Energy Process Engineering and Thermal Waste Treatment (EVT)

...closing the carbon cycle!

TU Bergakademie Freiberg
Institute of Energy Process Engineering and Chemical Engineering (IEC)
Institute Director Prof. Dr.-Ing. Bernd Meyer
Who?
Leading R&D institute in Europe for the sustainable chemical conversion of primary and secondary carbon resources.

What?
Enabling the transformation from a linear to circular carbon economy.

How?
Closing the carbon cycle through sector coupling i.e. integration of energy, chemical, waste management and recycling industries.

With Whom?
Connecting key international players at the nexus of science, technology and society.
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The history of the Institute of Energy Process Engineering and Chemical Engineering (IEC) dates back to 1918, when the Lignite Foundation of the State of Saxony was founded to support and develop the upcoming Saxon lignite industry. Since then, significant milestones and developments have been achieved. Building on that tradition, the IEC is the largest institute at TU Bergakademie Freiberg today, both in terms of personnel and research funding.

Although the institute’s R&D and education focuses have undergone changes in recent decades, IEC has maintained its close collaboration with the industry and broadened its research areas and competences in particular over the last years. The drive for excellence in theoretic and experimental research in the fields of energy process engineering and reaction engineering remains the key focus of IEC’s activities today.

**History of IEC at „Reiche Zeche“**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918</td>
<td>“Lignite Foundation” in Freiberg founded by the State of Saxony and industry</td>
</tr>
<tr>
<td>1919</td>
<td>Establishment of “Heat-economy Department” as precursor of IEC</td>
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<tr>
<td>1921</td>
<td>Construction of the first buildings and test plants at “Reiche Zeche”</td>
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<tr>
<td>1945</td>
<td>Affiliation as Institute of Technical Fuel Utilization with the Bergakademie Freiberg</td>
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<tr>
<td>1949</td>
<td>Erich Rammler as Institute Director (until 1966)</td>
</tr>
<tr>
<td>1952</td>
<td>First industrial Coke Oven Plant Lauchhammer for Lignite High Temperature Coke (BHT), based on E. Rammlers invention</td>
</tr>
<tr>
<td>1975</td>
<td>Erhard Klose as Institute Director (until 1994)</td>
</tr>
<tr>
<td>1986</td>
<td>Establishment of the Chair “Reaction Engineering”</td>
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<tr>
<td>1991</td>
<td>Scientific reorganization after German reunification</td>
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<tr>
<td>1994</td>
<td>Prof. Dr.-Ing. Bernd Meyer as Institute Director (until now)</td>
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<td>2003</td>
<td>First pilot plant HP POX</td>
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<tr>
<td>2009/16</td>
<td>BMBF funded “Center for Innovation Competence VIRTUHCON” (Virtual High Temperature Conversion) Phase I/II</td>
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<td>2010</td>
<td>Syngas-to-Fuel pilot plant</td>
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<tr>
<td>2013</td>
<td>FlexiSlag gasification pilot plant</td>
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<tr>
<td>2017</td>
<td>“Chemical Conversion Processes” Business Unit of the Fraunhofer Institute for Microstructure of Materials and Systems (IMWS)</td>
</tr>
<tr>
<td>2018</td>
<td>GSP gasification pilot plant operated by DBI Virtuhcon GmbH in cooperation with EVT</td>
</tr>
</tbody>
</table>

...closing the carbon cycle!
The Institute of Energy Process Engineering and Chemical Engineering (IEC) focuses on the comprehensive experimental investigation, theoretic description, modeling and simulation of material and energy conversion processes. Examples include syngas generation for the production of basic chemicals or fuels, the beneficiation of carbonaceous feedstock for metallurgical and environmental applications as well as catalytic and non-catalytic flue gas treatment and syntheses of alternative transportation fuels.

The two chairs at IEC are responsible for education including fundamental lectures and multiple major subjects in the bachelor, master and diploma courses for “Process Engineering”. Additionally, IEC is involved in the study courses “Environmental Engineering”, “Energy Technology”, “Mechanical Engineering” and “Industrial Engineering”.

IEC is equipped with a wide range of experimental facilities ranging from laboratory to large-scale pilot plants as well as comprehensive software packages for modeling and simulation of single processes and complete process chains. Due to its strong R&D background, the IEC belongs to the leading institutes in Germany in terms of third-party funds. It is Europe’s top R&D institute in the fields of large-scale gasification and circular carbon economy.

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The R&D activities of the Chair Energy Process Engineering and Thermal Waste Treatment (EVT) are focused on the efficient and sustainable use of primary and secondary carbon resources such as coal, oil, natural gas, biomass and wastes/residues. The objective is the development and optimization of innovative and new technologies for the sustainable chemical conversion and utilization of carbon resources. The goal is to close the carbon cycle and to include all carbon resources in a circular carbon economy.

