

Global Fuel Cell (Market) Activity

David Hart

HTAC, November 2019



E4tech

Strategy | Energy | Sustainability

Storyline

- E4tech
- Hydrogen – driving fuel cells
- Growing markets
- Leading regions
- Maturing supply chains?

Speaker Bio: David Hart



- Dr David Hart is a Director of E4tech, a specialist global sustainable energy consultancy, and an expert advisor, consultant and researcher on hydrogen energy and fuel cells for 25+ years. He leads and conducts projects in these sectors from research to strategy for governments, corporations and investors worldwide, has sat on venture capital investment committees and clean energy company boards. He has been an invited keynote speaker on fuel cells and hydrogen energy on six continents. In 2001, having built a successful research group at Imperial College London, he co-founded E4tech's London office. Now based in Switzerland, he heads E4tech's Hydrogen and Fuel Cell consulting practices, while retaining a role as a Visiting Professor at Imperial College.

E4tech

E4tech perspective: Strategy | Energy | Sustainability

- International consulting firm, offices in UK and Switzerland
- Focus on sustainable energy, transport and systems
- 22 years old this year, always independent
- Deep expertise in technology, business and strategy, market assessment, techno-economic modelling, policy support...
- A spectrum of clients from start-ups to global corporations



LONDON



TOYOTA



DAIMLER



NISSAN



BRITISH AIRWAYS



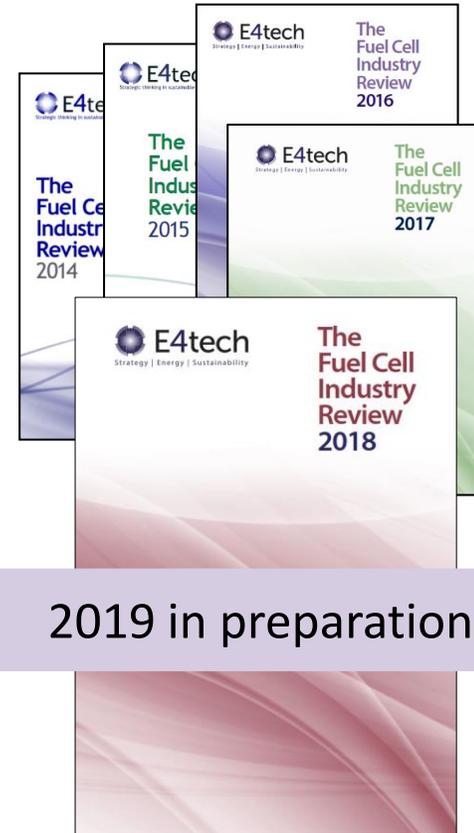
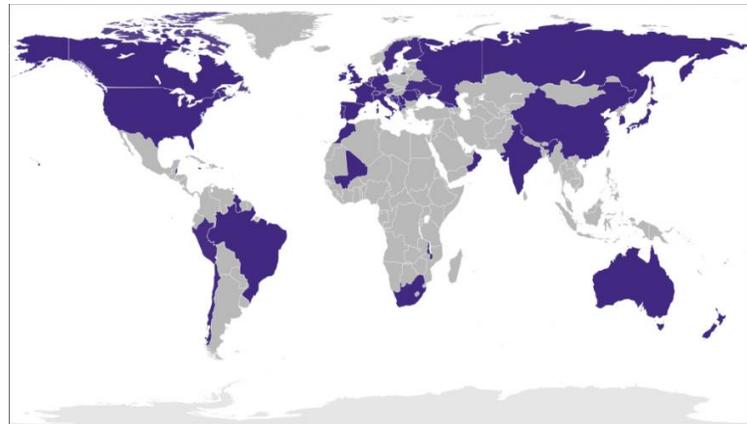
Imperial College London



