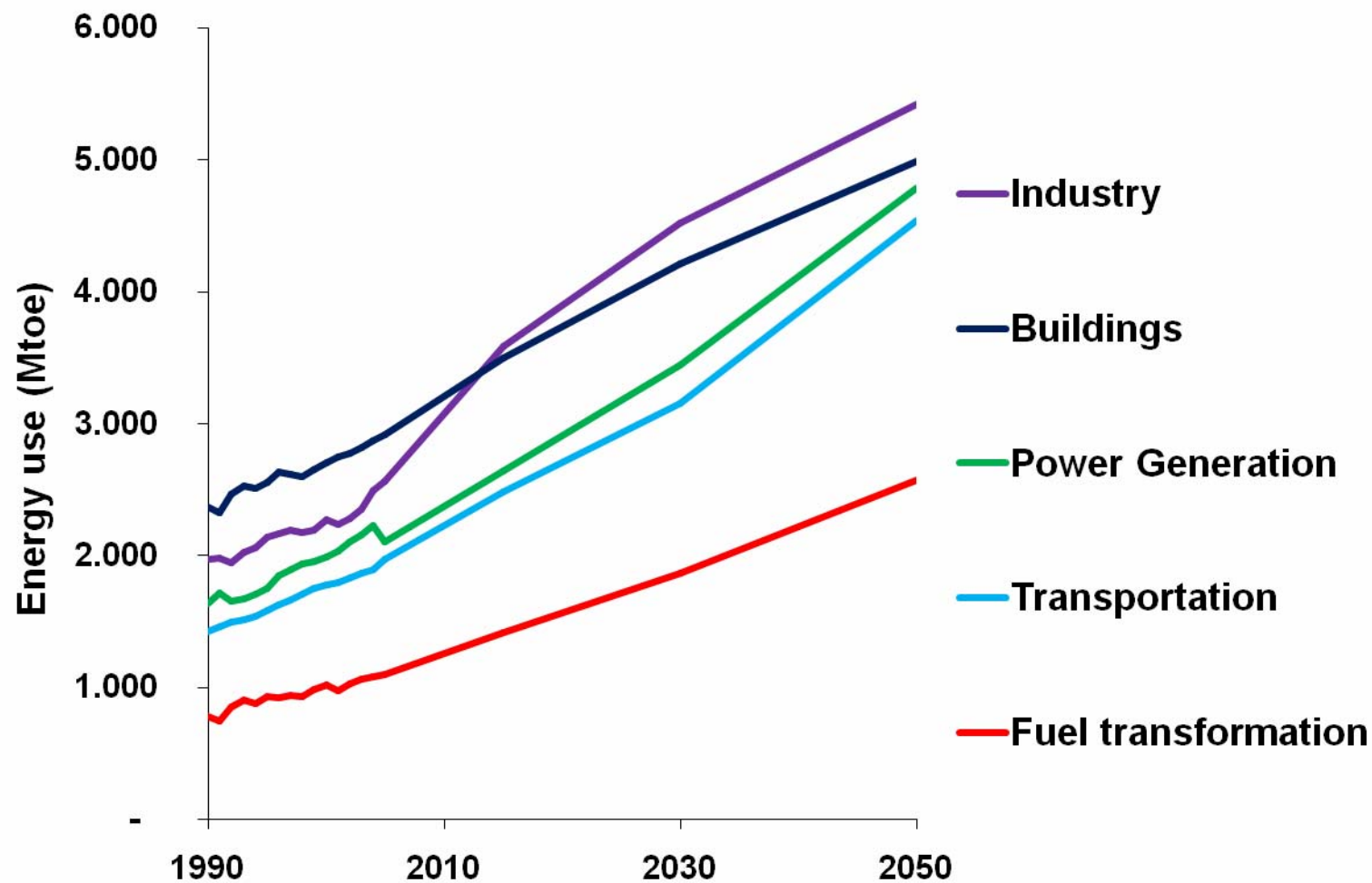


Key Messages

- We are facing an urgent challenge in the energy sector and we need a global solution
- Emissions stabilization – mainly energy efficiency and power sector measures (ACT scenarios)
- Halving emissions by 2050 implies deep cuts for transport and industry (BLUE scenarios)
- Marginal cost ACT USD 50/t; BLUE USD 200/t (optimistic technology estimates)
 - The cost uncertainty increases with ambition level
- USD 45 trillion additional investment needs for BLUE (1% of GDP)
- Important supply security benefits
- We need a step change in government policies, with closer international collaboration
- The roadmaps can provide a focus for this



Baseline Sectoral Energy Use



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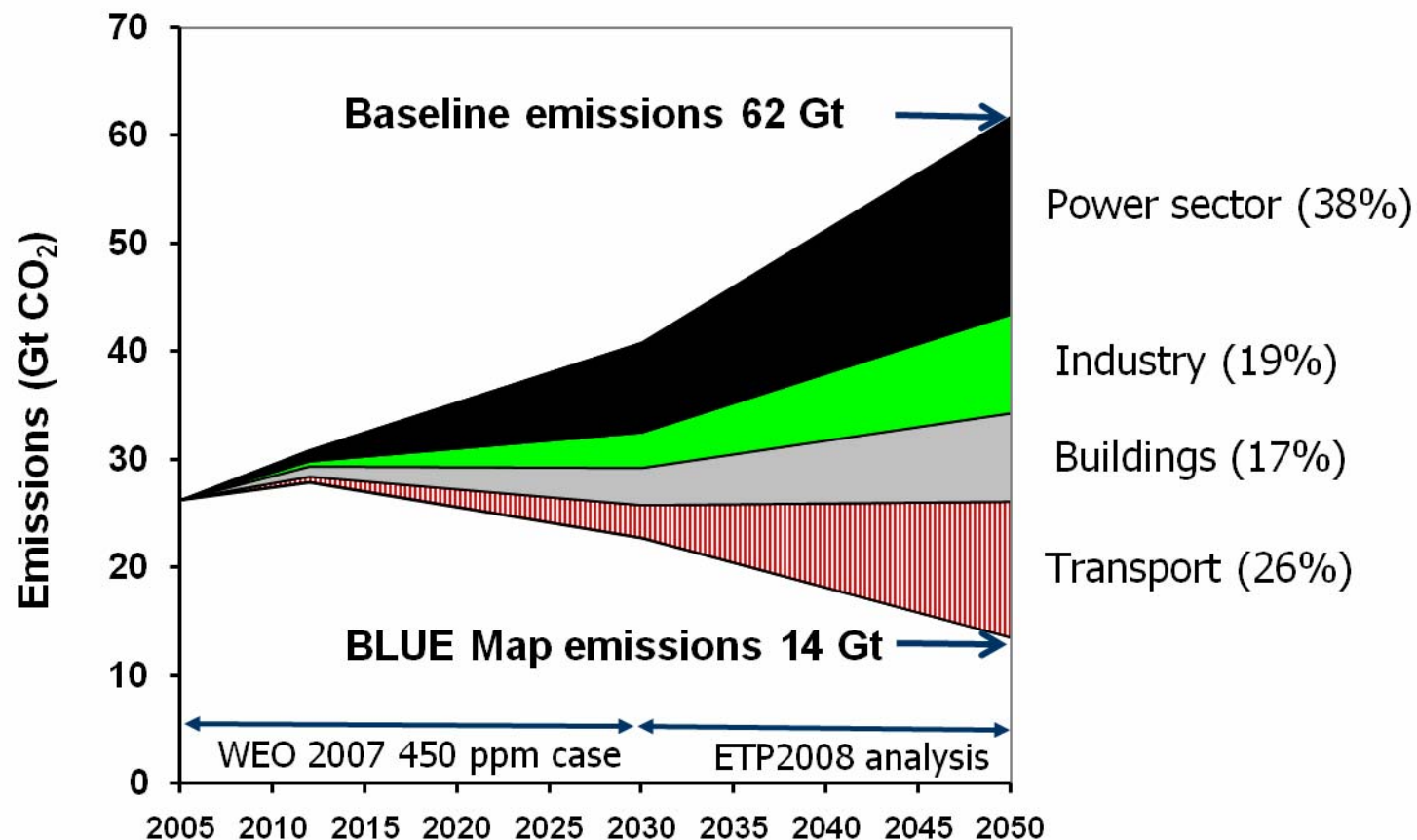
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Sector Contributions