The research topics of the Chair Reaction Engineering (RT) address fundamental and applied aspects in the fields of exhaust gas purification, CO₂ abatement as well as production of synthetic and biogenic fuels. A particular feature is the knowledge-based development of advanced catalytic materials and chemical processes. These activities cover a wide area of research ranging from preparation and physical-chemical characterization of catalysts, in situ/operando spectroscopy, kinetic modeling to reactor and process engineering.

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The education and R&D profile of the Chair of Energy Process Engineering and Thermal Waste Treatment (EVT) focuses on innovative processes, technologies and systems associated with closing the carbon cycle for sectors ranging from energy, chemical, waste, metallurgy to processing industries. This profile is strengthened by the integration of the business unit „Chemical Conversion Processes“ of the Fraunhofer Institute IMWS Halle at the Chair. Key objective is the minimization of CO$_2$ emissions associated with the thermo-chemical conversion of primary and secondary carbon resources. These include fossil as well as renewable energy resources such as crude oil, natural gas, coal, biomass, carbon-containing waste and CO$_2$. Through a coupling with renewable energy („green" electricity, „green" hydrogen) and the chemical recycling of secondary carbon resources, CO$_2$ emissions-free chemical production can be achieved and technically realized. Our R&D activities thus make a critical contribution to the successful and sustainable transformation of the energy and raw material sectors from a linear to circular carbon economy in Germany.

To achieve our objectives, modern energy process engineering methods ranging from experimental process evaluation, CFD simulation, flow-sheet simulation, mineral phase simulation, reactive fluid dynamics to thermodynamic process chains analysis are utilized. The interdisciplinary integration with chemistry (organic, inorganic, physical and analytical), numerical mathematics, material engineering, non-ferrous and ferrous metallurgy as well as with business administration/economics/social sciences support a holistic evaluation of energy and raw material systems which is a unique strength of the chair.

The following R&D areas at EVT are highlighted:
- processes and technologies for low emission, thermo-chemical conversion of primary and secondary carbon resources (extraction, hydrogenation, pyrolysis, coking, gasification, partial oxidation, reforming, XIL and PiX technologies) as well as metallurgical reduction
- predictive process simulation and virtualization i.e. integration of simulation and experiments at all levels of scale-up including large-scale test facilities – a unique R&D approach for universities in Germany
- process chains simulation and life cycle assessment (LCA)
- technology assessment, scientific and technology communication as well as public acceptance research

Key is the synergetic interaction between fundamental and applied research through to the development of new technologies as well as the close collaboration with national and international businesses at the nexus of science, society and technology.
R&D Areas and Divisions at EVT

**Feedstock & Conversion**
- **Mineral Matter**
  Dr.-Ing. Stefan Guhl
- **Thermo-Chemical Conversion**
  Dr.-Ing. Steffen Krzack

**Process & Components**
- **CFD Modeling**
  Dr.-Ing. Andreas Richter
- **Plant Operation**
  Dipl.-Ing. Olaf Schulze

**Systems**
- **Technology Assessment**
  Dr. rer. pol. Roh Pin Lee
- **Process Chains Development**
  Dr. rer. nat. Felix Baitalow

**Technologies**
- **Technologies for Solid Fuels Gasification**
  Dipl.-Ing. Friedemann Mehlhose
- **Syngas Technologies**
  Dr.-Ing. Peter Seifert

**Research Groups**
- **Virtuhcon** – Dr.-Ing. habil. Andreas Richter: Dr. Sebastian Kriebitzsch (Multiphase Models/MM), Dr.-Ing. Jörg Kleeberg (Material and Process Analysis/MPA)
- **STEEP-CarbonTrans** (STEEP-Evaluation of Technological and Resource Alternatives for Carbon Feedstock to Support a Raw Materials Transition in the German Industry) – Dr. rer. pol. Roh Pin Lee

**Laboratory**
Dr. rer. nat. Marcus Schreiner

**Mechanical Workshop**
Tom Mader

**Head of Business Unit:**
Prof. Dr.-Ing. Bernd Meyer

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...closing the carbon cycle!
Feedstock & Conversion

Mineral Matter

The mineral matter behavior in high-temperature conversion processes such as gasification and combustion is of special interest as process disturbances and wear and tear of plant components are often linked to the ash/slag properties of the feedstock. The objectives of the “Mineral Matter” division are the chemical and physical characterization of these mineral components to deepen the understanding of the influence of ash/slag in high temperature processes and support the development of new approaches. Besides analytical and experimental investigations, chemical equilibrium calculations are used to estimate the behavior of mineral components in high temperature processes.

