ECN

Energy research Centre of the Netherlands

Market Opportunities for PEM FC Technologies

– A Distance-to-Market Analysis –

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Fuel Cell Seminar & Exposition, November 18th 2009

Introduction (1)

- ECN – Energy research Centre of the Netherlands

  - Mission: ECN develops high-quality knowledge and technology and brings them to the market for a sustainable energy system

- EU project “Roads2HyCom” (www.roads2hy.com)
  - Studies on fuel cells and hydrogen
  - Technical and socio-economic issues
  - One of them:

Opportunities & Gaps for PEM FC Technologies
-- VEHICLES --

Introduction (2)

- How do we define a “Market Opportunity” ?
  - In our study: based on cost only
  - Market opportunity = cost-competitiveness of PEM FC vehicles compared to conventional vehicles **under the same conditions**
    - equal performance
    - equal usage
    - equal lifetime

- How can we compare vehicle costs?
  - **Total cost per driven kilometer**
  - Only considering major differences between conventional and PEM FC vehicles → e.g. body of the car is not considered

Methodology (1) – Sample Calculation

- Light Duty Truck (<3500 kg)

Lifetime		10	years
Annual usage	x	50 000	km / year
Total usage	=	500 000	km
Power			
Relative drivetrain cost	x		
Total drivetrain cost	=		
Specific drivetrain cost	=		
Fuel (diesel) consumption			
Cost of fuel (hydrogen)	x		
+ Specific fuel cost	=		
+ Cost of maintenance		7	€-cent / km
= Specific total cost		15,48	€-cent/km

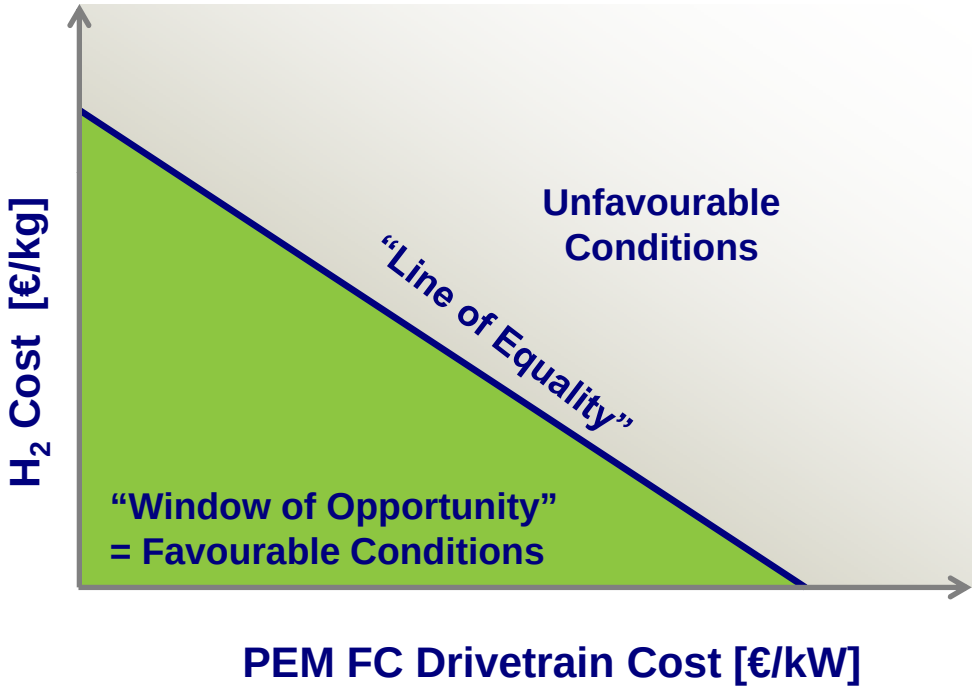
In case of PEM FC vehicles:

Two major uncertainties!

→ Different approach

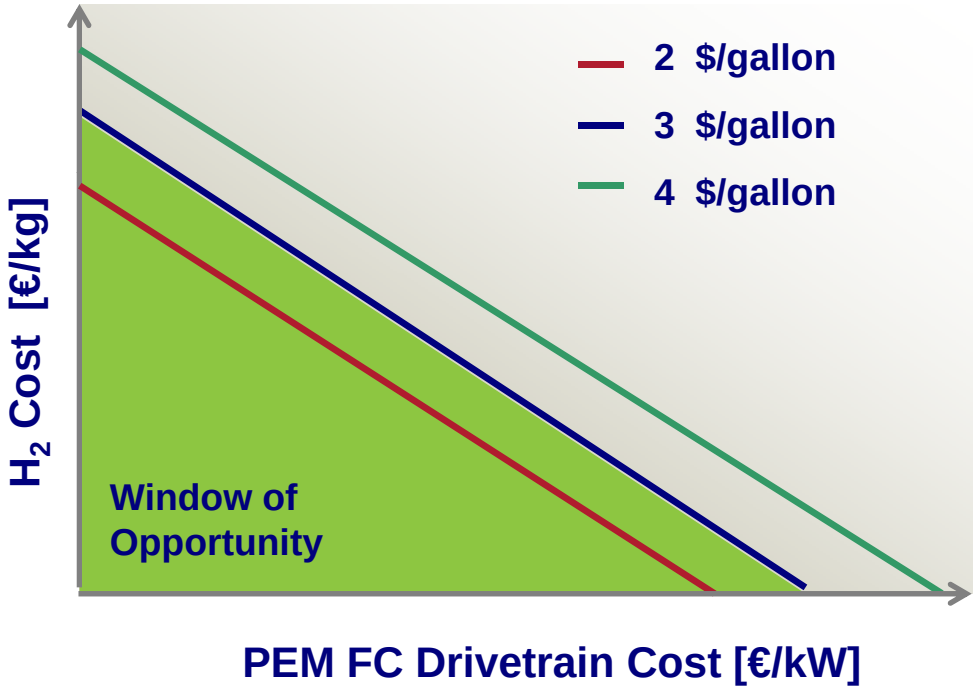
Methodology (2) – Evaluating Windows of Opportunities

- Specific Cost (conventional vehicle) = Specific Cost (PEM FC vehicle)



