Hydrogen Economy 氢经济

Urban hydrogen concepts in transport, energy, buildings (fuel cell CHP), and industry in Germany

交通，能源，建筑（燃料电池热电联产）和德国工业中的城市氢概念

Presentation 简报:

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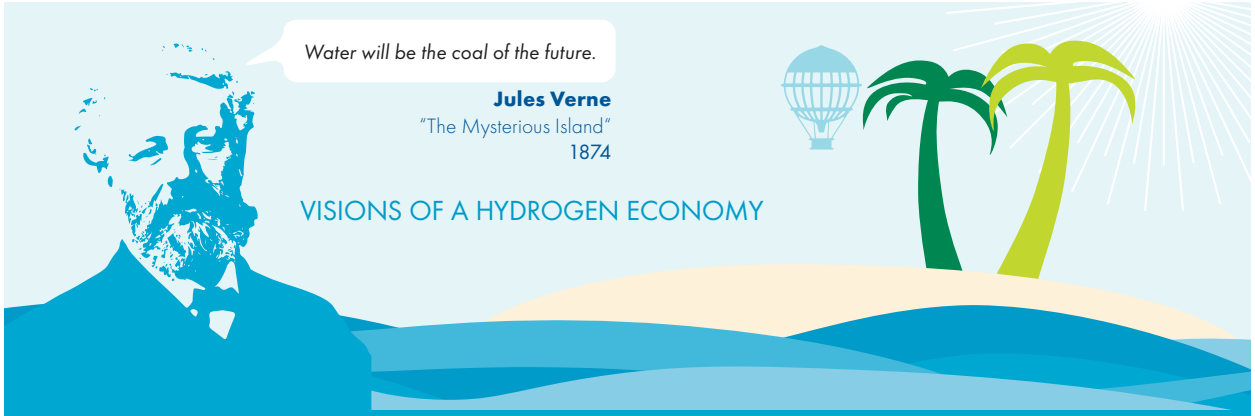
Introduction 介绍

Vision of a hydrogen economy is not new
氢经济并不是新的愿景
Old dream but now in a phase with realistic implementation chances
旧的梦想但现在处于一个将要实现的阶段

“水将成为未来的煤炭”
朱尔·凡尔纳
「神秘岛」
1874



Almost since its discovery, hydrogen has played an important part in contemporary visions of the future, especially in relation to the energy industry and locomotion.

As early as 1874, the French science fiction writer Jules Verne (1828 – 1905) in his novel "L'Île mystérieuse" (The Mysterious Island) saw hydrogen and oxygen as the energy sources of the future. In his vision, hydrogen would be obtained by the breaking down of water (via electrolysis). Water, resp. hydrogen, would replace coal, which at the time was the dominant energy source in the energy supply industry.

In the 1960s, the successful use of hydrogen as a rocket propellant and of fuel cells to operate auxiliary power units in space – especially in the context of the US Saturn/Apollo space travel programme – provided further impetus to the fantasies surrounding hydrogen. Also in the 1960s, first passenger cars were fitted with fuel cells as basic prototypes resp. technology demonstrators.

During the 1970s, under the impression of dwindling and ever more expensive fossil fuels, the concept of a (solar) hydrogen economy was developed, with H_2 as the central energy carrier. Since the 1990s, hydrogen and fuel cells have made huge technical progress in the mobility sector. After the turn of the century, not least against the background of renewed global raw material shortages and increasingly urgent questions of sustainability, the prospects for a hydrogen economy were considered once again (Rifkin 2002).

More recently, the focus has increasingly been on hydrogen's role in a national and global energy transition. Within this context, the value added of hydrogen (from renewable energies via electrolysis) in an increasingly electrified energy world has also been subject to discussion. Nevertheless, an important role is envisaged for hydrogen – especially as a clean, storable and transportable energy store – in an electricity-based energy future (Nitsch 2003; Ball/Wietschel 2009).

Use cases of hydrogen and (selected) experiences in Germany
德国氢气的使用案例和经验

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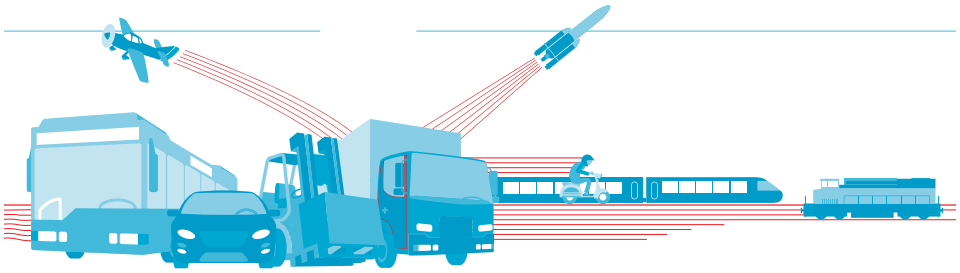
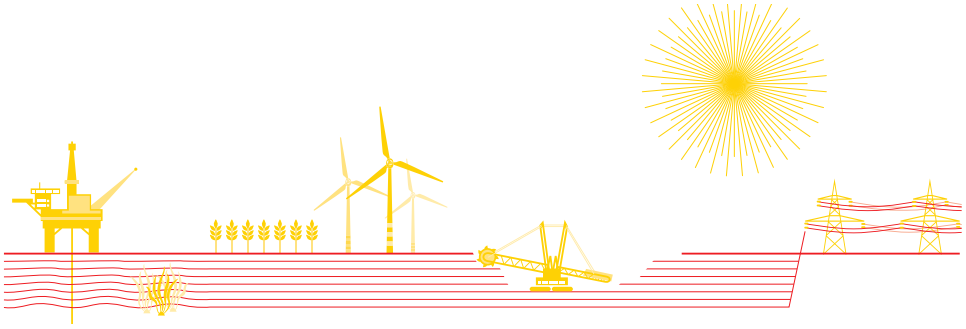
Mobility applications 交通领域的应用