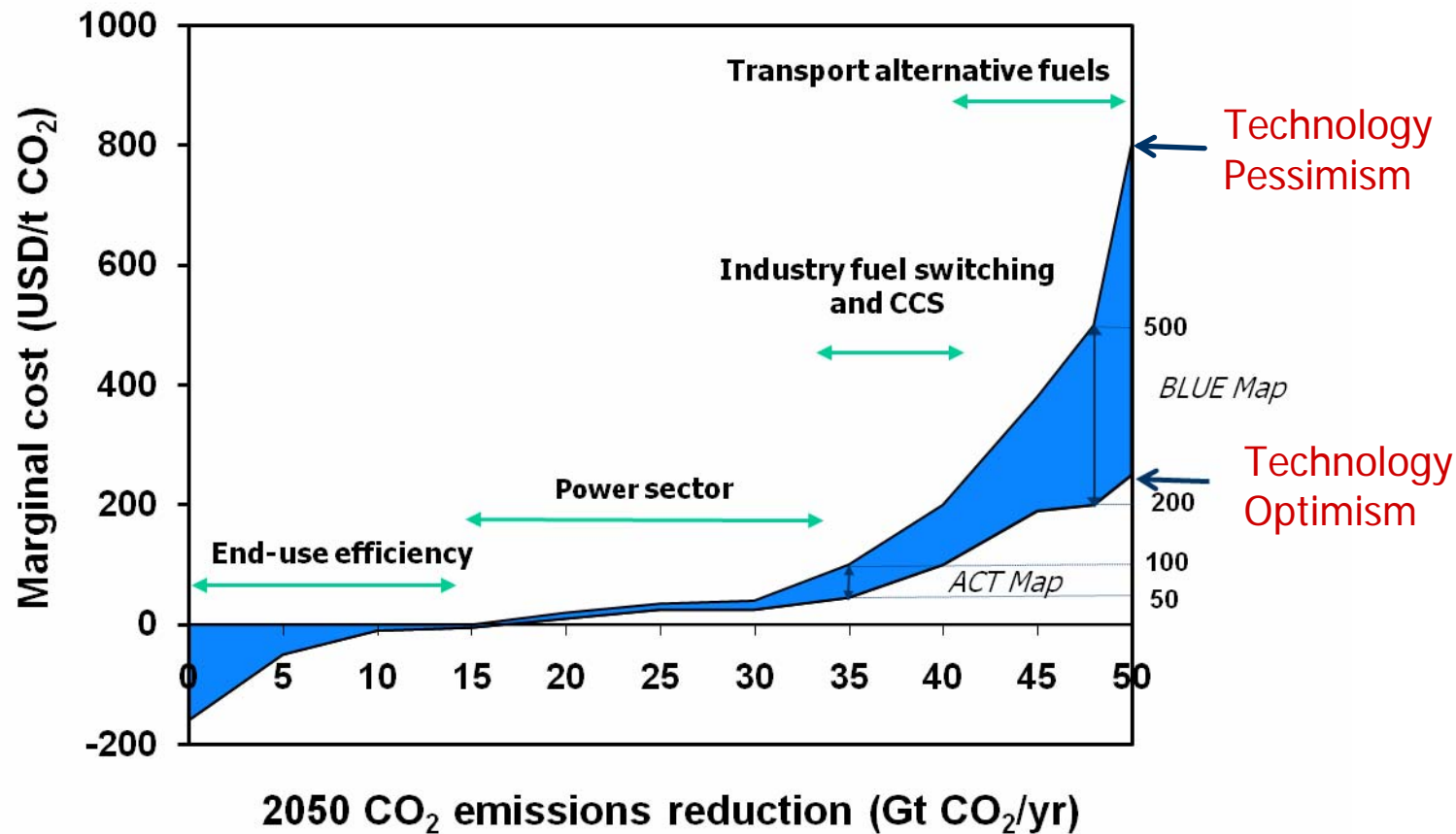


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A New Energy Revolution ?



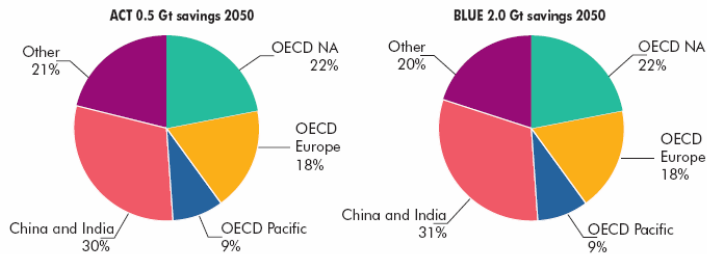
To bring emissions back to current levels by 2050 options with a cost up to USD 50/t are needed. Reducing emissions by 50% would require options with a cost up to USD 200/t, possibly even up to USD 500/t CO₂.



Roadmaps – Example Electric and Plug-in Vehicles

4% of CO₂ reduction potential in BLUE Map

Electric and plug-in vehicles



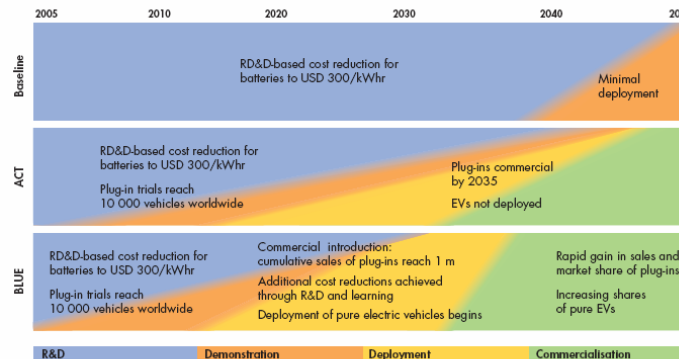
Plug-in hybrids, but not electric vehicles are deployed under ACT. Plug-in Commercial costs are about 10% higher than if they were regular hybrids. Costs cover plug-ins and pure electric vehicles. Between 2020 and 2050, EVs cost, on average, about 20% higher than gasoline vehicles.

	Deployment sales share of plug-in hybrid sales 2035	RD&D Inv. Cost USD bn 2005-2035	Deployment Cost USD bn 2005-2050		Deployment sales share plug-ins (2035)/EVs (2050)	RD&D Inv. Cost USD bn 2005-2035	Deployment Cost USD bn 2005-2050
OECD NA	9%	10-12	40-50	OECD NA	20% / 25%	20-25	950-1 100
OECD Europe	9%	8-10	30-40	OECD Europe	20% / 25%	15-20	800-900
OECD Pacific	9%	6-8	30-40	OECD Pacific	20% / 25%	12-16	400-450
China & India	6%	6-8	20-30	China & India	15% / 15%	12-16	1 050-1 200
Other	6%	8-10	10-20	Other	15% / 15%	15-20	750-850

Technology targets

	ACT: Emissions Stabilisation	BLUE: 50% Emissions Reduction
RD&D		
Plug-in hybrid system	Optimise configuration for maximum consumer acceptability at minimum cost	
Energy storage	Cut cost of battery storage to USD 300 per kWh by 2020, resolve technical issues. Long life span, deep cycling and rapid charging of batteries	Accelerated RD&D to cut cost of battery storage to USD 300 per kWh by 2015, resolve technical issues. Long life span, deep cycling and rapid charging of batteries
Deployment		
Plug-in hybrid vehicle	Semi-commercial deployment of plug-in hybrids up to 5% sales share in IEA countries by 2020	
Pure electric vehicle	No deployment assumed	Pure electric vehicle deployment begins in 2025, to achieve 5% sales share by 2030 (5 years earlier in "EV Success" scenario)

Technology timeline

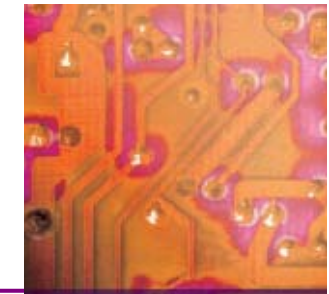


Key actions needed

- The primary hurdle for both plug-in hybrids and electric vehicles is the energy storage system. Despite slow progress, there now appears tremendous potential for key breakthroughs.
- A great deal of RD&D is now occurring in battery manufacturing companies. Governments need to re-double efforts to identify emerging, promising battery (and other energy storage) technologies and support research (whether commercial, scientific, etc.) to bring these technologies to market. Partnerships with vehicle manufacturers may be particularly useful as they have now taken an active stake in developing and commercialising new technologies.
- Most (but not all) recent efforts focus on further development of Li-ion batteries, e.g. Li-polymer, Li-sulfur, etc. Ultracapacitors and flywheels also deserve attention, as do systems that combine storage technologies, such as batteries with ultracapacitors.
- Research and consumer acceptance and early adopter markets.

Key areas for international collaboration

- International collaboration for Electric vehicles and component (especially battery) research already exists in a number of forms, including an IEA implementing agreement on Electric and Hybrid Vehicles. Emphasis is placed on energy storage and power densities of batteries and other storage systems, including ultra-capacitors and flywheels.
- International networks are critical in order to maximise the information sharing and learning. This is a critical time for battery development as a) recent breakthroughs, i.e. new types of Li-ion batteries, appear promising and b) consumers have become interested again in vehicle electrification.
- In general IEA countries need to ensure that their RDD&D programmes complement each other and provide assistance to companies to promote battery demonstration, deployment, and commercial production.



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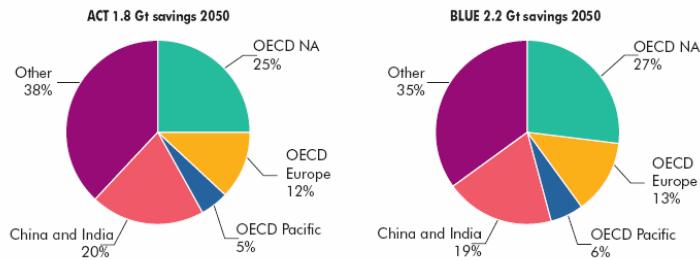
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Roadmaps- Example 2nd-Generation Biofuels

5% of CO₂ reduction potential in BLUE Map

Second-generation biofuels

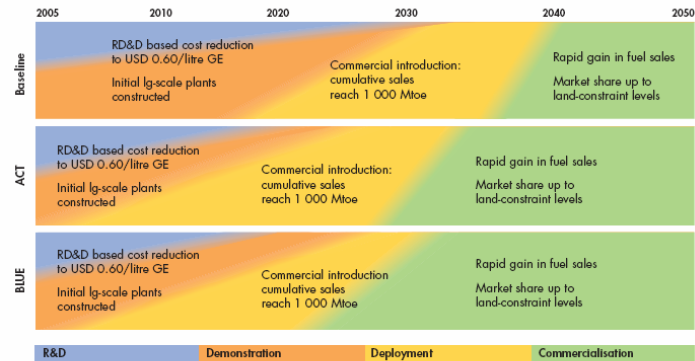


	Global Deployment Share 2035	RDD&D Inv. Cost USD bn 2005-2035	Commercial Inv. Cost USD bn 2035-2050		Global Deployment Share 2030	RDD&D Inv. Cost* USD bn 2005-2030	Commercial Inv. Cost USD bn 2030-2050
OECD NA	25%	25-30	1 300-1 500	OECD NA	27%	30-35	1 100-1 300
OECD Europe	12%	15-20	850-950	OECD Europe	13%	15-20	900-1 000
OECD Pacific	5%	5-10	250-300	OECD Pacific	6%	8-10	300-350
China & India	20%	15-20	800-850	China & India	19%	15-20	1 400-1 600
Other	38%	30-35	450-500	Other	35%	30-35	1 400-1 600