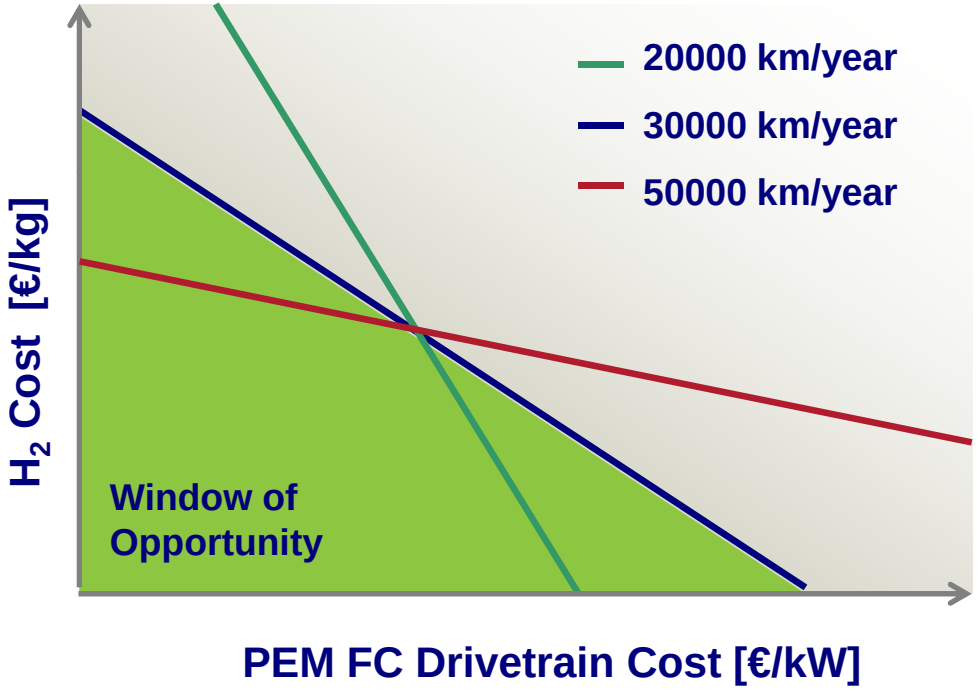
Methodology (3) – Windows of Opportunity Sensitivities

- Cost of (conventional) fuel



Methodology (4) – Windows of Opportunity Sensitivities

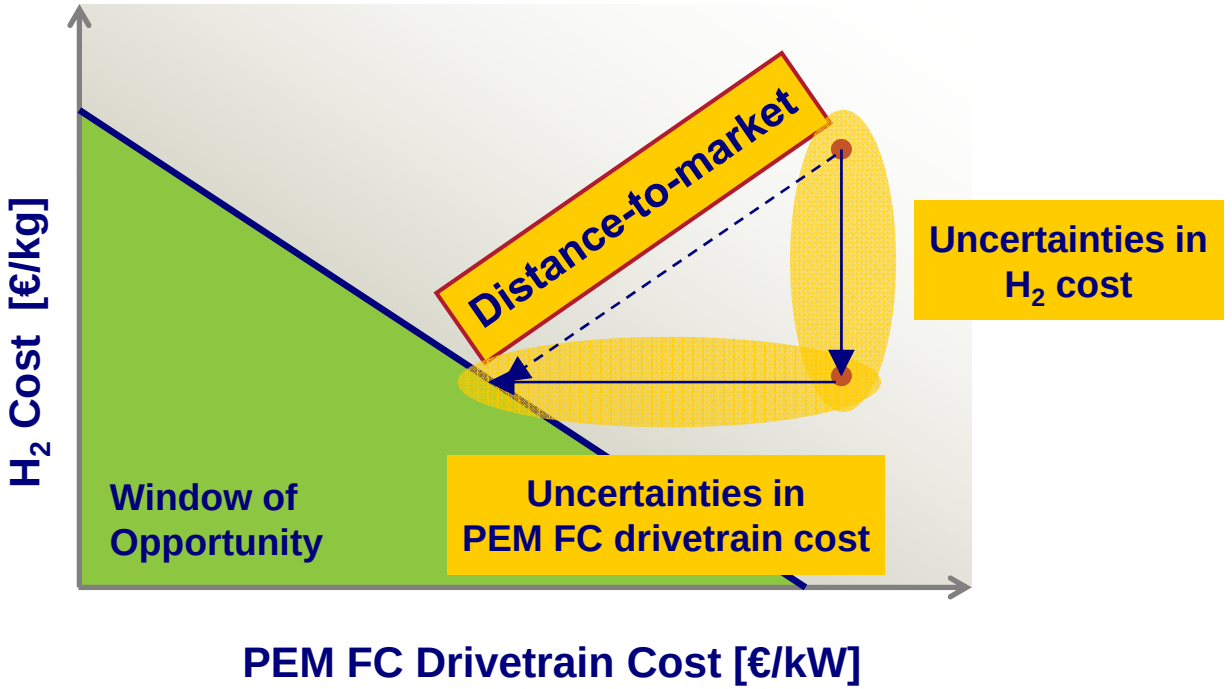
- Annual Usage



One Window of Opportunity → One market segment

Methodology (5) – Comparing conventional to FC Vehicles

- Analyzing distance-to-market



- **H_2 cost reduction: Large-scale infrastructure & standardization**
- **Drivetrain cost reduction: Research & mass production**

Methodology (6) – PEM FC Drivetrain Costs

- 4 PEM FC drivetrain components considered

	Cost Basis [€]	Production Capacity [units/year]	System Power [kW]	Reference
– PEM FC System	1000	500 000	100	DTI/DOE
– H_2 Storage Tank	1350	500 000	100	TIAX LLC
– Electromotor	2160	> 50 000	80	CONCAWE/JRC/ EUCAR
– Battery	6240	> 50 000	80	CONCAWE/JRC/ EUCAR

- Adjusting cost basis to number of units produced in 2006 (using economies-of-scale indices)
- Scaling component's basic costs to required system power (using power laws)
- Projecting future cost using learning curves

Methodology (7) – "Cumulative Learning"