R&D:

- Chemical characterization of feedstock and process samples (slags, agglomerates, fouling layers)
- Determination of viscosity, density, surface tension and wetting behavior of slags
- Experimental investigation of slag formation and the interactions between solid, liquid and gaseous phases at high temperatures and under different gas atmospheres
- Modeling of the ash/slag behavior on the basis of chemical equilibrium considering experimental data e.g. slag formation and solidification, mobilizing of trace elements and extraneous materials (sulphur and alcalis), deposit formation/fouling, refractory corrosion etc.

Thermo-Chemical Conversion

Conversion processes at elevated temperatures are applied to produce higher value products from primary and secondary carbon resources. Typical process routes for chemical conversion and utilization include the generation of transportation fuels, basic chemicals and the production of metallurgical coke or adsorbent for environmental protection. The focus lies on beneficiation and conversion of biomass, coal, wastes and residues by pyrolysis, gasification or related processes. The “Thermo-Chemical Conversion” division aims for a better understanding and improvement of conversion processes as well as for the development and realization of new applications and variants of conversion processes for alternative feedstock and new products.

R&D:

- Fuel technological evaluation of carbon resources
- Characterization of thermochemical behavior of coal, biomass, wastes and residues
- Investigation of mechanism, kinetics, energy and material balances of pyrolysis processes
- Investigation of reactivity of fuels and kinetics of gasification reactions
- Production and characterization of coke and chars for various applications including the development and optimization of carbon-based adsorbents
- Investigation of the influence of feed properties and operating conditions on the product quality of conversion processes

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The tasks of the “CFD Modeling of High-Temperature Processes” division focus on the modeling of high-temperature processes across the entire spectrum ranging from chemically reacting particles to the complete reactor. One key aspect is the development of models and strategies for the simulation of high-temperature reactors such as fixed-bed, fluidized-bed, and entrained-flow in metallurgy and chemical engineering. Fundamental research on sub-systems is incorporated into the development of advanced sub-models. These sub-models are then integrated into reactor models for an improved simulation of reacting fluid-solid systems. Based on insights gained through such advanced modeling, optimization strategies can be developed for an accelerated adaption of existing technologies as well as for the development of new technologies.

**R&D:**
- CFD Modeling of catalytic and non-catalytic reforming of natural gas
- CFD Modeling of coal gasification processes (entrained-flow, fluidized-bed, slag-bed)
- CFD Modeling of metallurgical processes (roasting, bed smelting, blast furnaces)
- Design and modeling of high-temperature test reactors
- Studies of isolated particles in high-temperature environments (heat and mass transfer, pyrolysis, gasification, particle shape development)
- Heat and mass transfer in porous media
- Sub-model development (e.g. slag film, carbon conversion, pore growth)

The “Plant Operation” division is involved in the design, construction and operation of bench-scale and large-scale pilot plants. These plants enable investigation, process development, equipment performance assessment and optimization under industrial operating conditions. Diverse experimental activities contribute to the realization of innovative process concepts and process chains.

**R&D:**
- Designing, planning, construction and operation of bench-scale and large-scale pilot plants
- Assessment of process design parameters for industrial plants
- Optimization of process design and equipment
- Sampling under real process conditions (high pressure and temperature)
- Development, implementation and operation of highly specialized measurement equipment
- Provision of synthesis gas products for external application
- Optical flame visualization under high pressure high temperature conditions
- New robust and highly efficient gasification burners for extreme operating conditions

**Operated plants:**
- HP POX pilot plant
- STF gasoline pilot plant
- FlexiSlag pilot plant
- KIVAN High pressure drop tube gasification reactor
- COORVED fluidized bed gasifier
The Technology Assessment (TA) research group focuses on deepening the understanding of the interaction between science, technology and society to support the transformation from a linear to circular carbon economy. Our tasks include the integrated assessment of “STEEP” (socio-technological-economic-environmental-political) impacts along technological and resource chains representing viable alternatives for the energy and resource economies. Both direct impacts as well as systemic and indirect effects are considered so as to facilitate a better understanding of the energy and raw materials systems as large-scale social-technical systems which are made up of interrelated components and stakeholders connected in complex networks and infrastructures.

R&D:
- "STEEP" evaluations to support decision-making for a transition from: i) fossil to renewable energy sources (energy transition), ii) primary to secondary/renewable substances (raw material transition), iii) a predominant energetic use of primary and secondary resources to a chemical utilization through an innovative integration of renewable energies (resource transition)
- Comparative eco-efficiency evaluations of the entire value chain for existing and promising technologies for the production of carbon-based products and fuels
- Life-cycle assessments for the conventional and alternative utilization of carbon resources as well as concepts integrating renewable energy and CO₂ in production pathways
- Identification of systemic factors in the social and institutional environments that are barriers to the societal acceptance of alternative utilization of carbon resources and the social uptake of innovative technologies and associated infrastructures.