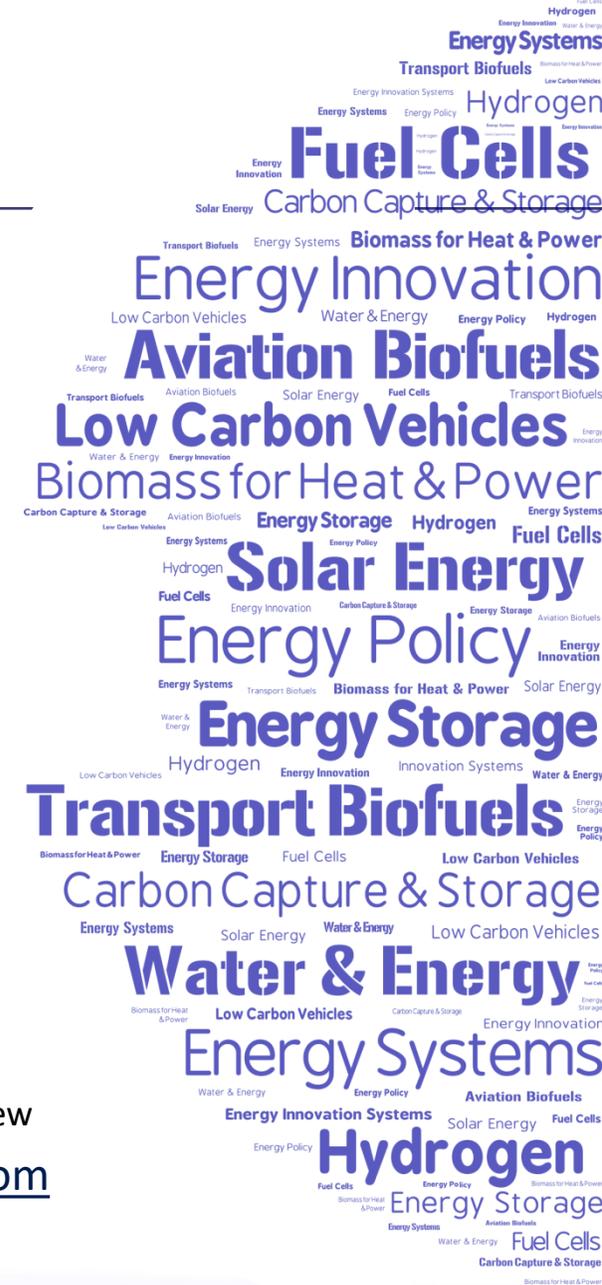
Unilever



ROLLS ROYCE

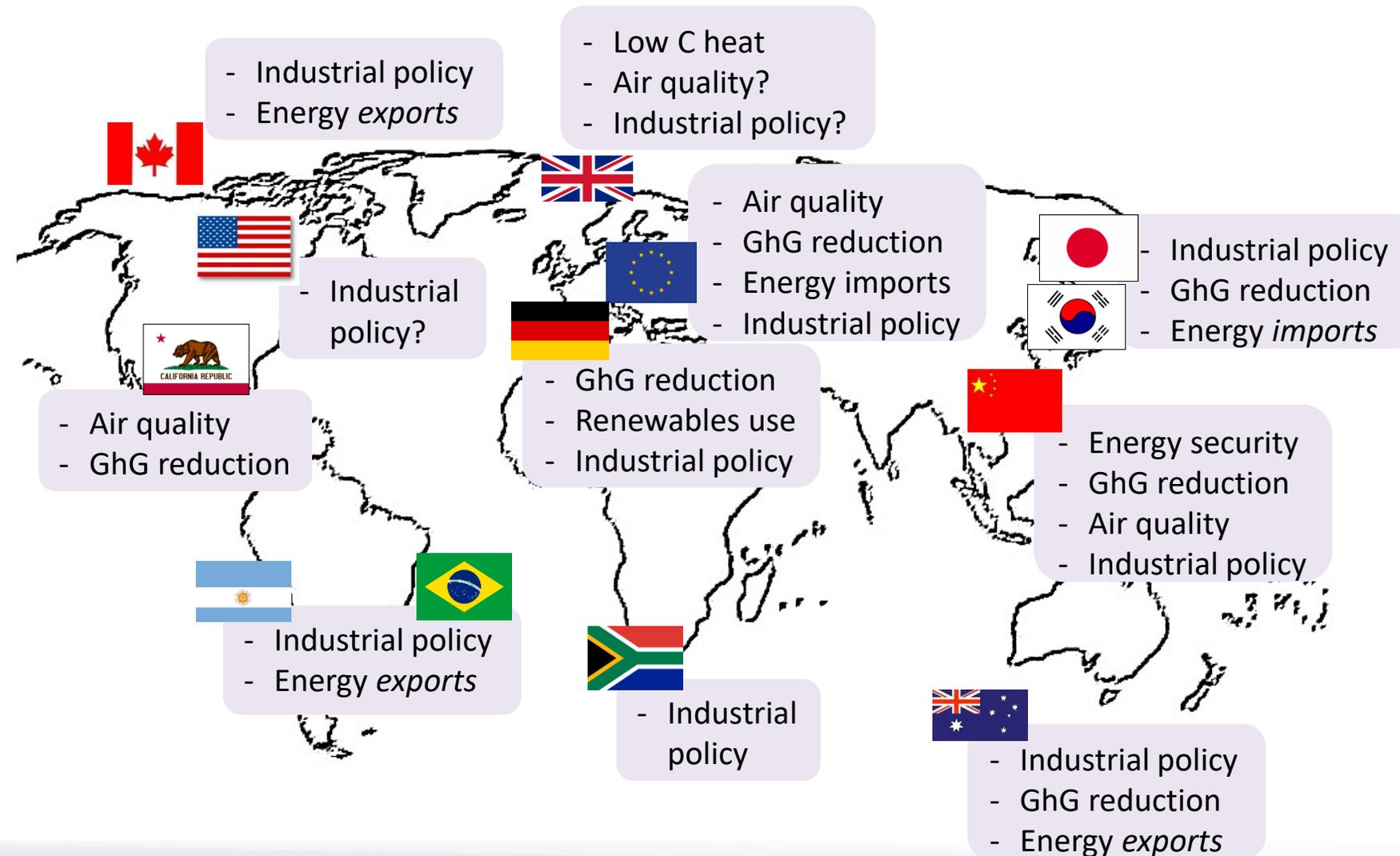


E4tech's annual Fuel Cell Industry Review
www.FuelCellIndustryReview.com



Interest in hydrogen is growing rapidly and dramatically

The primary market driver is national and regional policy, with Asia leading the way. But entrepreneurs increasingly see opportunities



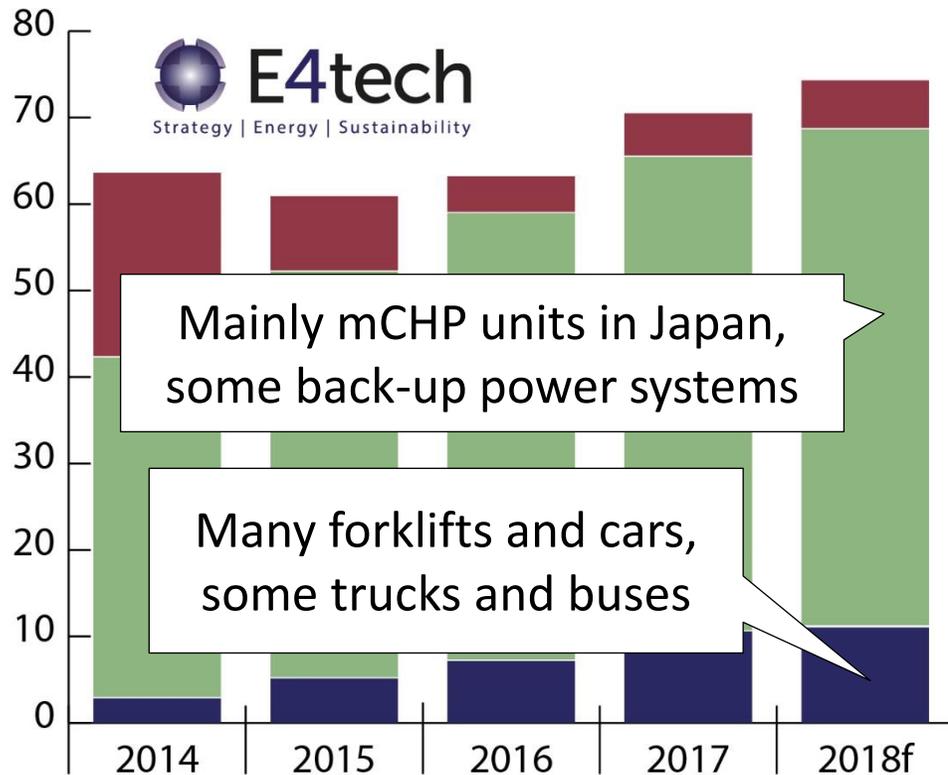
Business model drivers:

- Low-cost renewables and strong emissions pressure lead to inventive collaborations
- Increasing availability of components and products allows whole value chains to be built
- Increasing understanding of limitations of batteries leads to FCH solutions in some areas
- Scale drives cost and also corporate interest – it needs to be meaningful

