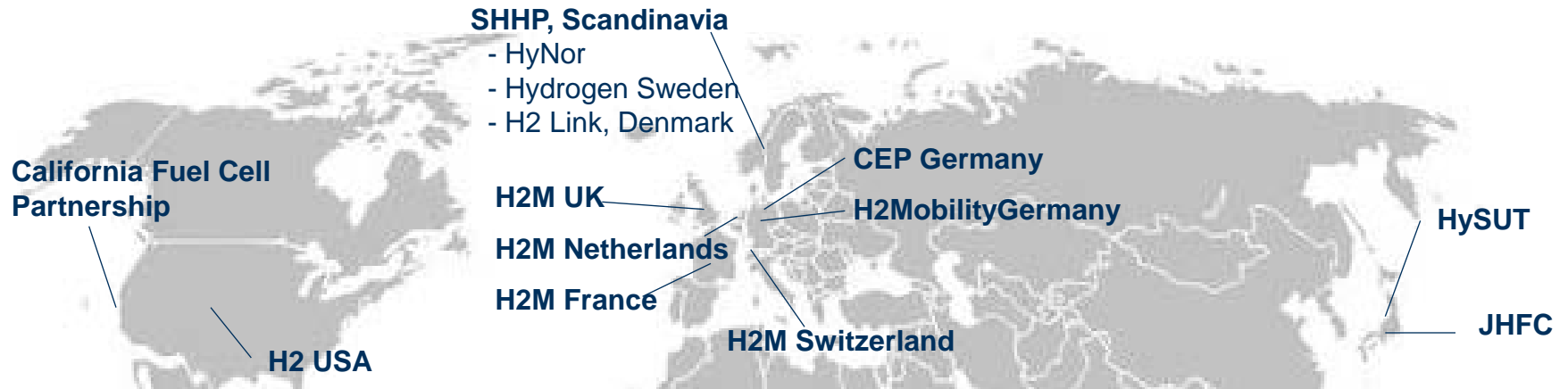


# Today numerous initiatives are ongoing in Europe, USA and Japan – Germany as fore-runner



## North America

H2 as fuel

- **Hot Spot California:** CARB Advanced Clean Cars Program / ZEV regulations
- First commercial market for **utility fleet vehicles (FLT)**

H2 infra.

- California H2 Stations Road Map:  
By 2016: 70 stations.

## Europe

- **Hot Spot Germany:** Focus of German OEMs due to funding structure (NIP/CEP)
- Various other projects in **UK, Benelux, Scandinavia, etc.**

- 50 HFS Program of BMVBS (NIP)
- EU: Clean Power for Transport Directive, Alternative Fuels Strategy

## Asia

- **Hot Spot Japan & Korea:** Focus of OEMs due to funding structure (METI)
- **China fast follower (?)**
- Japanese HySUT Program  
By 2015: 100 stations
- Korean HFS roll-out scenario

