ALTER-MOTIVE

IREES
Institute for Resources Efficiency and Energy Strategies

ALTER-MOTIVE Mid-Term Conference

Economic Assessment & Potentials of Alternative Fuels & Alternative Mobility Technologies

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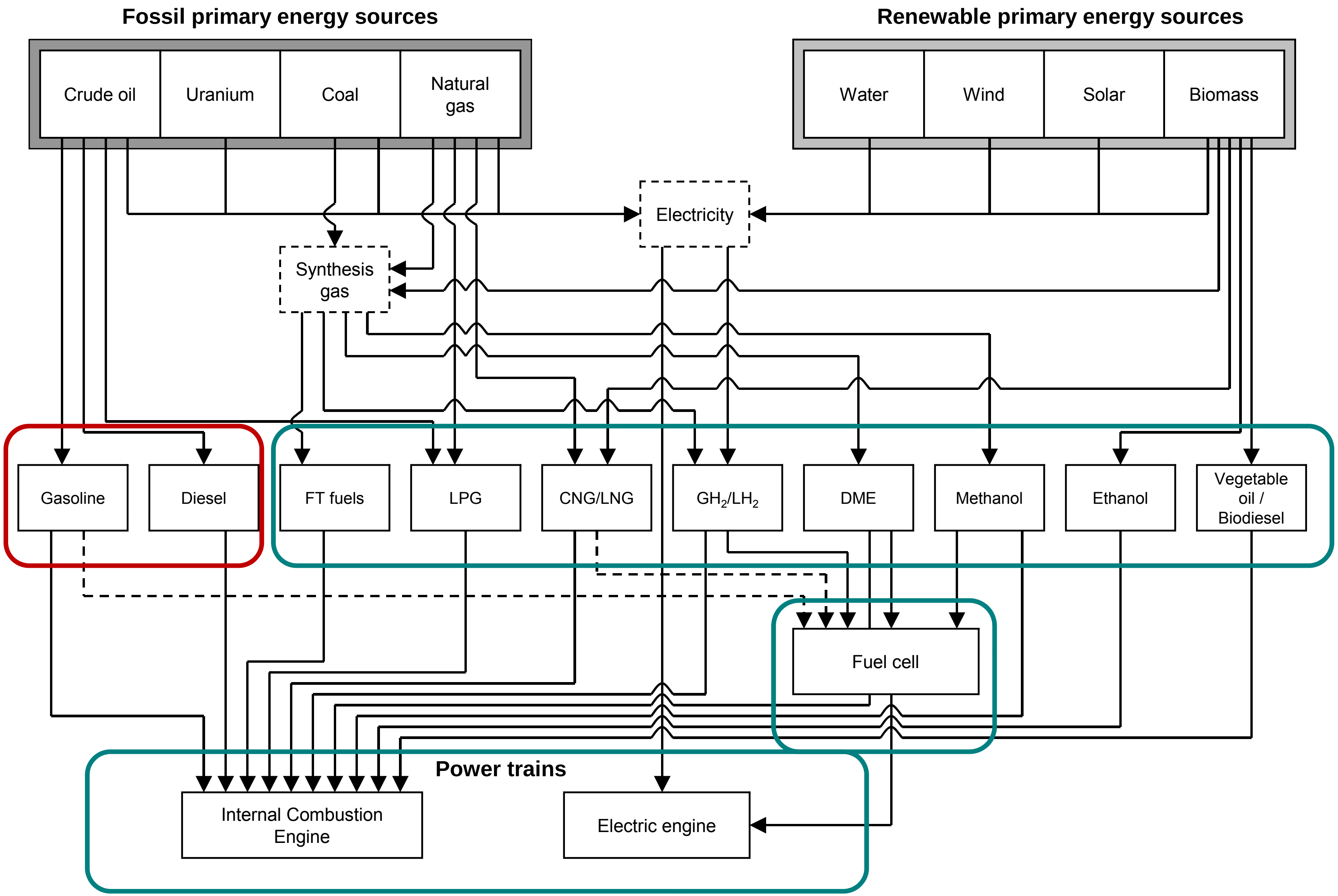
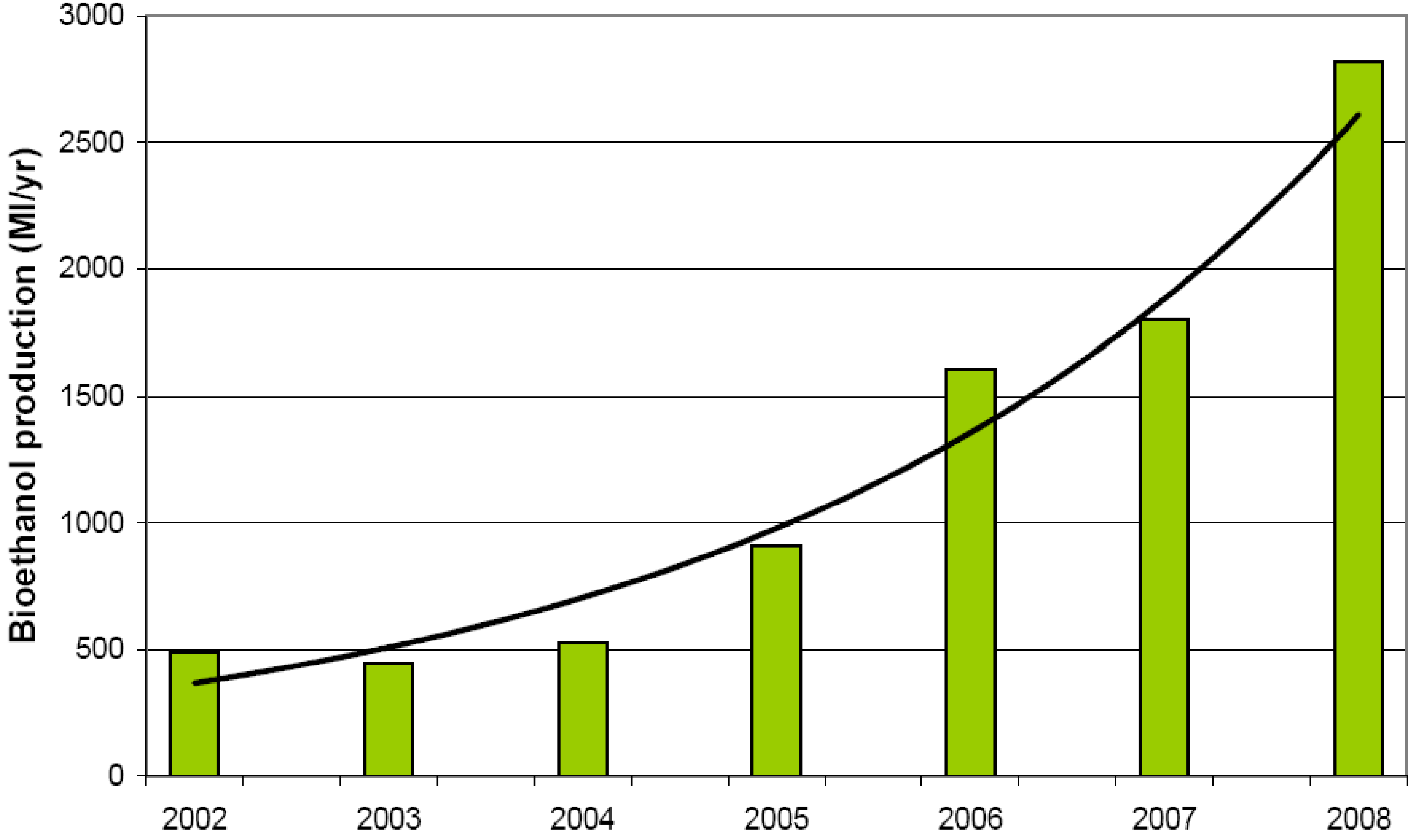
Contents