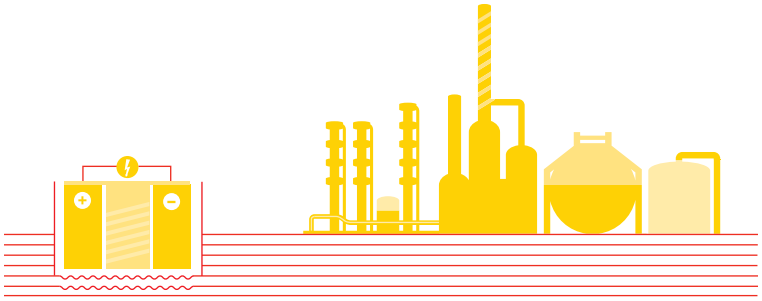


Stationary applications 固定的应用

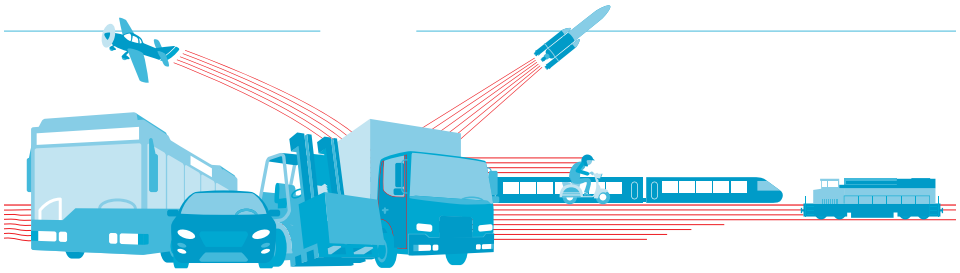
Applications at system level 系统层面的应用



Applications in industries 工业的应用



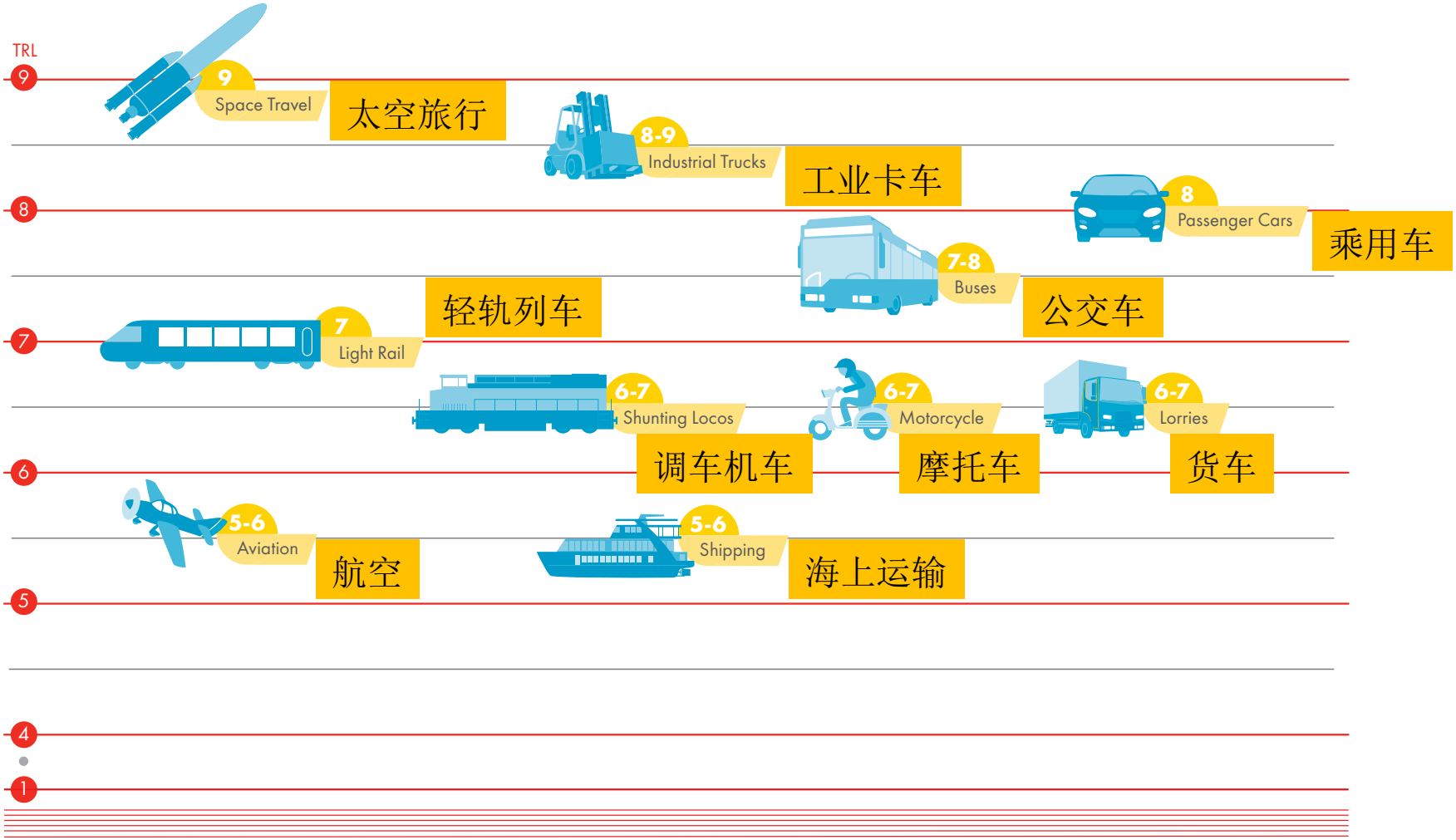
Mobility applications
交通领域的应用



Mobility applications 交通领域的应用

Broad range of options with different status (Technology Readiness Level)

不同状态的广泛应用（技术成熟级别）



Mobility applications in Germany 在德国的移动性应用

Fuel Cells used for mobility purposes in busses and trains

用于公交车和火车的燃料电池

Recent developments 近期发展:

- Regional Transport Company in Cologne (RK) ordered 30 FC busses and Wuppertaler Stadtwerke (WSW) ordered 10 FC busses

科隆的区域运输公司（RK）和Wuppertaler Stadtwerke（WSW）分别订购了30辆和10辆燃料电池公交车

- Biggest contract in this area at European level

在这个领域欧洲的最大合同

- Start of operation in spring 2019

2019年春季开始运营

- Busses are produced in Belgium (Koningshooikt)

公交车在比利时生产

- WSW implemented own supply structure for hydrogen (electrolyser connected to waste incineration plant

WSW使用了自己的氢供应设施（连接到垃圾焚烧厂的电解槽）

- First experience with fuel cell trains in northern part of Germany (substitute for diesel driven engines)

首次在德国北部使用燃料电池列车（替代柴油驱动发动机）

Erster Wasserstoffzug in Schleswig-Holstein

Premiere im Norden: Zwischen Neumünster und Kiel ist am Montag erstmals ein mit Wasserstoff angetriebener Zug unterwegs gewesen. Mit an Bord war Verkehrsminister Buchholz. (01.10.2018) **mehr**

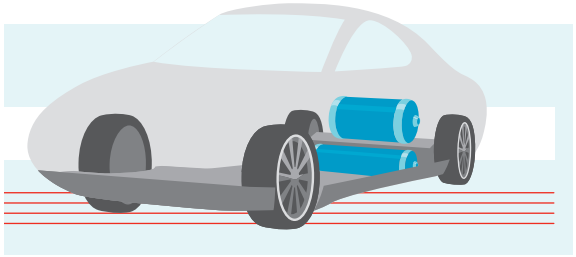
Brennstoffzellenzug: Premiere mit hohen Erwartungen

Wassertropfen statt Ruß: Der weltweit erste mit Wasserstoff angetriebene Zug ist in Bremervörde zur Premierenfahrt gestartet. Heute folgt der Linienverkehr für "Coradia iLint". (17.09.2018) **mehr**

Mobility applications in Germany 在德国的移动性应用

Fuel Cell Vehicles still at the very beginning of market introduction

燃料电池汽车仍处于市场引入的最初阶段



- Fuel cell car production clearly dominated by Asian companies (list of FC vehicles in series production)

燃料电池汽车生产明显由亚洲公司主导（系列生产中的燃料电池车辆清单）

模型	市场启动	到达范围			加速度	最大扭矩	合并的燃料消耗	油箱容量	年产量
Modell	**Markteinführung**	**Reichweite (km).**	**V_{max} (km/h)**	**kW (PS)**	**Beschleun. 0 auf 100 km/h (s)**	**Maximales Drehmoment**	**Verbrauch (H_2) kombiniert in kg/100 km**	**Tankinhalt in kg**	**jährliche Produktion (Stand)**
Honda FCX Clarity[1]	2008 (1. Generation)	650	165	44 (60)			0,87	1,78/2,09	
Hyundai ix35 FCEV[2][3]	2013	594	160	100 (136)	12,5	300	0,95	5,64	
Toyota Mirai[4][5]	2014	500	175	114 (155)	9,6	335	0,76	5	ca. 3.300 (2017)[6]
Honda Clarity Fuel Cell[7]	2016 (2. Generation)	650	165	130 (176)	9	300	0,77	5	
Renault Kangoo Z.E. H2[8]	2017	290	130	44 (60)			0,87	1,78/2,09	
Hyundai Nexo[9][10]	2018	756	179	120 (163)	9,5	395	0,84	6,33	
Mercedes-Benz GLC F-Cell[11]	Dezember 2018	437 plus 49 (Batterie)	160	147 (200)		350	0,97 (19 kWh elektrisch)	4,4 plus 9,3 kWh (Batterie)	
StreetScooter H2 Panel Van[12]	ab 2020	500	120	122 (166)				6	

Mobility applications in Germany 在德国的移动性应用

Fuel Cell Vehicles still at the very beginning of market introduction

燃料电池汽车仍处于市场引入的最初阶段

- In Germany mainly Mercedes (and BMW) are active and follow the technology line

在德国，梅赛德斯（和宝马）也活跃于该技术领域

Mercedes GLC F-Cell

Der GLC kombiniert zwei Energiespeicher: eine 90 PS starke Brennstoffzelle sowie einen Akku, der 100 kW beisteuert und das Auto zum Plug-in Hybriden macht. Batterieelektrisch sind nach NEFZ-Norm 50 Kilometer drin, 4,4 Kilogramm Wasserstoff bringen knapp 440 weitere Kilometer Reichweite. Beide schicken ihre Energie zu einem 211 PS starken Elektromotor, der die Hinterachse antreibt.

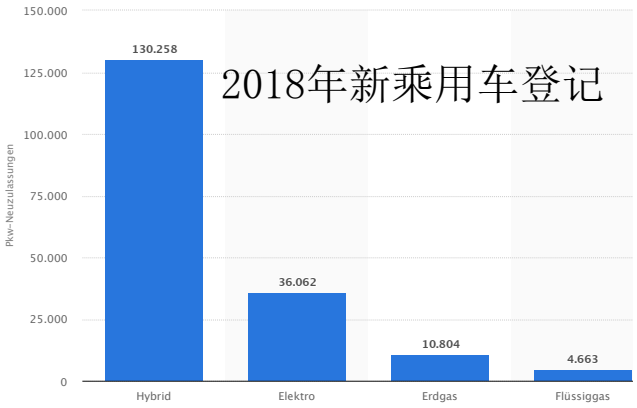
Mercedes GLC F-Cell.

- German government supports market introduction by up to 21,000 € per vehicle

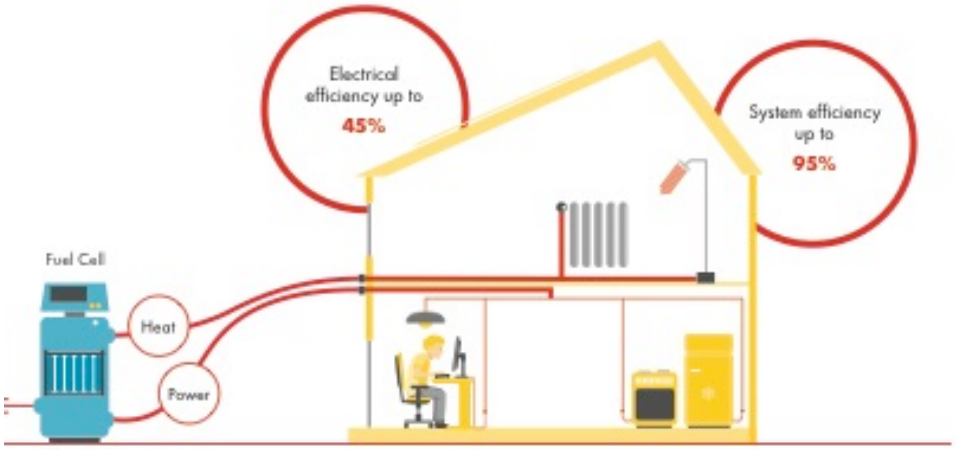
德国政府给予每辆车高达21,000欧元的补贴

- FC car fleet is however still very small (at the beginning of 2019 only FC 392 cars have been registered and were on the road – in comparison to a total car fleet > 40 Mio. cars)

燃料电池汽车的数目仍然非常小（相比于4000万辆汽车保有量，在2019年初只有392辆已注册的燃料电池汽车在路上行驶）



Stationary applications
固定的应用



Stationary applications in Germany 在德国的固定应用

Fuel Cells for stationary applications so far not in the focus – pilot and demonstration plants as well as first market offers

燃料电池在固定应用方面至今尚未成为焦点 – 试验和示范工厂以及首批市场供应

PROJECT DETAILS

Operation of 100 micro-cogeneration plants

PROJECT TARGET

Installation of various types of equipment in the field of micro-cogeneration (Stirling engine, Otto engine, fuel cell) as a comprehensive field test in Bottrop. Scientific support to optimise and support the introduction of energy-effficient gas-plus-application technologies. A secondary aim is the development and assessment of technology concepts which are adapted to the future application situation for the new building area but in particular also for the existing building stock and are highly efficient as regards primary energy.