Technology targets

	ACT: Emissions Stabilisation	BLUE: 50% Emissions Reduction
RD&D		
Cellulosic ethanol	Cut cost of ethanol production to USD 0.60 per litre gasoline equivalent (GE), mainly via better enzymes, by 2015-2020	
BTL (F-T) gasoline/diesel	Cut cost of BTL production to USD 0.70 per litre GE by 2015-2020 via optimisation of biomass handling, gasification, and synthesis gas production steps	
Deployment		
Cellulosic ethanol	Deployment begins by 2015, full commercialisation by 2035	Deployment begins by 2012, full commercialisation by 2030
BTL (F-T) gasoline/diesel	Deployment begins in 2015, full commercialisation by 2035	Deployment begins by 2012, full commercialisation by 2030

Technology timeline

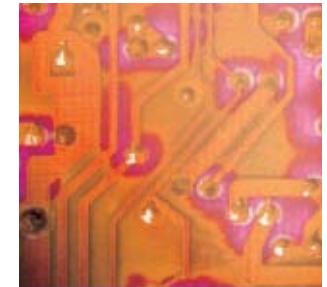


Key actions needed

- Both ligno-cellulosic ethanol and Fischer-Tropsch "biomass-to-liquids" are reaching the demonstration and, perhaps within a few years, the deployment phase, though basic R&D in some areas is still needed.
- Ligno-cellulosic demo. projects amounting to over USD 1 bn are expected in North America from 2008-2012; various technologies will be tested at scales less than half of expected future commercial size.
 - Similar trials are needed in other parts of the world; better data on feedstock availability and cost by region are needed; land use change analysis.
 - Pathways and strategies to get from demo. to deployment to commercialisation must be developed and clarified.
 - More work on co-products and bio-refinery opportunities.
- For BTL fuels, a small demo project in Germany has been announced, others expected (particularly in Europe) by 2010-2015.
 - Continued engineering research on feedstock handling, gasification/treatment, co-firing of biomass and fossil fuels.
 - Better understanding of cost trade-offs between plant scale and feedstock transport logistics.

Key areas for international collaboration

- Ongoing basic research collaboration (e.g. feedstock and enzyme research, feedstock handling/transport, process and plant scale optimisation).
- Global assessment of biomass availability / cost for production of 2nd generation biofuels.
 - Impacts on GHGs, sensitive eco-systems soils, food security, alternative uses of land ("land use change").
 - Assessment of economic viability of 2nd generation biofuels in the developing world.
- Better co-ordination of demo. projects, trials, deployment policies, biofuels trade.



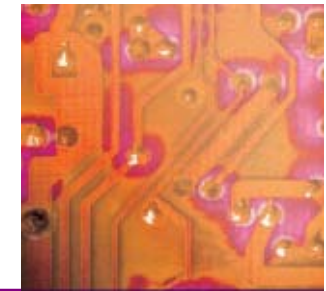
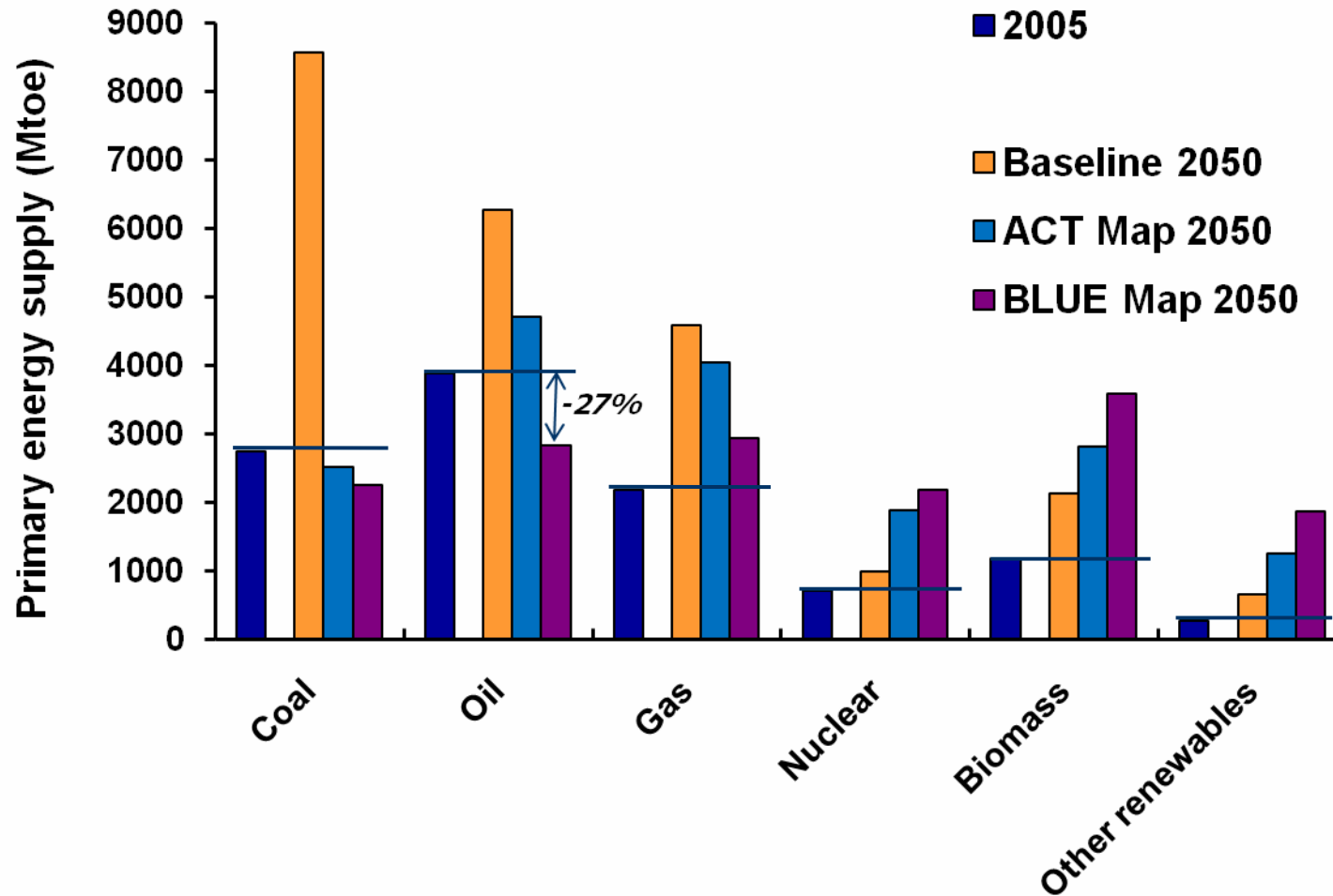
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Primary Energy Demand

Important supply security benefits



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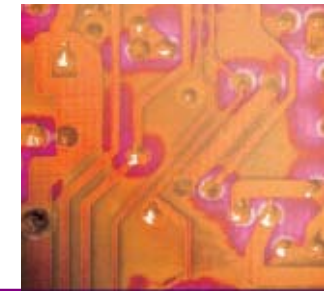
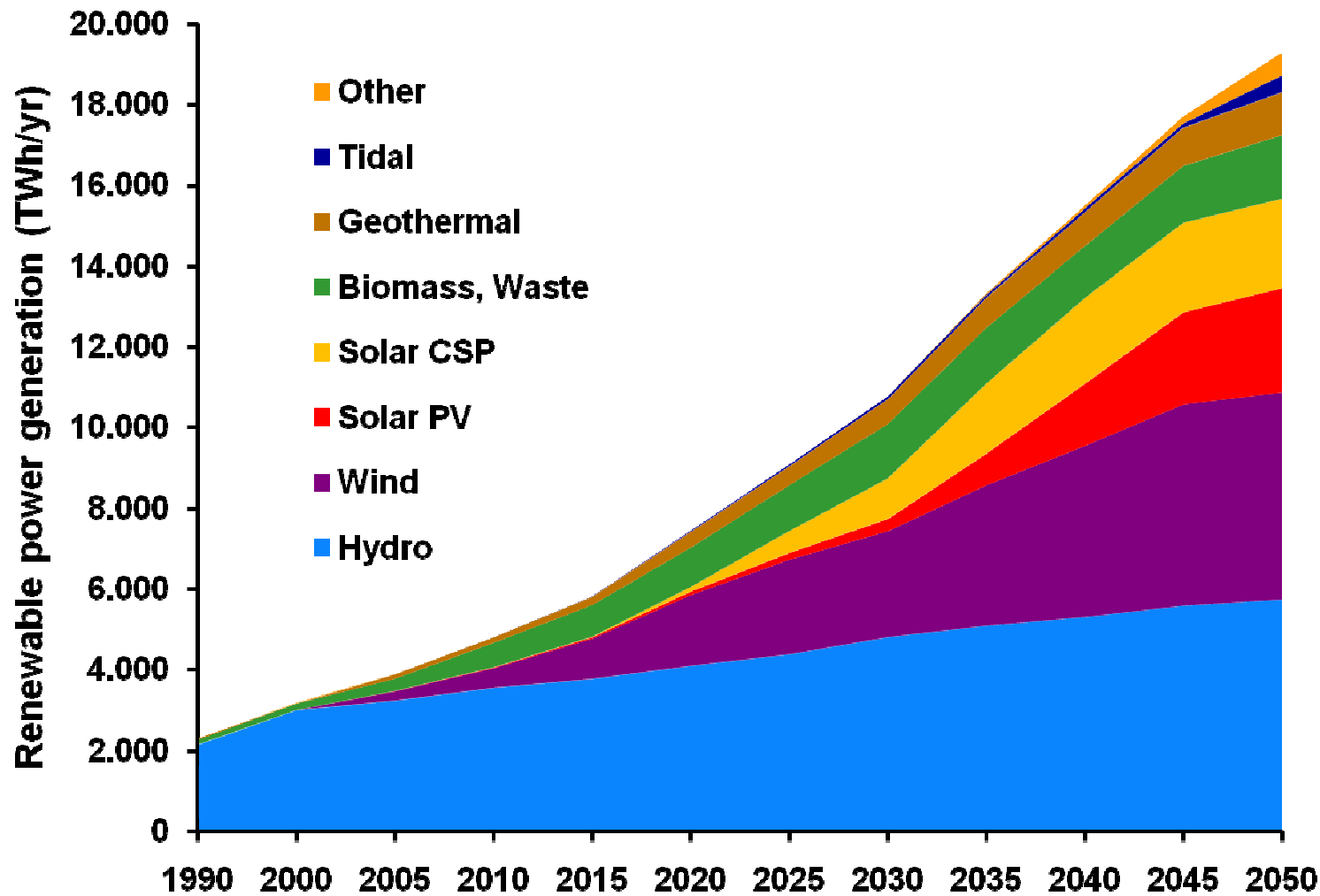
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Growth of Renewables in BLUE Map