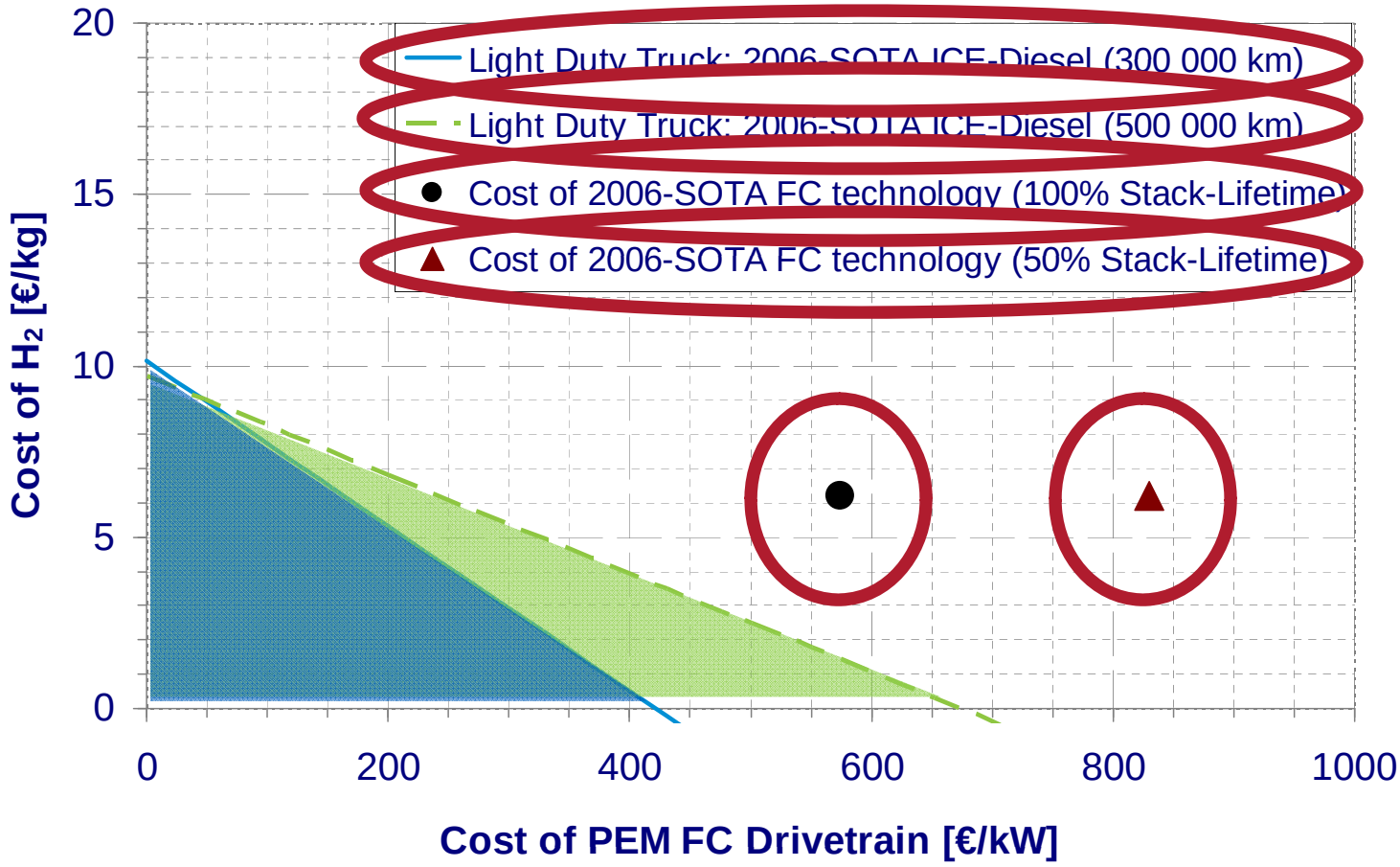
- Similar technology in different vehicles
- Cost reductions not limited to one type of vehicle

- Two distinguished markets
  - "Mass market applications"
    - Passenger Cars
    - Light Duty Trucks (<3500 kg)
    - City Buses

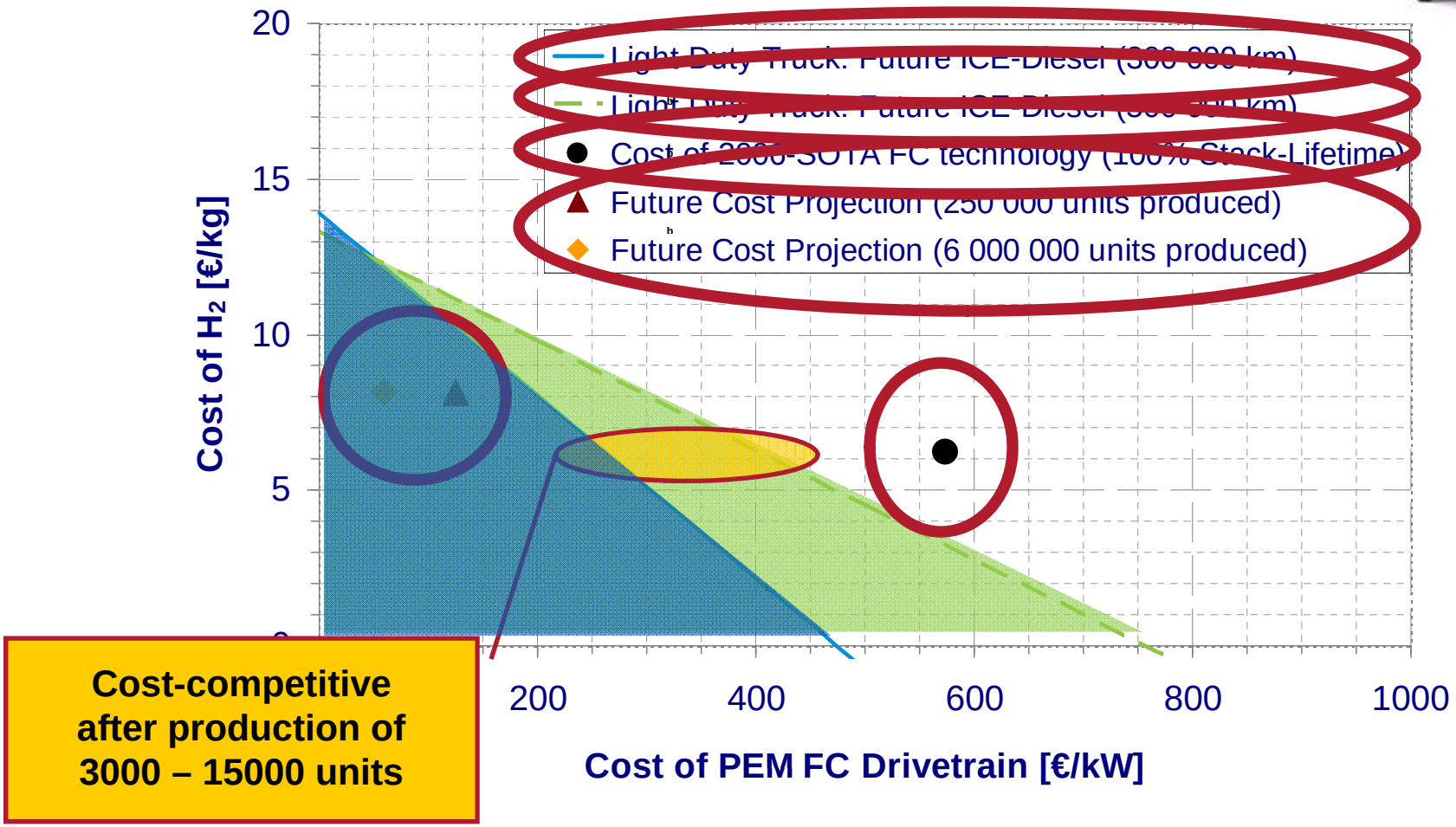
    High power, large markets
  - "Niche market applications"
    - Scooter
    - Utility Vehicles
    - Forklifts

