Hydrogen and Fuel Cells in NRW – Activies of companies, research and state government

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Fuel Cell, Hydrogen and Electric Mobility Network

The Future of Hydrogen in NRW/Fukushima – Koriyama City – November 1, 2019
Agenda

1. Introduction EnergieAgentur.NRW/
   Fuel Cell and Hydrogen, Electric Mobility Network

2. Activities of NRW State Government

3. Activities of Industry and Research Institutes

4. Ideas for Collaboration
Introduction EnergieAgentur.NRW/
Fuel Cell and Hydrogen, Electric Mobility Network

Activities of NRW State Government

Activities of Industry and Research Institutes

Ideas for Collaboration
NRW

No.1 energy state in Germany

- Population: 18 m; GDP: No.1 in GER
- 30% of German power generation
- 20% of German transport
- 200,000 employees in energy and 200,000 employees in automotive

EnergyAgency.NRW

Service provider for energy transition

Platform for:
- Energy research
- Development, demonstration to market launch
- Energy consulting
- Know-how-transfer, communication
- International relations

Subjects:
- Renewable energies and storage
- Energy efficiency
- Transport
Fuel Cell and Hydrogen, Electric Mobility Network NRW

- Non-profit organization, part of EnergieAgentur.NRW
- Regional technology platform
- More than 500 members and 100 project partners
- 70% companies (mostly SMEs), 20% research institutes and 10% others
- 8 staff, 4 for hydrogen & fuel cells
- www.fuelcell-nrw.de
NRW – Process of Innovation

Science

Training

Innovation process

Demonstration

Proof of functionality / improvements

„Laboratory“

Research

Economy

Further education

Spreading

Market introduction

Market preparation

The market

Platform for co-operation and information

CEF.NRW

Fuel Cell and Hydrogen Network NRW

EnergieAgentur.NRW
Network – Topics

- Renewable hydrogen, power-to-x
- H2 infrastructure/filling stations
- Vehicle development/deployment FCEVs
- Stationary applications
- R&D and special market applications
Network – Services

- Initiation of projects
- Information and communication
- Public relations
- Internationalisation
- Qualification
- Settlement Support
Network – Information and Communication

Annual Meeting

Biennial Meeting

For network members and interested parties

Expert Group Power-to-Gas
Janina Senner (GWI)

Expert Group H₂-System
Dr. Emonts (FZJ)

Expert Group H₂ for municipalities
St. Leuchten (MWIDE)

Expert Group H₂ for Public Transport
Dr. Frank Koch (NBWE)

Expert Group Electric Mobility
Georg Grothues (NBWE)

Organised by network management and partners

Specific Workshops, e.g.
- H₂ station approval, FC buses
- Micro CHP, UPS
- Tokyo: Fire Place Talk
Network – Activities in Japan

- **Support of cooperation of companies and institutes:**
  - Bilateral exchange with companies (Toyota, Honda, Iwatani, JX, Japan H2Mobility, Panasonic, Toshiba etc.) and organisations (NEDO, HySUT)
  - Asahi Kasei: started electrolyser testing in Herten in 2018

- **Cooperation and exchange with prefectures:**
  - **Fukushima:** Memorandum of Understanding with NRW on energy topics including hydrogen technologies, continuous cooperation, exchange on hydrogen since several years, matchmaking in 2019 in Tokyo
  - **Yamanashi:** Delegation visits in NRW (2017, 2018) and Yamanashi (2018, 2019 in Tokyo)
  - **Osaka:** Memorandum of Understanding with NRW on \( H_2 \), fuel cells and batteries (Oct. 2018), based on B2B matchmaking in 2018 in Essen, 2019 in Tokyo

- **Groundwork:** FC Expo (since 2008)
History of the Network
History: Change of topics reflected in name and logos

2004-2016: Fuel Cell and Hydrogen Network
Since 2017: Fuel Cell and Hydrogen, Electric Mobility Network
Evolution of topics