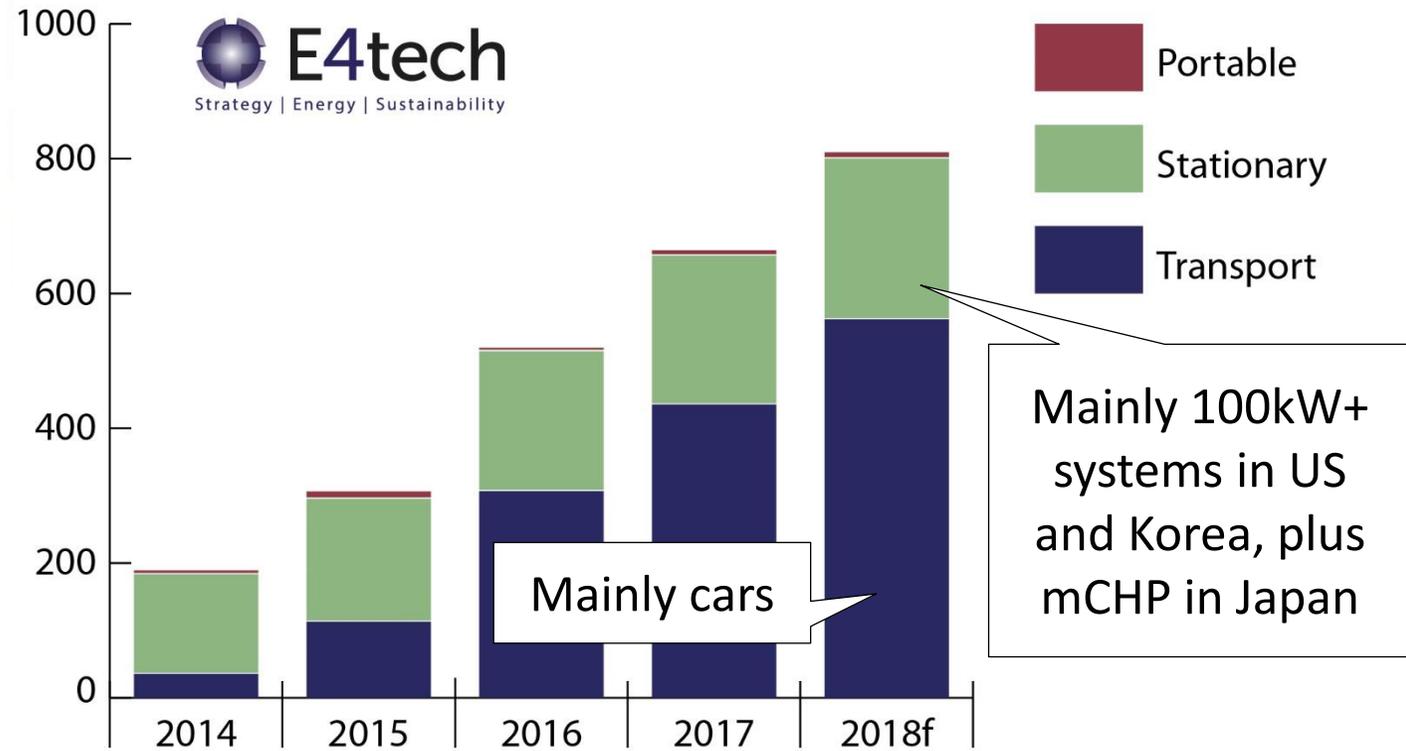
The fuel cell industry continues to grow too

Vehicle unit shipments are increasing, and have a major impact on MW shipped

Shipments by application 2014 - 2018 (1,000 units)



Megawatts by application 2014 - 2018

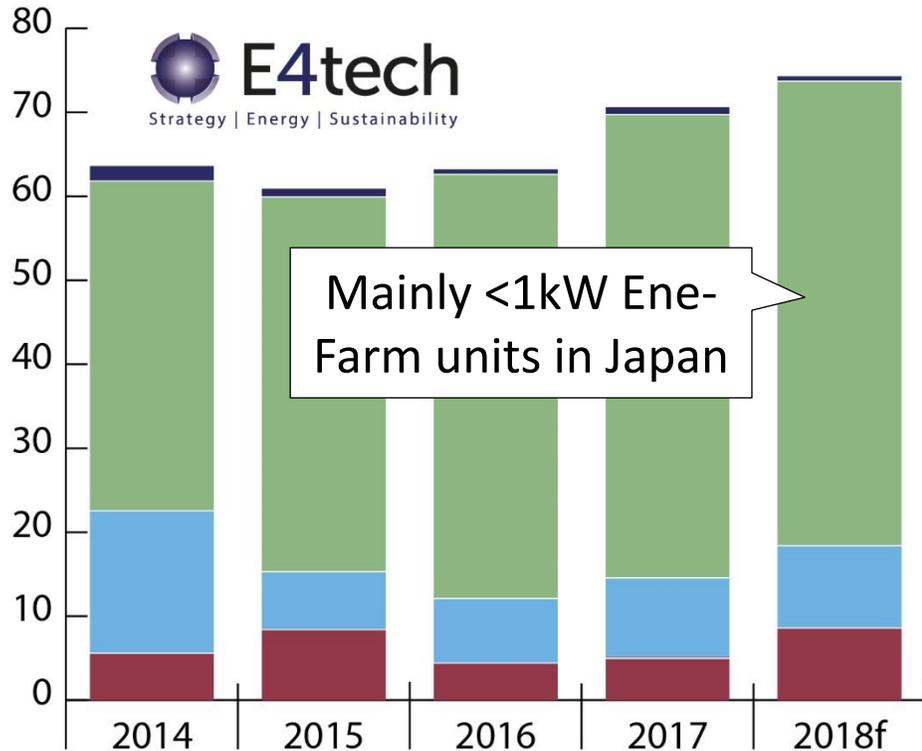


Full annual report available for download (free):