    Low power, small markets

Results (1) – Effect of PEM FC Durability on Cost



Results (2) – Light Duty Trucks (FC vs. Diesel-ICE)



Cost-competitive after production of 3000 – 15000 units

Results (3) – Bridging the Distance-to-Market

		Annual Usage [km/year]	Cumulative Number (Vehicles) produced
Mass Market Applications, replacing:			
Light Duty Truck	future ICE-Diesel	30 000	15 000
	future ICE-Diesel	50 000	3 000
Passenger Car	future ICE-Gasoline	20 000	95 000
	future ICE-Diesel	40 000	16 000
City Bus	future ICE-Diesel	75 000	5 000
Niche Market Applications, replacing:			
Outdoor Utility Vehicle	2006-SOTA ICE-Diesel	5 000	20 000
	2006-SOTA Battery-electric	5 000	cost-competitive
Scooter	2006-SOTA ICE-Gasoline	5 000	500 000
	2006-SOTA ICE-Gasoline	10 000	80 000
Forklift	2006-SOTA ICE-Diesel	10 000	150 000
	2006-SOTA Battery-electric	30 000	cost-competitive

➢ First-order analysis with rough parameters !

Conclusions

- Necessity to increase durability of PEM FC !
  - Example Light Duty Trucks:

    Lifetime (PEM FC stack) = 50% Lifetime (vehicle)
    → PEM FC drivetrain cost + 40% !

- Cost-competitive applications (at 6.2 €/kg hydrogen)
  - Emission-free utility vehicles
  - Emission-free forklifts in 24/5 or 24/7 (sustained) operation

- Mass market applications are more promising for near-term roll-out !
  - Special attention: Light Duty Trucks (<1% of the market could be sufficient)

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THANK YOU

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BACKUP SLIDES

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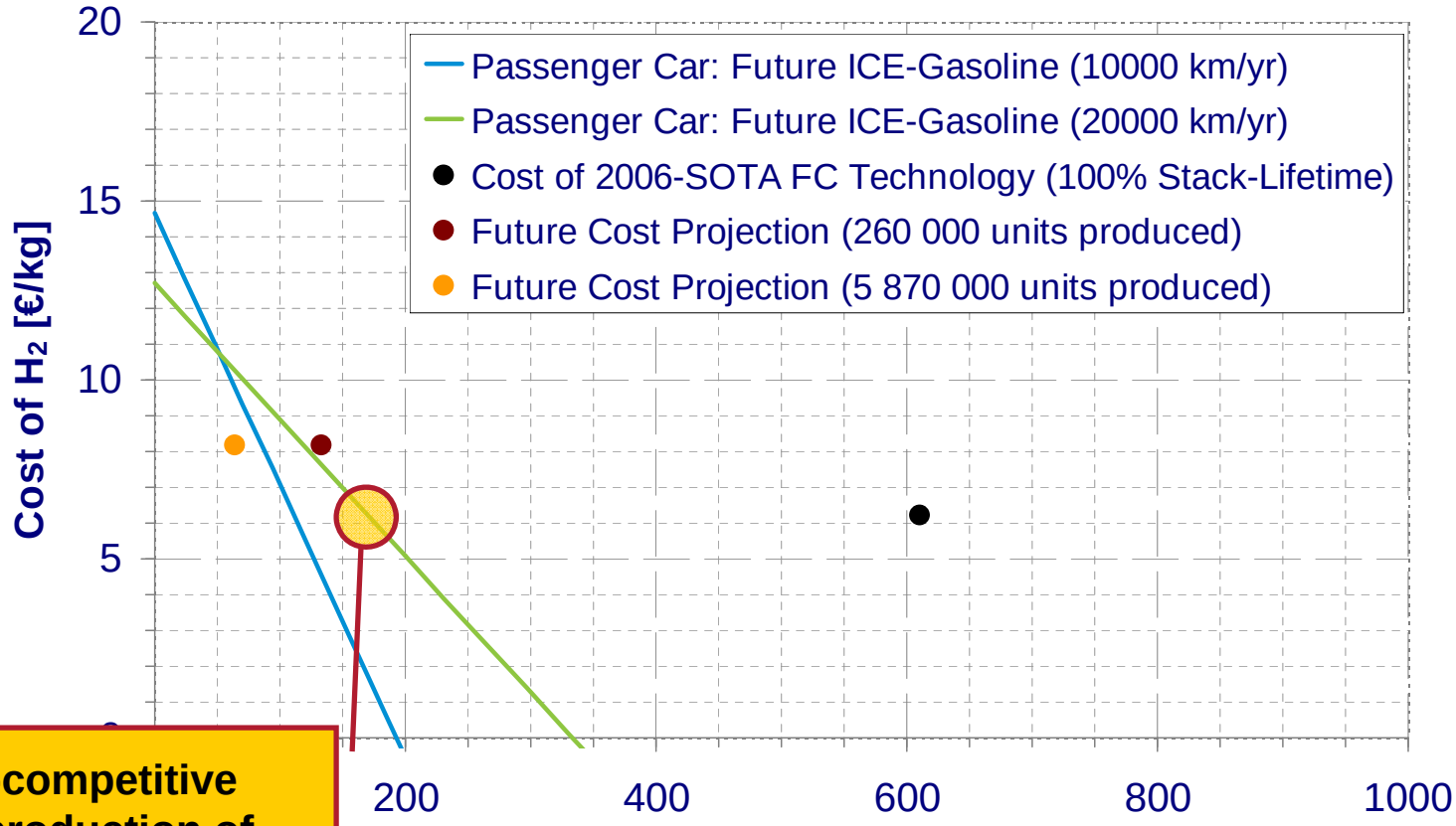
BACKUP (1) – Evaluating Costs of (dispensed) H_2