InnovationCity Ruhr
Modellstadt Bottrop

- Pilot and demonstration program 100 small scale CHP plants (incl. fuel cells) in Innovation City Ruhr

在创新城市鲁尔区的100个小型热电联产工厂（包括燃料电池）试点和示范项目

燃料电池供热的产品

Produktdetails zur Brennstoffzellenheizung

Details zur Vitovalor PT2 von Viessmann:

- Parallele Erzeugung von Strom und Wärme zur Minimierung der Stromkosten und zunehmende Unabhängigkeit vom Strompreis
- Integrierter Strom- und Gaszähler
- Brennstoffzelle: 750 Wel, 1 kWth; Gesamtwirkungsgrad 90 % (Hi); Elektrischer Wirkungsgrad 37 %
- Gas-Brennwertmodul: bis 18,9 kW oder 25,2 kW; (Trinkwasser bis 30 kW); Nutzungsgrad 98 % (Hs)
- Innovative Zukunftstechnologie
- Platzsparende Bauweise - benötigt nur 0,65 m² Aufstellfläche
- Leiser, komfortabler und intelligenter Betrieb
- Fernbedienung und Abruf von aktuellen Daten per App möglich

→ Weitere Details zur Vitovalor PT2 (/de/pk/heizung/brennstoffzellen-heizung/vitovalor.html)

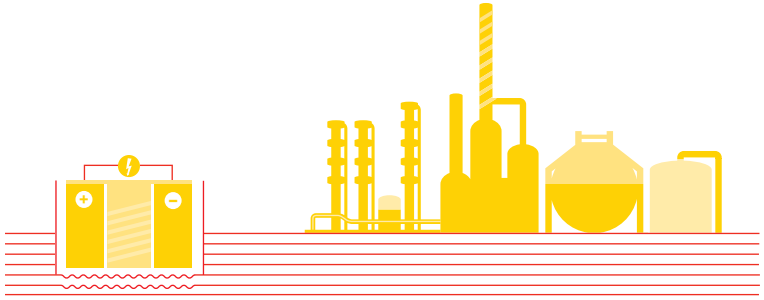
- First market offers from professional companies (cooperation between energy utilities and manufacturer of heating systems)

首个由专业公司提供的服务（能源公用事业和供暖系统制造商之间的合作）

- Market wins dynamic (based on financial support from government > 5,000 fuel cell systems have been ordered since 2016; cf. with > 200,000 in Japan)

赢得市场（基于政府的财政支持，自2016年以来已有超过5,000个燃料电池系统的订购；而日本超过200,000个）

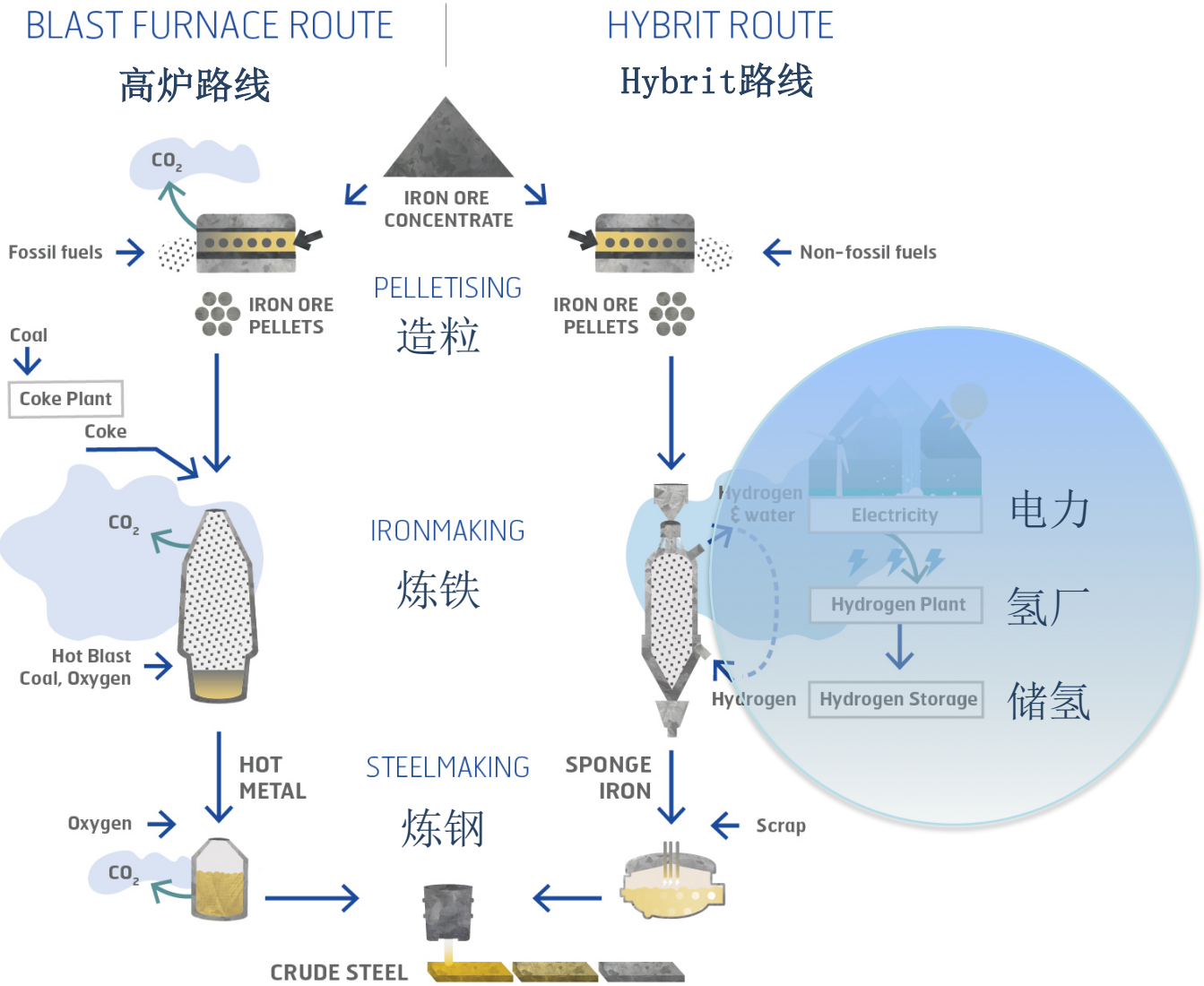
Applications in industry
工业的应用



Applications in industry in Germany 在德国的工业应用

Example: Steel making today and tomorrow (blast furnance -> hydrogen based steel making (direct reduction process))

示例：今天和明天的炼钢（高炉→氢气炼钢（直接还原工序））



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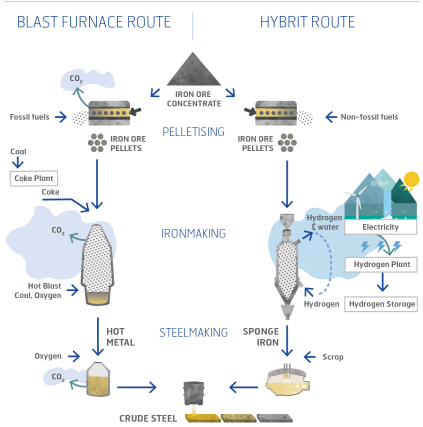
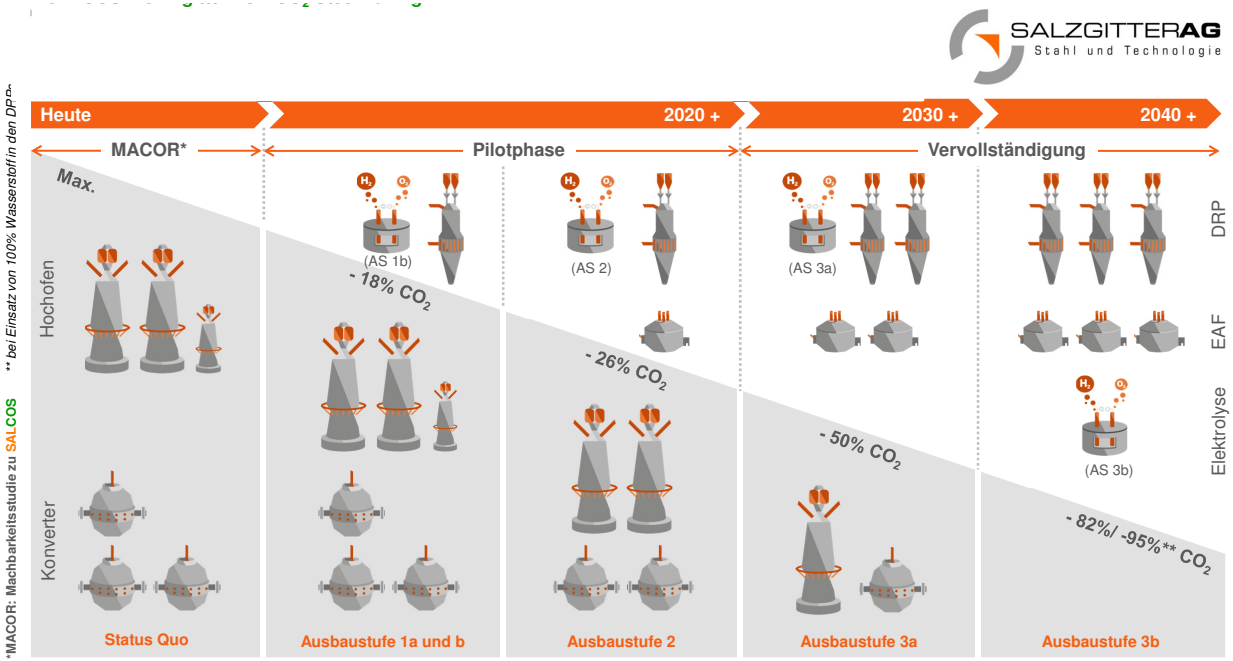


- Concrete plans for step by step change of steel making process of major German steel companies (e.g. Thyssen Krupp Steel, Salzgitter AG)

