Hydrogen vehicle deployment and required policy support for roll-out scenarios in the Dutch THRIVE project

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ABSTRACT

The work presented is part of the Dutch THRIVE[1] project which centers on dynamic simulation of joint roll-out of a hydrogen refuelling infrastructure and a hydrogen vehicle fleet. The simulation tool enables modelling of fuel supplier and car manufacturer strategies, and consumer attitude towards hydrogen. Currently, cost analysis is not an integral part of the tool. Simulations are carried out assuming a level playing field for hydrogen exists. This means that besides hydrogen costs being competitive to conventional fuels per driven kilometre, also hydrogen vehicles (HV) are assumed available at a competitive price from 2015 onwards. However, the costs of hydrogen and hydrogen vehicles will not be competitive to their conventional counterparts by 2015. Therefore, simulation results for car fleet development as a function of time are post-processed to analyse implications on cost and necessary policy support.

The number of hydrogen vehicles derived from roll-out simulations are used as input for an integrated and dynamic HV cost model. It projects HV price developments as a function of total HV sales using learning curves, and illustrates the influence of policy measures on HV price competitiveness. With this model, the policy support required over time to make the HV cost price competitive is determined. Furthermore, as the model is able to take into account total cost of ownership (including taxations and fuel costs), it can be used to explore how car taxation and fuel price policies affect hydrogen car cost.

The car cost model is used in the THRIVE project for the post-processing of roll-out simulation results to determine type and level of possible policy support necessary that make HV cost-competitive.

[1] THRIVE is an acronym for Towards Hydrogen Refuelling Infrastructure for VEhicles

ECN

Energy research Centre of the Netherlands

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World Hydrogen Energy Conference 2010, Essen, 18 May 2010

Presented by Bart Hoevenaars

www.ecn.nl

Overview

- Introduction THRIVE project
- Cost gap analysis FCEV rollout
- Results
- Summary and conclusions

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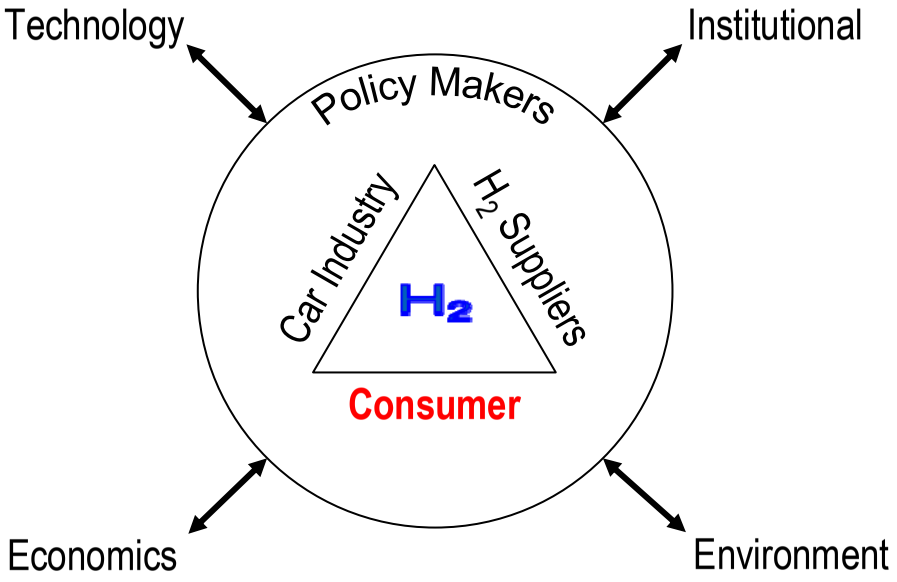
Introduction THRIVE project

