

Industrial-Urban-Symbiosis

Practical examples from the Industrial Park Höchst

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Dual challenge: Industrial parks in Germany must remain competitive today and prepare for CO₂ neutrality



TODAY

- Competitive **energy supply**
- Safe, reliable, high-quality, internationally competitive **production**
- Adaptation to **volatile business** and environmental influences
- **Skills shortage**

PREPARING for a climate-neutral future

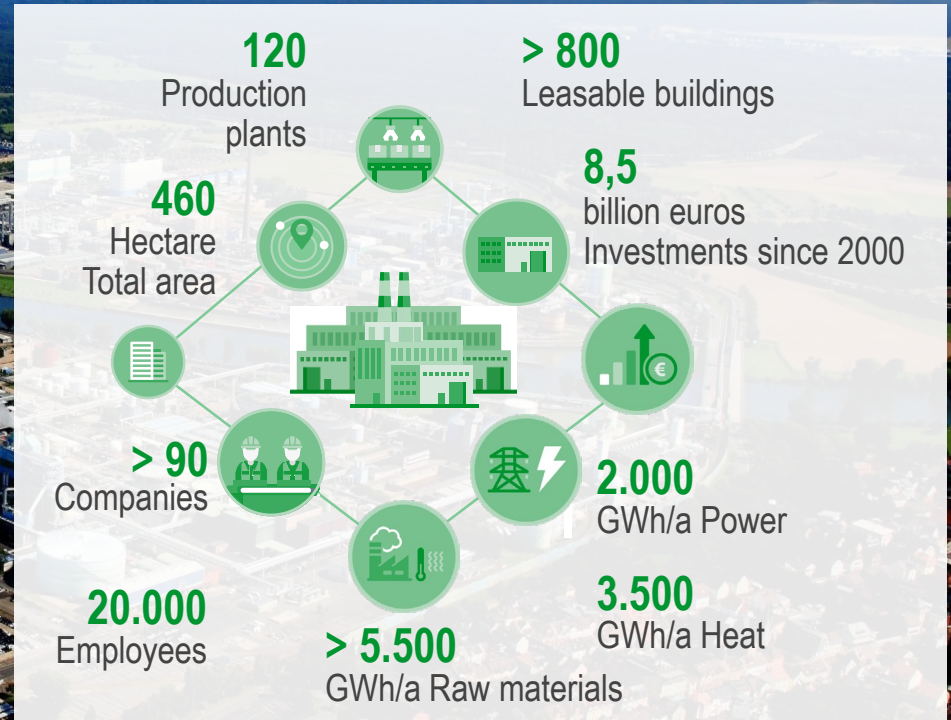
- Access to competitive **renewable energies** and raw materials (electricity, heat, hydrogen, CO₂ and other raw materials) and, if necessary, preparation for CCS
- Development of **new business potential** (e.g. chemical recycling, CCU)
- **Industrial symbiosis** with the region (industrial waste heat for the district heating network, location of data centers)

Industriepark Höchst

A lively cluster for chemical and pharmaceutical companies

Characteristics

- Excellent logistics and transport connections
- Research and production site
- Close network of companies
- Promoting information and innovation
- “Verbundstruktur” Energy and Waste Management
- Cost synergies through shared infrastructure