德国主要钢铁公司（如Thyssen Krupp Steel，Salzgitter AG）逐步改进炼钢工序的具体计划



Applications in industry in Germany 在德国的工业应用

Example: Blending of fuels with hydrogen to cover EU CO_2-standards in refineries

示例：燃料与氢气混合，以涵盖欧盟对炼油厂的二氧化碳标准

Refinery in Lingen (Emsland)
林根的炼油厂（埃姆斯兰）

- BP and Uniper, together with the Fraunhofer Institute for Systems and Innovation Research ISI, submit project outline for the "Real-world laboratories energy transition" competition
- The planned project envisages the integration of renewable energy in the form of hydrogen into the transport sector
- Power-to-gas technology (PtG) in refinery processes (PtGtR) makes a positive contribution to the energy transition

- 英国石油公司和Uniper公司，与弗劳恩霍夫系统与创新研究所合作提交“真实世界实验室能源转型”竞赛项目大纲
- 项目预期将基于可再生能源的氢气应用到交通领域
- 炼油工序中的电转燃气技术为能源转型做出了积极的贡献

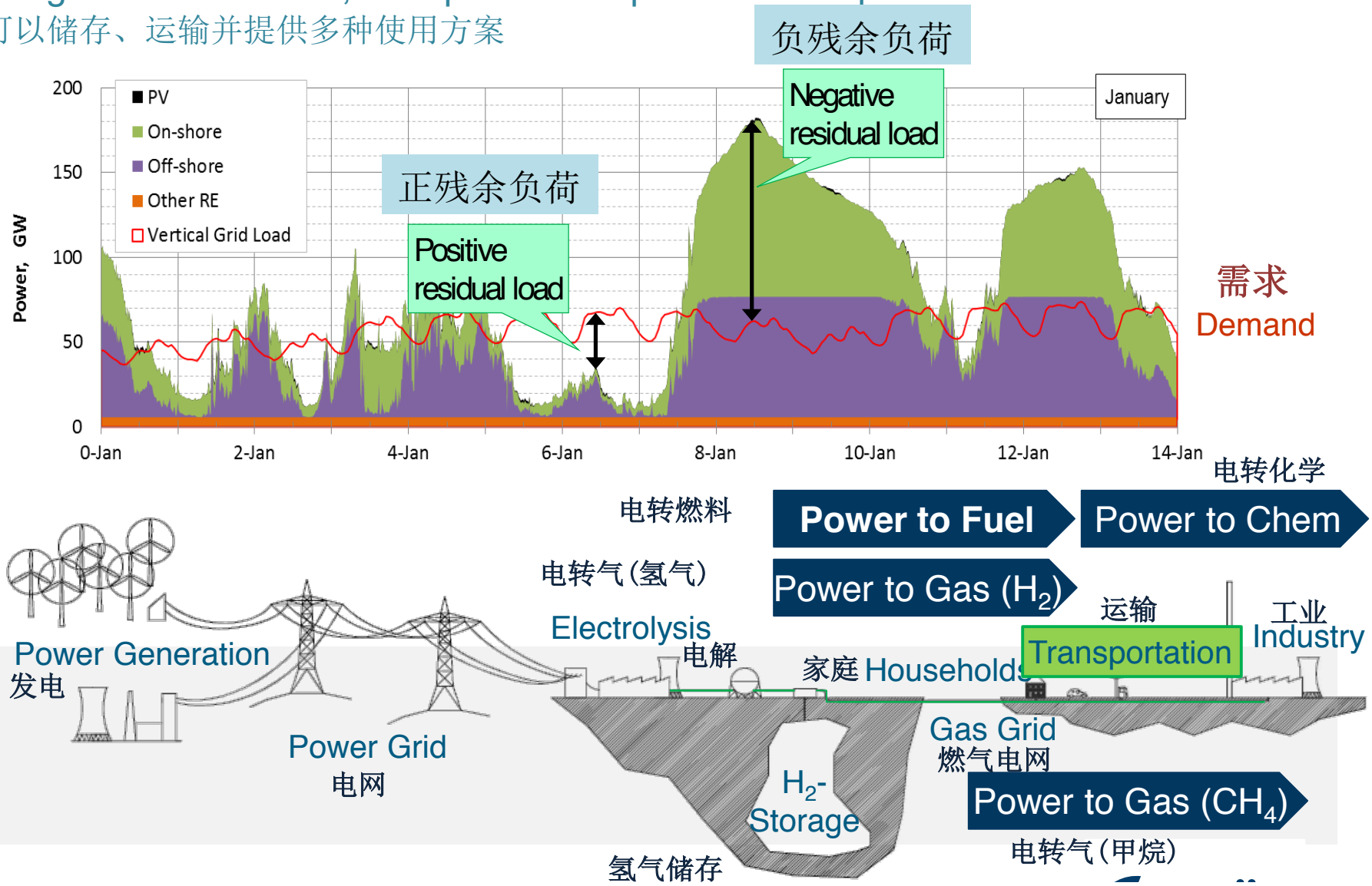
Use of hydrogen from a systems perspective
系统层面的氢气使用

Hydrogen as an option for sector coupling and potential answer for the intermittency of renewable energy (electricity) supply

氢气是行业耦合的一种选择，并可解决可再生能源（电力）供应的间歇性问题

Hydrogen can be stored, transported and provides multiple use cases

氢可以储存、运输并提供多种使用方案



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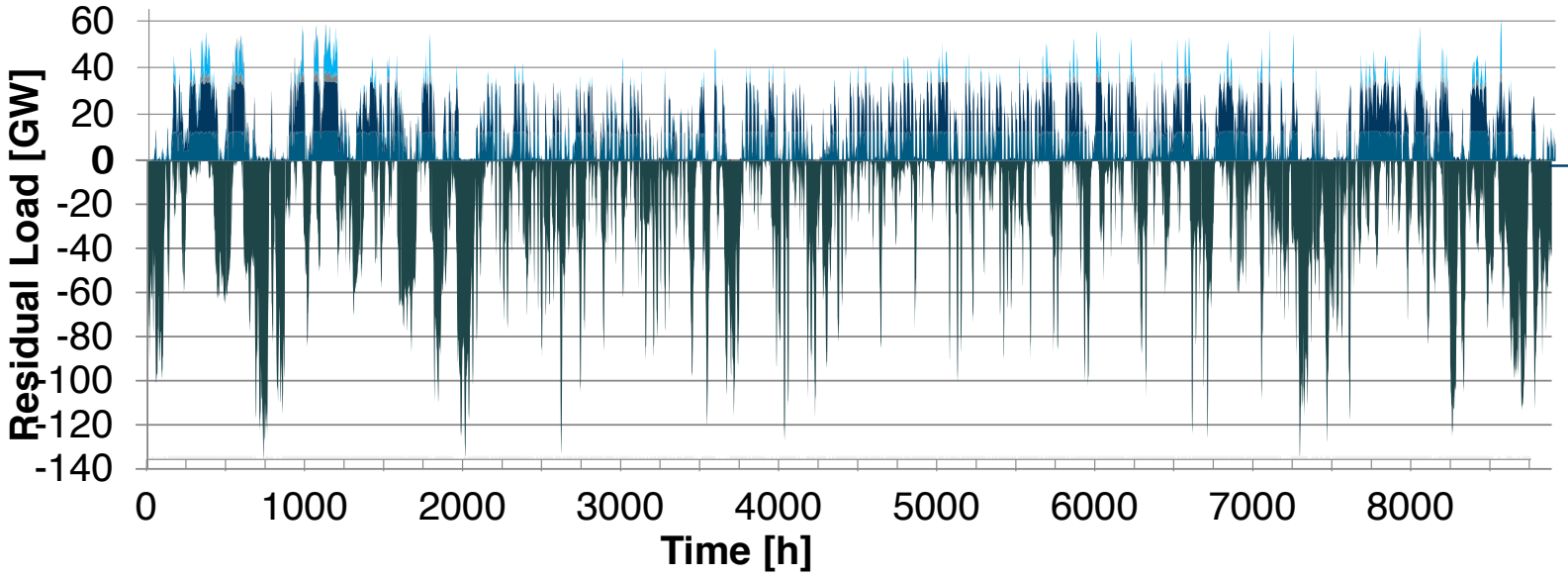
Growing fluctuations in the load curve over time (potential status in 2050 in Germany)