What are the options? – AF and AAMTs



Source: Wietschel, Ball, Weindorf, Toro, et.al (2009)

AF Production in the EU



Source: Ajanovic, Haas, et. al, 2010

Biodiesel State of the Art and Production Plants - EU

Biodiesel Plant/Country	Feedstock	Prod. Technology	Capacity	Investment
Biodiesel Kärnten/ AT	MF	BDI	50.000 t/a	14,5 Mio €
Agropodnik / CZ	RS oil	Oil mill+ Campa biod.	50.000 t/a	7-8.5 Mio €
ADM Connemann/ DE	RS oil	Oil mill+ Connemann	1'130 Ml/yr	10 Mio €
BIO Oelwerk Magd./DE	RS oil	Oil mill+ Connemann	50.000 t/a	20 Mio €
MUW in Greppin /DE	RS oil	Continuous/Dr Pollert	150.000 t/a	25 Mio €
SARIA Bioindustries/DE	AF	BDI	12.000 t/a	10 Mio €
Novaol SRL / IT	RS & SF	Ballestra	250.000 t/a	n.a. Mio €
Ekoil Biodiesel/Slovakia	Multi Feed	Ekoil process	40.000 t/a	2 Mio €
Stocks Valles /	Multi Feed	BDI	30.000 t/a	4.5 Mio €
Diester Industries	Multi-Feed	Transest.	2'250 Ml/yr	n.a.
Biopetrol Industries	RS oil	Transest.	840 Ml/yr	500-700 mio €
Verbio / De	Multi-Feed	Transest.	510 Ml/yr	300-400 mio €
Cargill / De	Multi-Feed	Transest.	42 Ml/yr	33 million €
Biodiesel Amsterdam	UCO Tallow	Transest.	100.000 t/yr	80 mio €

Source.Toro, et. al. 2008, Biofuels Plattform 2009

Bioethanol State of the Art and Plants - EU

Bioethanol Plant/Country	Feedstock	Prod. Technology	Capacity	Capacity (litres/yr)
Abengoa/Spain	Wheat	Fermentation	326.000 t/a	510,000,000
AB Bioenergie/France	Wheat, beets	Fermentation	180.000 t/a	50,000,000
Agroethanol AB/Sweden	Wheat, barley	Fermentation	40.000 t/a	50,000,000
Crista Union /France	Beet	Fermentation	23.800 t/a	150,000,000
Kwst/Germany	Sugarbeet, molasses	Fermentation	n.a.	20,000,000
NBE /Germany	Rye	Fermentation	225.000 t/a	
MBE/Germany		Fermentation	100.000 t/a	
Saint-Louis Sucre/France	Beet and Molasses	Fermentation	n.a.	15,000,000
Sauter/Germany	Rye	Fermentation	n.a.	310,000,000
Südzucker/Germany	Wheat	Fermentation	n.a.	260,000,000
Svensk etanolkemi/Sweden	n.a.	Fermentation	15.000 t/a	n.a.
Tereos/France	Wheat, beets	Fermentation	48.000 t/a	50,000,000

2nd generation bioethanol plants

Operator	Location	Ethanol capacity (t/yr)	Scale	Status
Abengoa Bioenergy	Salamanca, Spain	4000	Demo	Under construction, start-up 2009
BioGasol	Bornholm, Denmark	4000	Demo	Planned start-up 2009
DTU, BioGasol	Copenhagen, Denmark	10	Pilot	Operational, start-up 2006
SEKAB	Örnsköldsvik, Sweden Örnsköldsvik, Sweden Örnsköldsvik, Sweden Örnsköldsvik, Sweden	100 4500 50,000 120,000	Pilot Demo Demo Comm.	Operational, start-up 2004 Planned start-up 2011 Planned start-up 2014 Planned start-up 2016
Inbicon, DONG Energy	Fredericia, Denmark Fredericia, Denmark Kalundborg, Denmark	110 1100 4000	Pilot Pilot Demo	Operational, start-up 2003 Operational, start-up 2004 Under Const, start-up 2009
Procethol 2G, Futurol	Pomacle, France Pomacle, France	140 2840	Pilot Demo	Under Const, start-up 2010 Planned
Süd-Chemie	Münich, Germany	2	Pilot	Operational, start-up 2009

2nd generation Biofuel State of the Art

Biofuel group	Specific biofuel	Production process	Companies
Bio-ethanol	Cellulosic ethanol	Biochemical: Enzymatic hydrolysis & fermentation	Abengoa, Iogen,Sekab, Poet
Synthetic biofuels	Fischer-Tropsch diesel (FT), Synthetic diesel, Biomethanol, Dimethyl ether (DME), Heavy alcohols (butanol and higher), P-series (ethanol + MTHF etc.)	Thermo-chemical: Gasification and synthesis	Choren, Lurgi, Range Fuels, Chemrec, Enerkem
Biodiesel (hybrid of 1st and 2nd gen.)	Green pyrolysis diesel, H-Bio	Thermochemical: Pyrolysis Hydrogenation (refining, also applied to veg oils)	Dynamotive, Ensyn, BTG
Methane	Bio synthetic natural gas (SNG)	Thermo-chemical: Gasification and synthesis	Nexterra, ECN
Biohydrogen	Hydrogen	Thermo-chemical: Gasification & synthesis Biological	

AF: Biogas

- In EU mainly used for Electricity generation by cogeneration
- 58.4% of electricity production from biogas in 2007 compared to 55.3% in 2006
- 2009 out of total 5,900 Ktoe Biogas in EU, 49% is produced by Landfill gas, 36% from agricultural plants and 15% by sewage sludge treatment *(EurObserv'ER)*
- Sweden is the leader in EU. 1 plant in Germany providing Biogas to the first Biogas filling station (Bioenergy initiative Wendtal)
- Potential to contribute to transport is high and exhibit lower costs and lower emissions performance. Can be combined with electricity and heat generation easily in countries with supporting schemes for biogas.