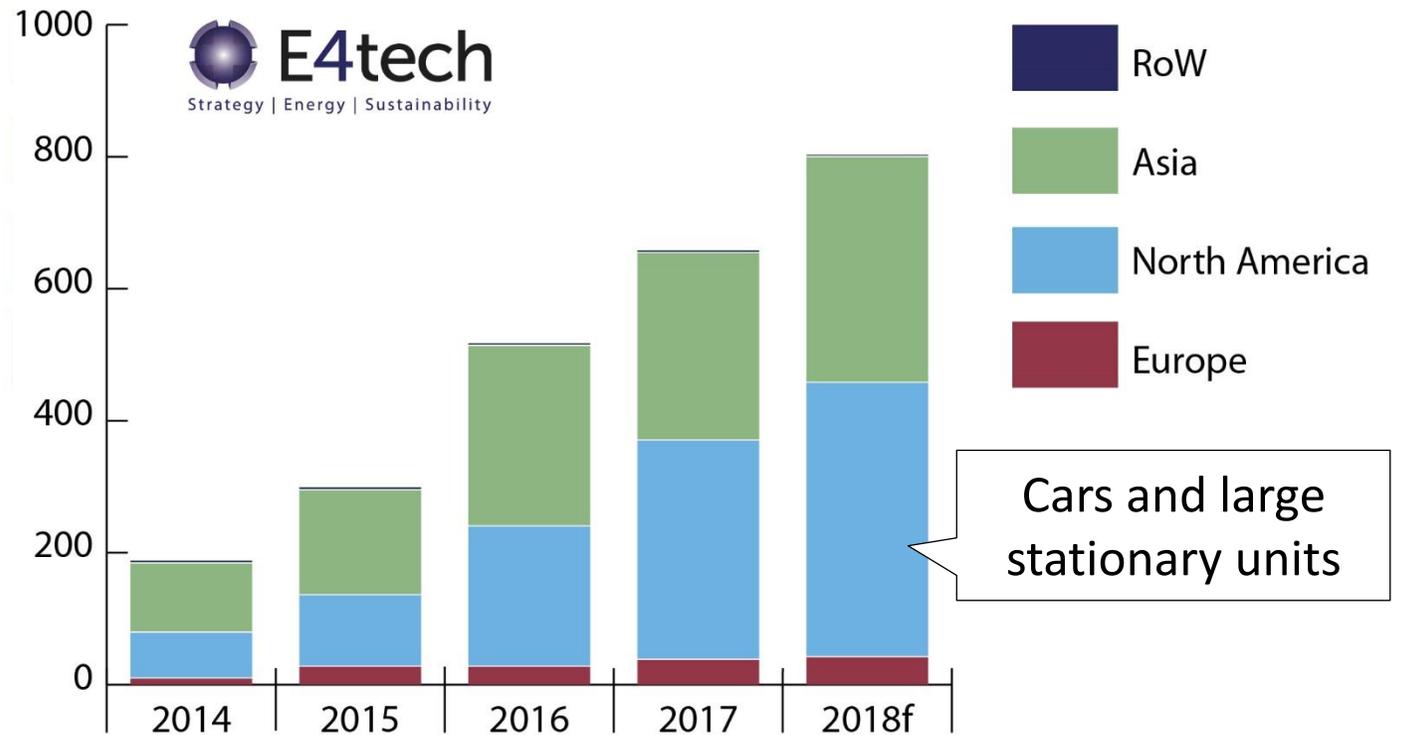
www.fuelcellindustryreview.com

Asia and North America dominate fuel cell deployment; Asia leads in manufacturing

Shipments by region of adoption 2014 - 2018 (1,000 units)



Megawatts by region of adoption 2014 - 2018

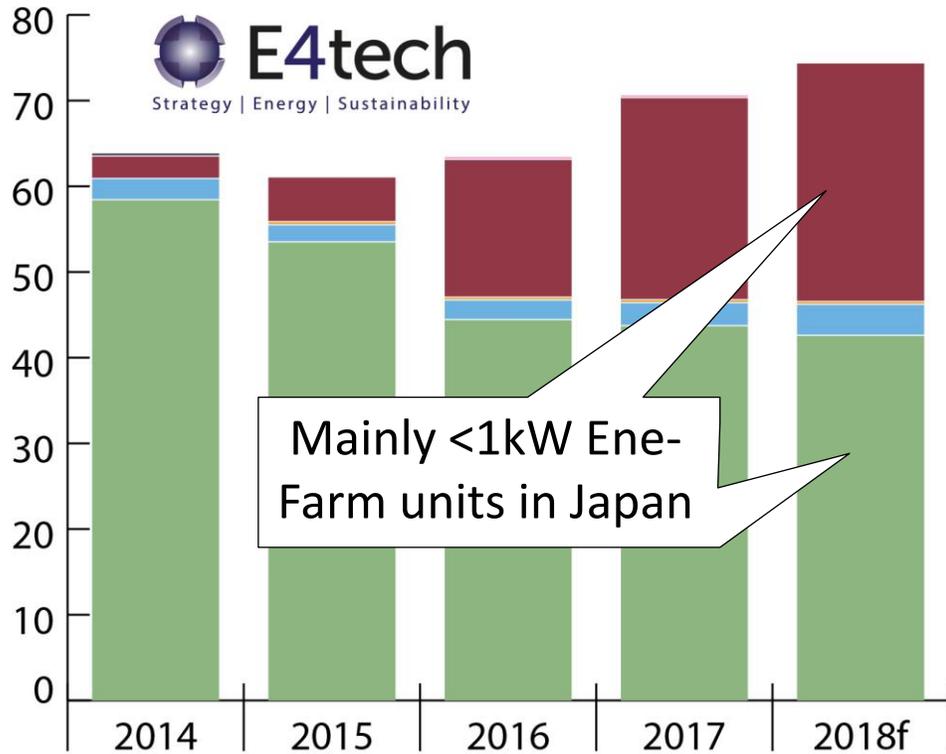


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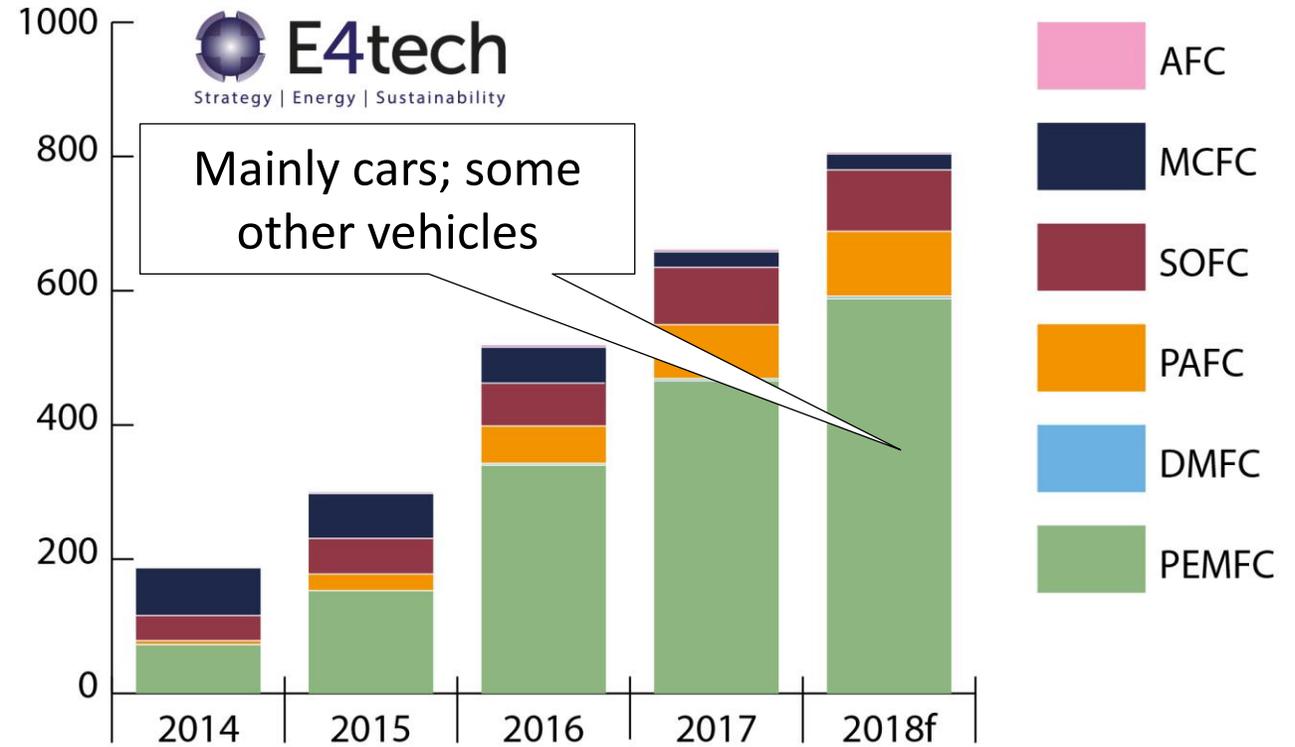
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The SOFC portion of unit shipments is growing, mainly in Japan for Ene-Farm. Car PEM units continue to dominate MW