Towards a **H**ydrogen **R**efuelling **I**nfrastructure for **Ve**hicles

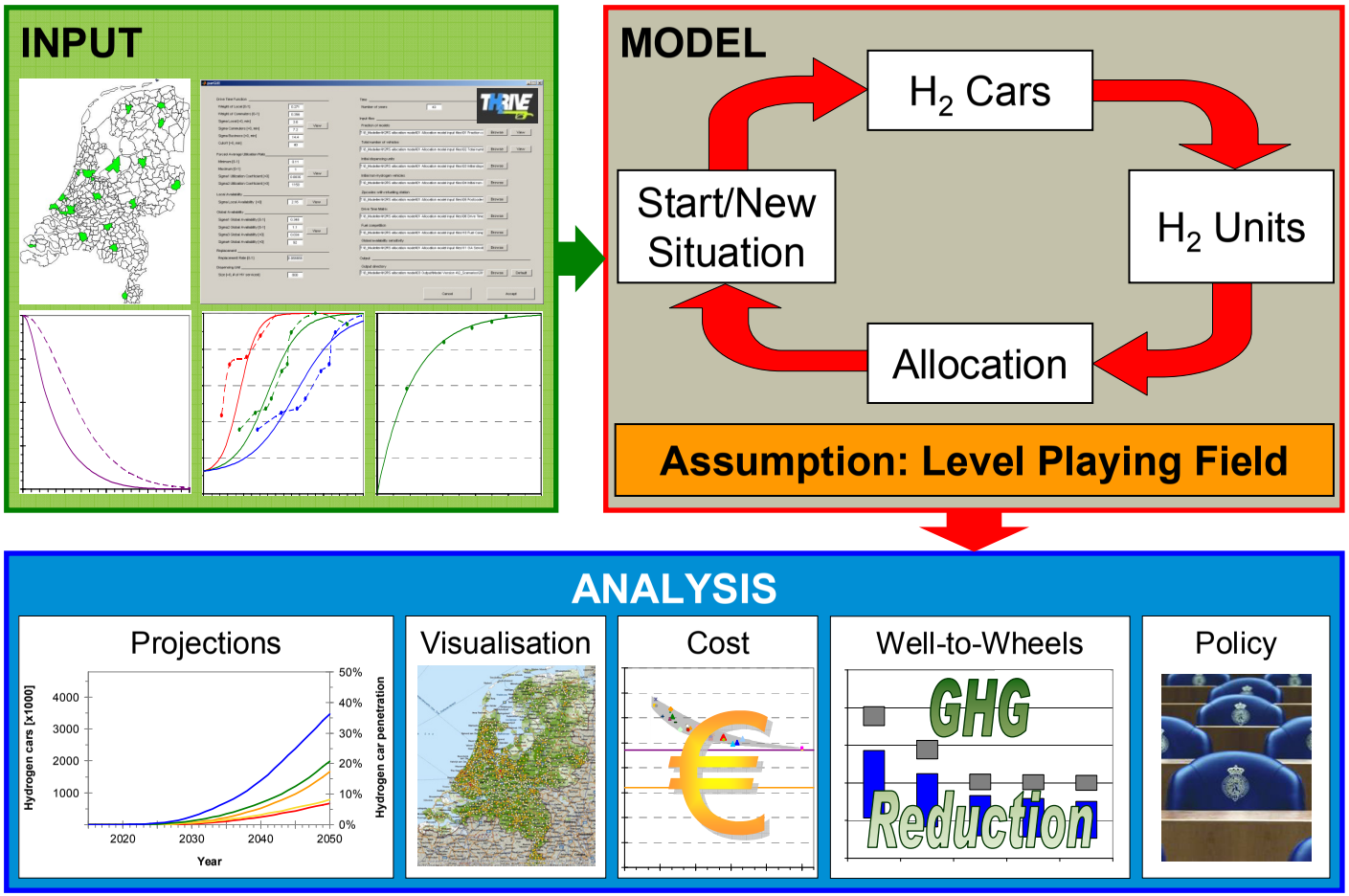
- A Dutch research project (2007 – 2010)
- Project partners: ECN, Linde, Shell, TNO
- Sponsor: Dutch Ministry of Economic Affairs
- Focus:
  - Hydrogen as transport fuel
  - Passenger cars
  - The Netherlands
  - Commercialisation phase

Project objective

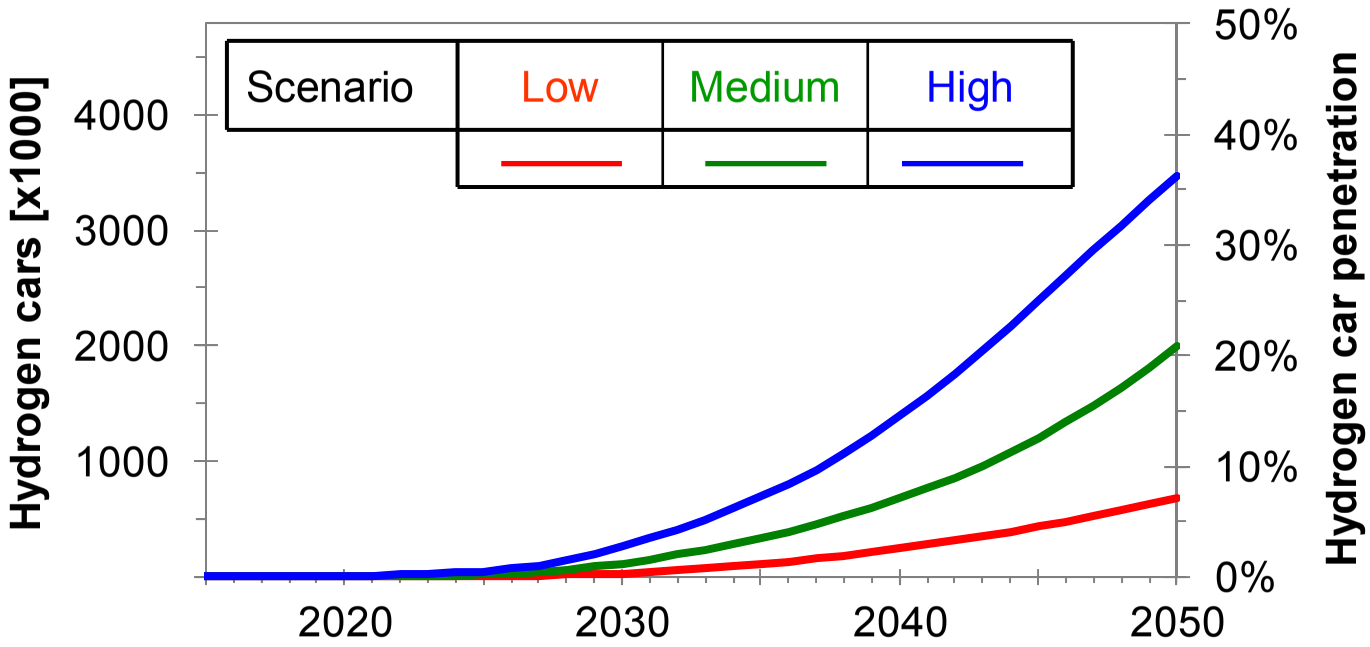
- Identification of plausible rollout scenarios
  - Growth of a H_2 car fleet
  - Development of a H_2 refuelling infrastructure
- Considerations