From part to system... and ...from small to large
Continuous increase in members

- 2000: 40 members
- 2019: 500 members: ~70% industry (mainly SME), ~20% research
  ~70% NRW / ~20% Germany / ~10% abroad

Annual growth approx. 30 members
- Plus 120 project partners from battery electric mobility

--> even after 19 years network is still growing
Highlight: NRW Hydrogen HyWay

- Nationwide first dedicated FC funding scheme on regional level
- Duration 2008-2011
- Topics:
  - Infrastructure / HRS
  - Vehicle development and demonstration (Bus / Car)
  - System development (fork lifts, UPS, APU etc.)
  - Component development
  - Production technologies
  - H2 production
Highlight: Fuel Cell Box Scholar Competition

- First time scholar year 2003/04
- 1,600 team applications
- 4,500 pupils of classes 9-11
Highlight: HYCHAIN MINITRANS

Coordinator: Air Liquide France
Total budget: 37,653,000 €
EU-Funding: 17,000,000 €
Duration: 2006-2011

Small Transport Applications

- Fuel cell scooters
- Fuel cell Wheelchairs
- Fuel cell utility cars
- Hybrid minibuses
- Fuel Cell portable generator
- Hydrogen infrastructure

Regional Coordinators

- Emscher-Lippe, Germany
- Rhône-Alpes, France
- Emilia Romagna, Italy
- Castilla León, Spain
- Emscher-Lippe, Germany
Highlight: FIFA Football Championship 2006

- **Shuttle Bus** (Feuerwehr Dortmund)
- **Cargo bike** (T-COM, Stadt Dortmund)
- **Telephone Pillar** (T-COM, München)
- **H₂ Trail Mobile station** (Linde Gas AG)
- **5 kW UPS System** (PASM, Stadien Dortmund + Köln)
- **Web Terminal** (T-COM, Westfalenhalle Dortmund)

*EnergieAgentur.NRW*
Highlight: WHEC 2010 in Essen

16.-21. Mai 2010, Essen
2.500 Participants

IPHE Rudolf A. Erren Award 2010
Highlight: H2Congress

Deutscher Wasserstoff Congress
- Since 2002 every 2 years
- Together with DWV und NOW
Role of Hydrogen
Hydrogen in NRW – Today: Industry

- **Chemical and other industry:**
  600,000 tons/a (2 m tons/a in Germany)
  mainly by reforming of natural gas

- **By-product:**
  mainly from Cl-Alkaline-Electrolysis (potential 35,000 tons/a), enough for 300,000 FCEV’s

- **Hydrogen pipeline (> 200 km)**
  Length: 240 km
  Pressure: 20 bar
  In operation since 1930’s
  Operator: Air Liquide
Hydrogen – Tomorrow: Power-to-X

Integration of renewables

Storage

Power-to-X: Sector coupling

- Power
- Industry
- Heat
- Transport

Source: BTU Cottbus, Innogy

50 GWh
Hydrogen – Tomorrow: Energy transport

One gas pipeline (Ø 1,20 m) transports as much energy as eight power lines (3 GW each).
Solution: Sector coupling through Hydrogen production using Power-to-Gas
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Core technology: Electrolysis
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Federal Government
Recent governmental statements

Chancellor Angela Merkel:
„We will also develop a national Hydrogen strategy by the end of the year. (...) Focusing only on (battery) electric mobility would, in our view, be completely wrong.“

Minister Andreas Scheuer, BMVI:
„I am convinced that electric mobility offers important industrial policy opportunities for Germany. (...) Electricity and Hydrogen are the fuels of the future.”

Minister Peter Altmaier, BMWi:
“We want to become the world's number one in Hydrogen technologies.”

Minister Svenja Schulze, BMUB:
„Power-to-X will make an important contribution to climate protection nationally and internationally in the future.“
NRW State Government

- **Background:** Hydrogen is as storage medium and for sector coupling necessary. For a successful turnaround in mobility, switching to battery-powered electric vehicles and, in future, hydrogen-powered **Fuel Cell vehicles** is an important requirement.

- **Goal:** To build a sustainable supply structure with Hydrogen and synthetic fuels.