Shipments by fuel cell type 2014 - 2018 (1,000 units)



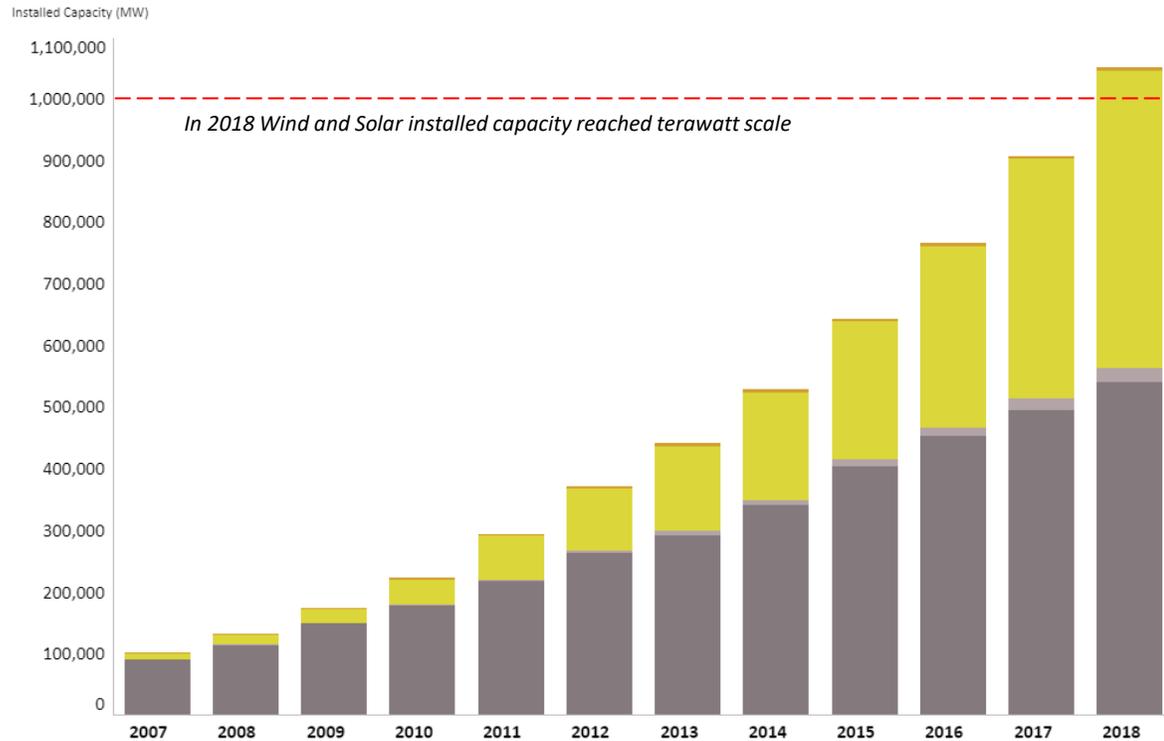
Megawatts by fuel cell type 2014 - 2018



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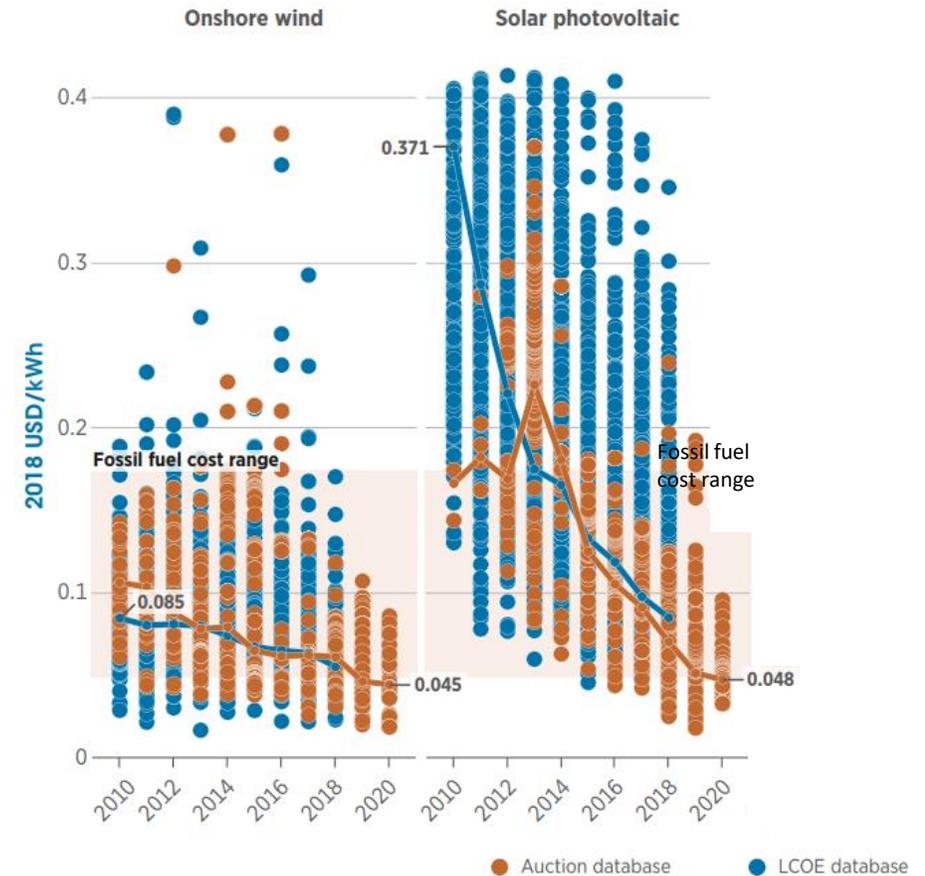
Low-cost renewables are an *essential* driver for hydrogen. Installations are growing globally, while cost is dropping