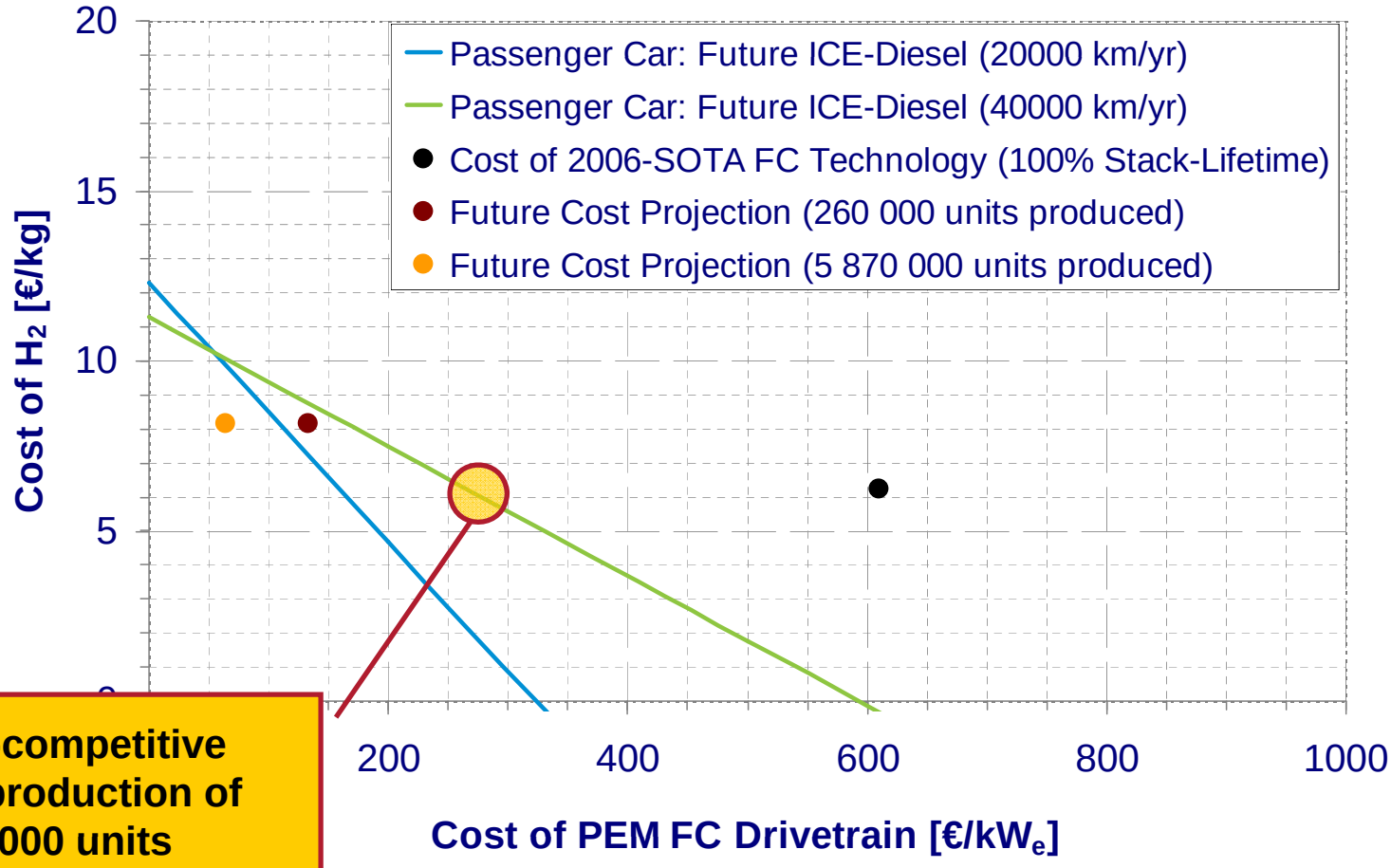
- 2 hydrogen costs are projected
  - 6.2 €/kg
    - For the evaluation of 2006-state-of-the-art PEM FC drivetrains
    - Hydrogen produced via steam methane reforming; mean feedstock prices: 12,1 €/GJ Natural Gas (IEA, 2006)
  - 8.2 €/kg
    - For the evaluation of future PEM FC drivetrains
    - Based on a projected production mix (EU project HyWays); high feedstock prices (IEA, 2006)
- These costs of hydrogen include
  - Cost of production, storage and transportation to the filling station
  - Forecourt costs & VAT
- They hold for a well established and utilized infrastructure

BACKUP (2) – Passenger Cars (FC vs. Gasoline-ICE)