Economic Assessment

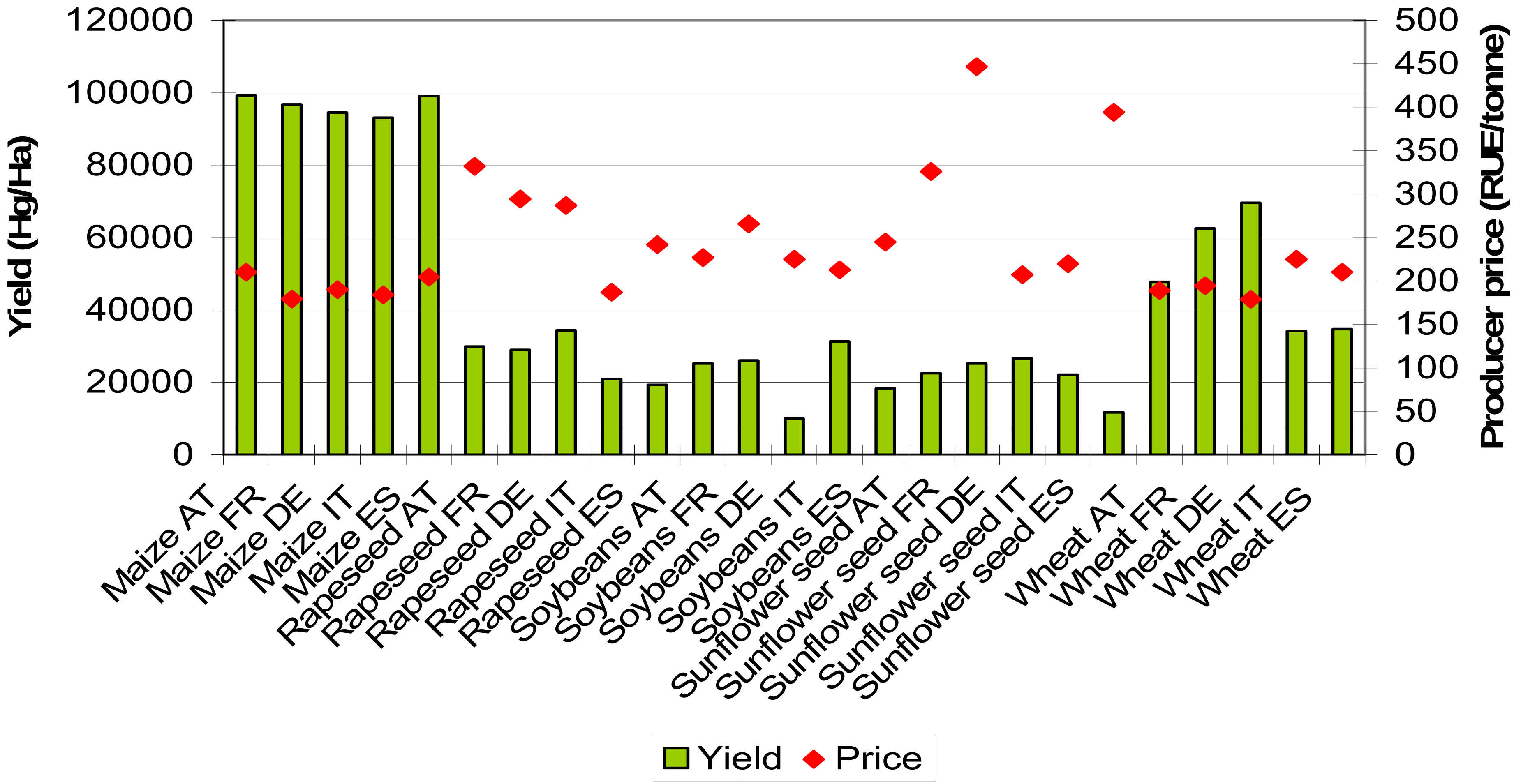
Drivers/Factors influencing the economic performance of AF – 1st Generation

- Feedstock costs – FC (driver Volatility)
- Inputs costs (e.g. electricity, heat etc) –C_I (Oil price)
- Annual capital costs – CC – (Investors risk mgt.)
- Operations and maintenance costs – OM (volatility)
- Total by-product credit – BP (by products markets)
- Other factors such as competition of uses for biomass such as food, electricity heat