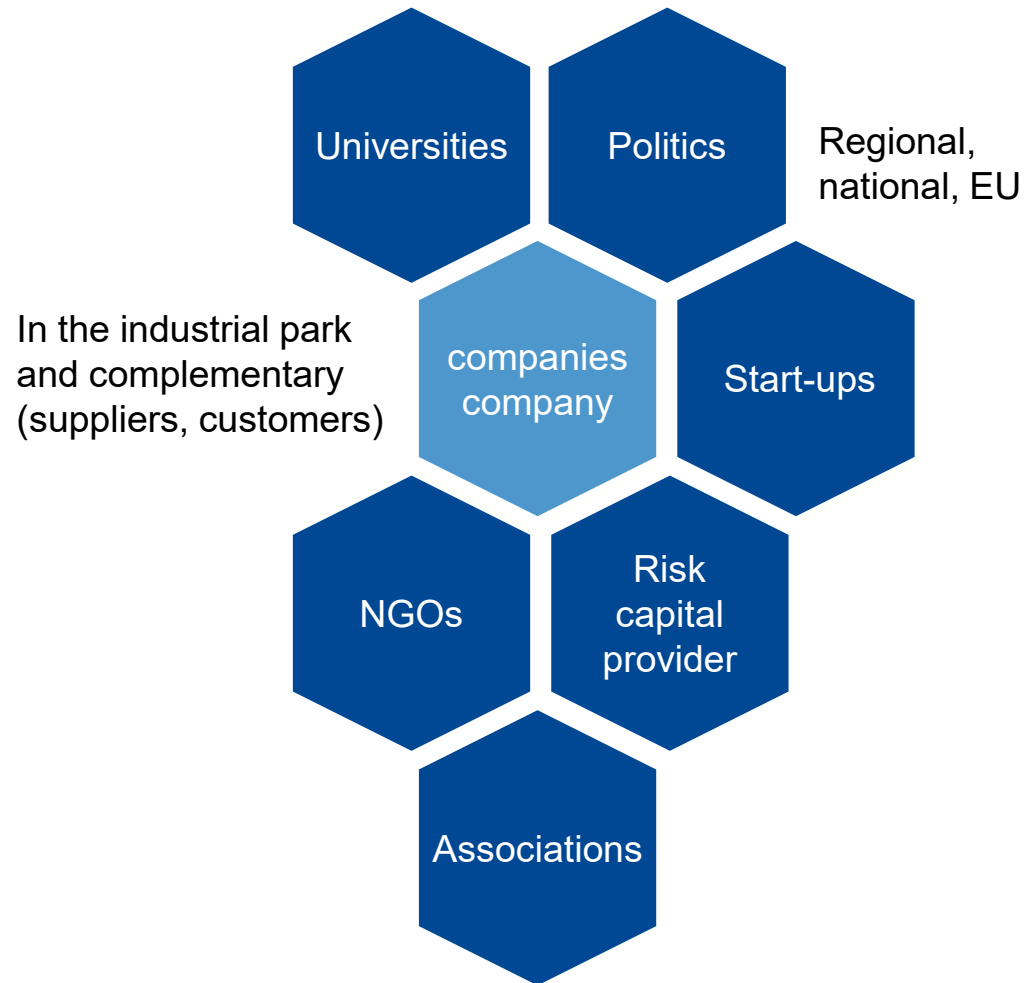
Center for Industry and Sustainability (ZIN) Think and do tank for sustainable industry at Industriepark Höchst



Mission:
We support the industry in its sustainable development

An innovative ecosystem comprises various complementary players.

Innovative ecosystem (MIT stakeholder model)



Value creation in the system

- Realize new ideas
- Access to know-how
- Access to finance

**Management approach:
Objectives, content, financing,
governance**

We define IS as cooperation at the inter-firm level that involves:

- the optimisation of energy, waste, and by-product use;
- the sharing of utilities and infrastructure;
- the joint provision of services and the joint purchase of energy and resources;
- the transfer of experience and joint learning

[Industrial symbiosis as enabler and barrier for defossilization: The case of Höchst Industrial Park](#)

Industrial Symbiosis and urban-industrial symbiosis in FrankfurtRheinMain: selected examples

	Industrial Symbiosis at the industrial park	Urban-industrial symbiosis
1 Optimization of energy, waste and by-product use	<ul style="list-style-type: none"> – Combined heat and power generation (cogeneration) – Use of waste heat in production and disposal facilities 	<ul style="list-style-type: none"> – Currently explored: Options for district heating
2 Sharing of utilities and infrastructure	<ul style="list-style-type: none"> – Buses inside the park are fuelled with hydrogen 	<ul style="list-style-type: none"> – Utilisation of H₂ (by-product of chlor-alkali electrolysis) – Hydrogen filling station outside the park – Fuel cell trains in public transport refuelled at the park
3 Joint provision of services and the joint purchase of energy and resources	<ul style="list-style-type: none"> – Residue incineration (production residues) – CO₂ from biogas 	<ul style="list-style-type: none"> – Cascade utilisation of sewage sludge – Phosphorus recycling – Sewage sludge incineration – Commercial and municipal waste is thermically recovered
4 Transfer of experience and joint learning	<ul style="list-style-type: none"> – Cluster Process4Sustainability 	<ul style="list-style-type: none"> – Eg. Expert Panel Climate at the city of Frankfurt

[Industrial symbiosis as enabler and barrier for defossilization: The case of Höchst Industrial Park](#)

Industrial Symbiosis: Industriepark Höchst has benefited from a reliable hydrogen supply for over 100 years.