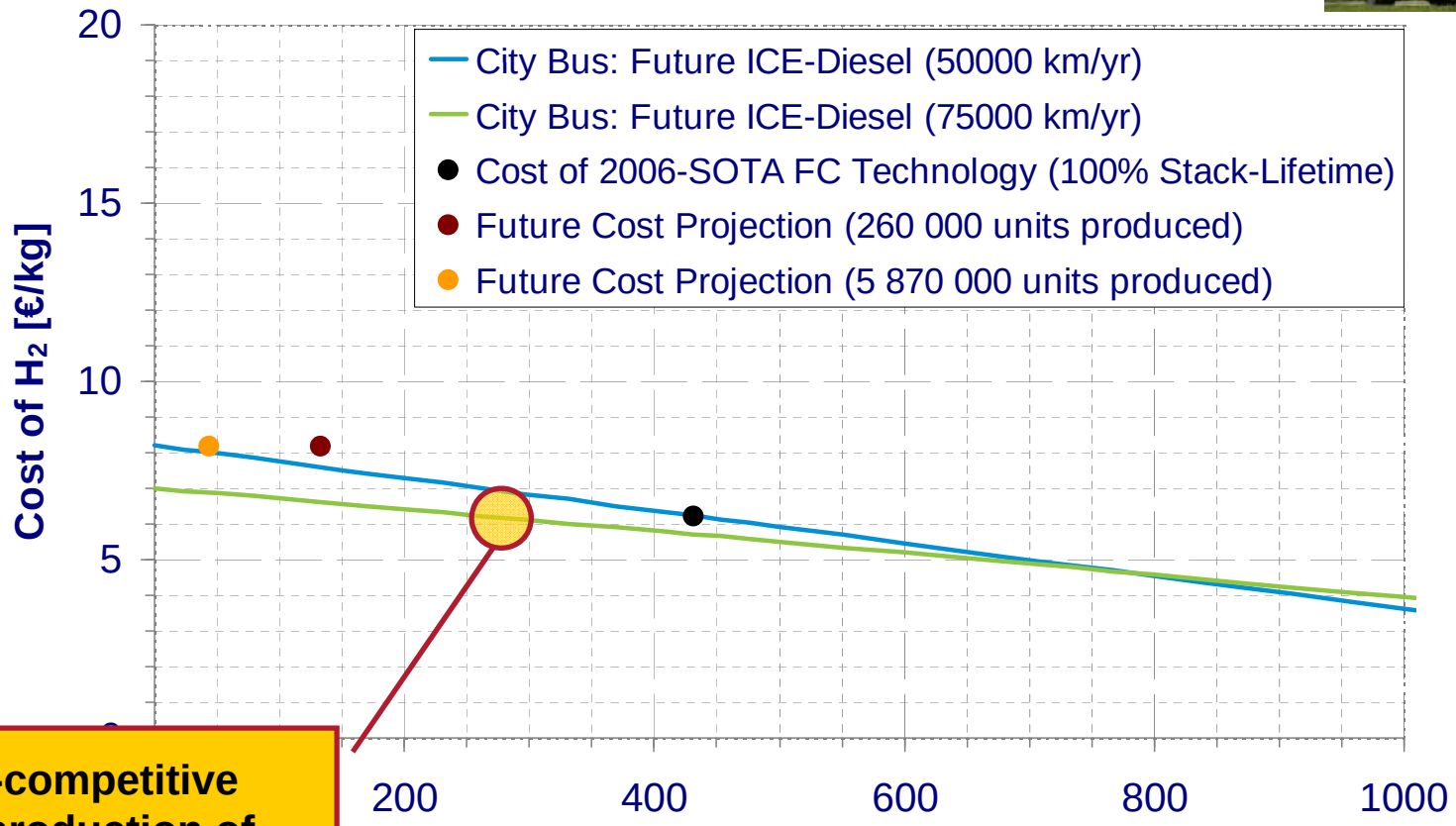
Cost-competitive after production of 95000 units

BACKUP (3) – Passenger Cars (FC vs. Diesel-ICE)



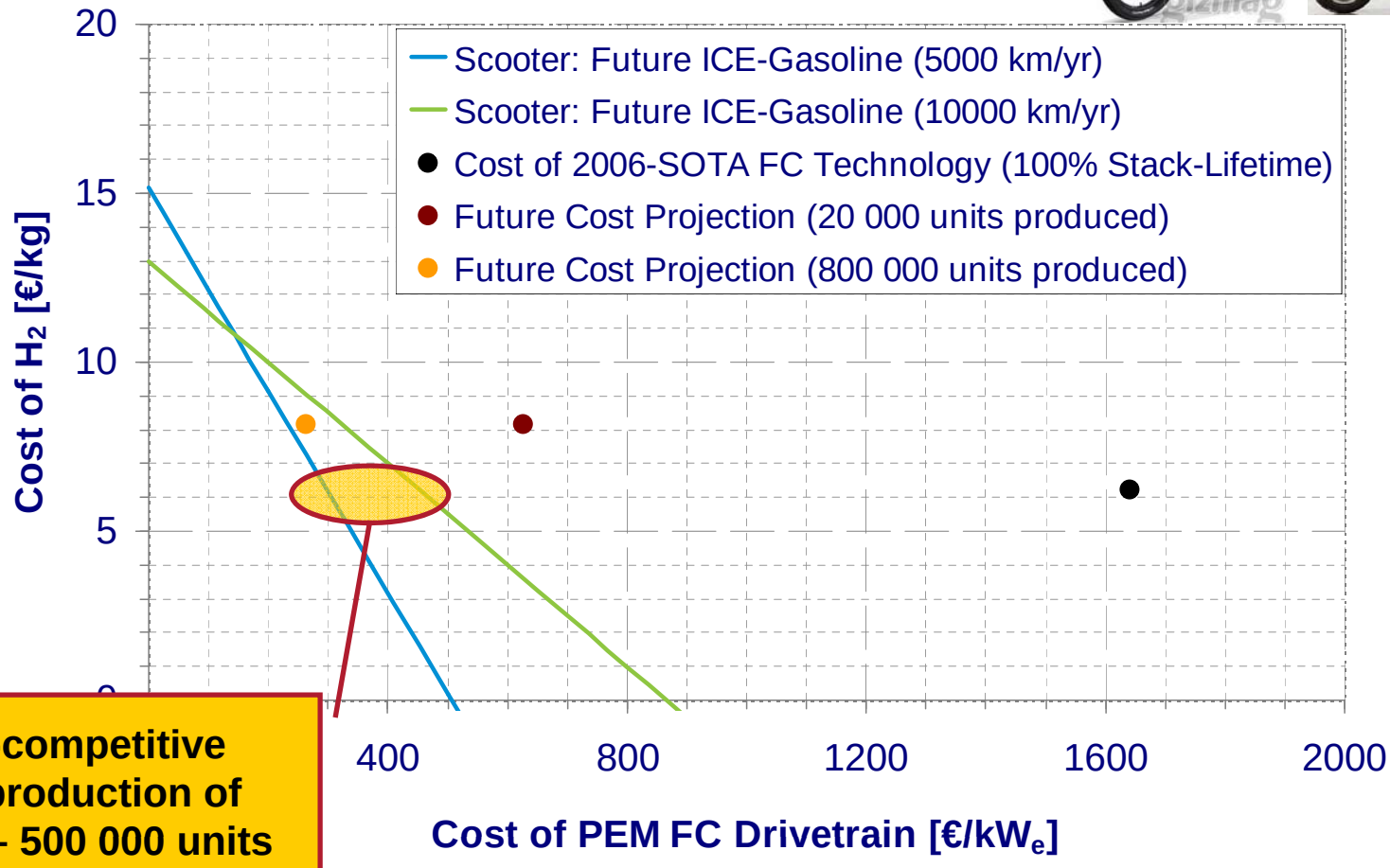
Cost-competitive after production of 16000 units