Installed capacity, wind and solar PV 2007-2018



Sources: IRENA, 2019

Cost curves for wind and solar PV 2010-2020



And heavy duty transport is increasingly the driver for fuel cells

- Batteries and charging are poor for heavy duty
- MoU for 800 Nikola H2 trucks from Anheuser Busch
- 1000 Hyundai H2 trucks for Swiss supermarkets (plus 600 more for other clients)
- Horizon and JMC (Ford) plan 42t trucks
- 100s already used in Chinese deliveries
- 100s of buses coming into daily use in Europe and China
- ‘Hydrail’ is here: passenger trains operating in Germany
 - Austria, Canada, Korea, UK and others have plans
- Ships in development: Norway, S Korea, Scotland and California
 - Ferries now, bigger units to come
- H2 from renewables is potentially important in remote islands (small and large)

Alexander Dennis



Coppe, Rio University, Brazil



Nikola European truck



Hyundai truck for Europe



Alstom Coradia iLint
© Rene Frampe



Zillertal train by
Stadler Rail



Scottish ferry design



Water-go-round design,
San Francisco



Sources: Author, Nikola, Hyundai, Rene Frampe, Stadler Rail, Ferguson Marine, Water-go-round

Different regions are evolving in different ways

Germany and France have significant national and regional government support

Germany

- Increasing buy-in across different Ministries – H₂ becoming part of the *Energiewende*
- National hydrogen strategy due end of 2019
- Strong programmes through NOW include R&D and entrepreneurship support, market activation
- KfW433 has supported thousands of FC mCHP installations
- Regions are also positive, e.g. Hessen, Baden-Württemberg, Bavaria
 - ‘Hydrogen Valleys’ are in development
- H₂Mobility continues to lay out infrastructure
- Germany’s supply chain is strong, e.g.
 - Bosch, ElringKlinger, SGL, Freudenberg, Umicore...

France

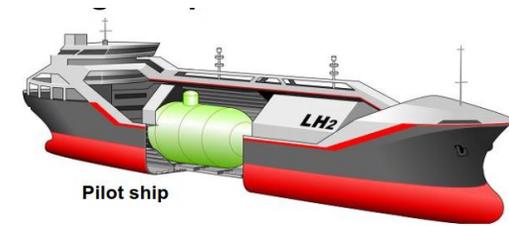
- National government has pledged support
- Major industry players have the ear of government, e.g.:
 - Air Liquide, Engie, Michelin, Faurecia, Total...
- Ambitious (renewable) H₂ schemes are in planning
- CEA is a source of technologies and start-up industries
 - E.g. Symbio, Sylfen
- Some regions are engaging strongly:
 - Rhône-Alpes, Nord-pas-de-Calais
- Vehicle roll-out strategy is largely around clusters

The Netherlands, Nordics, UK and Italy are also engaging

- **The Netherlands** has ambitious green and blue hydrogen schemes, as well as developing infrastructure, and large and small industrial players (e.g. Shell, Gasunie, Nedstack) and a government 'hydrogen envoy'
- **Norway** has increased interest in decarbonisation, zero emissions ferries and electrolysis
- **Sweden** has a cluster of fuel cell players (Sandvik, PowerCell, MyFC) and some H₂ infrastructure
- **Finland** has primarily worked on SOFC (Convion, Elcogen)
- **Denmark** has a history of smaller-scale fuel cells and is now looking at methanol (SerEnergy, Blue World)
- **The UK** has fuel cell and electrolyser players (e.g. Johnson Matthey, Intelligent Energy, ITM Power) and is deeply engaging in examining hydrogen for heat. Scotland has strong interest in renewable H₂
- **Italy** has had strong research for years and some industrial equipment players (e.g. SolidPower, Ansaldo, Nuovo Pignone, Giacometti); national government is now getting more involved

Japan remains a leader

- Hydrogen is enshrined in the national energy strategy and government liaises closely with industry (almost every company one can think of has an FCH link)
- An order of magnitude more fuel cells are installed in Japan than elsewhere (mainly Ene-Farm: ~300,000)
- Development covers much of the supply chain, including the only large-scale H₂ shipping trials
- Tokyo will host the 'Hydrogen Olympics' in 2020; after that things may accelerate or slow



Sources: Toyota, Panasonic, MHPS, Daimler/Mitsubishi, Kawasaki Heavy Industry

Korea has accelerated

- For some time large-scale stationary fuel cell installations (on natural gas or biogas) were driven by the Renewable Portfolio Standard
- Hydrogen has now come to the fore:
 - Pure hydrogen for stationary fuel cells (Doosan)
 - Aggressive targets for buses (2,000)
 - High expectations for cars (11,000 in 2020? 17,000?)
 - National hydrogen roadmap being supplemented by technology roadmap and legal enshrinement
- Hyundai has big plans, and a strong supply chain
- Doosan is also ramping up
- Smaller players (e.g. S-Fuelcell) are getting traction



Sources: Hyundai, S-Fuelcell

N American roll-out is mainly cars in California and some larger units in selected states; Canada mainly has manufacturing

- California has more cars than any other region globally – and an increasing fuelling network
- The US also has more forklifts than any other region
- Uptake of ‘large-scale’ stationary fuel cells is through Bloom and (recently fewer) FuelCell Energy units
- The US has some strong supply chain companies

- Canada has Ballard and Hydrogenics
 - Hydrogenics is now part of Cummins (and Air Liquide)
 - Ballard has strong China links through Weichai
- Uptake is mixed – some fuelling is coming to Vancouver, SFC Energy deploys units to oil and gas customers

The Chinese situation is evolving and complex

Chinese government appears (largely) HFC-supportive, but ambition and investment are not yet matched by full clarity or capacity

Strong policy drivers (13th 5-year plan)