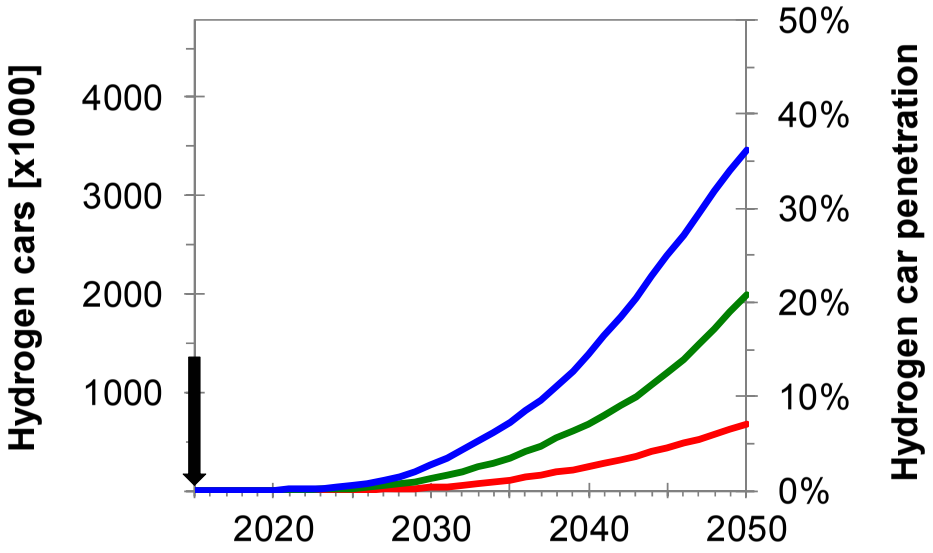
Project approach



Results – car penetration curves



High Scenario

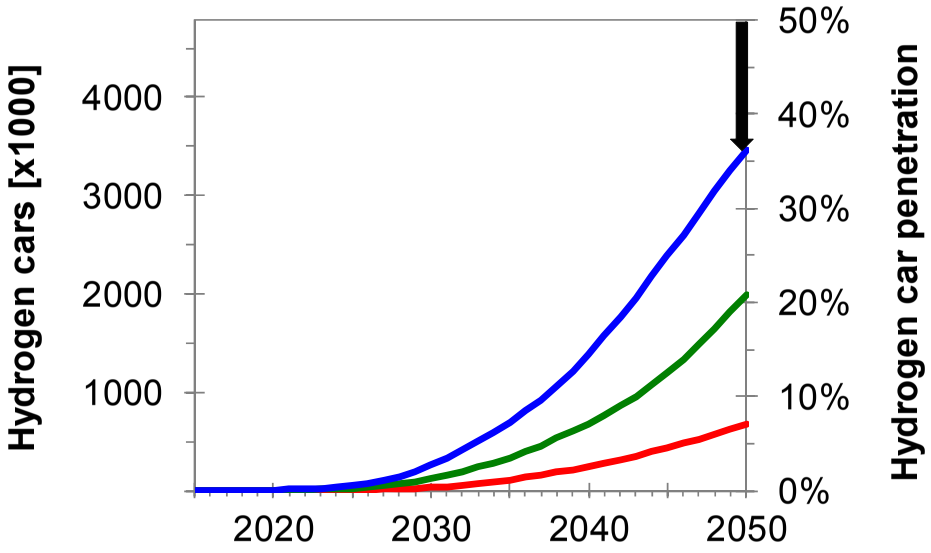


Scenario	Low	Medium	High

Increasing number of H2 refuelling units

Increasing H2 car penetration

High Scenario



Scenario	Low	Medium	High

Increasing number of H2 refuelling units

Increasing H2 car penetration

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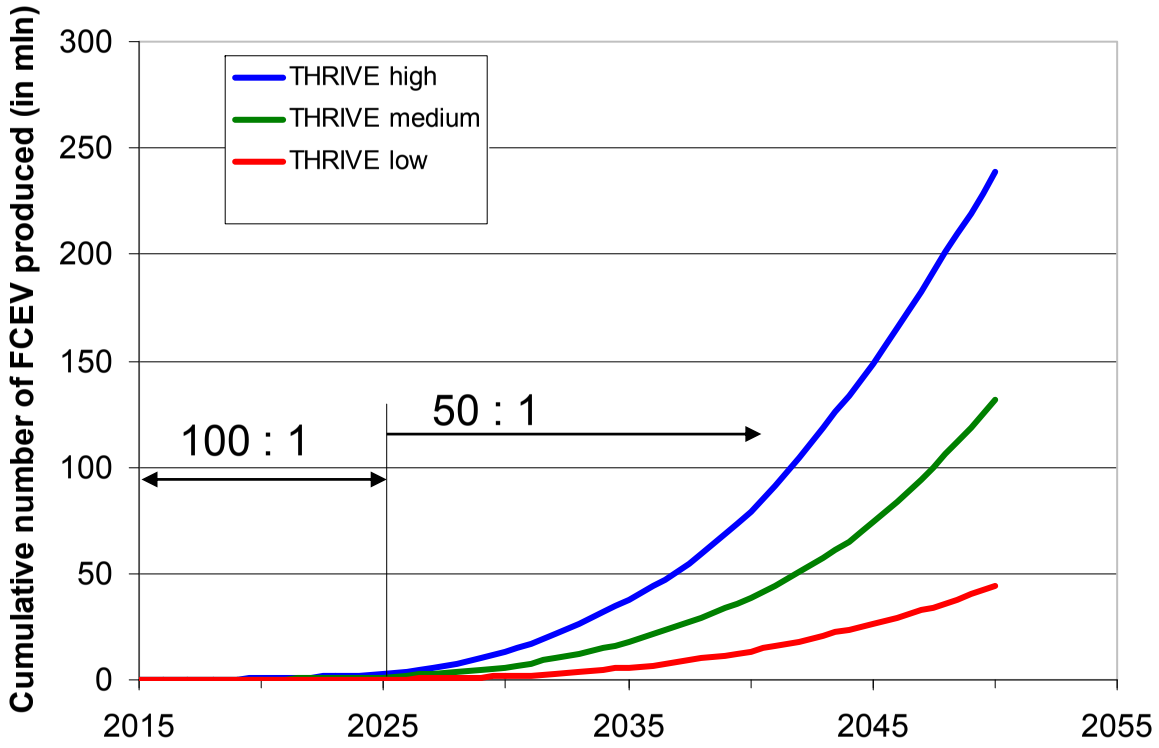
Cost gap analysis FCEV rollout