Hydrogen infrastructure

- Processing of 50 million scm of hydrogen per year
- Several compressors
- Gasometer 10,000 m³ & storage at 200, 300 and 500 bar
- H₂ grid > 20 km at 1, 7, 200 and 850 bar

H₂ Innovation Campus

- Settlement of start-ups and funded R&D projects
- Projects in the fields of sustainability, H₂, CO₂, PtL, PtG

H₂ Trailer filling

- 200, 300 and 500 bar

Consulting

- Concepts, infrastructure assessment, market research and analysis, studies, technology consulting
- Support in planning and approval process

Public hydrogen refueling station since 2006

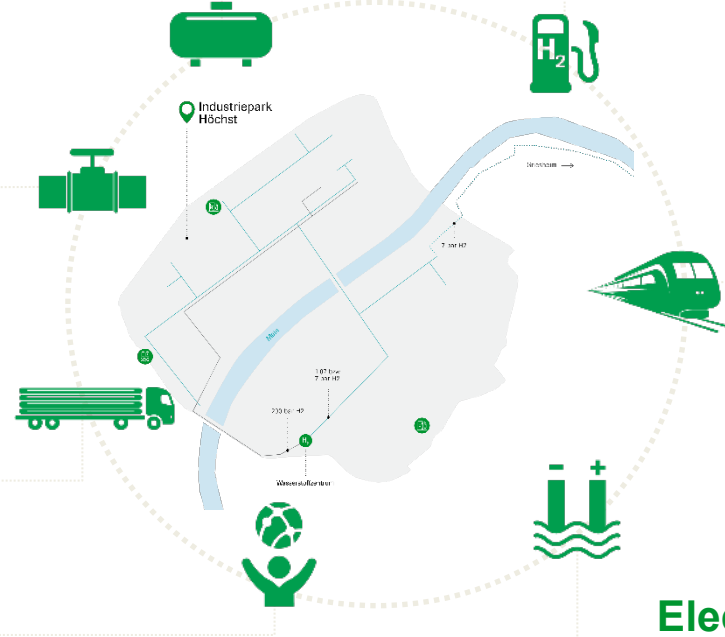
- Supply via 1,000-bar pipeline from Industriepark Höchst
- Refueling cars, trucks and buses at 350 and 700 bar
- Factory buses in Industriepark Höchst run on hydrogen