Technologies for Solid Fuels Gasification

The development and optimization of commercial/future gasifiers for the chemical conversion and utilization of carbon resources are conducted by the “Technologies for Solid Fuels Gasification” division. Accordingly, the influence of feedstock type and quality and process parameters such as temperature and pressure on operation results are analyzed. Addressed processes are investigated by applying various computer-based simulation tools as well as empirical non-dimensional correlations. Calculation results are presented as thermodynamic indices, exergy analyses and multi-dimensional maps (ternary diagrams). Additional topics include the gasification of low-quality (low-grade and/or high-ash, high melting) coal, the development of novel/advanced gasification concepts as well as the optimization of established commercial technologies.

R&D:
- Evaluation and comparison of commercial gasification technologies:
  - Thermodynamic efficiency under different operation conditions
  - Plant concepts
  - Investment and operational costs
- Development of novel/advanced gasifier concepts:
  - Reactor design
  - Gas-solid flow pattern
  - Feedstock blending
  - Feedstock feeding concepts

Syngas Technologies

The generation of synthesis gas through high-pressure partial oxidation and the synthesis of high-quality feedstock are important process steps of modern XIL routes. EVT operates a high-pressure synthesis gas plant for the gasification of liquid and gaseous carbon feedstock (HP POX – High Pressure Partial Oxidation) that is connected to a gasoline synthesis plant for the generation of high-octane gasoline out of synthesis gas (Syngas To Fuel – STF). The “Syngas Technologies” division focuses on modeling, planning, evaluation and test campaigns which are jointly carried out with the plant operation team. In addition, further development of gasoline synthesis is carried out at lab scale (STF+ test plant).

HP POX R&D:
- Generation and evaluation of complete sets of experimental data obtained from HP POX pilot plant operation
- Material and enthalpy balances, thermodynamical modeling
- Evaluation of trace components formation relevant for gas cleaning and utilization, e.g. HCN, NH₃, COS and organic acids
- Optimization of the gasification process for different carbon feedstock

Gasoline synthesis R&D:
- Generation and evaluation of complete sets of experimental data obtained from STF and STF+ pilot plants
- Material and enthalpy balances, thermodynamical modeling
- Optimization of operating parameters to improve gasoline quality
- Overall system analysis
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R&D:

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- Comparative eco-efficiency evaluations of the entire value chain for existing and promising technologies for the production of carbon-based products and fuels
- Life-cycle assessments for the conventional and alternative utilization of carbon resources as well as concepts integrating renewable energy and CO₂ in production pathways
- Identification of systemic factors in the social and institutional environments that are barriers to the societal acceptance of alternative utilization of carbon resources and the social uptake of innovative technologies and associated infrastructures.
Equipment – Pilot Plants

HP POX pilot plant (since 2003)
High pressure partial oxidation of gaseous and liquefied hydrocarbons

Characteristics:
- 5 MW(th)
- Up to 100 bar(g); up to 1500 °C
- Feedstock: natural gas, oils, heavy residues, slurries, ...
mixed max. 500 m³(STP)/h natural gas or 500 kg/h liquid
- Gas output max. 1500 m³(STP)/h

R&D:
- Gasification process design and modeling
- Reactor and burner design and modeling
- Trace component formation and modeling
- R&D for industry

Plant construction funded by:

STF gasoline pilot plant (since 2010)
Syngas-to-Fuel synthesis of high-octane gasoline

Characteristics:
- (1) methanol synthesis 50 bar and
  (2) gasoline synthesis
- Feedstock: 700 m³(STP)/h of syngas*
  * can be provided by the HP POX
- Stabilized gasoline output: 120 l/h

R&D:
- Process reactor development
- Catalyst testing
- Providing large gasoline quantities for fleet tests
- R&D for industry

Loc-scale catalyst test facility for tests up to 5 l/h gasoline

Plant construction funded by:
FlexiSlag gasification pilot plant (since 2013)
Next generation slagging gasifier for flexible feedstock qualities, esp. wastes

Characteristics:
- 10 MW(th)
- 40 bar(g)
- Feedstock: coal, biomass, waste,...
  up to 2 t/h carbon feedstock
- Gasification agents
  - O₂ max. 430 m³(STP)/h
  - Steam max. 450 kg/h
- Gas output: max. 2300 m³(STP)/h

R&D:
- Ash/slag behavior
- Optimization for different feedstock
- Gas quality and waste water
- R&D for industry

GSP gasification pilot plant (since 2018*)
Entrained flow gasifier with cooling screen and spray quench system