- Objective:
  - Estimate additional car costs that need to be bridged to reach ‘level playing field’
- Approach:
  - Translation of NL sales simulations to Global scale
  - Projection of FCEV cost reduction
  - Comparison with reference car costs

Translation of NL sales simulations to Global scale

- World car fleet : Dutch car fleet ≈ 100 : 1
- World hybrid car fleet : Dutch hybrid car fleet ≈ 50 : 1



Translation of NL sales simulations to Global scale

- World car fleet : Dutch car fleet ≈ 100 : 1
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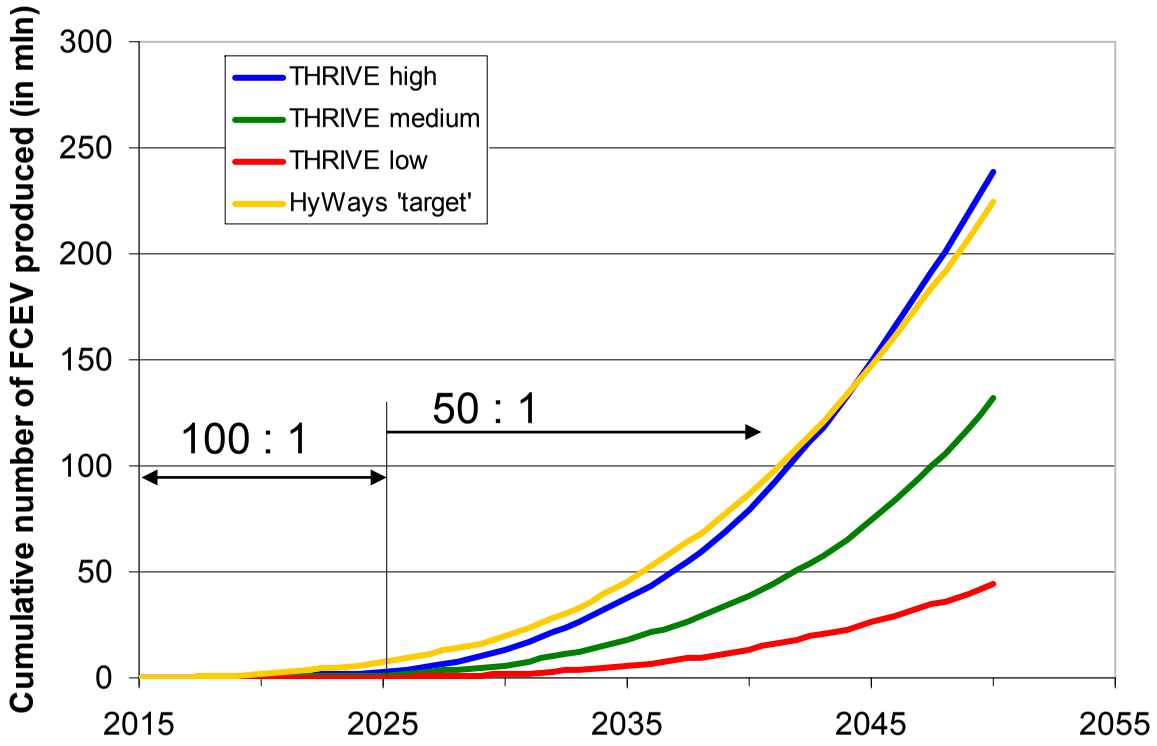


Projection of FCEV cost reduction:

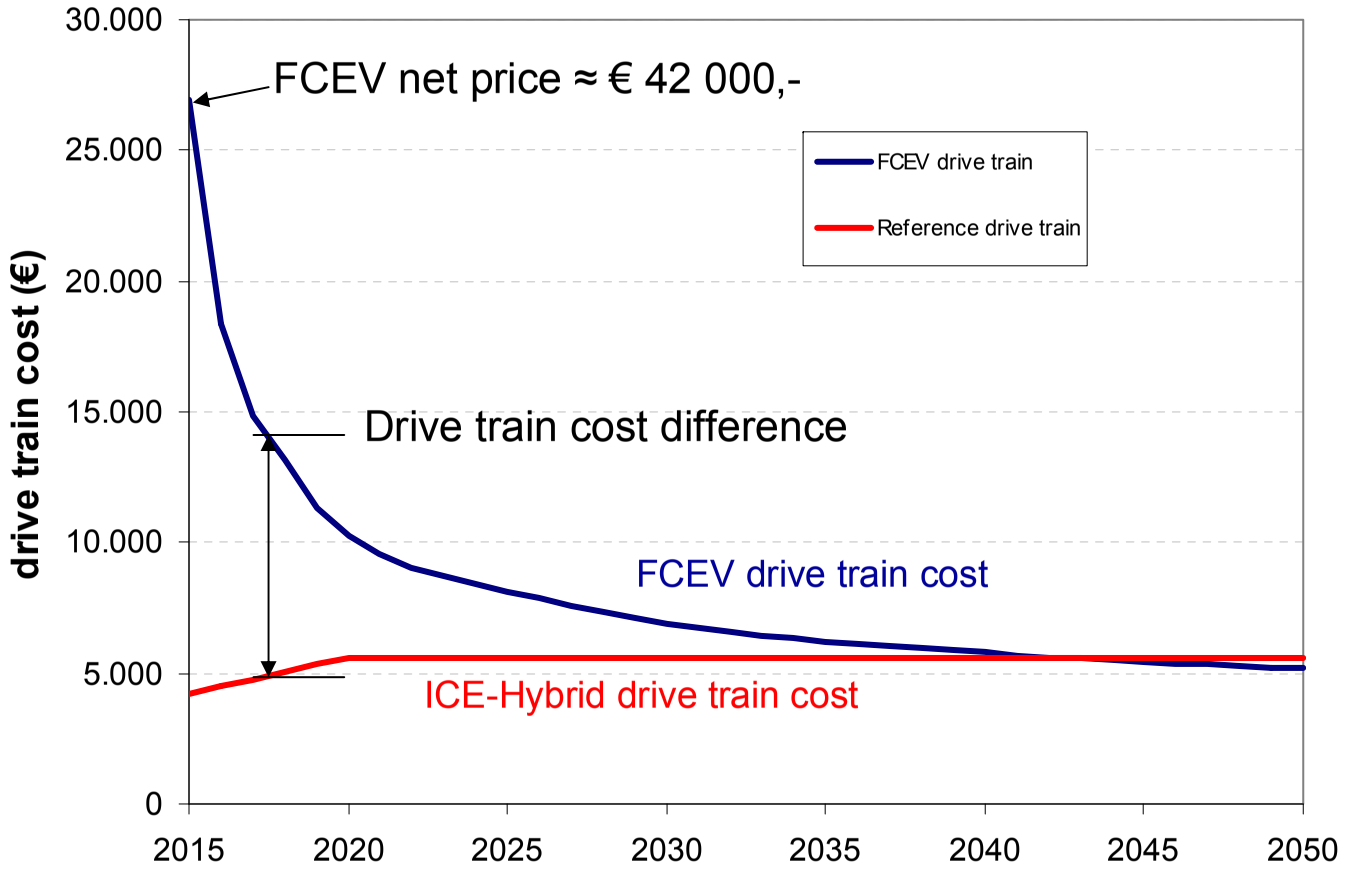
- Learning curve methodology: $I(C) = I_0 * (C/C_0)^{-(\ln(pr)/\ln(2))}$

C_0 = 2000 (in 2013)	80 kW FC system	H_2 tank	E-motor	Battery
I_0 (€)	28 000	7 000	4 000	2 750
progress ratio **(pr)**	0.80	0.90	0.90	0.90
pr after 1 mln cars	0.90	0.95	0.95	0.95

Source: CONCAWE, DRIVE (McKinsey), HyWays, DOE

- Lumped parameter **pr** reflects:
  - Learning by doing
  - Economy of scale
  - Learning by searching

Comparison with reference car cost



Comparison with reference car cost

- Annual additional costs of the FCEV-fleet in the Netherlands in year X:

  = (Cost gap FCEV – ICE-Hybrid) x Annual FCEV sales

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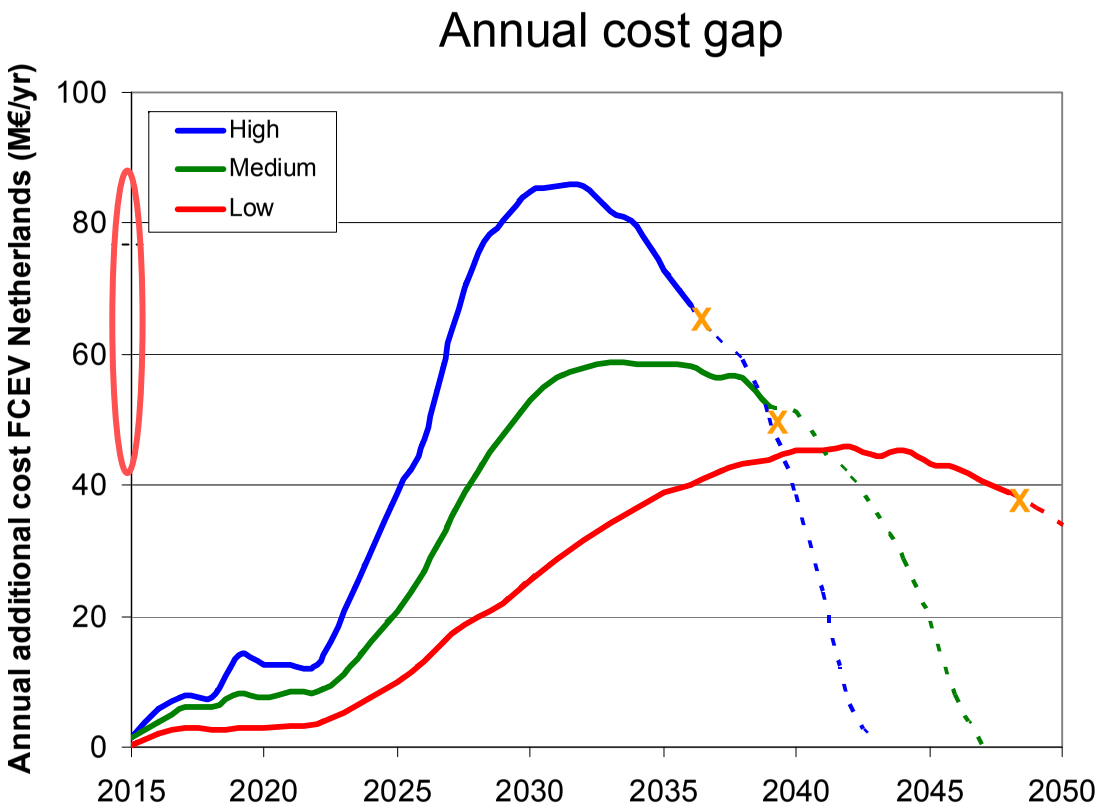
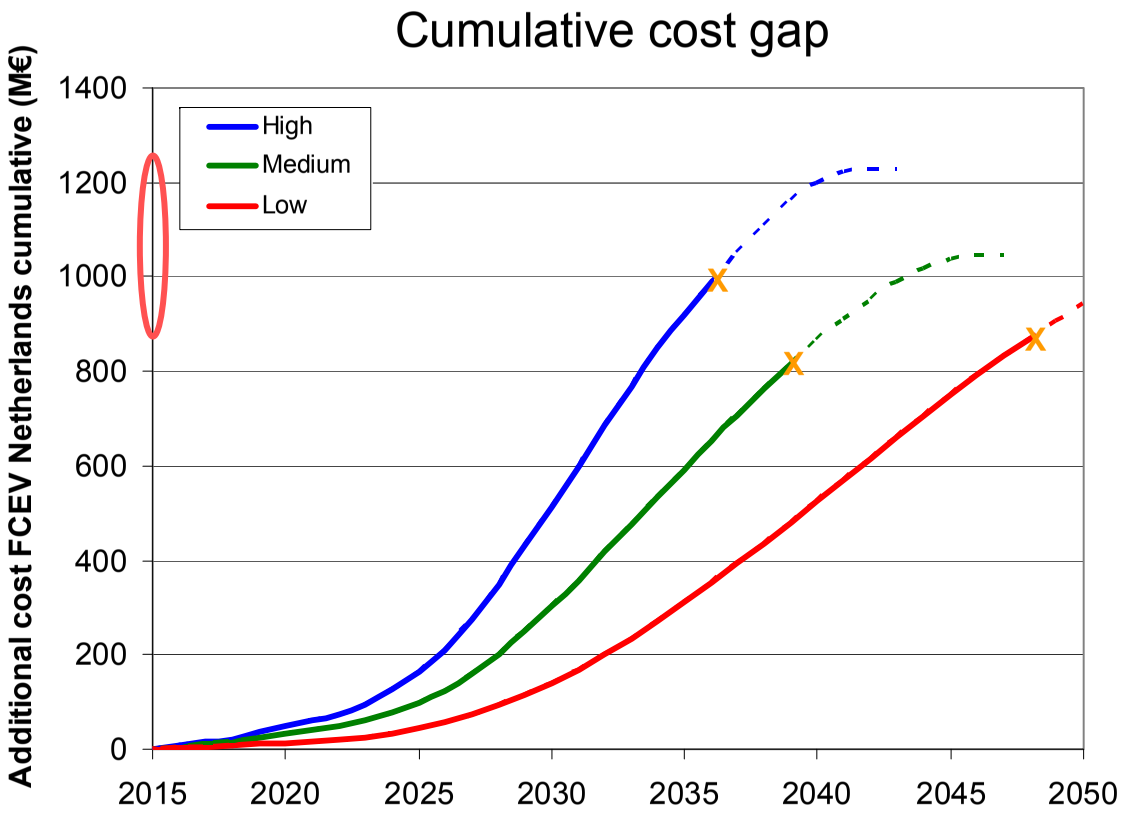
Additional cost FCEV compared to reference – ICE-Hybrid



X => cost difference between FCEV and reference (ICE-Hybrid) drive train dropped to 10%

Additional cost FCEV compared to reference – ICE-Hybrid



X => cost difference between FCEV and reference (ICE-Hybrid) drive train dropped to 10%