- **Measures:**
  - H₂-Roadmap (based on NRW H₂ study)
  - NRW Cross-border cooperation (with NL)
  - Innovative infrastructure projects for H₂ and P-t-X
NRW Ministry of Economics – H₂-Study NRW

Analysis of economic and climate potentials of H₂ in NRW as baseline for a middle and long term strategy of NRW government.

Positive effects of sector coupling due to Hydrogen:

- Lower system costs at GHG-Goal von -95%
- Intensified integration of renewable energies
- Considerably smaller expansion of power lines → higher acceptance

**Substantial growth of electrolysis in Germany:** 25-100 GW in 2030 | 75-250 GW in 2050

**Tremendous demand of H₂ in NRW:** 20-70 TWh/a in 2030 | 50-160 TWh/a (or 1.5 to 4.8M t/a) in 2050

**Conclusion 1:** H₂ and electricity as ideal partners in a future CO₂-free energy system

**Conclusion 2:** NRW will not be able to satisfy his H₂ demand independently

**Next steps:** Development of a H₂-Roadmap for NRW
H₂-Study NRW – Impressive Numbers for Germany

- Immense H₂ demand in Germany:
  200-600 TWh/a in 2050
  (or 6 to 18 million t/a)
  → today: 66 TWh/a
  → 3 to 9 times more

- High need for installations of electrolysis in Germany:
  75-250 GW in 2050
  → today: 50 MW in operation or set-up
    (demonstration)
  → 1.500 to 5.000 times more
NRW Ministry of Economics – H₂ model regions in NRW

- Funding call „H₂ model regions/municipalities in NRW on H₂ mobility“ 2018-2020: 3 detailed design concepts are funded
- Complement to national „HyLand“ and EU „H₂ Valley“ programmes
- Three winners out of 10 applicants have been selected: Cologne Area, Düsseldorf Area and Steinfurt District

Cologne with Brühl, Hürth, Wesseling, Rheinisch-Bergischer-Kreis, Rhein-Sieg-Kreis; Düsseldorf with Wuppertal, Kreis Neuss
Project Examples: H2 Station Wuppertal

- Production of hydrogen from surplus electricity at waste incinerating plant
- Storage, delivery to FC bus filling station
- Advantage: local value creation (no grid fees, reduced feed-in tariff)

**Abfallwirtschaftsgesellschaft (Operator of Waste Incinerating Plant)**
- Electricity Production Capacity
- Power
- Other Inputs
- Electrolyser
- H₂

**WSW Energie & Wasser AG**
- Optimisation of H₂ Production reflecting energy economical frame conditions
- H₂-delivery contract

**WSW mobil GmbH**
- Fuel Cell Bus Fleet
- Consuming H₂ and operation of H₂ buses
Hydrogen and Fuel Cell funding in NRW

- **Companies: BEV and FCEV**
  - 4,000 € in addition to the federal bonus
  - 8,000 € for commercial vehicles (2.3 - 7.5 tons)

- **Municipalities: BEV and FCEV**
  - BEV: up to 40% up to a maximum of 30,000 €
  - FCEV: up to 60% up to a maximum of 60,000 €

- **Public transport: Battery and FC bus incl. infrastructure**
  - 60% of the difference to a comparable diesel bus
  - Infrastructure and workshop facilities 90% of the eligible investment costs

- **R&D funding**: more than 140 projects with 160M € funding
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Activities of Industry and Research Institutes

- Renewable hydrogen, power-to-x
- H2 infrastructure/ filling stations
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Highlights in NRW: Power-to-X – Hydrogen in Industry

**Refinery project ReHyne, Shell**
- **Location:** Rheinland Raffinerie, near Cologne
- **Objective:** Use of green H₂ for refinery process, for refuelling
- **Partner electrolyser:** ITM (10 MW), 1,300 tonnes of hydrogen per year (1% of demand)
- **EU funding:** 10 m € (FCH JU)