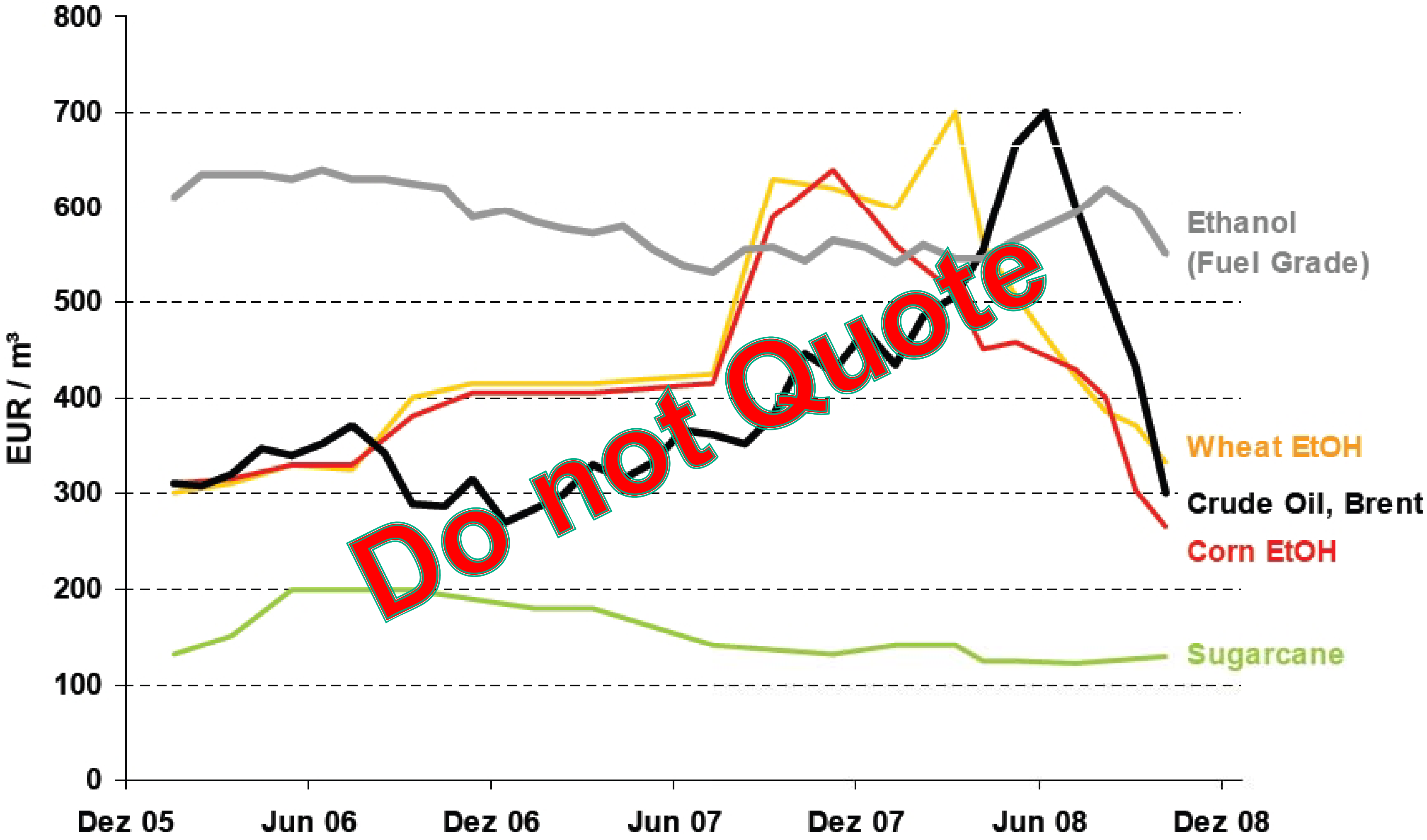
$$C_{BF} = FC + C_i + CC + OM - BP$$

Main Assumptions

Feedstock prices v/s yields in EU (2007)



Ethanol Feedstock prices development - volatilty



Do not Quote

Source: Ising, 2009

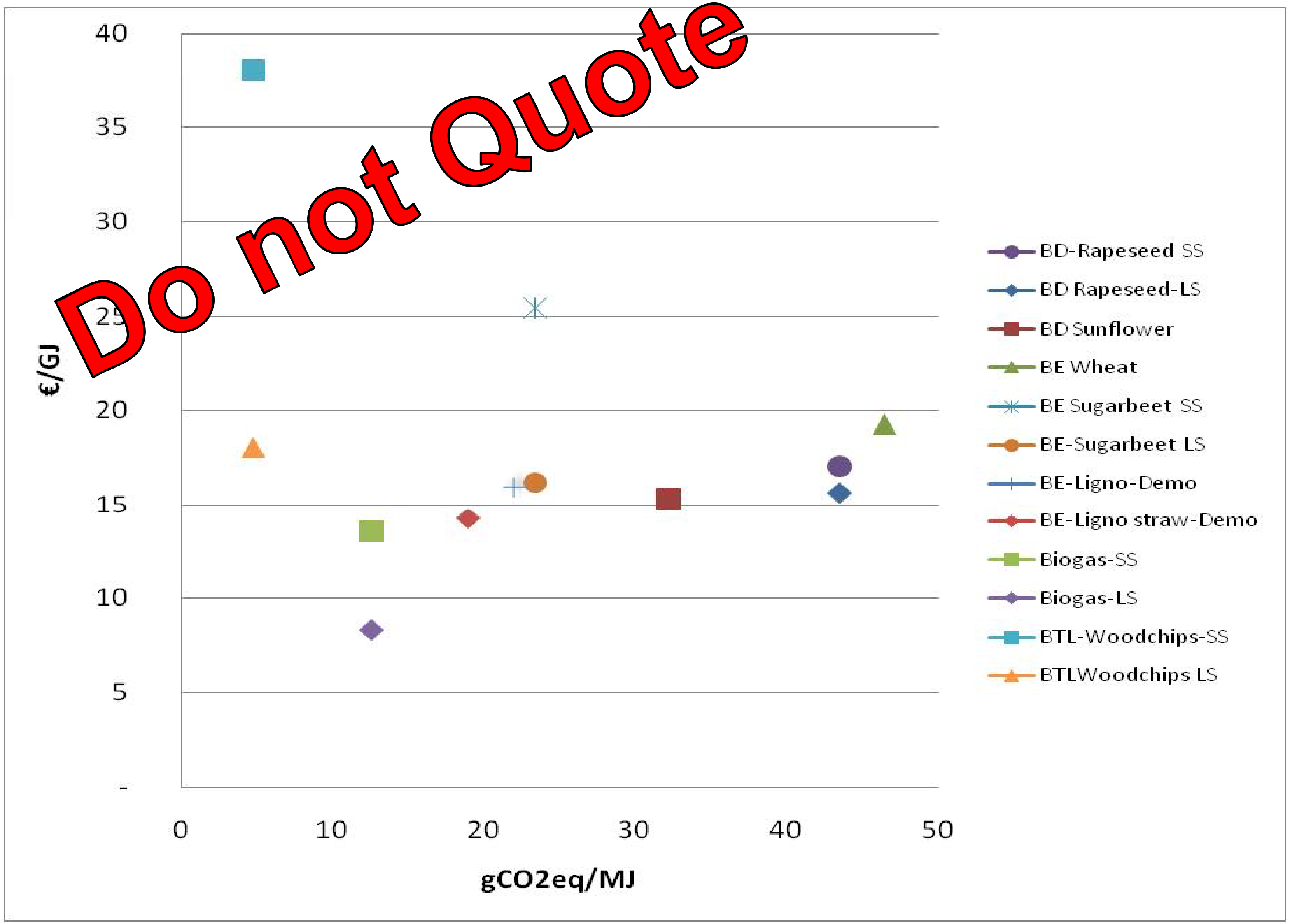
Drivers/Factors influencing the economic performance of AF – 2nd Generation

- **Feedstock costs** – FC (see assumptions)
- **Inputs costs** (e.g. electricity, heat etc) –C_I (Oil price)
- Annual **capital costs** – CC – (Investors behaviour)
- Annual utilization (**full load hours**) & O&M
- Total by-product credit – BP (by products markets)
- Other factors such as: support policies (e.g.US mandates on lignoETOH), R&D&D activities, technical innov. Pot. Feedstock quantities and trade

$$C_{BF} = FC + C_i + CC + OM - BP$$

Main Assumptions

AF: summary results €/GJ vs. gCO2/MJ (WTT)



Source: Database Calculations, WP3.