# Recent developments on the FCEV side.

20.11.2013 at LA Motor Show



20.11.2013 at Tokyo Motor Show



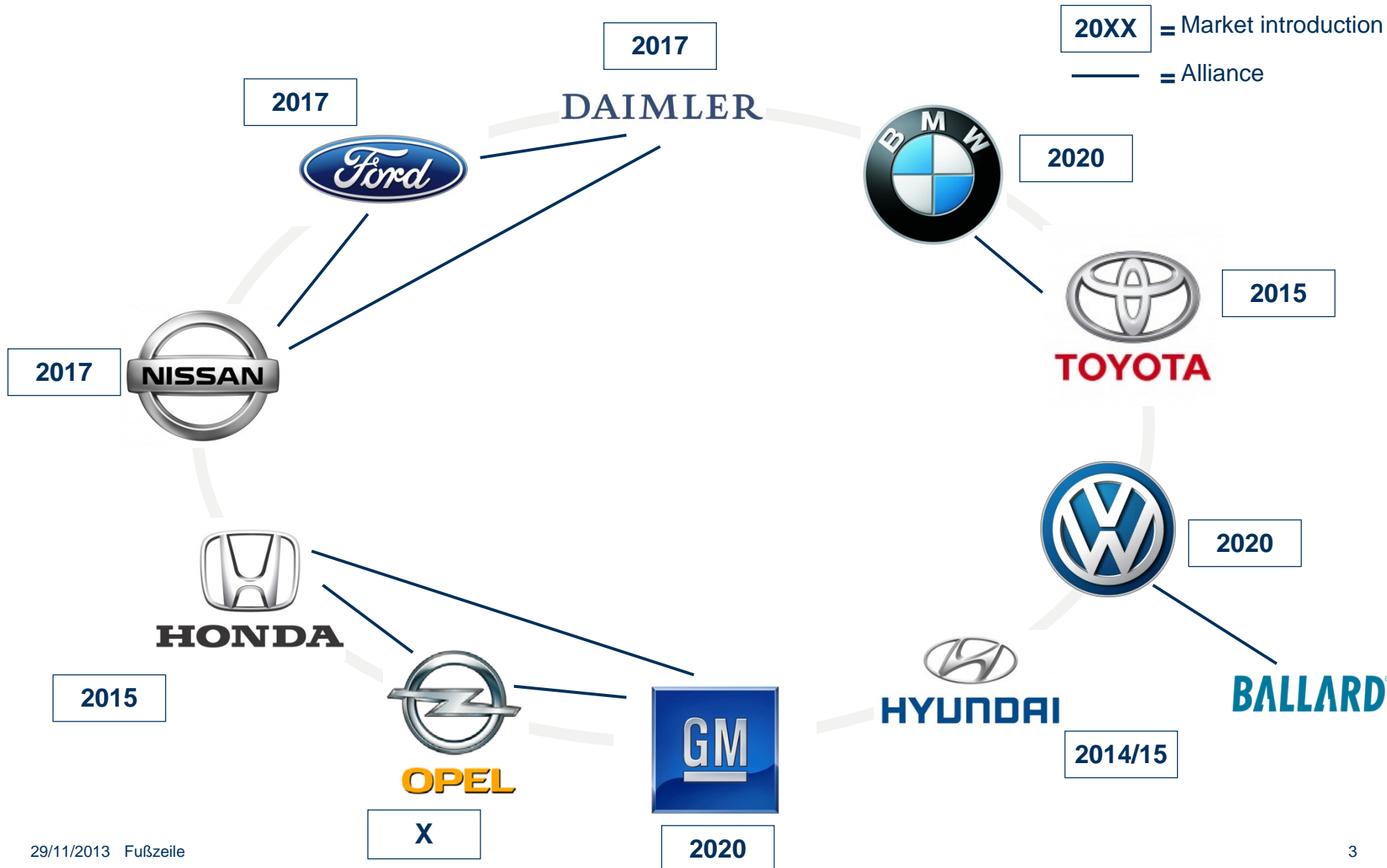
03.05.2013 at Linde Hydrogen Center



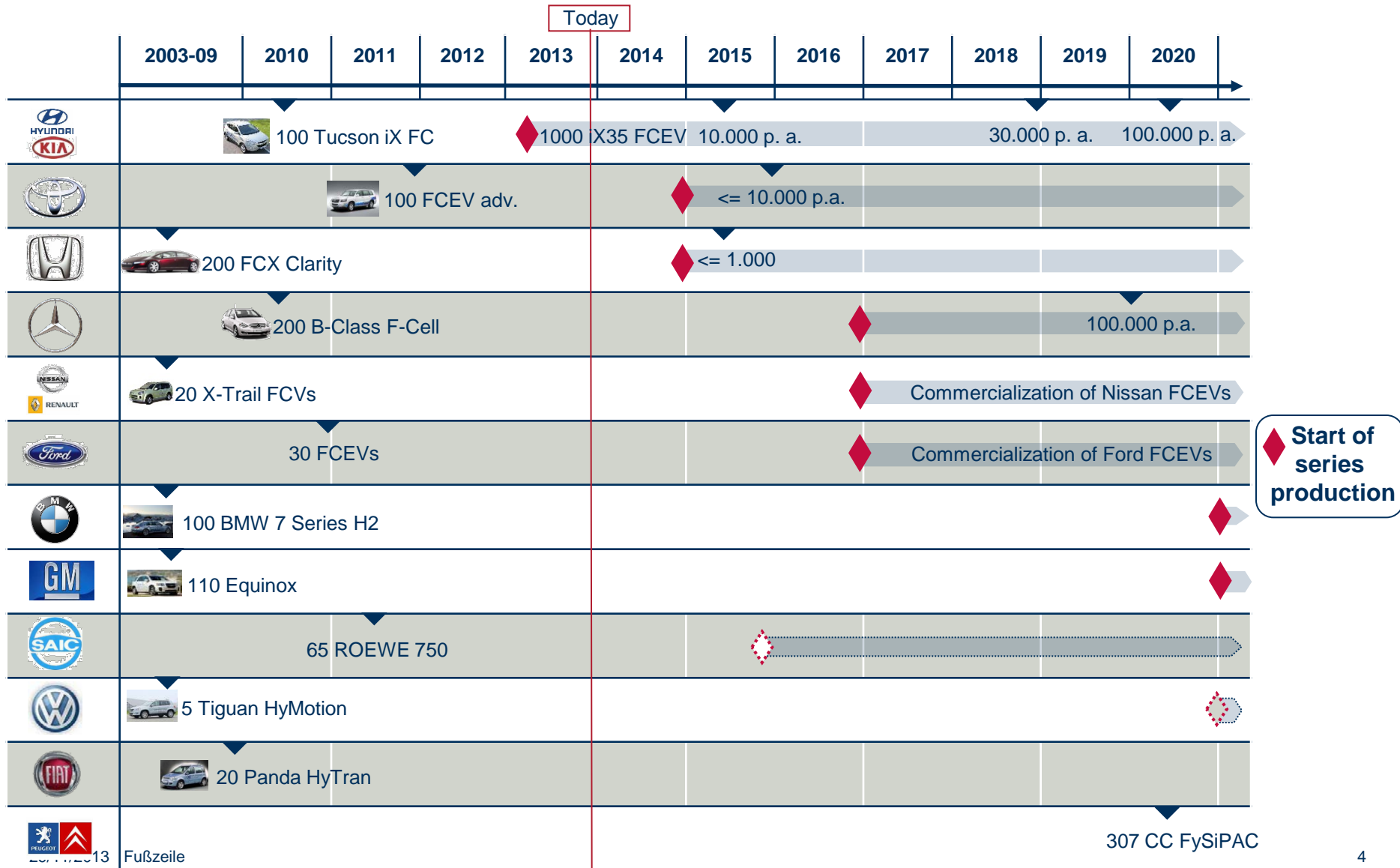
20.11.2013 at Tokyo Motor Show



# Forming of OEM alliances for FC-development



# FCEV: Project Pipelines



# Application areas for Hydrogen as fuel and Linde's fuelling experience



THE LINDE GROUP

 Focus areas

Linde's  
experience



## Passenger Cars

- > 50 stations delivered
- > 80.000 fuellings



## Public Transport

- > 10 stations delivered
- > 20.000 fuellings



## Material Handling

- > 10 stations delivered
- > 300.000 fuellings



## Backup Power

- > 10 units delivered

Linde's  
experience



## Maritime / ships

- 2 stations delivered
- ferry and submarines



## Aviation

- Supply of pilot projects
- Market studies



## H2 Based CHP private homes

- Market studies



## Portable Applications

- Market studies