FCEV rollout: effect of lease car market

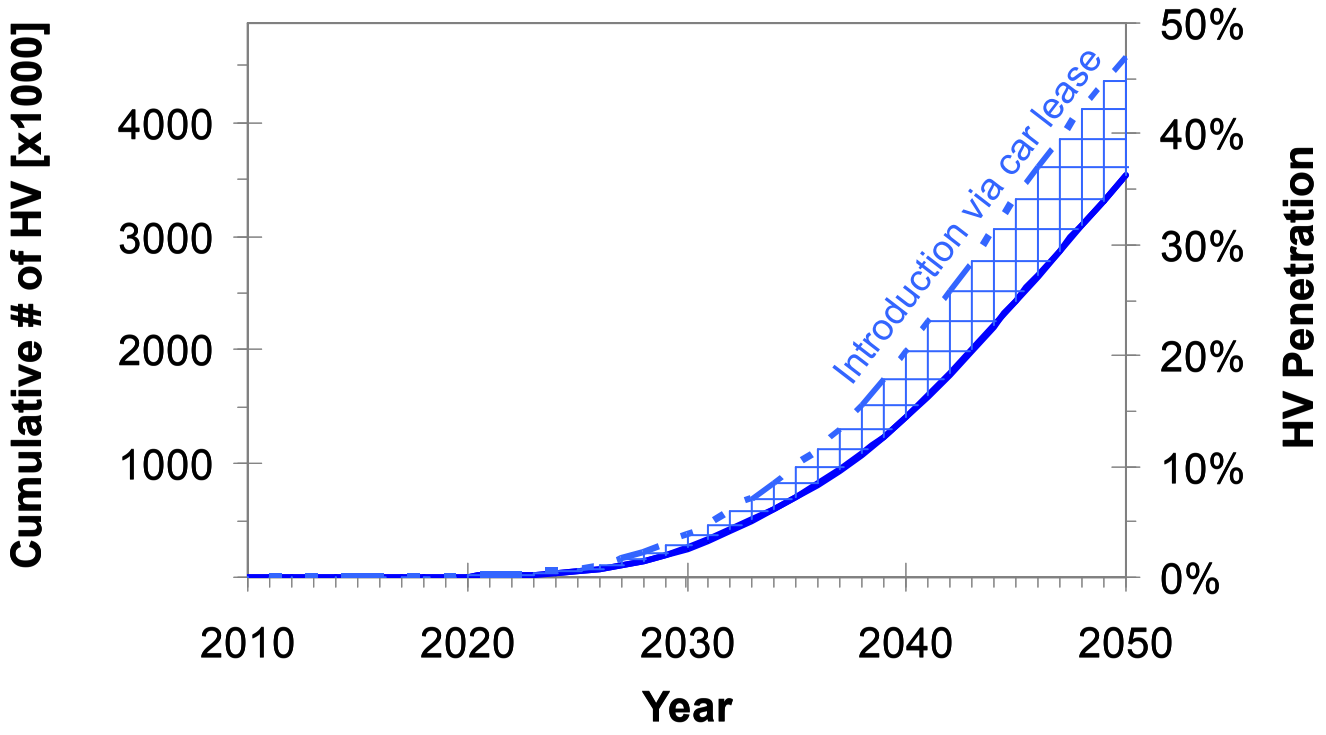
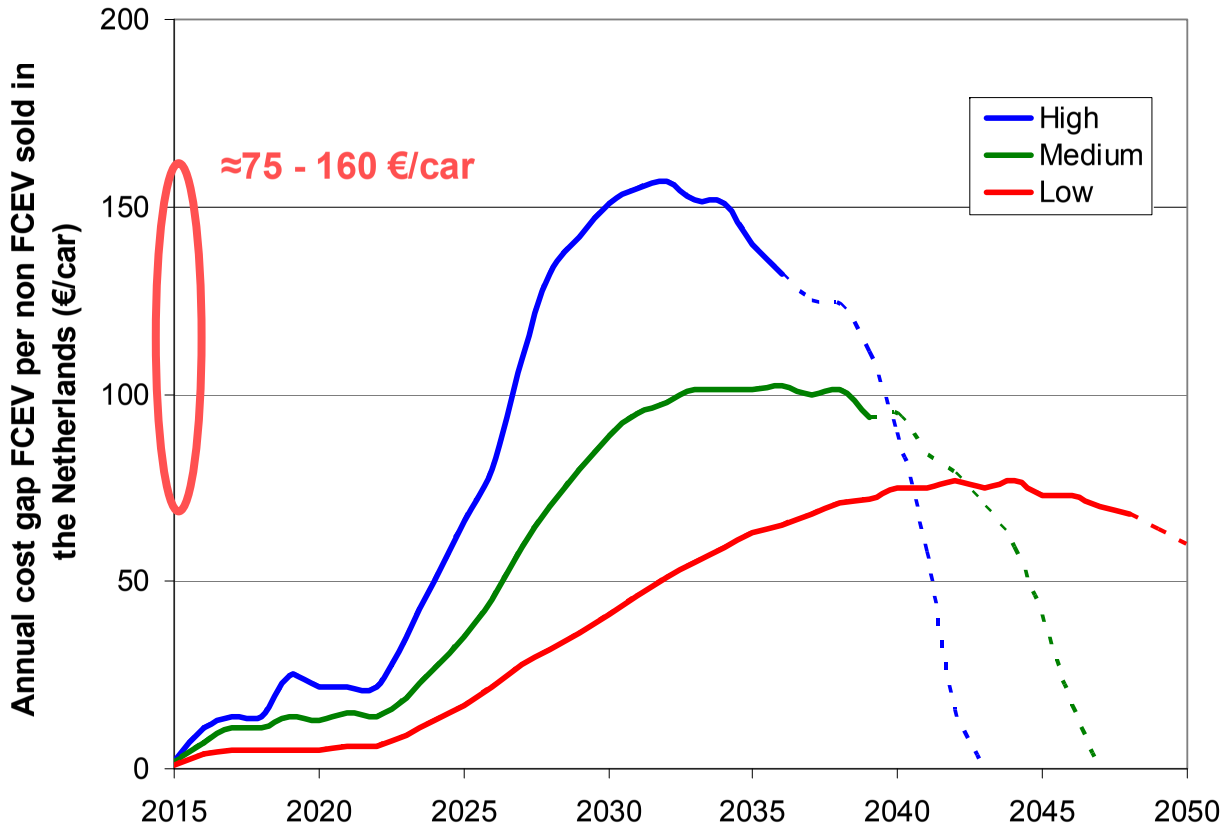
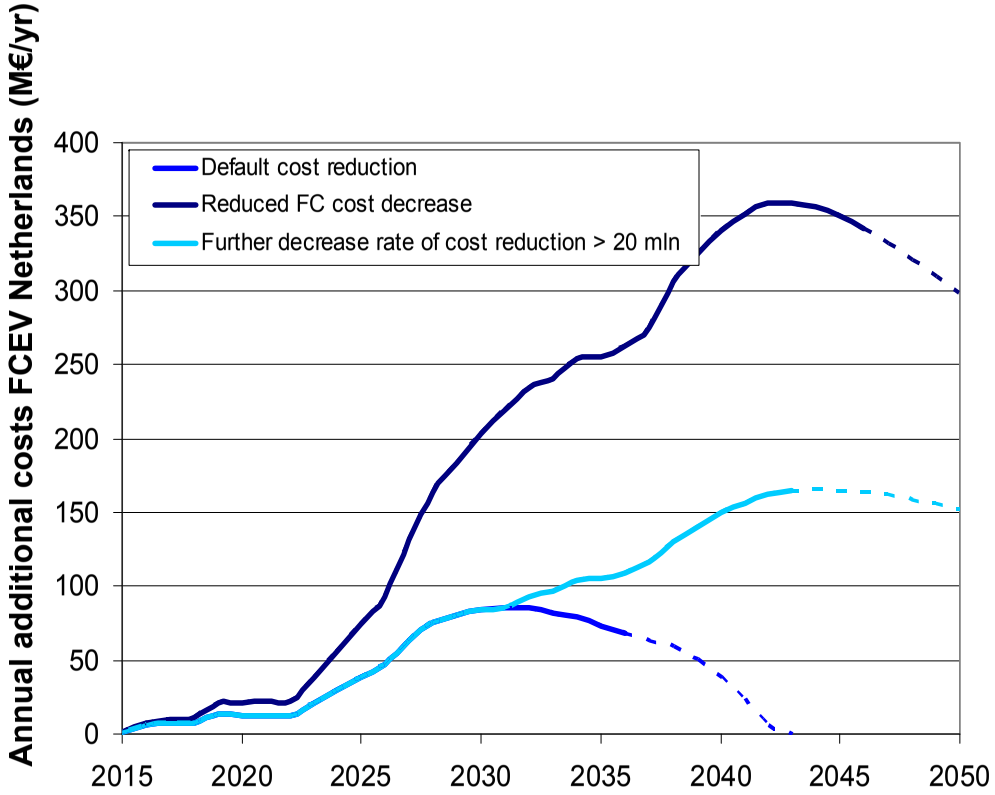