Refueling station for rail vehicles

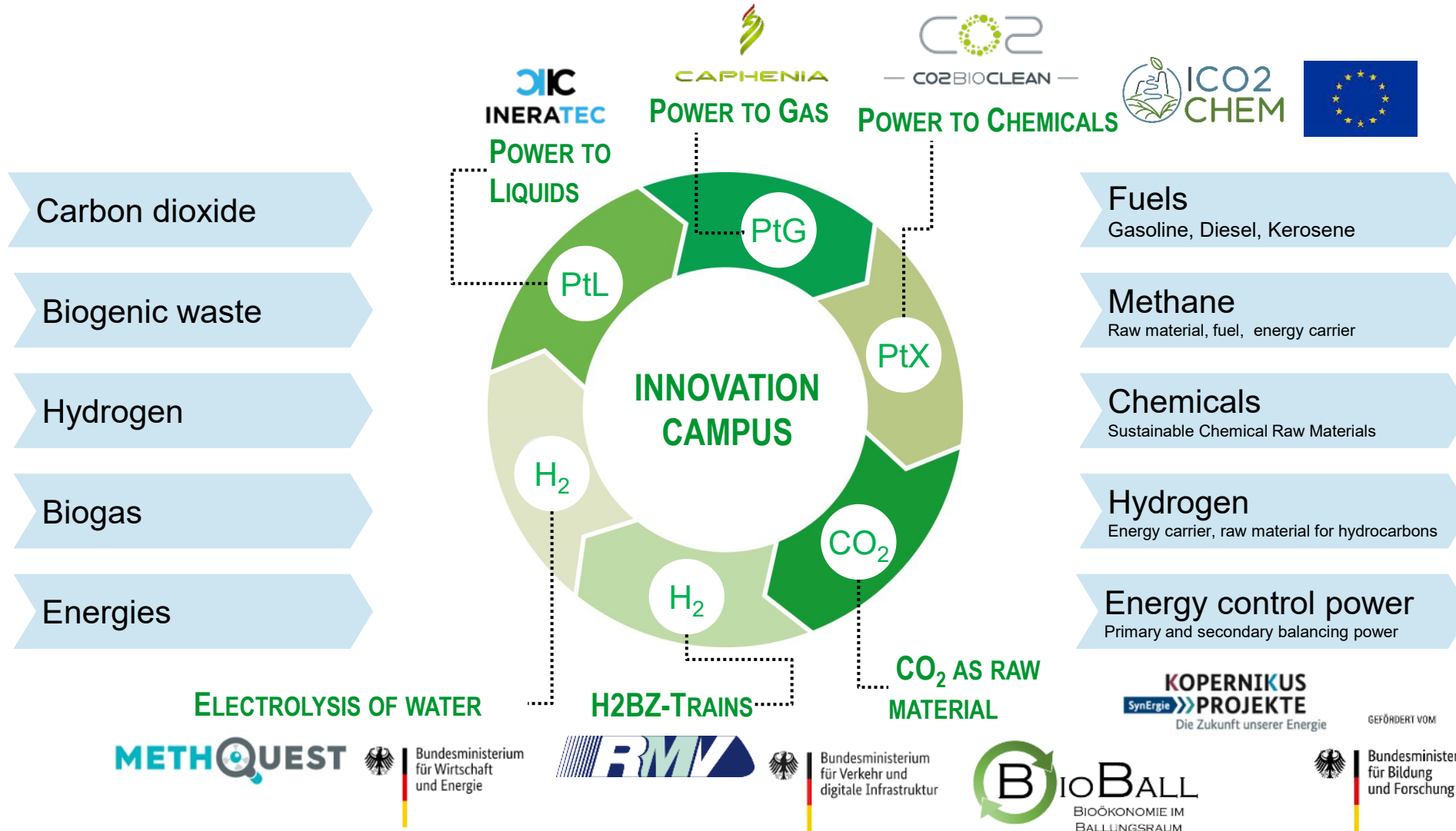
- Hydrogen supply for 27 Alstom "Coradia iLint" fuel cell trains
- Hydrogen requirement 2,000 - 2,400 kg per day
- replacement for diesel commuter trains

Electrolysis from 2022

- Construction of a PEM electrolysis plant with 5 MW
- Test facility for PEM electrolyser in MW scale