A need to build internationally-competitive high value-added industries

National energy security, moving from imported resources to domestic coal

Major air quality problems in China, especially in urban areas

A desire to develop a secure and efficient modern energy system

The challenge of climate change, need for CO₂ emissions reduction

Significant opportunity

Large subsidies

Deep-pocketed investors and companies

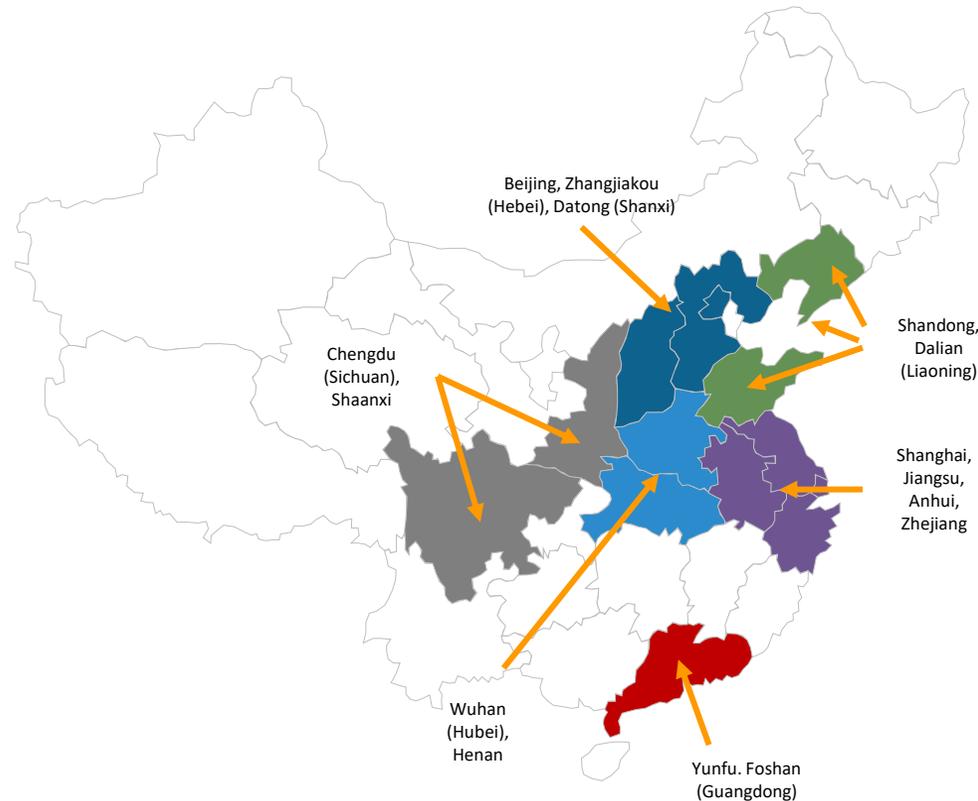
Evolving 'rules of the game'

'White space' to be occupied

Many different ...

- Companies
- Technology approaches
- Levels of capability
- Sets of numbers
- Expectations
- Supply chain dimensions

China is looking for its next industrial driver



- Fuel cells fit 5 year plan and subsidies are high
- Many regions have ambitious H₂ & FC plans
- South and east China most active (high population density, regional subsidies, capable industries)
- Vehicle deployment could overtake RoW

China's leading HFC actors are actively seeking partnerships abroad and also engaging in global initiatives, like the Hydrogen Council



Central government, regional authorities, and industry actors are working to industrialise fuel cells & hydrogen

NATIONAL SUBSIDIES

- Subsidies to vehicle manufacturers (in CNY): Car 200k; Light duty trucks 300k; Heavy duty 500k
- HRS subsidies to host city CNY 4m per HRS

INDUSTRY ROADMAP

- CATARC, SAE have put out road-maps with industry input to provide guidance on how HFC industry could evolve, and what economic value it can generate
- 1 million vehicles and 1,000 HRS by 2030 are the most widely reported goals
- Other goals include CNY 1 trillion industry output by 2030, size of supply chain, and hydrogen availability

REGIONAL SUBSIDIES & TARGETS

- Subsidies and goals in Shanghai, Beijing, Guangdong, Wuhan, and 10+ provinces and cities
- Local FCV subsidies top up national by 30% to 100%, with various conditions
- Vehicle deployment targets in 1-10k range per region; sum of regional targets exceeds nation-wide industry aspiration

BUT...

- Different ministries have different priorities
- Stakeholder alliances have overlapping scope, responsibility, and functionality
- Announced capacity could exceed targets, and hydrogen infrastructure is lagging

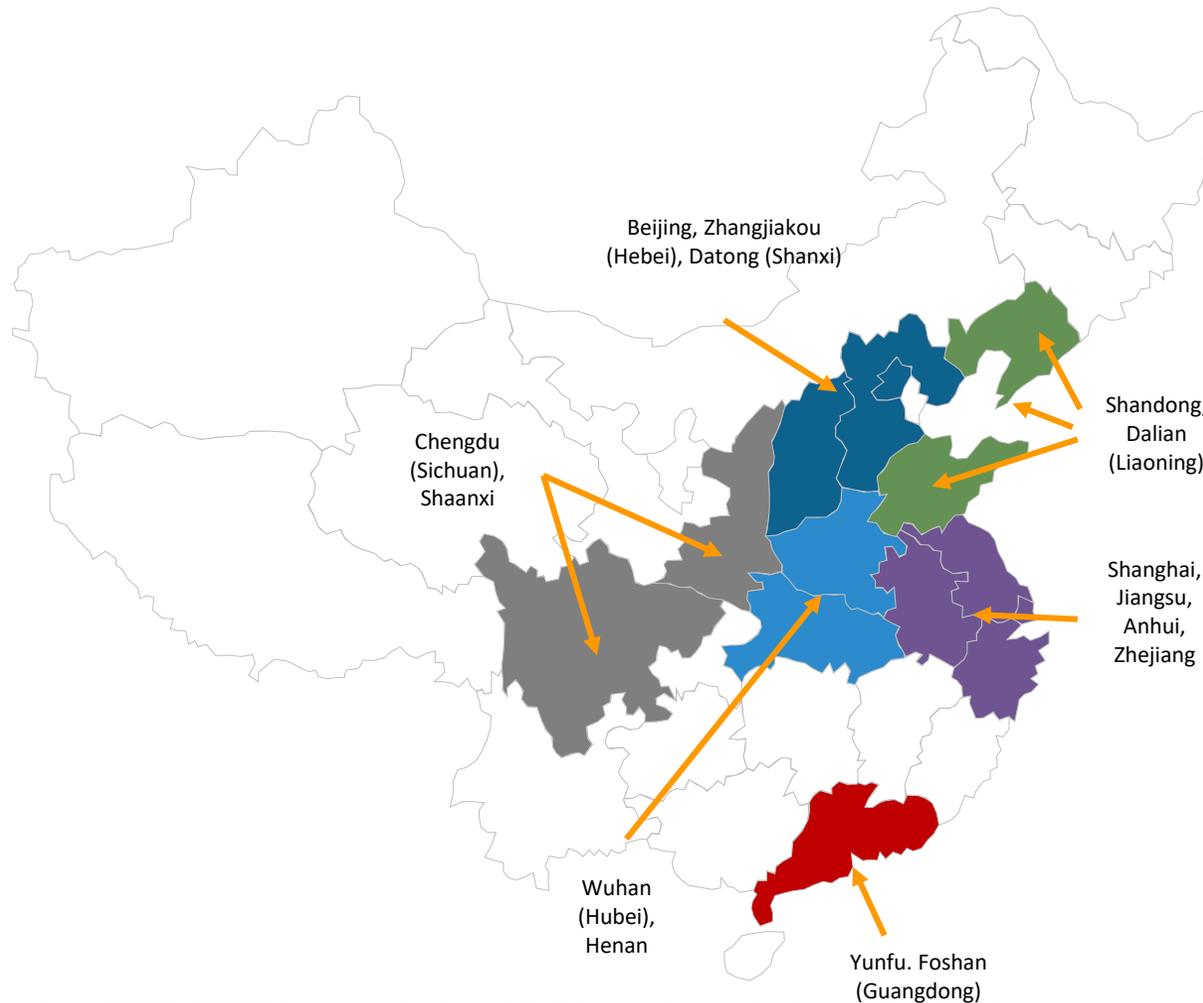
Policy remains supportive but may change focus