Characteristics:
- 5 MW(th)
- 26 bar(g)
- Feedstock: up to 450 kg/h of pulverized coal or coal slurry (other feedstock: brown coal, hard coal, petcoke, anthracite, biomass)
- Gas treatment: Desulphurization unit (Sulferox), COS hydrolysis, HCN hydrolysis
- Waste water treatment plant
- Test Rig for solid fuel feeding up to 300t/d

R&D:
- Ash/slag behavior
- Process validation for different feedstock
- Gas quality and waste water
- Transport behavior for pulverized feeding
- R&D for industry

* operated by DBI Virtuhcon GmbH, in cooperation with EVT
COORVED fluidized bed gasifier

Characteristics:
- 125 kW(th)
- Atmospheric pressure
- Feedstock: coal, waste, biomass max. 20 kg/h
- Gasification agents O₂, H₂O, CO₂
- Gas treatment: warm gas ceramic candle filter

R&D:
- Reactor development for pilot plant
- Gasification process design and modeling
- R&D for industry

Plant construction funded by:
and Pörner-Group

High pressure drop tube gasification reactor (KIVAN)

Characteristics:
- Up to 1150 °C, up to 100 bar(g)
- Feedstock: coal and biomass char max. 1.5 kg/h
- Gasifying agents: up to 300 l(STP)/min of CO₂ and up to 14.4 kg/h of steam
- Other gases: N₂ or Argon; H₂ and CO possible
- Inner diameter: 58 mm, length: 2.6 m
- 12 gas sampling points

R&D:
- Reaction rate kinetics
- Particle residence time

Plant construction funded by:
KIVAN, measurement

Plasma gasifier pilot plant (from 2019) Waste-to-syngas, powered by renewable energy

Characteristics:
- Up to 5000 °C (hot zone)
- Atmospheric pressure
- Feedstock: coal, waste (max. 50 kg/h)
- Plasma torch 80 kW (el)

R&D:
- Eco-friendly utilization of critical wastes
- Hot gas cleaning (tar removal)
- R&D for industry

Plant construction funded by:
DFG Deutsche Forschungsgemeinschaft
High temperature reactors:
- High-temperature drop tube gasification reactor (HTR)
- High-pressure drop tube gasification reactor (KIVAN)
- Laboratory pyrolysis facility (LPA)
- Pressurized pyrolysis facility (ALPA, DPA)
- High-pressure drop tube pyrolysis reactor (PYMEQ)
- Pyrolysis furnaces
- Rotary kiln
- Various tube furnaces

Gas and liquid lab:
- Gas chromatography (various micro gas chromatographs with different columns and detectors)
- Ion chromatography
- High-performance liquid chromatography: HPLC
- Pyrolysis facility coupled with gas chromatograph and mass spectrometer (Pyrolysis-GC-MS)
- Viscometer (temperature controlled up to 2000 °C)
- Total-reflection X-ray fluorescence analysis (TXRF)

Solid fuels analysis:
- Ambient pressure thermo-analysis (thermo-gravimetry: TG, differential thermo-analysis: DTA, differential-scanning calorimetry: DSC, all with optional mass spectrometer (MS) coupling)
- High-pressure thermo-analysis (TG, DTA, DSC)
- High-pressure magnetic-coupling thermo-balance
- Adsorption test facility for Hg and SO₂
- Simple particle disintegrator (SPaltor)
- Camsizers (particle size distribution)
- Reactivity test facility in fixed bed RiFix
- Coke reactivity index (CRI) and coke strength after reaction (CSR)
- Dilatometer (high temperature/Ruhr)
- Gieseler plastometer

Ash slag lab:
- Plasma ashing device
- X-ray analysis (X-ray fluorescence analysis: XRF, X-ray diffractometre XRD with in-situ temperature/pressure chambers)
- Electron microscopy (SEM, FIB-SEM)
- Thermo-optical measurement systems for surface tension and characteristic ash melting temperatures (with atmosphere control: TOM-AC, without atmosphere control: TOMMI)
- High-temperature viscometers
- Two-chamber double thermo-balance
- ETV-ICP OES – electrothermal vaporization - inductive coupled plasma – atomic emission spectroscopy for multielement-analysis, temperature dependent element release in combination with elemental speciation

Solid fuel lab:
- Leitz heated microscope (LEM) for investigations of ash melting behavior
- Elemental (ultimate) analyzer
- Combustion calorimeter
- Karl-Fischer titrations
- Direct mercury analyzer
- Microwave pressure digestion
- surface area measurement (N₂ or CO₂ isothermes)
- Mercury porosimetry
- Helium pycnometry
- Density measurement
- Refractometer

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Various software tools are available for different research and development activities including in-house code commercial and open source codes.