Industrial Symbiosis and urban-industrial symbiosis Innovation Campus

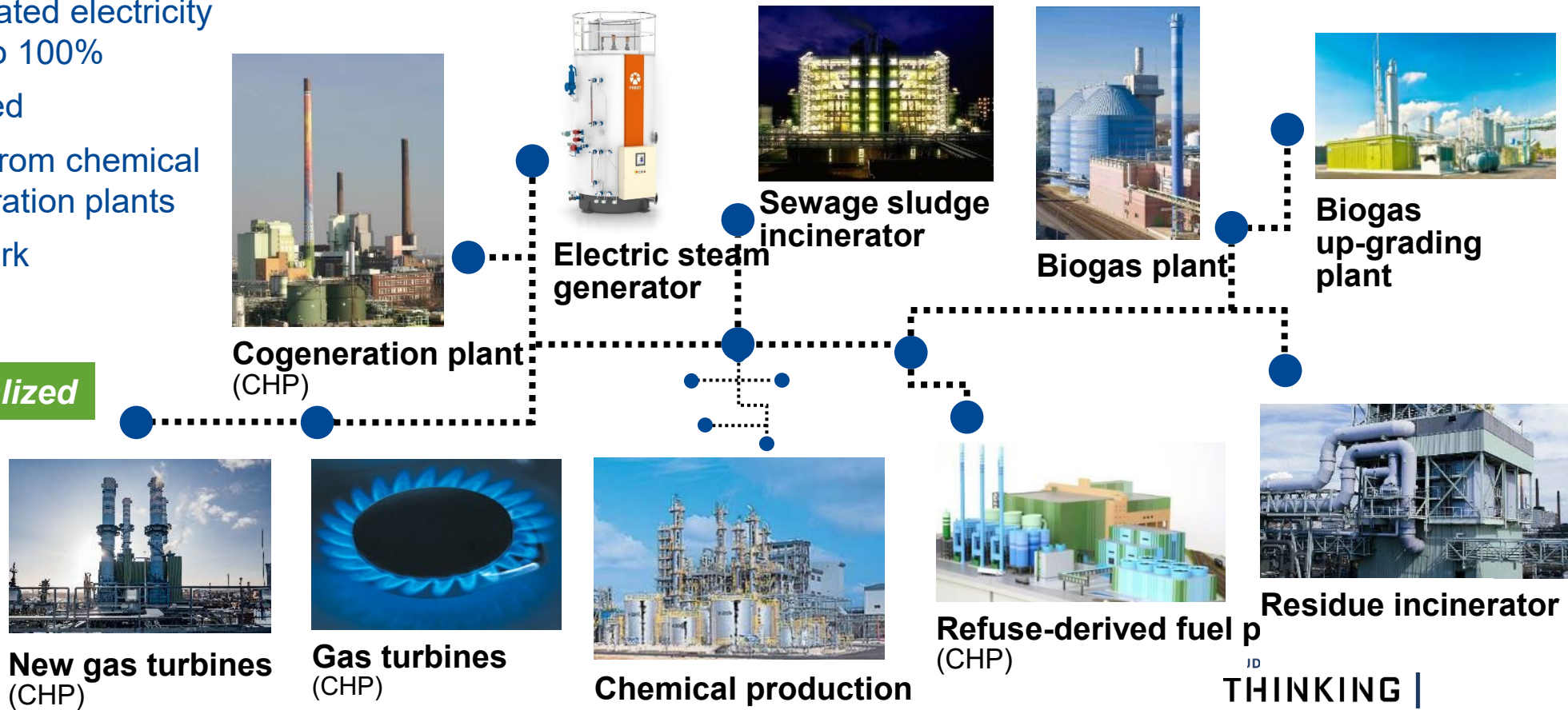


Starting Point: Integrated Heat and Electricity Network

Increasing energy efficiency and reducing CO₂ emissions in the energy network

- Highly efficient combined heat and power generation
- Increase in self-generated electricity
Generation capacity to 100%
- Coal combustion ended
- Waste heat recovery from chemical production and incineration plants
- Flexible system network

Waste-to-Energy realized



Carbon capture campaign with GEA pilot plant

Project example: From IS2H4C in 2025

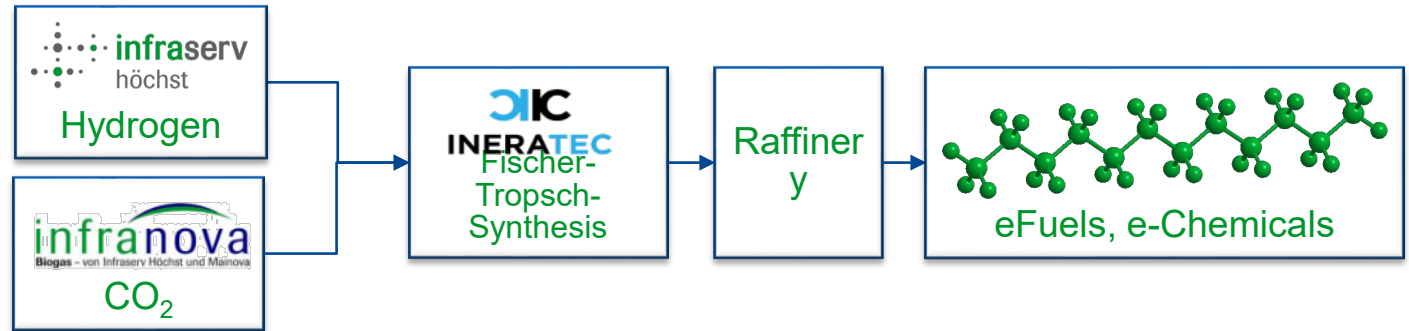
- CO₂ capture at a waste incineration plant
- Pilot plant campaign from May-August 2025
- Determine costs of CC
- Further costs for purification, compression, liquefaction, transport ex IPH
- Investigation of heat integration / optimization
- Determine alternative capture processes such as membrane technology incl. test trial