负荷曲线的波动随着时间越来越大（德国2050年的潜在状况）



保证电网稳定的补充电量

Supplementary feed-in for grid stabilzation

Renewable Excess energy e.g. for Sector coupling

多余可再生能源，例如用于耦合

Back-up power production with gas turbines needed

- First fed with natural gas
- Later fed by hydrogen

需要燃气轮机的备用电力生产

•先天然气

•后氢气

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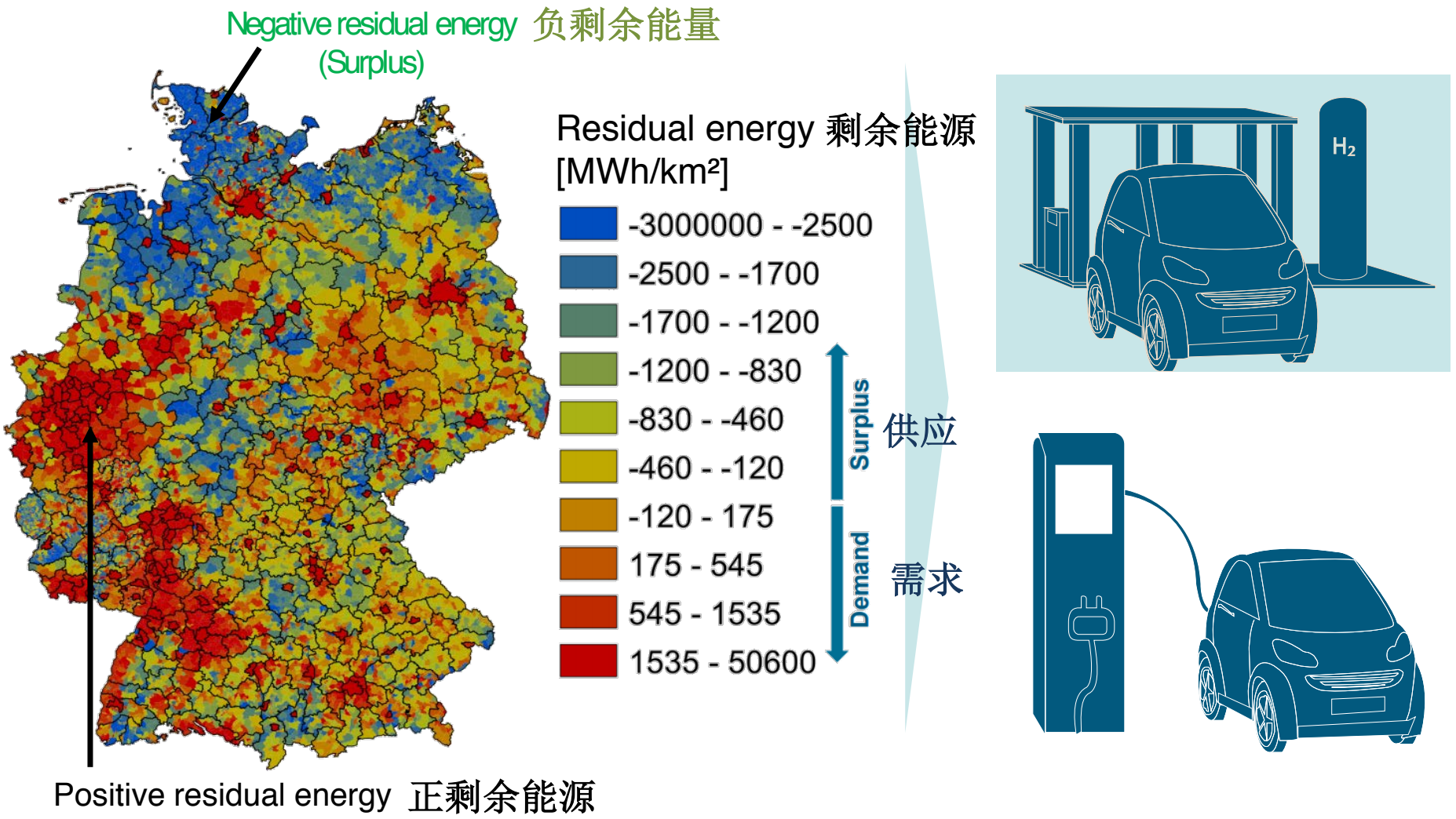
Linking the power and the transport sector

连接电力和交通领域

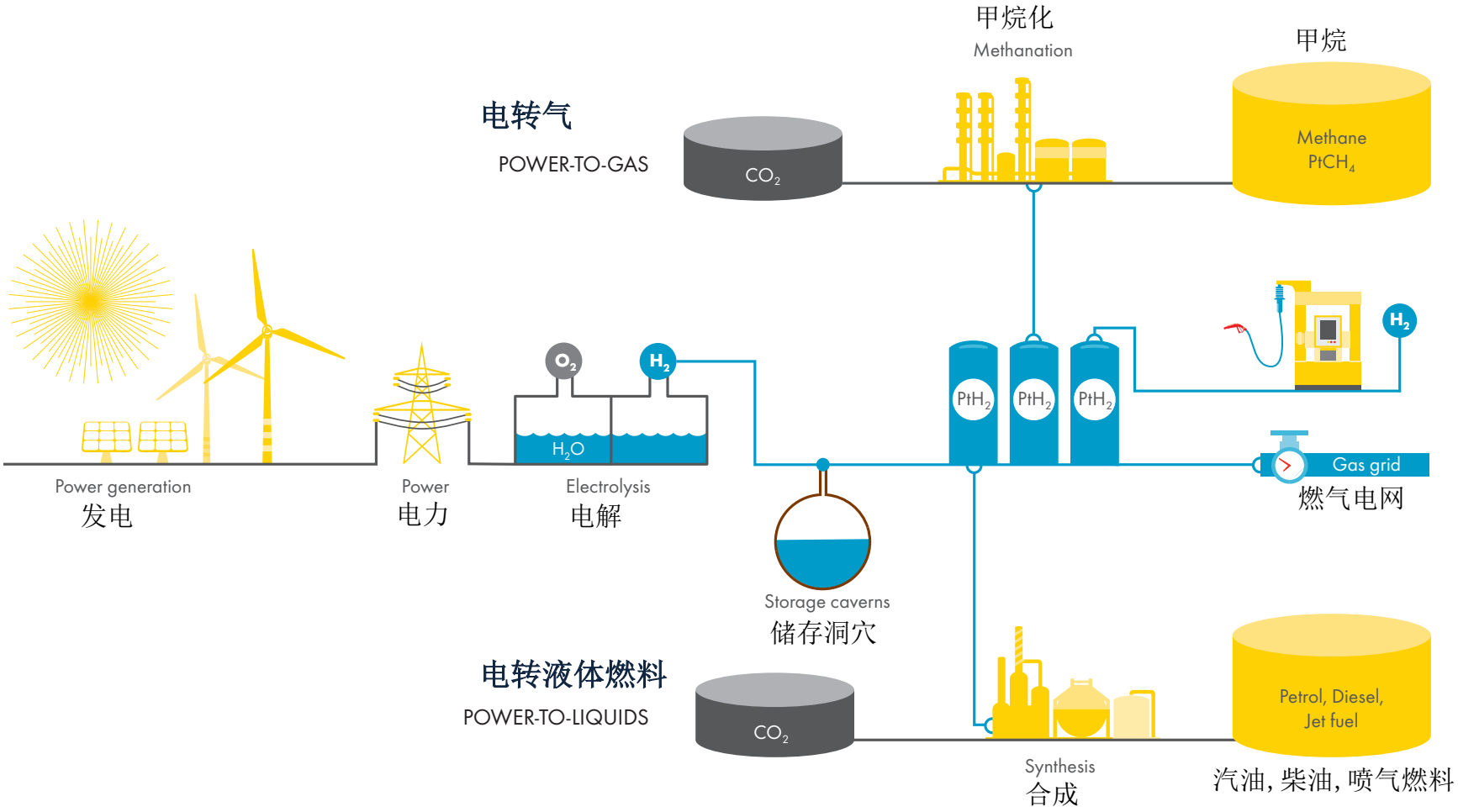


Use of hydrogen from a systems perspective in Germany (focus PtX)

德国系统角度的氢气使用（集中于电力转化）

Hydrogen as basis for provision of synthetic gas/fuels or substitute for natural gas in the gas grid via Power to x-technologies

氢气作为提供合成气体/燃料的基础，或通过电转X技术替代天然气



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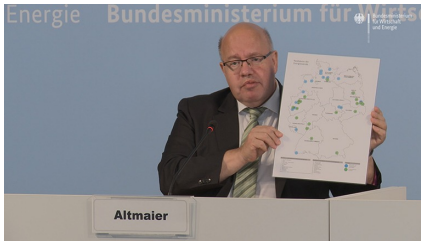
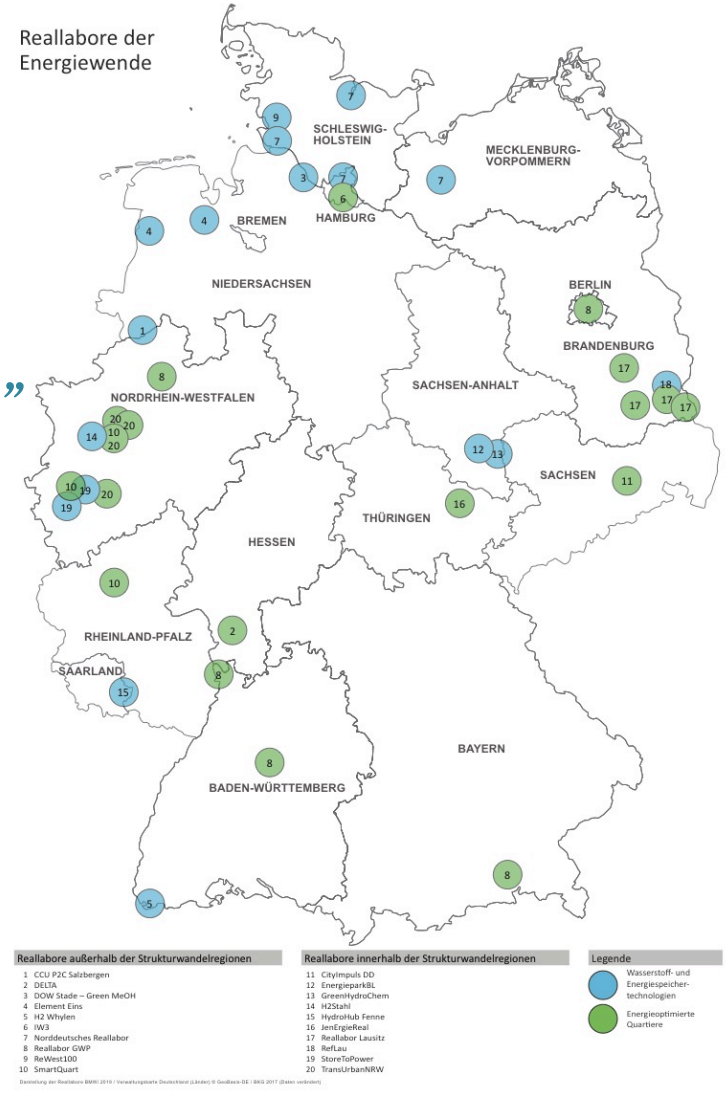
Altmaier verkündet Gewinner im Ideenwettbewerb ‚Reallabore der Energiewende': „Wir wollen bei Wasserstofftechnologien die Nummer 1 in der Welt werden"

In bundesweit 20 Reallaboren erproben Unternehmen künftig v.a. neue Wasserstofftechnologien im industriellen Maßstab und in realer Umgebung.