**CAD:**
- SolidWorks
- AutoCAD (c), AutoCAD P&ID
- Autodesk Inventor

**CFD:**
- ANSYS® Fluent®
- ANSYS® CFX®
- StarCCM+®
- OpenFOAM®
- PBS: in-house solver (2D and 3D, reactive and non-reactive flows, flows in porous media)

**DEM:**
- FB-DEM (ih): simulation of polydisperse packed beds

**Flow sheet simulation:**
- EBSILON® Professional

**Mesh Generation:**
- ANSYS® IceMCFD®
- ANSA®

**Mathematical tools:**
- Matlab®
- Origin®, Statgraphics
- MathCAD

**Optimization:**
- modeFRONTIER®

**Particle simulation:**
- Gasification simulator
- n RPG: direct pore growth modeling

**Process control:**
- LabView

**Slag analysis:**
- Slag Simulator: prediction of slag layer thickness in entrained flow gasifiers

**Thermodynamics:**
- FactSage, SimuSage

**Visualization:**
- e!Sankey, MathType, MS Visio, Paraview, Tecplot
- Avizo Fire

**Laboratory database:**
- enaio® lims

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**...closing the carbon cycle!**
Gasification Technology Center

Gasification competence and expertise including a full spectrum of pilot-scale gasification technologies which are suitable for carbon feedstock ranging from natural gas, oil, slurries, coal, biomass to liquid and solid waste are concentrated in the Gasification Technology Center in Freiberg.

(1) HP POX – Gas & Oil POX; Autothermal reforming
(2) GSP – Entrained flow gasification
(3) COORVED – Fluidized bed gasification
(4) FlexiSlag – Fixed bed slagging gasification
(5) Plasma – Plasma gasification
(6) STF – Syngas-to-Fuel synthesis of high-octane gasoline

Our R&D services include:

- **Large-scale test campaigns:**
  - For all kinds of carbon feedstock
  - Complete elemental and energy balance for main and minor elements including heavy metals, halogens, higher hydrocarbons, tars, oils, ...
  - Evaluation of ash and slag qualities as well as composition of grey water
  - Adjustment of different gasification conditions
  - ...

- **Technology development:**
  - New gasifier designs
  - Robust burners with extended life-span for multiple feedstock
  - Test of equipments
  - ...

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Examples</th>
<th>Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>Natural gas, flare gas, tail gas, ...</td>
<td>HP POX</td>
</tr>
<tr>
<td>Liquid</td>
<td>Refinery residues, liquid waste, ...</td>
<td>GSP</td>
</tr>
<tr>
<td>Slurries</td>
<td>Coal, pet coke, ...</td>
<td>COORVED</td>
</tr>
<tr>
<td>Solid</td>
<td>Coal, torrified biomass, ...</td>
<td>FlexiSlag</td>
</tr>
<tr>
<td>Pulverized Feedstock</td>
<td>Coal, biomass, waste, ...</td>
<td>Plasma</td>
</tr>
<tr>
<td>Grained Feedstock</td>
<td>Coal, biomass, waste, ...</td>
<td>STF</td>
</tr>
<tr>
<td>coarse Feedstock</td>
<td>Coal, biomass, waste, ...</td>
<td></td>
</tr>
</tbody>
</table>

...closing the carbon cycle!
EVT offers a full spectrum of services to companies, organizations and individuals tailored to your business:

1. **Scientific and technological consulting:**
   - Identification and evaluation of advantageous conversion routes for carbonaceous fuels
   - Independent technology consulting for companies
   - Technological evaluation (e.g. reactor design, burner design, refractory, components, feedstock preparation, handling of products and by-products)

2. **Lab services (esp. high temperature/pressure):**
   - Fuel analyses and evaluation
   - Thermal analyses and characterization of fuels
   - Pore structure analyses
   - Mineral matter analyses and characterization (e.g. slag viscosity)
   - Pyrolysis and gasification behavior (kinetics), characterization of feedstock and products

3. **Process routes evaluation:**
   - Development and modeling of syngas production routes (X|Y)
   - Energetic, environmental and technological evaluation
   - Estimation of CAPEX and OPEX (pre-feasibility)
   - Feasibility studies including technology selection and economical evaluation
   - Supporting different project phases

4. **CFD simulation:**
   - Detailed analyses of processes, designs and components
   - Development and optimization of improved designs and components

5. **Utilization of large-scale test plants:**
   - Test campaigns with existing plants for specific fuels or research topics
   - Determination of fuel suitability or process applicability

6. **Joint technology development**

7. **Utilization/transfer of patents for commercialization**

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**DBI-Virtuhcon GmbH**

Affiliated Institute of TU Bergakademie Freiberg

We are your partner for development and optimization of high temperature and high pressure conversion processes. We have a focus on chemical utilization of solid, liquid and gaseous feedstocks as well as metallurgical applications. We offer services from lab-scale to pilot-scale and from CFD simulations to technology development.