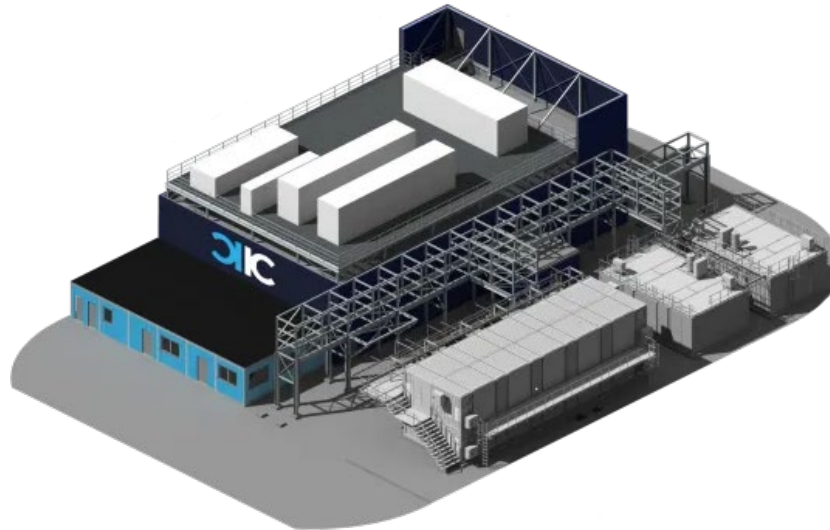
Example: Hydrocarbons produced from biogenic CO₂ and hydrogen: Settlement of INERATEC

Power-to-Liquid Pioneer plant in Germany

- Raw materials:
 - H₂ from electrolysis with renewable power und CO₂ from biogas up-grading
- Production of 2,500 tonnes of eFuel and e-Chemicals annually by INERATEC



The pioneering plant is one of the largest of its kind and will pave the way for further PtL projects from INERATEC



Industrial Symbiosis: Industrial parks as innovation hubs

Infrastructure

Energy supply

- Power generation
- Electricity grids
- Heat / Steam
- Hydrogen
- Biogas
- Biomethane
- ...

Disposal (Circular economy)

- Wastes
- Phosphate
- CO₂
- ...

Sustainable raw materials available

Innovation Campus

Initiation and participation in funded innovation projects

Settlement of innovative start-up companies

Pilot and demonstration plants for PtG, PtL and PtX

First-of-its-kind systems for sustainable processes

Industrial infrastructure in place

Networks

Formation and active participation in networks with chemical companies

Experience has shown that regional clusters offer significant synergies

Close cooperation with universities and research institutions

Entire value chain present

Industrial-Symbiosis

Transfer of experience and joint learning

Process4Sustainability

- Target: Creation of a CO₂-neutral industry by 2045
- Topic: Breaking down CO₂ neutrality to the individual company and making findings usable.
- The cluster supports companies on their way to climate neutrality by:
 - Identification of the levers for CO₂ neutrality (CO₂ footprint; Scenarios; Roadmap Development)
 - Identification of technical solutions for CO₂ neutrality (technology assessment, discussion papers, trend radar)
 - Dealing with new business models (circular economy, public-private partnership)
 - Networking with innovation partners and solution providers for CO₂ reduction (innovation and cooperation formats)
 - Project development and public funding, review of support programmes (application and innovation support)