BACKUP (4) – City Buses (FC vs. Diesel-ICE)



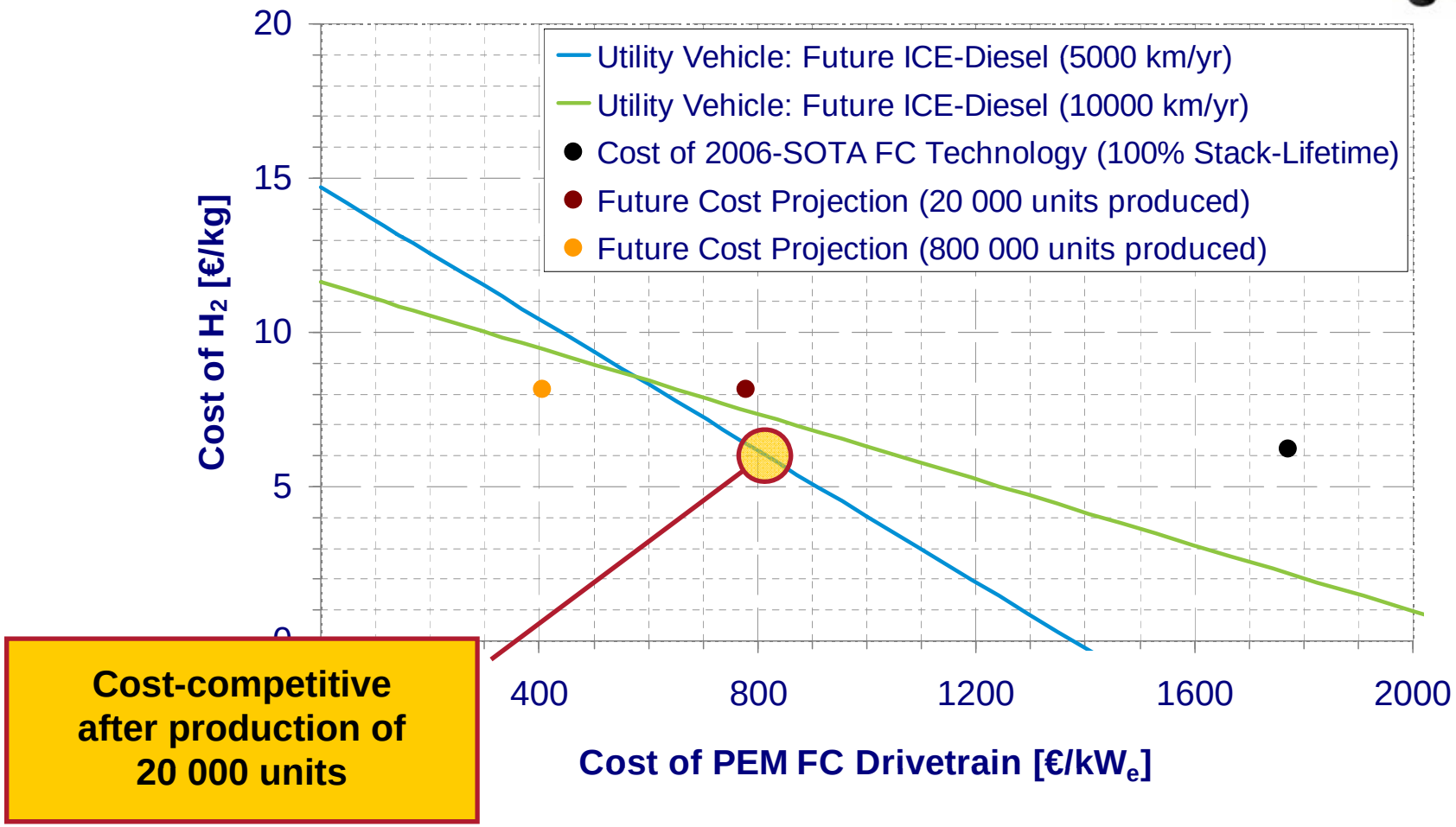
Cost-competitive after production of 5000 units

BACKUP (5) – Scooter (FC vs. Gasoline-ICE)