Illustration – Relative order of magnitude



Impact different rates of cost reduction by learning



Progress Ratios	Fuel Cell	H_2 tank	E-motor	Battery
Phase I	**0.85**	0.90	0.90	0.90
Phase II > 1mln cars	0.90	0.95	0.95	0.95

Progress Ratios	Fuel Cell	H_2 tank	E-motor	Battery
Phase I	0.80	0.90	0.90	0.90
Phase II > 1mln cars	0.90	0.95	0.95	0.95
Phase III >20mln cars	**0.95**	**0.98**	**0.98**	**0.98**

Progress Ratios	Fuel Cell	H_2 tank	E-motor	Battery
Phase I	0.80	0.90	0.90	0.90
Phase II > 1 mln cars	0.90	0.95	0.95	0.95

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Summary and conclusions:

- THRIVE presents an integrated perspective for the rollout of hydrogen vehicles and the refuelling infrastructure.
- THRIVE simulates consumer-driven rollout influenced by industry market strategies which reflect different policy settings.
- FCEV implementation costs seem feasible: plausible scenarios indicate annual additional costs of about 40 – 80 M€ for the Netherlands; additional cost translate to max. 150 €/non FCEV
- High cost reductions need to be maintained for FCEVs to become a cost-competitive alternative – combined effect of learning by doing, economies of scale AND learning by searching (= need for sustaining basic R&D)
- Resale-price garantuees may lead to additional cost, but also to accelerated rollout as it may attract business lease car market → further research required

THRIVE presentations

Day	Session	Time	Room	Presenter	Title
Tu.	HP.6	11:30	Mailand	Hoevenaars	Hydrogen vehicle deployment and required policy support for rollout scenarios in the Netherlands
Tu.	TA.4	12:00	Room L	Lebutsch	Impact of industry strategies and consumer attitude on growth of the H_2 vehicle fleet & refuelling infrastructure
Tu.	SA.3	15:00	Room S+T	Bunzeck	Building a H_2 refuelling infrastructure in the Netherlands: influencing factors from the car drivers' perspective
Tu.	HI.2	13:00 & 17:30	Poster exhibition Hall 3	Lebutsch / Weeda	THRIVE ALLOCATE – A dynamic model to simulate rollout of hydrogen vehicles and refuelling infrastructure
Th.	HI.1	8:30	Berlin	Weeda	Cost analysis of H_2 refuelling infra rollout scenarios in the Dutch THRIVE project

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Agentschap NL
Ministerie van Economische Zaken

Towards a Hydrogen Refuelling Infrastructure for VEhicles

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