**Process4
Sustainability**



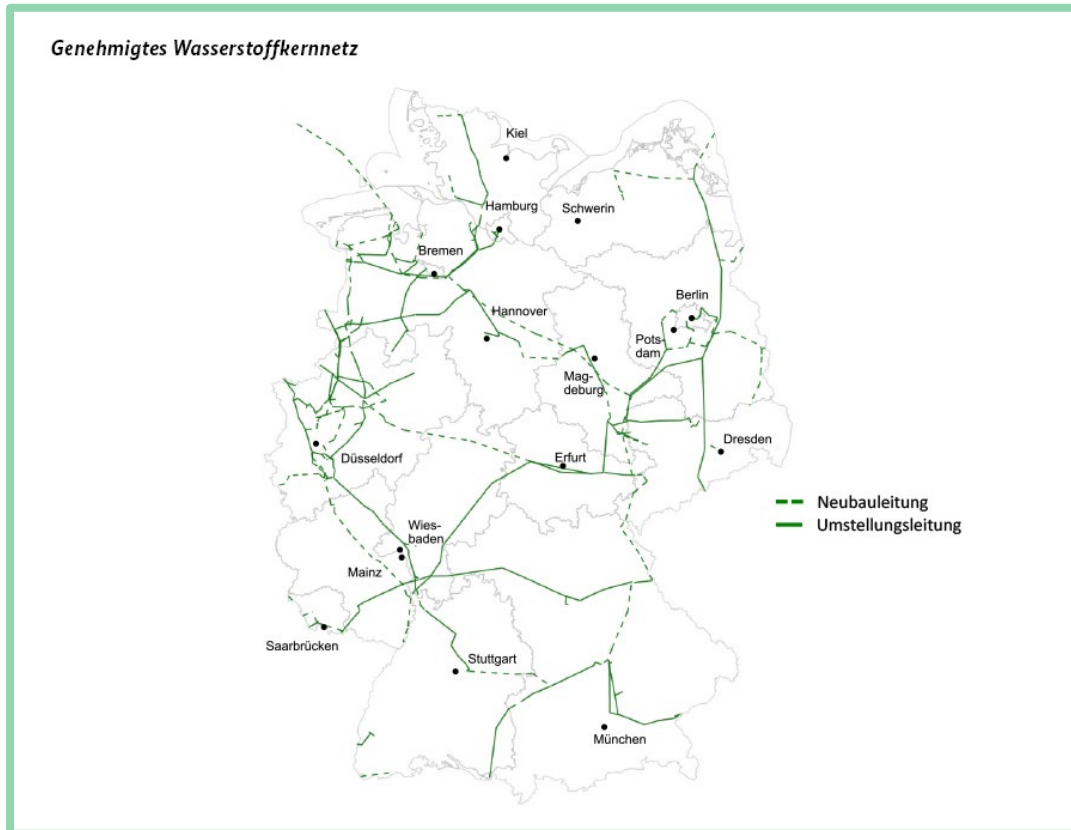
Levers

1. Replacement of natural gas
 - "Green" electricity
 - Electrification Heat
 - Synthetic methane from CO₂
 - C-free fuel gas (H₂; Methane pyrolysis)
 - Biogas / Biomethane
2. Substitute for fossil ethylene
 - "Green" ethylene from ethanol
 - Plastic recycling and cracking
3. Substitute for fossil methanol
 - Syngas from biomass; CO₂ und H₂
4. Substitute for fossil acetic acid
 - via "green" methanol
5. Other topics
 - CCS; Recycling

Industrial-urban symbiosis

Industrial transformation requires collective action

Example: Infrastructure H2



Relevant Stakeholders:

- Companies
- Policy makers
- Public administration
- Society incl. NGOs
- Media
- ...

Textbook world: Cooperation between politics, business, and society

But why does this interaction not work in real-life?

Policy Mix

Multi-Level

Poly-
centric

Wait-see

Mind-set

1. Fragmented and inconsistent transition policy mix
Transformation processes require coherent sets of instruments. Reality shows fragmentation and a lack of coherence
2. Multi-level governance :Too many veto players lead to compromise solutions and long coordination processes. As a result, companies increasingly lose track of responsibilities and decision-making logic.
3. Polycentric governance: In a complex system such as the energy transition, many levels of actors emerge. Without coordination, the overview is lost – for politics, business, and society alike.
4. Lack of credible commitment: Political uncertainty prevents investment. Companies do not recognize the long-term reliability of political commitments.
5. Cultural change needed: Social change can only succeed if technological, economic, and cultural dimensions are linked. The ability to shape change in a co-creative way is needed.