**Steel project H2BF, ThyssenKrupp Steel**
- **Location:** Steel mill, Duisburg
- **Objective:** CO₂ reduction by H₂ injection into the blast furnace (1st blow mold of > 20),
- **Partner hydrogen:** Air Liquide
- **NRW funding:** 1.6 m € (FCH JU)
Highlights in NRW: Power-to-X – Hydrogen and CCU

Lignite coal power plant by RWE Power, MHPS
- Location: Niederaußem
- Objective: Use of CO₂ and green H₂ for methanol (“MefCO₂”) and DME (“ALIGNCCUS”)
- Partners electrolyser: Hydrogenics (1 MW) and Asahi Kasei (100 kW)
- EU funding: 8.6 m € (MefCO₂), 15 m € (ALIGNCCUS with national co-funding)

Steel mill: Carbon2Chem by ThyssenKrupp
- Location: Duisburg
- Objective: Use of metallurgical gases from steel production (including CO₂) and and green H₂
- Topics: water electrolysis (2 MW from TKUCE), production of methanol, polymers, ammonia etc.
- Funding: 60 m € from Federal Ministry of Science
Highlights in NRW: Power-to-Gas – hybridge with 100 MW

Project of Amprion und Open Grid Europe

- **Location**: Lingen (Lower Saxony, border to NRW) interface of power and gas grid
- **Objective**: production, distribution, storage and usage of hydrogen for mobility, industry, energy
- Using converted natural gas lines and underground storage, also expansions
- **100 MW electrolyser**
- **150 m € investment**
- **Start**: 2023 (if framework conditions allow)
Highlight s in NRW: Cooperation Project with Asahi Kasei

Asahi Kasei with H2-Application Center Herten

- Herten: Power-to-gas facility for regenerative energy supply based on wind-H2
- Test center for components, i.a. of the Japanese electrolyser manufacturer Asahi Kasei:
  - Start of operation of alcaline electrolyser in April 2018
  - Test and certification for European market
  - Next step: Participation in EU project „AlignCCUS“ on carbon capture, utilisation and storage (CCUS)
Companies, e.g.: thyssenkrupp Uhde Chlorine Engineers (Japan) Ltd.

Main activity: Electrolysis

Main products:
- Chlor-Alkali Electrolysis
- Hydrochloric Acid Electrolysis
- Alkaline Water Electrolysis

Technologies and services:
- Skid-mounted technology
- EPC services
- After Service

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Companies, e.g.: AREVA H2 Gen GmbH, Cologne

Main activity: PEM Electrolyser

Main product/technology:
- Manufacturer of **PEM Electrolysis Systems** from 25 kW up to MultiMegawatt Systems (France, Germany)
- Hydrogen Solutions like **H2 Fueling Stations** or **Storage Systems** (Type4, LOHC) via partners/network

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Companies, e.g.: The h2herten Application Center, Herten

**Main activity:** Power-to-Gas (Hydrogen)

**Main product/technology:**
- Development and Demonstration of Integrated Hydrogen Based Energy Storage Systems for Micro Grids
- Promoting Hydrogen an Fuel Cell Technology in the Ruhr Region

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Activities of Industry and Research Institutes

- Renewable hydrogen, power-to-x
- H2 infrastructure/ filling stations
- Vehicle development/ deployment FCEVs
- Stationary applications
- R&D and special market applications
NRW – H₂ stations
- By end of 2019: 18 H₂ stations (100 in GER), 4 for buses
  - Aachen, Dortmund, Düsseldorf (2), Duisburg, Essen, Frechen, Herten, Kamen, Cologne Airport, Leverkusen, Mönchengladbach, Mülheim/Ruhr, Münster, Ratingen, Rheda-Wiedenbrück, Siegen, Wuppertal
  - Hürth, Meckenheim, Wermelskirchen, Wuppertal

Mobile H₂ refueler
- Interreg NWE project “H₂ Share”: build and demonstrate 27 ton rigid truck
- Flexible mobile H₂ refueler “WyRefueler” for 350 bar tanks: Wystrach