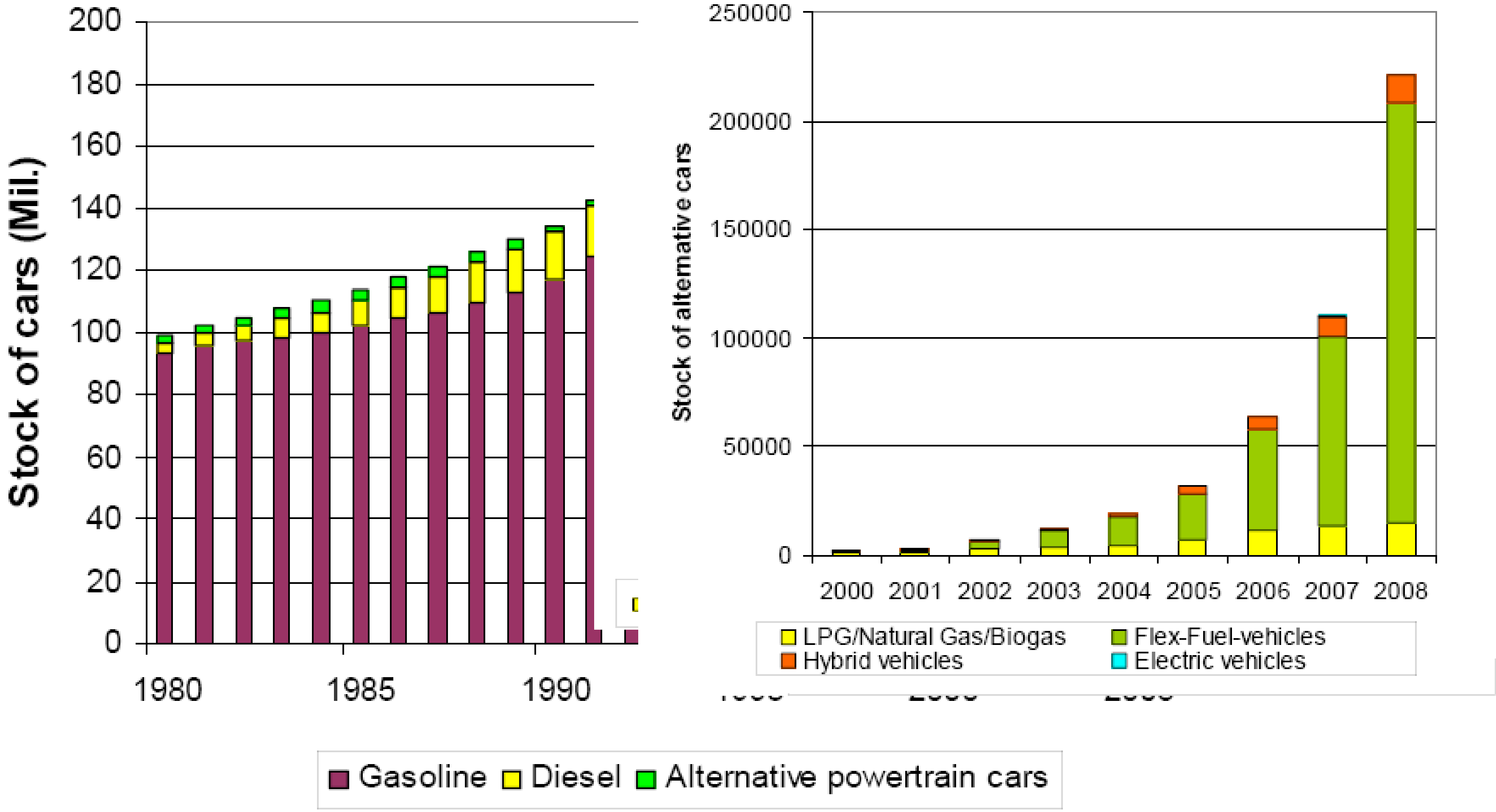
Technical improvement potentials – Bioethanol

Area	Developments	SoA & Potential
Crop production	**High yielding varieties** (use of BT); reduced tillage; decline in fertilisation	Reduce feedstock costs 20-30% Commercial. Several infl. factors
Starch hydrolysis	**Improved enzyme technology**; On-site enzyme propagation	R&D. Scale-up diff. due to use of Enzyme/Feedstock specific
Fermentation	High-concentration wort; continuous membrane bioreactor; **continuous fermentation units**; yeast immobilisation	R&D and Demo. Potential to increase efficiency and reduce O&M costs.
Process control	System automation; integrated thermal engineering (capture and re-use of process heat)	Energy efficiency potential. Increase acceptability.
Co-product use	Bagasse combustion; corn stillage refinery; corn-fibre oil and gum	Commercial. Increase eff. And reduces costs by 25-30%. Emissions reduction increase.
Genetic improvements	Feedstock, enzyme	Can bring down the costs lower by 20-40 Cents of current costs

Technical improvement potentials – 2^G AF

Area	**Developments**	**SoA & Potential**
Feedstock pretreatment	Improvements in physical & chemical (or both) treatment processes	Commercial / Demo – High potential efficiency increase Cost reductions 10-30%
Enzyme technology	Effective hydrolysis of cellulose, enzymes. Variability of feedstock	Potential to increase efficiency and reduce costs. Crop mgt. Demo.
C5 and C6 Sugar digesters	Engineering co-fermentation of both types of sugars (BT)	Potential to increase efficiency. Costs reductions unclear. Demo
Large-scale biomass gasification	FT tolerant to fluctuations in feedstock, by-product generation	Demo. Direct entrained flow gasifiers (c.o.p. o&m costs high)
Thermochemical technologies	Fischer-Tropsch method Methanation	Pyrolysis-gasification of biomass Demo. Business model to scale up Potential costs reduct. (20-40%)