- New Energy Vehicle (NEV: BEV + FCEV) subsidy is being withdrawn gradually: new FCEV subsidy will be 80% of previous standard (400k not 500k RMB).
- Other policy measures are being examined:
 - Lane (e.g. HOV) exemptions, number plate exemptions, convenience of access (e.g. parking). Encouragement for local governments to build hydrogen refuelling infrastructure
- MIIT (Ministry of Industry and Information Technology) and other ministries considering a targeted subsidy for key components, instead of a subsidy to OEMs
- NEV planning 2021-2035 has been published for industry comments:
 - Focus seems to consider BEV for passenger cars; FCEV for commercial vehicles
 - BEV, PHEV, and FCEV, “are part of the vehicle innovation chain” and require technology development
 - “orderly development of hydrogen fuel to guarantee supply and demand, ..., develop industrial by-product and renewable hydrogen, develop and demonstrate ... hydrogen storage technology, explore hydrogen pipeline construction, to reduce hydrogen fuel storage and transport cost“

Hydrogen infrastructure remains a big push

- For the first time ever, hydrogen refuelling infrastructure was referred to in the State Council's Annual Report on the Work of the Government, delivered by Premier Li
- Hydrogen-related development is increasing, though fuel cells remain the main industrial focus
 - Sinopec is now building HRS and recently invested in Shanghai Re-fire
 - Hydrogen infrastructure building is required to catch up with vehicle registrations
 - But regulations remain a barrier (is hydrogen an industrial chemical or energy carrier?)
- Despite slow infrastructure development and subsidy payment, vehicles are being deployed

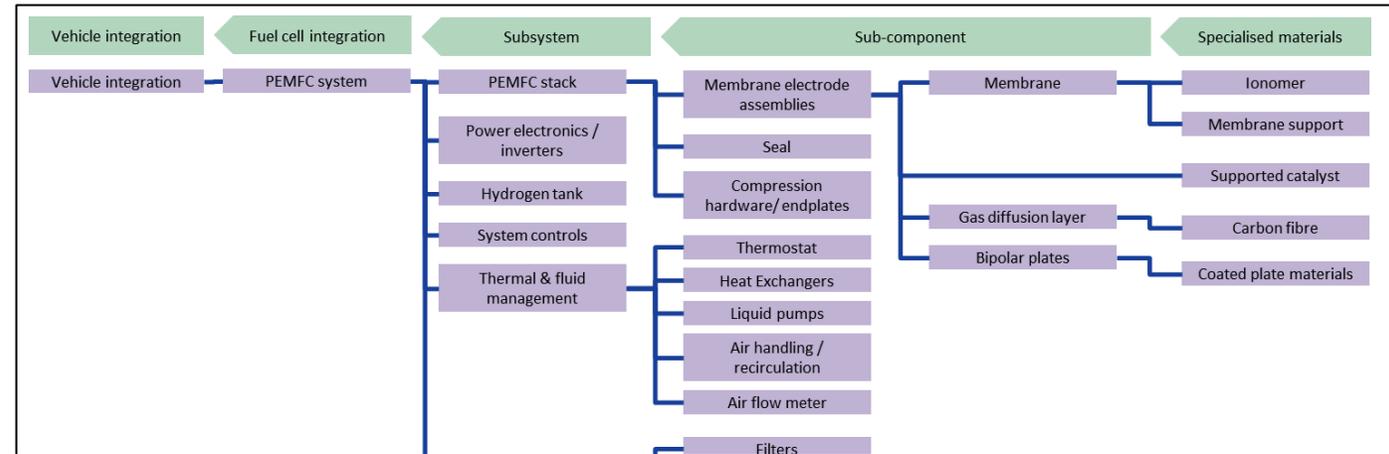
Developments are happening across China: Guangdong, Shanghai and Beijing are the most active regions



- China wants to 'localise' nationally...
- ...and many regions have ambitious HFC plans
- South and east China will see most activity (high population density, regional subsidies, and industry capabilities)
 - Guangdong – manufacturing-savvy and business-friendly
 - Shanghai – finance and automotive industry
 - Beijing – central government decision-makers

So China's HFC industry is growing fast, though durability needs to be proven

- E4tech's database now stands at 350+ HFC companies in China
- The situation has been compared to the Wild West:
 - Government subsidies are driving the market
 - Indigenous capability varies dramatically
 - Overseas expertise is in high demand
 - Even local experts get 'poached'
 - Some companies are long-term and serious...
 - ...others are not



Clean Energy Supply Chain and Manufacturing Competitiveness Analysis for Hydrogen and Fuel Cells. U.S Department of Energy Project DE-EE-0006935

	Manufacturing Readiness															
	Bipolar Plate				Catalyst				Gas Diffusion layer				Membrane			
	US	EU	Asia		US	EU	Asia		US	EU	Asia		US	EU	Asia	
			Japan	China			Japan	China			Japan	China			Japan	China
1-10k	H-M	HIGH	HIGH	HIGH	H-M	HIGH	HIGH	HIGH	H-M	HIGH	HIGH	HIGH	H-M	HIGH	HIGH	HIGH
100k	M-L	MOD	MOD	LOW	MOD	H-M	H-M	LOW	M-L	MOD	MOD	LOW	LOW	MOD	M-L	LOW

2017 in partnership with:   

Hydrogen sources exist, but refuelling infrastructure is still emerging. Component supply chains remain fragile and opportunities can be taken

- Enormous 'excess' hydrogen capacity exists in the chemicals industry, but green hydrogen is not (yet?) a priority
 - Partnerships, expats and returning Chinese experts are currently essential for successful development
 - Combining expertise with a Chinese cost base is likely to drive cost down fast
 - But the Chinese supply chain is incomplete
- ▼
- Good opportunities exist for co-development, company building, profitability and exit
 - Approaches to partnership vary widely
 - Succeeding will require technology, know-how, trust...
 - ...and luck?



Trucks at Bing Energy



Buses and Trucks at Synergy

Source: author

What to expect

The FC industry is *starting* to gel. H₂ potential needs to be proven. Developments in China *will* have an impact, for better or worse

Better

- Chinese policy is strong
- Technology and manufacturing are being forced to grow up fast
- The HFC industry globally needs market opportunities and funding for scale-up
- Tangible commercial scale fleets will enthuse investors
- Component costs could drop, with positive effects in different applications

Worse

- Policy is disjointed and could damage goodwill
- Companies will fail and manufacturing may not meet standards
- The industry can only deliver on a small amount right now
- Inadequate performance would weaken the industry case
- Making things cheaper but less well could damage the supply chain significantly

And if you have questions, please get in touch

Thank you!

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E4tech's annual Fuel Cell Industry Review
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