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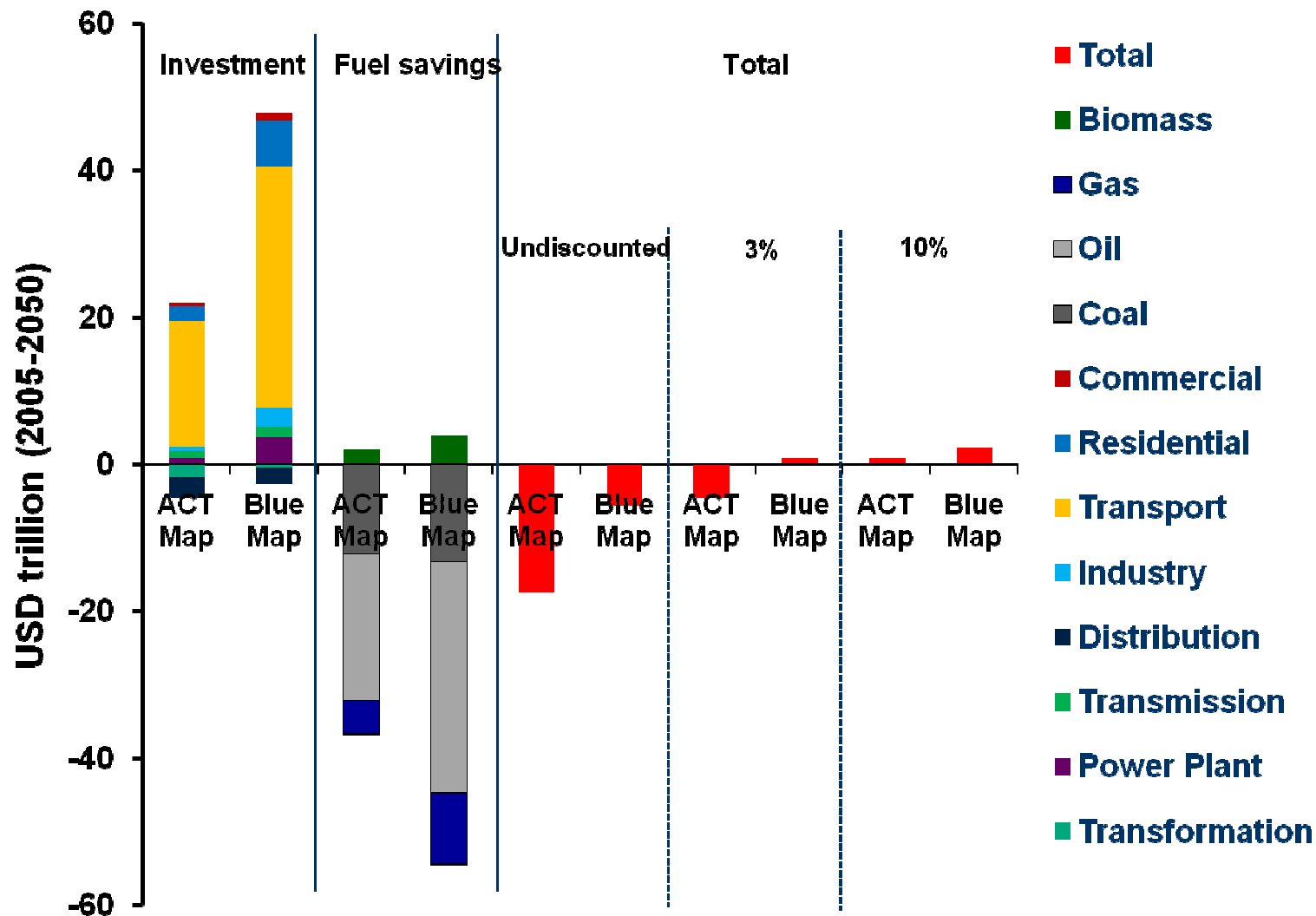
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Financing needs *on top of Baseline*

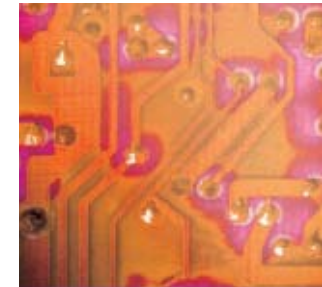
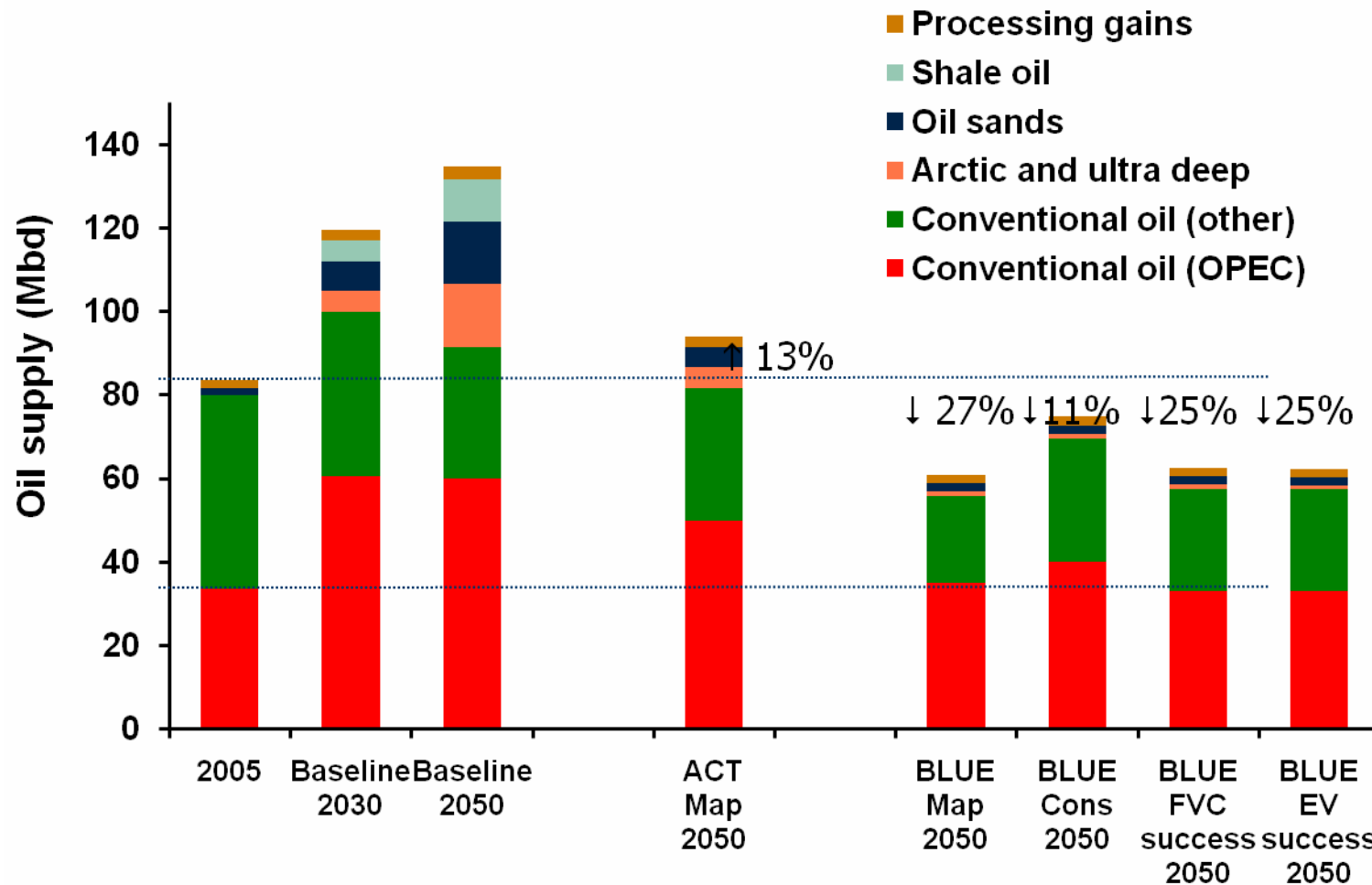
- USD +10 to +100 bn/yr RD&D (short to mid-term)
- USD +100 to +200 bn/yr learning investments (short to mid-term)
 - USD 7 trln total
- USD +1000 to +2000 bn/yr commercial investments (2020-2050)
 - Additional investments USD 45 tr total
- There are also enormous cost savings, mainly from lower fuel use