Highlights in NRW: H₂ stations and fuel cell buses

Source: Wystrach
Companies, e.g.: Wystrach GmbH, Weeze

Main activity: Power-to-Gas

Main product/technology:
- High-pressure solutions for gas storage and transport

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Companies, e.g.: NPROXX GmbH, Jülich

NPROXX
Hydrogen Tanks
CFRP Type 4 Tanks and Systems
Companies, e.g.: Andreas Hofer Hochdrucktechnik GmbH, Mülheim

Main activity: Hydrogen compressors

Main product/technology:
- High pressure compressors (diaphragm and piston type)
- Valves and fittings

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Activities of Industry and Research Institutes

- Renewable hydrogen, power-to-x
- H2 infrastructure/filling stations
- Vehicle development/deployment FCEVs
- Stationary applications
- R&D and special market applications
Highlights in NRW: Fuel cell buses and waste collectors

Fuel cell buses
- Hotspot NRW, starting in 2019:
  > 70 FC buses and 4 new H₂ stations, espec. in FCH2 JU projects JIVE1 and JIVE 2
  Cologne (RVK), Wuppertal (WSW mobil), Münster (Stadtwerke), Bielefeld
- Funding via EU (FCH2 JU), national (NIP 2), NRW

Fuel cell waste collectors
- 2 vehicles in cities of Duisbug and Herten by 2020
- Projet HECTOR, funding via EU (Interreg)
- More to come starting 2020 (national program NIP)
**Highlights in NRW: Fuel Cell Vehicles – Battery with FC-Rex**

**Streetscooter**
- Today: > 10,000 vehicles in operation (3 types of battery LDVs), production in NRW
- FC range extender with 30 kW fuel cell (500 km range instead of 170 km), 500 vehicles from 2019 in 15 regions in Germany

**e.GO Mover**
- Battery 60 kWh, FC range extender 22-30 kW, range 10 h, 15 passengers
- Goal: 15,000 vehicles annually from 2021
- e.GO REX as JV of e.GO and Proton Motor
Highlights in NRW: Developments and deployments
Companies, e.g.: e.GO REX GmbH, Aachen

Main activity: Fuel Cell Range Extender

Mission
Enable breakthrough of e-mobility through low cost fuel cell range extender

e.GO:REX

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GERMANY
Companies, e.g.: Hydrogenics Deutschland GmbH, Gladbeck

Main activity: HD fuel cells for vehicles (and electrolysis, HRS)

Main product/technology:
- Hydrail: Hydrogen Fuel Cell Trains
- Hydrogen powered buses
- Hydrogen Mobility Power
- Defence, Aerospace and Marine

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Companies, e.g.: Graebener Maschinentechnik GmbH, Netphen

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Contact:
Mr. Fabian Kapp
Board Member & Authorized Officer
Companies, e.g.: PTEC Pressure Technology GmbH, Burscheid

Main activity: Hydrogen High Pressure Components – 35 & 70 MPa

Main product/ technology:
• Manufacturer of check valve, filter, fittings, regulator, receptacle, solenoid valve, tube, TPRD (Thermal Pressure Release Device)

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Companies, e.g.: Anleg GmbH, Wesel

Main activity: Valve technology (FC trucks and ships)

Main product/technology:
- Gas supply systems for compressors
- Test stands
- H2 technology
- Valve Technology & Tank Systems
- Consulting, planning, construction, production, installation and commissioning

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Activities of Industry and Research Institutes

- Renewable hydrogen, power-to-x
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Highlight in NRW: Settlement Ceramic Fuel Cells (now Solid Power)

- First Serial FC CHP production in NRW
- Settlement 2007, start of production 2009
- Today: > 1,000 systems built, 100 employees
Highlight in NRW: Test of Japanese Technology

Fuji N2telligence at ZBT, Duisburg
- Project “iFlex KWK 4.0”
- Existing (in operation since 2015) phosphoric acid fuel cell (PAFC) will be combined with an absorption chiller
- Funded by NRW/EU as part of Virtual Institute CHP NRW