Altmaier在创意竞赛“现实能源转型实验室”宣布获奖者：「我们希望成为世界氢能技术的冠軍」

在全国20个现实实验室项目中，各公司对氢气创新技术进行工业规模的试验。



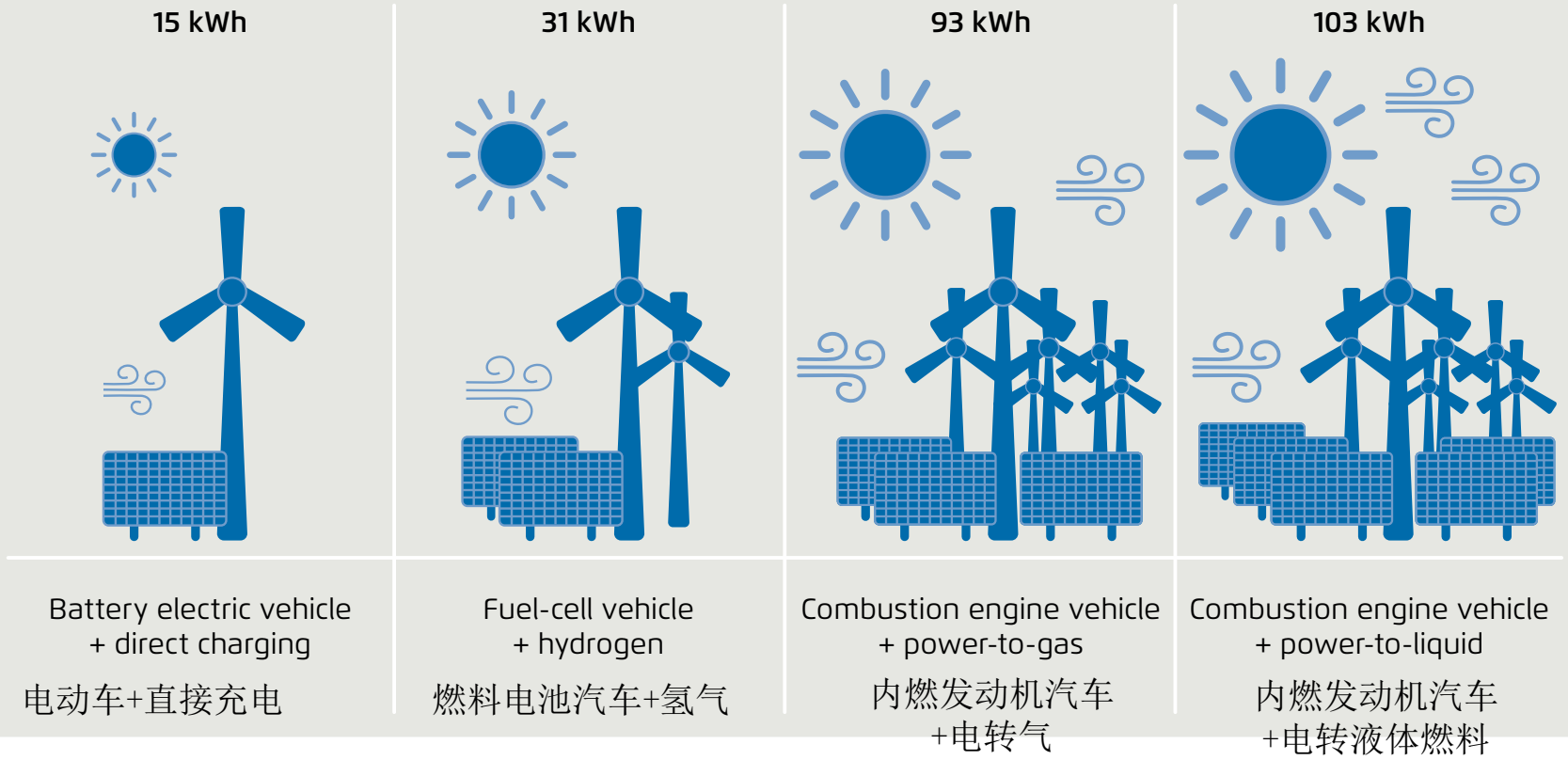
Hydrogen as an option for sector coupling
氢气是行业耦合的一种选择

Reflecting the efficiency losses hydrogen based mobility is less efficient than electric vehicles but much better than synthetic (renewable based) fuels
考虑到效率，以氢为基础的汽车比电动车低，但比合成燃料车（以可再生能源为基础）好很多

Amount of renewable energy required for various powertrain and fuel combinations (per 100 km)

Figure 6.1

各种动力系统和燃料组合所需可再生能源量（每100公里）



Hydrogen supply structures – how to get sufficient and competitive hydrogen

氢供应结构 – 如何获得充足和有竞争力的氢气

Hydrogen supply structures
氢供应结构

Hydrogen supply structure will most likely require a new way of thinking (e.g. big offshore wind farms dedicated to provide hydrogen)

氢供应结构可能需要一种新的思维方式（例如专门提供氢气的大型海上风电场）

North Sea Wind Power Hub
北海风力发电枢纽

Project partner项目伙伴:

TenneT TSO B.V. (Niederlande荷兰)

Energinet.dk (Dänemark丹麦)

TenneT TSO GmbH (Deutschland德国)

Gasunie (Niederlande荷兰)

Port of Rotterdam (Niederlande荷兰)

- Artificial island in the North Sea (6 sqare kilometers)

北海人工岛（6平方公里）

- Crossroad for offshore wind parks (30 GW installed capacity) and interconnectors for the European electricity trading market

海上风电场的十字路口（30 GW装机容量）和欧洲电力交易市场的枢纽

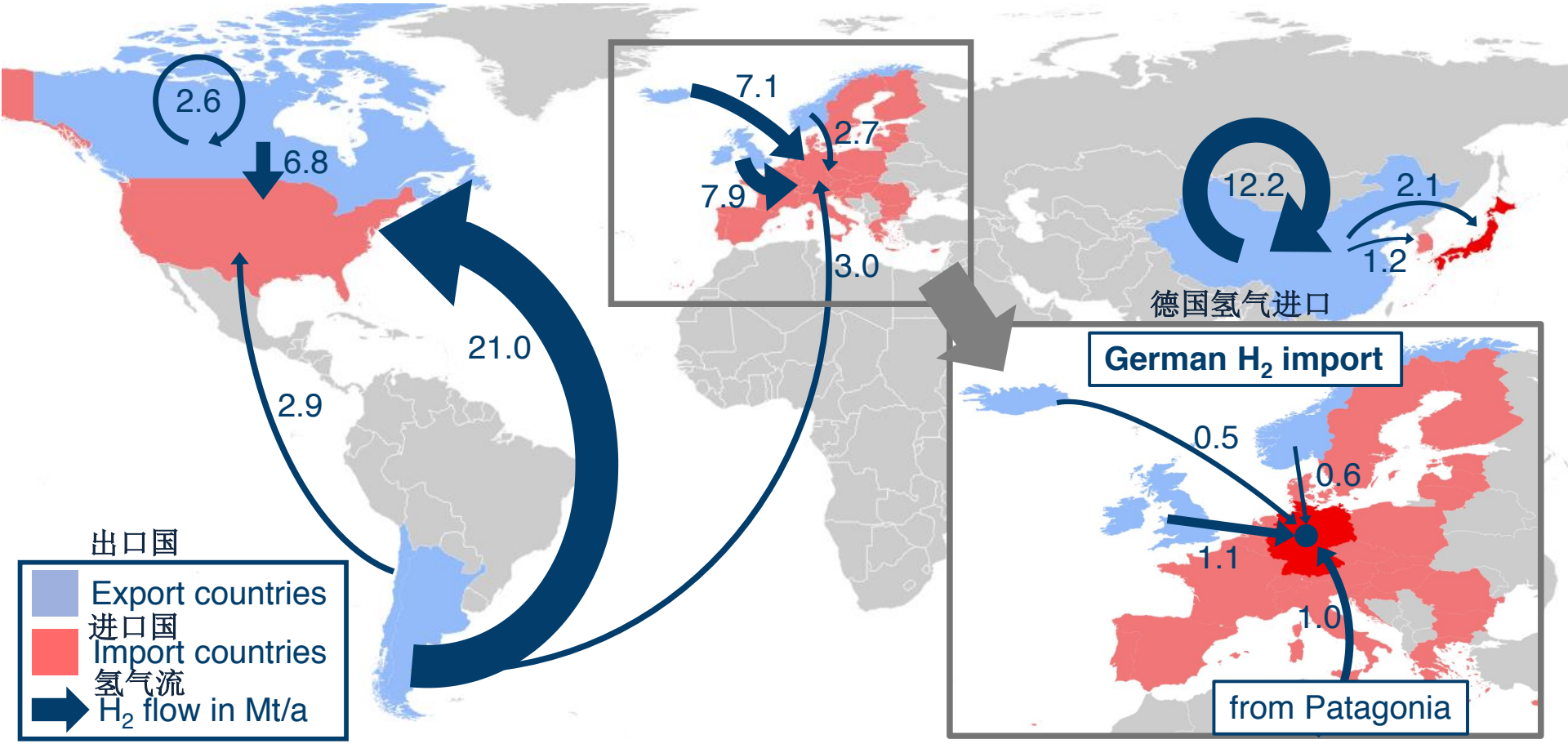
- Starting point for delivering either electricity or hydrogen to neighbouring countries

以给邻国提供电力或氢气作为起点

Sonne Wind & Wärme 5/2017, S.20 „Oase in der Nordsee“
https://northseawindpowerhub.eu/wp-content/uploads/2017/11/Concept-Paper-3-Hub-as-an-Island.pdf

Hydrogen supply structures
氢供应结构

Hydrogen supply structure will be most likely based on global commodity streams making use of low generation costs in sun/wind rich countries
氢气供应结构最有可能基于在太阳/风能丰富的国家中低供应成本的全球商品流