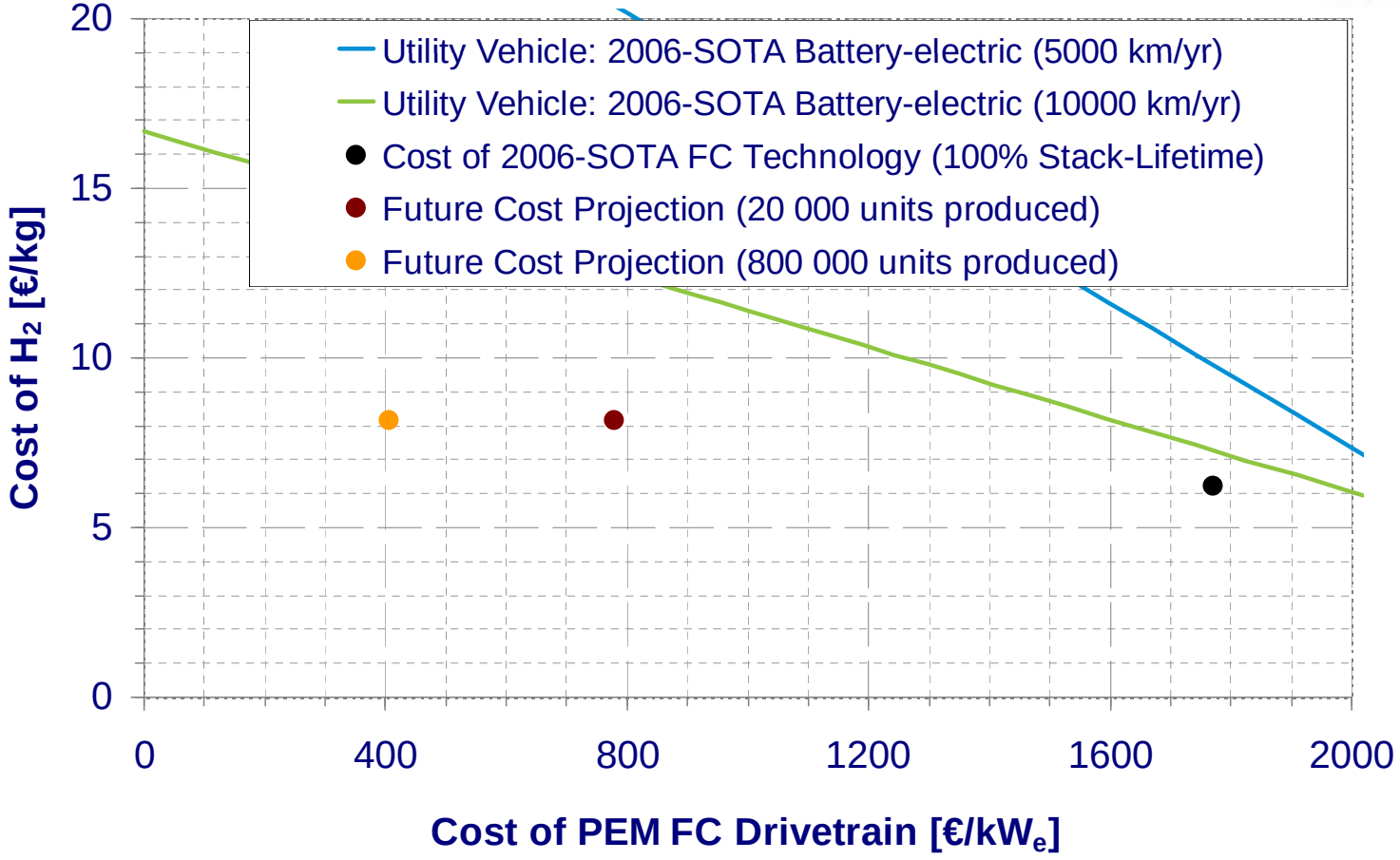
Cost-competitive after production of 80 000 – 500 000 units

BACKUP (6) – Utility Vehicles (FC vs. Diesel-ICE)

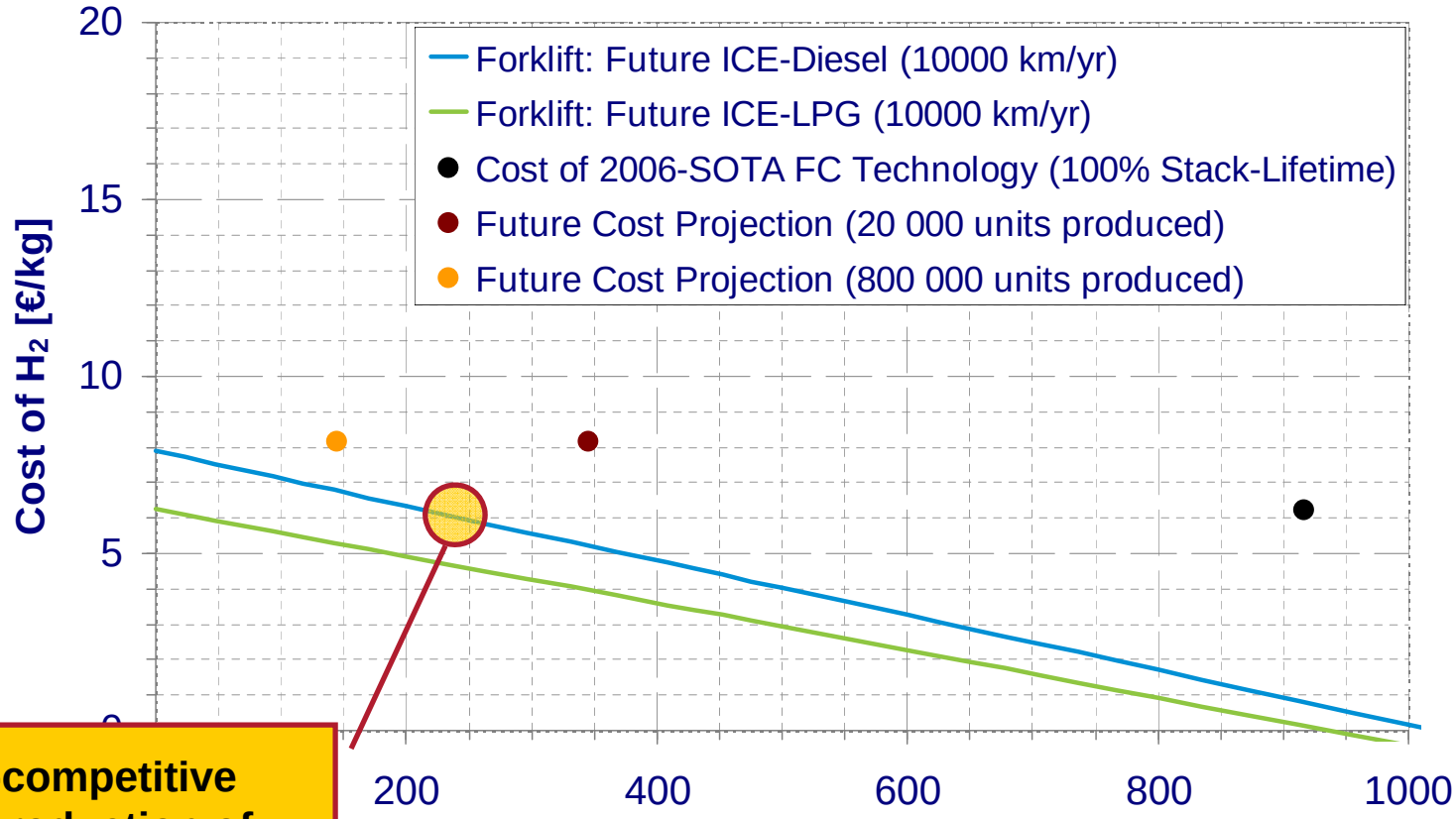


Cost-competitive after production of 20 000 units

BACKUP (7) – Utility Vehicles (FC vs. battery-electric)



BACKUP (8) – Forklifts (FC vs. ICE)



Cost-competitive after production of 150 000 units

BACKUP (9) – Forklifts (FC vs. battery-electric)