Cumulative Additional Investment and Fuel Savings



Oil Supply Projections



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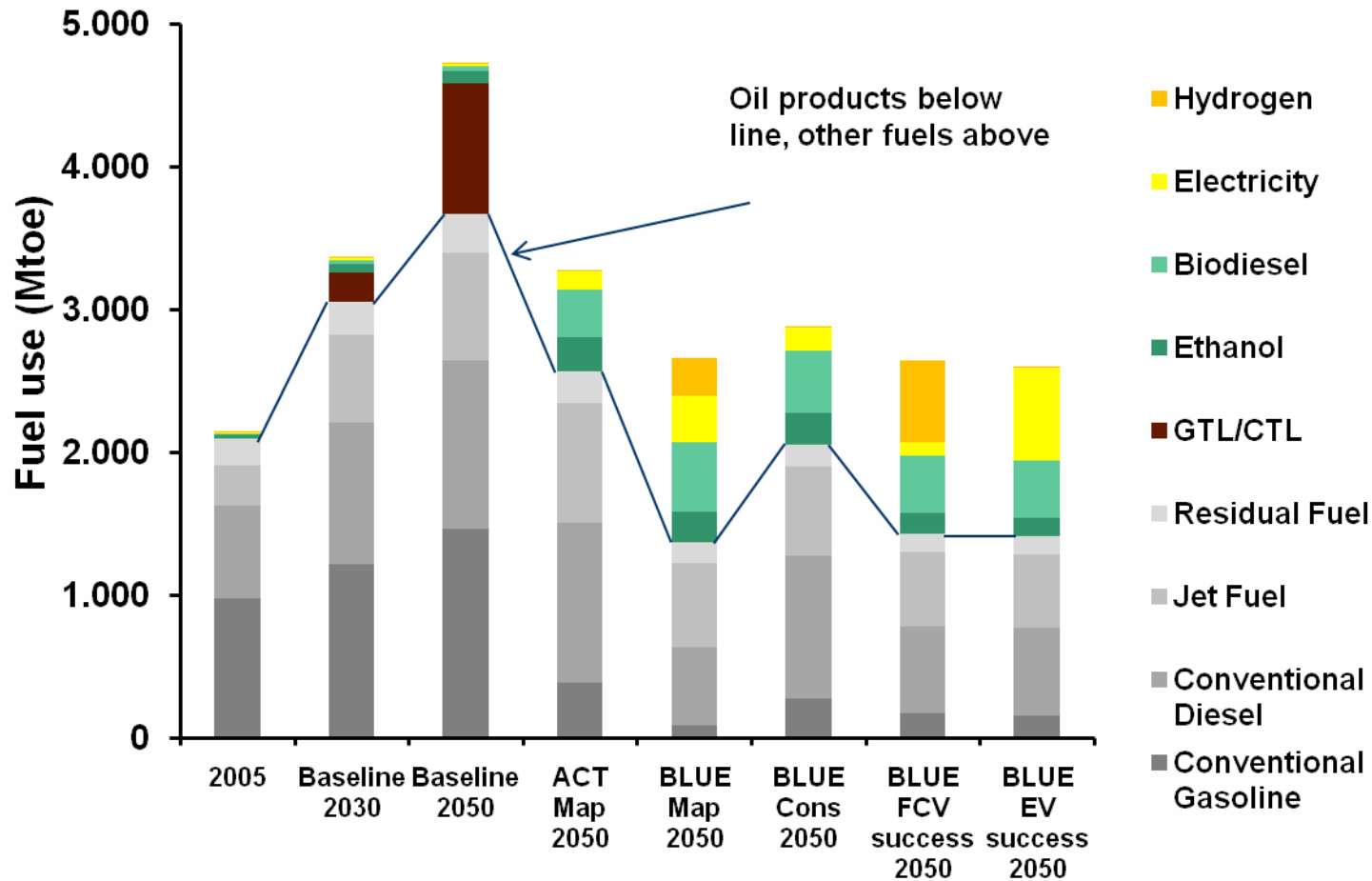
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Transport Energy Use



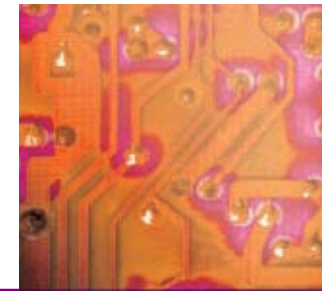
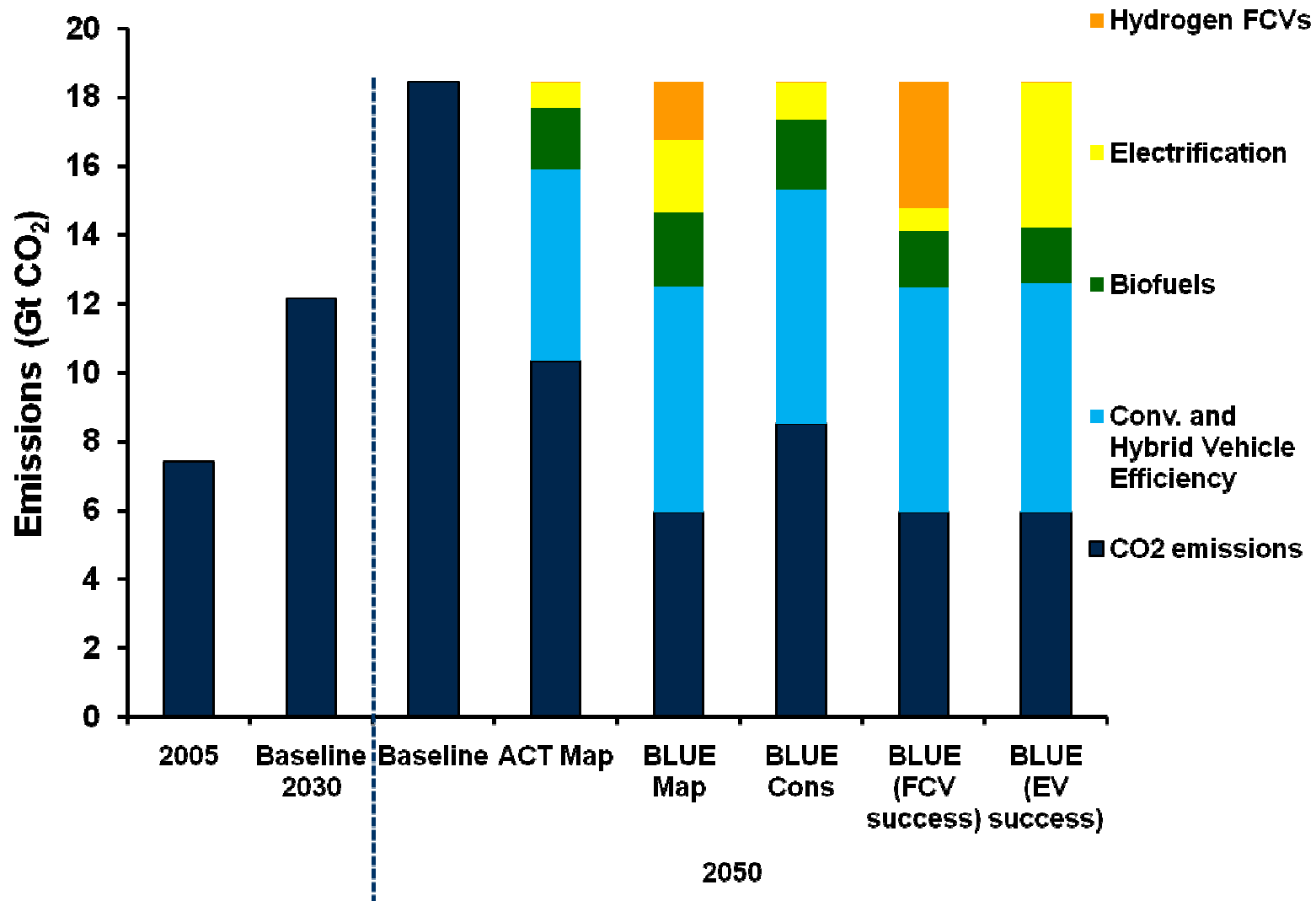
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Transport GHG Emissions

(well-to-wheels CO₂-equivalent emissions)