**Contact:** Dr.-Ing. Alexander Laugwitz; Phone: +49 3731 39-4558; E-mail: info@dbi-virtuhcon.de; Web: dbi-virtuhcon.de
Since 2005, the IEC has organized the „International Freiberg Conference on IGCC & XIL Technologies“ – a leading international conference addressing a wide range of topics relating to the thermo-chemical conversion of carbonaceous feedstock and related process chains. The event focuses on innovative carbon value chains and the transformation from a linear to a circular carbon economy.

The conference provides a high-level discussion forum to facilitate the exchange of information and expertise between political, industry and scientific stakeholders. Participants come from diverse fields and industrial branches ranging from researchers and specialists engaged in fundamental and applied R&D to policymakers, industry experts from mining companies as well as equipment and technology providers/manufacturers. Previous conferences have been held in various locations in Germany as well as in Inner Mongolia in China. During the conference, studies and new developments by researchers and technology developers as well as current or planned projects and operational experiences by plant operators related to innovative carbon value chains are presented.

Topics for presentations include:
- Fuel preparation and upgrading (e.g. drying, feeding and deashing)
- Low temperature conversion processes (e.g. extraction, torrefaction and pyrolysis)
- Upgrading of low-temperature conversion products (e.g. tar reforming)
- Coal conversion (e.g. characterization, reaction kinetics)
- Gasification/co-gasification (for solid, liquid and gaseous feedstock)
- Underground coal gasification
- Mineral matter characterization and behavior
- Synthesis gas treatment and synthesis technologies
- Carbon dioxide capture, storage and utilization
- Combined cycle and gas turbine developments for IGCC and polygeneration
- Coke production
- Direct liquefaction of coal
- Integration of coal and renewables for chemical storage
- Concept evaluations and flow sheet simulation
- Numerical modeling of conversion processes
- Perspectives from industry (e.g. coal mining organizations, technology developers)
- Public acceptance, trends and global boundary conditions (economic, regulatory and political) for fuel conversion to chemicals/fuels and electricity
- ...

In addition to a stimulating scientific conference program, the event also includes exciting technical tours such as visits to lignite mines, innovative and modern R&D facilities, power plants, XIL facilities and chemical plants etc. During the tours, participants not only obtain first-hand experience of the facilities, they also have the opportunity to engage experts and industry specialists on-site in intensive discussion about their activities. Last but not least, the conference program also consists of interesting social events (e.g. welcome reception, conference dinner, walking tours etc.) which are dedicated to facilitating networking and interaction between conference participants.

International Freiberg Conference on IGCC & XIL Technologies

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...closing the carbon cycle!
The Energy Raw Materials Network (ERN) continues the activities of the former information platform “German Center for Gasification Technologies” (DeZeV). Currently, eleven partners from science and industry in the fields of energy and Carbon resource conversion are active in the ERN.

The network provides a platform for collaboration, knowledge transfer and exchange through regular meetings, courses, workshops and conferences.

**Partners are:**

- BASF SE
- Mibrag mbH
- BASF SE
- TAF Thermische Apparate Freiberg GmbH
- Mibrag mbH
- RWE Power AG
- Eurofins
- TAF Thermische Apparate Freiberg GmbH
- Envirotherm GmbH
- UTF GmbH
- German Biomass Research Center
- IBExU Institut für Sicherheitstechnik GmbH
- Linde Engineering Dresden GmbH
- Dr.-Ing. Sindy Bauersfeld

Topics addressed by the ERN include new developments, current projects and operational experiences linked to:

- The efficient, sustainable and economical utilization of primary and secondary carbon resources in particular for the provision of base chemicals, fuels, coke, other carbonaceous products and hydrogen
- Strategies, approaches and technologies for reduction of carbon footprint, e.g. CO₂ minimization (\(\text{CO}_2\) untergesetzt), carbon capture, storage and utilization (CCS&U).

*The network activities promote scientific exchange along the whole carbon innovation and value chain from fundamental research to commercial applications. The ERN will be integrated into the Circular Carbon Economy Network (CCE). This network brings together science and industry partners from energy, chemical, waste management and recycling sectors and focuses on promoting a transformation from a linear to circular carbon economy and closing the carbon cycle.*
EVT offers intensive courses in the field of gasification technologies. The courses aim to provide a detailed introduction to the scientific fundamentals and technologies of:

- Gasification
- Synthesis gas production
- Synthesis gas purification
- IGCC power plants

Leading commercialized gasification technologies such as those from Shell, GE, Siemens etc. are presented in detail. Furthermore, the course program provides introductions to various simulation software tools and visits to lab facilities and large-scale test plants.

The limited number of participants allows for an intensive and comprehensive presentation of this scientific field which is tailored to individual participants. By request, special courses for different audiences or participants can be arranged to meet specific needs. To ensure a high level of quality, experienced specialists from the industry are invited to present special topics in the courses.