需求	Germany	Japan	EU	USA	Canada	China	South Korea
Demand in Mt/a (75% Scenario)	3.14	2.05	17.58	30.61	2.55	12.22	1.15
Import LCOH in €/kg (*)	4.66	4.81	4.67	4.34	4.66	4.71	4.77

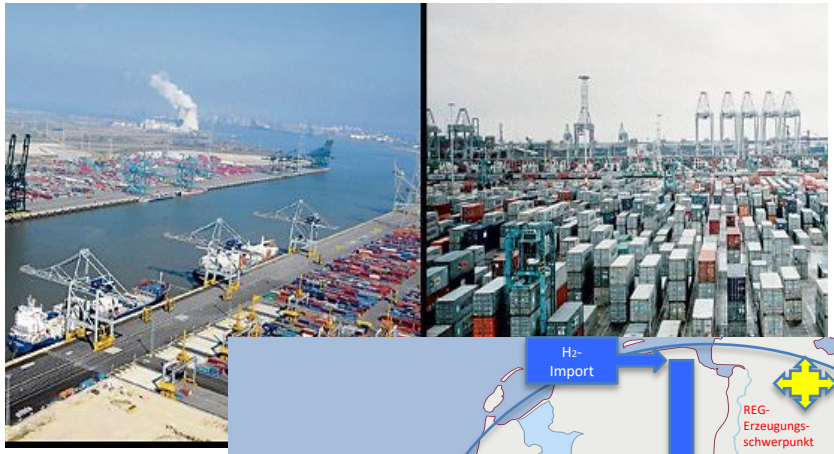
Hydrogen supply structures
氢供应结构

Ports will play important role - existing oil based hubs (e.g. ports) could become a future hub for clean fuels embedded in own low carbon strategy

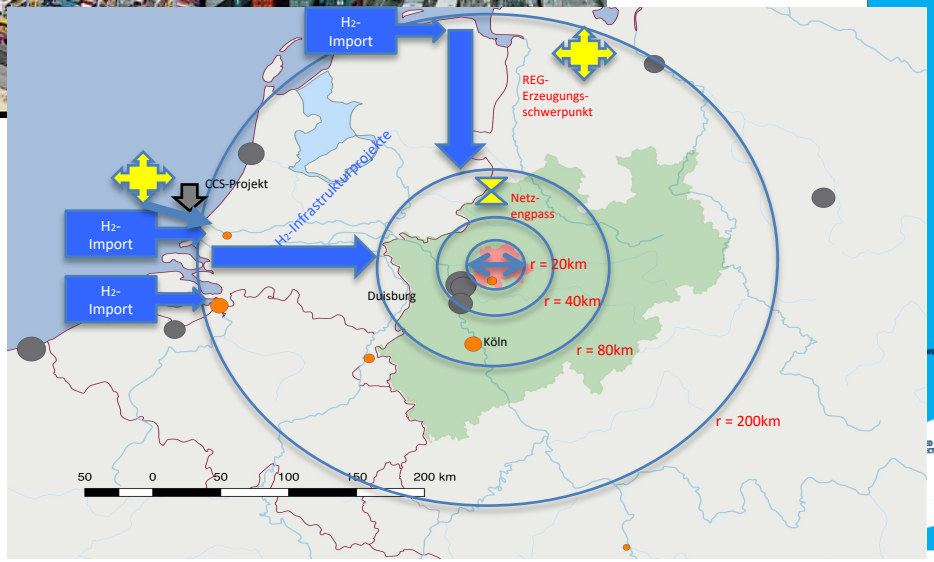
港口将发挥重要作用 – 现有的石油枢纽（如港口）可能成为未来低碳战略中的清洁燃料中心

Example: Port of Rotterdam in the Netherlands with direct connection to Germany

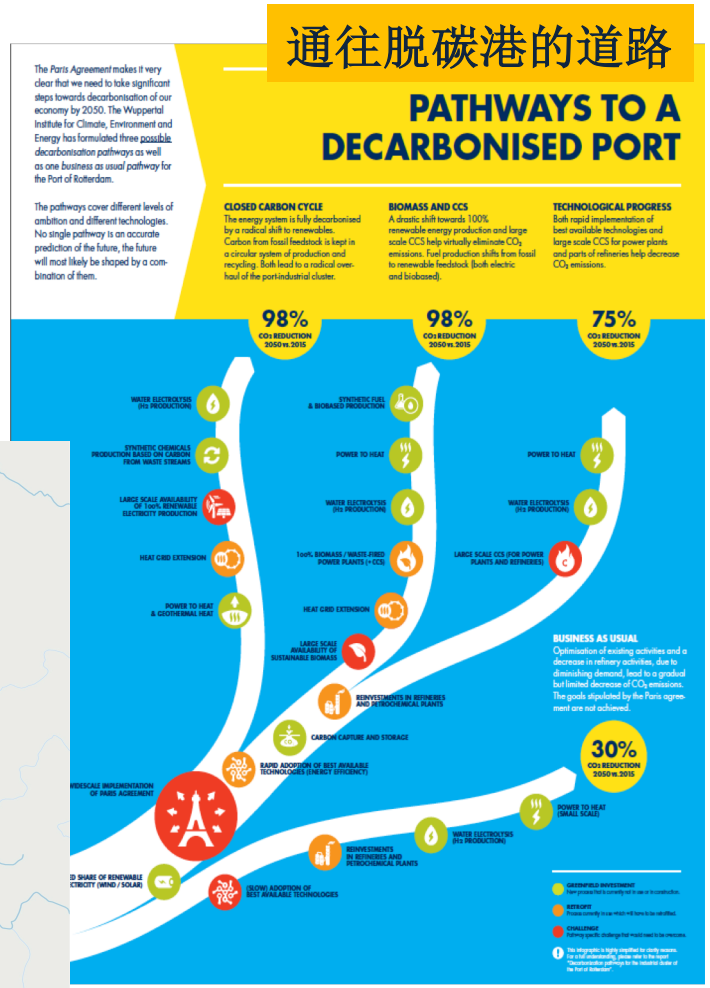
示例：荷兰鹿特丹港与德国直接相连



来源: Visum.hfr



通往脱碳港的道路

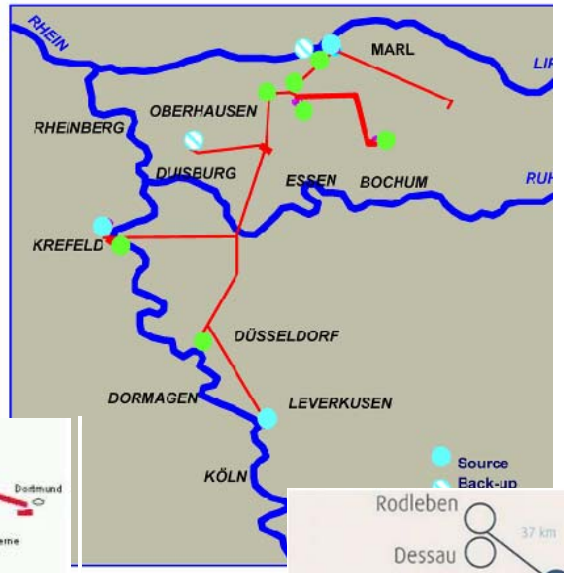


Hydrogen supply structures
氢供应结构

…and how to support – simply via conversion of existing natural gas grid and extension of already existing hydrogen pipeline system
如何支持 – 简单地通过现有天然气网的转换和已有的氢气管道系统的扩展

Existing hydrogen pipelines
现有的氢气管道

North Rhine Westphalia
北莱茵威斯特伐利亚



Eastern Germany
德国东部

Hydrogen supply structures
氢供应结构

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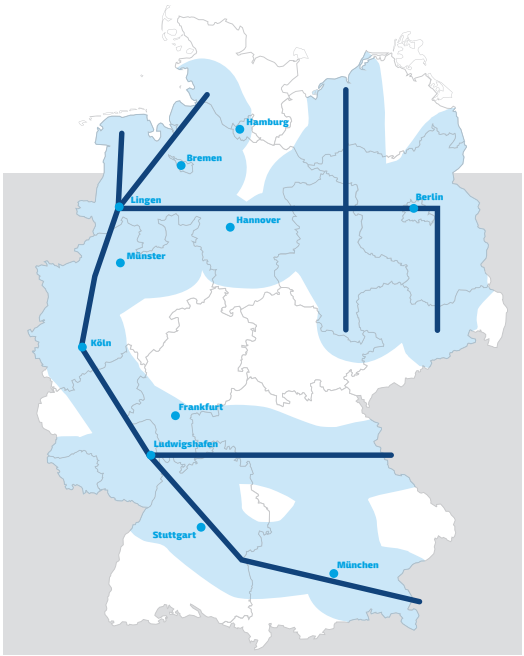
GetH2 project – consortium (electricity and gas utilities, research institutions) set starting point to build up a hydrogen infrastructure in Germany via conversion of existing natural gas grid

GetH2项目组（电力和燃气公用事业，研究机构）通过改造现有天然气网络，在德国建立氢能基础设施的起点



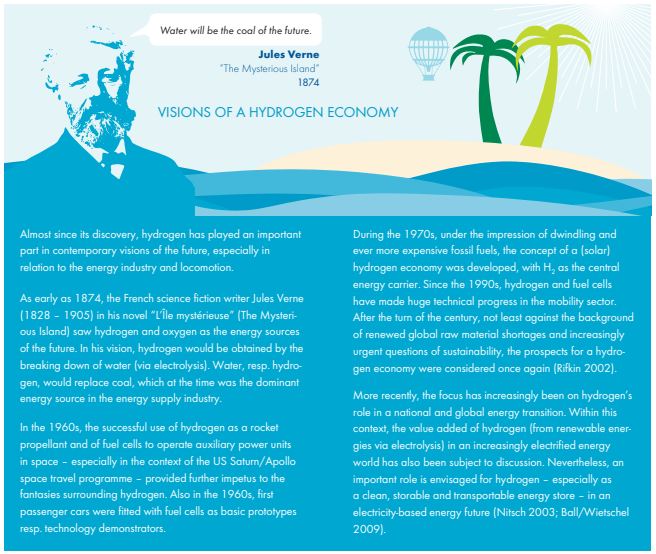
Conclusion
总结

Vision of a hydrogen economy is not new

氢经济并不是新的愿景

Old dream but now in a phase with realistic implementation chances and growing political support and public attention

旧的梦想但现在处于一个将要实现并拥有更多的政治支持和公众关注的阶段



Water will be the coal of the future.