AAMT: Current situation



Source: Ajanovic, Haas, et. Al. Altermotive WP2 (2010)

AAMT: State of the art

	Commercial	Demonstration	R&D
Technologies	*LNG/CNG* *Bifuel (NG+Gasoline/Diesel)* *Flexi Fuel (BD/BEth)* **Electric Vehicles** *(Micro-MildHybrid (HEV)* *Full Hybrid* *BEV (only light vehicles, no convertor, DC Motor, Range<100 km)* **Battery types** *Lead-Acid, NiCd, Nickel Metal Hybrid (NiMh)* **Infrastructure** *Private Connections* *Public Connections (unidirectional)*	*Solo BD/Beth* **Electric Vehicles-FCV** *Enhanced HEV-PHEV* *PHEV* *BEV (with convertor, AC Motor, Range > 100 km)* *Fuel Cell Hybrid* **Battery types** *Lead-Acid, NiCd, Nickel Metal Hybrid (NiMh), Lithium-Ion* **Infrastructure** *Private Connections* *Public Connections (unidirectional)*	**Electric vehicles** *HEV* *H-FCV* *Plug-In functionality for FCV/HEV* *BEV (with convertor, AC Motor)* *Biogas V.* *Dual Fuel (gas+Gasoline/Diesel)* **Battery types** *Lead-Coal, NiCd, NiMh, Lithium-Ion-Nanotechnology, innovations* **Infrastructure** *Private and Public* *Connection ports with vehicle to grid functionality (bi-directional)*

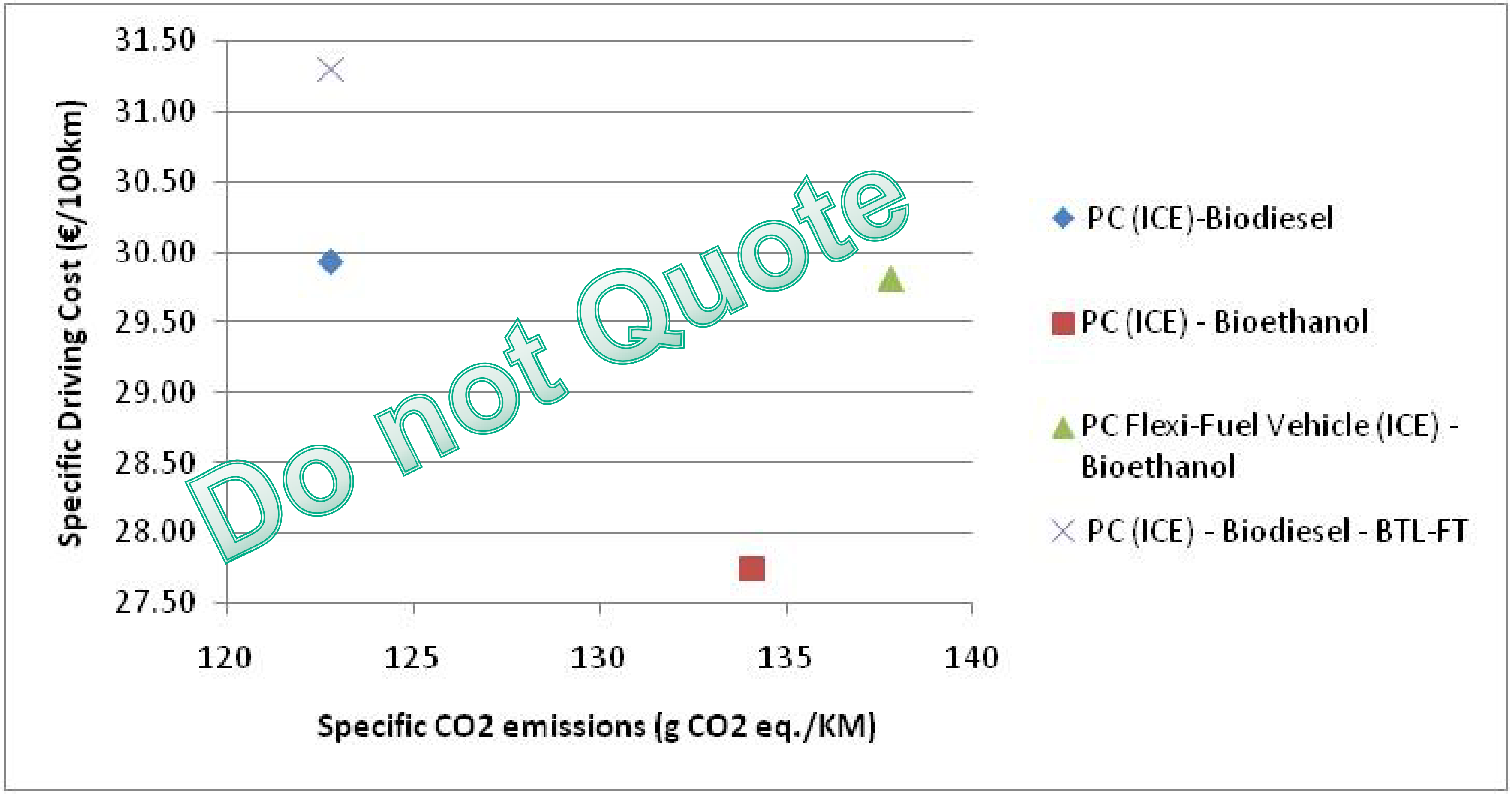
Source: WP3 results, Wietschel, Toro 2007

Drivers/Factors influencing the economic performance of AAMT – BEV & Hybrids

- Cost range per kWh and size for batteries
- Investments for car+battery
- Electricity costs
- Other factors such as: support policies, battery costs development, R&D&D activities