Since 2006, the IEC has regularly offered two to three courses per year. Representatives from leading national and international companies have participated in the courses for example Shell, Linde, Alstom, RWE, Haldor Topsoe, Siemens, BASF, E.ON, Total, Hydro Oil and Energy, GSP China Technology, MAN and Lurgi.

**The courses are aimed at:**

- Process and development engineers
- Plant engineers
- Executives of companies in the fields of plant construction, carbon conversion and utilization
- Development companies in the fields of thermal fuel technology, power plant technology, waste management etc. who would like to update and expand their knowledge on gasification processes and technologies.

Dr.-Ing. Sindy Bauersfeld

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Web: http://tu-freiberg.de/en/iec_evt/events/compact-courses
Selected Projects & References

- **HP POX** (2001 – 2011): Large-scale pilot plant for high-pressure partial oxidation of gaseous and liquid hydrocarbons, 70-100 bar, 5 MW thermal power (BMWi, Lurgi)

- **COORIVA** (2004 – 2008): Concept development and feasibility studies for IGCC power plants with CO₂ capture (BMWi, RWE, Vattenfall, EoN, SIEMENS, Uhde, Lurgi, Linde)

- **COORAMENT** (2005 – 2010): Development of IGCC power plant technology with CO₂ capture (BMWi)


- **Coal-based power generation through polygeneration** (2008 – 2011) (BMWi, Alstom)


- **STF** (2008 – 2013): Large-scale pilot plant for demonstration of a new technology to produce high-octane gasoline from synthesis gas, 55 bar, 100 kg/h gasoline (SMWK, Chemieanlagenbau Chemnitz)

- **COORVED** (2009 – 2016): Development of an innovative gasification technology for ash-rich coal (BMWi, Pörner)

- **Centre for Innovation Competence VIRTUHCON** (2009 – 2021): Virtual High-Temperature Conversion Processes (BMBF, SMWK)


- **ibi** (2011 – 2014): Development of innovative technologies for coal upgrading (supercritical extraction, catalytic cracking, thermochemical conversion) to produce valuable chemical feedstocks (BMBF, MIBRAG, Linde p.e. Industry)

- **SBV** (2011 – 2014): Pilot-scale fixed-bed slagging gasifier for difficult solid feedstock (SMWA, SMUL)


- **RUDERU** (2015 – 2016): Cooperation network for the Russian German Resource University (DLR, BMBF)

- **HITECOM** (2015 – 2017): High temperature conversion optical measurement (BMBF)


- **CODY** (2015 – 2017): CO₂ conversion through dynamic methanol synthesis (BMWi)

- **Brenngas-BGL** (2015 – 2017): Further development of the BGL gasification technology (BMWi, Bamag)

- **ERA-NET** (2015-2017): Technical and economical evaluation of an innovative technology for the chemical utilization of associated gas (crude oil) in the north regions of Russia


- **Kopernikus P2X** (2016-2019): Validation and implementation of “Power-to-X” concepts. Economic utilization and storage concepts for electricity from fluctuating renewable energy sources (BMBF)

- **STOBRA** (2017-2018): Low CO₂ coal chemistry and chemical recycling as contribution to a sustainable and low carbon circular economy in Saxony and neighbouring regions (SMWK/SAB)

- **STEEP-CarbonTrans** (2017-2022): “STEEP” evaluation of technological and resource alternatives for carbon feedstock to support a raw materials transition in the German Industry (BMBF)

- **OptoVirT** (2017-2021): Optical diagnostics and virtualization for technologies with minimal CO₂ footprint (BMWi)

- **OptoVirT+** (2017-2020): Optical diagnostics, virtualization, and optimization for technologies with minimal CO₂ footprint (SMWA)

- **Coalbypro** (2017-2020): Innovative management of coal by-products leading also to CO₂ emissions reduction (RFCS)

- **OptiCon** (2017-2020): Optical in-situ investigation and modeling of high temperature conversion processes (BMBF)


- **StoKo** (2018-2019): Sustainability evaluation of concepts for a circular carbon economy (BMBF)
Directions to IEC:

- Leave A4 at the “Siebenlehn” exit and travel along the B101 towards Freiberg
- In Freiberg, turn left at the second set of traffic lights towards Dresden
- At the next traffic lights, go straight ahead
- Turn left towards “Silberbergwerke/Reiche Zeche” in front of the church
- Follow the signs “Silberbergwerke/Reiche Zeche”, “IEC/Energiepark” to our institute

GPS: Latitude: 50.92918, Longitude: 13.35831

Postal address and contact data:

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Bird’s-eye view of the Institute of Energy Process Engineering and Chemical Engineering and its pilot plants (foreground) including the GSP gasification pilot plant (background)