Jules Verne
"The Mysterious Island"
1874

VISIONS OF A HYDROGEN ECONOMY

Almost since its discovery, hydrogen has played an important part in contemporary visions of the future, especially in relation to the energy industry and locomotion.

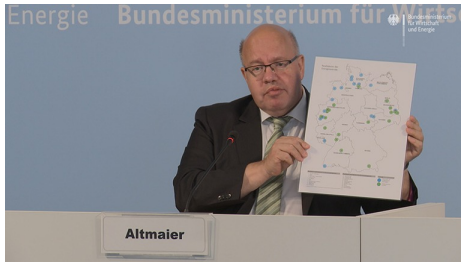
As early as 1874, the French science fiction writer Jules Verne (1828 – 1905) in his novel "L'Île mystérieuse" (The Mysterious Island) saw hydrogen and oxygen as the energy sources of the future. In his vision, hydrogen would be obtained by the breaking down of water (via electrolysis). Water, resp. hydrogen, would replace coal, which at the time was the dominant energy source in the energy supply industry.

In the 1960s, the successful use of hydrogen as a rocket propellant and of fuel cells to operate auxiliary power units in space – especially in the context of the US Saturn/Apollo space travel programme – provided further impetus to the fantasies surrounding hydrogen. Also in the 1960s, first passenger cars were fitted with fuel cells as basic prototypes resp. technology demonstrators.

During the 1970s, under the impression of dwindling and ever more expensive fossil fuels, the concept of a (solar) hydrogen economy was developed, with H_2 as the central energy carrier. Since the 1990s, hydrogen and fuel cells have made huge technical progress in the mobility sector. After the turn of the century, not least against the background of renewed global raw material shortages and increasingly urgent questions of sustainability, the prospects for a hydrogen economy were considered once again (Rifkin 2002).

More recently, the focus has increasingly been on hydrogen's role in a national and global energy transition. Within this context, the value added of hydrogen (from renewable energies via electrolysis) in an increasingly electrified energy world has also been subject to discussion. Nevertheless, an important role is envisaged for hydrogen – especially as a clean, storable and transportable energy store – in an electricity-based energy future (Nitsch 2003; Ball/Wietschel 2009).

Federal Ministry for Economic Affairs and Energy



Deutschland

Altmaier公布联邦政府的氢战略

Altmaier kündigt Wasserstoffstrategie des Bundes an

28. Juni 2019, 11:33 Uhr / Quelle: AFP

Düsseldorf (AFP) Bundeswirtschaftsminister Peter Altmaier (CDU) hat noch für dieses Jahr eine Wasserstoffstrategie des Bundes angekündigt. Zuvor werde die Bundesregierung in sogenannten Reallaboren der Energiewende Innovationen im industriellen Maßstab umsetzen, kündigte Altmaier in der "Wirtschaftswoche" an. "Noch im Sommer werden wir die ausgewählten Projektideen bekanntgeben." Die technische Realisierung könne dann ab 2020 starten.

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Berliner Morgenpost

ENERGIE

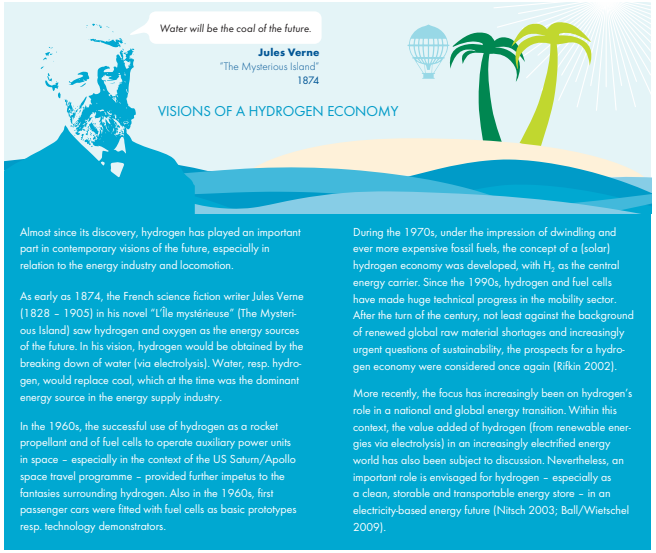
Brandenburg will Vorreiter für Wasserstoffwirtschaft werden

Die Wasserstofftechnologie wird für Brandenburg als riesige Chance gesehen. Das Interesse ist groß. Doch es müssen dafür einige Weichen gestellt werden.

Von dpa
07.08.2019, 16:57

Jörg Steinbach (SPD), Energieminister von Brandenburg. Foto: dpa

Potsdam. Brandenburg möchte bundesweit Vorreiterregion für die Wasserstoffwirtschaft werden. "Das Potenzial ist gewaltig", sagte Landesenergieminister Jörg Steinbach (SPD) am Mittwoch in Potsdam. Vorgestellt wurde eine Studie des Wasserstoff- und Brennstoffzellenverbandes im Auftrag des Ministeriums. Allein durch die Ansiedlung von Herstellern, die etwa zehn Prozent des deutschen Marktes bedienten, könnten in Brandenburg 3500 bis 7000 Arbeitsplätze entstehen, wird in der Studie errechnet. Kosten für notwendige Investitionen werden allerdings nicht beziffert.



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HAMBURG ENERGIEWENDE

Wasserstoff-Offensive der norddeutschen Bundesländer

Veröffentlicht am 02.05.2019 | Lesedauer: 4 Minuten

Ministerpräsident Daniel Günther (CDU, v.l.), Bürgermeister Carsten Sieling, Ministerpräsidentin Manuela Schwesig, Bürgermeister Peter Tschentscher (alle drei SPD) ,UV-Nord-Präside...

Quelle: dpa

Die Ministerpräsidenten des Nordens wollen die Energiewende vorantreiben und dabei die Wirtschaft ankurbeln. Der Fokus liegt dabei auf einem Element, von dem sich die Politik wahre Wunder verspricht.

Es ging um die Energiewende, die Wissenschaft und die Industrie im Norden – und um die Frage, wie sich der zunehmende Einsatz von Wasserstoff positiv auf das Klima auswirken kann. Die Regierungschefs der fünf norddeutschen Länder trafen sich am Donnerstag zum Gipfeltreffen im Hamburger Rathaus, um unter anderem eine norddeutsche Wasserstoffstrategie zu beschließen.

…however Japan and Korea are without any doubt forerunner with regard to shaping a hydrogen economy

然而，日本和韩国在氢经济发展方面毫无疑问是先行者

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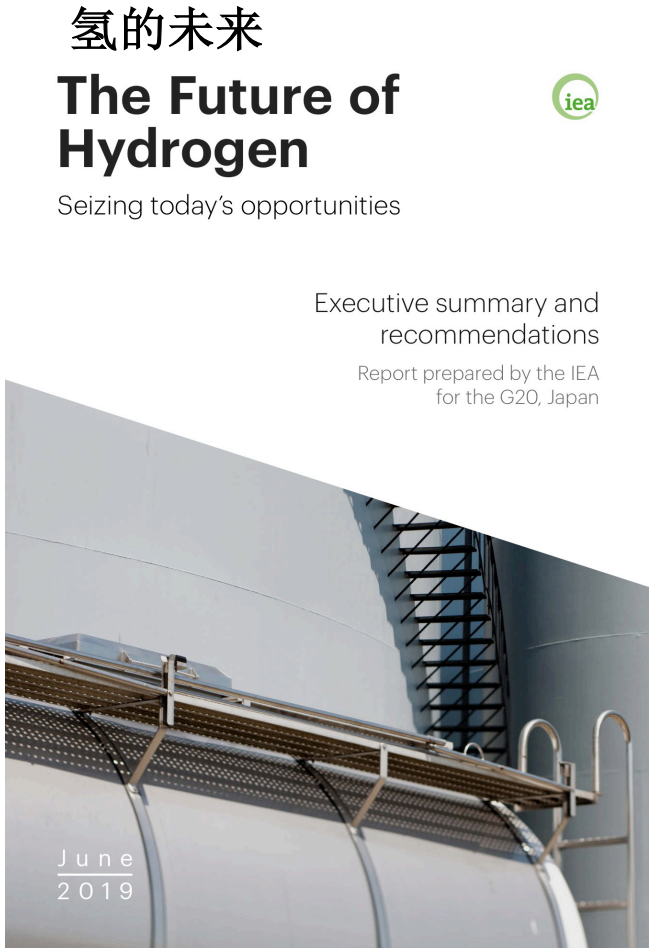
„The time is right to tap into hydrogen's potential to play a key role in a clean, secure and affordable energy future.“ IEA 2019

“现在是氢气在清洁、安全和廉价的能源未来发挥关键作用的时候了。” IEA 2019

The IEA has identified four near-term opportunities to boost hydrogen on the path towards its clean, widespread use.

国际能源署已经确定了四个近期的机遇，以进一步推动清洁氢气。

1. Make industrial ports the nerve centres for scaling up the use of clean hydrogen.
   使工业港成为扩大清洁氢气使用的枢纽。
2. Build on existing infrastructure, such as millions of kilometres of natural gas pipelines.
   以现有基础设施为基础，例如数百万公里的天然气管道。
3. Expand hydrogen in transport through fleets, freight and corridors.
   通过车队、货运和综合运输通道扩大氢气运输。
4. Launch the hydrogen trade's first international shipping routes.
   启动氢贸易的第一条国际航线。



Thank you very much for your attention

非常感谢您的关注