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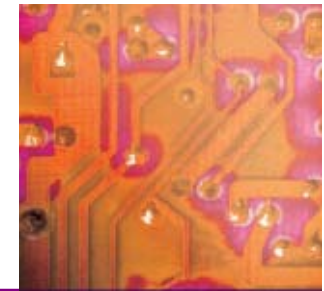
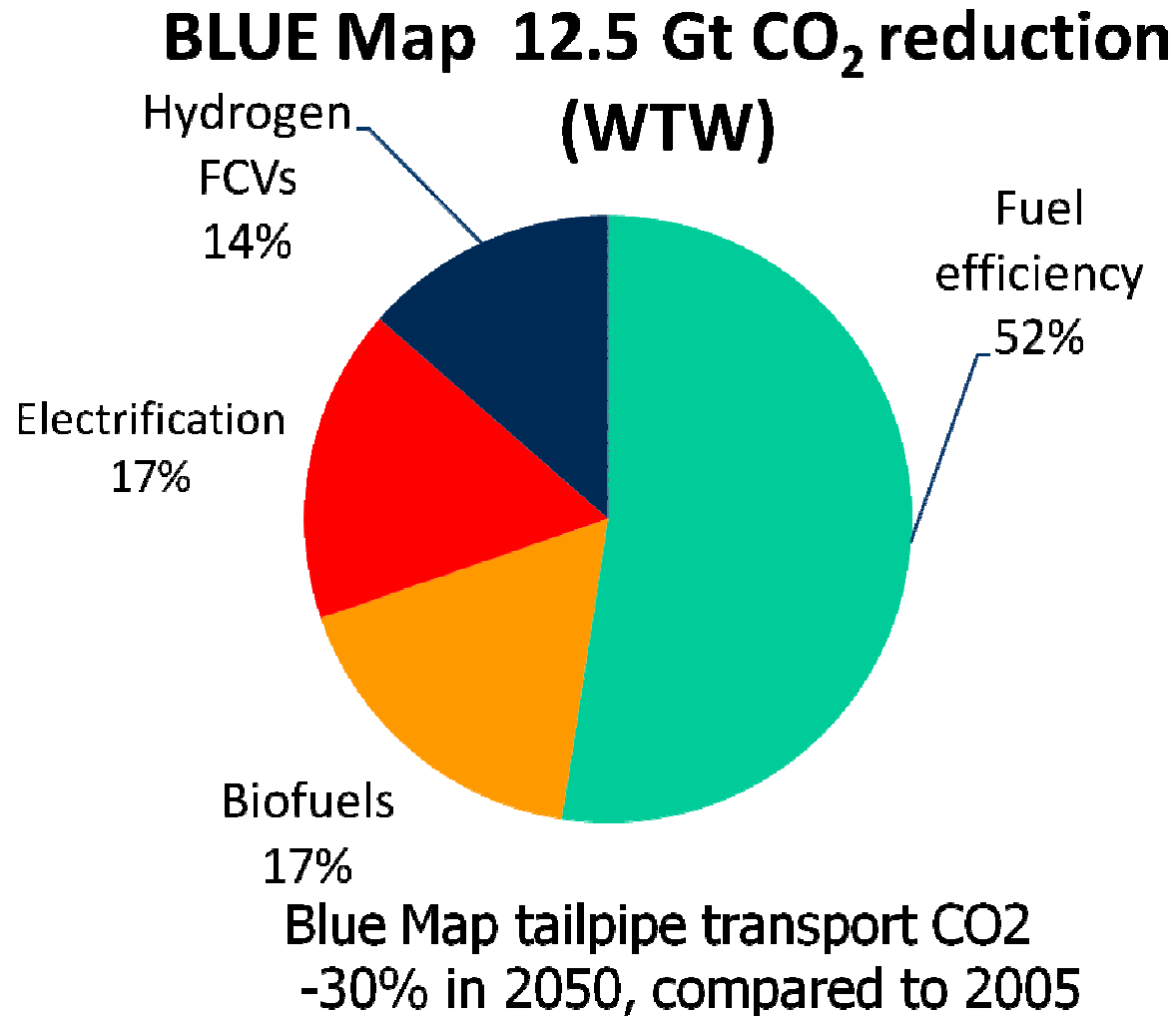
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Transport Sector Emissions Reductions



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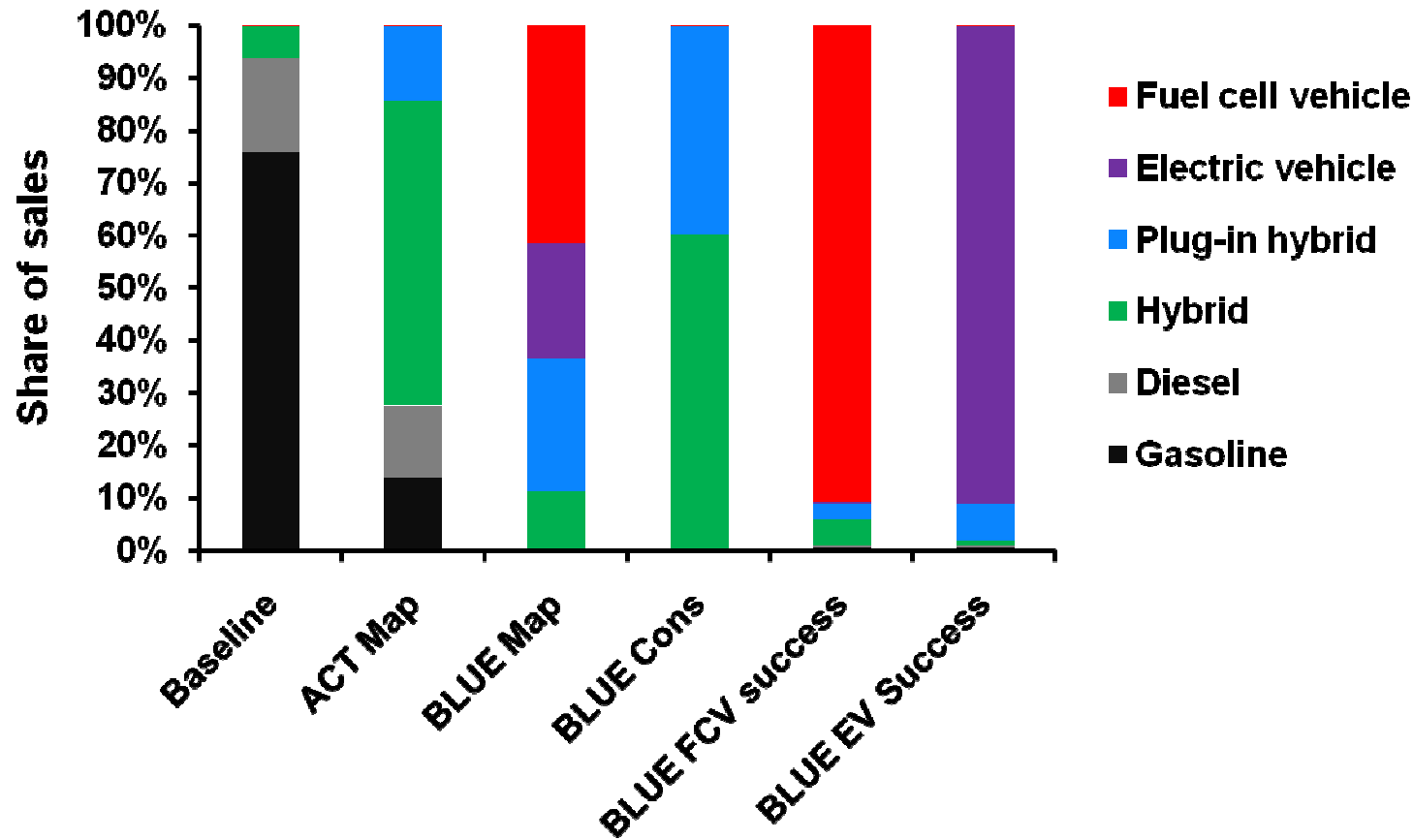
ETP Blue

Light-duty Vehicles (cars, SUVs)

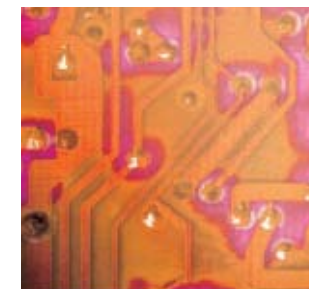
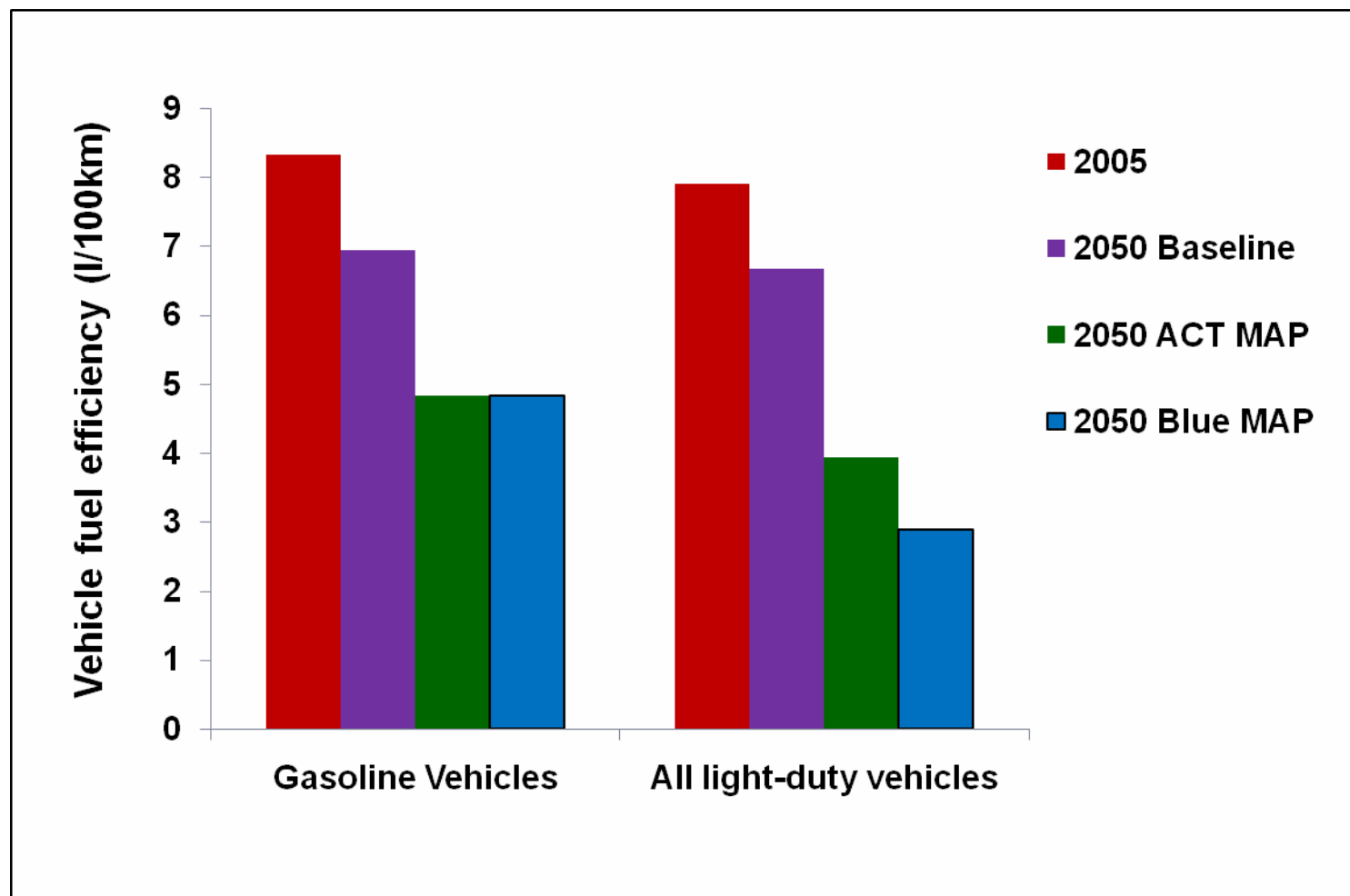
- LDVs 50% more efficient by 2030
- Hybrids dominate by 2030, plug-in hybrids dominate by 2050
- H₂ fuel cell vehicles (and/or EV) begin to penetrate market by 2025, steady ramp-up to 60-90% of sales by 2050
 - Electricity, H₂ are available for vehicles in large quantities at near-zero CO₂
- Biofuels reach up to 12% of total liquid fuel share by 2030, mostly 2nd gen, mostly diesel
 - Rising to 26% by 2050 (20-fold increase compared to 2007)
 - LDVs may not be the best application