Main Assumptions

Results: ICE – Specific driving costs vs. Emissions



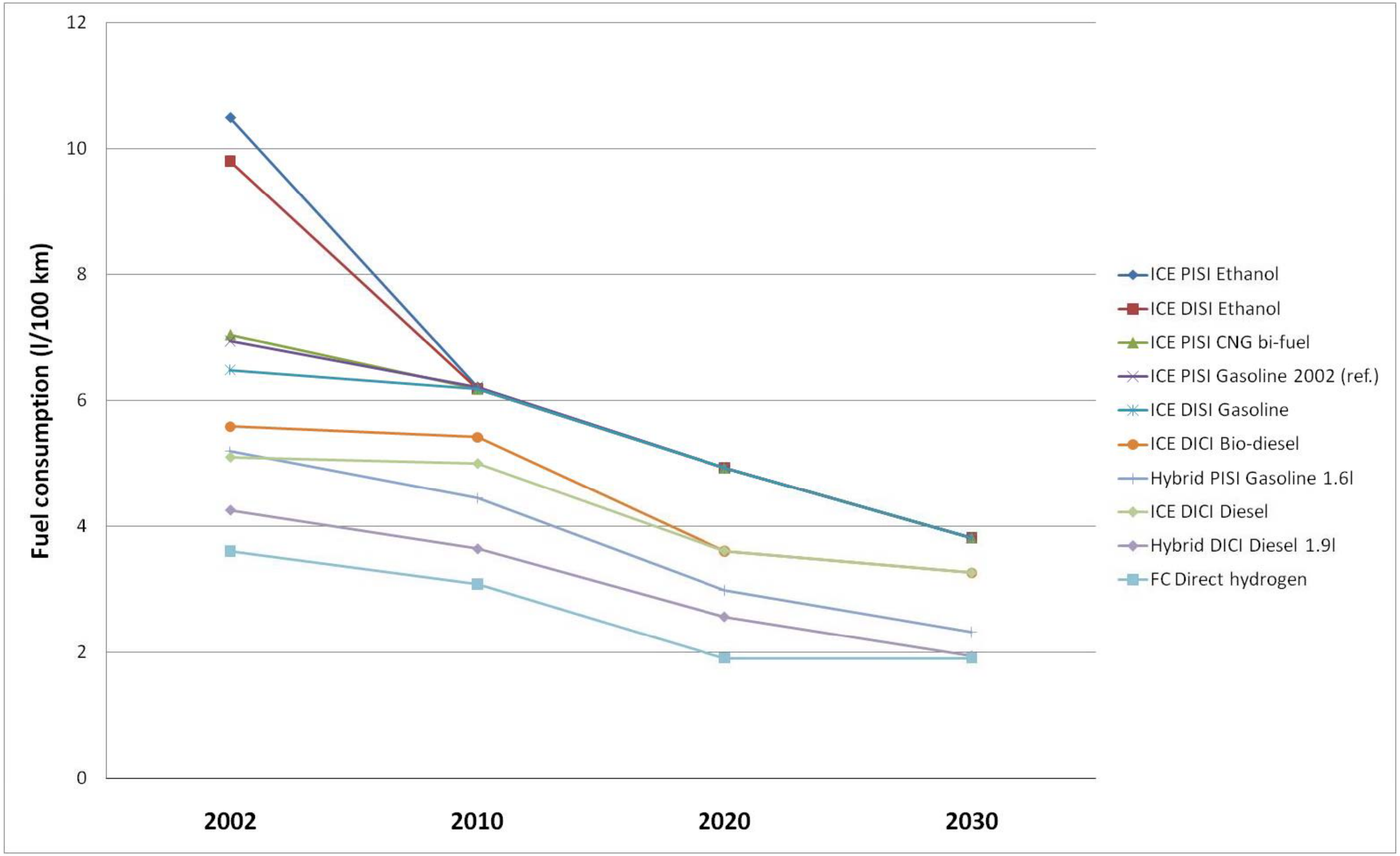
Source: Database Calculations, Furlan, S.

Technologies and expected increase in efficiency

Technology	Sample Manufacturers (Models)	Increase in fuel efficiency (%)
Variable Valve Lift & Timing	Honda (Honda DOHC i-VTEC® System), Toyota (Toyota VVT-i,), BMW (BMW VALVETRONIC), Ford F-150	1-9
Gas Direct Injection (S)	Audi (A3, A4, A6), Isuzu (Rodeo), Mazda (Speed 6)	3-15
Cylinder Deactivation	Chevrolet (Trailblazer, Impala SS), DaimlerChrysler, Honda (Odyssey, Pilot, Hybrid Accord), Honda Accord (V6)	7-7.5
AMTs	Ford (Fusion), BMW, Jaguar, Audi (A3, TT), VW (Beetle, Jetta)	7-9
CVTs	Honda (Civic), Ford (Five Hundred, Freestyle) Nissan (Murano), Audi MultiTronic CVT	3-8

Source – US EPA Interim Report: New Powertrain Technologies & Their Projected Costs (2005); Kobayashi, Plotkin & Ribeiro, (2008)

Fuel consumption improvements until 2030



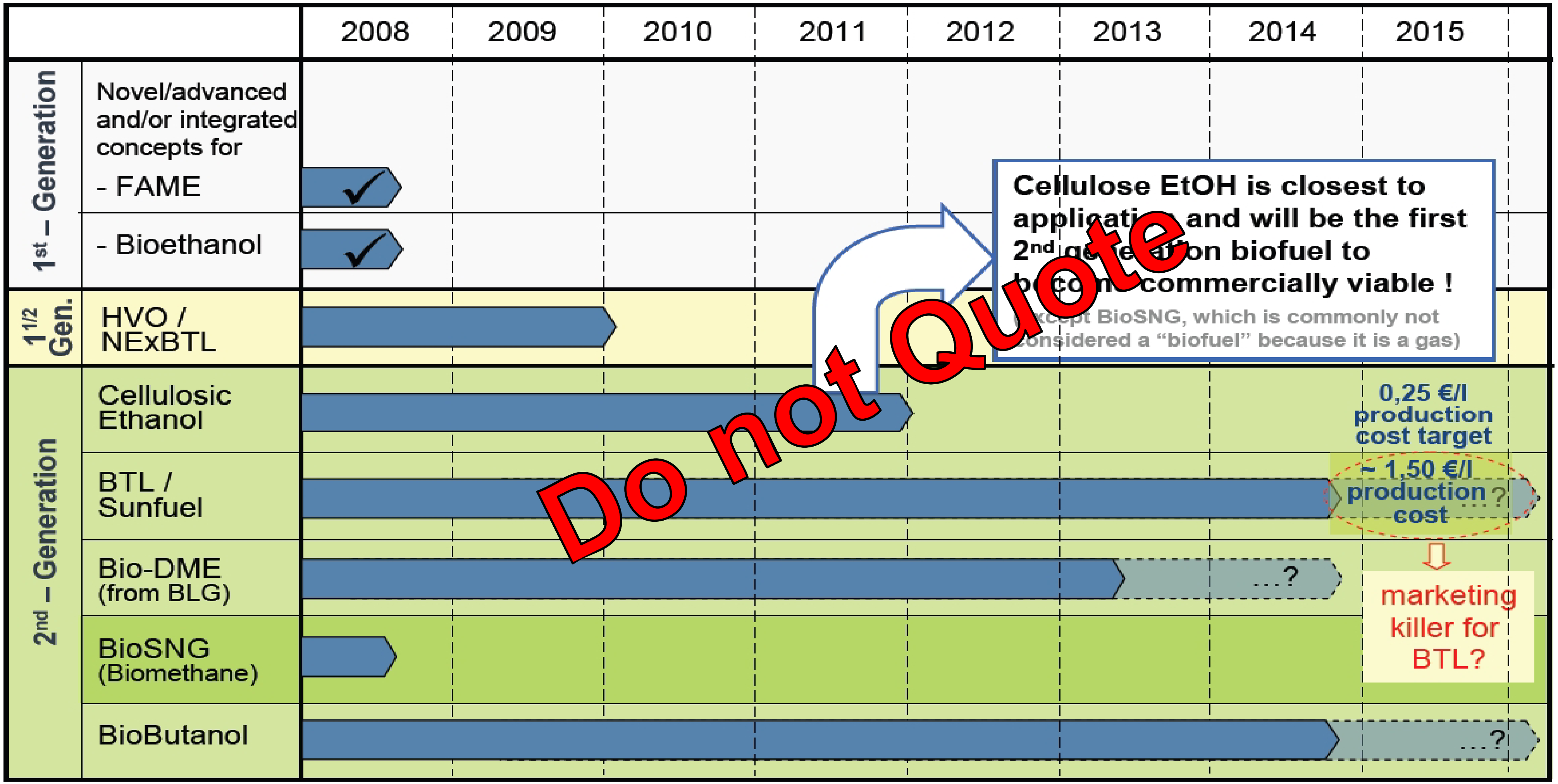
Source – US EPA Interim Report: New Powertrain Technologies & Their Projected Costs (2005); Kobayashi, Plotkin & Ribeiro, (2008)