Mitsubishi Hitachi Power Systems at GWI, Essen
- Project „Demo Hybrid-SOFC“
- The first hybrid SOFC system in Europe - a solid oxide fuel cell (SOFC) with a downstream micro gas turbine
- Funded by NRW/EU as part of Virtual Institute CHP NRW
Highlight in NRW: Siemens Hydrogen Gas Turbine

Feasibility Study „CO2-free energy supply system“

- Siemens feasibility study for a cogeneration-integrated power-to-X plant with reverse-current conversion (100% H2 turbine) and use of HT heat pumps
- Start Dec. 2018 (with NRW funding)

Reallabor GET H2 (2020-2024)

- Partner: RWE, Nowega, Siemens et al.
- 105 MW electrolysis at the gas power station
- Conversion of a natural gas pipeline to H2
- Test of electricity from 25% to 100% H2 in existing 60 MW gas turbine
Companies, e.g.: 2G Energietechnik GmbH

Main activity: Hydrogen cogeneration (CHP)

Main product:
• manufactuer of cogeneration systems for gasified fuels
  (Biogas, Natural gas, Hydrogen)

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Companies, e.g.: Gebrüder Becker GmbH

Main activity:
Innovative blowers for efficient air supply in commercial stationary fuel cell systems

Main product/ technology:
• Manufacturer of vacuum pumps, compressors and systems

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Activities of Industry and Research Institutes

- Renewable hydrogen, power-to-x
- H2 infrastructure/ filling stations
- Vehicle development/ deployment FCEVs
- Stationary applications
- R&D and special market applications
Hydrogen Testing and R&D Facilities

**H₂-Center Herten**
- Power-to-gas facility based on wind H₂, test center for components, e.g. of electrolyser from Asahi Kasei
- Further R&D projects e.g. H₂ quantity measurement
- H₂ refuelling station (H2Mobility), March 2019

**ZBT: Center for Fuel Cell Technology, Duisburg**
- ZBT: application oriented institute for FC, electrolysers and energy technologies (100 staff)
- Development and testing of components, stacks/systems
- Installing a large electrolyser/hydrogen test center

**Forschungszentrum Jülich, IEK-3**
- IEK-3 performs application-oriented R&D
- Fuel cells (SOFC, HT-PEFC), stacks up to complete systems
- Large-scale PEM water electrolysis
- System analysis
Hydrogen Testing and R&D Facilities

**GWI (Gas-Heat-Institute), Essen**
- Training and Consulting Center
- Certification and Testing of Products
- International Research Projects
- Power-to-Gas, Hydrogen, Methane, Biogas
- Smart Cities, Smart Energy Systems
- CHP, Fuel Cells, District Heating and Cooling

**Westfälische Hochschule, Gelsenkirchen**
- PEM fuel cells
- PEM electrolysis
- Test benches for hydrogen related technologies
Companies, e.g.: Coatema Coating Machinery GmbH

Main activity: Coating and Laminating Equipment for CCM, GDE and the complete MEA including gasket

Main product/technology:
- Coating, Printing and Laminating equipment.
- Lab, Pilot and Production scale

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Ideas for collaboration

- **R&D cooperations**: Representatives of ZBT Duisburg and Forschungszentrum Jülich took part in the business trip in February 2019
  → Exchange of scientists / collaborative projects

- **Exchange of municipal activities**: e.g. NRW model communities

- **Corporate cooperation**: business trip from February 2019

- **Exchange on project experiences** e.g. of major demo projects: in Fukushima 10 MW project for Olympic Games, similar projects in NRW and with NRW companies (NOW-NEDO workshops on Power to Gas)

- ...
Conclusion

- **NRW** shows outstanding environment for **hydrogen technology**
  - High potential for applications
  - R&D institutes and testing facilities with international reputation
  - World class manufacturers and suppliers
  - Business opportunities for operators and investors
  - Available funding: R&D, demonstration, market introduction, settlement

- **International** information exchange, coordination and **cooperation essential**
ありがとうございます
&
Vielen Dank!
Contact:

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