Technology Market Share in 2050, by Scenario and Variant



New LDV Fuel Economy



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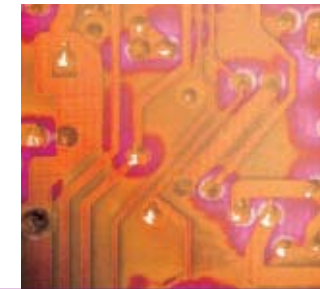
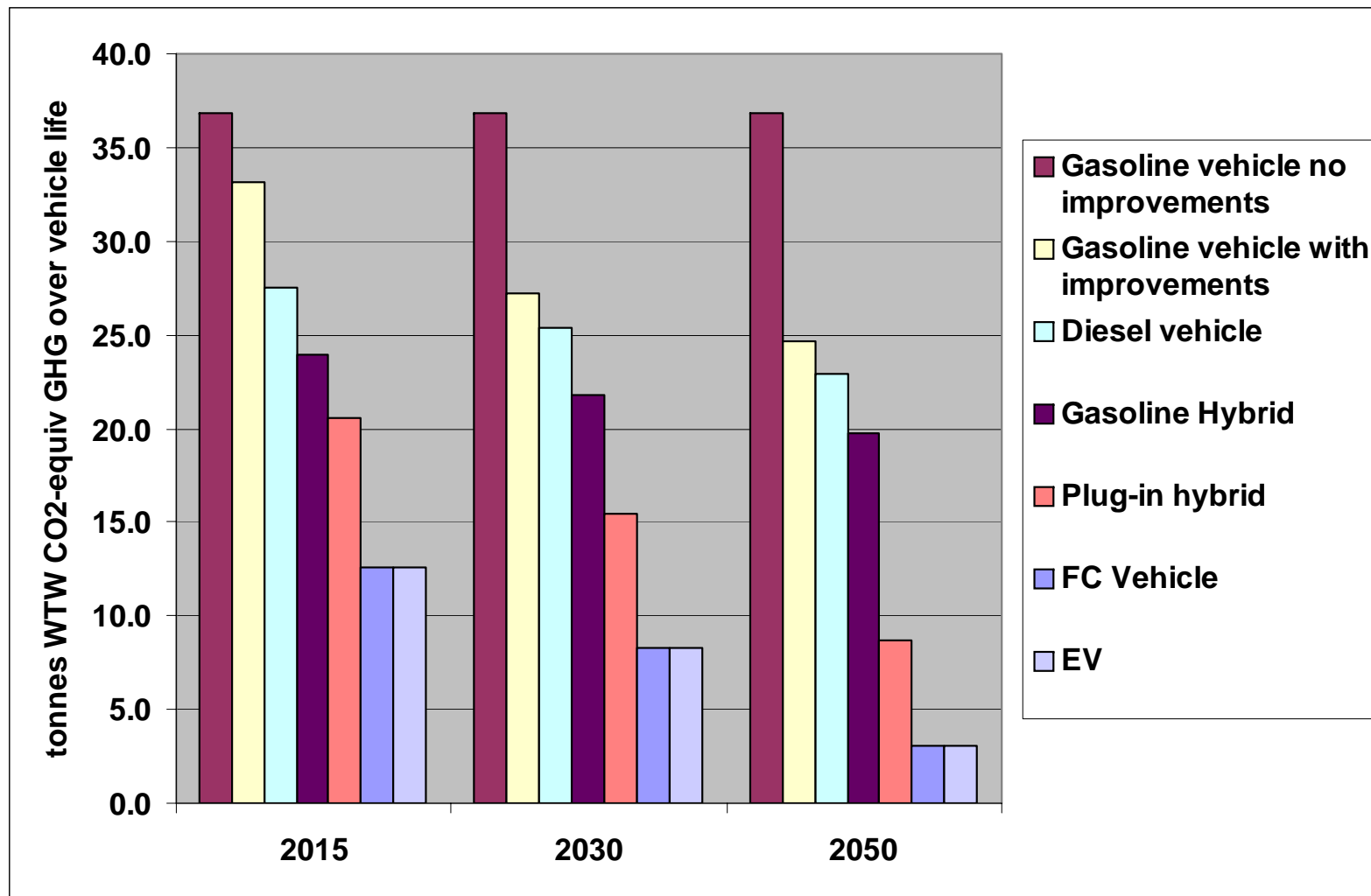
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GHG over vehicle life

(well-to-wheel CO₂-equiv, preliminary)



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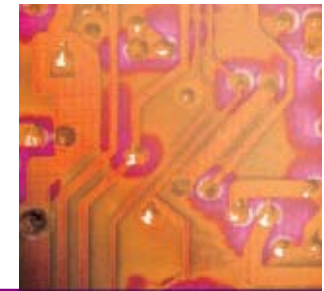
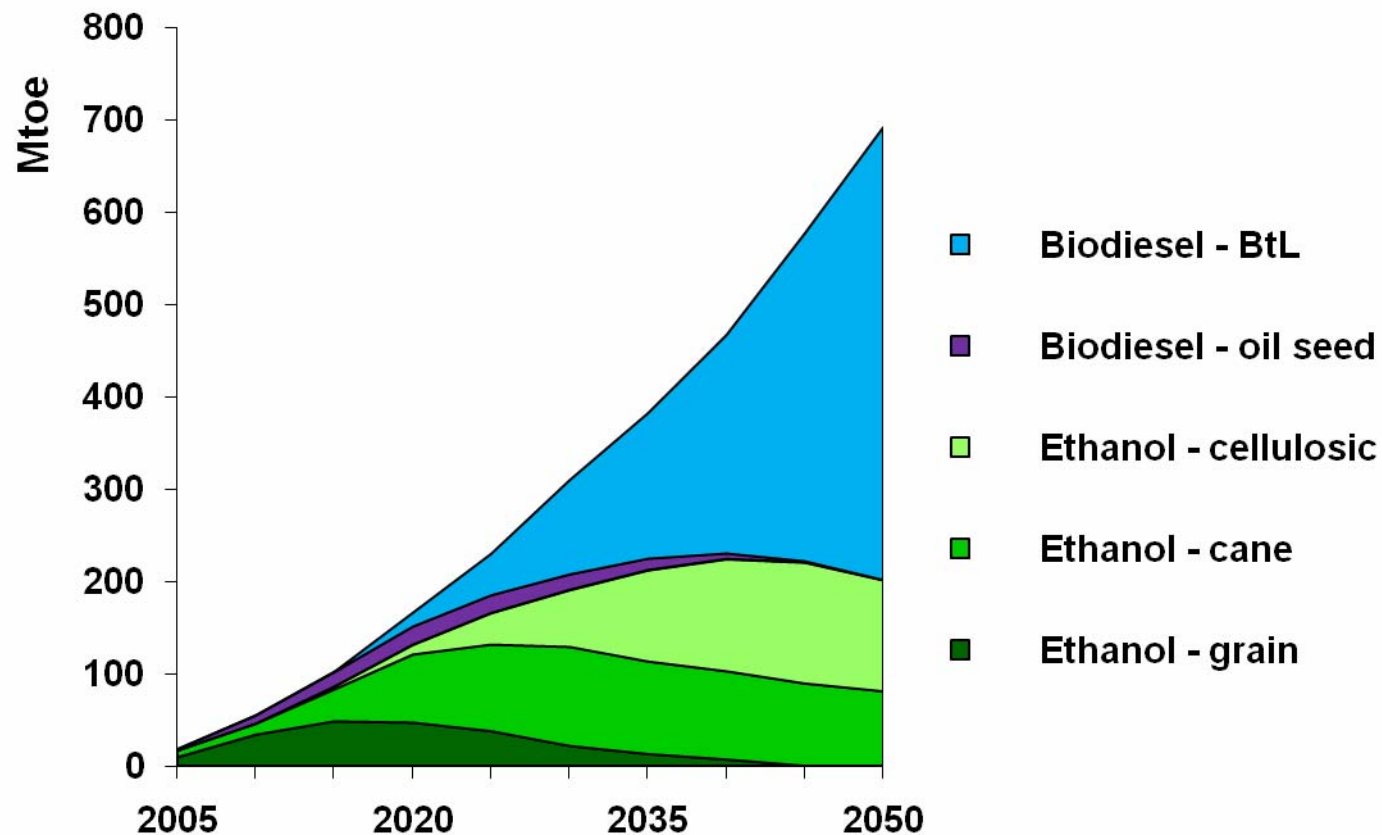
The Biomass Resource

- Biomass currently provides around 190 Mtoe (8 EJ)/yr of heat and power and 40 Mtoe (1.7 EJ)/yr of liquid transport fuels.
- Traditional biomass accounts for over a further 800 Mtoe (35 EJ) /yr.
- In BLUE Map scenario biomass will increase to around 3600 Mtoe (150 EJ)/yr.
- This will require 15 000 Mt biomass with half from crop and forest residues and the rest from purpose grown energy crops.
- 700 Mtoe /yr will be used for transport fuels, 700 Mtoe /yr to produce 2 450 TWh of electricity, and the rest used for bio-chemicals, heating and cooking.