IS Model	What can be found in the Frankfurt area? (own impression)
Self-organised	<ul style="list-style-type: none"> ▪ If complementary actors identify joint economic interests (e.g. construction industry and landfill operator)
Facilitated	<ul style="list-style-type: none"> ▪ Some funded initiatives e.g. Bioball ▪ Process4sustainability.eu network
ICT enabled	<ul style="list-style-type: none"> ▪ ? (data on CO₂ or biomass in the region as a challenge)
Strategic or planned	<ul style="list-style-type: none"> ▪ Initiatives within the industrial park Höchst and between the park and the district (if significant economic benefits are identified)

Societal readiness level

In addition to the Technology Readiness Level, the Societal Readiness Level describes society's readiness to accept, understand, and use new technologies. This approach calls for the parallel development of technical and societal innovation pathways.

Societal	Readiness Level	Technology
Successful deployment in real stakeholder context	9	Successful user deployment in real life
Final testing in real stakeholder context	8	Final user testing in real life
Demonstrated in operational stakeholder context	7	Demonstrated in operational user environment
Demonstrated in simulated stakeholder context	6	Demonstrated in simulated user environment
Validated in simulated stakeholder context	5	Validated in simulated user environment
Stakeholder context validated	4	Validated in lab
Stakeholder context proof of concept	3	Experimental proof of concept
Proposed solution in stakeholder context	2	Technology concept
Societal problem in stakeholder context	1	Basic principles

- Redesigning the economy within the planetary boundaries is a large-scale socio-technical transition. In addition to the technical challenge, it includes the redesign of a variety of societal fields (e.g. industries, policies, markets, customer preferences, regulation, science). The multi-level perspective helps to capture the dynamic nature of these transitions.
- Real-life-challenges in the transition: 1. inconsistent policy mix; 2. multi-level governance, 3. lack of overview of in polycentric governance, 4. lack of commitment, 5. cultural deficits
- Societal acceptance of industrial activities can be understood as a relationship between an accepting subject and an object of acceptance. Social acceptance is developed in a societal discourse process and influenced by project and process characteristics (project: e.g. perceived cost-benefit, risks; process: perceived fairness, perceived social influence and participation).
- One way of capturing the societal acceptance of a project are the so-called societal readiness levels which complement the established technological readiness levels.

Literature and project references

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[zin-publikationen.pdf \(provadis-hochschule.de\)](#)



**Process⁴
Sustainability**

HESSEN



Hessisches Ministerium
für Wirtschaft, Energie,
Verkehr und Wohnen



**Sustainable
Industrial Area
Management**

[zin-projectlist.pdf \(provadis-hochschule.de\)](#)

Transforming Industries



We are supporting the industry to become more sustainable, reduce CO₂ emissions and benefit from digitalization. Through our projects we identify options for industry defossilization and new business development.

Accelerating Sustainable Businesses



We conceptualized the EIT Climate-KIC cleantech accelerator and managed it both regionally and internationally. We offer start-ups mentorship and support with sustainable business model development. For organizations we develop business creation and matchmaking formats.

Educating Change Makers



We create learning opportunities for national and international change makers. Our formats (e.g., workshops, trainings, summer schools) focus on real-life challenges and bring latest knowledge in effect. We make knowledge work!

20+ high-impact projects on regional, national and global scale with partners from academia, industry and public authority.

Key facts since 2016



Cooperations with **50+** companies



350+ start-ups in 13 countries supported



2.500+ participants in our education formats



Activities with a funding of **18** million euros

Selected Projects

Hochschule

CO₂ -Neutrality: Process4Sustainability cluster



Process4Sustainability



Management of European Cleantech Accelerator



Sustainable Industrial Area (SIA) Management Courses with GIZ



Projects with impact in **30+** countries



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