Discussion - Conclusion

Factors influencing competitiveness of AF

- Volatility of feedstock costs
- Potentials available to be exploited
- Strategies/Technologies using multi-feedstock or using residual oils
- Ethanol and Ethanol Ligno exhibit great synergies to achieve competitiveness (e.g. Hybrid plant)
- Risk management though integrating Fermentation, Co-generation and Ligno Cellulosic production
- BTL dependent on technological development. Concepts like pyrolysis oil plants and gasification centers. Biomass crops management to reduce costs vs. high efficiencies needed.
- Important with respect to electricity and heat inputs. Co-generation strategies

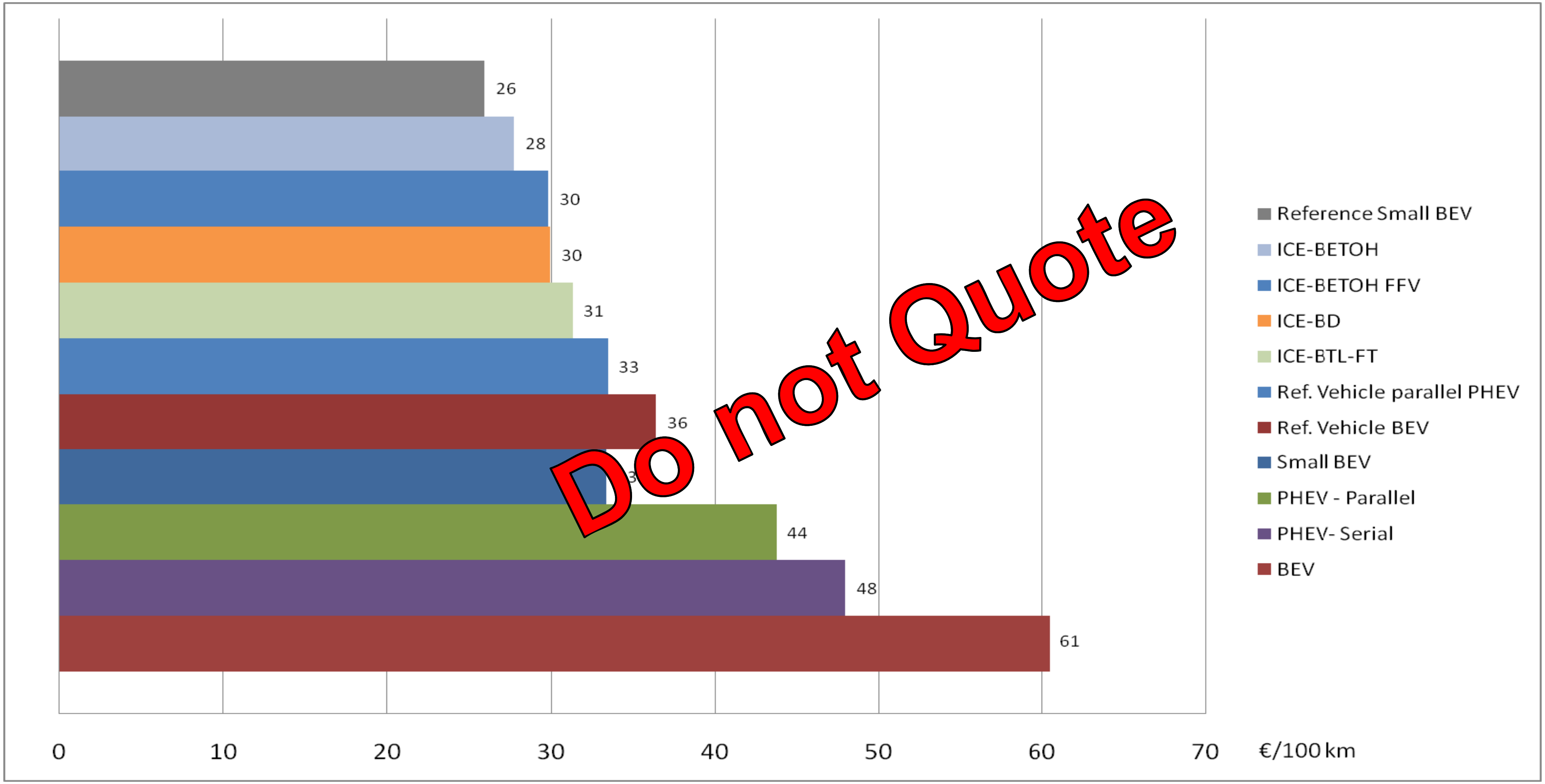
Discussion - Conclusion



Do not Quote

Source: Ising, 2009.

Results AAMT overall driving costs (2015-2020)



Thank you very much for your attention