## Production



Conventional  
(e.g. SMR)



Green  
(e.g., BTH)

## Supply/Storage



CGH2 storage



LH2 storage

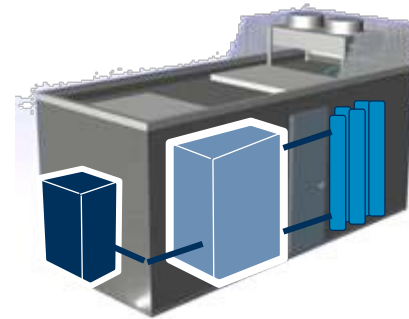


Onsite SMR



Onsite Electrolysis

## Compression/Transfer



Ionic compressor



Cryo pump

## Dispenser



350 bar



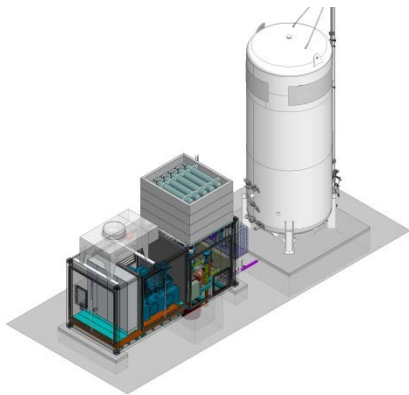
700 bar

## Advanced fuelling

### Ionic compressor



### Cryo Pump



- Standardized fast fuelling protocol (SAE):
  - 3 min / fuelling (up to 7kg H<sub>2</sub>)
- Up to 6 fuellings / hour per dispenser<sup>1</sup>
- Underground storage implemented
- Invest cost reduced by 60 %<sup>2</sup>
- Footprint reduced by 70 %<sup>2</sup>
- Energy consumption reduced by 25 %<sup>3</sup> plus
- Maintenance intervals extended by up to 400%<sup>2</sup>
- CE and ASME conformity

<sup>1</sup> Based on H<sub>2</sub> Mobility “small”, “medium” doubles number of fuellings/hr

<sup>2</sup> Compared to demonstration units in 2005

<sup>3</sup> Compared to standard dry running compressor.