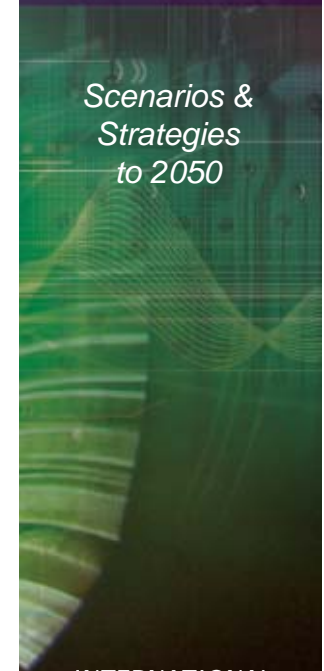
Biofuels Use in BLUE Map

26% of Transport Fuel Use in 2050



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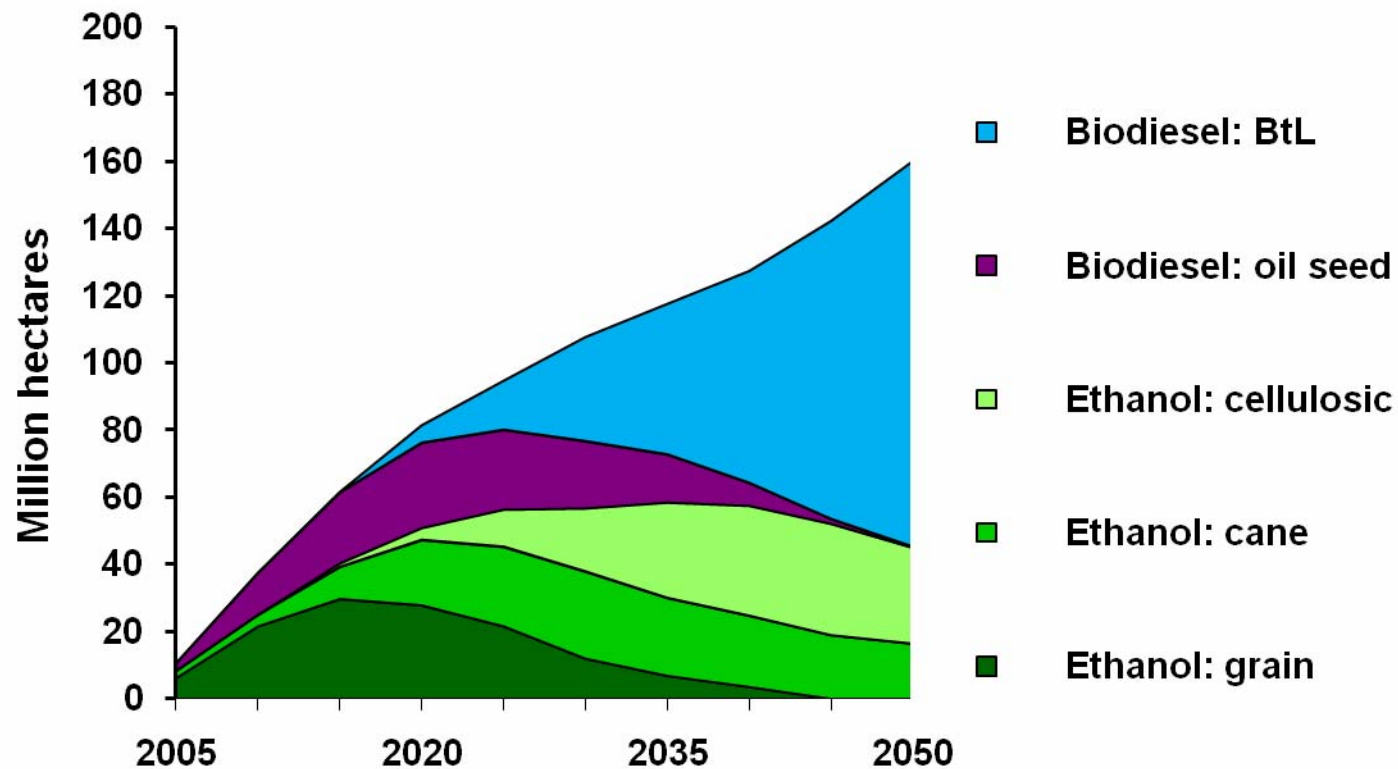
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Biofuels Land Use in Blue

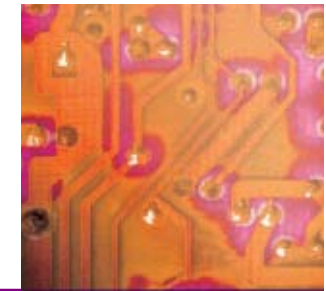
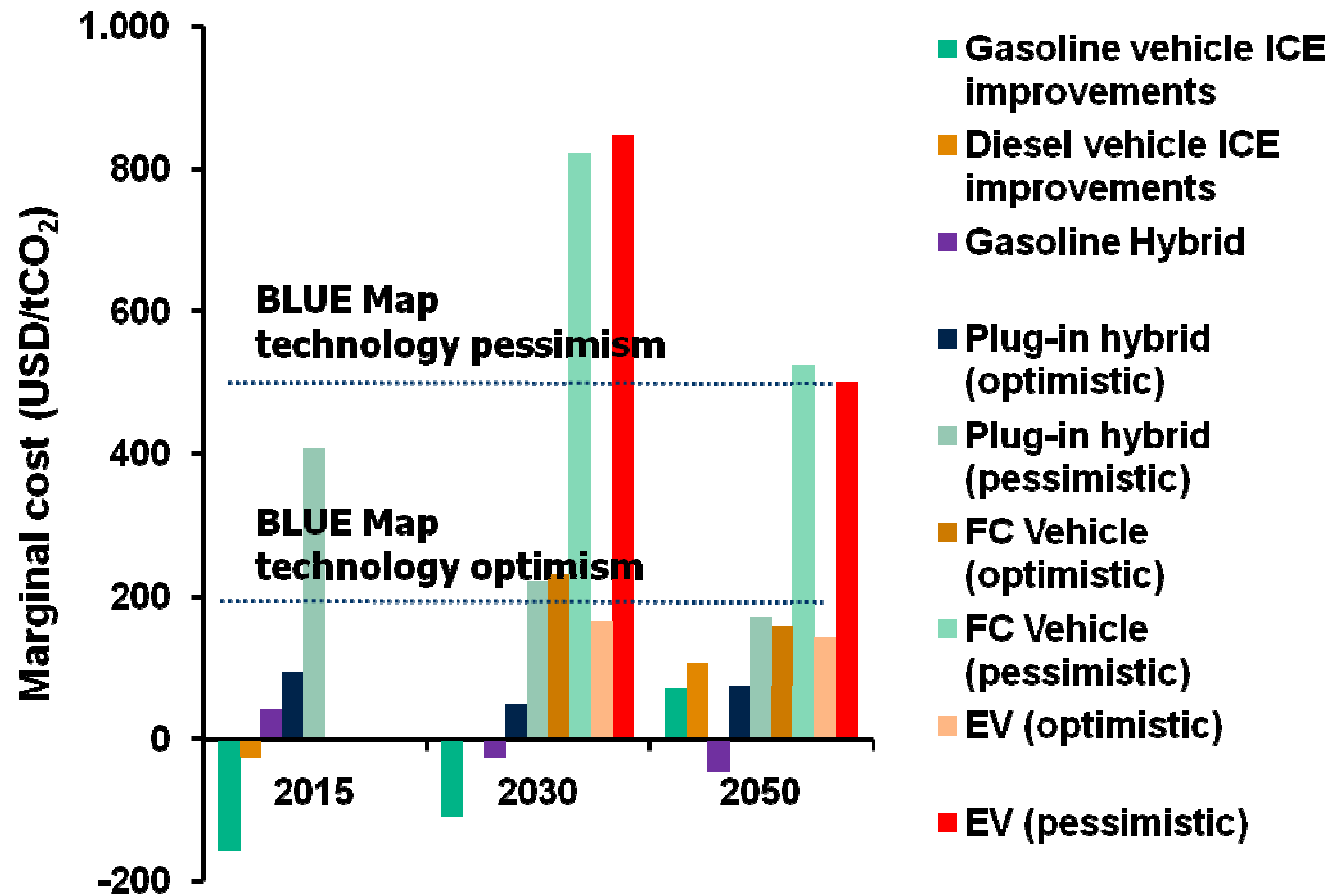
Perhaps about 150 million hectares worldwide



Based on yields for different feedstocks reported in literature; assumes 100% from agricultural/forest crops; other sources like residues would reduce land requirement.

LDV Technology Costs

Cost per tonne CO₂



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Other Transport Modes

Half of total demand

- Air – 15% efficiency improvement over baseline (30% in baseline) by 2050
 - 30% BTL fuel by 2050
- Shipping – 30% efficiency improvement by 2050; 30% biofuels by 2050
- Trucks, buses – 30-50% efficiency improvement by 2050
 - Same biofuels share as for LDVs
 - Medium trucks – 50% fuel cell/EV by 2050
- Modal shift
 - Strong transit development in developing cities
 - Intensive development of high-speed rail
 - Shift of ¼ of long-distance freight from truck to rail
 - Overall perhaps a 10-15% reduction in car, truck, air travel in 2050



Conclusions

- For a very low CO₂ future, transport *must and can* achieve deep GHG reductions
- Basically to decarbonise, transport must get off oil (even CCS doesn't change this)
 - Baseline CO₂ intensity could rise dramatically with rise in unconventional oil and synthetic fuels
 - In Blue-type scenario, gasoline seems easier than diesel to eliminate
 - A transition will take decades
 - We will need massive oil investments in any case
- Substantial efficiency improvements in all modes are available at modest cost
 - Costs of other types of measures are widely variable
- Role of biofuels could be large but many questions
 - Long run need may be mainly to replace diesel/jet fuel



Thank You !