IC 45

- Fork lift refuelling system
- Cheap solution for industrial use

IC 50

- Bus fleet refuelling system
- For high duty vehicles with 450 bar tank

IC 90

- Comercial 700 bar refuelling station
- High frequent use – SAE 2601

Dry Runner (MF 90)

- Small Fleets / H2 introduction
- Cheap solution for first 900 bar contact

Mobile Solutions

- Mobile use at demonstrations and presentations
- High mobility of the complete system

High duty compressor

- High hydrogen use - highest delivery rates
- Ionic compressor / cryogenic compressor

Focus Area for  
Australia

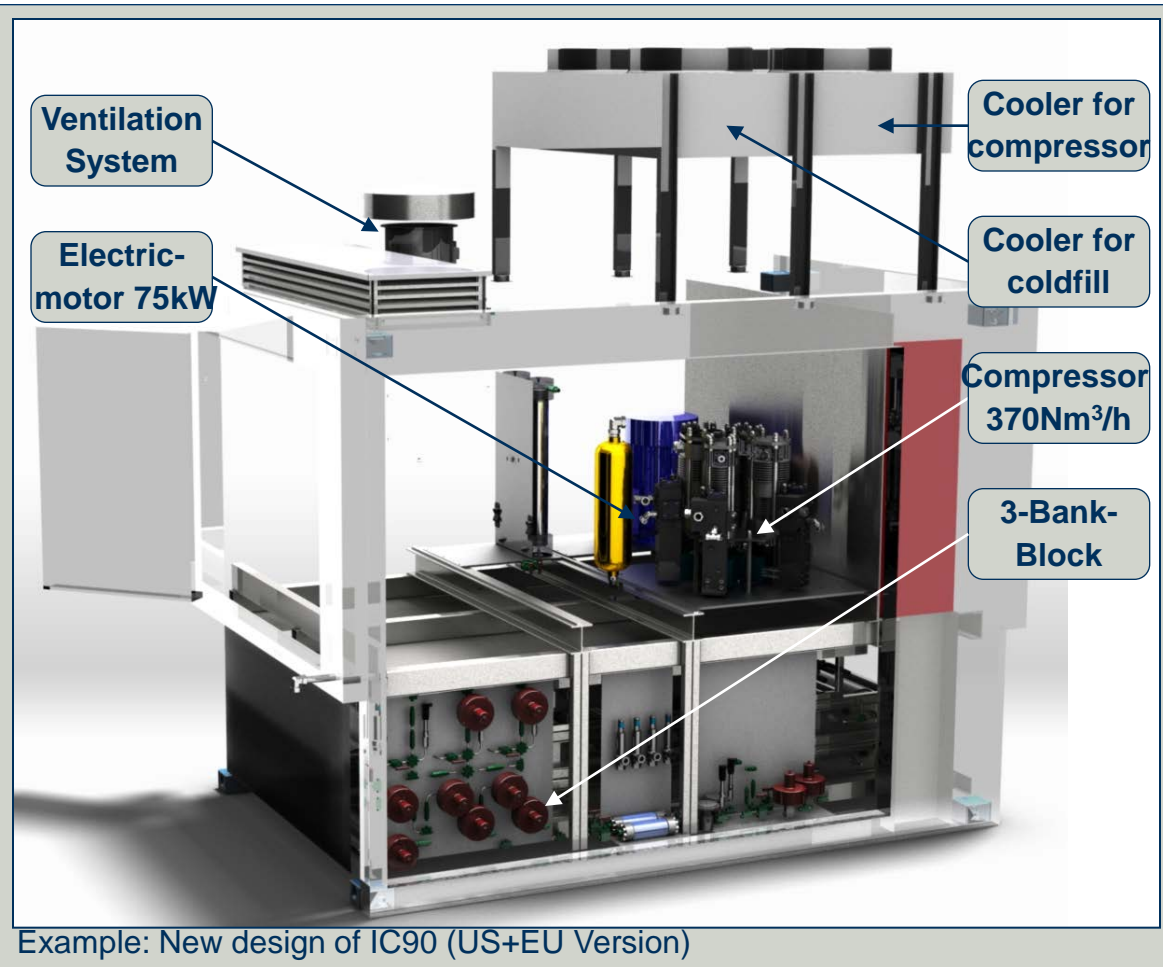


# IC90 for serial production

## Layout



THE LINDE GROUP



## Layout

- Small footprint: **2,7m x 4,3m**
- Height: 3m (without roof coolers and vents)
- Noise emission: <75dB(A)
- Supply: **gaseous** or **liquid**
- Connected load: 100kW
- Possible option for **capacity upgrade** from **33,6kg/h** to **67,2kg/h**
- HP Storage: **0,9m<sup>3</sup> 1000bar** upgradeable up to 1,3m<sup>3</sup>